Nucleic Acids (DNA/RNA) -- Structure and Function

DNA = Deoxyribonucleic Acid

RNA = Ribonucleic Acid

-- nucleus-based acids (the phosphate group derived from phosphoric *acid*).

-- these two molecules enable organisms to reproduce their complex equipment from one generation to the next.

- DNA can replicate *itself*; RNA requires DNA for its production.

- DNA replication occurs prior to cell division (mitosis for somatic cells, meiosis for sex cells)

- DNA possesses what it known as hereditary information.

-- DNA is a blueprint for the eventual, yet indirect, building of proteins of all shapes, sizes, and functions; its sequence of nucleotides *codes* for particular proteins.

-- different regions of DNA coding for different proteins are called GENES.

-- three different forms of RNA play a role in the synthesis of proteins.

-- DNA serves as a direct template for RNA.

Major functions/contributions of DNA:

1. Able to self-replicate for distribution to daughter cells.

2. Stores information that controls development and cellular activities (ie. the instructions for RNA synthesis and eventual Protein Synthesis).

3. Experiences mutations that create genetic variability which contributes to evolution.

Main function of RNA:

- to serve as an intermediary between DNA and protein production in cells.

STRUCTURE

-- DNA makes up CHROMATIN/CHROMOSOMES in the nucleus of a cell

-- again, RNA has three types of molecules that serve various functions which will be detailed later.

-- the monomer of DNA is the DNA nucleotide (RNA nucleotide for RNA).

-- DNA nucleotides join by dehydration synthesis to form DNA:

$$\textbf{X} \text{ DNA nucleotides } \underset{\text{Hydrolysis}}{\overset{\text{Dehydr. Synth.}}{\rightleftharpoons}} \text{ DNA strand} + \textbf{(X-1)} \; H_2O$$

* similar for RNA.

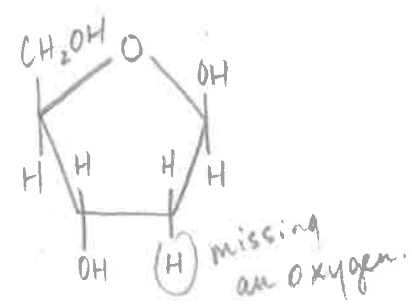
Nucleotide Structure

-- made up of three constituents:

i. A Phosphate Group (PO_4^{3-}) (evident in both DNA and RNA)

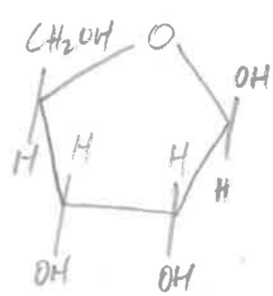
ii. A Pentose (5-carbon) Sugar (DNA's sugar is ***deoxyribose*** and RNA's sugar is ***ribose***).

* deoxyribose sugar has one less *oxygen* atom than the ribose sugar, giving each molecule slightly different properties.



DEOXYRIBOSE

VS.



RIBOSE

iii. A Nitrogenous Base (nitrogen-containing):

-- there are two classes of bases and five types overall:

Class I -- PURINES -- double-ring structure

a. Adenine (A): found in DNA and RNA

b. Guanine (G): found in DNA and RNA

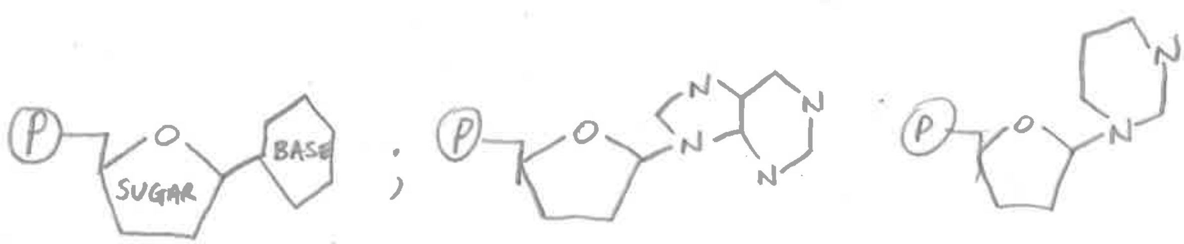
Class II -- PYRIMIDINES -- single-ring structure

a. Cytosine (C): found in DNA and RNA

b. Thymine (T): found in DNA only

c. Uracil (U): found in RNA only

-- simple nucleotide diagrams (see fig. 2.28 p.40):



general PURINE PYRIMIDINE

-- notice, in fig. 2.28 p. 40, the 'backbone' of what is often called the 'ladder'.

-- the 'backbone' of the DNA strand is made up of the following sequence: sugar--phosphate--sugar--phosphate--sugar etc...(same for RNA).

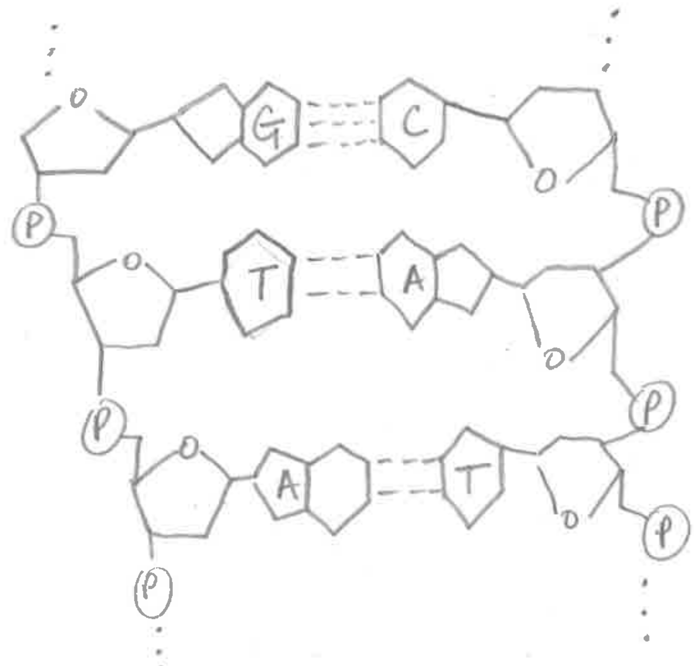
-- nucleotides join by dehydration synthesis between a -OH group (hydroxyl group) on the sugar and a -OH group on a phosphate (ie. the phosphate group joins a sugar from *another* nucleotide).

-- the nitrogenous bases project to one side of the 'backbone'.

Structure of DNA

-- DNA is a DOUBLE-STRANDED molecule forming a 'ladder-like' structure with the sugars/phosphates forming the sides of the ladder, and the bases forming the 'rungs'.

-- hydrogen bonds that exist between nitrogenous bases on different strands hold the two halves of this ladder structure together (again, fig. 2.28 p. 40).



-- it has been determined through research that in DNA, the amount of thymine (T) always equals the amount of adenine (A), and the amount of cytosine (C) always equals the amount of guanine (G).

-- led to the concept of COMPLEMENTARY BASE-PAIRING:

-- A always binds to T (and vice versa).
-- forms 2 H-bonds.

-- G always binds to C (and vice versa).
-- forms 3 H-bonds.

-- in 1953, Watson and Crick discovered the *double-helix* structure possessed by DNA (the twisting of the double-strand into helical form).

-- this structure forms naturally and it allows for the least amount of strain on the H-bonds holding the two strands together.

-- RNA only exists as a single strand, which forms a helical structure like that of proteins.

DNA vs. RNA (A summary)
-- remember, RNA is mainly utilized during the process of Protein Synthesis.
-- also, some of these differences will be covered when we discuss Protein Synthesis in detail.

Basis of Contrast	DNA	RNA
1. Sugar	deoxyribose	ribose
2. Location in Cell	nucleus	nucleus and cytoplasm
3. Shape	double-stranded helix	single-stranded helix
4. Bases	A, T, C, G	A, U, C, G
5. Base-Pairs	A=T, C≡G	A=U, C≡G

DNA Replication

-- occurs so that a parent cell can divide to form two daughter cells, with each of the resulting cells receiving a full complement of DNA.

-- must be highly accurate.

-- each single strand that makes up the double-stranded structure of DNA can serve as a TEMPLATE (guide) for the formation of a *complementary* daughter strand (ie. each 'parent' strand is a template for each new daughter strand).

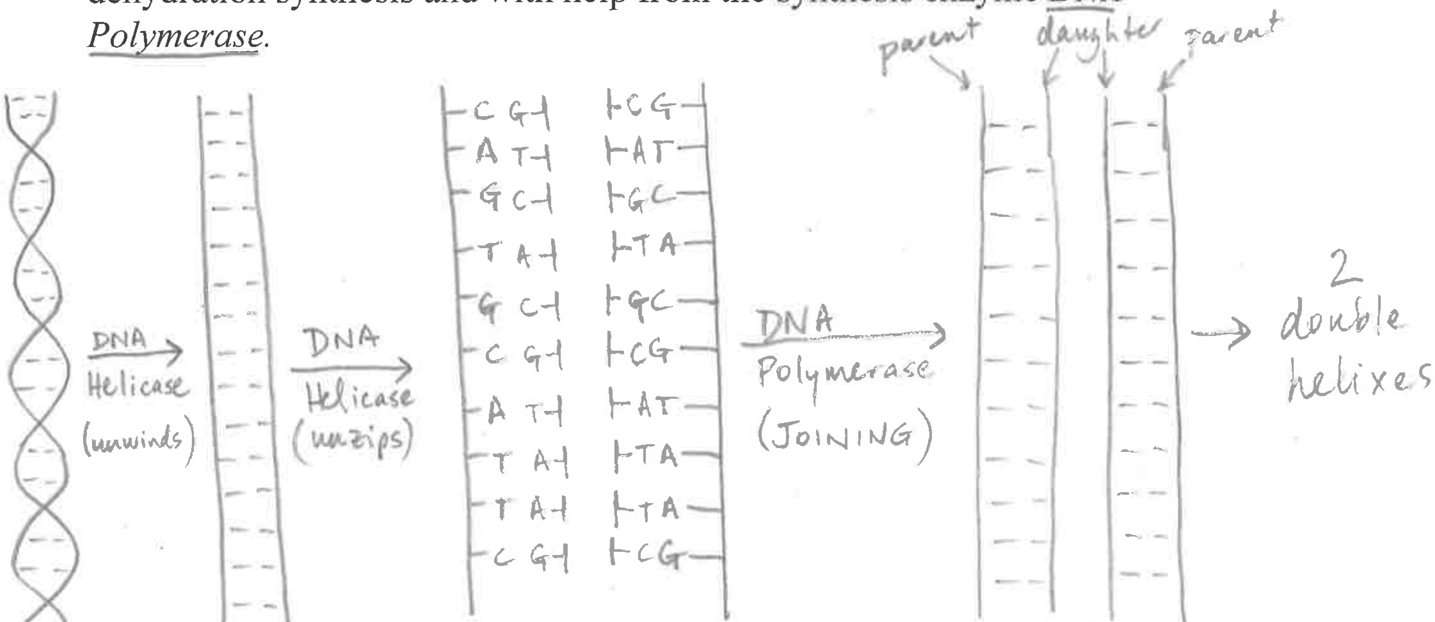
-- DNA replication occurs during *Interphase* of the Cell Cycle.

Steps (see fig. 25.3 p. 509):

1. **Unwinding** – the enzyme *DNA Helicase* unwinds and unzips the 'ladder' by breaking the hydrogen bonds between the complementary bases.

2. **Complementary Base Pairing** – new, complementary, singular DNA nucleotides (always available in the nucleus) move into place on each strand by the process of *complementary base-pairing.*

3. **Joining** – the new complementary DNA nucleotides are joined together (phosphate of one nucleotide to the sugar of another) through the process of dehydration synthesis and with help from the synthesis enzyme *DNA Polymerase.*



-- after replication, two double-stranded DNA molecules exist (both are identical, barring any errors).

-- DNA Polymerase also serves as an 'editor' or 'proof-reader', fixing any minute errors that may have occurred during replication.

-- after replication, the cell will divide.

-- DNA Replication is referred to as being SEMI-CONSERVATIVE because each new double-helix possesses one OLD (parent) strand and one NEW (daughter) strand (ie. one of the parent strands is 'conserved' in each new double-helix).