

## Chemistry



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## All Matter Consists of Elements

- **Chemistry** is the study of matter
- **Matter is:**
  - Anything that has mass and occupies space
  - Composed of elements
- **Elements**
  - Cannot be broken down to a simpler form
  - Periodic table of elements – lists all known elements

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|               |             |             |                     |  |  |  |  |  |  |  |  |  |             |             |             |             |             |             |  |
|---------------|-------------|-------------|---------------------|--|--|--|--|--|--|--|--|--|-------------|-------------|-------------|-------------|-------------|-------------|--|
| Group number  | 1           | 2           | Transition elements |  |  |  |  |  |  |  |  |  | 3           | 4           | 5           | 6           | 7           | 8           |  |
| Atomic number | 1           | 2           |                     |  |  |  |  |  |  |  |  |  | 3           | 4           | 5           | 6           | 7           | 8           |  |
|               | H<br>1.008  |             |                     |  |  |  |  |  |  |  |  |  | B<br>10.81  | C<br>12.01  | N<br>14.01  | O<br>16.00  | F<br>19.00  | Ne<br>20.18 |  |
| 2             | Li<br>6.941 | Be<br>9.012 |                     |  |  |  |  |  |  |  |  |  | Al<br>26.98 | Si<br>28.09 | P<br>30.97  | S<br>32.06  | Cl<br>35.45 | Ar<br>39.95 |  |
| 3             | Na<br>22.99 | Mg<br>24.31 |                     |  |  |  |  |  |  |  |  |  | Sc<br>44.96 | Ti<br>47.88 | V<br>50.94  | Cr<br>52.00 | Mn<br>54.94 | Fe<br>55.85 |  |
| 4             | K<br>39.10  | Ca<br>40.08 |                     |  |  |  |  |  |  |  |  |  | Cu<br>63.55 | Zn<br>65.38 | Ga<br>69.72 | Ge<br>72.64 | As<br>74.92 | Se<br>78.96 |  |
| 5             | Rb<br>85.47 | Sr<br>87.62 |                     |  |  |  |  |  |  |  |  |  | Ni<br>58.69 | Cd<br>112.4 | In<br>114.8 | Sn<br>118.7 | Sb<br>121.8 | Te<br>127.6 |  |
| 6             | Cs<br>132.9 | Ba<br>137.3 |                     |  |  |  |  |  |  |  |  |  | Pd<br>106.4 | Hg<br>200.6 | Tl<br>204.4 | Pb<br>207.2 | Bi<br>209.0 | Po<br>(209) |  |
| 7             | Fr<br>(223) | Ra<br>(226) |                     |  |  |  |  |  |  |  |  |  | Ag<br>107.9 | Au<br>197.0 | Hs<br>(261) | Me<br>(261) | At<br>(210) | Oh<br>(200) |  |
|               |             |             |                     |  |  |  |  |  |  |  |  |  | Metals      |             |             |             |             | Non metals  |  |
| Lanthanides   |             |             |                     |  |  |  |  |  |  |  |  |  |             |             |             |             |             |             |  |
| Actinides     |             |             |                     |  |  |  |  |  |  |  |  |  |             |             |             |             |             |             |  |

## Atoms – Smallest Functional Unit of Elements

- Atoms consist of
  - Nucleus (central core)
    - **Protons**
      - positive charge
      - have mass
    - **Neutrons**
      - no charge
      - have mass
  - Shells (surrounding nucleus)
    - **Electrons**
      - negative charge
      - no discernable mass

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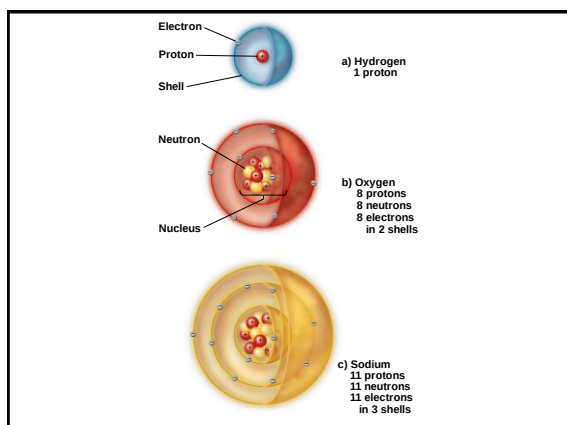
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## More About Atoms

- **Atomic symbol:** one or two letters
  - Na: sodium
  - O: oxygen
- **Atomic number**
  - Number of protons
- **Atomic mass**
  - Roughly equal to number of protons plus neutrons

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## Energy Fuels Life's Activities

- **Energy:** the capacity to do work
- **Potential energy:** stored energy
- **Kinetic energy:** energy in motion, doing work
- Potential energy can be transformed into kinetic energy

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a) Potential energy is locked up in the chemical bonds of energy-storage molecules in Greg Louganis' tissues.

b) Kinetic energy is energy in motion.

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## Life Depends on Water

- Water molecules are polar
- Water is liquid at body temperature
- Water can absorb and hold heat energy
- Water is the biological solvent
- Water helps regulate body temperature

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## Water Is the Biological Solvent

- **Solvent:** liquid in which other substances dissolve
- **Solute:** any dissolved substance
- **Hydrophilic:** molecules that are attracted to water and interact easily with water
- **Hydrophobic:** molecules that do not interact with or dissolve in water

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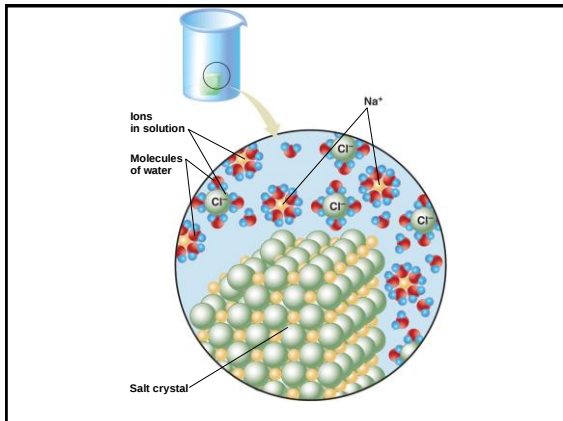
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## The Importance of Hydrogen Ions

- **Acids:**
  - Donate hydrogen ions (protons)
  - Increase hydrogen ion concentration in solutions
- **Bases**
  - Accept hydrogen ions (protons)
  - Lower hydrogen ion concentration in solutions
- **pH Scale**
  - A measure of hydrogen ion concentration

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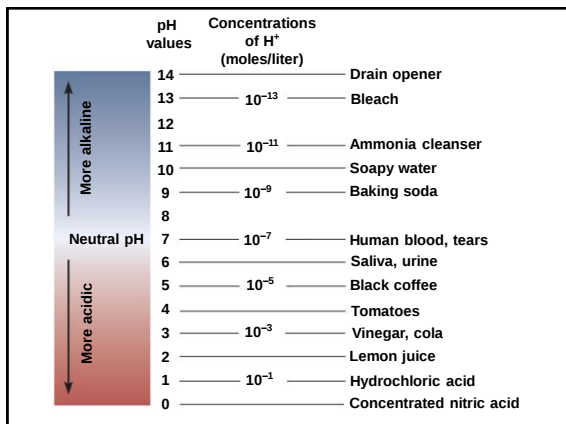
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## Buffers

- Minimize pH change
- Help maintain stable pH in body fluids
- Carbonic acid and bicarbonate act as one of the body's most important buffer pairs
  - $HCO_3^- + H^+ \rightarrow H_2CO_3$

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## The Organic Molecules of Living Organisms

- Carbon
  - The building block of living things
  - Comprises ~18% of the body by weight

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## Macromolecules Are Synthesized and Broken Down within the Cell

- Dehydration synthesis
  - Removes equivalent of a water molecule
  - Requires energy
  - Builds macromolecules from smaller subunits
- Hydrolysis
  - Adds the equivalent of a water molecule
  - Releases energy
- Dehydration synthesis is the reverse of hydrolysis

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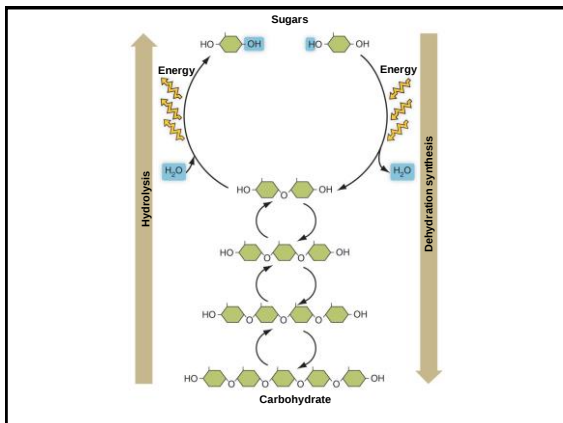
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## Carbohydrates: Used for Energy and Structural Support

- General formula:  $C_n(H_2O)_n$
- Monosaccharides: simple sugars
  - Glucose
  - Fructose
  - Galactose
  - Ribose
  - Deoxyribose

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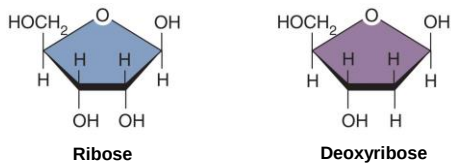
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## Oligosaccharides: More than One Monosaccharide Linked Together

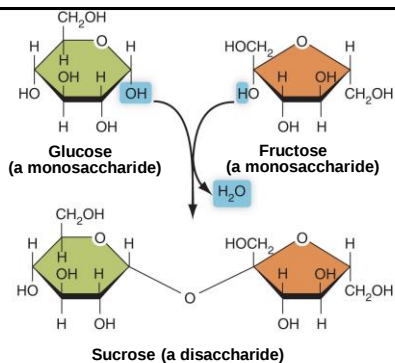
- Monosaccharides can be linked together via dehydration synthesis
- Disaccharides: two monosaccharides linked together
  - Sucrose: glucose + fructose
  - Maltose: glucose + glucose
  - Lactose: glucose + galactose

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a) The five-carbon monosaccharides ribose and deoxyribose.

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b) Two 6-carbon monosaccharides (glucose and fructose) are joined together by dehydration synthesis, forming sucrose.

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## Polysaccharides Store Energy

- Polysaccharides: thousands of monosaccharides joined in chains and branches
  - Starch: made in plants; stores energy
  - Glycogen: made in animals; stores energy
  - Cellulose: indigestible polysaccharide made in plants for structural support

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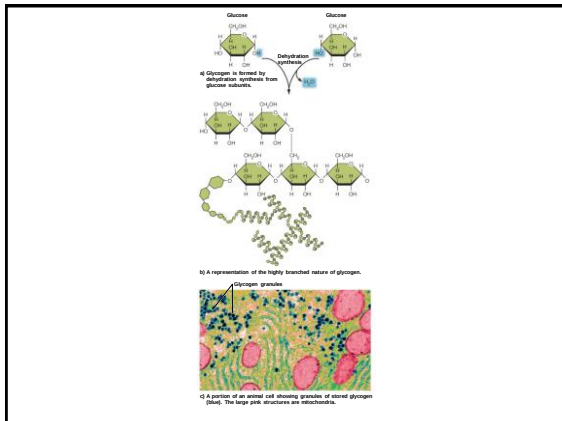
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## Lipids: Insoluble in Water

- Three important classes of lipids
  - **Triglycerides**: energy storage molecules
  - **Phospholipids**: cell membrane structure
  - **Steroids**: carbon-based ring structures

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## Triglycerides

- Also known as fats and oils
- Composed of glycerol and three fatty acids
  - Fatty acids
    - Saturated (in fats)
    - Unsaturated (in oils)
- Energy storage molecules

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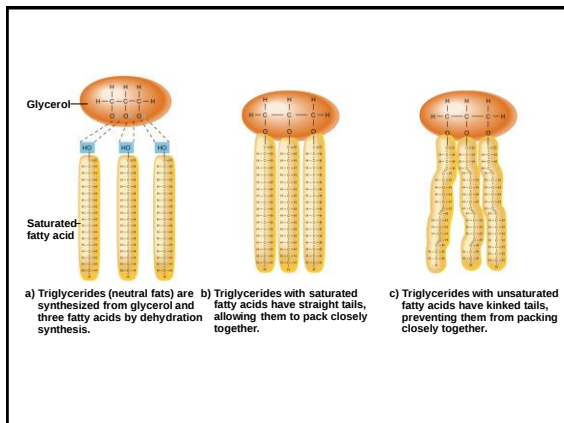
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## Phospholipids

- Structure
  - Glycerol + two fatty acids and phosphate group
  - One end of molecule is water soluble (hydrophilic)
  - Other end of molecule is water insoluble (hydrophobic)
- Function
  - Primary component of cell membranes

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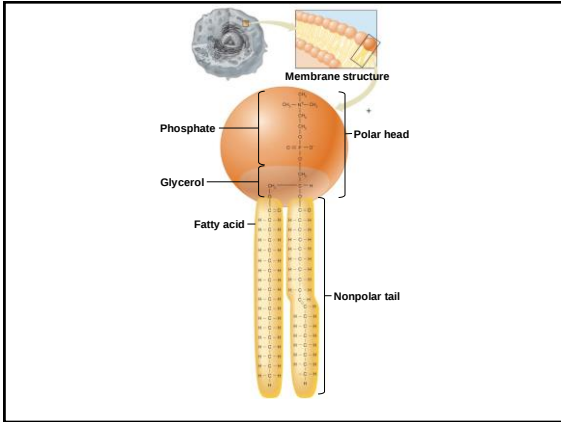
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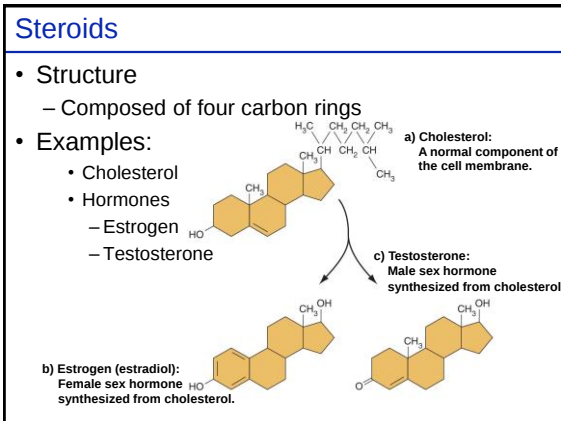
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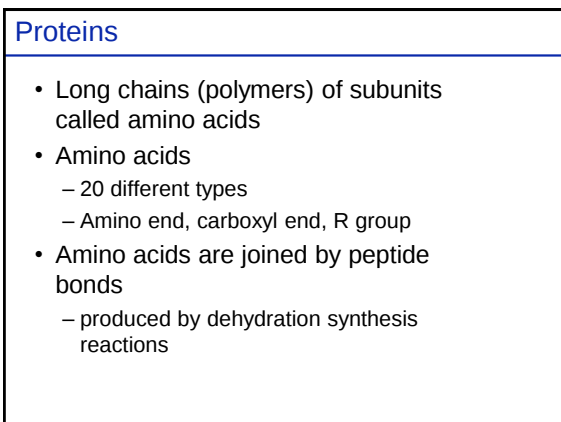
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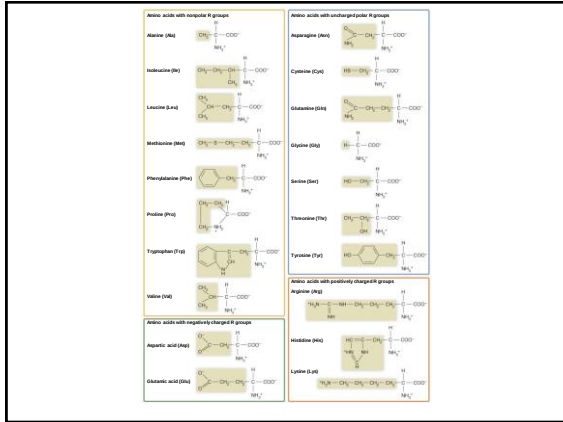
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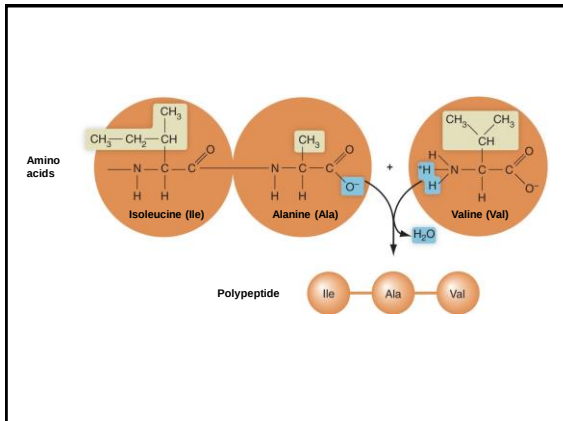
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## Nucleic Acids Store Genetic Information

- Two types
  - DNA: deoxyribonucleic acid
  - RNA: ribonucleic acid
- Functions
  - Store genetic information
  - Provide information used in making proteins
- Nucleic acids are long chains containing subunits known as nucleotides

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## Nucleic Acids Store Genetic Information

- **Nucleotides:** building blocks of nucleic acids
- Each nucleotide contains
  - 5 carbon sugar
    - DNA nucleotides: deoxyribose
    - RNA nucleotides: ribose
  - Nitrogenous base
  - Phosphate group

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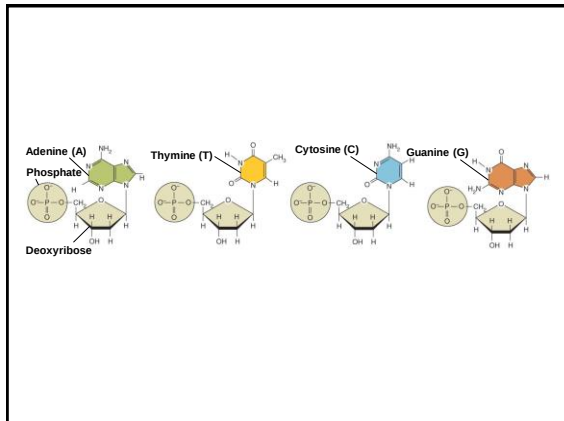
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## Nucleic Acids Store Genetic Information

- Structure of DNA (deoxyribonucleic acid)
  - Double-stranded
  - Nucleotides contain
    - Deoxyribose (sugar)
    - Nitrogenous bases
      - Adenine
      - Guanine
      - Cytosine
      - Thymine
  - Pairing
    - Adenine (A) – Thymine (T)
    - Guanine (G) – Cytosine (C)

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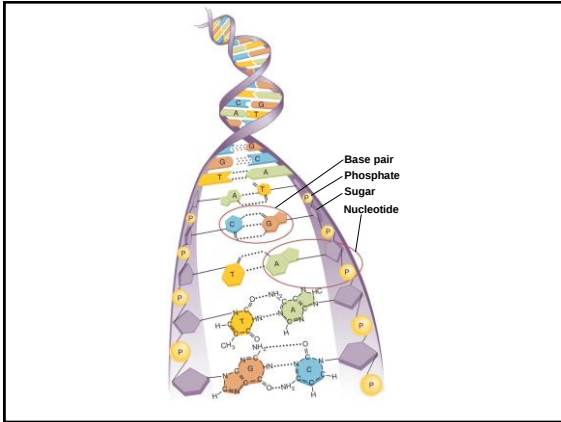
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### Nucleic Acids Store Genetic Information

- Structure of RNA (ribonucleic acid)
  - Single-stranded
  - Nucleotides contain
    - Ribose
    - Nitrogenous bases
      - Adenine (A)
      - Guanine (G)
      - Cytosine (C)
      - Uracil (U)

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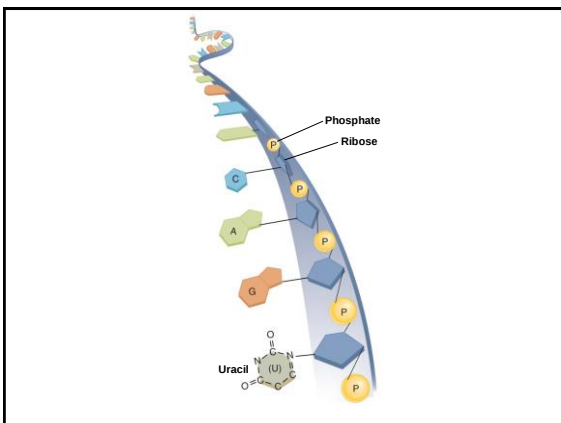
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## Nucleic Acid Function --- Nucleic Acids Store Genetic Information

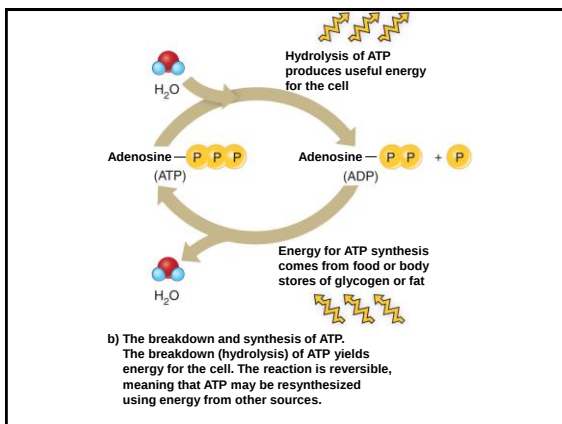
- Nucleic acid function
  - DNA: instructions for making RNA
  - RNA: instructions for making proteins
  - Proteins: direct most of life's processes
  - DNA → RNA → Proteins

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## ATP Carries Energy

- Structure and function of adenosine triphosphate (ATP)
  - Universal energy source
  - Bonds between phosphate groups contain potential energy
  - Breaking the bonds releases energy
    - ATP → ADP + P + energy

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