

8.2: Primary structure of deoxyribonucleic acid (DNA)

Learning Objectives

- Define nucleic acids and understand the mechanism of nucleic acid synthesis and the related terminologies.
- Define and be able to write the primary structure of nucleic acids.

Nucleic acid

Nucleic acids are long unbranched strands (polymers) of nucleotide subunits (monomers) that primarily store and express genomic information in living things.

Nucleic acids are long unbranched strands (polymers) of nucleotide subunits (monomers). A nucleotide triphosphate is the starting material for nucleic acid synthesis. The synthesis of DNA is controlled by an enzyme called DNA polymerase. A nucleoside triphosphate containing adenine (A), guanine (G), cytosine (C), or thymine (T) uses —OH group at 3' position of deoxyribose to attack α -phosphorous of triphosphate group at 5' position of the next nucleoside in an $\text{S}_\text{N}2$ mechanism. It results in a **phosphodiester linkage** between the 3' position of the first and 5' position of the second nucleotide, and a pyrophosphate (diphosphate) is eliminated as shown in Figure 8.2.1. The pyrophosphate breaks down into two phosphate units which make the reaction irreversible.

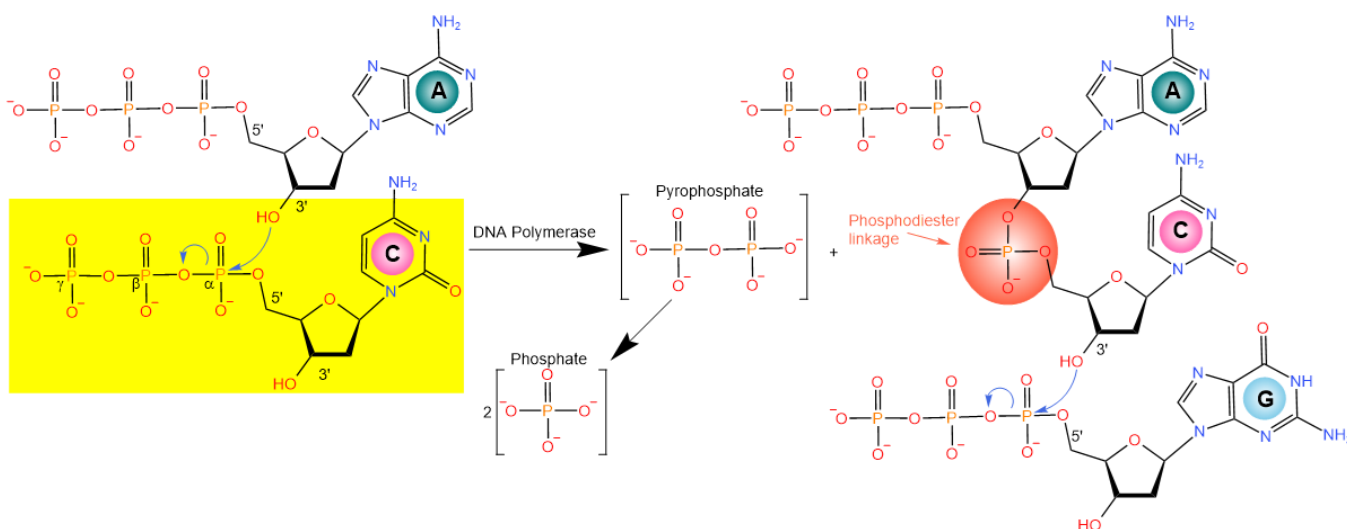


Figure 8.2.1: Chemical reaction mechanism for forming a phosphodiester linkage between nucleotides during DNA synthesis. (Copyright; Public domain)

Next, nucleotide triphosphate repeats the process and links at the 3' end of the growing strand; the cyclic process keeps repeating this way, as shown in Figure 8.2.1. The first nucleotide has unlinked triphosphate at the 5' position, called the **free 5' end**. The last nucleotide has an unlinked —OH group at the 3' position, and it is called the **free 3' end**. DNA synthesis occurs from 5' to 3' as shown in Figure 8.2.2. Deoxyribose and phosphodiester linkage alternate in the polymer's backbone, and the nitrogen bases hang on the side (1' position) of the deoxyribose units. Two nucleotides linked by a phosphodiester linkage are called a **dinucleotide**, 3 to 10 linked nucleotides are called an **oligonucleotide**, and many nucleotides linked are called a **polynucleotide**.

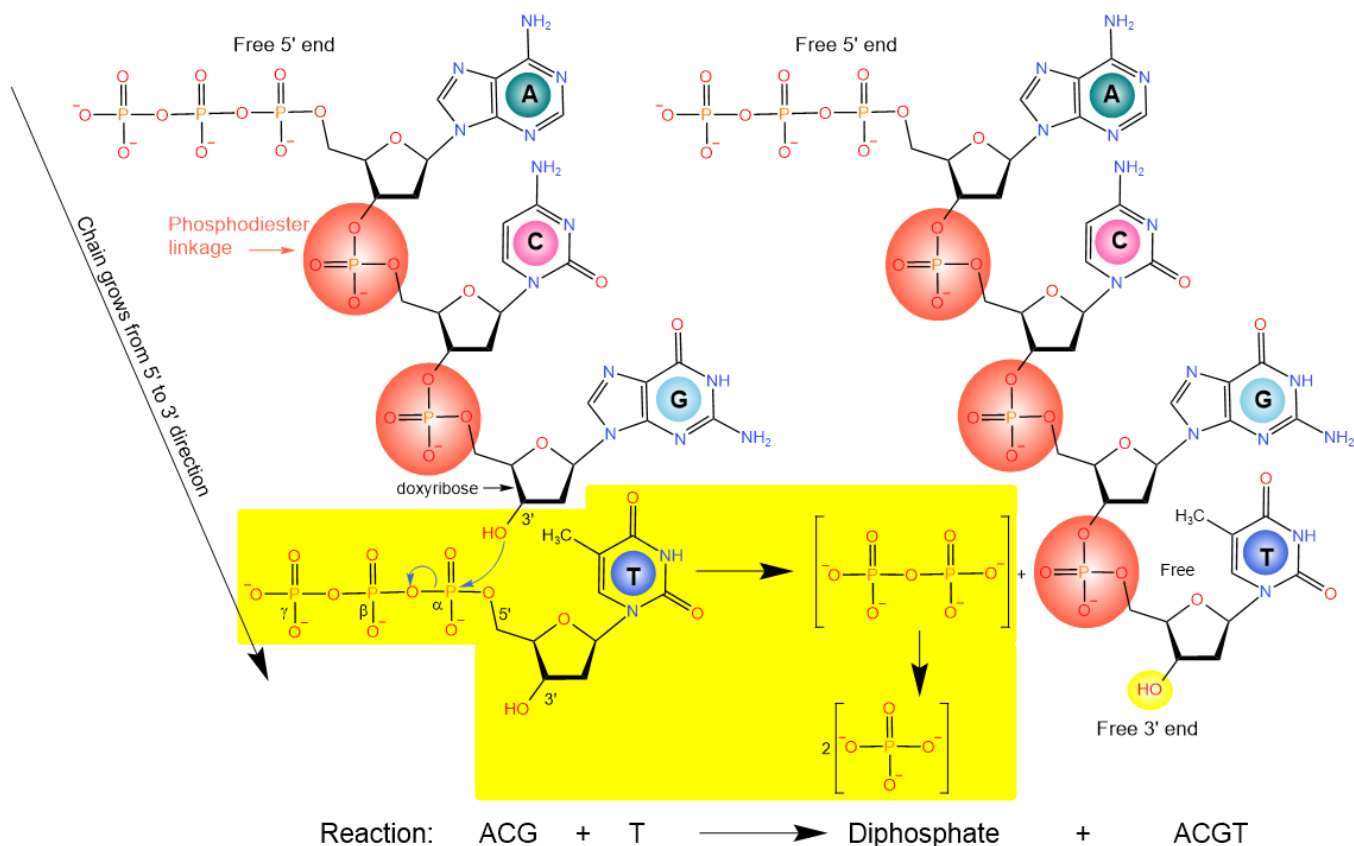


Figure 8.2.2: Synthesis of DNA illustrated. (Copyright; Public domain)

The synthesis of RNA takes place the same way as that of DNA, except for the following differences:

1. the enzyme carrying out the synthesis is RNA polymerase,
2. the sugar (5-carbon carbohydrate) is ribose, and
3. uracil (U) is used in place of thymine (T).

Primary structure of nucleic acid

The sequence of nucleotides in the nucleic acid is called the primary structure of nucleic acid.

The primary structure is written from the 5' to 3' direction, where the 5'-end is on the left end, and the one-letter abbreviation of the nitrogen base represents the nucleotides. For example, the primary structure of the oligonucleotide product shown in Figure 8.2.2 is ACGT. It is the sequence of nucleotides that carries the genetic information.

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