(1) Give unique definitions of the following terms:

(a) pitch

(b) tilt

(2) Which of the nucleic acid backbone torsion angles are not completely free to rotate?

(3) Draw a Hoogsteen base pair.

(4) Which of the following repeating B-DNA sequences adopt a stable, bent DNA conformation?

(a) `xxxxAAAxxxxAAAxxxxAAA`

(b) `AAAxxxxxxxAAAxxxxxxx`

(c) `xxxxAAxxxxxxxxAAxxxx`

(5) Draw the structure of the products of the first elementary reaction catalyzed by RNase A.

(6) The molecular basis of scurvy is the inability of the body to generate 4-hydroxyproline residues within collagen.

(a) Draw the structure of 4-hydroxyproline.

(b) How does 4-hydroxyproline contribute to the structure and function of collagen?

(7) Typically, a “hair perm” is used to add waves or curls to hair. How would you use a “hair perm” to straighten curly hair? Describe the reagents and steps involved.

(8) The function of fibrous protein can be understood in terms of their repetitive primary sequence and the quaternary structure(s) they form. (6 marks)

(a) What is the repetitive sequence in keratins and how does it contribute to their structure?

(b) What types of cross-linking interactions stabilize collagen fibers?

(9) Why do nucleic acid bases aggregate in aqueous solutions?

(10) How do intercalating agents affect DNA conformation?

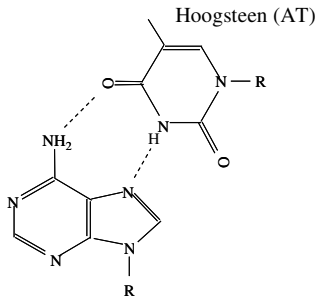
(11) What is the difference between twist and writhe?

Answers:

1a – The distance between sucessive turns of dsDNA or the length of a single turn of dsDNA.
1b – The deviation from planarity of complementary DNA base pairs

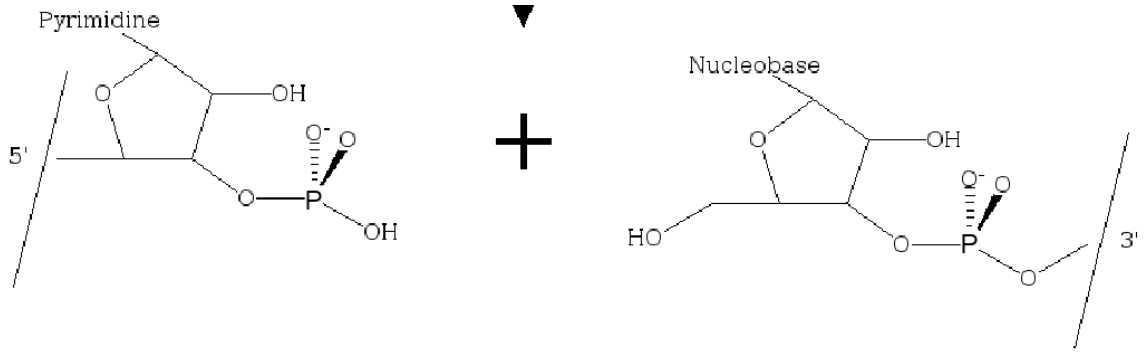
2 – The bond between C3' and C4' is highly constrained as it is part of the ribose ring. The C4' – C5' and C3' – O3' bonds are also constrained as C4' and C3' are part of the ribose ring. Consequently, the C4' – C5' and C3' – O3' bonds tend to adopt a single staggered torsion angle. The remaining torsion angles are basically free to adopt any staggered torsion angle.

3 –

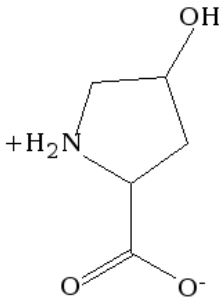


4 – Only (b) and (c) will form stably bent DNA conformations

5 -



6 –
(a)



(b) The free amino acid form of 4-hydroxyproline. 4-hydroxyproline stabilizes the collagen triple helix through bridging hydrogen bonds that involve water molecules. The hydrogen bonds are between subunits of the collagen triple helix.

7 –

i) native disulfide bonds in the curly hair must be reduced
ii) rinse to remove reducing agent
iii) moist heat followed by mechanical force to straighten the hair
iv) reform disulfide in straightened hair using an oxidant
v) rinse to remove oxidants

8a – Keratins form coiled-coil structures characterized by a heptad repeat (a-b-c-d-e-f-g) (1 mark). The positions 'a' & 'd' are always hydrophobic residues. The 'a' & 'd' residues of each subunit of the coiled-coil form a hydrophobic core for these long helices.

The 'p' and 'n' values for the keratin helix are different from those in a-helices. The pitch (p) is changed from 5.4 to 5.1Å and the number of residues per turn (n) is reduced from 3.6 to 3.5. Consequently, exactly seven residue result in two turns of the keratin helix and facilitate the heptad repeat (1 mark).

8b – What types of cross-linking interactions stabilize collagen fibers? Collagen does not utilize disulfide bridges for cross links as it contains very few cystyl residues. Instead, collagen uses modified lysyl residues that have been oxidized by lysyl oxidase. The collagen cross links are unusual as 2 or 3 lysyl residues may be involved and sometimes a histidyl residue is also part of a 4 residue cross link. These highly branched cross links contribute to collagen's high tensile strength.

9 – Nucelobase aggregation is driven by the hydrophobic effect. Unlike the case with proteins, the aggregation is enthalpically driven.

10 – Intercalating agents insert themselves between consecutive base pairs. This unwinds or untwists the nucleic acids locally while increasing the writhe number.

11 – Twist is equal to the number of turns of double stranded helix. Writhe is equal to the number of times, two double stranded helices cross-over (forming a “helix” from two regions of double stranded DNA). For closed circular dsDNA, any conformational change that alters the supercoiling will affect the twist and writhe numbers equally and oppositely.