Primary DNA Molecular Structure*

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1 Basic Properties of Primary DNA Molecular Structure

Fundamental Properties of DNA

- Two antiparallel and complimentary strands of deoxyribonucleic acid
- Hydrophillic polar external sugar-phosphate backbone
- Hydrophobic core of bases: Adenine, Thymine, Guanine, Cytosine
- DNA has significant secondary structure.

2 Sugar-Phosphate Backbone

The basic structure of DNA can be divided into two portions: the external sugar-phosphate backbone, and the internal bases. The sugar-phosphate backbone, as its name implies, is the major structural component of the DNA molecule. The backbone is constructed from alternating ribose sugar and phosphate molecules which are highly polar. Because the backbone is polar, it is hydrophillic which means that it likes to be immersed in water.

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Molecular Structure of DNA

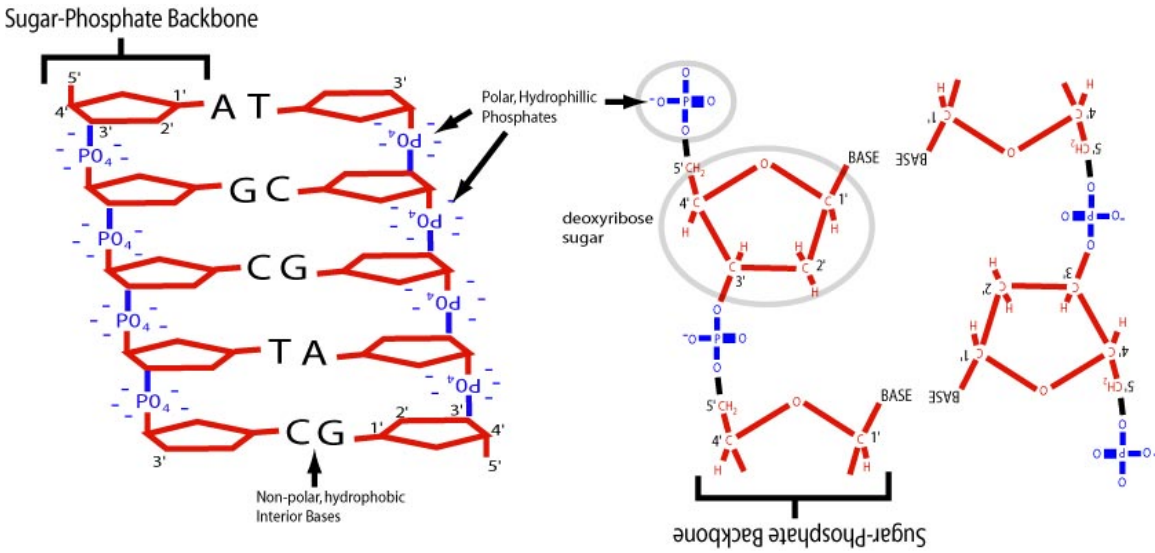

Figure 1

3 Complimentary Core of Bases

The interior portion of a DNA molecule is composed of a series of 4 nitrogenous bases: adenine (A), guanine (G), thymine (T), and cytosine (C). These bases are non-polar and therefore hyrdophobic (they don't like water). Inside a DNA molecule these bases pair up, A to T and C to G, forming hydrogen bonds that stabilize the DNA molecule. Because the interior bases pair up in this manner, we say the DNA double helix is complimentary. It is this sequence of bases inside the DNA double helix that we refer to as the genetic code.

4 Hydrostatic Interactions

Hydrostatic forces are very important to the molecular structure of DNA. Hydrostatic forces arise because of hydrogen bonding between the hydrogen and oxygen atoms in water. Polar molecules, because of thier charge, can interact with water without disrupting the ubiquitous latice of hydrogen bonds that the water molecules naturally form. This allows polar molecules to easily dissolve into water. Therefore we call them hydrophilic. Non-polar molecules, however, cannot form electrostatic bonds with the hydrogen and oxygen atoms in water. Non-polar molecules, to be immersed in water, must break potential electrostatic hydrogen bonds between water molecules. Breaking potential bonds represents a net increase in the free energy of the system of water molecules and this has a destabilizing effect the result of which is that non-polar molecules tend to get pushed out of water. Thus we call them hydrophobic. If you have ever seen a water and oil mixture shook up and then slowly settle apart, you have seen these forces in action. The desktop wave boxes are an example of this. Actually, you see these forces in action constantly; you wouldn't exist without them: your cells would lyse apart, your proteins wouldn't fold properly, and your would die a horribly messy death if these hydrostatic forces quit working:)

The sugar-phosphate backbone of DNA is polar, and therefore hydrophillic; thus it likes to be proximal to water. The interior portion of DNA, the bases, are relatively non-polar and therefore hydrophobic. This duality has a very stabilizing effect on the overall structure of the DNA double helix: the hydrophobic core of the DNA molecule 'wants' to be hidden inside the sugar-phosphate backbone which acts to isolate it from the polar water molecules. Due to these hydrostatic forces there is a strong pressure gluing the two strands of DNA together.

5 Antiparallel - Direction and Polarity in DNA

DNA is Antiparallel

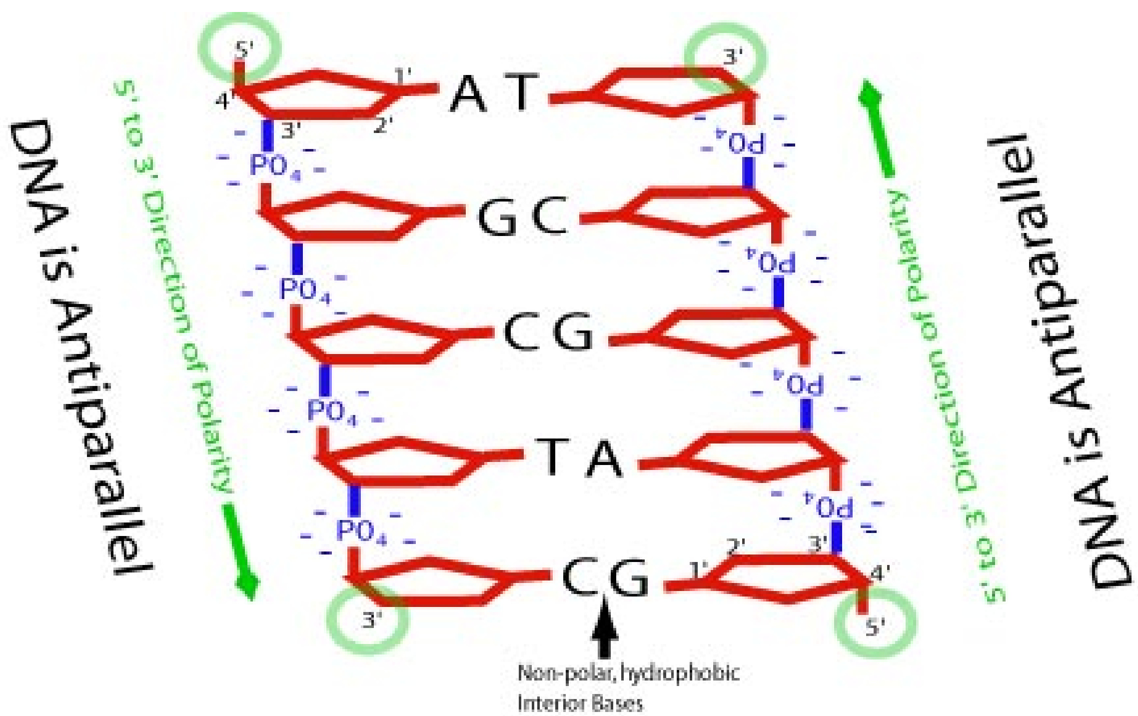

Figure 2

That DNA is antiparallel means that the two strands of DNA have opposite chemical polarity, or, stated another way, their sugar-phosphate backbones run in opposite directions. Direction in nucleic acids is specified by referring to the carbons of the ribose ring in the sugar-phosphate backbone of DNA. 5' specifies the the 5th carbon in the ribose ring, counting clockwise from the oxygen molecule, and 3' specifies the 3rd carbon in the ring. Direction of, and in reference to, DNA molecules is then specified relative to these carbons. For example, transcription, the act of transcribing DNA to RNA for eventual expression, always occurs in the 5' to 3' direction. Nucleic acid polymerization cannot occur in the opposite direction, 3' to 5', because of the difference in chemical properties between the 5' methyl group and the 3' ring-carbon with an attached hydroxyl group.