Different Forms of DNA

DNA is a remarkably flexible molecule. Considerable rotation is possible around several types of bonds in the sugar-phosphate (phosphodeoxyribose) backbone, and thermal fluctuation can produce bending, stretching, and unpairing (melting) of the strands. Many significant deviations from the Watson-Crick DNA structure are found in cellular DNA, some or all of which may be important in DNA metabolism. These structural variations generally do not affect the key properties of DNA defined by Watson and Crick: strand complementarity, antiparallel strands, and the requirement for A = T and G:C base pairs. Structural variation in DNA reflects three things: the different possible conformations of the deoxyribose, rotation about the contiguous bonds that make up the phosphodeoxyribose backbone, and free rotation about the C-1'-*N*-glycosyl bond. Because of steric constraints, purines in purine nucleotides are restricted to two stable conformations with respect to deoxyribose, called syn and anti. Pyrimidines are generally restricted to the anti-conformation because of steric interference between the sugar and the carbonyl oxygen at C-2 of the pyrimidine. The Watson-Crick structure is also referred to as **B-DNA**. The B form is the most stable structure for a random-sequence DNA molecule under physiological conditions and is therefore the standard point of reference in any study of the properties of DNA. Two structural variants that have been well characterized in crystal structures are the **A** and **Z forms**. The **A form** is favored in many solutions that are relatively devoid of water. The DNA is still arranged in a right-handed double helix, but the helix is wider and the number of base pairs per helical turn is 11, rather than 10.5 as in B-DNA. The plane of the base pairs in A-DNA is tilted about 20' with respect to the helix axis. These structural changes deepen the major groove while making the minor groove shallower. The reagents used to promote crystallization of DNA tend to dehydrate it, and thus most short DNA molecules tend to crystallize in the A form. **Z-form DNA** is a more radical departure from the B structure; the most obvious distinction is the left-handed helical rotation. There are 12 base pairs per helical turn, and the structure appears more slender and elongated.

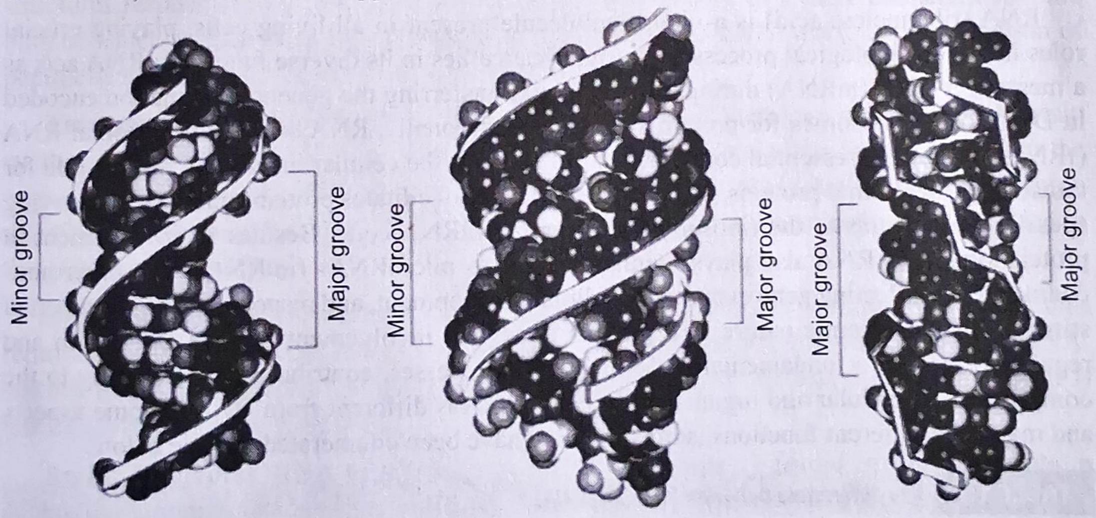

Fig. 1.4. *A comparison between three forms of DNA.*

The DNA backbone takes on a zigzag appearance. Certain nucleotide sequences fold into left-handed Z helices much more readily than others. Prominent examples are sequences in which pyrimidines alternate with purines, especially alternating C and G or 5-methyl-C and G residues. To form the left-handed helix in Z-DNA, the purine residues flip to the syn conformation, alternating with pyrimidines in the anti conformation. The major groove is barely apparent in Z-DNA, and the minor groove is narrow and deep. Whether A-DNA occurs in cells is uncertain, but there is evidence for some short stretches (tracts) of Z-DNA in both bacteria and eukaryotes. These Z-DNA tracts may play a role (as yet undefined) in regulating the expression of some genes or in genetic recombination. Table below provides comparative account of three forms of DNA.

TABLE 1.2 *Three forms of DNA, A-form, B- form and Z-form.*

	A-DNA	B-DNA	Z-DNA
Helix Structure	Right-handed	Right-handed	Left-handed
Major Groove	Narrow and deep	Wide and shallow	Shallow
Minor Groove	Wide and shallow	Narrow and deep	Deep
Base Pair Per Turn	11	10	12
Base Pair Tilt	Tilted away from axis	Nearly perpendicular	Tilted towards axis
Sugar-Phosphate Backbone	Tilted	Relatively straight	Zig-zag pattern
Residues Per Turn	11-12	10.5-11	12
Stability	Intermediate	High	Low
DNA Forms	RNA-DNA hybrids	Most common DNA form	May be present in vivo
Examples	Seen in some DNA-RNA hybrids, in RNA duplexes	Found in most natural DNA	Often occurs in regions with alternating purine-pyrimidine sequences