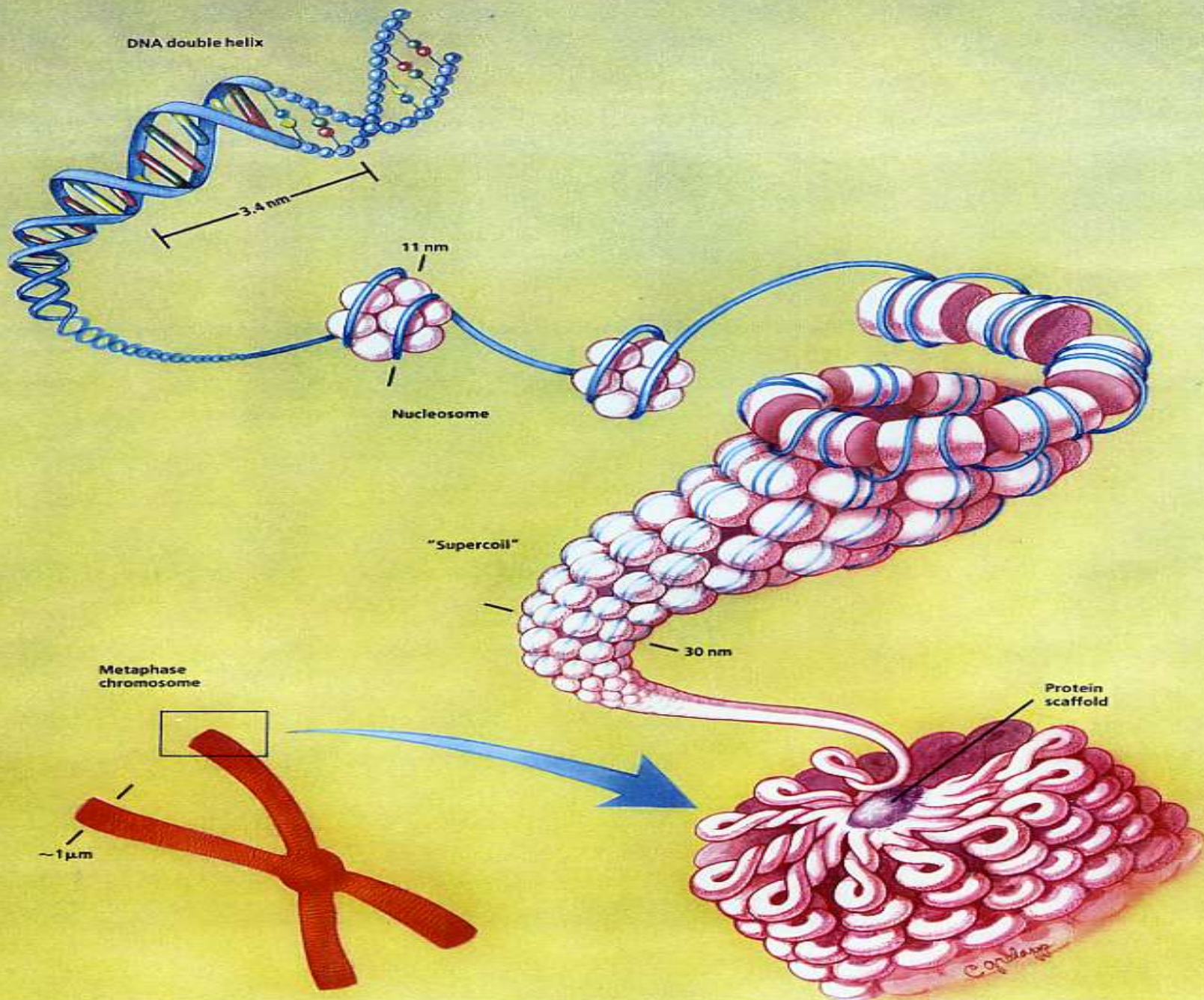


DNA Structure

**Prepared by: Mohamed Mohamed Tarik Bashir
M.Sc Microbiology and Immunology**

- Deoxyribonucleic Acid (**DNA**) is the genetic material of nearly all living organisms.
- It controls hereditary and located in cell nucleus.
- DNA is (**macromolecule**) a nucleic acid composed of **two strands**, made up of units called **nucleotides**.
- The two strands are wound around each other into **a double helix**



- The two strands are linked together by hydrogen bonds (Base pairing).
- The genetic information is contained in the sequence of bases along the molecule. (**genetic code**).
- DNA molecule can make exact **copies of itself** by a process of **replication**, thereby passing the genetic information to the daughter cells when the cell divides.

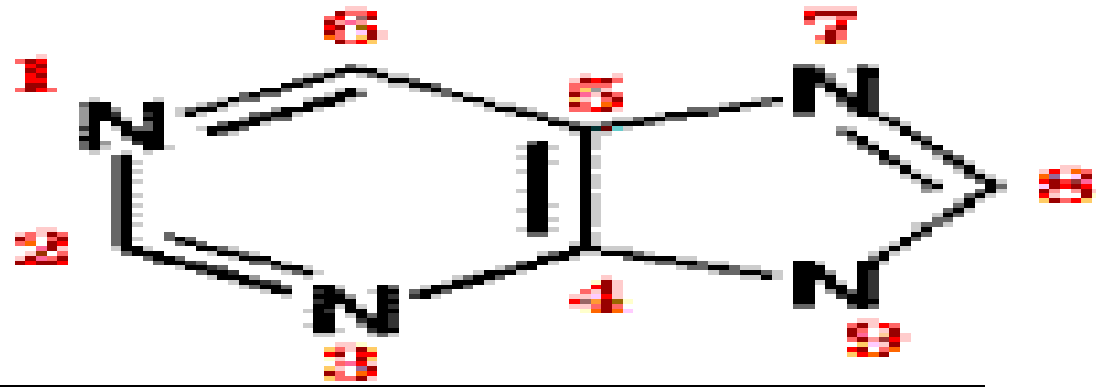
The chemical composition of DNA

- Chemically, DNA is composed of nucleotides, these nucleotides are mainly made up of a nitrogenous base, sugar and one or more phosphate groups.
- When the nitrogenous base is linked to the sugar without phosphate group, the compound is called nucleoside

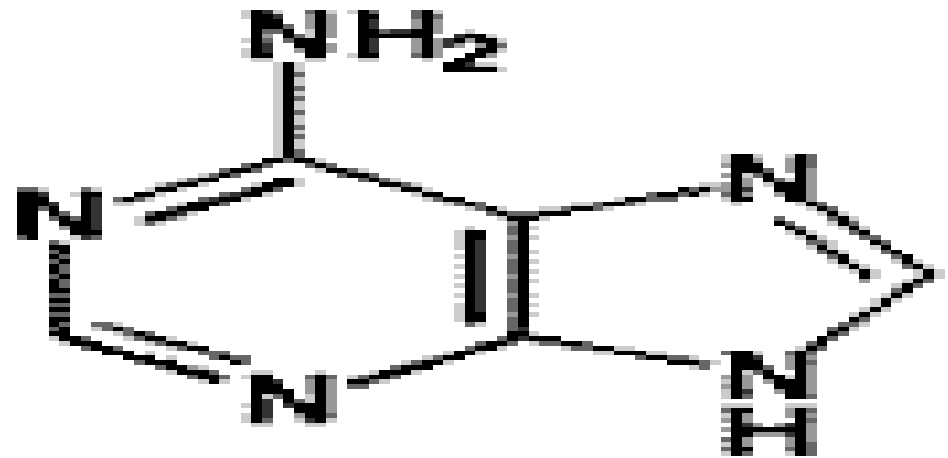
Nitrogenous Bases

- The nitrogenous bases of nucleotides are ring structures of nitrogen and carbon with other organic side chains attached to specific location.
- Bases are classified into two groups:
 - 1- **Purine**: have a double ring structure.
depending upon the side chain attached they are either **Adenine** or **Guanine**

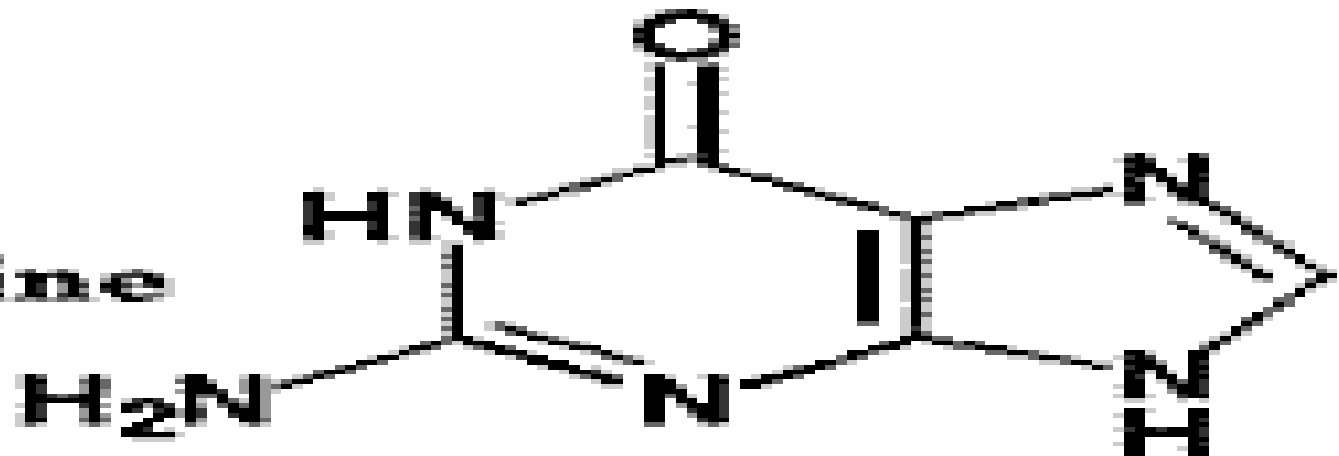
Purine



Adenine



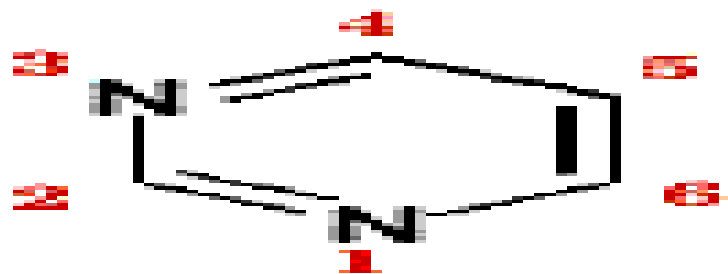
Guanine



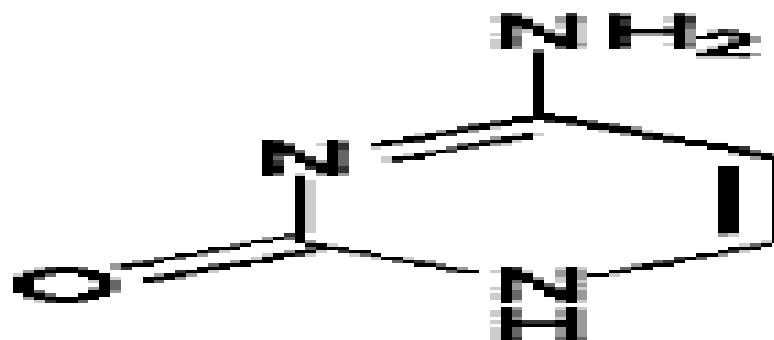
2- Pyrimidines: have a single ring structure

- May be **cytosine**, **thymine** or (**uracil** in RNA).
- **Uracil** is not normally found in DNA but it replaces in RNA.
- The numbering system of carbon atoms in these structures lack the (primes) sign (‘) to differentiate them from the carbon atoms of the sugar moiety, which carry the sign (‘).

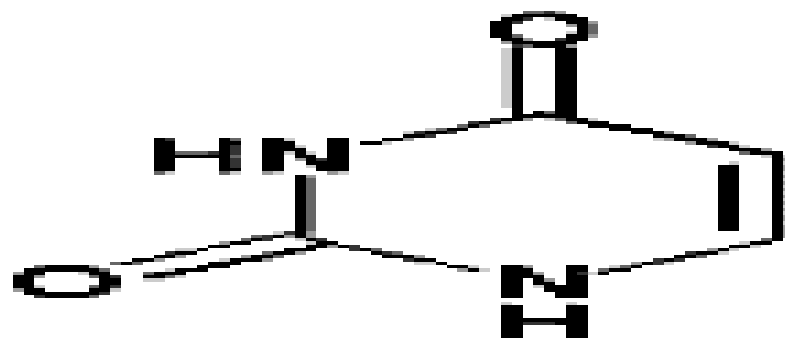
Pyrimidine



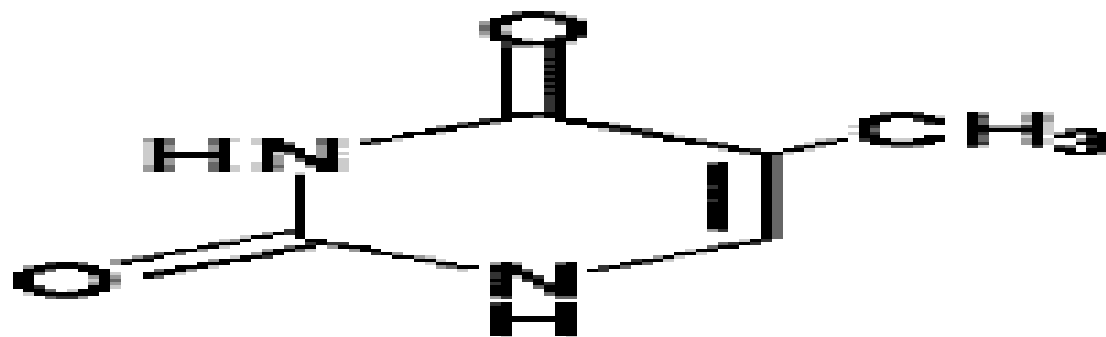
Cytosine



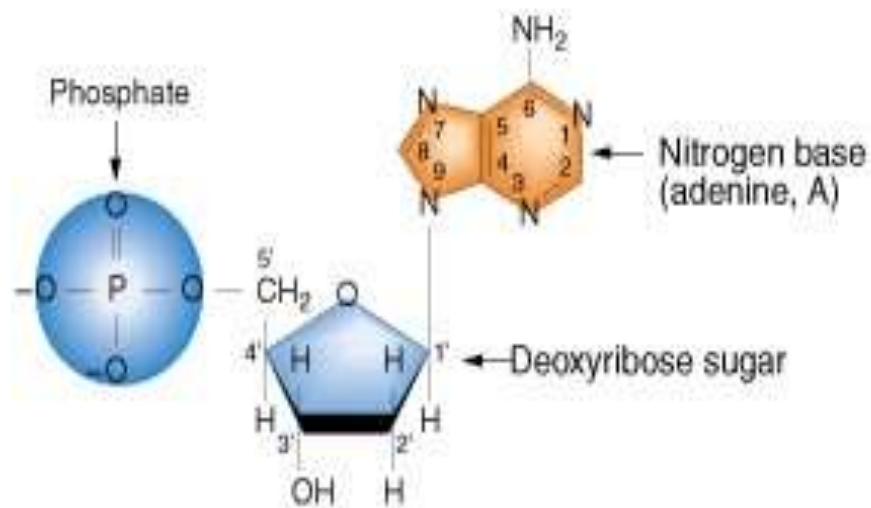
Uracil



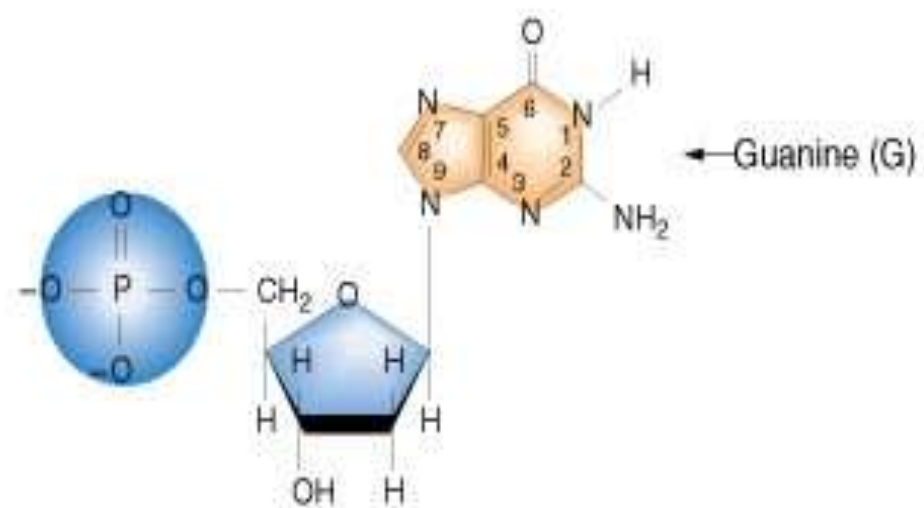
Thymine



Purine nucleotides

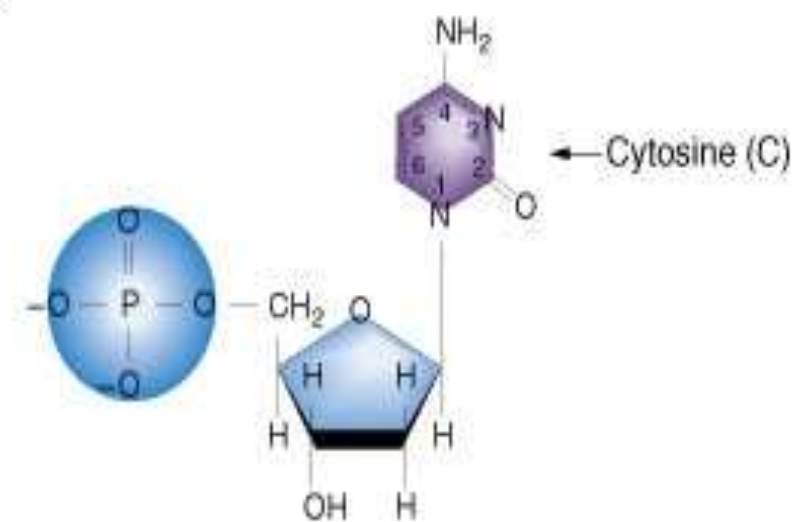


Deoxyadenosine 5'-phosphate (dAMP)

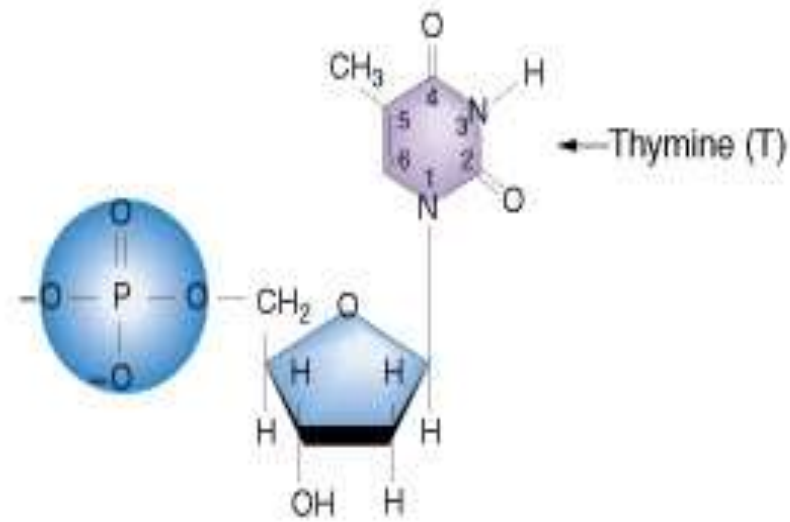


Deoxyguanosine 5'-phosphate (dGMP)

Pyrimidine nucleotides



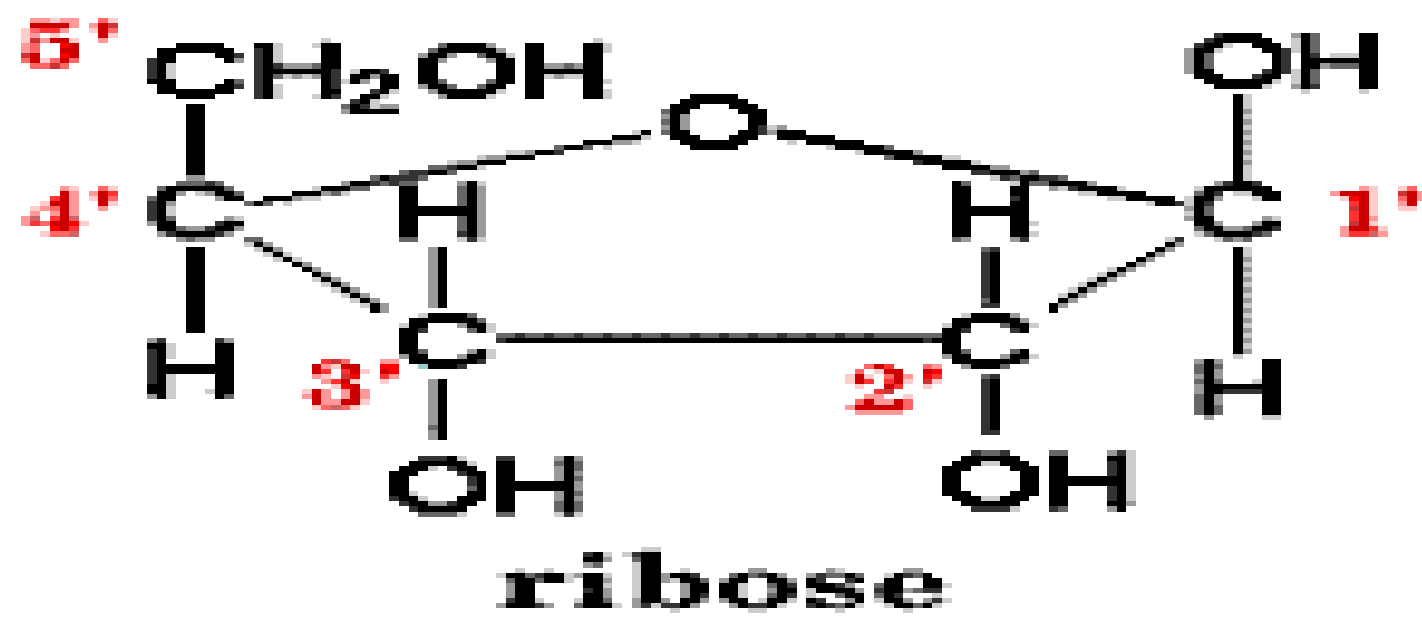
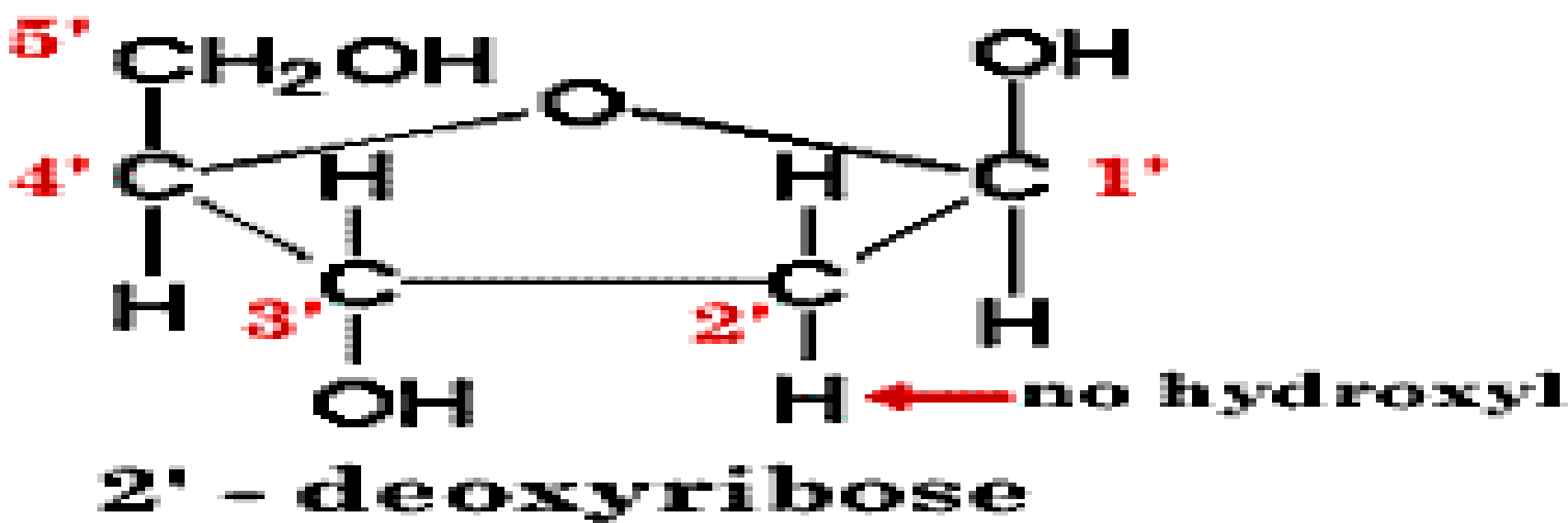
Deoxycytidine 5'-phosphate (dCMP)

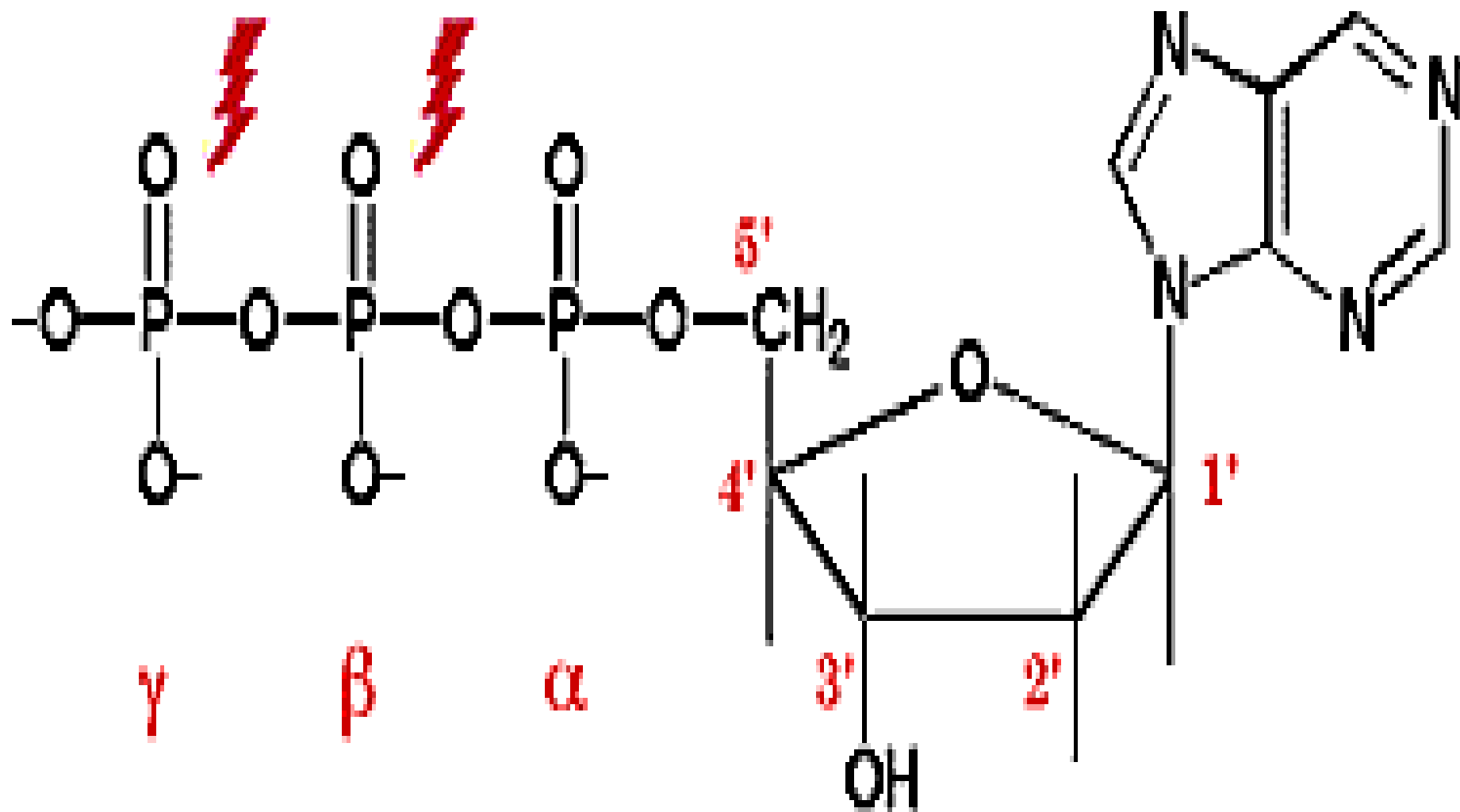


Deoxythymidine 5'-phosphate (dTMP)

Sugars

- ◉ The sugars present in the nucleotides of DNA are **deoxyribose** While **ribose** is found in RNA.
- ◉ **Deoxyribose** and **Ribose** are **pentose sugars** (contain 5 carbon atoms).
- ◉ The 5' (5 prime) carbon atom is not part of the ring, the fifth atom in the ring is the oxygen.
- ◉ The difference between **deoxyribose** and **ribose** is that **deoxyribose lacks the hydroxyl group (OH) in the 2' position**





(purine) - 5' - triphosphate

- The molecule **lacking** a **phosphate group** (containing **just the sugar and base**) is referred to a **nucleoside**.
- A nucleoside with a single phosphate group attached to its 5' carbon is known as a nucleoside-5'-monophosphate (abbreviated NMP).
- A nucleoside with two phosphate groups attached to its 5' carbon is known as a nucleoside-5'-diphosphate (NDP); a nucleoside with three phosphate groups attached to its 5' carbon is known as a nucleoside-5'-triphosphate (NTP).

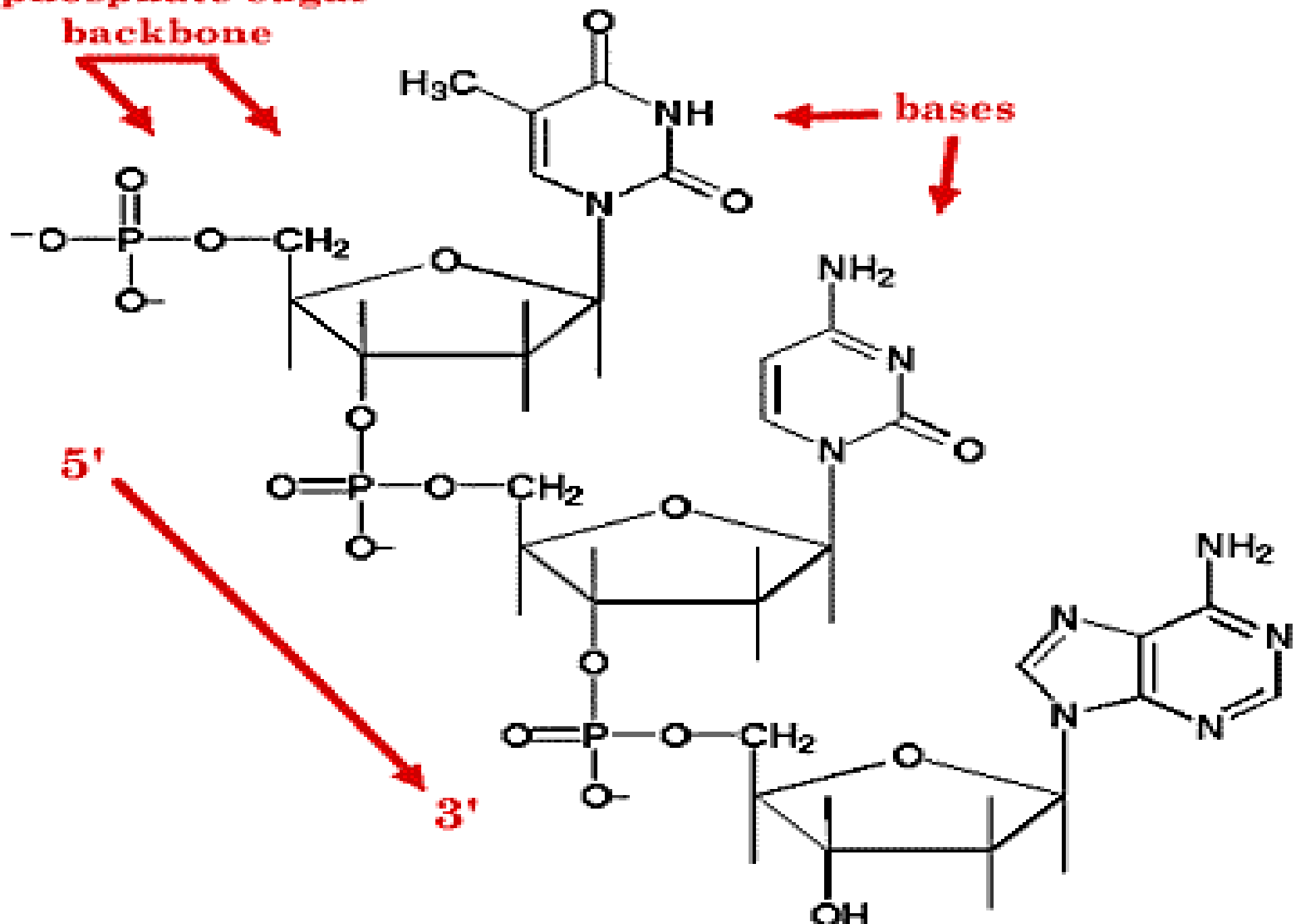
-
- The phosphate group located closest to the 5' carbon is the alpha phosphate. Additional phosphate groups are designated beta and gamma, respectively.
 - Nucleotide-triphosphates containing deoxyribose are designated dNTP.

Single strand:

- Nucleotides are combined end-to-end to form a single strand of nucleic acid.
- nucleotides are linked by a phosphodiester_bond,
- a covalent bond, between the alpha phosphate of one nucleotide to the 3' carbon of the adjacent nucleotide.
- At one end of the strand, a free (unattached) 5' phosphate group from the terminal nucleotide is found

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- This end is referred to as the 5' end of the nucleic acid strand.
 - At the opposite end is a free 3' hydroxyl group marking the 3' end of the strand.
 - each nucleic acid strand has a 5'->3' directionality

phosphate-sugar backbone



Base pairing:

- DNA typically exists as a double stranded molecule.
- The two strands are held together by hydrogen bonding between bases, forming a base pair.
- Only bases which are complementary to one another may pair appropriately.
- Thymine and adenine pair via two hydrogen bonds, and cytosine and guanine pair via three hydrogen bonds.

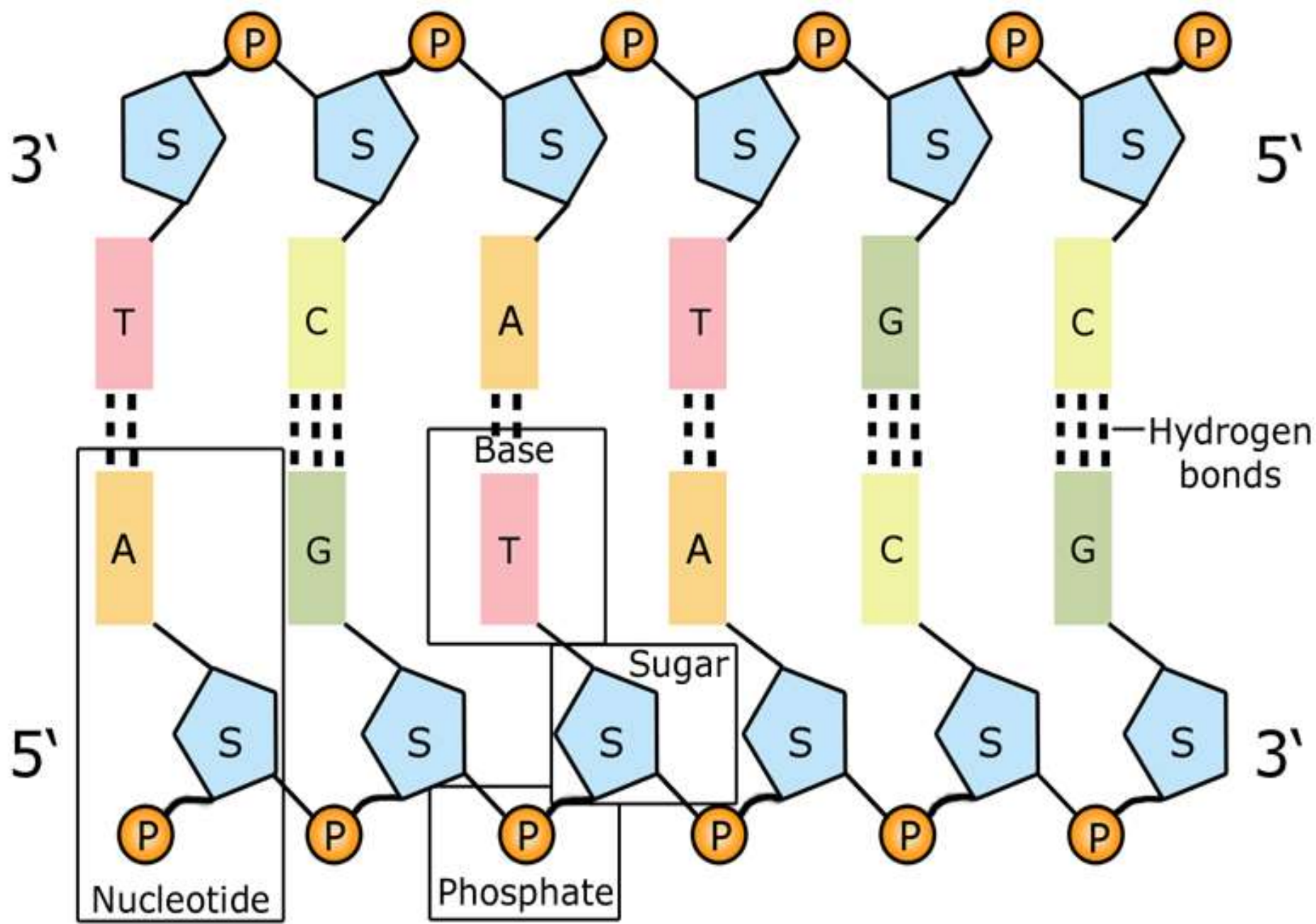
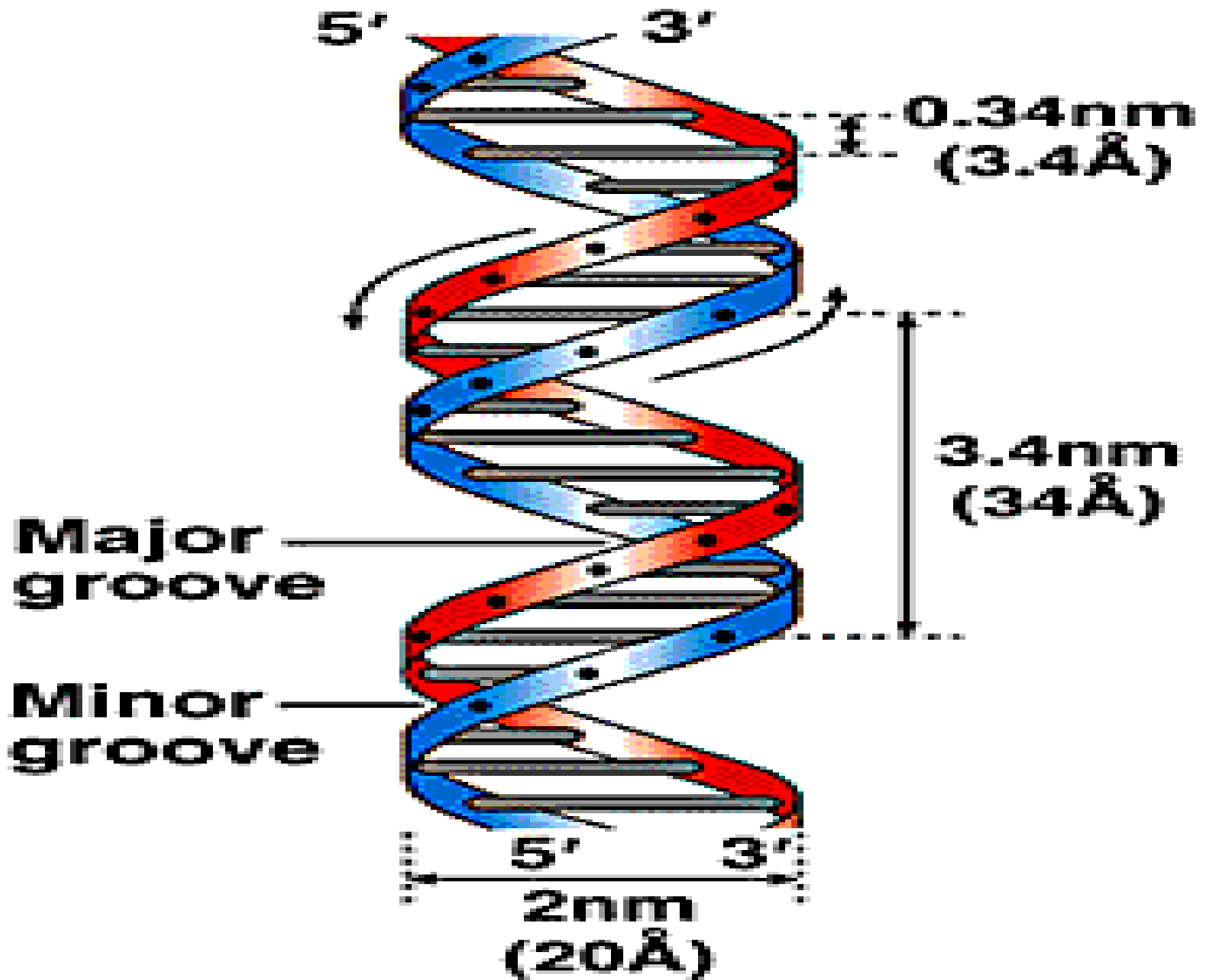


Image adapted from: National Human Genome Research Institute.

- ◉ 1953, James Watson and Francis Crick elucidated the structure of DNA. (B form)
- ◉ Each base pair is composed of one purine paired with one pyrimidine so that the width of the chain is roughly equivalent.
- ◉ The strands are **antiparallel** to one another with each strand oriented **5'->3'** in **opposite directions.**



RNA, Types, Structure and Function

RNA:

- RNA is the abbreviation for **Ribo Nucleic Acid.**
- Like DNA, RNA is a long molecule made up of a chain of nucleotides.
- Each nucleotide is made up of sugar, a phosphate and a nitrogenous base.
- In RNA the sugar is ribose. Ribose has (OH) group on the 2' carbon, unlike DNA which is missing the oxygen atom

- ◉ Another difference from **DNA** is that instead of containing the base **thymine**, **RNA** has a different one, called **uracil**.
- ◉ Although **RNA is single stranded**, parts of it can bend and form loops where bases can pair up with each other.
- ◉ There are three main types of RNA:
 - ◉ messenger RNA (mRNA)
 - ◉ ribosomal RNA (rRNA)
 - ◉ transfer RNA (tRNA)

Messenger RNA (mRNA):

- Messenger RNA is the familiar type of RNA.
- The information stored in this type of RNA is used to make proteins.
- When mRNA is first created in eucaryotes it is called precursor mRNA or heterogeneous RNA (hnRNA), it needs to be modified before translation takes place.
- The modification involves three steps:
- **Capping, tailing** and **splicing**.

- **Capping** is addition of a 5' cap composed of a **5' to 5' triphosphate** linkage between two modified nucleotides: **7-methylguanosine and a 2' O-methyl purine.**
- This cap serves to identify this RNA molecule as an mRNA to the translational machinery.
- Tailing is addition of poly A tail at the 3' end.

- Both the 5' cap and the 3' tail are added after the RNA is transcribed and contribute to the stability of the mRNA in the cell.
- **A spliceosome** is a complex of proteins and **small RNA molecules**, and is where the **removal** of **introns** and the splicing together of exons takes place.
- Messenger RNA makes up only about 5% of all RNA in a typical cell

Ribosomal RNA (rRNA):

- Ribosomes are made of protein and ribosomal RNA (rRNA) and are where translation of RNA to protein takes place.
- In *E. coli* ribosomes contain three kinds of rRNA - 23S, 16S and 5S.
- In eucaryotes, there are four kinds of rRNA - 18S, 28S, 5.8S, and 5S.

-
- One 18S molecule is used to make the small subunit of the ribosome, with the help of several proteins.
 - The 28S, 5.8S, and 5S rRNA molecules are involved with the construction of the large subunit of the ribosome.

Transfer RNA (tRNA) :

- There are at least 32 different kinds of tRNA in an eucaryotic cell.
- Small molecules, each one is made up of 74-95 ribonucleotides.
- Although tRNA is a single strand of RNA, it bends around in certain places resulting in some ribonucleotides pairing up with others in the same chain, forming four arms and three loops.
- Each tRNA molecule has one amino acid attached to its 3' end.

- Since there are only 20 amino acids and around 32 different kinds of tRNAs, some amino acids are carried by more than one type of tRNA.
- On one of the three loops is called an anticodon.
- Anticodon is a sequence of three bases complementary to the codon sequence in the mRNA, which codes for one amino acid of the protein.

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- The particular amino acid attached to a tRNA molecule is determined by its anticodon sequence.

