Unit 1 · Biomolecules

ANSWER KEY · FOR TEACHERS

Full marks 39

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. aldoses
2. glycosidic
3. peptide
4. condensation
5. primary
6. denaturation
7. nucleoside
8. activation energy

K · 4

Each carries 0.5 mark.

2 Label the diagram

1. choline
2. phosphate
3. glycerol
4. hydrophilic head
5. hydrophobic tails
6. lipid bilayer

K · 3

Each carries 0.5 mark.

3 Multiple choice

i. **b.** histidine, isoleucine, leucine — K · 1

Histidine, isoleucine and leucine are three of the nine **essential** amino acids. All in the other groups are non-essential.

ii. **a.** glycolipids — K · 1

Glycolipids (lipid + carbohydrate), such as cerebrosides and gangliosides, are plentiful in myelin, the white matter. Phospholipids are in all membranes too, but they carry a phosphate, not a sugar; cholesterol is a derived lipid.

iii. **b.** its glycosidic bond uses the carbonyl carbons of both its sugars — U · 1

Sucrose's bond joins glucose's carbon 1 to fructose's carbon 2, the very carbons that carry the reducing groups, so neither sugar is left with a free one. In maltose, the second glucose's carbon 1 is still free, so it can reduce Cu^{2+}.

iv. **c.** a conjugated (chromo-) protein with quaternary structure — U · 1

Its heme, a colored prosthetic group with iron, makes hemoglobin a **conjugated protein**, a **chromoprotein**; its **four chains** (two α, two β) packed together are its **quaternary** structure. It is globular, not fibrous.

v. **b.** the pH there is about 8, far from its best pH, so its shape changes — A · 1

Each enzyme works only near its own **optimum pH**. In the alkaline small intestine (about pH 8), pepsin's shape changes and its active site no longer fits; trypsin, which works best near pH 8, takes over the digestion of protein there.

4 Very short answers

a. MARKING SCHEME — K · 1

✓ The formula $C_x(H_2O)_y$, with glucose as $C_6(H_2O)_6$.

b. MARKING SCHEME — K · 1

✓ Tryptophan.

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c. MARKING SCHEME U · 1

✓ A regular shape of part of the chain held by backbone hydrogen bonds, not the whole chain's fold held by side chains.

5 Short answers

a. MARKING SCHEME U · 2

✓ Two correct differences.
✓ Two more correct differences.

b. MARKING SCHEME U · 2

✓ Ghee: saturated, straight chains pack tightly, higher melting point.
✓ Mustard oil: unsaturated, cis double bonds bend the chains, they can't pack, lower melting point.

c. MARKING SCHEME A · 2

✓ Essential amino acids must come from food; rice is low in lysine, dal in methionine.
✓ Together each supplies what the other lacks: complementary proteins.

d. MARKING SCHEME U · 3

✓ mRNA: carries the gene's instructions to the ribosome.
✓ tRNA: brings the right amino acid to the matching codon.
✓ rRNA: forms the ribosome and joins the amino acids.

6 Numerical problems

ANSWER A · 4

i. A pairs with T, so **T = 30 %**; G + C = 100 − 60 = 40 %, so **G = C = 20 %**.
ii. 2000 pairs × 2 = 4000 bases; G = 20 % of 4000 = 800, one in each G–C pair: **800 G–C pairs**, and 1200 A–T pairs.
iii. 1200 × 2 + 800 × 3 = 2400 + 2400 = **4800 hydrogen bonds**.
iv. 2000 × 0.34 nm = **680 nm**; 2000 ÷ 10 = **200 turns**.

MARKING SCHEME

✓ T = 30 %, G = C = 20 % (Chargaff's rule).
✓ 800 G–C pairs (and 1200 A–T).
✓ 4800 hydrogen bonds.
✓ 680 nm and 200 turns.

7 Long answers

a. ANSWER U · 4

Primary: the **sequence** of amino acids in a chain, held by **peptide bonds**, set by the gene; insulin's was the first found (Sanger).
Secondary: a regular shape in parts of the chain, the **α-helix** (α-keratin of hair) or the **β-pleated sheet** (silk fibroin), held by **hydrogen bonds** between the backbone's C=O and N–H.
Tertiary: the whole chain folded into a compact 3D shape, typical of globular proteins, held by bonds between **side chains**: ionic and hydrogen bonds, hydrophobic interactions and **disulphide bonds**; e.g. ribonuclease, myoglobin.
Quaternary: two or more folded chains (subunits) fitted together, as **hemoglobin** (2 α + 2 β) and antibodies (2 heavy + 2 light chains).

MARKING SCHEME

✓ Primary: sequence, peptide bonds, an example.
✓ Secondary: α-helix and β-sheet, backbone hydrogen bonds.
✓ Tertiary: the whole chain's fold, side-chain bonds named.
✓ Quaternary: two or more chains, hemoglobin or antibody.

b. ANSWER

Starch (plants' store) is α-glucose: **amylose** an unbranched $\alpha(1\rightarrow4)$ chain that coils into a helix, **amylopectin** the same chain with $\alpha(1\rightarrow6)$ branches every 24 to 30 glucoses; compact and insoluble, it stores glucose without upsetting the cell's water.
Glycogen (animals' store, in liver and muscle) is built like amylopectin but **branched far more**, every

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8 to 12 glucoses; its many ends let enzymes add or remove glucose at many points at once, so glucose is released fast. A · 4

Cellulose (plant cell walls) is β-**glucose joined** β**(1→4)**: each unit is turned over, so the chain is **straight**; chains lie side by side and **hydrogen-bond into microfibrils**, strong fibers that our enzymes can't break.

So one sugar gives a coiled store, a fast-release store and a strong fiber, decided by α **or** β **bonds and branching**.

MARKING SCHEME

- ✓ Starch: $\alpha(1\rightarrow4)$ coiled amylose, $\alpha(1\rightarrow6)$ branched amylopectin; a store.
- ✓ Glycogen: branched every 8–12 units; many ends for fast release.
- ✓ Cellulose: $\beta(1\rightarrow4)$, straight chains hydrogen-bonded into microfibrils.
- ✓ The difference is α versus β bonds and branching, each suiting its job.

8 Think

ANSWER

HA · 3

Yes. In double-stranded DNA every G is paired with a C and every A with a T, so **G must equal C** (Chargaff's rule); here G (24 %) and C (20 %) differ, so the numbers can't come from a double strand (or they were measured wrongly).

The sample could be **single-stranded** nucleic acid, whose bases need not pair. It is not RNA, because it contains **thymine**, which RNA lacks (RNA has uracil); so it may be single-stranded DNA, as in some viruses.

To check: test for the sugar (deoxyribose or ribose) and for uracil, and measure again; a double strand must give A = T and G = C.

MARKING SCHEME

- ✓ A = T and G = C in double-stranded DNA; 24 % ≠ 20 %, so it is not a double strand.
- ✓ Thymine (not uracil) rules out RNA: single-stranded DNA, or a measuring error.
- ✓ A sensible check: the sugar, uracil, or measuring again.

9 Activity: Test foods for starch

(not marked)

WHAT STUDENTS SHOULD FIND

Rice, potato, bread and unripe banana turn **blue-black** (starch); ripe banana only a little (its starch has turned to sugar); sugar water stays brown-yellow. Cotton wool stays brown: cellulose's straight $\beta(1\rightarrow4)$ chains don't coil into a helix, and iodine colors starch by slipping inside the helix of amylose.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	11	14	11	3	**39**

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