Week 1

AP Biology

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

1. Chemistry of Life

Starter Quiz · 课前小测

AP Biology Name: ______ Score: ______

1. Why is a water molecule **polar**?
   - ☐ It contains two hydrogen atoms
   - ☐ Oxygen pulls the shared electrons more strongly than hydrogen
   - ☐ It is a very small molecule
   - ☐ It is a liquid at room temperature
2. Four elements make up about **96%** of a living body. Which are they?
   - ☐ Carbon, hydrogen, oxygen, nitrogen
   - ☐ Iron, calcium, sodium, potassium
   - ☐ Gold, silver, copper, zinc
   - ☐ Helium, neon, argon, xenon
3. A **polymer** is best described as…
   - ☐ a long chain built from repeating monomer units
   - ☐ a single small molecule
   - ☐ an atom of carbon
   - ☐ a type of water
4. A **monosaccharide** is…
   - ☐ a single sugar unit, like glucose
   - ☐ a chain of hundreds of sugars
   - ☐ a type of protein
   - ☐ a fat
5. A **triglyceride** is made of one glycerol joined to…
   - ☐ three fatty acids
   - ☐ three sugars
   - ☐ three amino acids
   - ☐ three nucleotides
6. A single hydrogen bond is stronger than the bond holding an O and H together inside a water molecule.

   ☐ True ☐ False

7. How many covalent bonds can one carbon atom form?

____

8. A **condensation reaction** releases a molecule of water each time it joins two monomers.

☐ True ☐ False

9. Table sugar, sucrose, is a disaccharide made of glucose and ______.

____

10. The bond that joins two amino acids is a ______ bond.

____

1. Chemistry of Life

Answers · 答案

AP Biology

1. **Oxygen pulls the shared electrons more strongly than hydrogen**

   Oxygen has a higher **electronegativity**, so the electrons sit closer to it — giving oxygen a partial negative and the hydrogens a partial positive charge.

2. **Carbon, hydrogen, oxygen, nitrogen**

   Carbon, hydrogen, oxygen and nitrogen (CHON) make up about 96% of living matter.

3. **a long chain built from repeating monomer units**

   A **polymer** is a large molecule made by linking many small **monomer** subunits into a chain.

4. **a single sugar unit, like glucose**

   A **monosaccharide** ("one sugar") is a single sugar unit — glucose and fructose are examples.

5. **three fatty acids**

   A triglyceride is a glycerol backbone with **three fatty acid** tails attached.

6. **False**

   A single hydrogen bond is **weak**. Water is powerful because it has an enormous *number* of them.

7. **4**

   Carbon has **four** outer electrons, so it forms four bonds — letting it build long chains, branches and rings.

8. **True**

   Condensation joins monomers and removes one water molecule per bond formed.

9. **fructose**

   Sucrose = glucose + **fructose**, joined by a condensation reaction.

10. **peptide**

    A **peptide bond** links amino acids into a chain called a polypeptide.

AP BIOLOGY • EXERCISE SHEET

1.1 Structure of Water and Hydrogen Bonding

Name: ______________ Class: __________ Date: ____________ **Total: 10 marks**

KEY WORDS polar 极性 • hydrogen bonds 氢键 • specific heat 比热容 • cohesion 内聚力 • adhesion 附着力

Objective

Build the skills to answer exam questions on **water and hydrogen bonding** — the properties that support life.

You must be able to:

- explain that water is **polar 极性** and forms **hydrogen bonds 氢键**
- link hydrogen bonding to cohesion, adhesion, high specific heat, and being a solvent
- connect each property to a biological role

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

Polarity and hydrogen bonds

Water's oxygen pulls electrons more strongly than its hydrogens, giving a slightly negative O and slightly positive H (**polar**). These opposite charges attract, forming **hydrogen bonds** between water molecules.

Cohesion and adhesion

Cohesion (water sticking to water) gives surface tension and lets water columns rise in plants; **adhesion** (water sticking to other surfaces) helps water climb narrow tubes (capillary action).

High specific heat

Hydrogen bonds resist temperature change, so water has a **high specific heat** — it stabilizes the temperature of cells, organisms, and habitats.

Universal solvent

Because it is polar, water dissolves polar and ionic substances (a **solvent**), so most biological reactions happen in aqueous solution.

2 Practice

Now apply the methods above.

2.1 Why is water described as polar? [1]

2.2 Name the bond that forms between two water molecules. [1]

2.3 State one biological benefit of water's high specific heat. [1]

3 Exam-style questions

3.1 Water can dissolve many substances because it is [1]

- **A** nonpolar
- **B** polar
- **C** acidic
- **D** a gas

3.2 Water rises up the xylem of a tall tree.

(a) Name the two properties of water involved. [2]

(b) Explain how hydrogen bonding causes cohesion. [2]

3.3 Explain how water's high specific heat helps organisms survive changes in environmental temperature. [2]

Solutions

2.1 Its oxygen pulls electrons more strongly, giving a slightly negative O and slightly positive H (uneven charge).

2.2 A hydrogen bond.

2.3 It stabilizes the temperature of cells/organisms/habitats (resists rapid temperature change).

3.1 **B** — polar.

3.2 (a) Cohesion and adhesion. (b) Water molecules are polar, so the slightly positive H of one attracts the slightly negative O of another, holding the molecules together.

3.3 Hydrogen bonds absorb a lot of energy before the temperature rises, so water (and the organisms in it) warms and cools slowly, buffering them against sudden temperature swings.

AP BIOLOGY • EXERCISE SHEET

1.2 Elements of Life

Name: ____________ Class: ________ Date: __________ **Total: 10 marks**

KEY WORDS carbon 碳 • amino acids 氨基酸 • nucleotides 核苷酸

Objective

Build the skills to answer exam questions on the **elements of life** and the special role of carbon.

You must be able to:

- name the main elements in living matter (C, H, O, N, P, S)
- explain why **carbon** 碳 is central (four covalent bonds)
- link carbon's bonding to the diversity of biological molecules

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The elements of life

Living matter is built mostly from a few elements: **carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur** (CHONPS). Trace elements (like iron) also matter.

■ Why carbon is central

Carbon has four valence electrons, so it forms **four stable covalent bonds**. This lets it build long chains, branches, and rings — the skeletons of all biological molecules.

■ Carbon's versatility

Because carbon can bond to itself and to many other elements, it produces an enormous variety of stable molecules — the basis of life's molecular diversity.

■ A worked link

Fatty acids, sugars, amino acids, and nucleotides all have carbon backbones; their different arrangements (built on carbon's four bonds) give them different structures and functions.

2 Practice

Now apply the methods above.

2.1 Name four of the main elements found in living matter. [2]

2.2 How many covalent bonds can carbon form? [1]

2.3 Why can carbon build such varied molecules? [1]

3 Exam-style questions

3.1 Carbon is central to biological molecules because it can form [1]

- **A** one covalent bond
- **B** two covalent bonds
- **C** four covalent bonds
- **D** ionic bonds only

3.2 A student examines the backbones of a fatty acid, a sugar, and an amino acid.

(a) What element forms the backbone of all three? [1]

(b) Explain how carbon's bonding allows chains, branches, and rings. [2]

3.3 Explain why carbon's ability to form four bonds contributes to the diversity of life's molecules. [2]

Solutions

2.1 Any four of: carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur.

2.2 Four.

2.3 It forms four stable covalent bonds and can bond to itself and many elements.

3.1 **C** — four covalent bonds.

3.2 (a) Carbon. (b) Its four bonds let carbon atoms link into long chains, add side branches, and close into rings, giving many possible skeletons.

3.3 Four bonding sites allow a huge number of stable arrangements of atoms, so an enormous variety of different molecules (and functions) can be built.

1.3 Introduction to Macromolecules

Name: ____________ Class: ________ Date: __________ **Total: 11 marks**

KEY WORDS monomers 单体 • hydrolysis 水解 • dehydration synthesis 脱水缩合 • polymers 聚合物 • nucleic acids 核酸

Objective

Build the skills to answer exam questions on **macromolecules** — polymers, monomers, and how they are built.

You must be able to:

- describe **polymers** 聚合物 built from **monomers** 单体
- explain **dehydration synthesis** 脱水缩合 and **hydrolysis** 水解
- name the four classes of biological macromolecule

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Monomers and polymers

Large biological molecules (**macromolecules**) are **polymers** — long chains of repeating subunits called **monomers**. The four classes are carbohydrates, lipids, nucleic acids, and proteins.

■ Dehydration synthesis (building)

Cells join two monomers by **removing a water molecule** to form the bond — **dehydration synthesis** (condensation). Building a polymer removes one water per bond formed.

■ Hydrolysis (breaking)

The reverse — **adding water** to break a bond between monomers — is **hydrolysis**. Digestion breaks polymers into monomers by hydrolysis.

■ A worked link

Two monosaccharides join by dehydration synthesis (losing water) to form a disaccharide; adding water (hydrolysis) splits it back into two monosaccharides.

2 Practice

Now apply the methods above.

2.1 What is a polymer? [1]

2.2 What is removed when two monomers join by dehydration synthesis? [1]

2.3 Name the four classes of macromolecule. [2]

3 Exam-style questions

3.1 Breaking a polymer into monomers by adding water is called [1]

- **A** dehydration synthesis
- **B** hydrolysis
- **C** condensation
- **D** denaturation

3.2 A cell links many glucose monomers into a starch polymer.

(a) Name the process and what is removed at each bond. [2]

(b) State how the starch could later be broken back into glucose. [2]

3.3 Explain why dehydration synthesis and hydrolysis are described as opposite processes. [2]

Solutions

2.1 A long chain of repeating monomers.

2.2 A water molecule.

2.3 Carbohydrates, lipids, nucleic acids, proteins.

3.1 **B** — hydrolysis.

3.2 (a) Dehydration synthesis; a water molecule is removed at each bond. (b) By hydrolysis — adding water to break the bonds back into glucose.

3.3 Dehydration synthesis **removes** water to form a bond and build a polymer; hydrolysis **adds** water to break the bond — each reverses the other.

AP BIOLOGY • EXERCISE SHEET

1.4 Carbohydrates

Name: ____________ Class: ________ Date: __________ **Total: 11 marks**

KEY WORDS cellulose 纤维素 • polysaccharides 多糖 • monosaccharides 单糖 • carbohydrates 碳水化合物 • monomers 单体

Objective

Build the skills to answer exam questions on **carbohydrates**.

You must be able to:

- identify **monosaccharides** 单糖, disaccharides, and **polysaccharides** 多糖
- state the functions (energy storage and structure)
- link structure to function (starch, glycogen, cellulose)

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

The sugar building blocks

Carbohydrates are made of sugar monomers (**monosaccharides**, such as glucose). Two joined make a disaccharide; many joined make a **polysaccharide**.

Storage polysaccharides

Starch (plants) and **glycogen** (animals) store glucose for energy. Their branched/coiled shapes pack many glucose units for quick release.

Structural polysaccharides

Cellulose (plant cell walls) is made of glucose linked in a way that forms strong, straight fibers — providing support, not easily digested.

Structure sets function

The **same** glucose monomer builds both starch (storage) and cellulose (structure); the **difference is the type of bond**, which changes the shape and therefore the role.

2 Practice

Now apply the methods above.

2.1 Name the monomer of carbohydrates. [1]

2.2 State one storage polysaccharide and one structural polysaccharide. [2]

2.3 Which polysaccharide makes up plant cell walls? [1]

3 Exam-style questions

3.1 The monomer that makes up starch, glycogen, and cellulose is [1]

- **A** glucose
- **B** an amino acid
- **C** a nucleotide
- **D** glycerol

3.2 Starch and cellulose are both polymers of glucose but have different functions.

(a) State the function of each. [2]

(b) Explain how they can differ if they share the same monomer. [2]

3.3 Explain why glycogen's branched structure suits its role in animals. [2]

Solutions

2.1 Monosaccharide (e.g. glucose).

2.2 Storage: starch or glycogen; structural: cellulose.

2.3 Cellulose.

3.1 **A** — glucose.

3.2 (a) Starch stores energy (in plants); cellulose provides structure/support (cell walls). (b) The glucose units are joined by **different bonds**, giving different shapes and therefore different functions.

3.3 Its many branches provide many ends where glucose can be quickly added or removed, allowing fast energy storage and release to meet an animal's needs.

2. Geneticists investigated the mode of inheritance of a rare disorder that alters glucose metabolism and first shows symptoms in adulthood. The geneticists studied a family in which some individuals of generations II and III are known to have the disorder. Based on the pedigree (Figure 1), the geneticists concluded that the disorder arose in individual II−2 and was caused by a mutation in mitochondrial DNA.

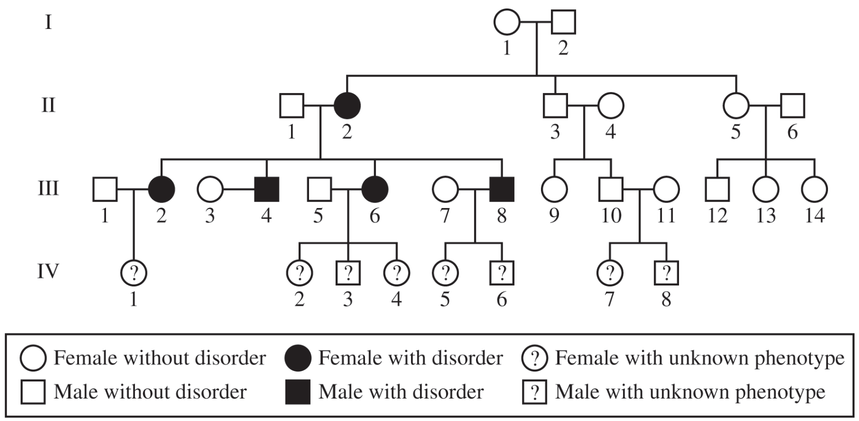


Figure 1. Pedigree of a family showing individuals with the glucose metabolism disorder. A question mark indicates that the phenotype is unknown.

TABLE 1. AVERAGE BLOOD GLUCOSE LEVELS OF INDIVIDUALS IN GENERATION IV

Individual	Average Blood Glucose Level (mg/dL $\pm$ $2SE_{\bar{x}}$)
IV−1	170 ± 15
IV−2	190 ± 10
IV−3	145 ± 5
IV−4	165 ± 15
IV−5	110 ± 15
IV−6	125 ± 5
IV−7	105 ± 15
IV−8	120 ± 10

TABLE 2. PHENOTYPIC CLASSIFICATIONS BASED ON BLOOD GLUCOSE LEVELS

Phenotype	Blood Glucose Level (mg/dL)
Normal	< 140 mg/dL
At risk	140 − 199 mg/dL
Affected	≥ 200 mg/dL

(a) The disorder alters glucose metabolism. **Describe** the atoms AND types of bonds in a glucose molecule.

(b) Using the template in the space provided for your response, **construct** an appropriately labeled graph based on the data in Table 1. **Determine** one individual who is both at risk of developing the disorder and has a significantly different blood glucose level from that of individual IV−1.

(c) Based on the pedigree, **identify** all individuals in generation IV who can pass on the mutation to their children.

(d) Based on the fact that individual II−2 is affected, a student claims that the disorder is inherited in an X-linked recessive pattern. Based on the student's claim, **predict** which individuals of generation III will be affected by the disorder. Based on the pedigree, **justify** why the data do NOT support the student's claim.

Write your responses to this question only on the designated pages in the separate Free Response booklet.

AP BIOLOGY • EXERCISE SHEET

1.5 Lipids

Name: ____________ Class: ________ Date: __________ **Total: 11 marks**

KEY WORDS phospholipid 磷脂 • hydrophobic 疏水 • polar 极性 • lipids 脂质 • carbohydrates 碳水化合物

Objective

Build the skills to answer exam questions on **lipids**.

You must be able to:

- describe lipids as **nonpolar** and **hydrophobic** 疏水
- describe a **phospholipid** 磷脂 (polar head, nonpolar tails)
- link phospholipid structure to the cell membrane

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

Lipids are hydrophobic

Lipids are mostly nonpolar, so they do **not** mix with water (**hydrophobic**). They include fats (energy storage), phospholipids (membranes), and steroids.

Fats store energy

Fats (triglycerides) pack a lot of energy per gram — more than carbohydrates — making them efficient long-term energy stores.

Phospholipids build membranes

A **phospholipid** has a **polar (hydrophilic) head** and two **nonpolar (hydrophobic) tails**. This dual nature is the key to the membrane.

The bilayer

In water, phospholipids arrange into a **bilayer**: heads face the water on both sides, tails hide inside, away from water. This forms the basic structure of the cell membrane.

2 Practice

Now apply the methods above.

2.1 Do lipids mix with water? Give the term. [1]

2.2 Describe the two parts of a phospholipid. [2]

2.3 Which lipid stores energy efficiently? [1]

3 Exam-style questions

3.1 A phospholipid has a polar head and [1]

- **A** a polar tail
- **B** two nonpolar tails
- **C** no tail
- **D** a charged tail

3.2 Phospholipids form a bilayer in water.

(a) Describe how the heads and tails are arranged in the bilayer. [2]

(b) Explain why this arrangement forms spontaneously in water. [2]

3.3 Explain why fats are better than carbohydrates for long-term energy storage. [2]

Solutions

2.1 No — they are hydrophobic.

2.2 A polar (hydrophilic) head and two nonpolar (hydrophobic) tails.

2.3 Fats (triglycerides).

3.1 **B** — two nonpolar tails.

3.2 (a) The polar heads face the water on both surfaces; the nonpolar tails point inward, away from water. (b) The hydrophobic tails are excluded from water and cluster together, while the hydrophilic heads interact with water, so the bilayer self-assembles.

3.3 Fats store more energy per gram than carbohydrates and are hydrophobic (stored without water), making them a compact, efficient long-term store.

AP BIOLOGY • EXERCISE SHEET

1.6 Nucleic Acids

Name: ____________ Class: ________ Date: __________ **Total: 11 marks**

KEY WORDS nucleotides 核苷酸 • nucleic acids 核酸 • polymers 聚合物

Objective

Build the skills to answer exam questions on **nucleic acids**.

You must be able to:

- describe **nucleotides** 核苷酸 (sugar, phosphate, nitrogen base)
- compare DNA and RNA
- explain that the base sequence stores information

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

The nucleotide monomer

Nucleic acids (DNA and RNA) are polymers of **nucleotides**. Each nucleotide has three parts: a **sugar**, a **phosphate** group, and a **nitrogen base**.

DNA vs RNA

- **DNA** — double-stranded, sugar deoxyribose, bases A, T, C, G; stores genetic information.
- **RNA** — single-stranded, sugar ribose, bases A, U, C, G; carries and helps express information.

Information in the sequence

The **order of bases** along the strand encodes the genetic instructions — like letters spelling out a message. Different sequences mean different genes.

Directionality and pairing

DNA strands run antiparallel and pair by complementary bases (A–T, C–G), the basis of accurate copying (replication) and reading.

2 Practice

Now apply the methods above.

2.1 Name the three parts of a nucleotide. [3]

2.2 State one difference between DNA and RNA. [1]

2.3 What part of the nucleotide sequence stores genetic information? [1]

3 Exam-style questions

3.1 The genetic information in DNA is stored in its [1]

- **A** sugar type
- **B** phosphate groups
- **C** sequence of bases
- **D** double helix width

3.2 Compare DNA and RNA.

(a) State the number of strands and the sugar in each. [2]

(b) State which base is found in RNA but not DNA. [1]

3.3 Explain how the same four bases can encode a huge number of different genes. [2]

Solutions

2.1 A sugar, a phosphate group, and a nitrogen base.

2.2 Any one: DNA is double-stranded / RNA single-stranded; DNA has deoxyribose / RNA has ribose; DNA has thymine / RNA has uracil.

2.3 The sequence of bases.

3.1 **C** — the sequence of bases.

3.2 (a) DNA: double-stranded, deoxyribose; RNA: single-stranded, ribose. (b) Uracil.

3.3 The bases can be arranged in any order along a long strand, and the number of possible sequences grows enormously with length, so a vast number of distinct genes is possible.

The following information applies to all parts.

1. Molecules known as dinucleoside polyphosphates, a type of nucleotide, are signaling molecules that accumulate in plant cells during dry or stressful conditions.

Part A

Describe the three structural components of a nucleotide.

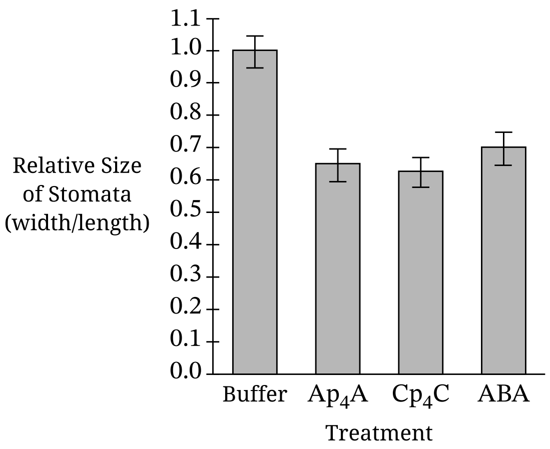
The following information applies to parts B, C, and D.

Stomata are pores on the surface of leaves that open when exposed to light and regulate the flow of carbon dioxide, oxygen, and water vapor in and out of a plant. In response to dry environmental conditions, many plants close their stomata, which reduces water loss.

Scientists hypothesized that the dinucleoside polyphosphates Ap_4A and Cp_4C bind to DORN1 receptors on the plasma membrane of plant cells and initiate signaling cascades that cause stomata to close. The scientists exposed plants to light to open the stomata and then placed samples of the leaves in buffer alone or in buffer containing one of three different compounds: Ap_4A, Cp_4C, or abscisic acid (ABA), a molecule that causes stomata to close.

The scientists measured the size of the stomata in each sample and calculated their sizes relative to the size of the stomata in the sample kept in buffer alone, as shown in Figure 1.

Figure 1. Effect of Ap_4A, Cp_4C, and ABA on Relative Stomatal Size (Error Bars Represent $\pm SE_{\bar{x}}$)



Part B

i. **Identify** the dependent variable in the scientists' first experiment.

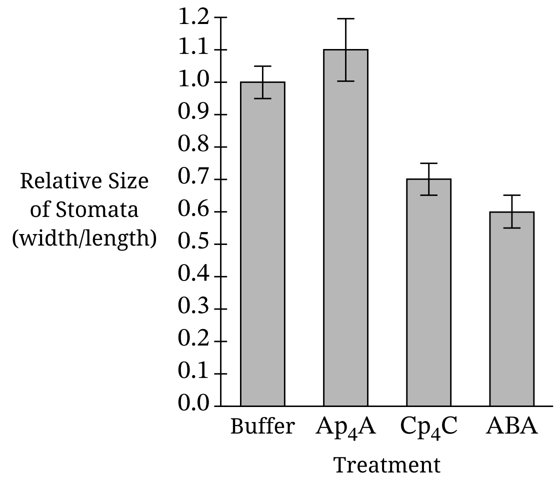
ii. Based on Figure 1, **describe** the relative size of the stomata in the Cp_4C treatment group as compared with the size of the stomata in the group treated with buffer alone.

iii. **Justify** the use of buffer alone as a control in the scientists' experiments.

Part C

In a second experiment, the scientists used plants that were identical to those in the first experiment except that the gene encoding the DORN1 receptor was mutated. The scientists repeated the procedure of the first experiment. Their results are shown in Figure 2.

Figure 2. Effect of Ap_4A, Cp_4C, and ABA on Relative Stomatal Size in DORN1 Mutants (Error Bars Represent $\pm SE_{\bar{x}}$)



i. **Justify** the scientists' treating one sample of leaves with ABA in the experiments.

ii. Based on Figure 2, **describe** the difference between the effects of Ap_4A and Cp_4C treatments on the size of stomata in plants with mutated DORN1 receptors.

iii. Activation of DORN1 receptors induces plant cells to produce certain molecules that cause the stomata to close. Based on the data in Figures 1 and 2 for cells treated with Ap_4A, **predict** the relative production of the molecules by DORN1-mutated cells in comparison to the production by nonmutated cells.

Part D

The DORN1 receptor transmits signals that result in an increase in the transcription of genes involved in plant defenses. The scientists then developed DORN1-mutant plants in which the DORN1 receptor lacked most of its intracellular domain.

i. In cells homozygous for this mutation, **predict** the effect of $\mathrm{Ap_4A}$ treatment on transcription of the genes involved in plant defenses relative to the effect of $\mathrm{Ap_4A}$ on nonmutated cells.

ii. **Justify** your prediction.

AP Biology: **2017**

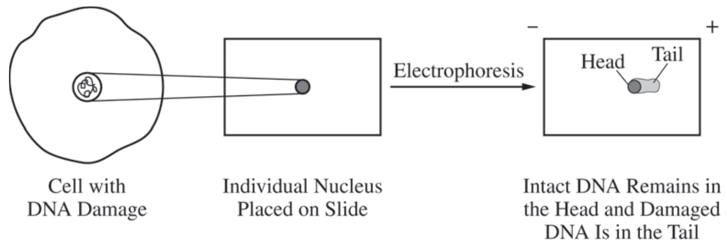


Figure 1. Comet assay to detect double-stranded breaks in DNA

6. A comet assay is a technique used to determine the amount of double-strand breaks in DNA (DNA damage) in cells. The nucleus of an individual cell is placed on a microscope slide coated with an agarose gel. An electric current is applied to the gel that causes DNA to move (electrophoresis), and the DNA is stained with a fluorescent dye. When viewed using a microscope, undamaged DNA from the nucleus appears as a round shape (the head), and the fragments of damaged DNA extend out from the head (the tail). The length of the tail corresponds to the amount of the damage in the DNA (see Figure 1).

(a) To explain the movement of DNA fragments in the comet assay, **identify** one property of DNA and **provide reasoning** to support how the property contributes to the movement during the comet assay technique.

(b) In a different experiment, cells are treated with a chemical mutagen that causes only nucleotide substitutions in DNA. **Predict** the likely results of a comet assay for this treatment.

AP BIOLOGY • EXERCISE SHEET

1.7 Proteins

Name: ____________ Class: ________ Date: __________ **Total: 10 marks**

KEY WORDS amino acids 氨基酸 • peptide bonds 肽键 • denaturation 变性 • proteins 蛋白质 • polymers 聚合物

Objective

Build the skills to answer exam questions on **proteins**.

You must be able to:

- describe proteins as polymers of **amino acids 氨基酸** joined by **peptide bonds 肽键**
- name the four levels of protein structure
- explain that **shape determines function** and how **denaturation 变性** works

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

The amino-acid monomer

Proteins are polymers of **amino acids** joined by **peptide bonds**. There are 20 different amino acids; their order determines the protein.

Four levels of structure

- **Primary** — the sequence of amino acids.
- **Secondary** — local folds (helices and sheets) from hydrogen bonds.
- **Tertiary** — the overall 3-D shape of one chain.
- **Quaternary** — two or more chains together.

Shape determines function

A protein's **specific shape** lets it do its job — as an enzyme, transporter, receptor, or structural part. Change the shape and the function is lost.

Denaturation

Heat or a pH change can **denature** a protein — breaking the bonds that hold its shape, so it unfolds and stops working. The primary sequence is unchanged, but the function is lost.

2 Practice

Now apply the methods above.

2.1 Name the monomer of proteins and the bond joining them. [2]

2.2 What is the primary structure of a protein? [1]

2.3 What can denature a protein? [1]

3 Exam-style questions

3.1 A protein's function is determined mainly by its [1]

- **A** color
- **B** three-dimensional shape
- **C** mass
- **D** charge only

3.2 An enzyme is heated strongly and stops working.

(a) Name the process that has occurred. [1]

(b) Explain why the enzyme no longer functions. [2]

3.3 Explain how a change in a single amino acid (primary structure) could affect a protein's function. [2]

Solutions

2.1 Amino acids; peptide bonds.

2.2 The sequence (order) of amino acids.

2.3 Heat or a change in pH.

3.1 **B** — its three-dimensional shape.

3.2 (a) Denaturation. (b) Heat breaks the bonds holding the protein's shape, so it unfolds; its active site no longer fits the substrate, so it cannot function.

3.3 A different amino acid can change how the chain folds, altering the 3-D shape; if the active site or key region changes, the protein's function can be reduced or lost.

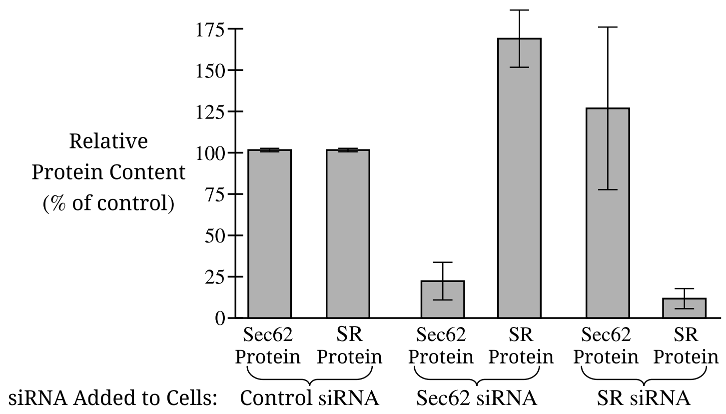
1. Most proteins that are secreted from a cell must be transported to the endoplasmic reticulum (ER) either during translation or after translation.

A. Describe the function of ribosomes.

For proteins transported during translation, this process begins in the cytosol and pauses when a specific sequence of amino acids is translated. The translation complex is then transported to the surface of the ER where translation continues. Proteins that are transported after translation are translated entirely in the cytosol and then transported to the ER. In both instances, the translated proteins enter the ER through a protein channel in the membrane of the ER.

Researchers studying the two types of protein transport identified that the ER membrane protein SR is necessary for transport during translation, while the ER membrane protein Sec62 is necessary for transport after translation. To investigate which transport mechanism is used for different proteins, researchers first created small interfering RNAs (siRNAs) that reduce expression of either SR or Sec62. They then treated groups of cells with either the SR siRNA or the Sec62 siRNA and determined the relative amount of SR and Sec62 protein in each group of cells compared with cells treated with a control siRNA (Figure 1).

Figure 1. Average relative amounts of Sec62 and SR proteins in cells treated with control siRNA, Sec62 siRNA, or SR siRNA. Error bars represent $\pm SE_{\bar{x}}$.



B.

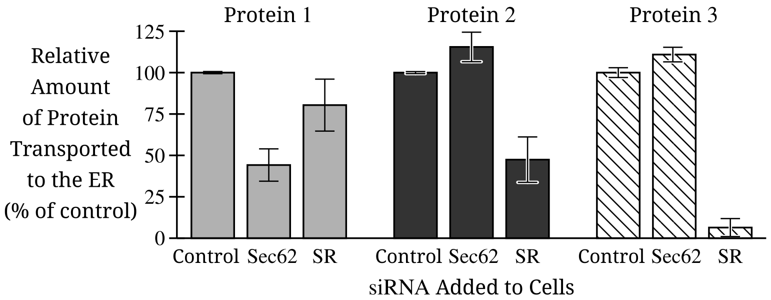
i. **Identify** the dependent variable in the experiments shown in Figure 1.

ii. **Justify** why the researchers included the control of measuring the relative amounts of both Sec62 and SR proteins in cells that were treated with Sec62 siRNA only (data shown in Figure 1).

iii. Based on Figure 1, **describe** the effect on the production of SR protein when cells are treated with Sec62 siRNA.

The researchers then measured the amount of each of three different proteins that was transported to the ER in cells treated with Sec62 siRNA or SR siRNA. The researchers calculated the percent transported relative to the cells treated with control siRNA (Figure 2).

Figure 2. Average relative amounts of three proteins that were transported to the ER when treated with control siRNA, Sec62 siRNA, or SR siRNA. Error bars represent $\pm SE_{\bar{x}}$.



C.

i. **Identify** the independent variable in the researchers' second experiment (data shown in Figure 2).

ii. Based on Figure 2, **identify** the protein(s) that when treated with Sec62 siRNA showed an increase in percent transport to the ER compared with the control.

iii. Protein 1 is encoded by 234 nucleotides, while protein 2 is encoded by 495 nucleotides. Assuming all nucleotides for both proteins encode amino acids, **calculate** the difference in the number of amino acids between the two proteins.

D.

i. Researchers claim that protein 1 is the only tested protein that is transported to the ER following its complete translation in the cytosol. Using data from Figure 2, **support** the researchers' claim.

ii. For any protein that enters the ER, researchers claim that amino acids close to the protein's amino terminus determine how likely the protein is to pass through the protein channel within the ER membrane. **Justify** the researchers' claim based on your understanding of factors that affect the transport of proteins across membranes.

3. Gibberellin is the primary plant hormone that promotes stem elongation. GA 3-beta-hydroxylase (GA3H) is the enzyme that catalyzes the reaction that converts a precursor of gibberellin to the active form of gibberellin. A mutation in the *GA3H* gene results in a short plant phenotype. When a pure-breeding tall plant is crossed with a pure-breeding short plant, all offspring in the F_1 generation are tall. When the F_1 plants are crossed with each other, 75 percent of the plants in the F_2 generation are tall and 25 percent of the plants are short.

Second Base in Codon

First Base in Codon	U	C	A	G	Third Base in Codon
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met or Start	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

Figure 1. The universal genetic code

(a) The wild-type allele encodes a GA3H enzyme with alanine (Ala), a nonpolar amino acid, at position 229. The mutant allele encodes a GA3H enzyme with threonine (Thr), a polar amino acid, at position 229. **Describe** the effect of the mutation on the enzyme and **provide reasoning** to support how this mutation results in a short plant phenotype in homozygous recessive plants.

(b) Using the codon chart provided, **predict** the change in the codon sequence that resulted in the substitution of alanine for threonine at amino acid position 229.

(c) **Describe** how individuals with one (heterozygous) or two (homozygous) copies of the wild-type *GA3H* allele can have the same phenotype.