

# Chemistry of Life

## Chapter 3

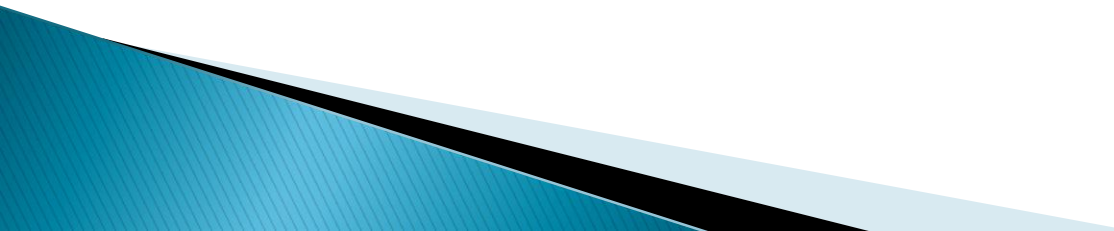
Matter and Substances

Section 3-1

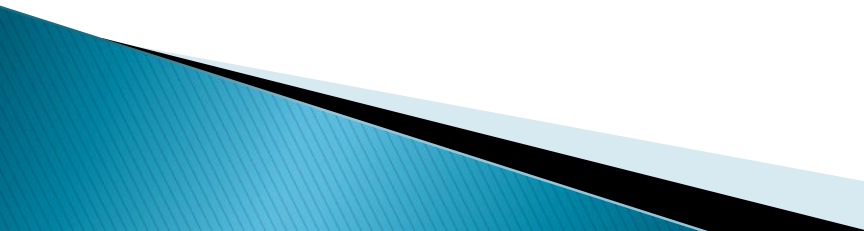


# Atoms

**Key Idea:** All matter is made up of **atoms**. An **atom** has a positively charged **core** surrounded by **a negatively charged region**.

- ▶ An atom is the smallest unit of matter that cannot be broken down by chemical means.
  - ▶ An element is a substance made up of atoms that have the same number of protons.
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# Atomic Structure

- ▶ The nucleus of an atom is made up of positively charged protons and uncharged neutrons.
  - ▶ Negatively charged electrons have very little mass and move around the nucleus in a large region called the electron cloud.
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# Elements

- ▶ Atoms of an element may have different numbers of neutrons. These atoms are called isotopes of elements.

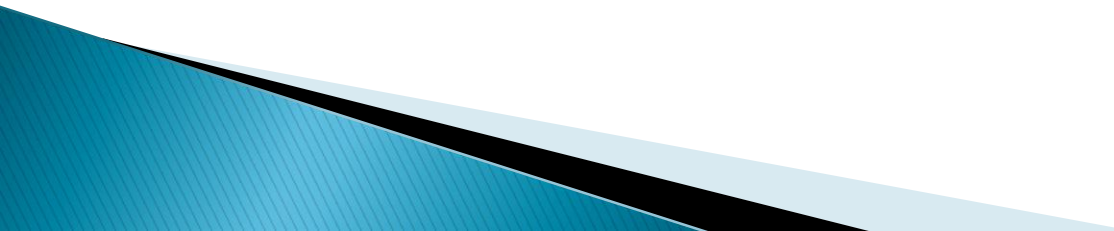
# Reading Check:

What is a proton?

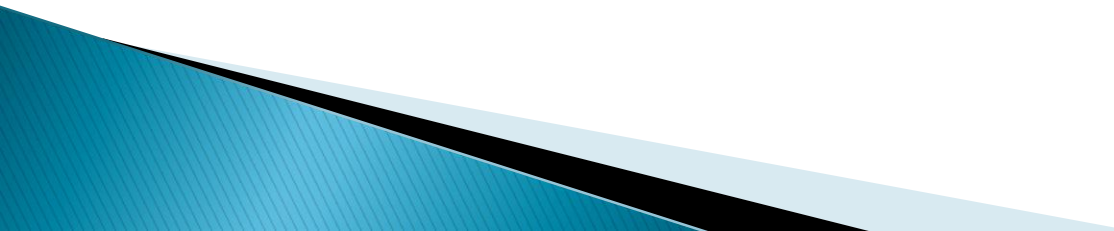
A positively charged particle that is part of the nucleus of an atom.

# Chemical Bonds

**Key Idea:** Chemical bonds form between groups of **atoms** because **most atoms** become stable when they have **eight electrons** in the valence shell.

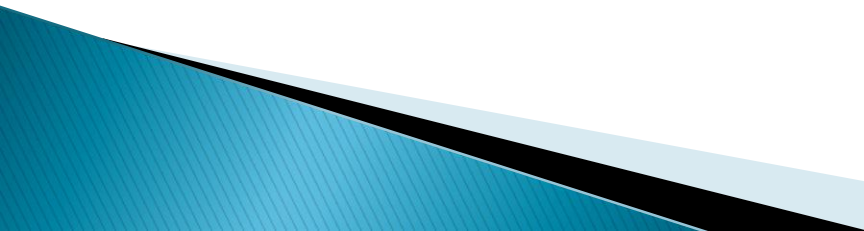


# Covalent Bonding

- ▶ A covalent bond is atoms sharing valence electrons.
  - ▶ A **molecule** is a group of atoms held together by covalent bonds.
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# Ionic Bonding

- ▶ An ionic bond is the attractive force between oppositely charged ions.
  - ▶ An **ion** is an atom or group of atoms that has an electric charge because it has gained or lost electrons.
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# Reading Check:

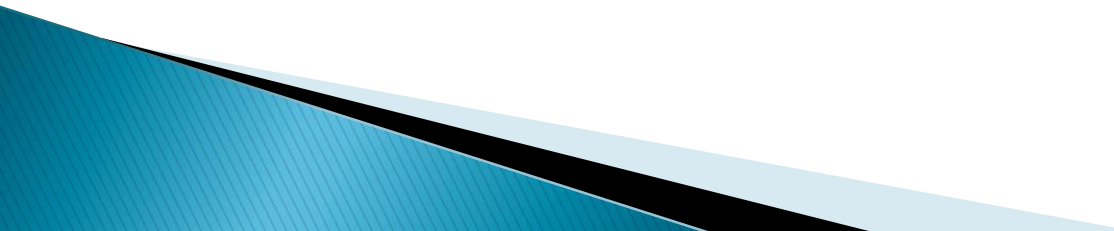
What is a chemical bond?

The attractive force that holds atoms or ions together.

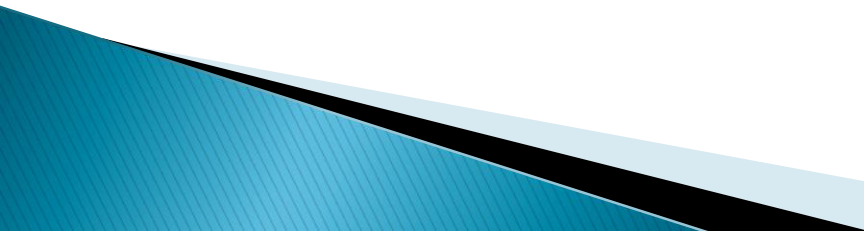
# Polarity

**Key Idea:** Hydrogen bonding plays an important role in many of the molecules that make up living things.

# Solubility

- ▶ Polar molecules can dissolve other polar molecules and ionic compounds.
  - ▶ Nonpolar substances, such as oil, grease, and wax, do not dissolve well in water.
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# Hydrogen Bonds

- ▶ A hydrogen bond is the attraction of the negative pole to other nearby molecules.
  - ▶ It is stronger than attractions between other molecules, but not as strong as covalent bonds.
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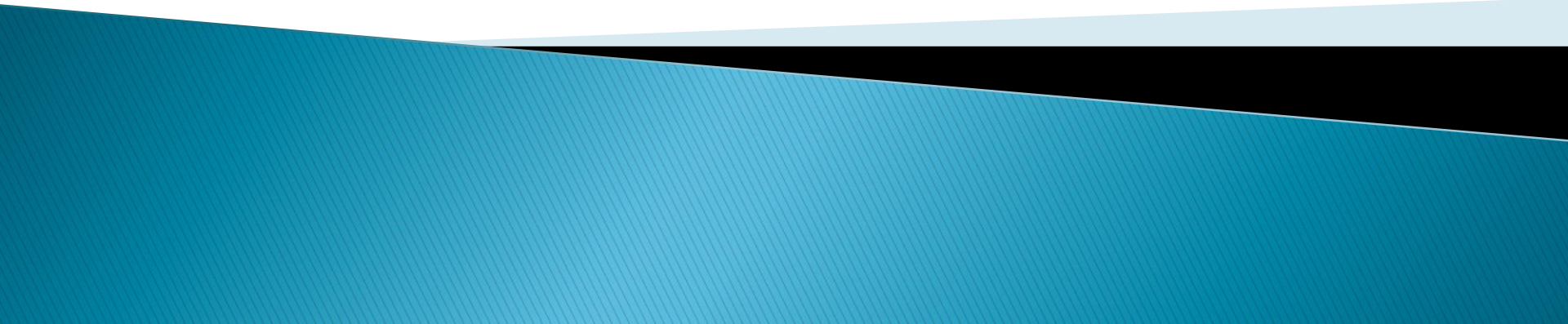
# Reading Check:

Why does salt dissolve in water?

The H atoms in water attract the chloride ions in salt. The O atoms attract the sodium ions in salt.

# **Water and Solutions**

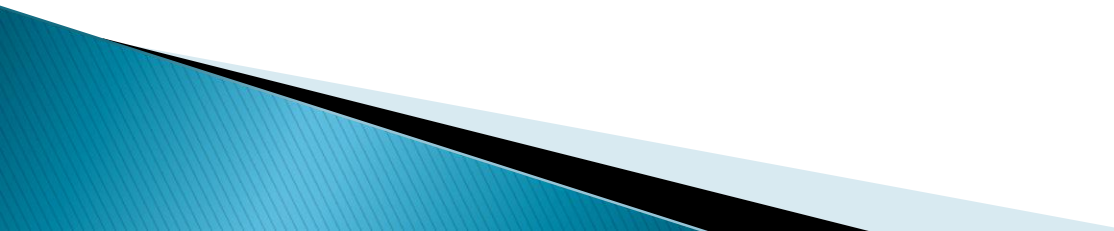
## **Section 3-2**



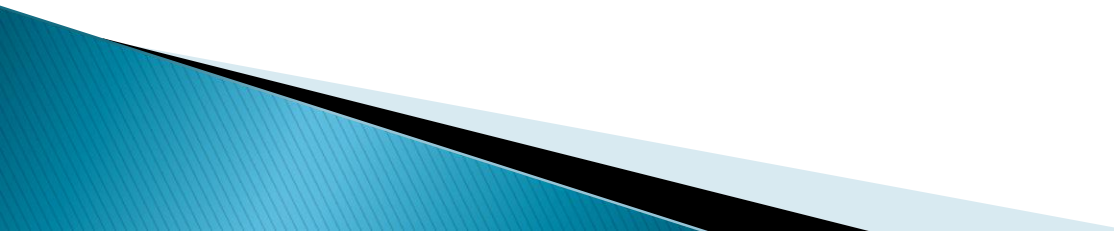
# Properties of Water

**Key Idea:** Most of the unique properties of **water** result because **water** molecules form hydrogen bonds with each other.



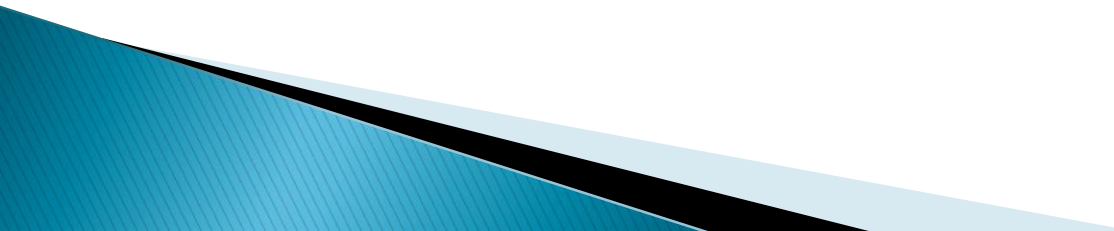
- ▶ **Cohesion** is the attraction of particles of the same substance, such as water.
  - ▶ **Adhesion** is the attraction between particles of different substances .
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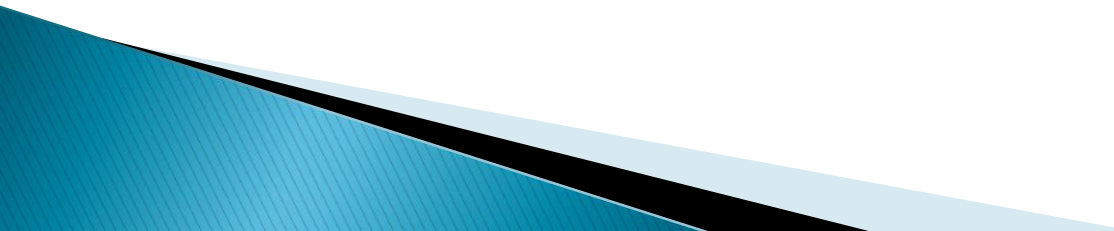
# Properties of Water

- ▶ Water can absorb a large amount of heat without changing temperature.
  - ▶ This property can help organisms maintain a constant internal temperature.
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# Solutions

**Key Idea:** In solutions, some substances change the balance of **these ions**.

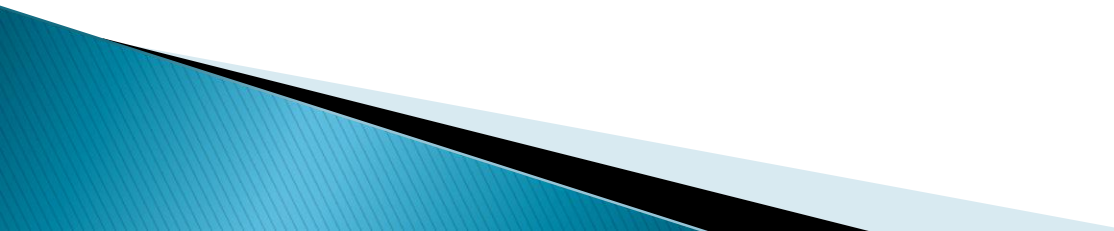


- ▶ A **solution is** a mixture in which ions or molecules of one or more substances are evenly distributed in another substance.
  - ▶ An **acid is** a compound that forms extra hydronium ions when dissolved in water.
  - ▶ A **base is** a compound that forms extra hydroxide ions when dissolved in water.
  - ▶ **pH is** a measure of how acidic or basic a solution is.
  - ▶ A **buffer is** a substance that reacts to prevent pH changes in a solution.
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# Acids and Bases

- ▶ When acids and bases are mixed, the extra hydronium and hydroxide ions react to form water.

# pH and Buffers

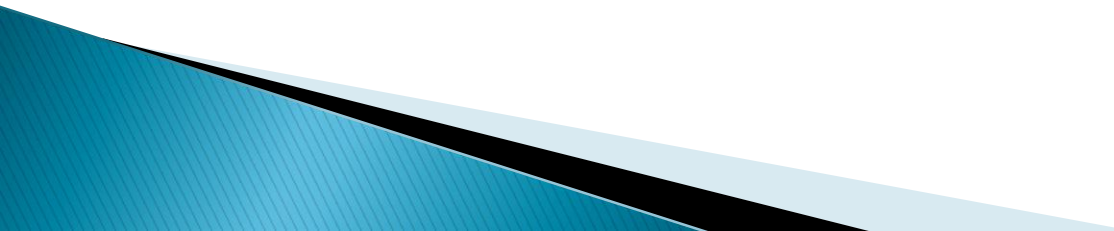
- ▶ Each one-point increase in pH represents a 10-fold decrease in hydronium ion concentration.
  - ▶ Pure water has a pH of 7. Acidic solutions have a pH below 7, and basic solutions have a pH above 7.
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# **Carbon Compounds**

## **Section 3-3**

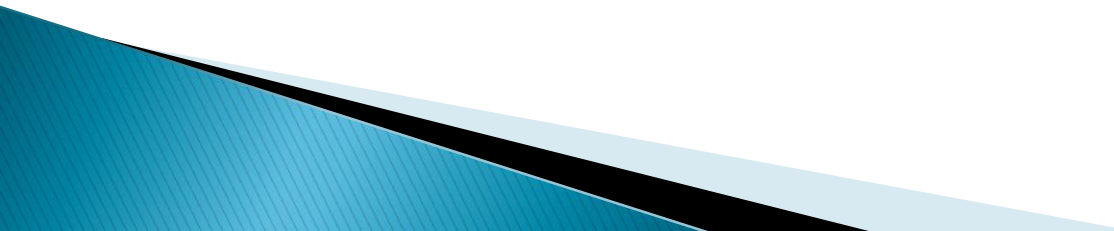
# Building Blocks of Cells

**Key Idea:** Large, complex **biomolecules** are built from a few smaller, simpler, repeating units arranged in an extremely precise way.





# Carbon Compounds

- ▶ The basic unit of most biomolecules contain atoms of carbon.
  - ▶ Carbon atoms can form covalent bonds with as many as four other atoms.
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# Reading Check:

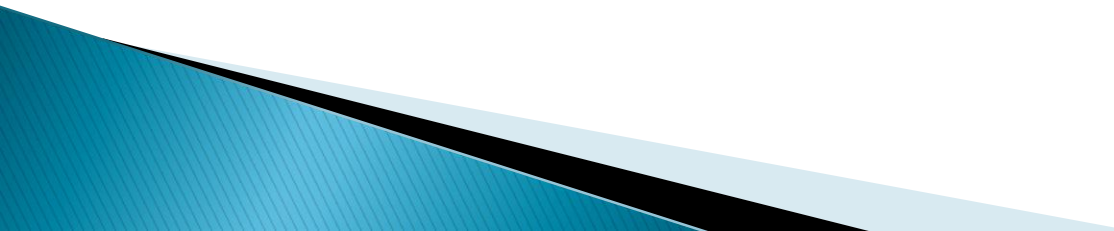
What element is the basis of biomolecules?

Carbon



# Carbohydrates

**Key Idea:** Cells use carbohydrates for sources of energy, structural materials, and cellular identification.

- ▶ A **carbohydrate** is a class of molecules that includes sugars, starches, and fiber; contains carbon, hydrogen, and oxygen.
  - ▶ A **lipid** is a fat molecule or a molecule that has similar properties, including waxes and steroids.
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# Energy Supply

- ▶ Carbohydrates are a major source of energy for many organisms, including humans.

# Structural Support

- ▶ *Chitin* and *cellulose* are complex carbohydrates that provide support.
- ▶ Chitin is found in the shells of insects and the cell walls of mushrooms. Cellulose is found in the cell walls of plants.

# Cell Recognition

- ▶ In a complex organism, cells recognize neighboring cells by the short, branched chains of varying sugar units on their outer surface.

# Reading Check:

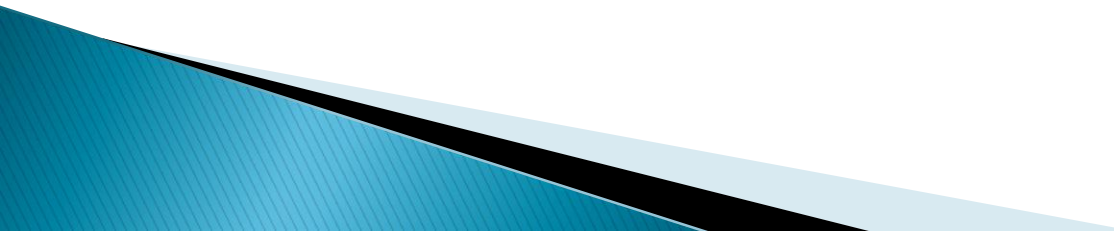
What is the basic unit of a carbohydrate?

a sugar





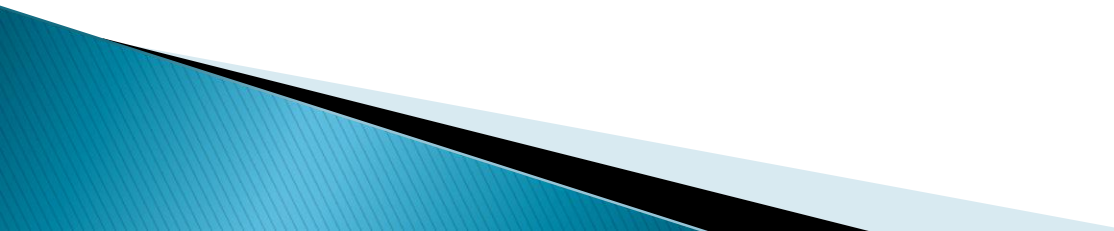
The word **vary** means  
to make a minor or  
partial change in.



# Lipids

**Key Idea:** The main functions of lipids include storing energy and controlling water molecules.

# Energy Stores

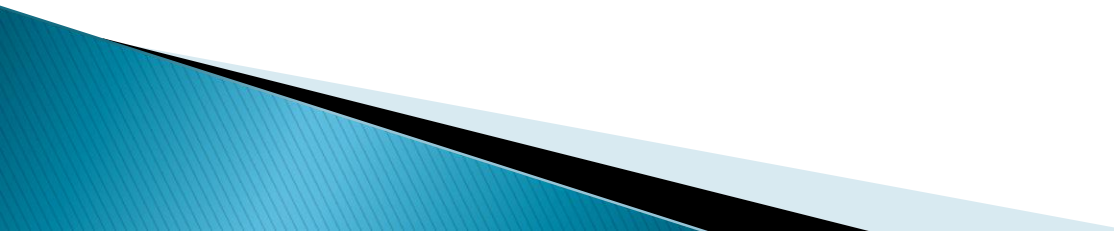
- ▶ The main purpose of fats is to store energy.
  - ▶ Fats can store energy even more efficiently than carbohydrates.
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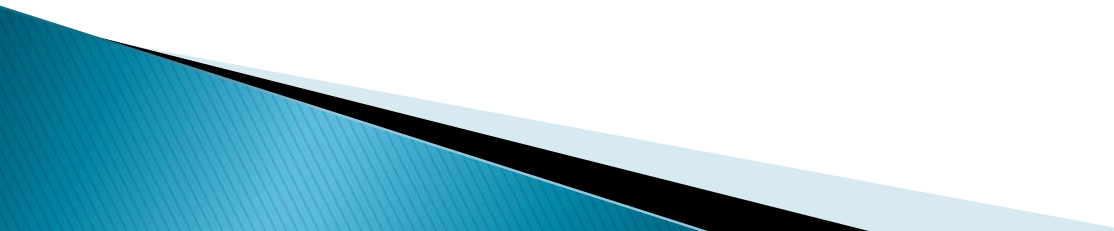
# Water Barriers

- ▶ The cell's boundary is made of phospholipids. The structure of cell membranes depends on how this molecule interacts with water.

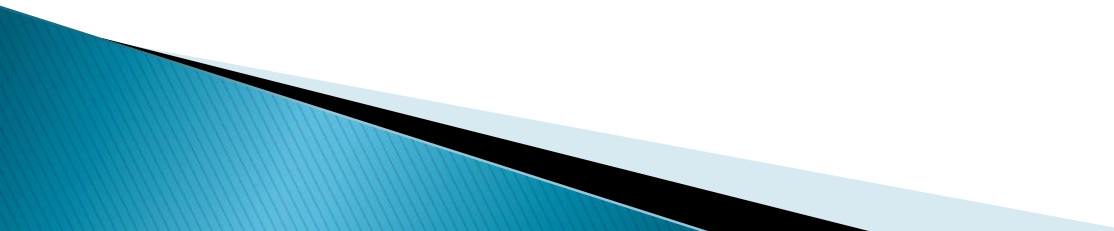
# Proteins

**Key Idea:** Proteins are chains of **amino acids** that twist and fold into certain shapes that determine **what the proteins do.**



- ▶ A **protein** is an organic compound that is made of one or more chains of amino acids and that is a principle component of all cells.
  - ▶ An **amino acid** is a compound of a class of simple organic compounds that contain a carboxyl and an amino group and that combine to form proteins
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# Amino Acids

- ▶ Units of amino acids can form links called *peptide bonds*.
  - ▶ Twenty different amino acids are found in proteins.
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# Levels of Structure

- ▶ **Primary Structure** = amino acid arrangement
- ▶ **Secondary Structure** = interactions of the various side groups may form coils and folds
- ▶ **Tertiary Structure** = overall shape of a single chain of amino acids
- ▶ **Quaternary Structure** = overall shape that results from combining the chains to form proteins.



# Reading Check:

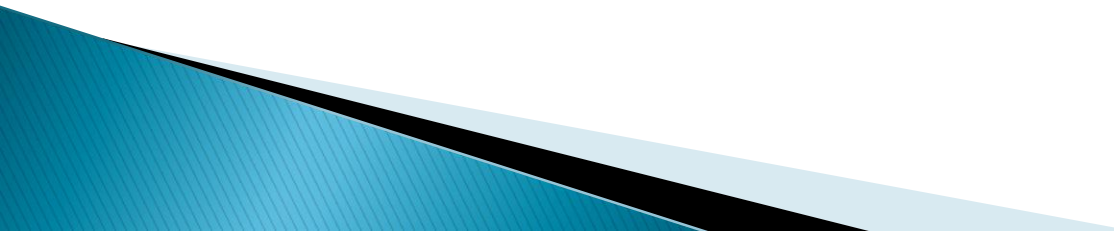
What is a protein's primary structure?

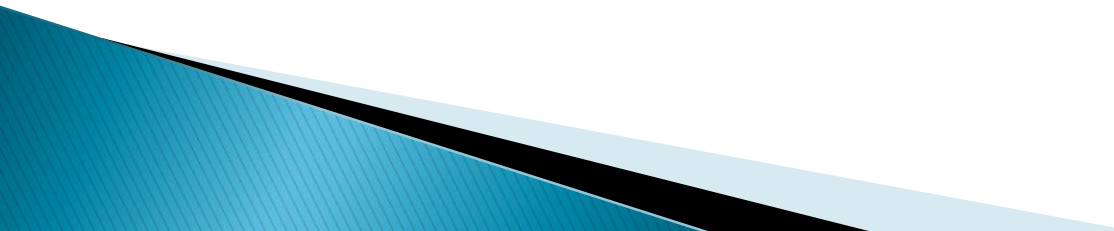
The order of amino acids

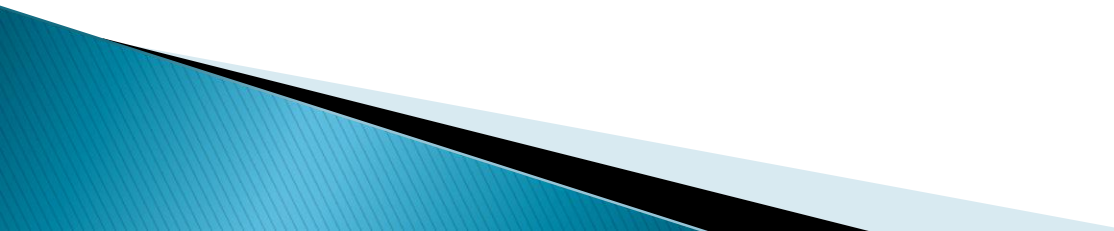


# Nucleic Acids

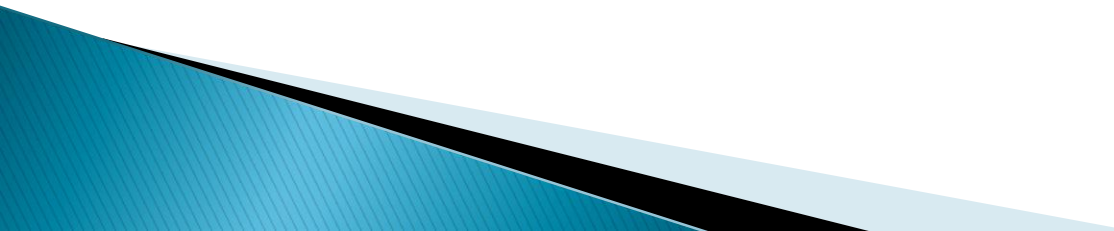
**Key Idea:** Nucleic acids **store** and **transmit hereditary information.**



- ▶ **A nucleic acid** is an organic compound, either DNA or RNA, whose molecules are made up of one or two chains of nucleotides and carry genetic information.
  - ▶ **A nucleotide** is an organic compound that consists of a sugar, a phosphate, and a nitrogenous base.
  - ▶ **DNA** is deoxyribose acid, the material that contains the information that determines inherited characteristics.
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- ▶ **RNA** is ribonucleic acid, a natural polymer that is present in all living cells and that plays a role in protein synthesis.
  - ▶ **ATP** is adenosine triphosphate, an organic molecule that acts as the main energy source for cell processes.
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# Hereditary Information

- ▶ DNA molecules act as “instructions” for the processes of an organism’s life.
  - ▶ Nucleic acids store and transmit hereditary information.
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# Energy Carriers

- ▶ Cells need a steady supply of ATP to function.

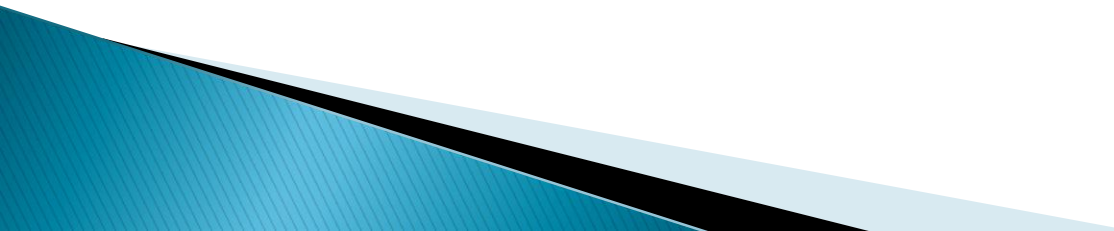
# **Energy and Metabolism**

## **Section 3-4**



# Changing Matter

**Key Idea:** Living things use different **chemical reactions** to get the energy needed for **life processes**.

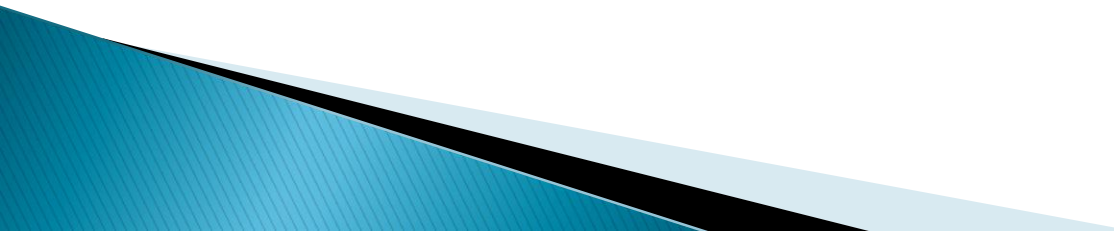




# Conservation of Mass

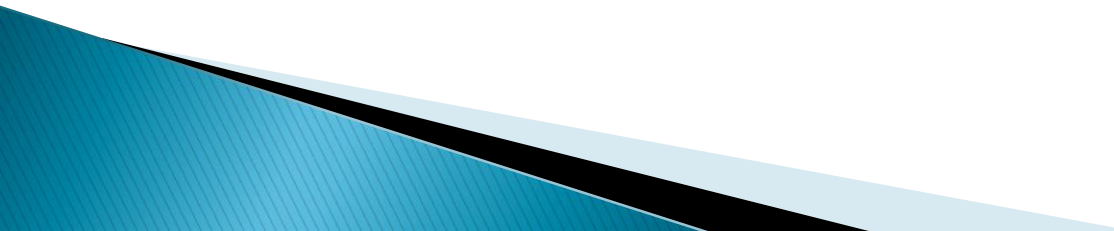
- ▶ Matter is neither created nor destroyed in any change. This observation is called the *law of conservation of mass*.

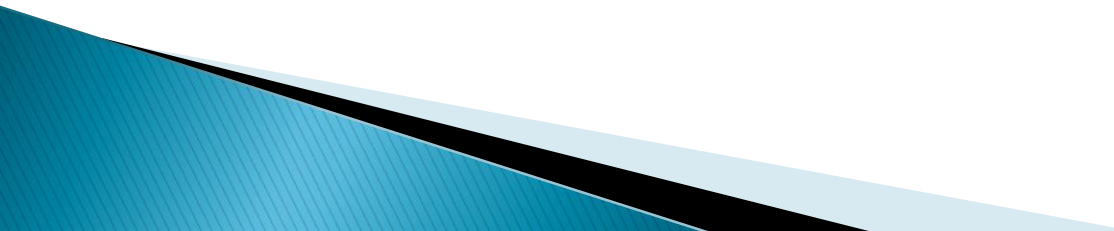
# Conservation of Energy

- ▶ The ability to move or change matter is called energy.
  - ▶ Energy exists in many forms and can be converted from one form to another.
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# Chemical Reactions

**Key Idea:** Chemical reactions can only occur when **the activation energy is available and the correct atoms are aligned.**



- ▶ **Energy** is the ability to move or change matter.
  - ▶ A **reactant** is a substance that is changed in a chemical reaction
  - ▶ A **product** is a new substance that is formed.
  - ▶ **Activation energy** is the minimum amount of energy required to start a chemical reaction.
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# Activation Energy

- ▶ To form new bonds, the particles must collide fast enough to overcome the repulsion between their negatively charged electron clouds.

# Alignment

- ▶ When the reactant particles collide, the correct atoms must be brought close together in the proper orientation.

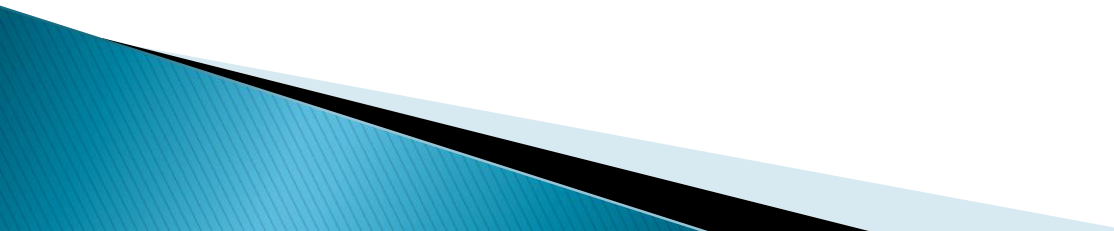
# Reading Check:

What causes particles to repel other particles?

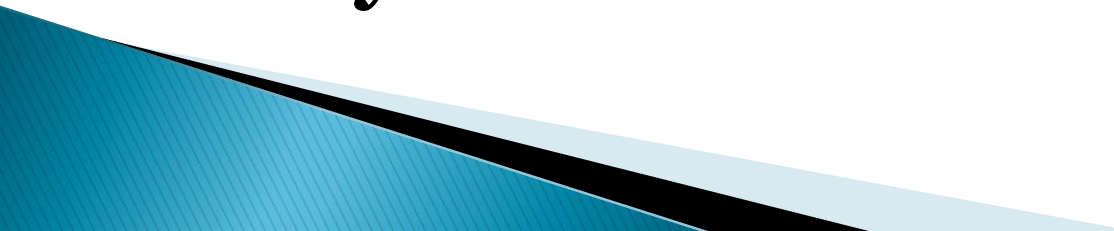
Their negatively charged electron clouds

# Biological Reactions


**Key Idea:** By assisting in necessary biochemical reactions, **enzymes** help organisms maintain **homeostasis**.





- ▶ An **enzyme** is a molecule that increases the speed of biochemical reactions.
  - ▶ An **active state** is the region where the reaction takes place.
  - ▶ **Substrate** is the reactant in reactions catalyzed by enzymes.
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# Enzymes

- ▶ Enzymes hold molecules close together and in the correct orientation. An enzyme lowers the activation energy of a reaction.
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# Metabolism

- ▶ Cells get most of the energy needed for metabolism by breaking down food molecules.

# Reading Check:

Why is the shape of an enzyme important?

The shape of the active site determines which reactant will bind to the active site.