DNA Structure

DNA

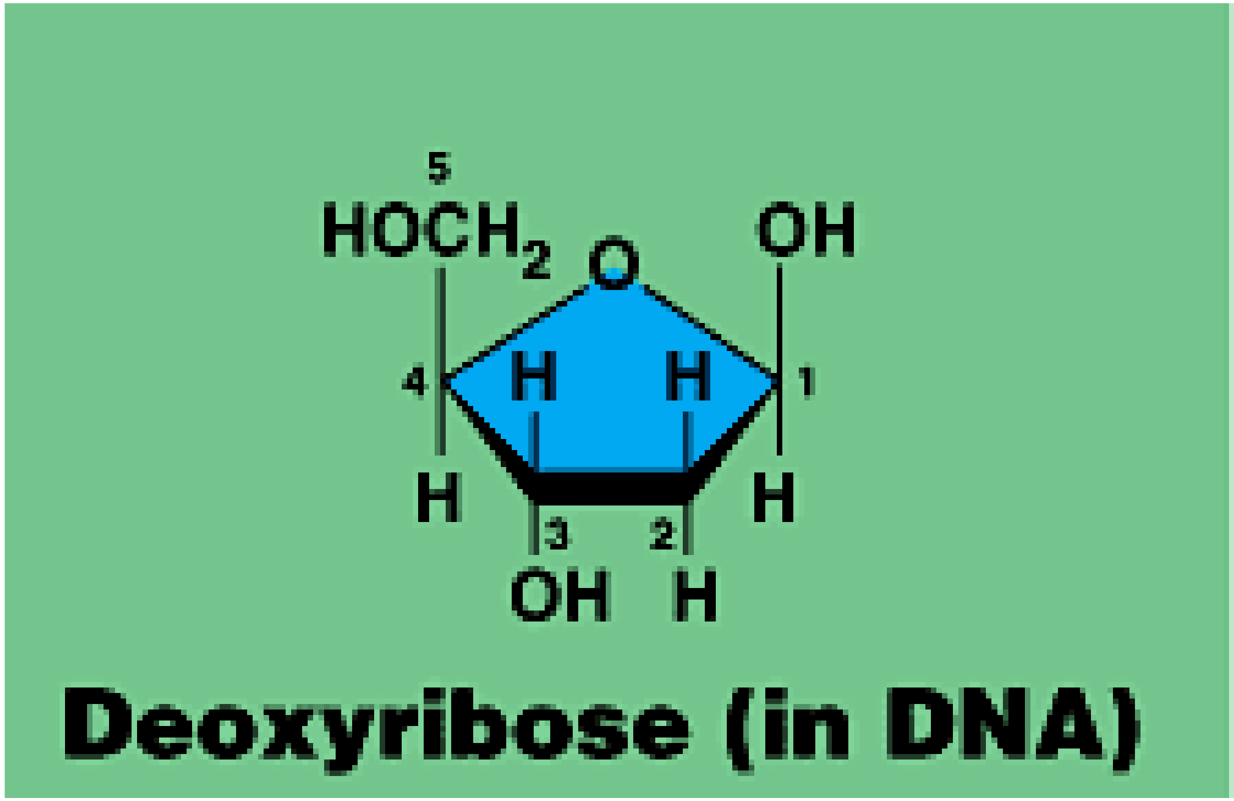
- DNA
- a polymer of **deoxyribonucleotides or Polynucleotide**
- found in **chromosomes**, **mitochondria** and **chloroplasts**
- carries the **genetic** information
- **Components of a nucleotide**
- **Nitrogen Base**
- **Sugar**
- **Phosphate**

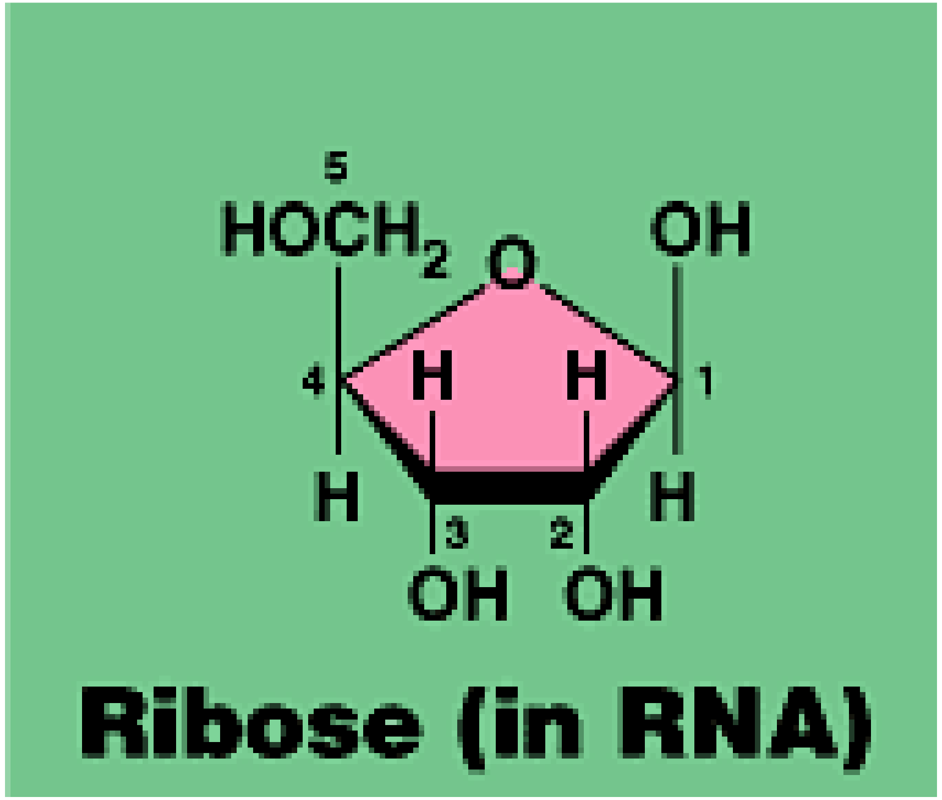
Nucleic Acids

- Nucleic acids are polymers
- Monomer---nucleotides
  - Nitrogenous bases
    - Purines
    - Pyrimidines
  - Sugar
    - Ribose
    - Deoxyribose
  - Phosphates
    - +nucleoside=nucleotide

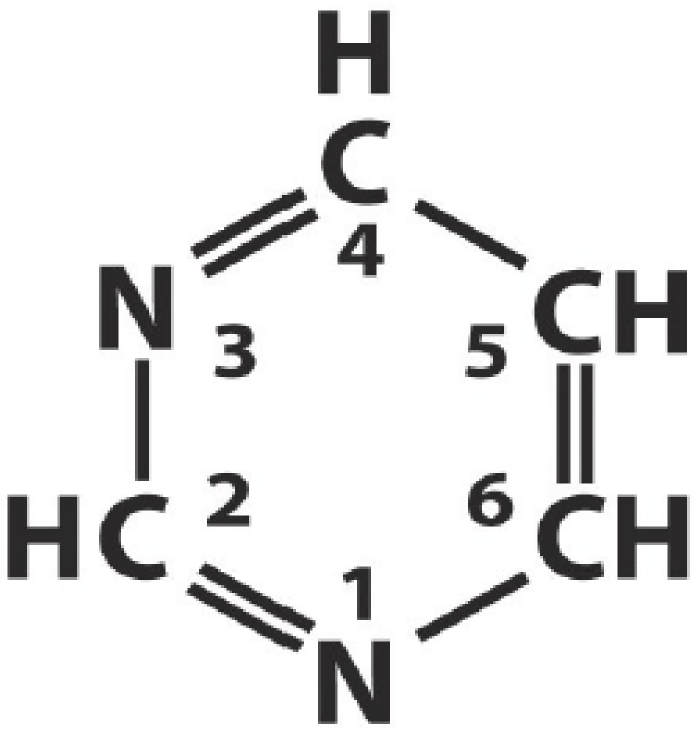
} Nucleosides

Sugars in Nucleic Acids

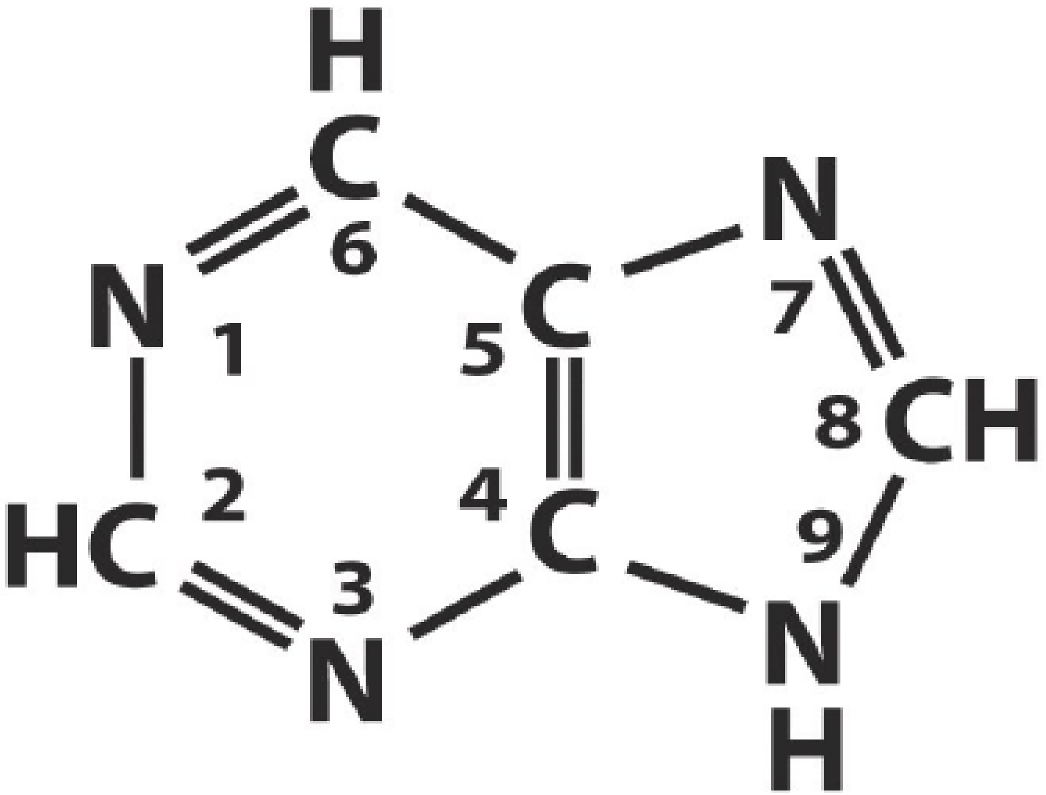




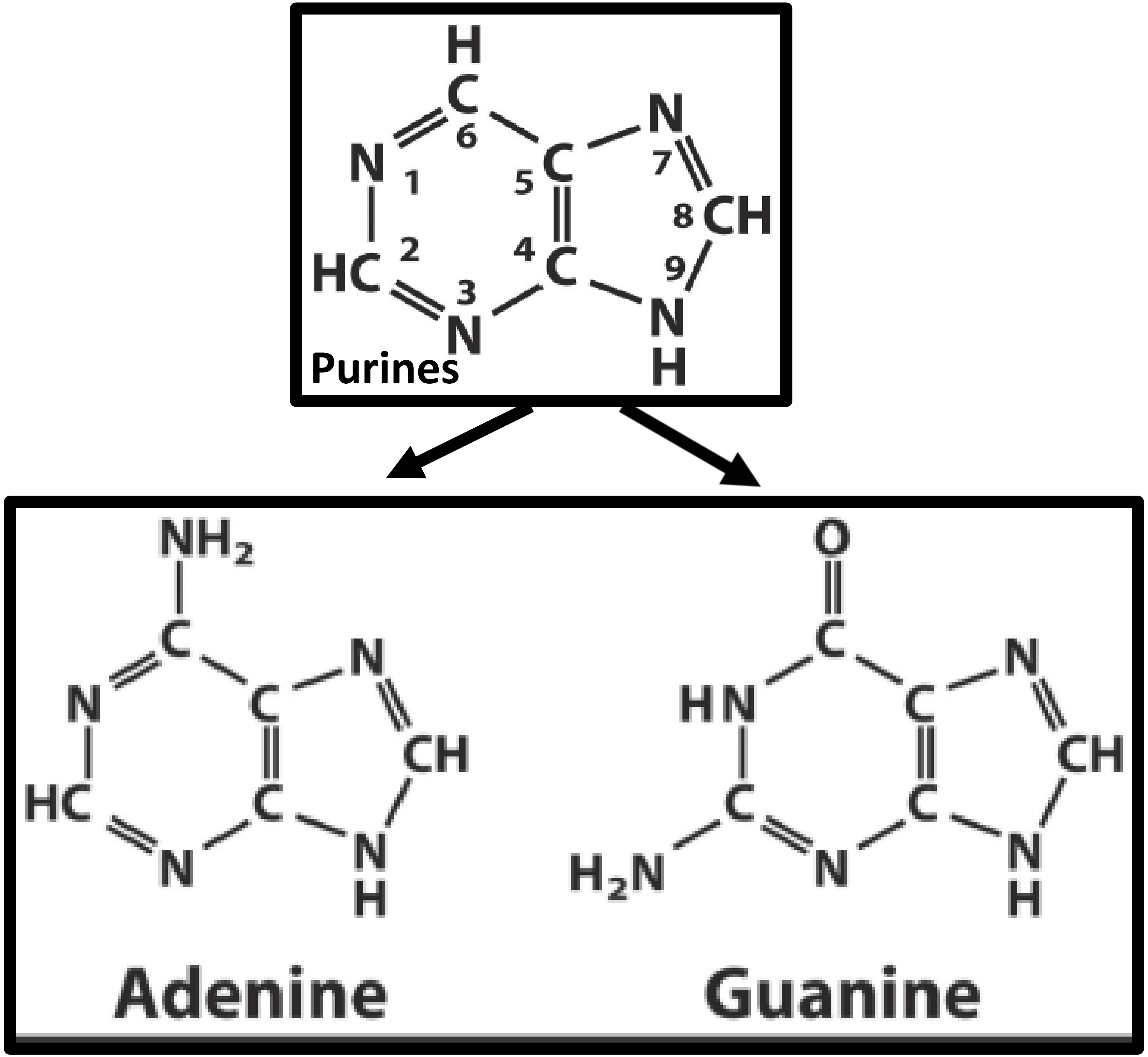
Basic Structure of Pyrimidines & Purines

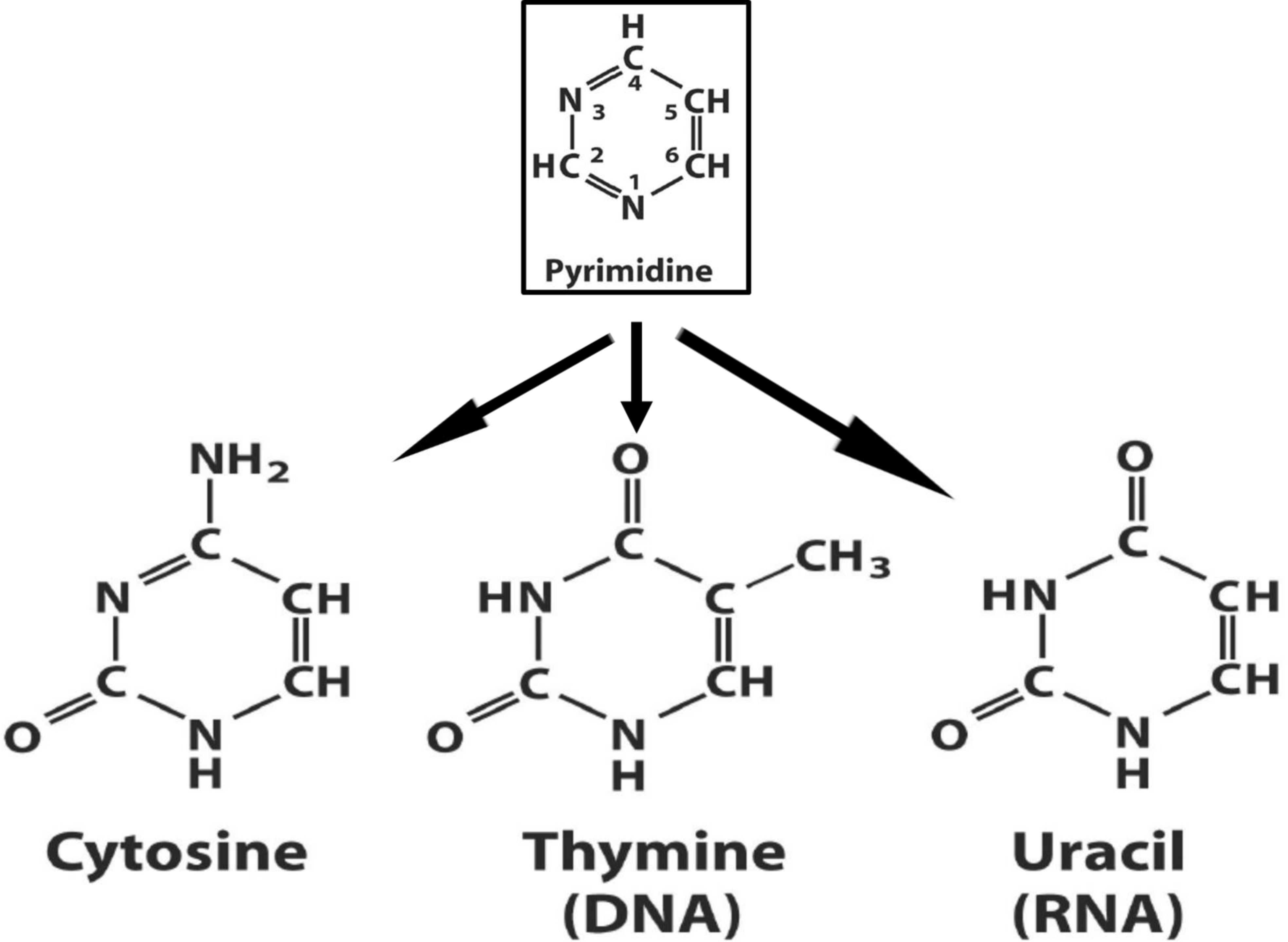


Pyrimidine



Purine


Purines
Adenine
Guanine

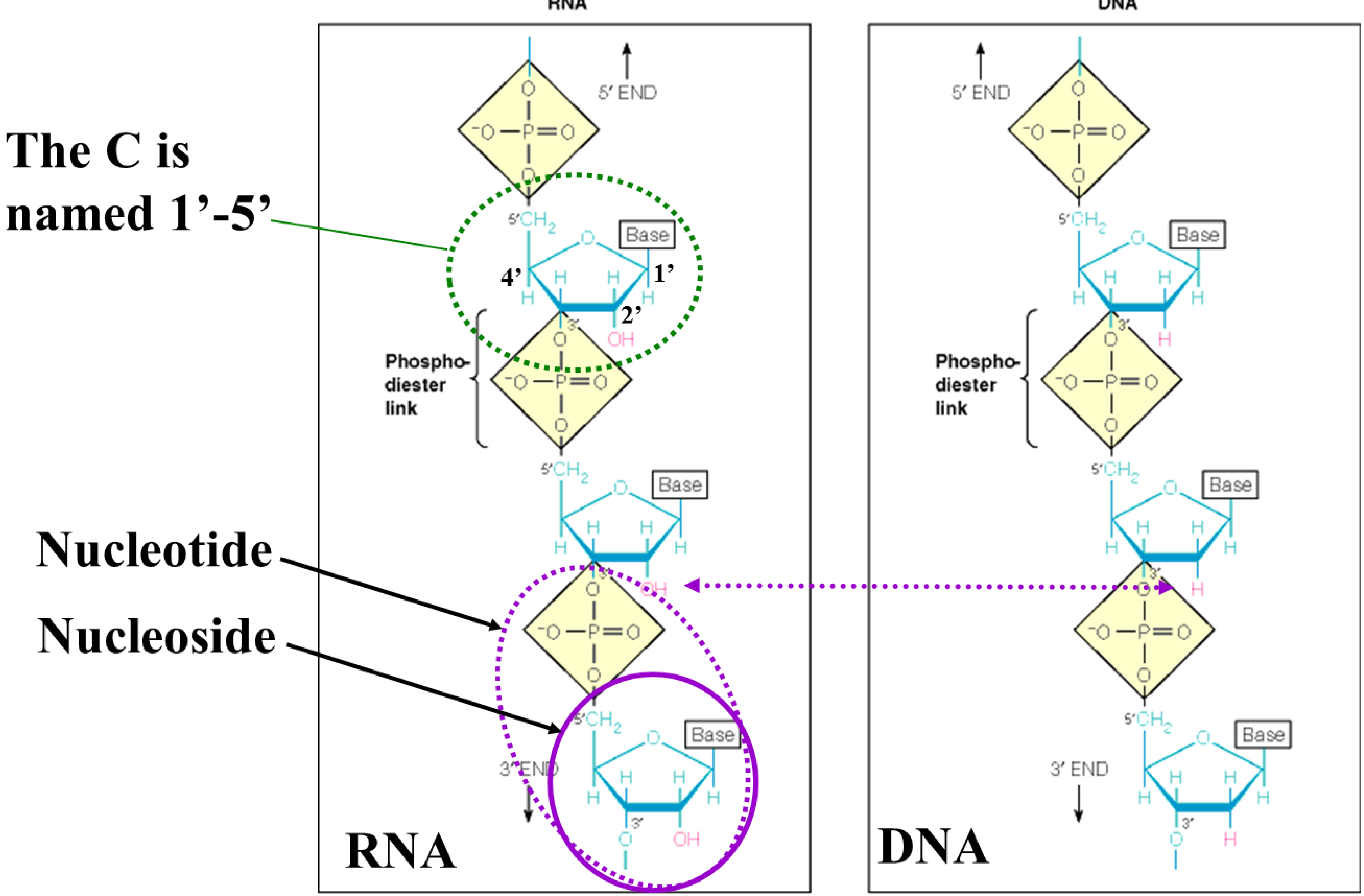

H
C
N
3
4
5
CH
HC
2
6
CH
1
N
Pyrimidine
NH2
C
N
CH
C
CH
O
N
H
Cytosine
O
C
HN
C
CH3
C
CH
O
N
H
Thymine
(DNA)
O
C
HN
CH
C
CH
O
N
H
Uracil
(RNA)

Nomenclature of Nucleic Acid Components

Base	*Nucleoside*	*Nucleotide*	*Nucleic acid*
Purines			
Adenine	Adenosine	Adenylate	RNA
	Deoxyadenosine	Deoxyadenylate	DNA
Guanine	Guanosine	Guanylate	RNA
	Deoxy guanosine	Deoxyguanylate	DNA

Nomenclature of Nucleic Acid Components

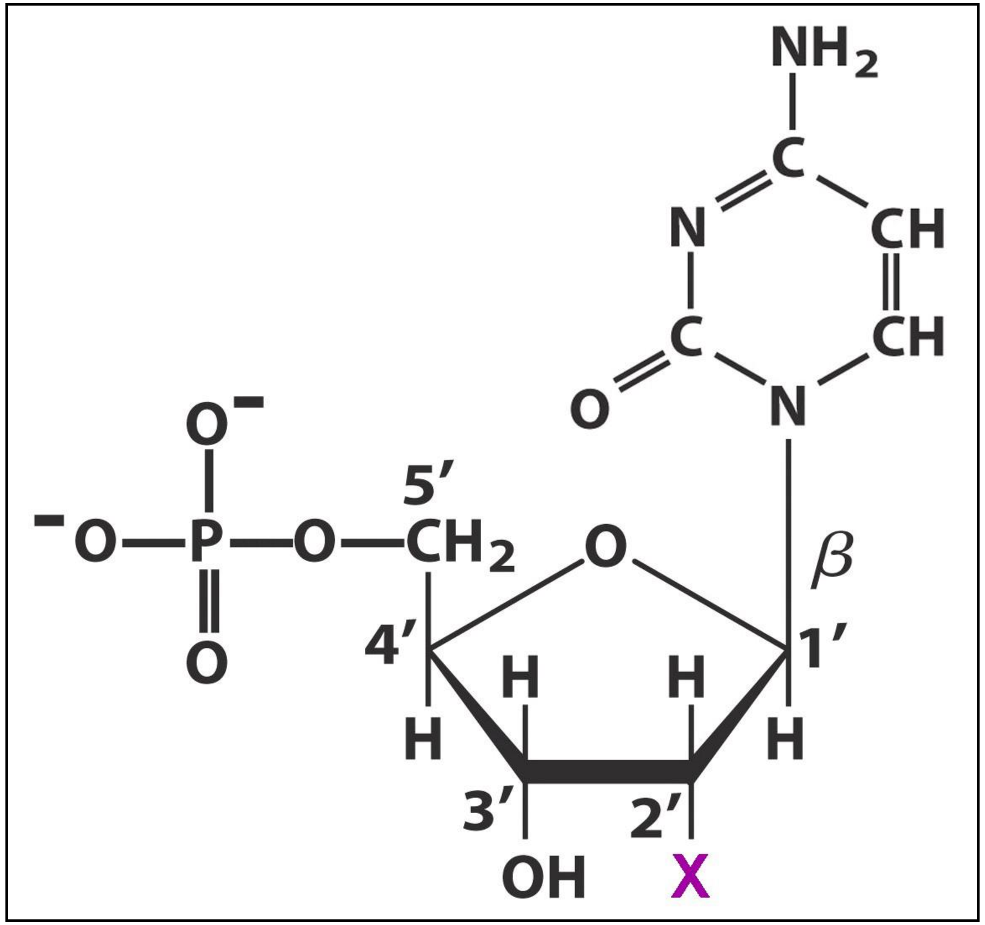
Base	*Nucleoside*	*Nucleotide*	*Nucleic acid*
Pyrimidines			
Cytosine	Cytidine	Cytidylate	RNA
	Deoxycytidine	Deoxycytidylate	DNA
Thymine	Thymidine	Thymidylate	DNA
	(deoxythymidine)	(deoxythymidylate)	
Uracil	Uridine	Uridylate	RNA



RNA
DNA
The C is named 1'-5'
Nucleotide
Nucleoside
5' END
3' END
Phospho-diester link
Base
4'
1'
2'
3'
5'CH2
OH
RNA
DNA

Nucleotide

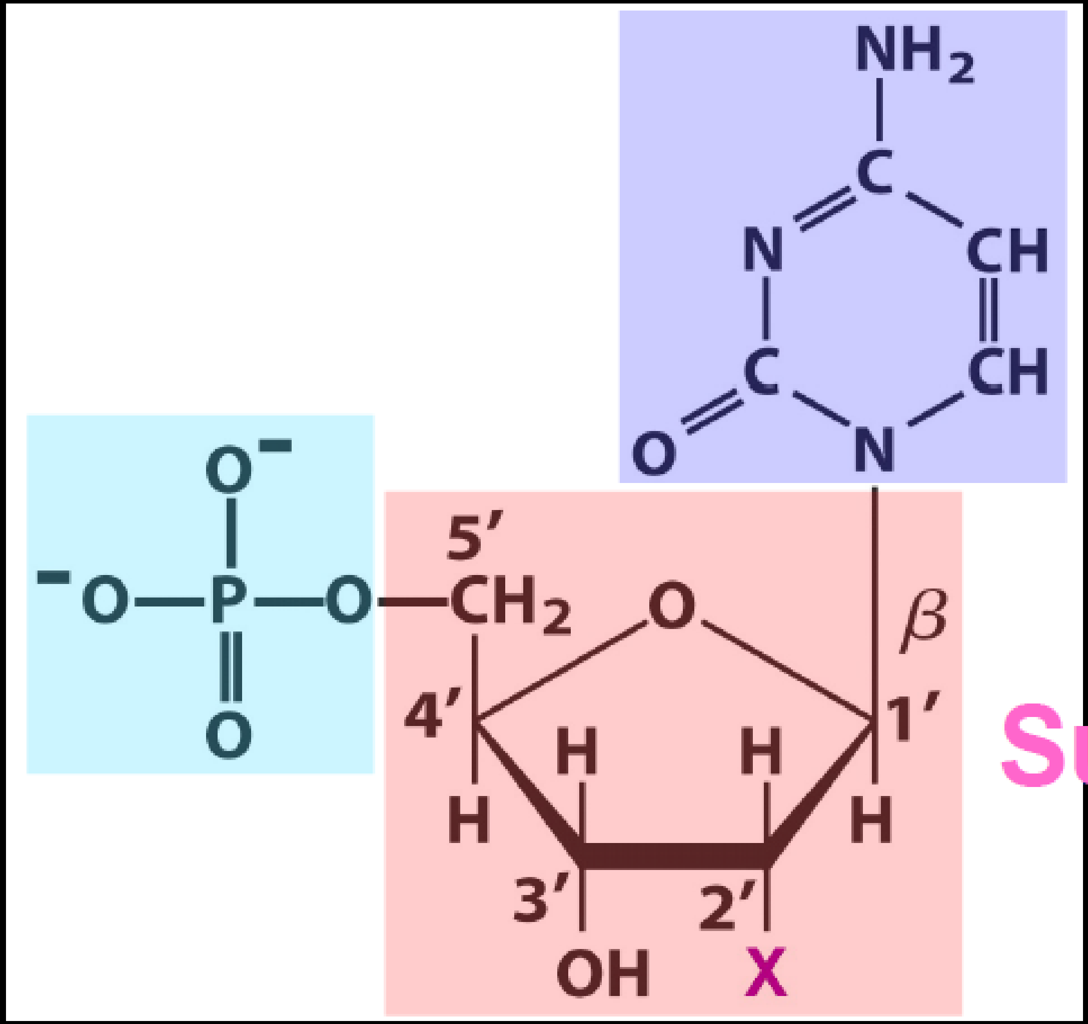
Phosphate



Base

Sugar

Phosphate



Base

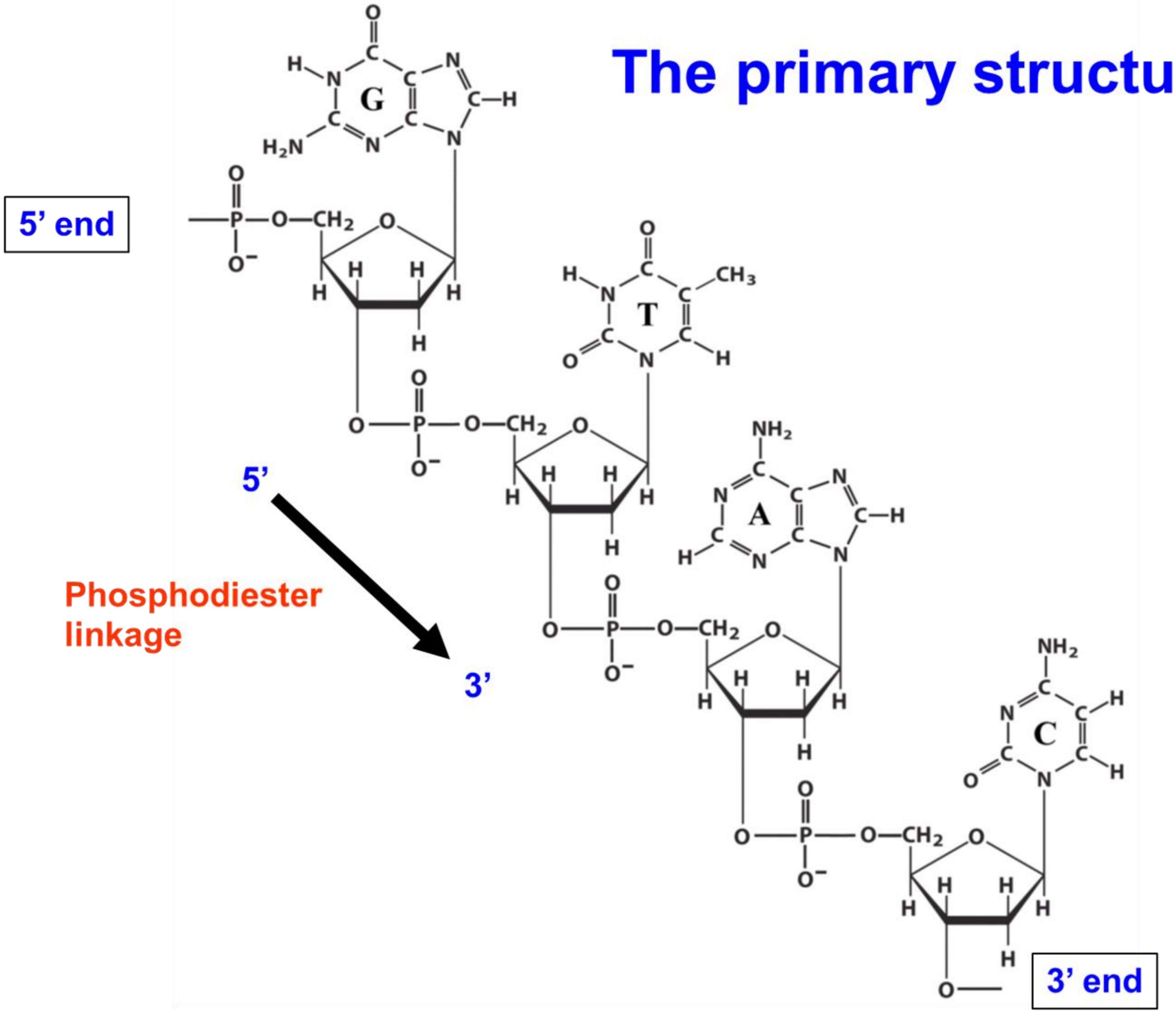
Sugar

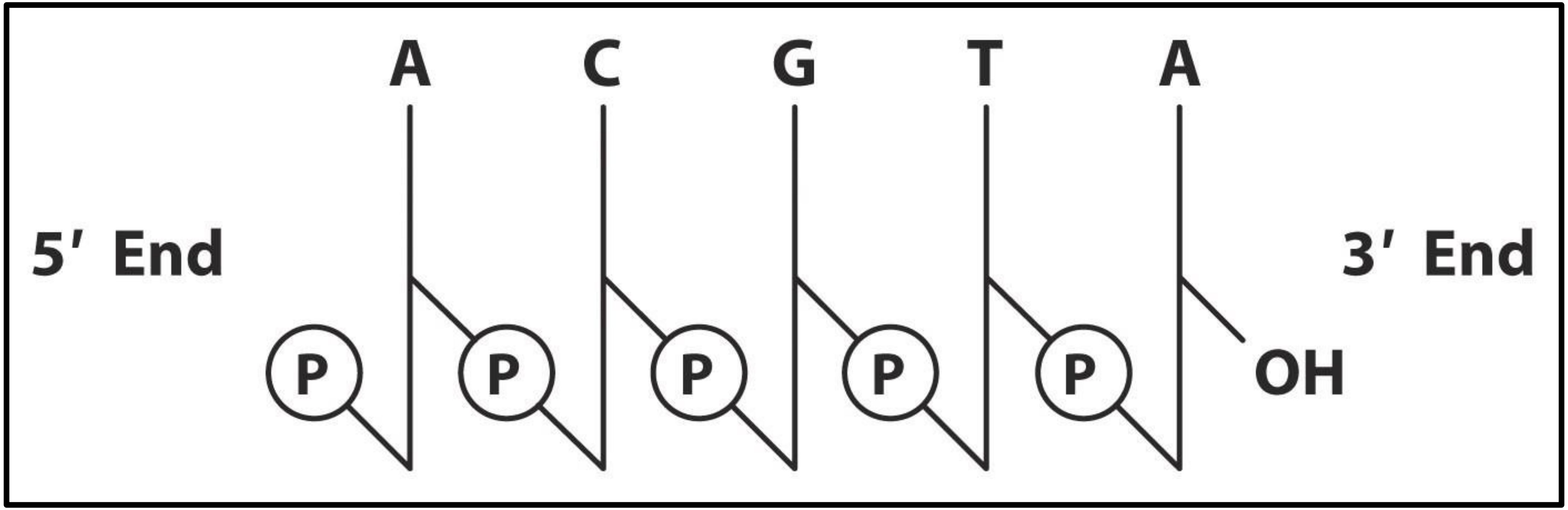
X=H: DNA
X=OH: RNA

Nucleoside

Nucleotide

The primary structure of DNA

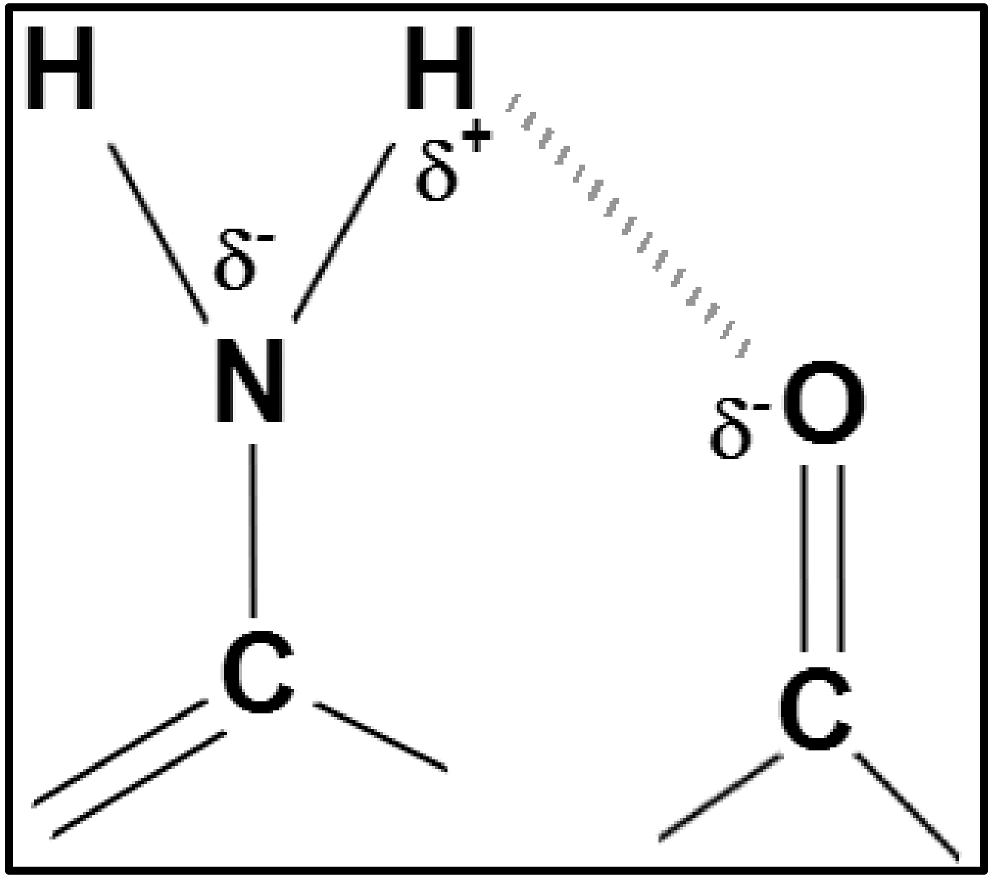




Traditionally, a DNA sequence is drawn from 5’ to 3’ end.
A shorthand notation for this sequence is ACGTA

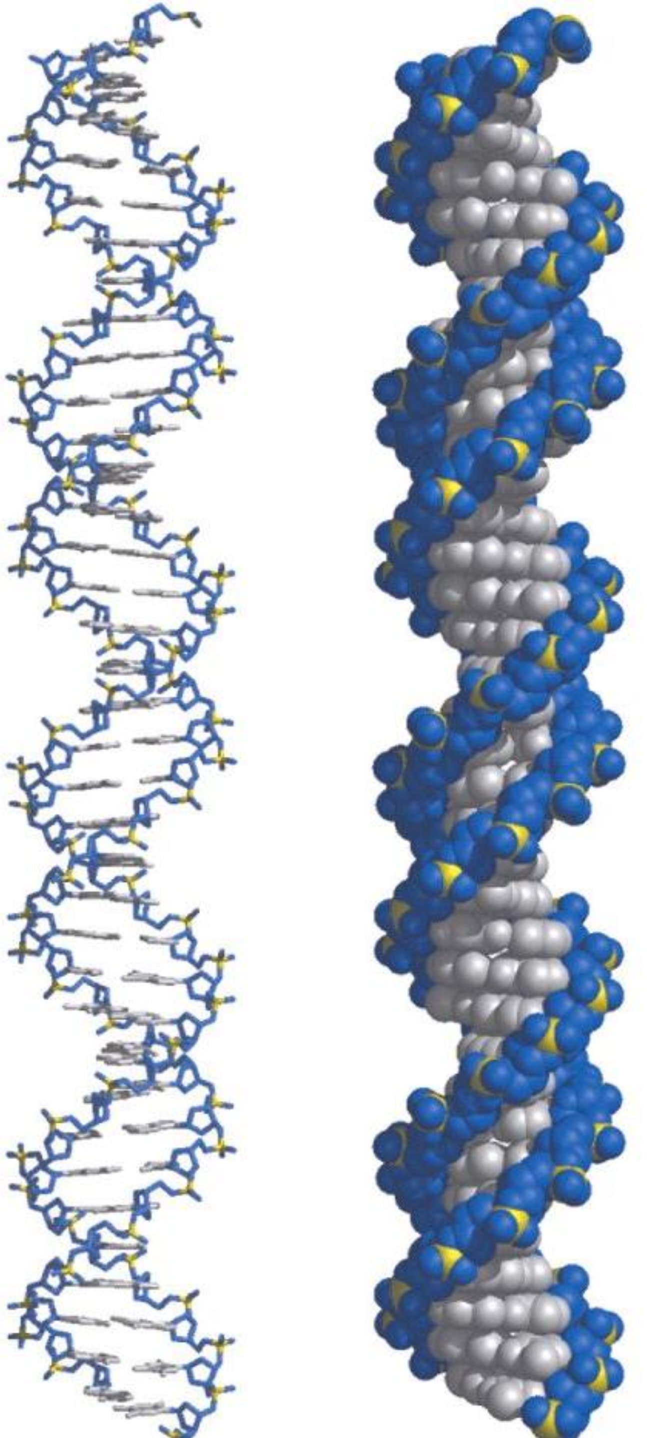
Hydrogen bond

- Hydrogen bond is a chemical **bond** in which a **hydrogen** atom of one molecule is attracted to an **electronegative** atom, especially a **nitrogen**, **oxygen**, or **fluorine** atom, usually of another molecule.
- Note: δ represents partial charges

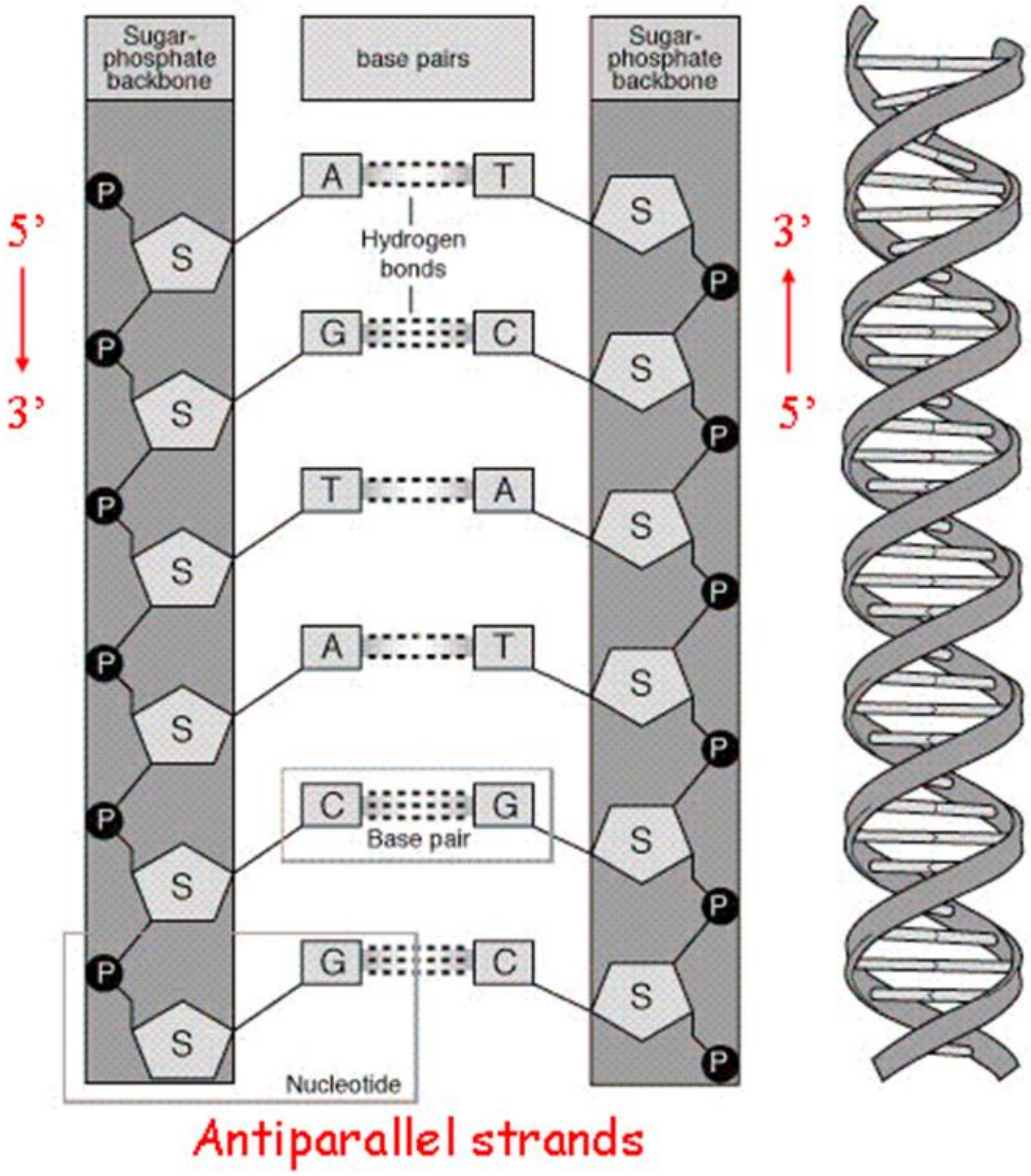


The secondary structure of DNA

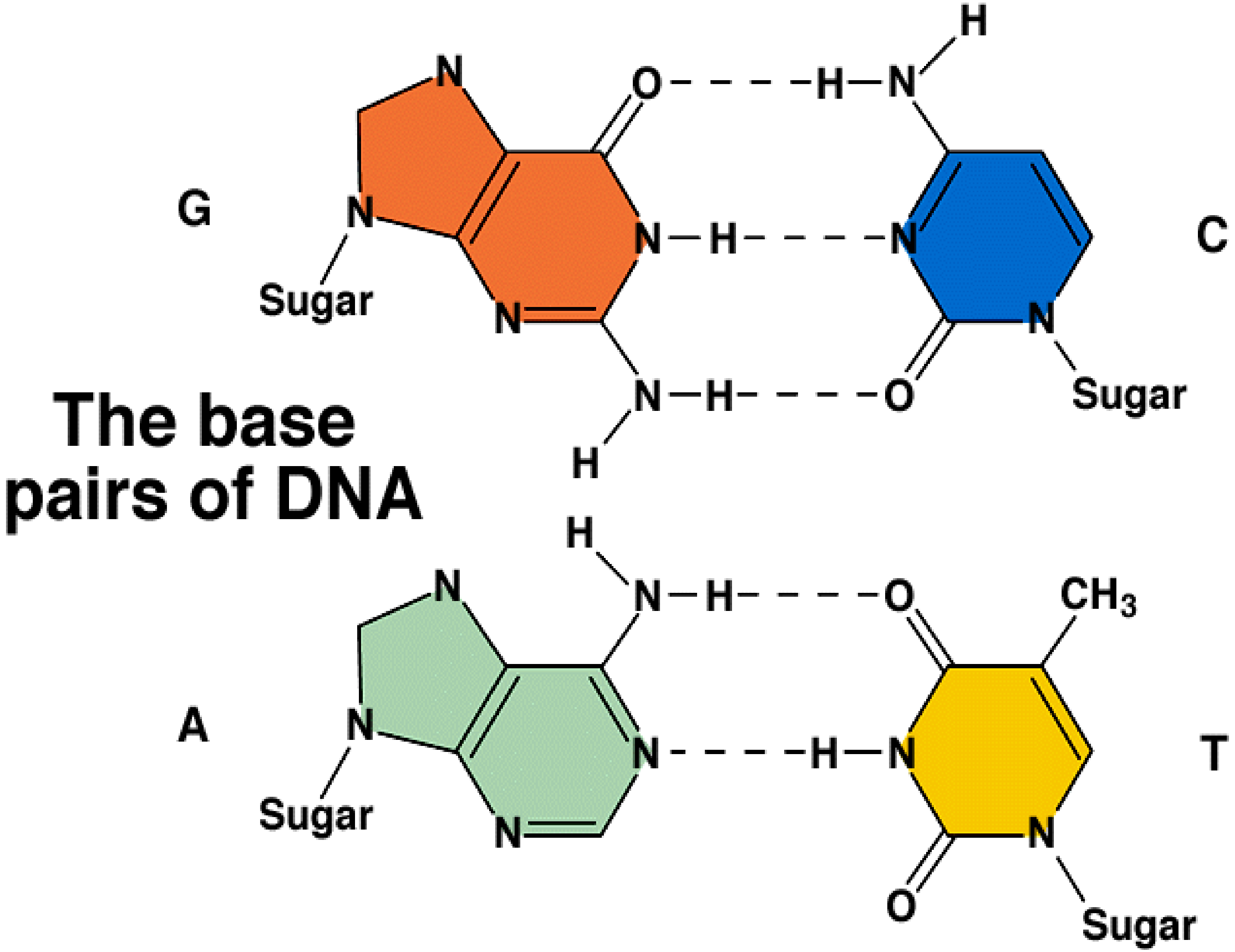
- Two anti-parallel polynucleotide chains wound around the same axis.
- Sugar-phosphate chains wrap around the periphery.
- Bases (A, T, C and G) occupy the core, forming complementary A · T and G · C Watson-Crick base pairs.
- The DNA double helix is held together mainly by- Hydrogen bonds

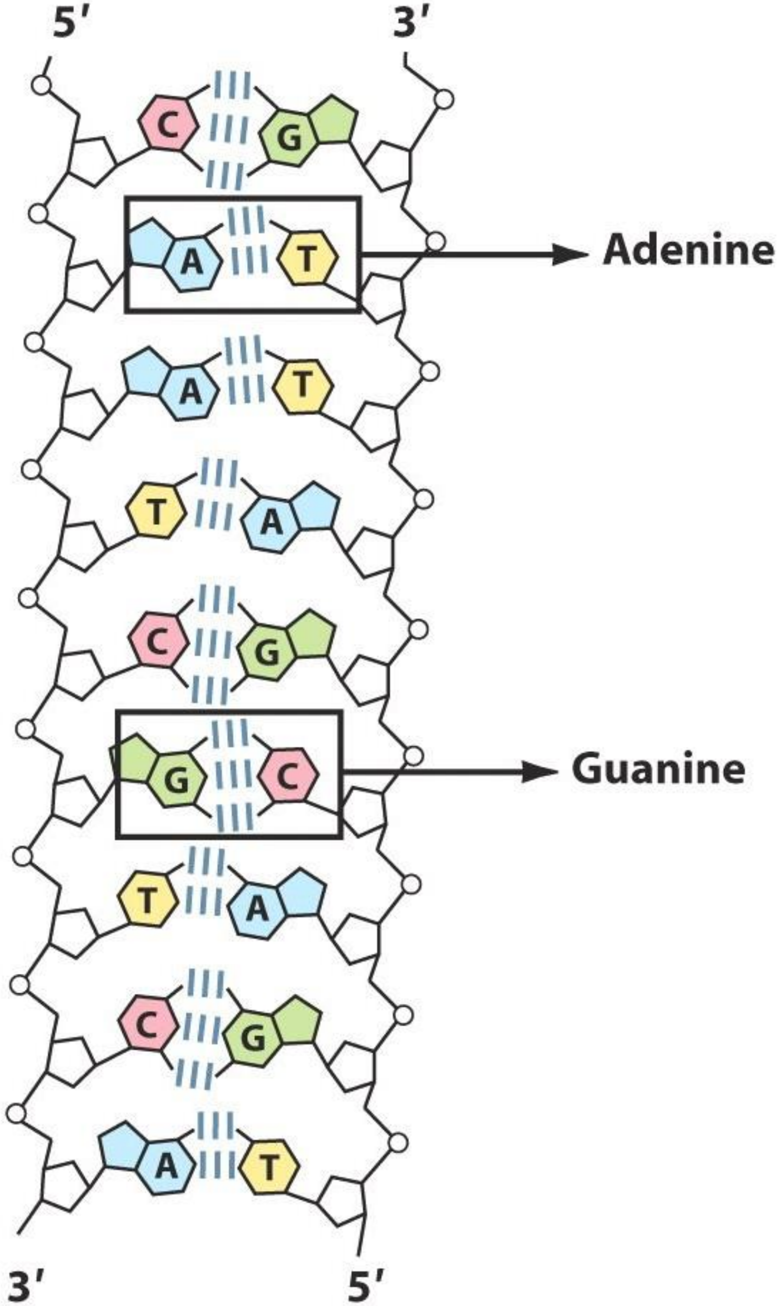


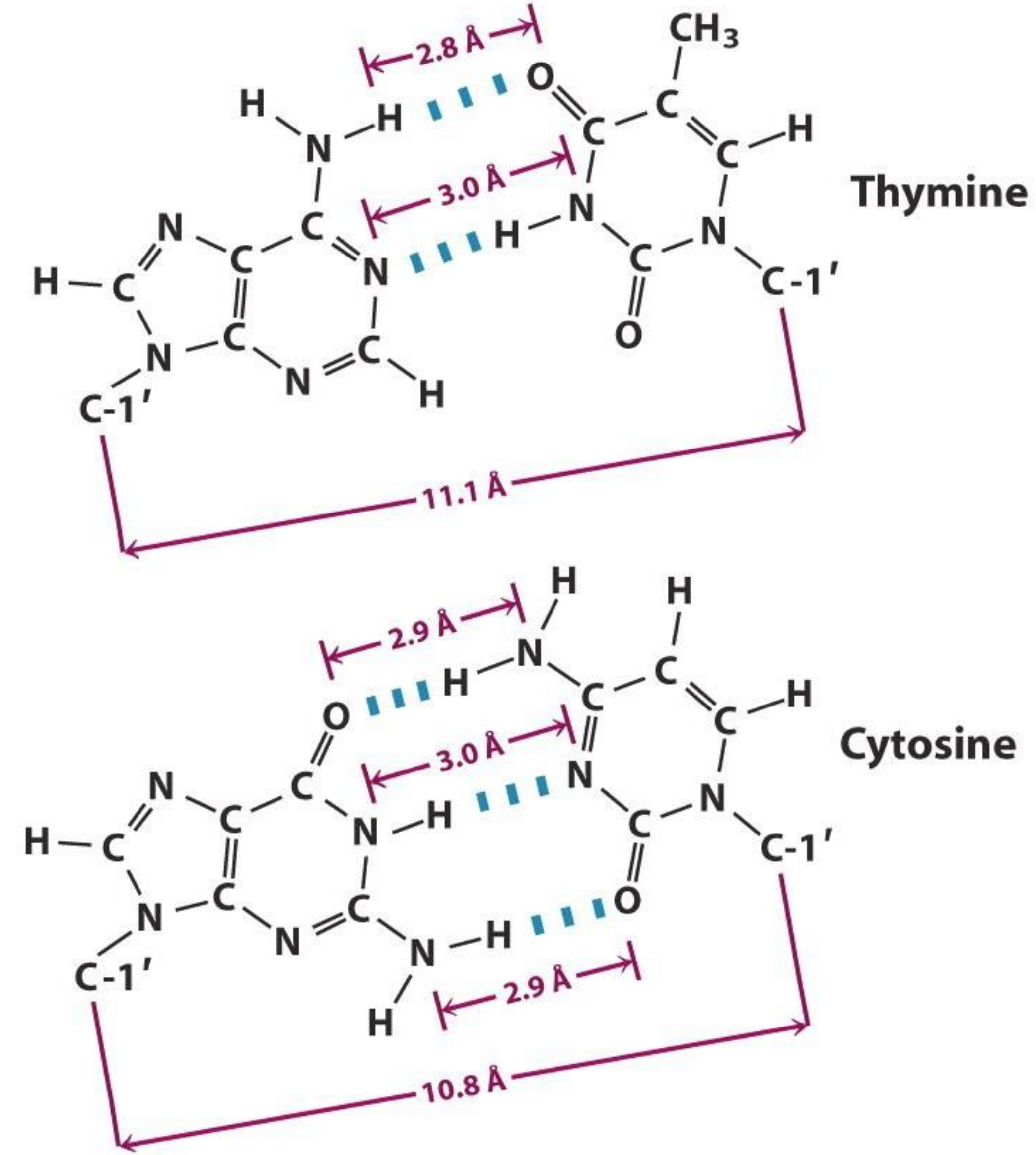
The secondary structure of DNA



DNA Stabilization– Complementary Base Pairing







Two hydrogen bonds between A:T pairs

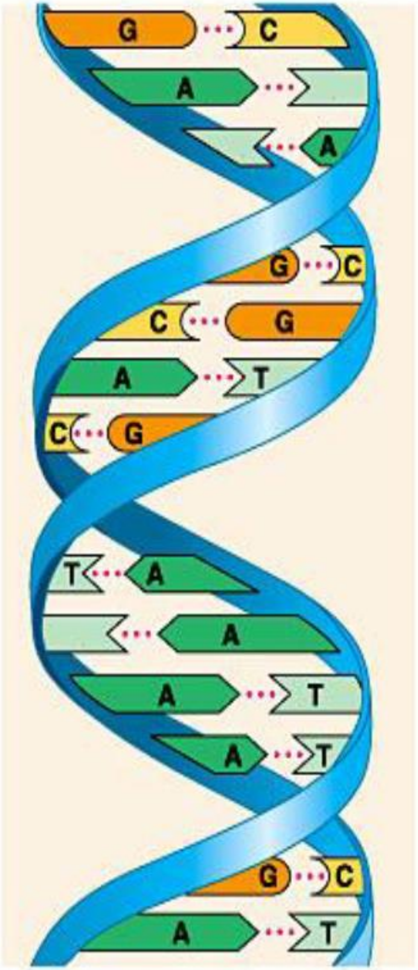
Three hydrogen bonds between C: G paired

Hydrogen bond

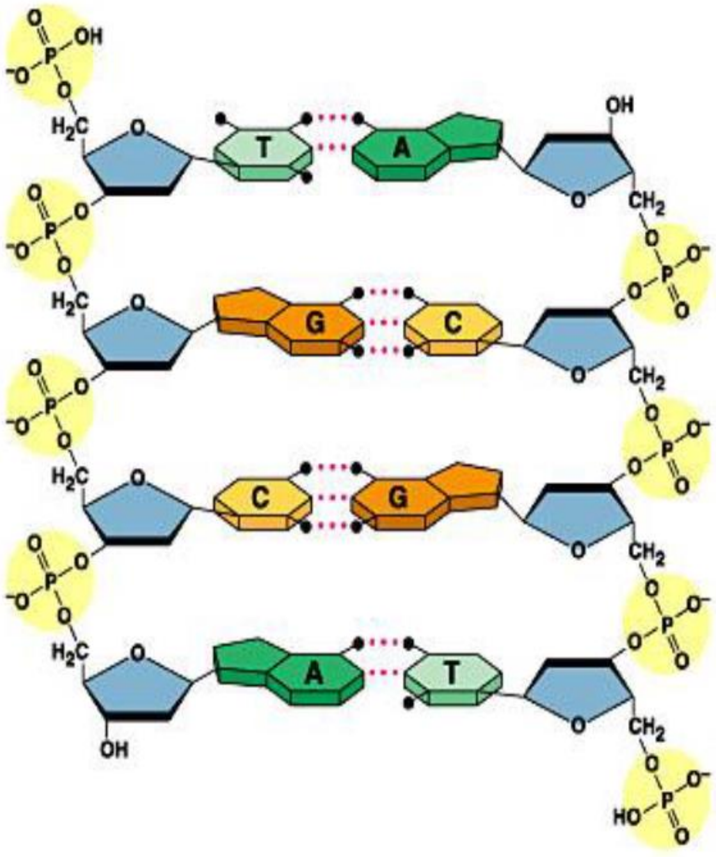
- Hydrogen bonds between bases hold the strands together:

  A and T,

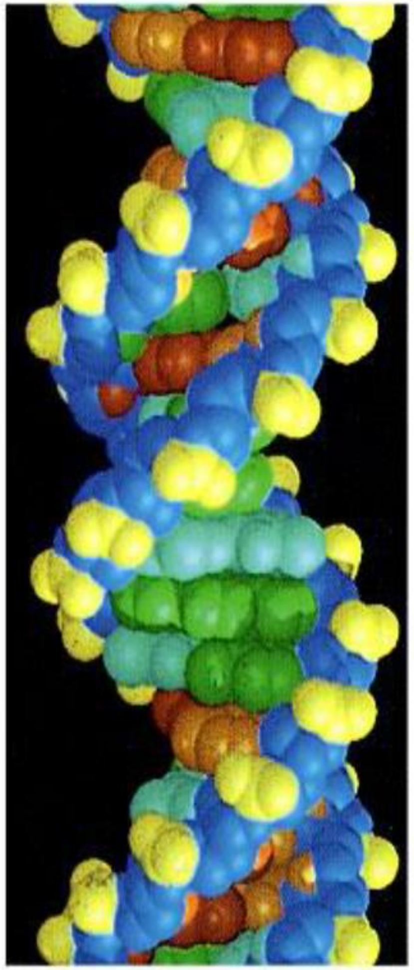
  C and G



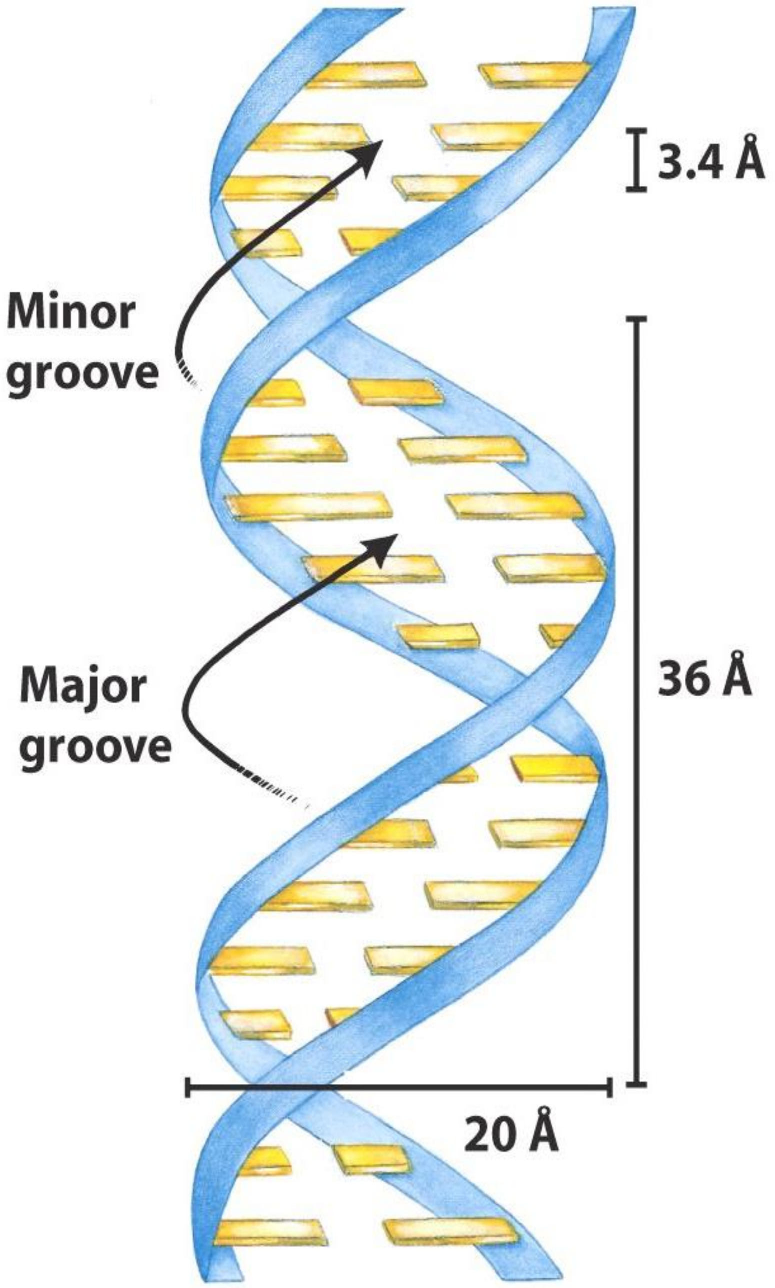
Ribbon model Partial

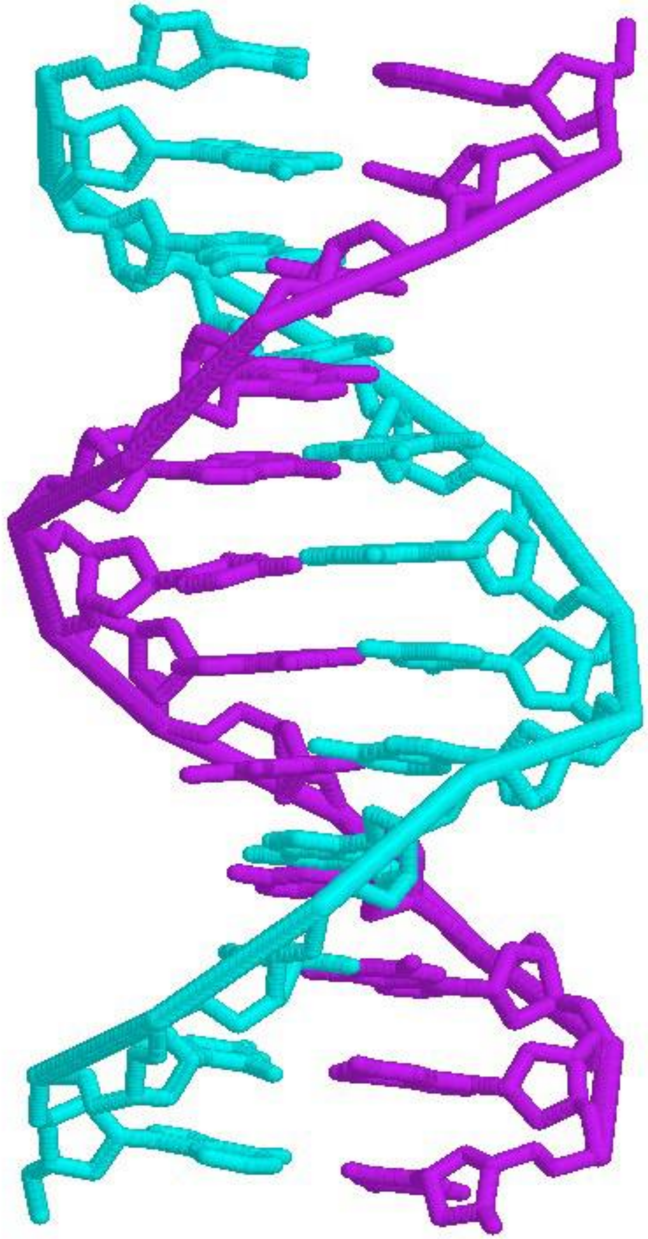


chemical structure



Computer model





Base Stacking

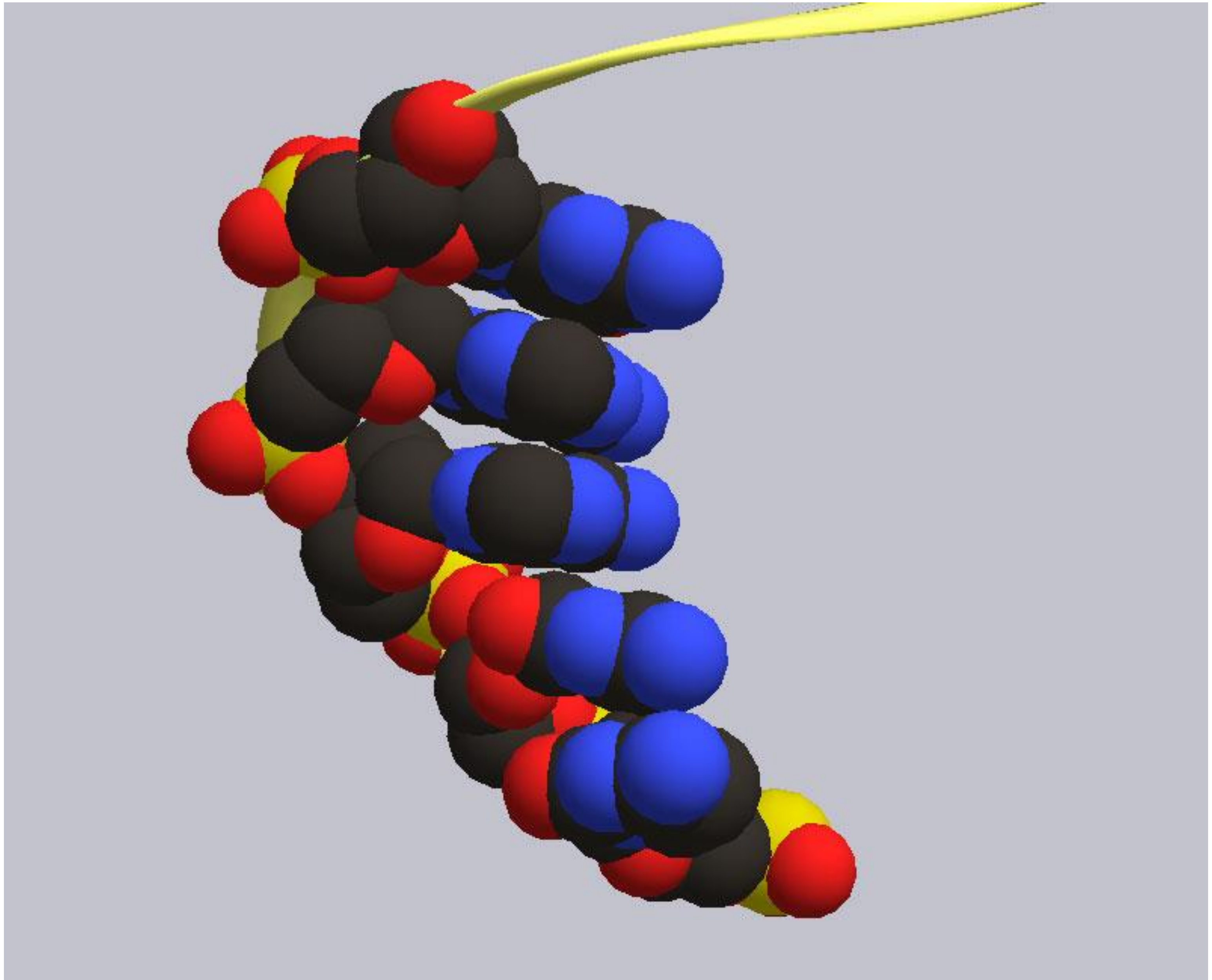
The bases in DNA are planar and have a tendency to "stack".

Major stacking forces:

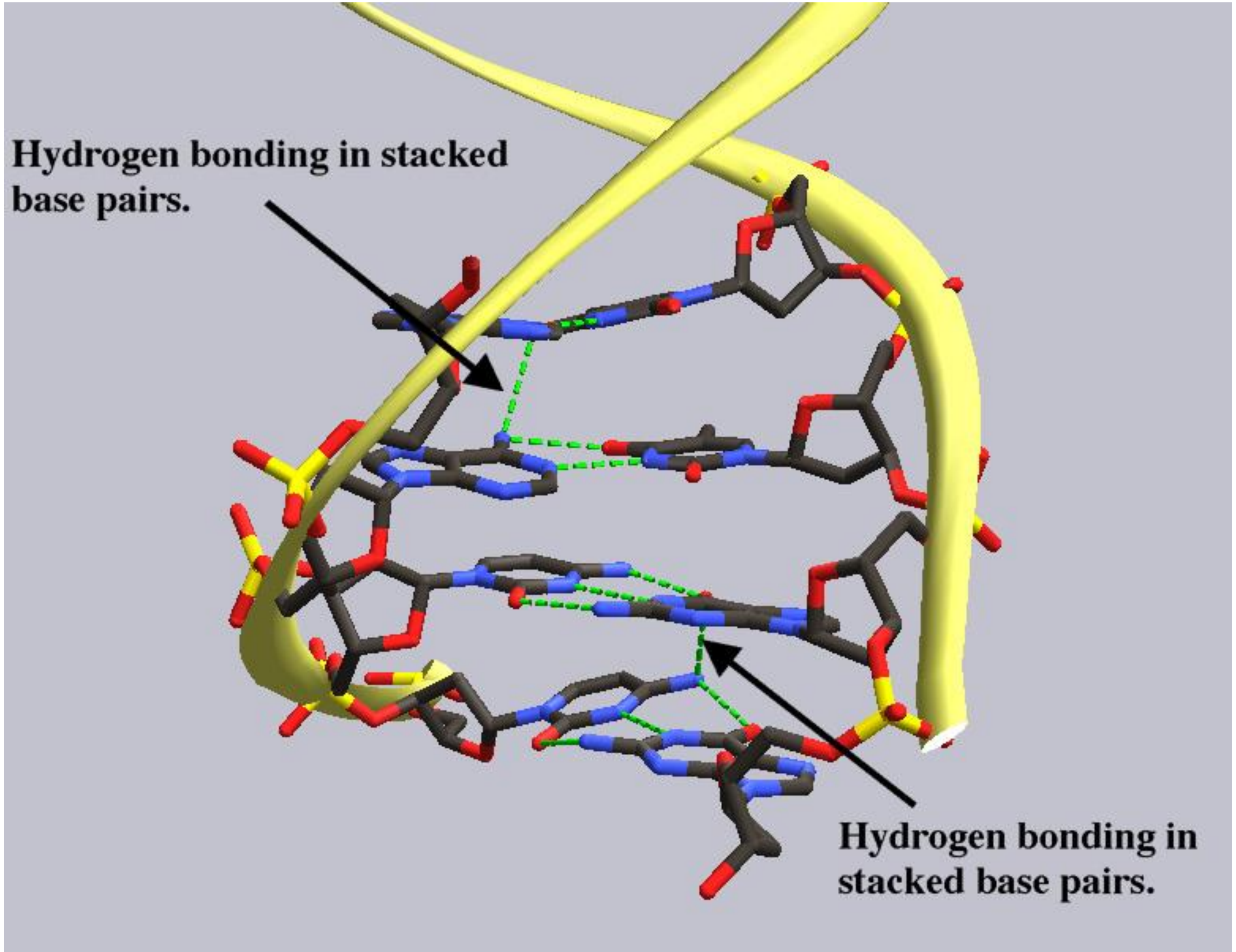
(1) hydrophobic interaction

(2) Van der Waals forces

DNA Stabilization-Base Stacking



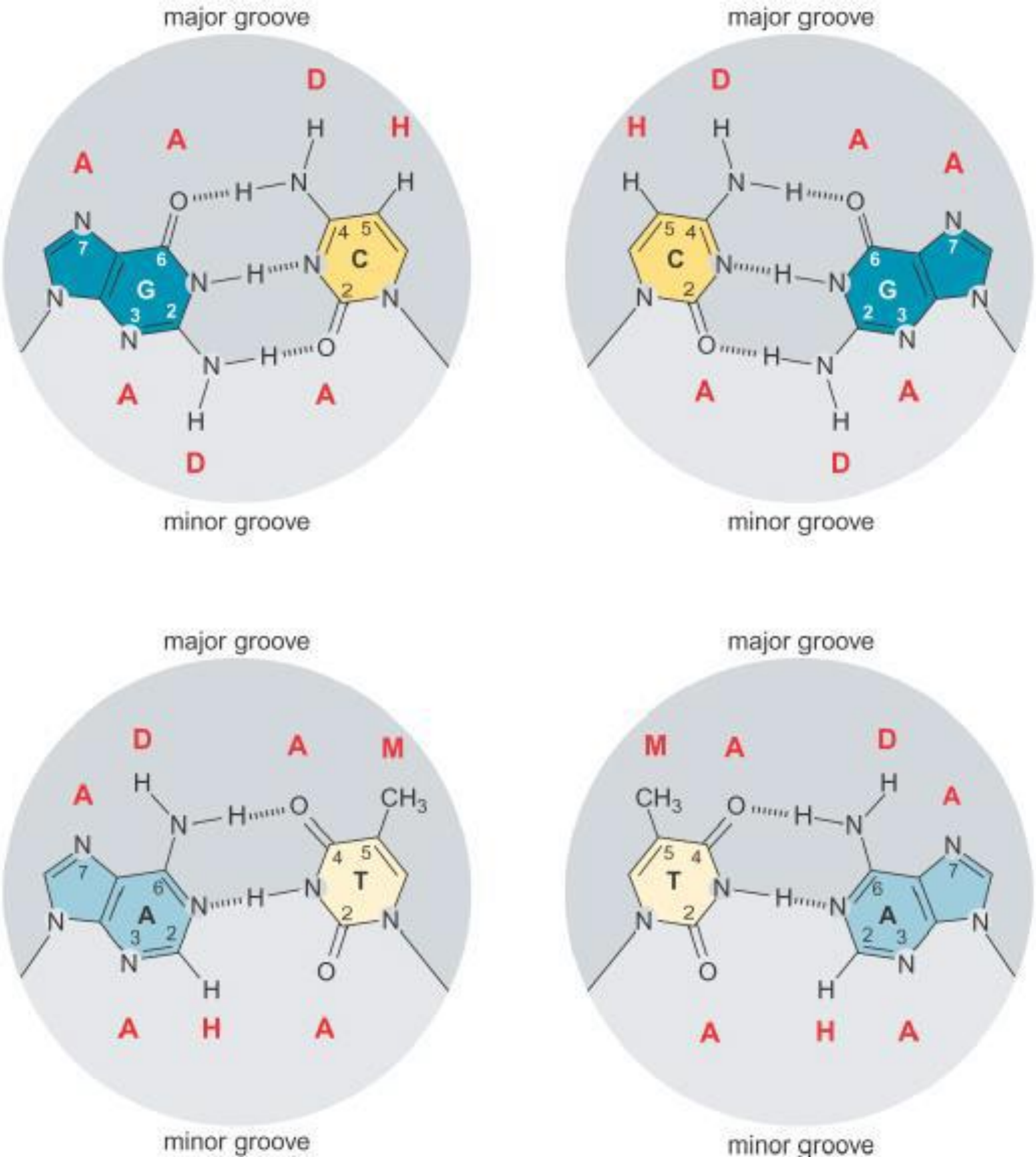
DNA Stabilization--H-bonding between DNA base pair stacks



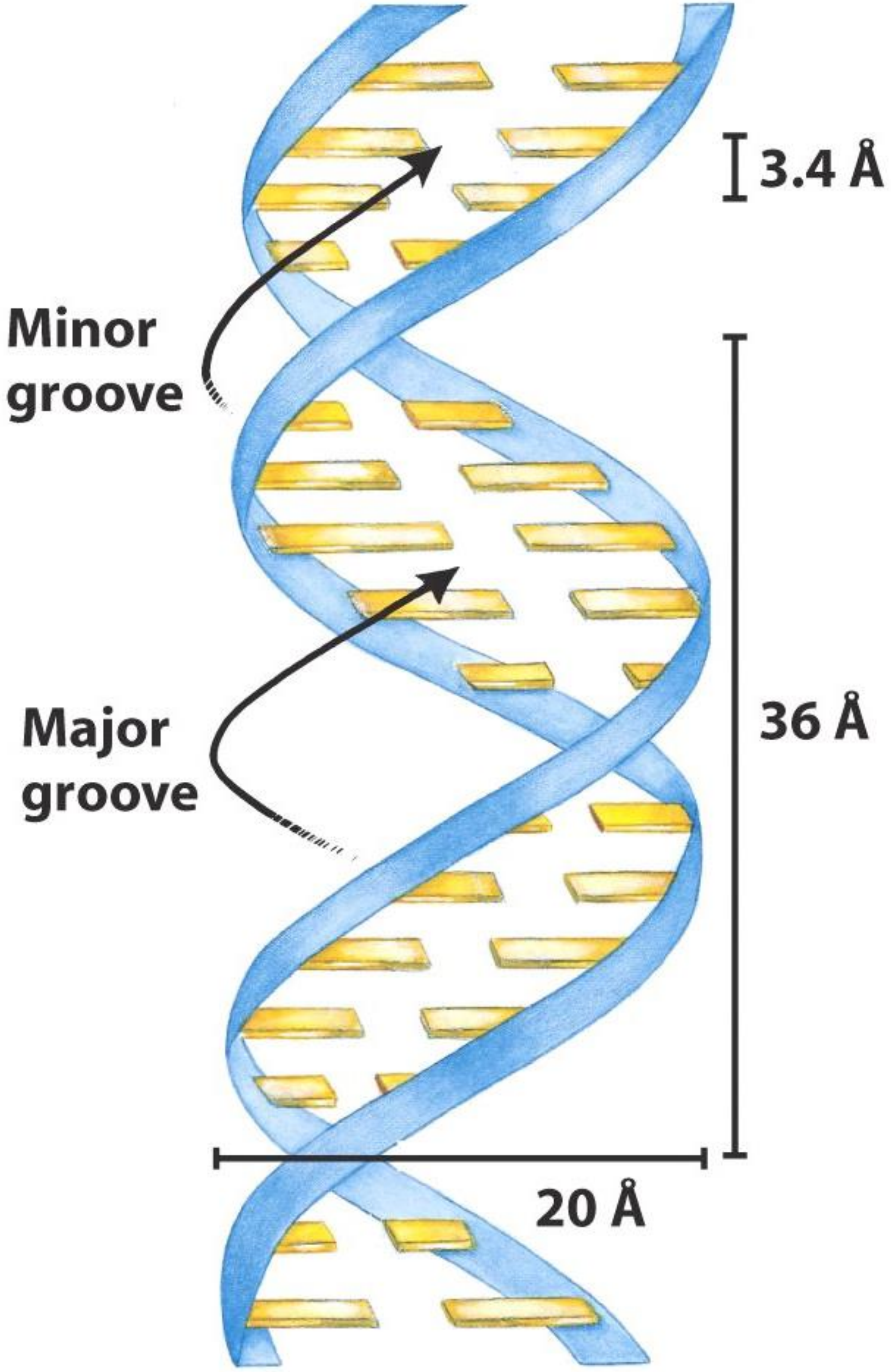
The secondary structure of DNA is the double helix

The secondary structure of DNA is the double helix

The secondary structure of DNA is the double helix



A: H-bond acceptors
D: H-bond donors
H: non-polar hydrogens
M: methyl groups



Normally hydrated DNA: B-form DNA

Helical sense: **right handed**

Base pairs: almost **perpendicular** to the **helix** axis;

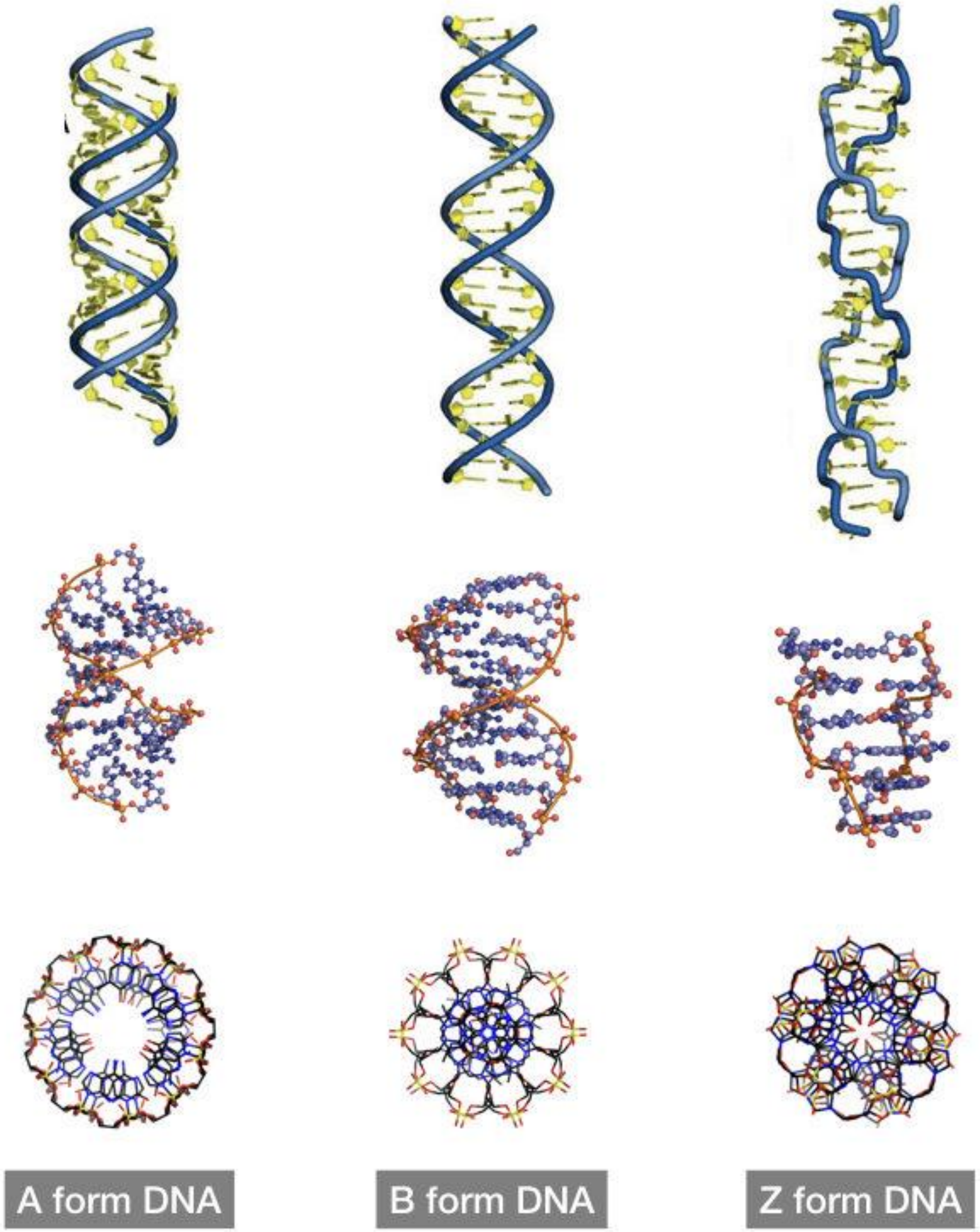
3.4 Å apart

One turn of the helix: **36 Å**; ~**10.4** base pairs

Minor groove: 12 Å across

Major groove: 22 Å across

Types of DNA



Forms of DNA

- **1- *B-form helix*:**
- **It is the most common form of DNA in cells.**
- **Right-handed helix**
- **Turn every 3.4 nm.**
- **Each turn contain 10 base pairs (the distance between each 2 successive bases is 0.34 nm)**
- **Contain 2 grooves;**
- **Major groove (wide): provide easy access to bases**
- **Minor groove (narrow): provide poor access.**

Forms of DNA

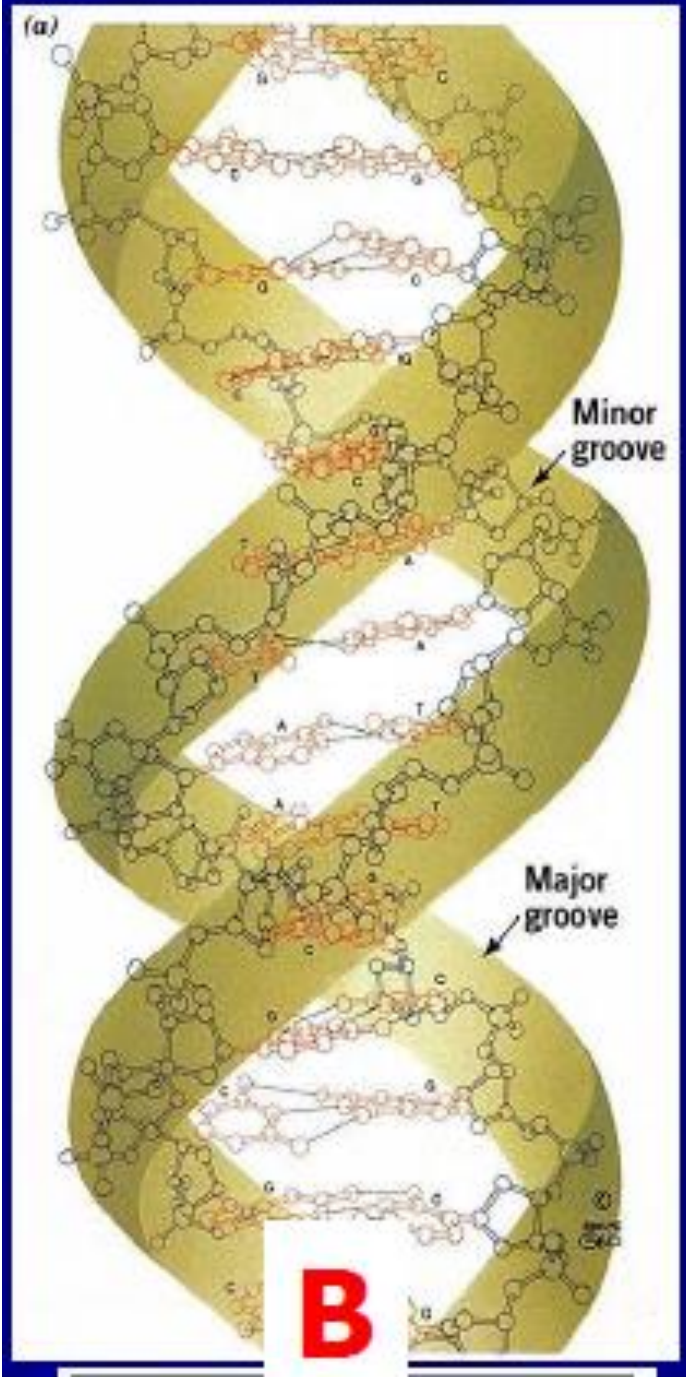
- **1- *B-form helix*:**
- **The Major groove is rich in chemical information :**
- The edges of each base pair are exposed in the major and minor grooves, creating a pattern of hydrogen bond donors and acceptors and of van der Waals surfaces that identifies the base pair.

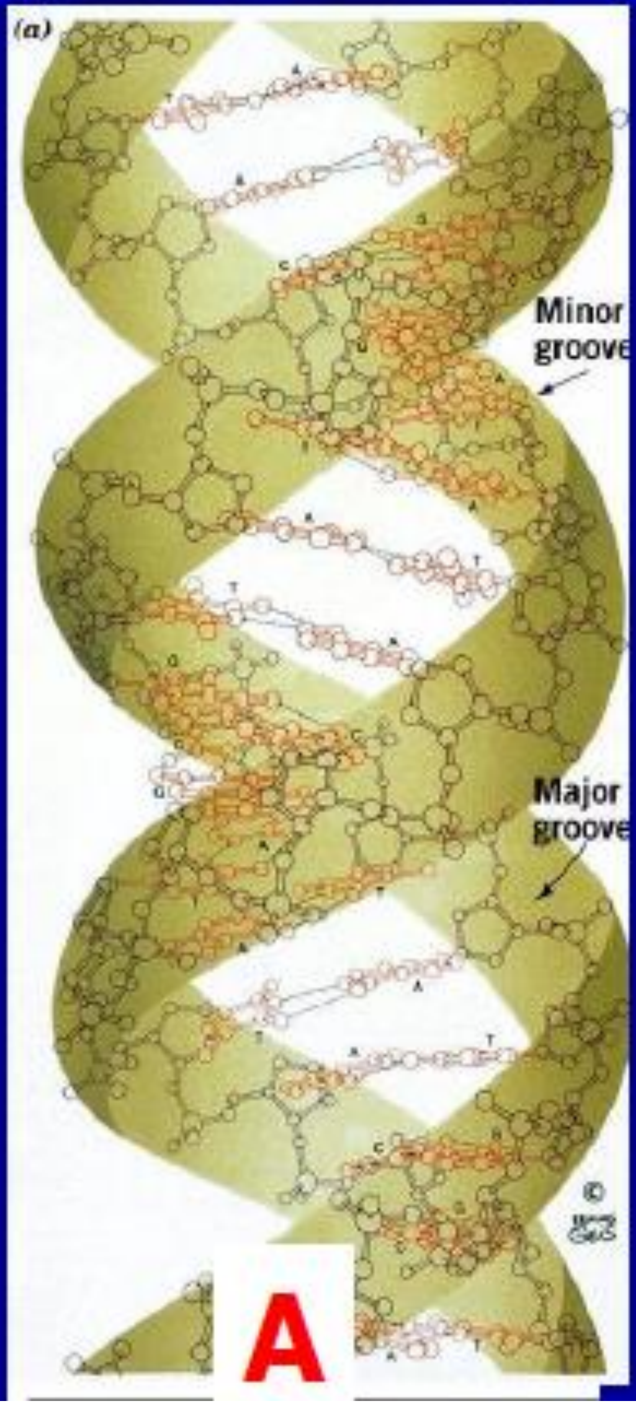
Forms of DNA

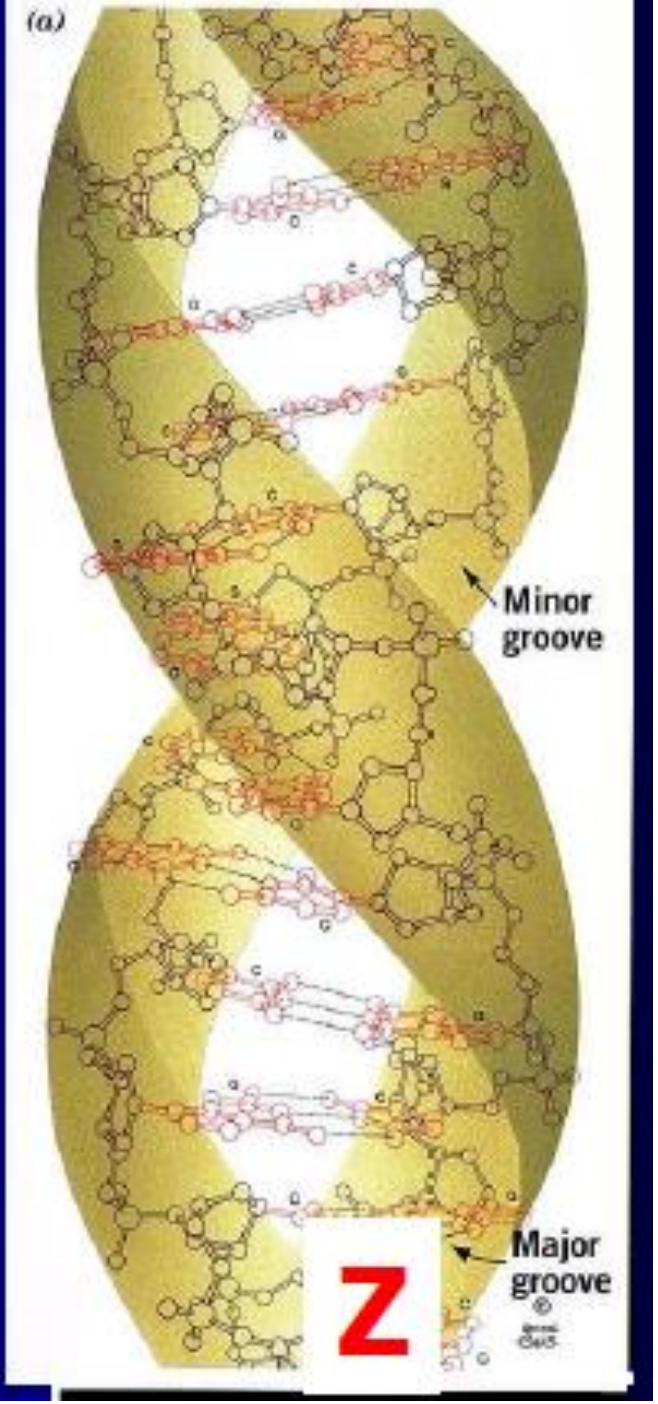
- **2- *A-form DNA*:**
- **Less common form of DNA , more common in RNA**
- **Right handed helix**
- **Each turn contain 11 b.p/turn**
- **Contain 2 different grooves:**
- **Major groove: very deep and narrow**
- **Minor groove: very shallow and wide (binding site for RNA)**

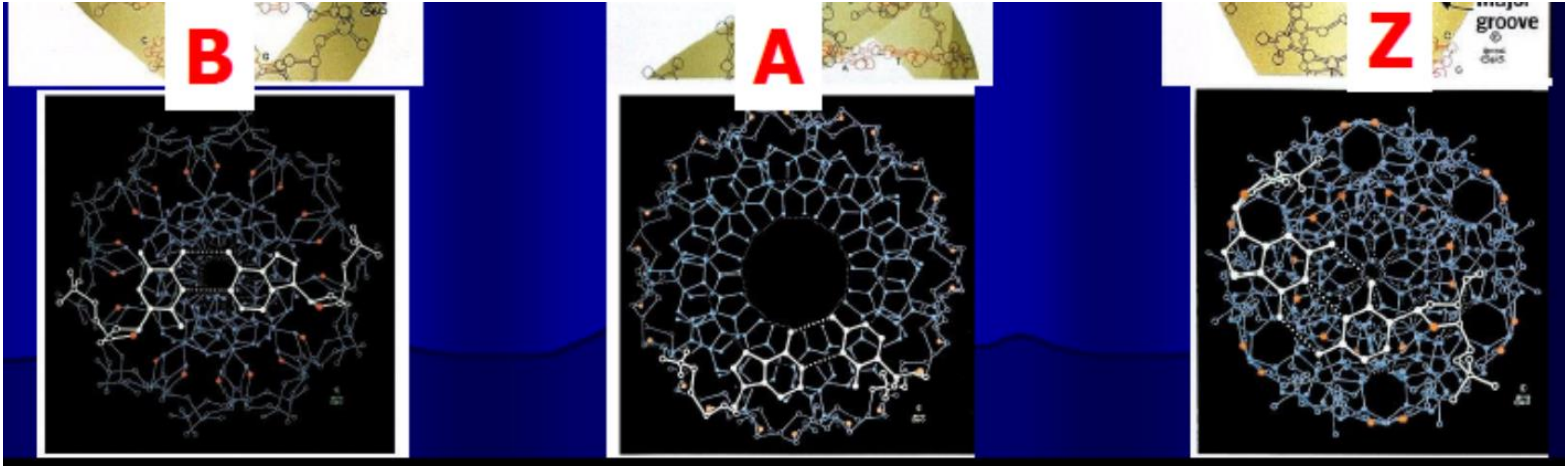
Forms of DNA

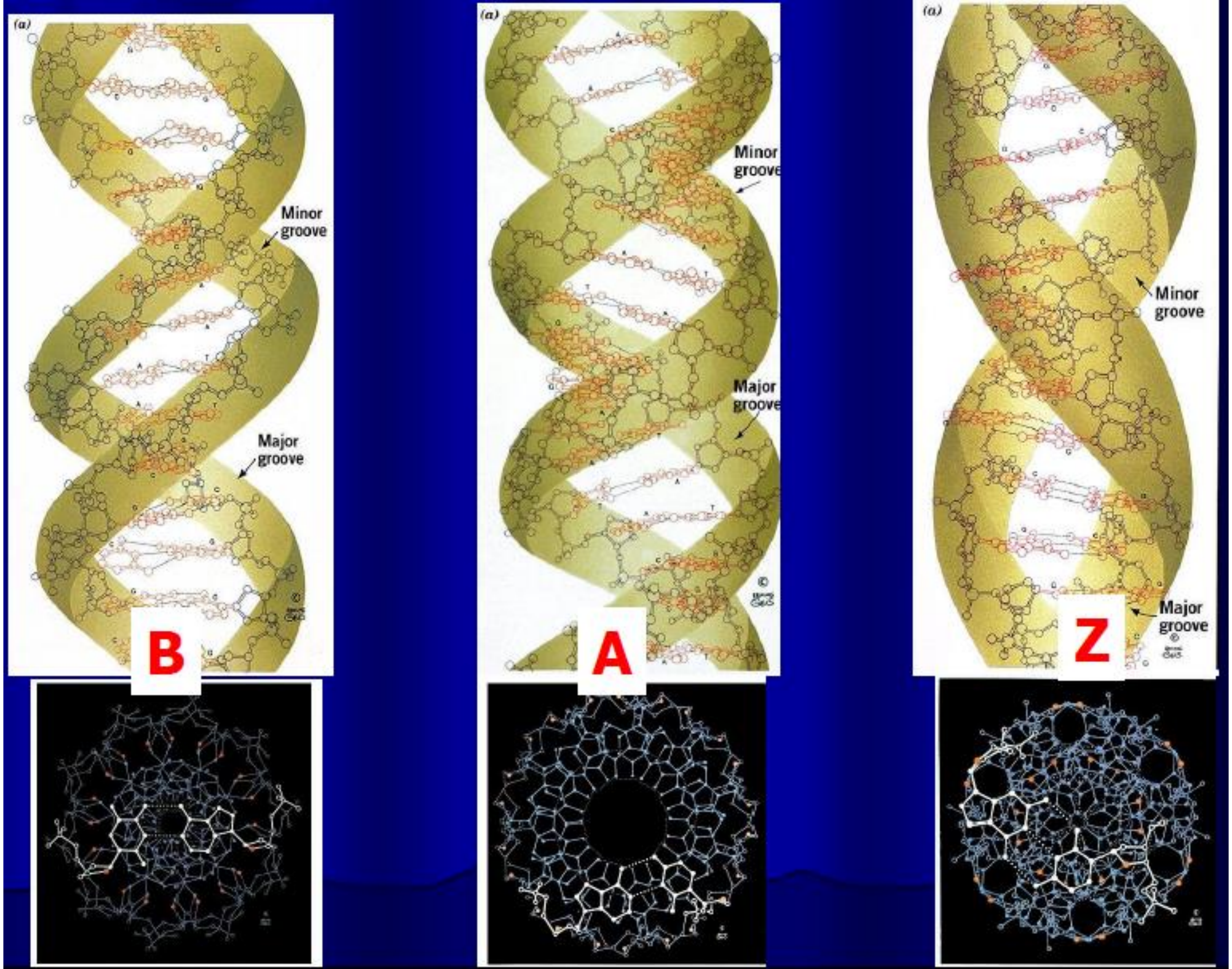
- **3- *Z-form DNA*:**
- **Radical change of B-form**
- **Left handed helix, very extended**
- **It is GC rich DNA regions.**
- **The sugar base backbone form Zig-Zag shape**
- **The B to Z transition of DNA molecule may play a role in gene regulation.**


(a)
Minor groove
Major groove
B

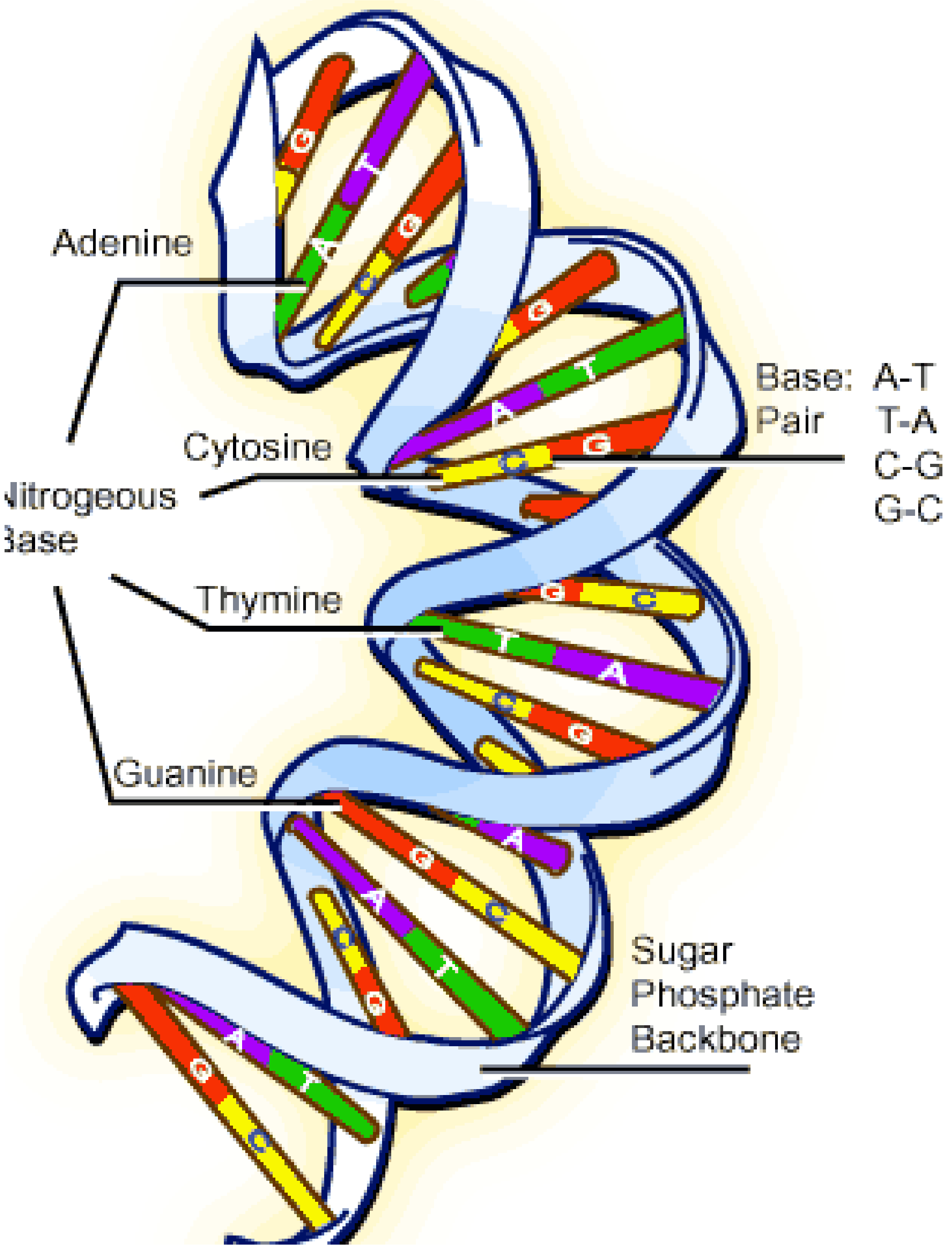

(a)
Minor groove
Major groove
A

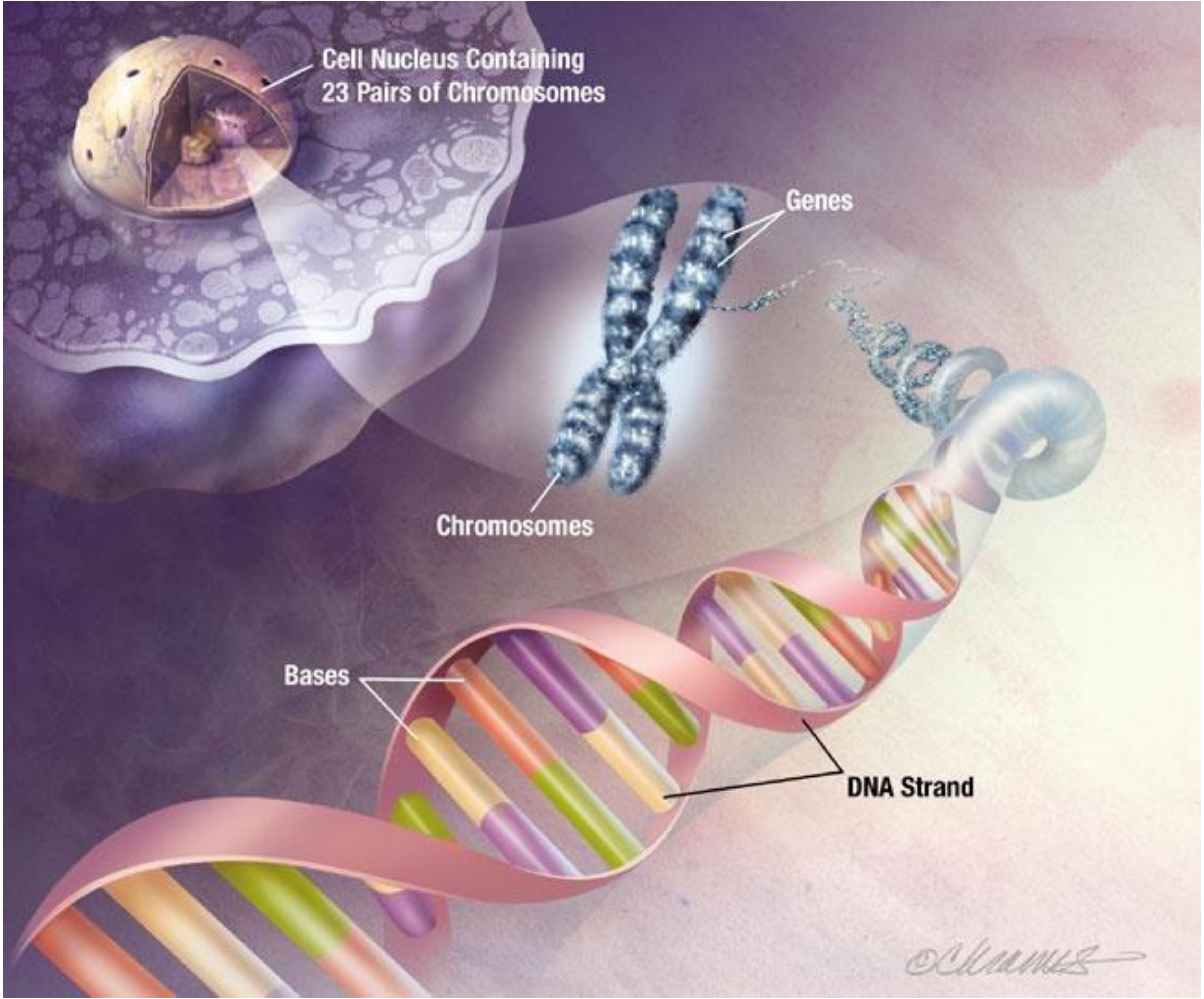

(a)
Minor groove
Major groove
Z


B
A
Z
groove


(a)
Minor groove
Major groove
B
(a)
Minor groove
Major groove
A
(a)
Minor groove
Major groove
Z

Thank You


Adenine
Cytosine
itrogeous
ase
Thymine
Guanine
Base: A-T
Pair T-A
C-G
G-C
Sugar
Phosphate
Backbone


Cell Nucleus Containing
23 Pairs of Chromosomes
Genes
Chromosomes
Bases
DNA Strand