Nucleotides and Nucleic Acids
Nucleotides: Composed of a sugar; a weak nitrogenous base; at least one phosphoryl group

*Nucleoside: sugar + base
2 Classes of Nucleotides: Ribonucleotides and Deoxyribonucleotides

Ribose (β-D-ribofuranose)

Deoxyribose (2-Deoxy-β-D-Ribofuranose)
Nitrogenous bases are substituted purines or pyrimidines.

Pyrimidine is a heterocyclic compound containing 4 carbon and 2 nitrogen atoms.

Purine is a bicyclic structure consisting of pyrimidine fused to an imidazole ring.
Major pyrimidines found in nucleotides are: cytosine, uracil, thymine
Major purines in nucleotides are guanine, adenine.
Ribonucleoside: ribose sugar linked to base by an N-glycosidic bond (β)

Adenosine is shown here

Other ribonucleosides:
- Guanosine
- Uridine
- Cytidine
(Thymidine is a deoxy-ribonucleotide)
Nucleotides:

- Adenosine-5’-monophosphate (AMP)
- Adenosine-5’-diphosphate (ADP)
- Adenosine-5’-triphosphate (ATP)
Polynucleotides are formed by joining the 5’ phosphate of one nucleotide to the 3’ OH of another. These are phosphodiester bonds.
Chargaff’s Rules:

*Base composition of DNA is such that the numbers of dA and dT residues are equal and the numbers of dG and dC residues are equal.*

*Ratio of pyrimidines to purines is 1:1!*

*Discovered by Edwin Chargaff - 1940s. Helped Watson and Crick to deduce the structure of DNA.*
**Watson-Crick (B-DNA):**

2 polynucleotide chains wound along a common axis with a right-handed twist in an antiparallel fashion.

- Planes of bases are perpendicular to the axis.
- Complementary base pairing.
- Ideal helix has 10 bases per turn and has a rise per turn of 34 angstroms.
There are two H-bonds in an A-T base pair and three in a G-C base pair.

Watson-Crick base pairing occurs because the bases are in their correct tautomeric forms.
Tautomers: Isomers that differ only in their degree of protonation. Keto (lactam) and enol (lactim) forms exist.

* Groups involved in H-bonding

Uracil
*Groups involved in H-bonding

Adenine
In B-DNA rotation of the base about its glycosidic bond can result in either the *syn* or *anti* conformation.

Because of steric hinderance, all bases are usually *anti*. 
The C2’ or C3’ substituent on the ribose ring is generally out of plane causing the sugar ring to pucker. If the out of plane atom is to the same side as the C5’ substituent, the sugar is in the \textit{endo} conformation; if on the opposite side the sugar is \textit{exo}. C2’ endo is the most common.

\textit{C3’ substituent is out of plane in this ribose ring}
DNA inside the cell changes conformation as the strands bend and interact with other molecules.

**A-DNA** occurs under conditions of dehydration

- 11 bases/turn; pitch = 24.6 angstroms
- C3’ endo sugar pucker
- Differences in major groove and minor groove reduced
**Z-DNA is a left-handed helix**

Discovered by studies of synthetic dCG

12 bases/turn; pitch = 45.6 angstroms

Guanosines are in the syn conformation; sugar pucker is C3’ endo for G’s

There is no major groove
Double Helix is Stabilized By:

- **Hydrophobic Effects;** burying of bases to the interior
- **Base Stacking;** van der Waals contacts
- **Electrostatic Interactions;** electrostatic repulsion of phosphate groups relieved by interaction with cations ($\text{Mg}^{2+}$)
- **Hydrogen Bonding;** complementary base pairing
• dsDNA is more stable than its separated strands under physiological conditions, so dsDNA predominates in vivo.

• dsDNA can be disrupted in the process of denaturation by temperature or urea.

• When the two strands are separated, there is a decrease in viscosity of the solution.

• Can measure denaturation by the increase in absorption at 260 nm that occurs.
Hyperchromic Effect: Increase in 260 nm absorption of DNA upon denaturation due to exposure of bases.

Temperature at the midpoint of the melting curve is the melting temperature.

This is where one half of the DNA is still duplex.