A-LEVEL BIOLOGY • EXERCISE SHEET

2.2 Carbohydrates and lipids

Name: _____ Class: _____ Date: _____ **Total: 18 marks**

KEY WORDS polysaccharide 多糖 • glucose 葡萄糖 • triglyceride 甘油三酯 • monomer 单体 • polymer 聚合物

Objective

Build the skills to answer exam questions on **carbohydrates and lipids** — the structure of sugars and **polysaccharides** 多糖, the bonds that join them, and how **triglycerides** 甘油三酯 and **phospholipids** 磷脂 are built and used.

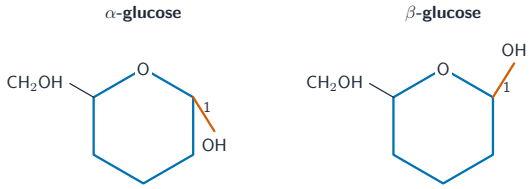
You must be able to:

- describe α-glucose and β-glucose and the **glycosidic bond** 糖苷键 formed by condensation
- relate the structures of starch, glycogen and **cellulose** 纤维素 to their functions
- describe a triglyceride (glycerol + three fatty acids, **ester bonds** 酯键) and relate it to its function
- describe a phospholipid and its hydrophilic head and hydrophobic tails

1 Worked examples

Glucose and the glycosidic bond

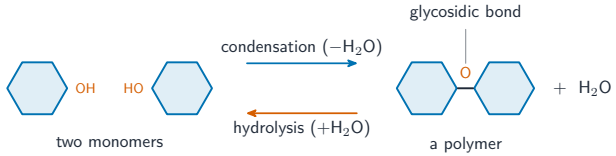
Glucose forms a ring with six carbons. The two ring forms differ only at carbon 1: in **α-glucose** the –OH points **down**; in **β-glucose** it points **up**. This small difference decides which polysaccharide can be built.



only carbon 1 differs: the OH points **down** in α, **up** in β

The two ring forms differ only at carbon 1

Two sugars join by **condensation** 缩合 — a glycosidic bond forms and **one water molecule is removed**. The reverse, **hydrolysis** 水解, adds water to break the bond.

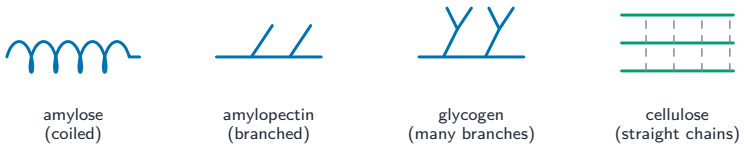


Condensation removes water to join monomers; hydrolysis adds water to split them

Polysaccharides: shape fits function

- **starch** 淀粉 (plant store) = **amylose** (unbranched, coils) + **amylopectin** (branched).
- **glycogen** 糖原 (animal store) = like amylopectin but more branched → broken down fast.
- **cellulose** = β-glucose, so chains are straight and pack into strong fibres for the cell wall.

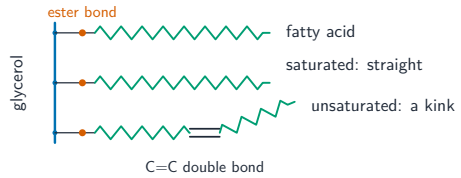
Storage polysaccharides are compact, **insoluble** 不溶 (stay in the cell) and do not change the **water potential** 水势.



Branched, coiled stores (starch, glycogen) vs straight, strong cellulose fibres

Triglycerides and phospholipids

A **triglyceride** is one **glycerol** 甘油 + three **fatty acids** 脂肪酸, joined by three ester bonds (three water molecules removed). **Saturated** 饱和 fatty acids have no C=C double bonds; **unsaturated** 不饱和 have one or more. Triglycerides are a good energy store: they release about twice the energy per gram of carbohydrate, and are insoluble.



3 ester bonds form → 3 H_2O removed (condensation)

One glycerol plus three fatty-acid tails, joined by ester bonds

A **phospholipid** has one fatty acid replaced by a **phosphate** 磷酸 group, giving a **hydrophilic** 亲水 head and two **hydrophobic** 疏水 tails — why phospholipids form membranes.

2 Practice

2.1 Name the bond formed when (a) two monosaccharides join, and (b) a fatty acid joins glycerol. [2]

2.2 State **two** ways the structure of starch suits its function as an energy store. [2]

2.3 Explain why cellulose is strong enough to support a plant cell wall. [3]

3 Exam-style questions

3.1 Which statement about α-glucose and β-glucose is correct? [1]

- **A** they are different elements
- **B** they differ in the position of an –OH group on carbon 1
- **C** β-glucose cannot form a ring
- **D** only α-glucose is a reducing sugar

3.2 How many water molecules are released when one glycerol joins three fatty acids to form a triglyceride? [1]

- **A** 1
- **B** 2
- **C** 3
- **D** 6

3.3 Which polysaccharide is made of β-glucose and forms straight chains? [1]

- **A** amylopectin
- **B** amylose
- **C** cellulose
- **D** glycogen

3.4 (a) Describe how a glycosidic bond is formed between two glucose molecules. [2]

(b) Glycogen and cellulose are both polymers of glucose, but have very different functions. Explain how their structures relate to their functions. [4]

3.5 Explain why a triglyceride is a good long-term energy store. [2]

Solutions

2.1 (a) glycosidic bond; (b) ester bond.

2.2 Any two: compact / insoluble (does not leave the cell or affect water potential) / branched so many ends for fast hydrolysis / large molecule.

2.3 β-glucose means every other glucose is flipped, so chains are long and straight; many straight chains lie side by side, held by hydrogen bonds into strong microfibrils.

3.1 B. They differ only in the position of the –OH on carbon 1.

3.2 C. Three ester bonds form, so three water molecules are released.

3.3 C. Cellulose is made of β-glucose and forms straight chains.

3.4 (a) a glycosidic bond forms by condensation, removing one water molecule.
(b) glycogen is highly branched, giving many ends for fast hydrolysis to release glucose for respiration; cellulose is straight β-glucose chains held side by side by hydrogen bonds into strong fibres that support the cell wall.

3.5 insoluble / does not affect water potential; releases about twice the energy per gram of carbohydrate.