Fig 4.19 defines some of the characteristics of such supercoiling.

Consider first that we bend the B form of DNA into a circle and then seal the ends together. If the bend is gradual, the resulting circular DNA would be relaxed, i.e., would have no strain.

The indicated DNA molecule of 105 bp would have ten turns (or twists, T=10) of 10.5 nucleotides per turn that corresponds to the normal stable conformation of B-DNA.

L is the linking number that is the number of times that the two circular strands are linked together. L would also be equal to 10 as indicated in Fig 4.19(b).

W, the writhe, is the number of twists in the supercoil. W is zero because there is no supercoil.

L, T and W are related by the following equation: L=T+W. For the structure in Fig 4.19(b) 10=10+0.

Now imagine that before sealing the ends together, one unwinds the right-handed double helix so that there are 9 turns for the 105 bp, i.e., the DNA is unwound by one turn. This would correspond to a clockwise twist.

If the ends are now joined together, there will be a strain in the molecule because the molecule prefers the more stable 10.5 bp/turn.

The resulting structure could remain in a circle although the molecule would be strained because it would have 105/9 = 11.6 bases per turn.

Alternatively the molecule could relax by supercoiling and changing the number of turns (twists). In the example shown in Fig 4.19(d) the strain is relieved entirely by supercoiling allowing the number of turns in the double helix to revert to the original value of 10 with 10.5 bp/turn.

Note that the one twist of the supercoil is right-handed which is defined as a negative supercoil, i.e., W=-1. Thus for the structure in Fig 4.19(d) L=9, T=10 and W=-1.

W will be negative if the circular DNA is underwound such that the supercoil will be right-handed. Most naturally occurring supercoiled DNA molecules are right-handed.

W will be positive if the circular DNA is overwound before sealing such that the supercoil will be left-handed.

Note that while L must be an integer, T and W need not be integers.

Supercoiling of DNA is referred to as the tertiary structure because it represents another order of the three dimensional structure.

Supercoiled DNA is typical of the natural structure of phage and plasmid DNA as shown in Fig 4.20.

One of the characteristics of supercoiled DNA is that it is more compact than linear or circular DNA.

The extent of DNA supercoiling is often expressed in terms of the superhelical density, σ (sigma).

σ is defined as the change in linking number relative to the relaxed DNA divided by the linking number in the relaxed DNA

$$\sigma = \Delta \mathbf{L}/L_0$$

In the example shown,

$$\sigma = -1/10 = -0.1$$

Consider the transition of DNA from a double helix to randomly coiled single chains as shown in Fig 4.23.

The loss of the native secondary structure is referred to as denaturation and can be brought about by heating.

As shown in Fig 4.23 the transition can be monitored by following the change in UV absorbance at 260 nm associated with the nucleotide bases.

The absorbance of the nucleotide bases is less in the double helical form than in the random coil form. This phenomenon is called hypochromisn.

Fig 4.23(d) shows the typical change in absorbance vs. temperature. The midpoint of the curve is referred to as the "melting" temperature, Tm, which corresponds to the midpoint in the transition from the double helix to single stranded DNA in a random coil conformation.

Differences in the melting temperatures of different DNA molecules under a variety of conditions provide information about the factors that contribute to the stability of the double helix.

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