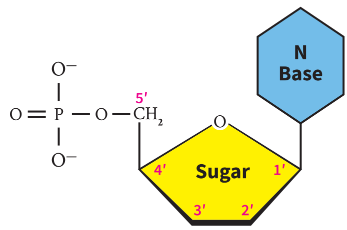

Fig. 5.26 The sugar in a nucleotide has five carbons labelled 1' to 5'. The phosphate is attached to the 5' C while the nitrogenous base is attached to the 1' C.

The sugar in nucleic acid is a five-carbon molecule called a *pentose*. As shown in figure 5.27, the carbon position in the sugar is labeled 1' to 5'. If the sugar has a hydroxyl (OH) in the second position of the carbon, it is called *ribose*, the sugar in RNA (fig. 5.27a). If the sugar lacks oxygen in the same position of the carbon, the sugar is called *2-deoxy-d-ribose*, the sugar in DNA. The 2-deoxy means the oxygen in the second position of the carbon is removed (fig. 5.27b).

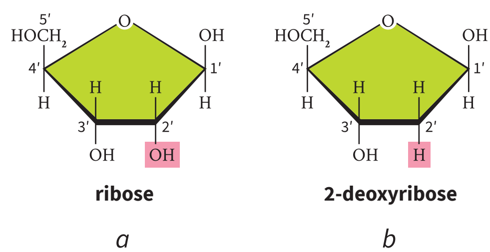

Fig. 5.27 Pentose is present in both RNA and DNA. The carbons are labeled 1' to 5'. (*a*) Ribose is the sugar in RNA. (*b*) 2-deoxy-d-ribose is the sugar in DNA. In 2-deoxy-d-ribose, the oxygen in the 2' C is absent while in ribose, the oxygen is retained.

NUCLEOTIDES AS BASIC BUILDING BLOCK OF NUCLEIC ACIDS

Nucleic acids are composed of repeating units of monomers called *nucleotides*. The two nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). A nucleotide is composed of the following: phosphate group ($-PO_4$), sugar, and nitrogenous base (fig. 5.26).

The nitrogenous bases (fig. 5.28) are divided into purines (composed of double ring structures) and pyrimidines (composed of one ring structures). The two purines are adenine (A) and guanine (G), while the three pyrimidines are thymine (T), cytosine (C), and uracil (U). The DNA molecule has A, C, G, and T. On the other hand, RNA also has A, C, G, and U (T is replaced by U in RNA).

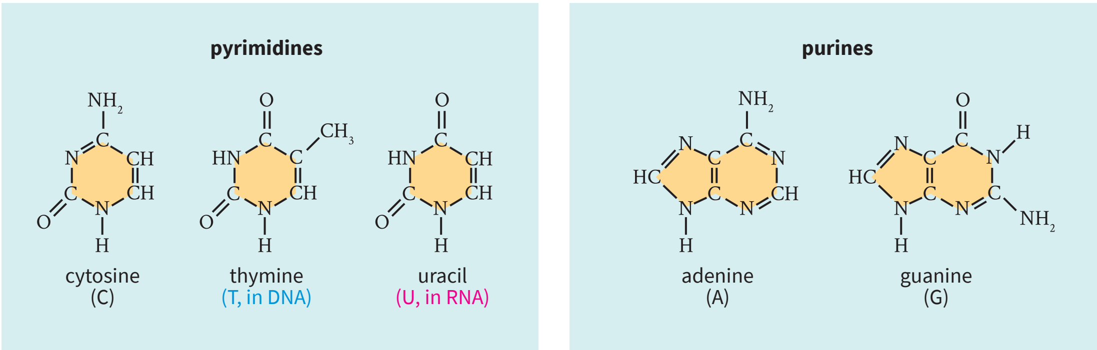

Fig. 5.28 The nitrogenous bases in nucleic acids

Certain bonds bind the different components of a nucleotide. The sugar is linked to the nitrogenous base to form a nucleoside. The bond formed is called *N-glycosidic bond*. The nucleoside binds to the phosphate group to form a nucleotide. When several nucleotides are joined together, a polynucleotide is formed. One nucleotide is attached to another nucleotide by forming a *phosphodiester linkage*. The phosphate group in the 5' carbon of the sugar in the nucleotide is linked to the 3' carbon of the sugar of the next nucleotide (fig. 5.29). This phosphodiester linkage contributes to the stability of the DNA. The linkage between the phosphate and the sugar creates the backbone of the DNA molecule.

THE DNA DOUBLE HELIX

The two polynucleotide strands pair by forming hydrogen bonds between their bases. This makes the DNA double stranded. The two strands are anti-parallel. The orientation of the sugar is opposite in direction: one strand has a 5' PO_4 end while the other strand has a 3' OH end, as shown in figure 5.29.

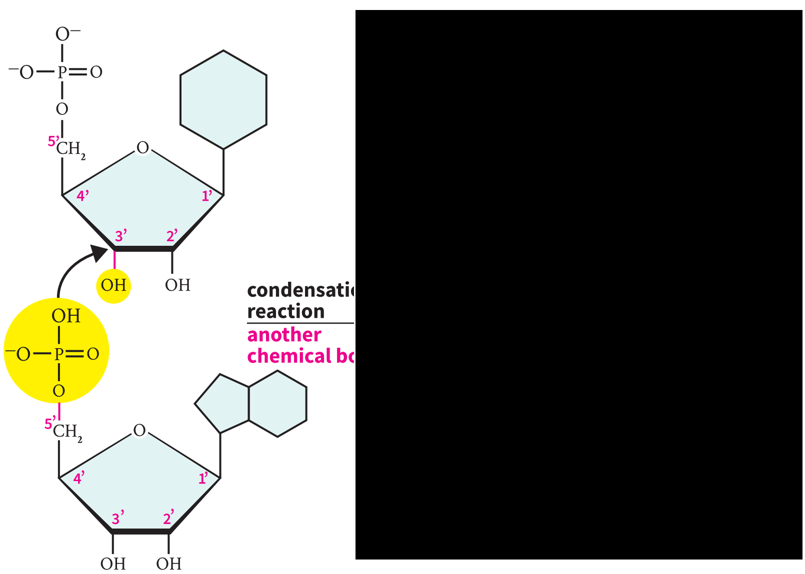

Fig. 5.29 The DNA and RNA are composed of repeating units of nucleotides. The 5' phosphate of one nucleotide is attached to the 3' OH of the next nucleotide in the process of forming phosphodiester bond.

Specific pairing occurs between the bases. As shown in figure 5.30, A pairs with T by forming two hydrogen bonds, while C pairs with G by forming three hydrogen bonds. The pairing is purine to a pyrimidine. This is known as Chargaff's rule. There is a 1:1 ratio of purine (A+G) to pyrimidine (C+T) in double-stranded DNA.

This specific pairing is important in the accurate duplication or replication of DNA. The sequence of nucleotides in the DNA varies indefinitely. The longer the DNA, the more varied its base sequence.

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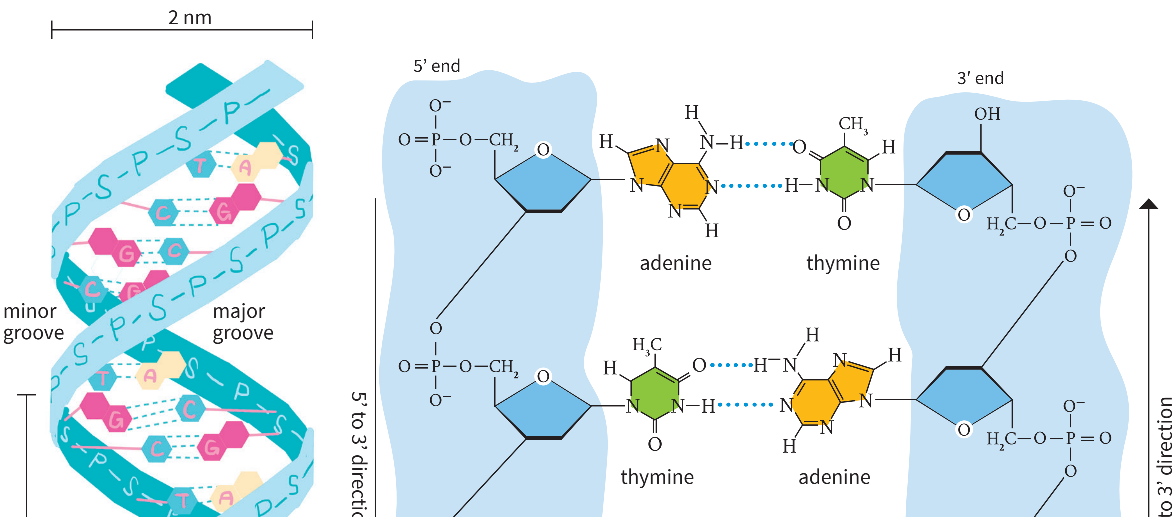

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(*a*) double helix

(*b*) antiparallel orientation of strands

Fig. 5.30 (*a*) Pairing of the two polynucleotide strands is made possible by hydrogen bond formation between the bases. (*b*) The two strands are antiparallel in direction with one end having a 3’ OH while the other strand has 5’ PO4 end.

You may visualize the double helix or the twisted double-stranded DNA by thinking of a spiral staircase. The alternating phosphate and sugar that form the backbone of the DNA represents the railing that you hold on to, while the paired nitrogenous bases (A ≡ T, C ≡ G), which are laid flat one on top of the other, are the steps of the staircase.

The complementary pairing in the DNA provides a mechanism for the DNA to duplicate or replicate. DNA is synthesized through the process known as *replication*. During this process (fig. 5.31), the two strands separate to form template strands. The double strands in DNA are separated by cutting the hydrogen bonds between the two polynucleotide strands to form two single-stranded DNA templates. The nitrogenous bases in the two template strands are complemented one by one. There is a specific base pairing where A is complemented by T while C is complemented by G. This specific base pairing ensures that the two copies of the DNA formed at the end of replication are identical to each other. Since pairing is specific, the template strands are complemented, forming two double-stranded DNA.

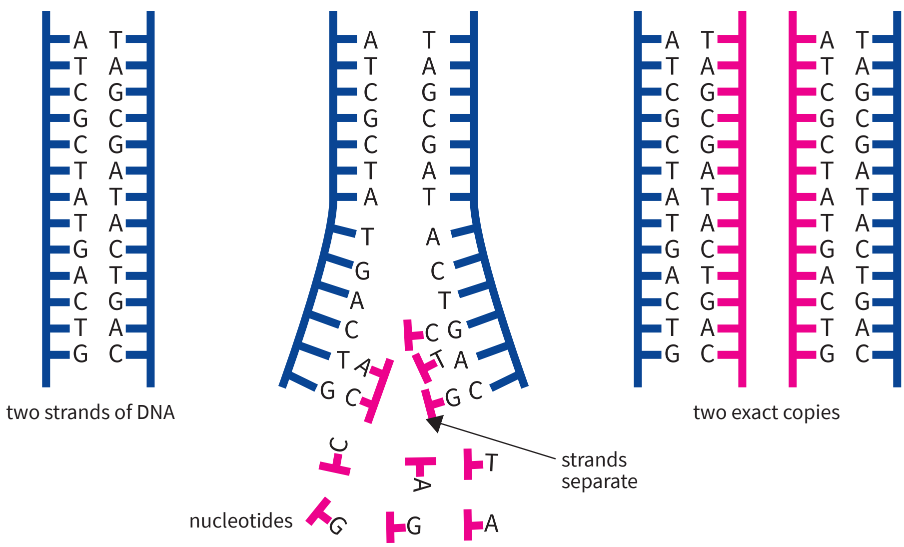

Fig. 5.31 The process of DNA replication ensures the retention of genetic information in the DNA strands formed.