

2.3 Carbon-Based Molecules

KEY CONCEPT

Carbon-based molecules are the foundation of life.

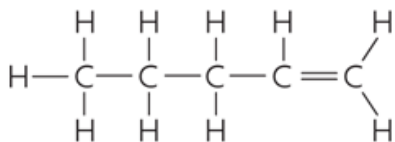


2.3 Carbon-Based Molecules

► Carbon atoms have unique bonding properties.

- Carbon forms **covalent** bonds with up to **four** other atoms, including other carbon atoms.
- Carbon-based molecules have three general types of structures.
 - straight chain
 - branched chain
 - ring

Straight chain

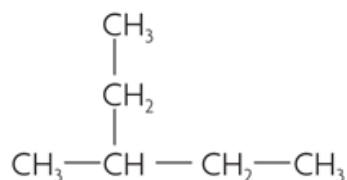


A simplified structure can also be shown as:



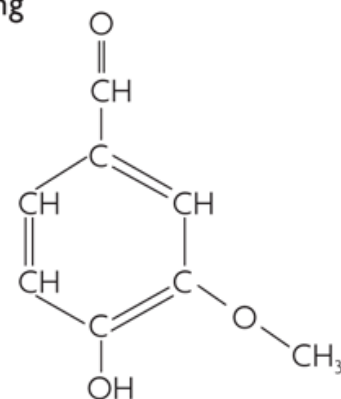
Pentene

Branched chain



Hexane

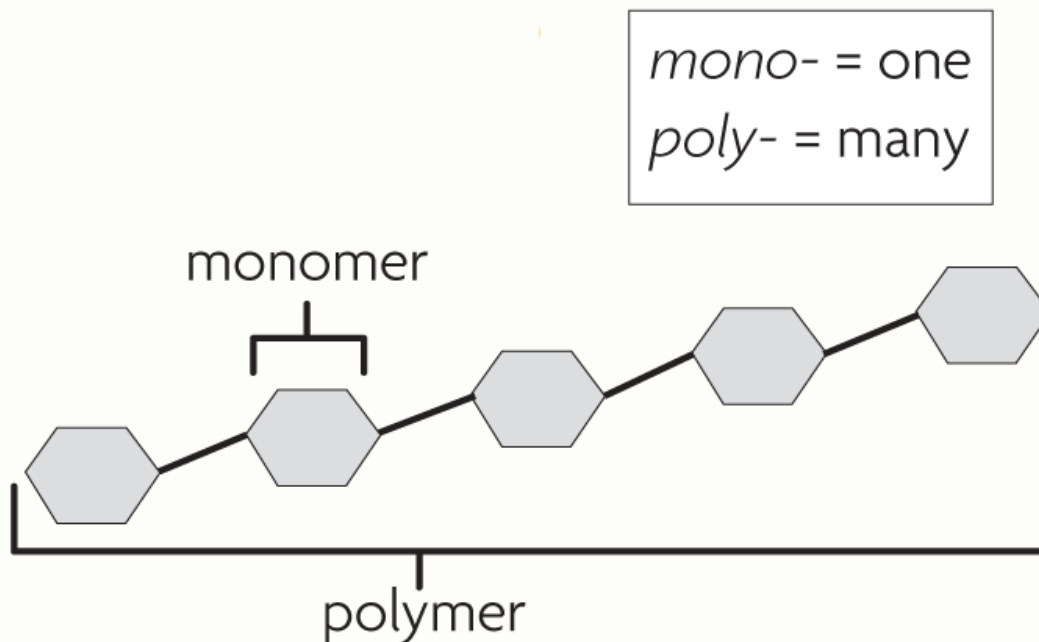
Ring



Vanillin

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- Many carbon-based molecules are made of many small subunits bonded together.
 - **Monomers** are the individual subunits.
 - **Polymers** are made of many monomers.



2.3 Carbon-Based Molecules

- Many carbon-based molecules are made of many small subunits bonded together.

| Monomer | Polymer |
|------------------------------------|-------------------------|
| monosaccharides (simple sugars) | polysaccharides |
| amino acid | proteins |
| nucleotides | nucleic acids |
| fatty acids | lipids (triglycerides)* |

* Lipids are smaller than true polymers and are not all made up of repeating units.

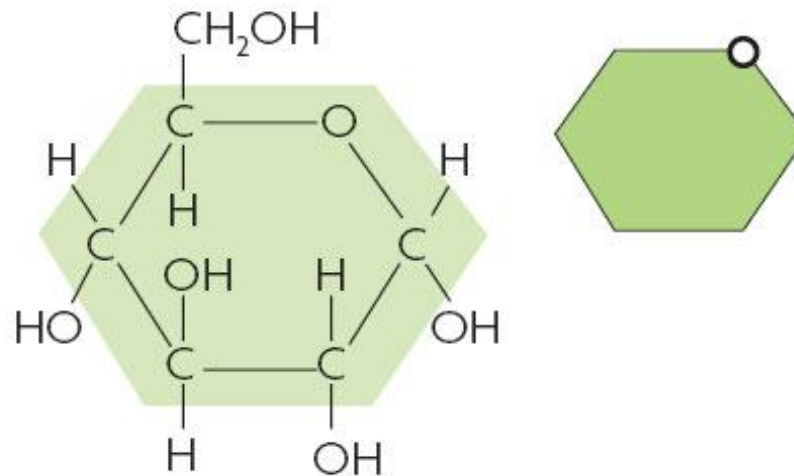
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▶ Analogy : Formation of Polymer from Monomer



2.3 Carbon-Based Molecules

- ▶ Four main types of carbon-based molecules are found in living things.
 - **Carbohydrates** are made of carbon, hydrogen, and oxygen.



Glucose (C₆H₁₂O₆) can be ring shaped and is often shown as a simplified hexagon.

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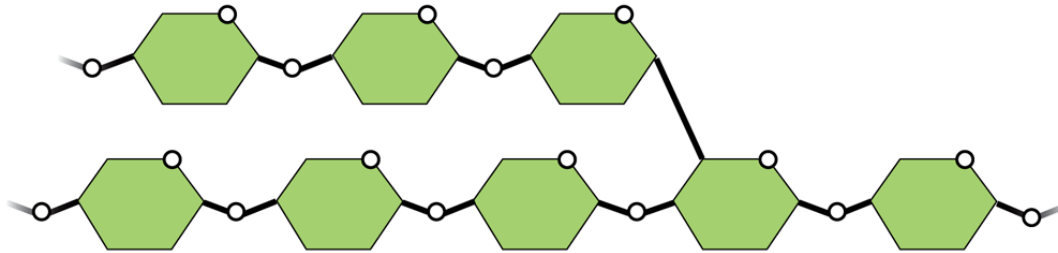
- ▶ **Four main types of carbon-based molecules are found in living things.**
 - **Carbohydrates** are made of **c**arbon, **h**ydrogen, and **o**xygen.
 - Carbohydrates include sugars and starches.
 - **Monosaccharides** are simple sugars.
 - **Polysaccharides** include starches, cellulose, and glycogen.



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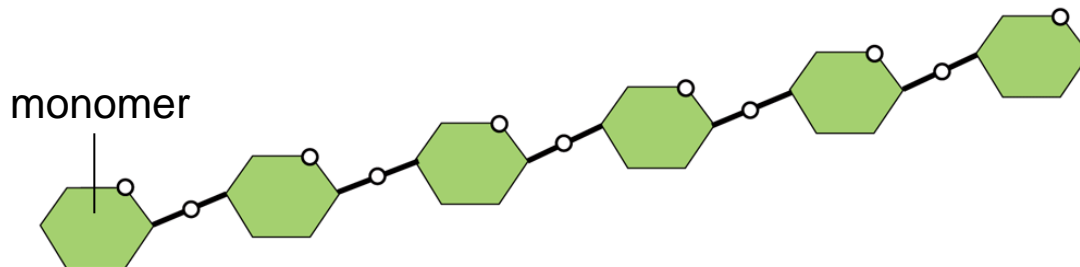
- **Carbohydrates** can be broken down to provide energy for cells.
- Some carbohydrates are part of cell structure.

Polymer (starch)



Starch is a polymer of glucose monomers that often has a branched structure.

Polymer (cellulose)



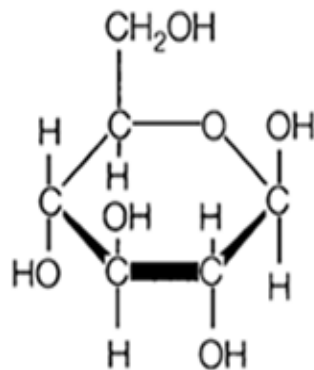
Cellulose is a polymer of glucose monomers that has a straight, rigid structure

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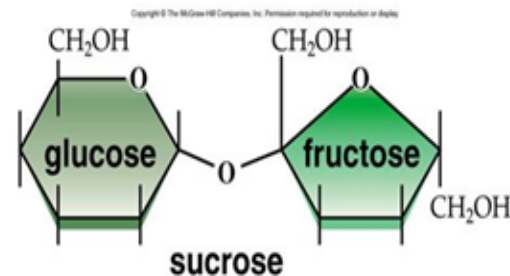
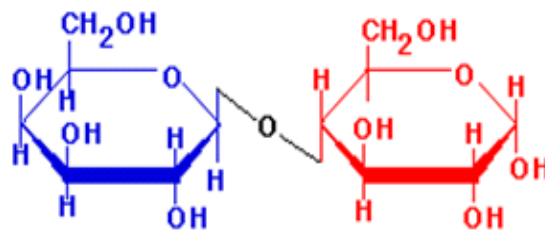
▶ Polysaccharides as Structural Molecules

- **Cellulose** - glucose bonded to form "fibers", composes cell walls (cotton is almost pure cellulose); not easily digested
- **Chitin** - polymer of glucose, makes up exoskeletons of arthropods

Glucose



LACTOSE



Glucose is a molecule that can be combined to make lactose and sucrose.

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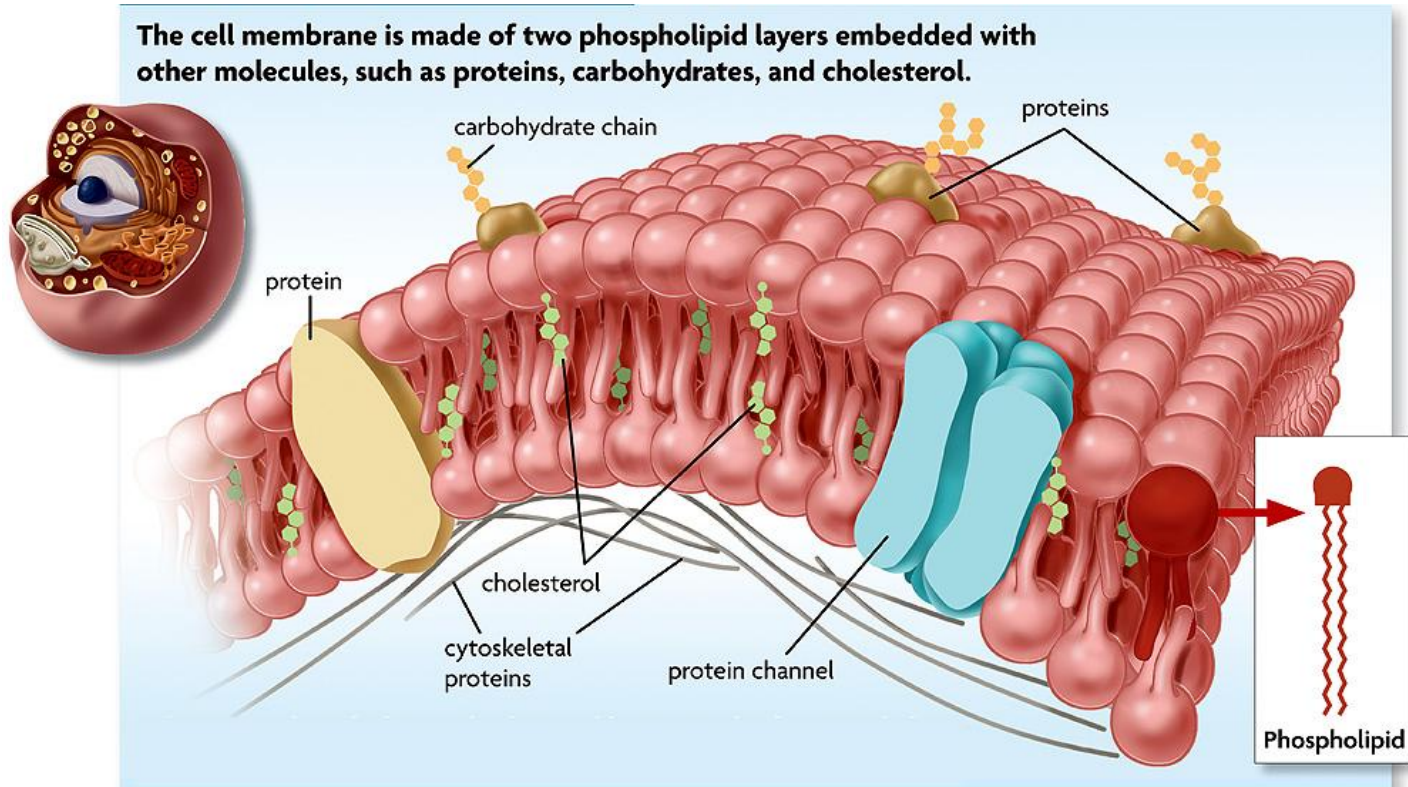
- **Lipids** are nonpolar molecules that include fats, oils, and cholesterol.
 - Used for insulation and long term energy storage (fat)*
 - Many contain carbon chains called **fatty acids**.
 - **Fats** and **oils** contain fatty acids bonded to **glycerol**.

Triglyceride



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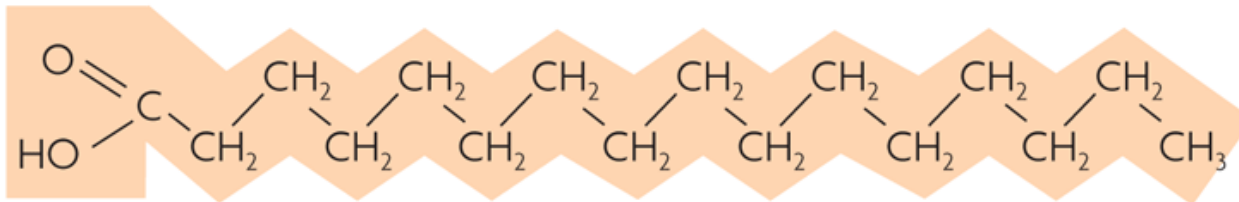
- **Lipids** have several different functions.
 - broken down as a source of energy
 - make up cell membranes
 - used to make hormones



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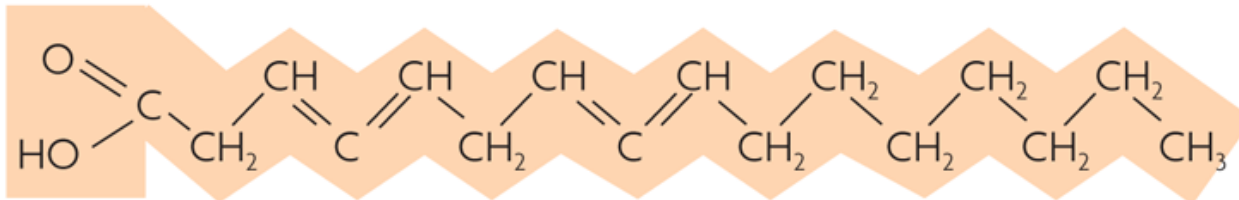
- **Fats** and **oils** have different types of fatty acids.
 - saturated fatty acids
 - unsaturated fatty acids

Saturated fatty acid



Saturated fats contain fatty acids in which all carbon-carbon bonds are single bonds.

Unsaturated fatty acid



Unsaturated fats have fatty acids with at least one carbon-carbon double bond.

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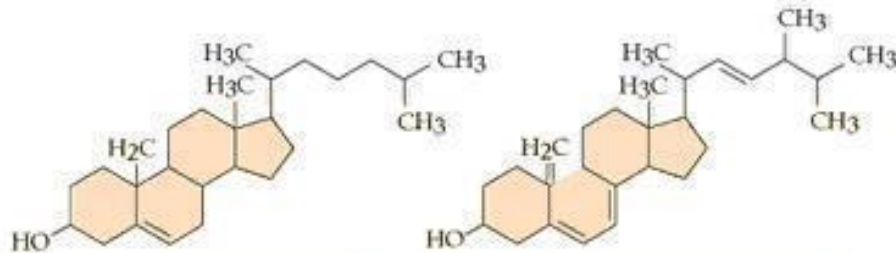
- **Phospholipids** make up all cell membranes.
 - Polar phosphate “head”
 - Nonpolar fatty acid “tails”

Phospholipid



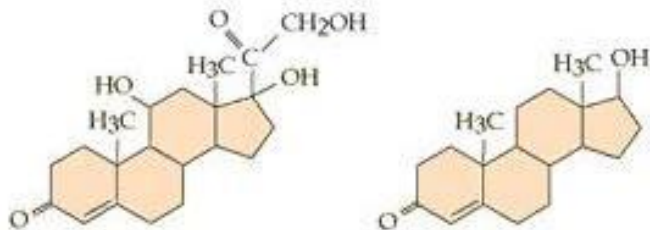
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- **Steroids** - cholesterol & sex hormones (estrogen & testosterone) – made of 4 fused rings



Cholesterol is a constituent of membranes and the source of steroid hormones.

Vitamin D₂ can be produced in the skin by the action of light on a cholesterol derivative.



Cortisol is a hormone secreted by the adrenal gland

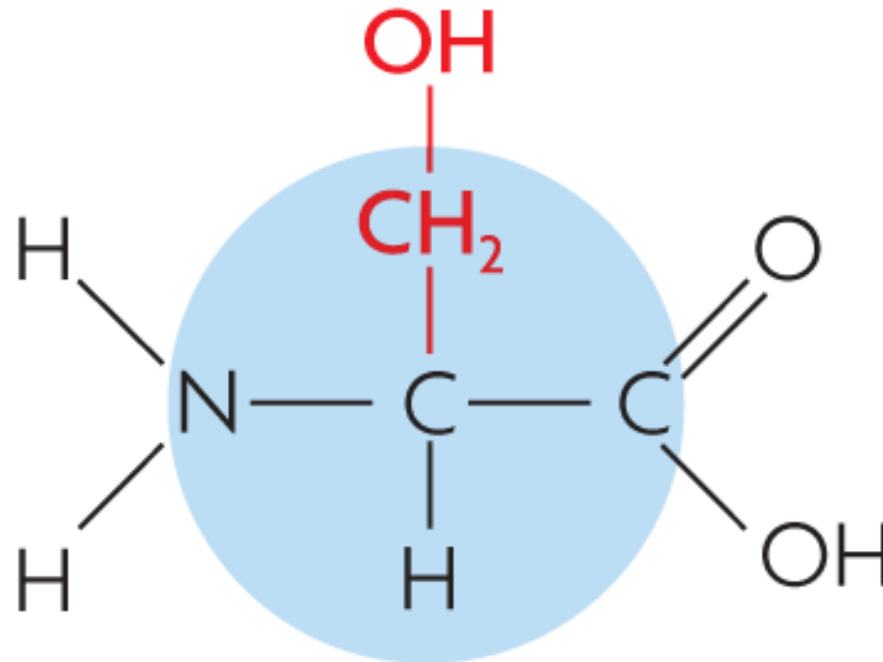
Testosterone is a male sex hormone.

steroids



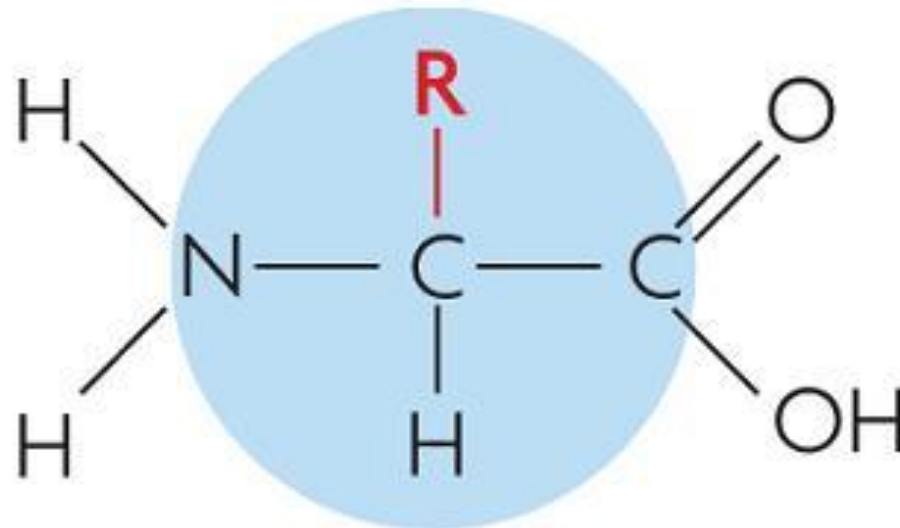
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- **Proteins** are polymers of amino acid monomers.
 - Twenty different amino acids are used to build proteins in organisms.



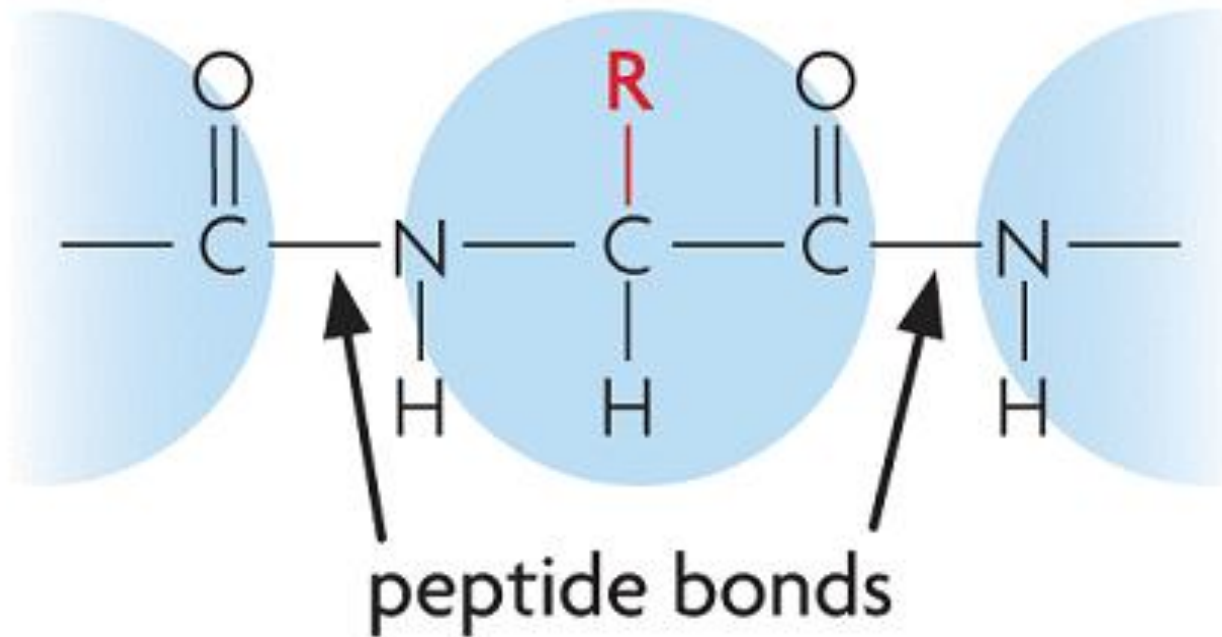
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- **Proteins** are polymers of **amino acid** monomers.
 - Twenty different amino acids are used to build proteins in organisms.
 - Amino acids differ in side groups, or **R** groups.



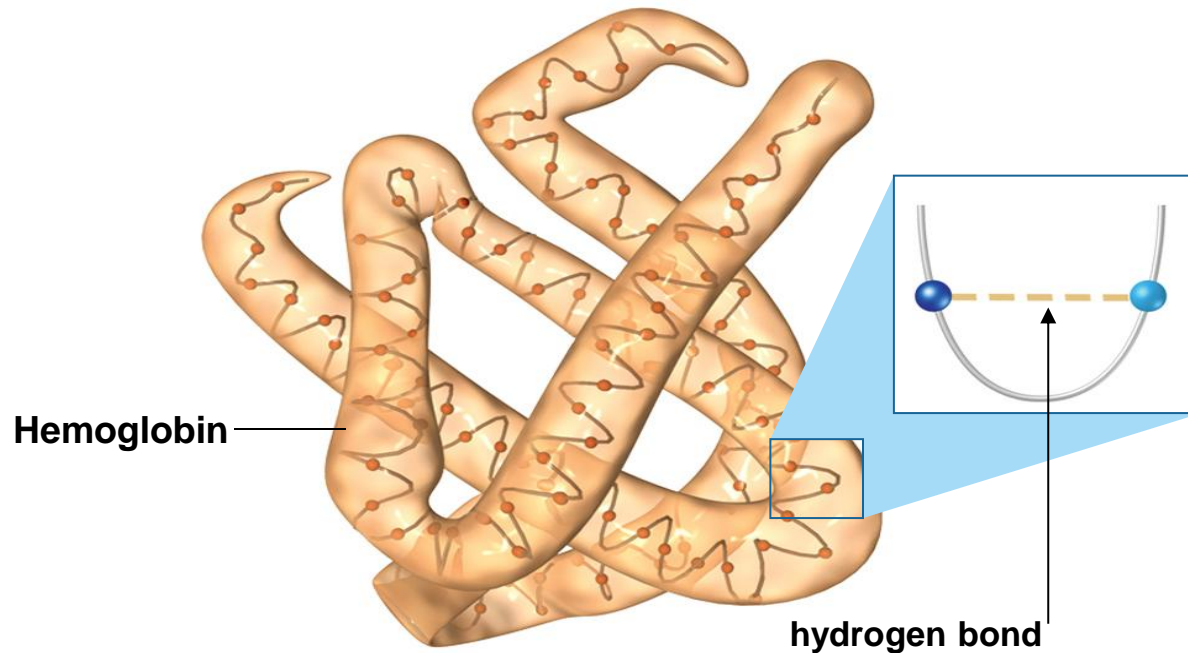
2.3 Carbon-Based Molecules

- Proteins are polymers of amino acid monomers.
 - Twenty different amino acids are used to build proteins in organisms.
 - Amino acids differ in side groups, or R groups.
 - Amino acids are linked by **peptide** bonds.



2.3 Carbon-Based Molecules

- Proteins differ in the **number** and **order** of amino acids.
 - Amino acids interact to give a protein its shape.

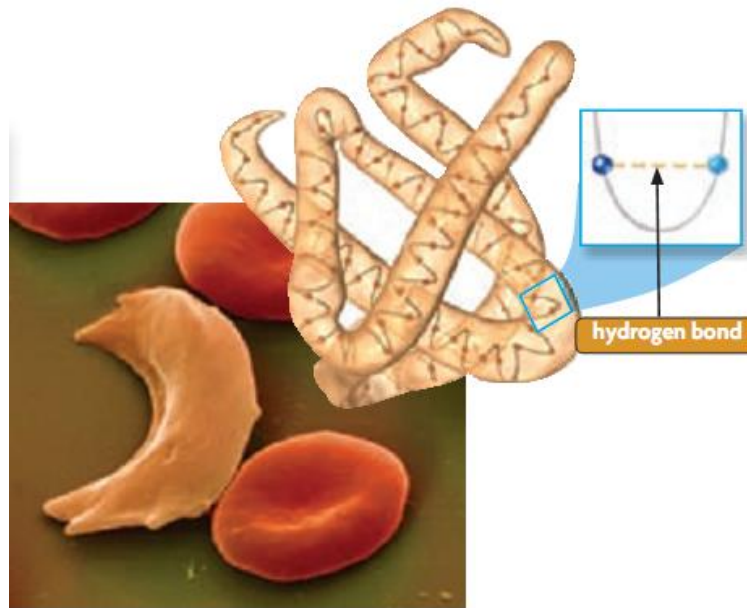


- Incorrect amino acids change a protein's structure and function.

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▶ Hemoglobin S in Sickle Cell Disease

For example, **FIGURE 3.8** shows the structure of one of the four polypeptides that makes up hemoglobin, the protein in your red blood cells that transports oxygen. Each of the four polypeptides contains an iron atom that bonds to an oxygen molecule. The four polypeptides are folded in a way that puts the four oxygen-carrying sites together in a pocketlike structure inside the molecule. If a protein has incorrect amino acids, the structure may change in a way that prevents the protein from working properly. Just one wrong amino acid of the 574 amino acids in hemoglobin causes the disorder sickle cell anemia.

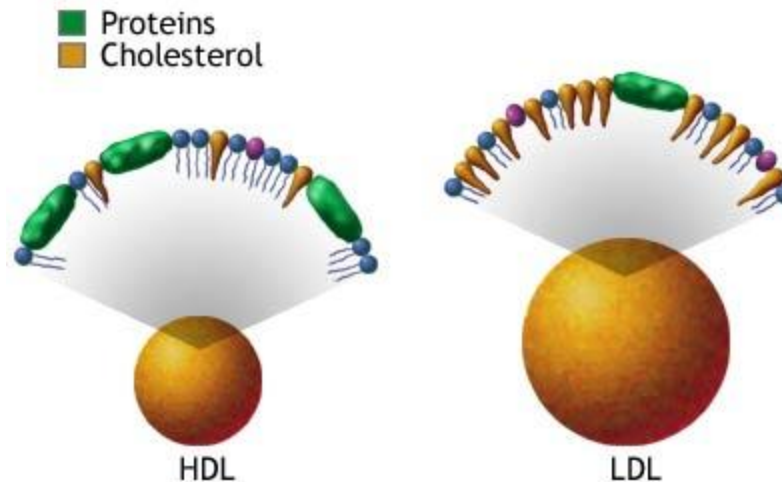


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▶ Lipoproteins

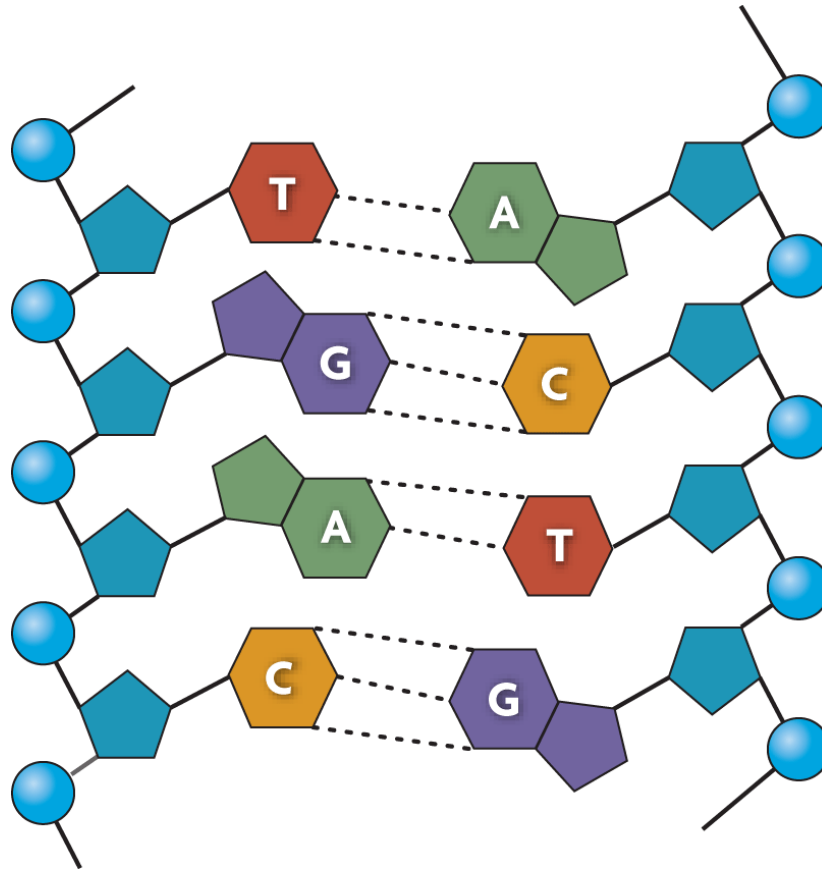
- **Lipoproteins** are clusters of lipids (including cholesterol) and proteins that travel in blood plasma.
- 2 Kinds:
 - **LDL** (low-density lipoprotein) – “bad cholesterol”; implicated in high BP, and heart disease; deposited in arteries thus causing blockade
 - **HDL** (high-density lipoprotein) – “good cholesterol”; they remove cholesterol from arteries & return it to the liver

Lipoproteins vary in size and composition



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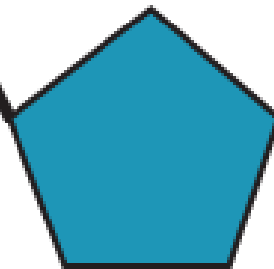
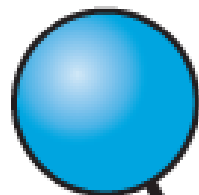
- **Nucleic acids** are polymers of monomers called **nucleotides**.



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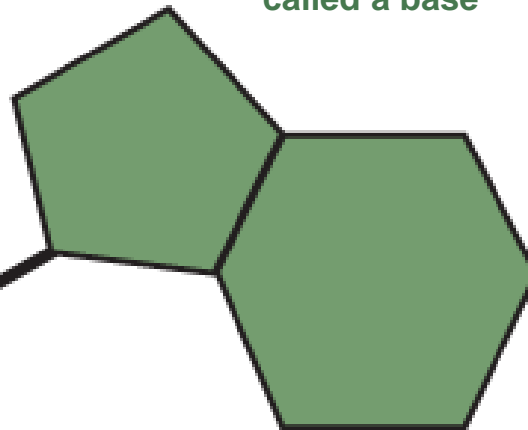
- **Nucleic acids** are polymers of monomers called **nucleotides**.
 - Nucleotides are made of a sugar, phosphate group, and a nitrogen base.

A phosphate group



deoxyribose (sugar)

nitrogen-containing molecule,
called a base



2.3 Carbon-Based Molecules

- Nucleic acids are polymers of monomers called nucleotides.
 - Nucleotides are made of a sugar, phosphate group, and a nitrogen base.
 - **DNA** stores genetic information.
 - **RNA** builds proteins.

