Nucleic Acids

- **MAIN Function:**
  - store & transmit hereditary information

- **Examples:**
  - RNA (ribonucleic acid)
  - DNA (deoxyribonucleic acid)

- **Structure:**
  - monomers = nucleotides

Nucleotides

- 3 parts
  - nitrogen base (C-N ring)
  - pentose sugar (5C)
    - ribose in RNA
    - deoxyribose in DNA
  - PO₄ group

Types of Nucleotides

- 2 types of nucleotides
  - based on different nitrogenous bases
- purines
  - double ring N base
    - adenine (A)
    - guanine (G)
- pyrimidines
  - single ring N base
    - cytosine (C)
    - thymine (T)
    - uracil (U)

Building the Polymer

- Backbone
  - sugar to PO₄ bond
  - phosphodiester bond
    - a COVALENT bond
    - new base added to sugar of previous base
    - polymer grows in one direction
  - N bases hang off the sugar-phosphate backbone
Nucleic Acid Types
- RNA
  - single nucleotide chain
- DNA
  - double nucleotide chain
    - $N$ bases bond in pairs across chains
  - spiraled in a double helix
    - double helix 1st proposed as structure of DNA in 1953 by James Watson & Francis Crick

Pairing of Nucleotides
- Nucleotides bond between DNA strands
  - H bonds
    - purine :: pyrimidine
    - $A :: T$
      - 2 H bonds
    - $G :: C$
      - 3 H bonds

Interesting note…
- Ratio of $A-T::G-C$ affects stability of DNA molecule
  - 2 H bonds vs. 3 H bonds
  - biotech procedures
    - more G-C bonds need higher $T^\circ$ to separate strands
    - high $T^\circ$ organisms
    - many G-C

Another interesting note…
- ATP: Adenosine Triphosphate
  - modified nucleotide
    - adenine ribose + P$_i$ + P$_i$ + P$_i$

Information Polymer
- Function
  - series of bases encodes information
    - like the letters of a book
  - stored information is passed from parent to offspring
    - need to copy accurately
  - stored information = genes
    - genetic information

DNA Molecule
- Double helix
  - H bonds between bases join the 2 strands
    - $A :: T$
    - $C :: G$

Again – understand the significance of the hydrogen bonds between strands!
Copying DNA

- Replication
  - 2 strands of DNA helix are complementary
    - have one, can build other
    - have one, can rebuild the whole
  - why is this a good system?
  - when in the life of a cell does replication occur?
    - mitosis
    - meiosis

DNA Replication

"It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material."

- 1953
  - James Watson
  - Francis Crick

What is Life?

- First we have to define LIFE...
  - organized as cells
  - respond to stimuli
  - regulate internal processes
    - homeostasis
    - metabolism
  - use energy to grow
  - develop
    - change & mature within lifetime
  - reproduce
    - heredity
    - DNA / RNA
    - adaptation & evolution

The Origin of Life is Theory!

- Special Creation
  - Was life created by a supernatural or divine force?
  - not testable
- Extraterrestrial Origin
  - Was the original source of organic (carbon) materials comets & meteorites striking early Earth?
  - testable
- Spontaneous Abiotic Origin
  - Did life evolve spontaneously from inorganic molecules?
  - testable

Conditions on early Earth

- Reducing atmosphere
  - water vapor (H₂O), CO₂, N₂, NOx, H₂, NH₃, CH₄, H₂S
  - lots of available H & its electron
- Energy source
  - lightning, UV radiation, volcanic

Origin of Organic Molecules

- 1920
  - Oparin & Haldane propose reducing atmosphere hypothesis
- 1953
  - Miller & Urey test hypothesis
    - formed organic compounds
    - amino acids
    - adenine
Origin of Cells (protobionts)
- Bubbles \(\rightarrow\) separate inside from outside \(\rightarrow\) metabolism & reproduction

Origin of Genetics
- RNA is likely first genetic material
  - multi-functional
  - codes information
    - self-replicating molecule THAT CAN MUTATE
    - makes inheritance possible
    - natural selection & evolution
  - enzyme functions
    - ribozymes
    - replication
  - regulatory molecule
  - transport molecule
    - tRNA

Carbohydrates
- Structure / monomer
  - monosaccharide
- Function
  - energy
  - raw materials
  - energy storage
  - structural compounds
- Examples
  - glucose, starch, cellulose, glycogen

Lipids
- Structure / building block
  - glycerol, fatty acid, cholesterol, H-C chains
- Function
  - energy storage
  - membranes
  - hormones
- Examples
  - triglycerides, phospholipids, steroids

Proteins
- Structure / monomer
  - amino acids
  - levels of structure
- Function
  - enzymes
  - defense
  - transport
  - structure
  - signals
  - receptors
- Examples
  - digestive enzymes, membrane channels, insulin hormone, actin

Nucleic acids
- Structure / monomer
  - nucleotide
- Function
  - information storage & transfer
- Examples
  - DNA, RNA