شرح الجزيئات الكبيرة (Macromolecules) – اللبنات الأساسية للحياة الدرس الثالث من الوحدة الأولى



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The Building Blocks of Life

Macromolecules

my handwritten summary * figures * tables * quizzes

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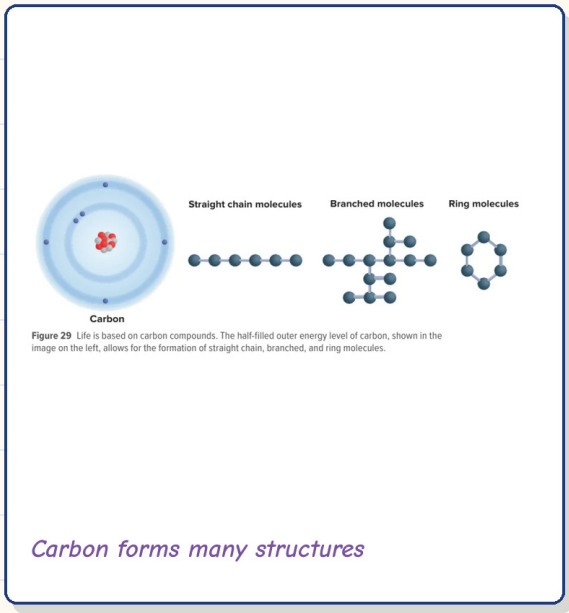


Figure 29 Life is based on carbon compounds. The half-filled outer energy level of carbon, shown in the image on the left, allows for the formation of straight chain, branched, and ring molecules.

Carbon forms many structures

Key questions

1. Why is carbon essential to life?
2. What are the four macromolecules?
3. How are their subunits linked?

Inside this notebook

Short notes and diagrams; helpful tables; Section and Unit MCQs; explained answer key.

Words to master

organic chemistry | carbon | macromolecule | monomer | polymer | carbohydrate | lipid | protein | amino acid | nucleotide | DNA | ATP

THE BIG IDEA

Carbon forms the building blocks of life. Four major groups of large molecules support cells and organisms.

Small building blocks, amazing life!

1. Organic chemistry

Why carbon is so useful

Organic chemistry is the study of carbon-containing compounds. Carbon is an essential element in almost all biological molecules.

Carbon has four outer electrons

A carbon atom can make four covalent bonds with other atoms, including other carbon atoms.

One element, many shapes

Carbon atoms can link into straight chains, branched chains and rings.

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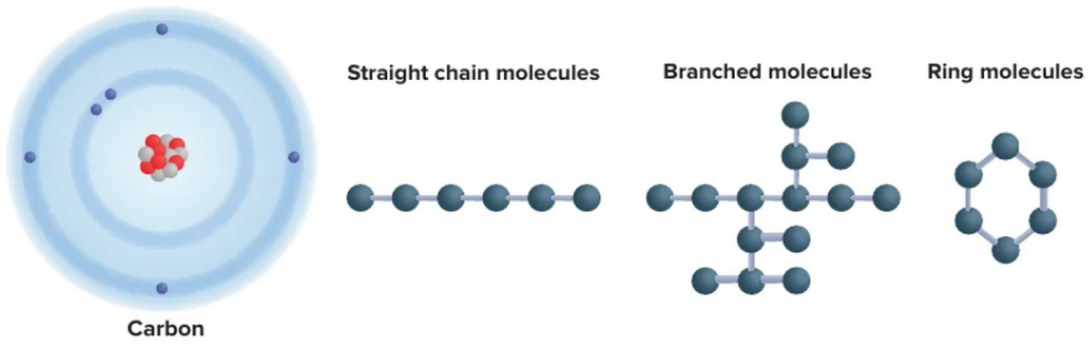


Figure 29 Life is based on carbon compounds. The half-filled outer energy level of carbon, shown in the image on the left, allows for the formation of straight chain, branched, and ring molecules.

Figure 29 - carbon atom and chain shapes

Connect the dots

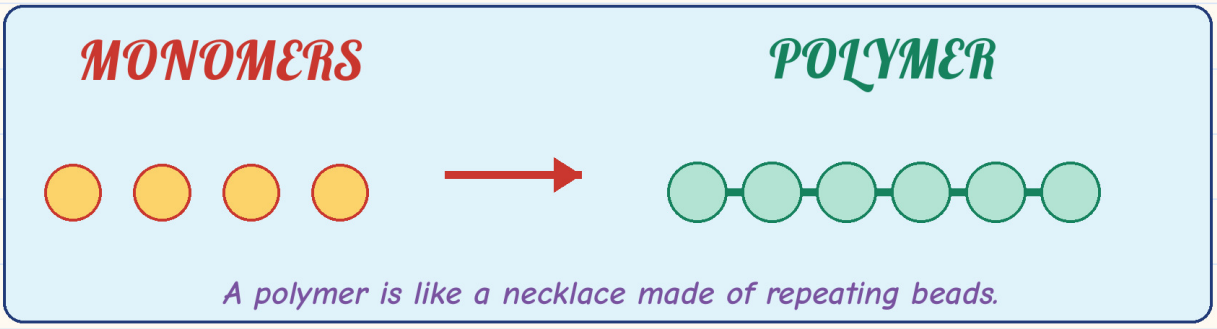
- Covalent bonds connect carbon atoms.
- Different arrangements create many kinds of organic compounds.
- This versatility allows a huge variety of biological molecules.

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2. Macromolecules and polymers

Build big from small

Macromolecules are large molecules formed by joining smaller organic molecules. Many are polymers: chains of repeating units called monomers.



A polymer is like a necklace made of repeating beads.

Four groups of life molecules

Group	Examples	Jobs
Carbohydrates	Glucose, glycogen	Energy storage; support
Lipids	Fats, waxes	Energy storage; barriers
Proteins	Enzymes, muscle proteins	Support; transport; reactions
Nucleic acids	DNA, RNA	Store and transmit genes

Remember

The four groups are carbohydrates, lipids, proteins and nucleic acids.

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3. Carbohydrates

Sugars: quick energy and more

Carbohydrates contain carbon, hydrogen and oxygen in a 1:2:1 ratio. Their general formula is written as $(CH_2O)_n$. ← subscript.

Formaldhide group

Type	Meaning	Examples
Monosaccharide	One simple sugar	Glucose
Disaccharide	Two simple sugars joined	Maltose, sucrose, lactose
Polysaccharide	A longer chain of sugars	Glycogen, cellulose

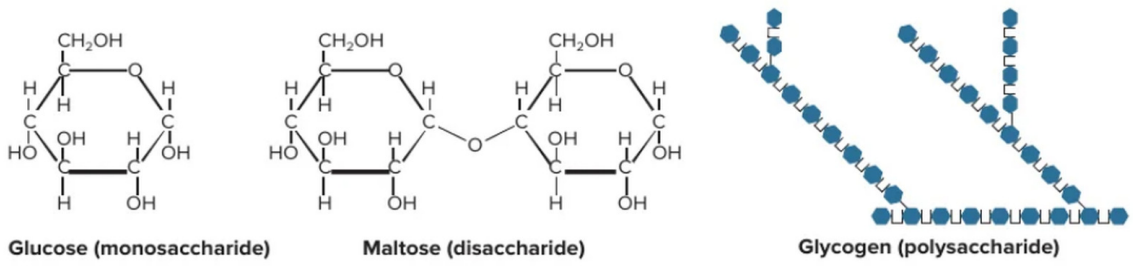


Figure 30 Glucose is a monosaccharide. Maltose is a disaccharide composed of two glucose molecules. Glycogen is a branched polysaccharide made from glucose monomers.

Figure 30 - glucose, maltose and glycogen

From small sugars to big chains

Glucose is a monosaccharide. Two monosaccharides can join to make a disaccharide. Many units can build a polysaccharide.

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4. Carbohydrates at work

Energy storage versus structure

Glycogen

Animals store glucose as glycogen, especially in the liver and skeletal muscles. Glycogen is broken down when extra energy is needed.

Cellulose

Cellulose forms fibers that support plant cell walls. It helps plants, including trees, keep their shape.

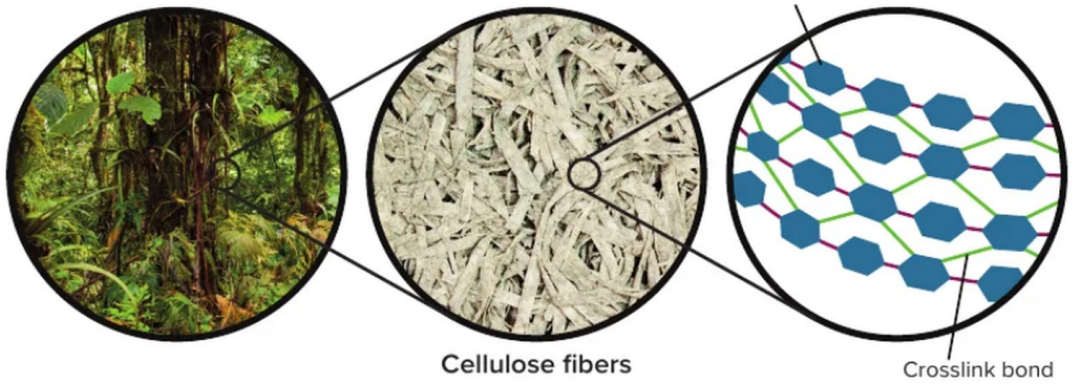


Figure 31 The cellulose in plant cells provides the structural support for trees to stand in a forest.

Figure 31 - cellulose fibers support plant cells

One more structural carbohydrate

Chitin

Chitin helps form the hard outer shells of insects, shrimp and lobsters. It also occurs in the cell walls of some fungi.

Memory trick: glycogen = storage; cellulose = support.

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5. Lipids: fats, oils and waxes

Energy storage and protection

Lipids are molecules made mostly of carbon and hydrogen. They include fats, oils and waxes; some are composed of fatty acids and glycerol.

Fats vs. oils

A triglyceride is called a fat if it is solid at room temperature, and an oil if it is liquid.

Stored energy

Triglycerides are stored in fat cells. Waxes can coat plant leaves, helping to prevent water loss.

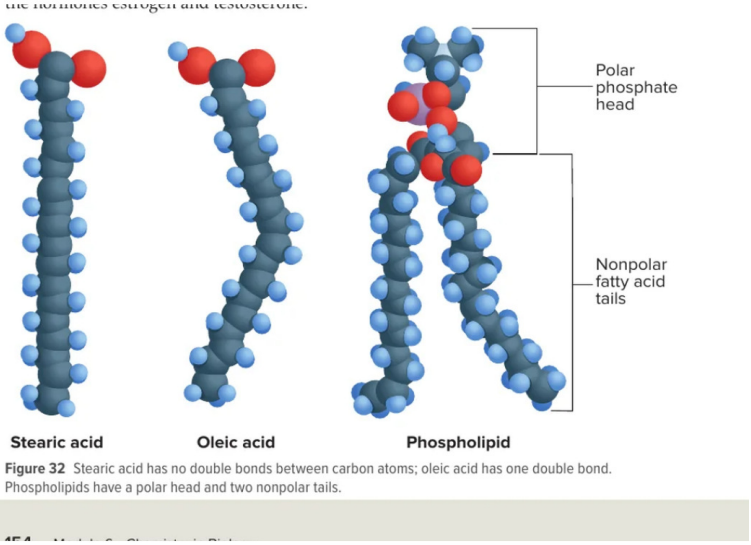


Figure 32 Stearic acid has no double bonds between carbon atoms; oleic acid has one double bond. Phospholipids have a polar head and two nonpolar tails.

Figure 32 - two fatty acids and a phospholipid

Fatty acid	Carbon bonds	Key idea
Saturated	Single C-C bonds	No double bonds in the tail
Unsaturated	At least one C=C bond	Double bond(s) in the tail

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6. Special lipids

Phospholipids help form membranes

A phospholipid has a polar phosphate head and nonpolar fatty acid tails. Lipid barriers are important in the structure and function of the cell membrane.

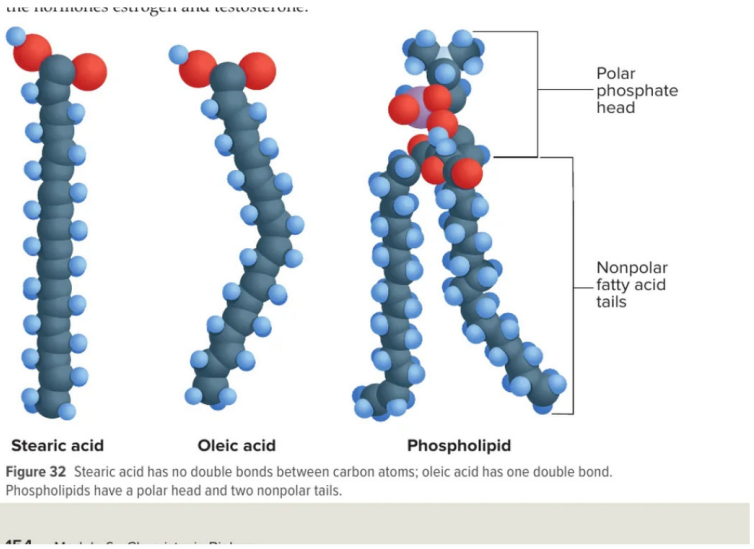


Figure 32 Stearic acid has no double bonds between carbon atoms; oleic acid has one double bond. Phospholipids have a polar head and two nonpolar tails.

Figure 32 - phospholipid: polar head and nonpolar tails

Hydrophobic

Many lipids do not dissolve in water. This feature allows lipids to form a barrier within biological membranes.

Steroids

Steroids are another lipid group. Examples include cholesterol and hormones such as estrogen and testosterone.

What is cholesterol for?

Despite its reputation as a "bad" lipid, cholesterol is a starting material for other necessary lipids, including vitamin D and certain hormones.

sexual hormones
Reproductive hormone.

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7. Proteins are chains of amino acids

20 amino acids
8 from food
12 in body

The amino acid building block

Proteins are made of small carbon compounds called amino acids. Every amino acid has a central carbon with a hydrogen atom, amino group, carboxyl group and variable R group.

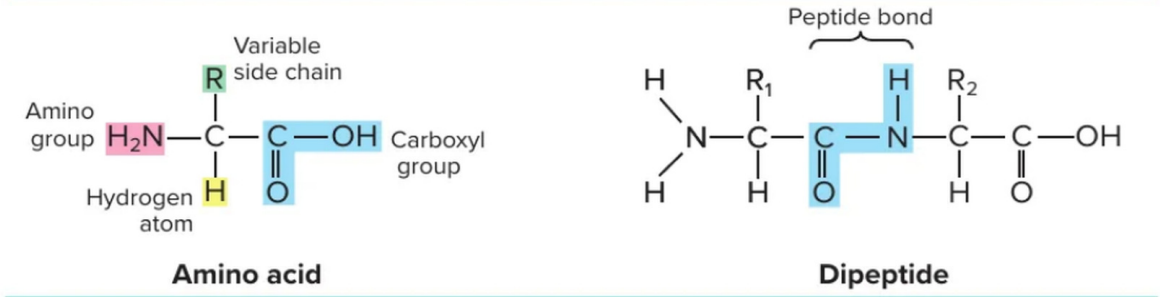


Figure 33 **Left:** The general structure of an amino acid has four groups around a central carbon. **Right:** The peptide bond in a protein happens as a result of a chemical reaction.

Figure 33 - amino acid and peptide bond

A unique side chain

The variable R group differs among amino acids. This helps explain why there are 20 different amino acids.

Peptide bonds

A peptide bond links the amino group of one amino acid to the carboxyl group of another.

Proteins have many jobs

- Provide structural support and transport substances.
- Help cells communicate, speed up reactions and control growth.

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8. Four levels of protein structure

Primary
Secondary
Tertiary
Quaternary

A protein folds into a working shape

A protein's amino acid order controls its primary structure. Folding and interactions among amino acids determine its three-dimensional shape.

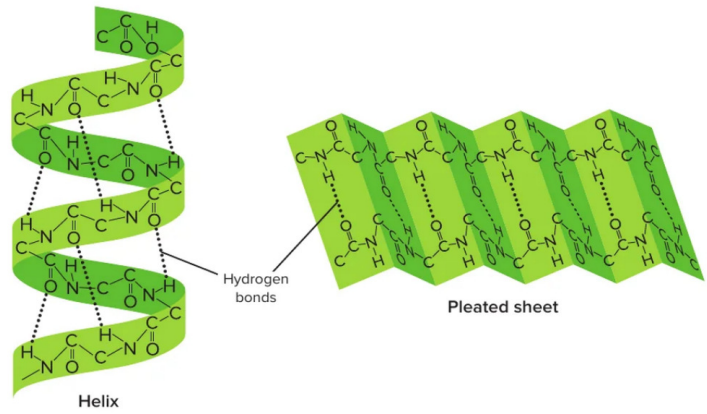


Figure 34 The shape of a protein depends on the interactions among the amino acids. Hydrogen bonds help the protein hold its shape.

Figure 34 - helix and pleated sheet

Level	What it describes
Primary	The number, kinds and sequence of amino acids.
Secondary	Alpha helices or pleated sheets after folding.
Tertiary	The overall three-dimensional shape of one protein.
Quaternary	Combination of multiple protein subunits.

Key idea

The shape of a protein is directly linked to its function.

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9. Nucleic acids and ATP

How cells store information

Nucleic acids are large molecules that store and transmit genetic information. The two types are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

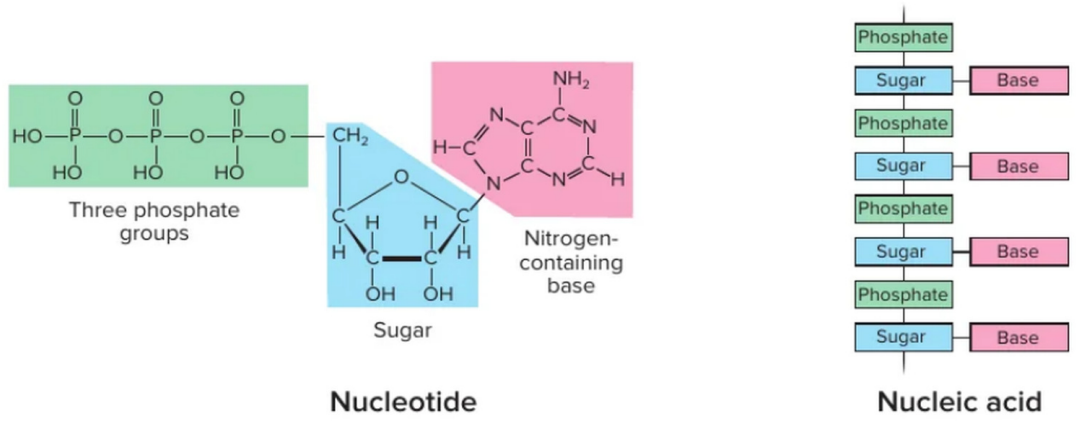


Figure 35 - the nucleotide and a nucleic acid chain

A nucleotide has...

A phosphate group, a sugar and a nitrogen-containing base. Nucleotides join into long chains.

DNA vs. RNA

DNA nucleotides contain deoxyribose sugar. RNA nucleotides contain ribose sugar.

ATP: energy ready for use

Adenosine triphosphate (ATP) has three phosphate groups. Cells can use energy released when the bond between the second and third phosphate is broken.

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10. Vocabulary and fast revision

Important words

Term	Simple meaning
Organic	Containing carbon in the studied compounds.
Macromolecule	Large molecule made from smaller compounds.
Monomer	Small repeating building block.
Polymer	Large chain of linked, repeated monomers.
Carbohydrate	Carbon compound with C:H:O near 1:2:1.
Polysaccharide	Long chain of sugars.
Lipid	Group including fats, oils, waxes and steroids.
Saturated	Fatty-acid tail with single carbon-carbon bonds.
Unsaturated	Fatty-acid tail with carbon-carbon double bond(s).
Amino acid	Monomer that builds proteins.
Peptide bond	Bond linking amino acids.
Nucleotide	Phosphate, sugar and nitrogen-containing base.
Nucleic acid	DNA or RNA; carries genetic information.
ATP	Molecule that supplies energy for many cell reactions.

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Final memory check

Carbs = energy / support. Lipids = energy / barriers. Proteins = many cell jobs. Nucleic acids = genetic information.

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Section review - multiple choice

Circle the best answer. Answers with explanations are on page 16.

1 **Why can carbon form many complex compounds?**

A It has four outer electrons and can make four covalent bonds.

B It cannot bond to other carbon atoms.

C It has no electrons in its outer energy level.

D It forms only single isolated atoms.

Section review - Q1

2 **Organic chemistry focuses mainly on...**

A materials containing only water.

B compounds that contain carbon.

C the movement of planets.

D substances without carbon.

Section review - Q2

3 **Which statement correctly describes a polymer?**

A It is always a single atom.

B It contains no chemical bonds.

C It consists of repeating units called monomers.

D It can never be part of living cells.

Section review - Q3

4 **What are the four groups of biological macromolecules?**

A Water, oxygen, iron and nitrogen.

B Acids, bases, salts and water.

C Carbon, hydrogen, oxygen and sulfur.

D Carbohydrates, lipids, proteins and nucleic acids.

Section review - Q4

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Section review (continued)

Circle the best answer. Answers with explanations are on page 16.

5 **Which ratio is typical of carbohydrates?**

A C:H:O = 1:2:1.

B C:H:O = 3:1:2.

C C:H:O = 1:1:3.

D C:H:O = 2:1:1.

Section review - Q5

6 **Two monosaccharides join to form a...**

A fatty acid.

B disaccharide.

C nucleic acid.

D steroid.

Section review - Q6

7 **What is the main job of glycogen?**

A Form a waxy leaf coating.

B Carry genetic information.

C Store glucose for energy in animals.

D Join amino acids with peptide bonds.

Section review - Q7

8 **Cellulose is important because it...**

A stores genes in animal cells.

B forms peptide bonds in proteins.

C acts as a steroid hormone.

D supports plant cell walls.

Section review - Q8

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Unit review - apply the ideas

Circle the best answer. Answers with explanations are on page 16.

1 **Which components can make up lipids?**

A Fatty acids and glycerol.
B Only glucose molecules.
C Only amino acids.
D Only nucleotides.

2 **Which statement matches fats and oils?**

A Oils must always be solid at room temperature.
B Fats are solid; oils are liquid at room temperature.
C Both are types of nucleic acid.
D Fats are made of amino acids.

3 **Which statement describes a saturated fatty-acid tail?**

A It has many double bonds between carbon atoms.
B It has no carbon atoms.
C Its carbon atoms are linked by single bonds.
D It contains only phosphate groups.

4 **An unsaturated fat has...**

A no hydrogen atoms anywhere.
B no carbon atoms.
C only phosphate groups.
D one or more C=C double bonds.

5 **Why are phospholipids useful in cell membranes?**

A They help form a barrier that limits water passage.
B They are identical to starch.
C They join amino acids with peptide bonds.
D They store genetic codes.

6 **Which group includes cholesterol and some hormones?**

A Disaccharides.
B Steroids.
C Nucleotides.
D Simple sugars.

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Unit review (continued)

Circle the best answer. Answers with explanations are on page 16.

7 **Proteins are formed from...**

A glucose subunits.
B fatty acid tails.
C chains of amino acids.
D repeated water molecules.

8 **What makes one amino acid different from another?**

A A different number of oxygen atoms in water.
B The absence of a central carbon.
C An extra phosphate in every amino acid.
D Its variable R-group side chain.

9 **Which bond connects amino acids in a protein?**

A Peptide bond.
B Hydrogen bond only.
C Glycosidic bond in glycogen.
D No bond is necessary.

10 **An alpha helix or pleated sheet is part of...**

A a protein primary structure only.
B a protein secondary structure.
C a fat molecule at room temperature.
D a carbohydrate monosaccharide.

11 **Which subunits form DNA and RNA?**

A Only glycerol molecules.
B Only glucose rings.
C Nucleotides.
D Fatty acids.

12 **When does ATP release usable energy in the lesson?**

A When it becomes a protein.
B When oxygen stops sharing electrons.
C When its sugar changes into a fatty acid.
D When the bond to its third phosphate is broken.

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Answer key

S = Section review U = Unit review

Q	Ans	Why?
S1	A	Four outer electrons allow up to four covalent bonds.
S2	B	Organic chemistry studies carbon-containing compounds.
S3	C	Polymers contain repeated, linked monomer units.
S4	D	These are the four groups in Table 1.
S5	A	Carbohydrates have one C and O for every two H atoms.
S6	B	Disaccharides form when two simple sugars join.
S7	C	Glycogen stores glucose in liver and skeletal muscle.
S8	D	Cellulose provides structural support to plant walls.
U1	A	Lipids include compounds of fatty acids and glycerol.
U2	B	The text distinguishes fats and oils by room-temperature state.
U3	C	Saturated fatty-acid chains have single C-C bonds.
U4	D	Unsaturated fatty acids contain carbon-carbon double bonds.
U5	A	Phospholipids contribute to membrane barriers.
U6	B	Steroids include cholesterol and hormones.
U7	C	Amino acids link to form proteins.
U8	D	The variable group (R) distinguishes amino acids.
U9	A	Peptide bonds join adjacent amino acids.
U10	B	These are common secondary structures of proteins.
U11	C	Nucleic acids are built from nucleotide units.
U12	D	ATP releases energy when the final phosphate bond breaks.

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