

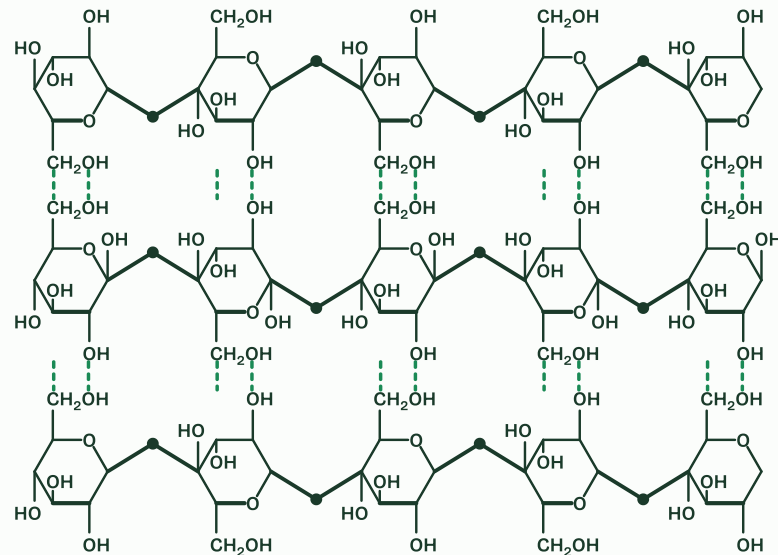
REVISION GUIDE

How sugars and fats *fuel* and build cells

Carbohydrates and lipids

Starch, wood, butter and the membrane round every cell are built from the same few atoms. Turn one OH group over and a food store becomes a plant fibre; add one double bond and a solid fat becomes an oil.

a plant fibre



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By the end you can

- ☐ Explain how carbon's four covalent bonds let it build chains, branches and rings B1.1.1
- ☐ Describe how condensation joins monomers into polymers and hydrolysis splits them, saying where the water goes B1.1.2, B1.1.3
- ☐ Tell pentoses from hexoses and alpha from beta glucose in ring diagrams, and link glucose's properties to its uses B1.1.4
- ☐ Explain how coiling, branching and size suit starch and glycogen to storing energy B1.1.5
- ☐ Explain how alternating beta glucose gives cellulose straight chains, bundled by hydrogen bonds B1.1.6
- ☐ Explain how glycoproteins let cells recognise each other, using the ABO blood groups B1.1.7
- ☐ Explain why lipids are hydrophobic, and how condensation builds triglycerides and phospholipids B1.1.8, B1.1.9
- ☐ Compare saturated, monounsaturated and polyunsaturated fatty acids and explain their melting points B1.1.10
- ☐ Explain why triglycerides suit long-term energy storage and insulation, and compare them with carbohydrates as stores B1.1.11
- ☐ Explain how amphipathic phospholipids form a bilayer in water B1.1.12
- ☐ Identify a steroid from its four rings and explain how oestradiol and testosterone cross the bilayer B1.1.13

Tick each one when you can do it without the book.

01

Chains, branches and *rings*

B1.1.1 CARBON COMPOUNDS

Every molecule in this guide is built round carbon atoms. To see why carbon is so good at it, start with how atoms join. A **covalent bond** is a pair of electrons shared by two atoms, and the shared pair holds them together.

A carbon atom has four electrons in its outer shell to share, so it can make up to four covalent bonds: four single bonds, or a **double bond** plus two single bonds. It bonds to other carbon atoms and to other non-metals: hydrogen, oxygen, nitrogen, phosphorus and sulfur.

Because carbon bonds to carbon, it builds skeletons. A **carbon compound** can have a **chain**, either unbranched, like the tail of a fatty acid, or branched; a single **ring**, like glucose; or several rings fused together, as in a steroid. Add other atoms to each skeleton and the number of possible molecules is enormous. That variety is why life, with all its forms, is built on carbon.

KEY POINTS

- Carbon makes four bonds in total, and a double bond counts as two.
- Three skeletons to recognise in a drawing: a chain (straight or branched), a single ring and fused rings.

KEY TERMS

covalent bond

A bond in which two atoms share a pair of electrons. The shared pair holds the atoms together.

double bond

Two pairs of electrons shared between the same two atoms. It uses two of a carbon atom's four bonds.

carbon compound

A molecule built on a skeleton of carbon atoms, with other atoms attached to it.

chain

A row of carbon atoms joined end to end. It is unbranched if it is a single row, and branched if a side chain comes off it.

ring

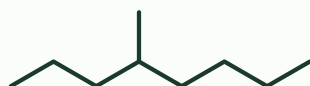
Carbon atoms (sometimes with an oxygen atom) joined in a closed loop, as in glucose.



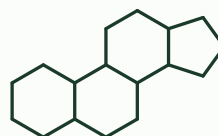
unbranched chain



one ring



branched chain

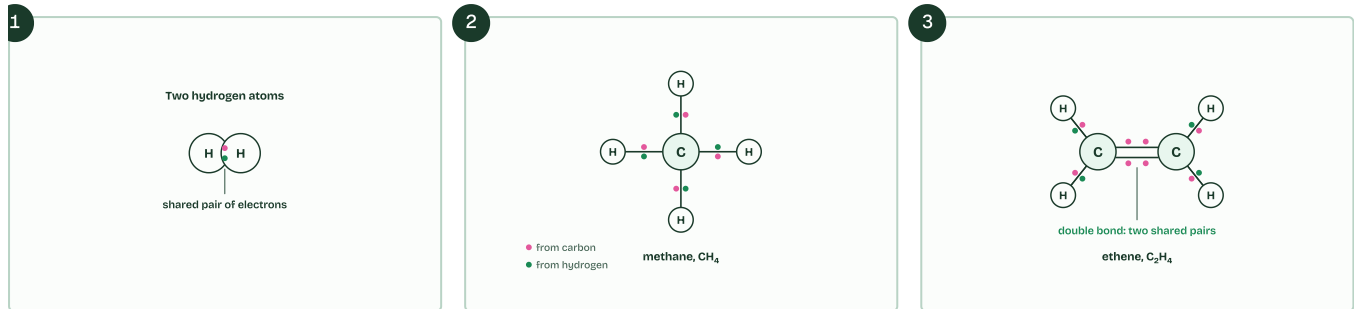


four fused rings

each corner and end is a carbon atom; hydrogens are left out

STEP BY STEP

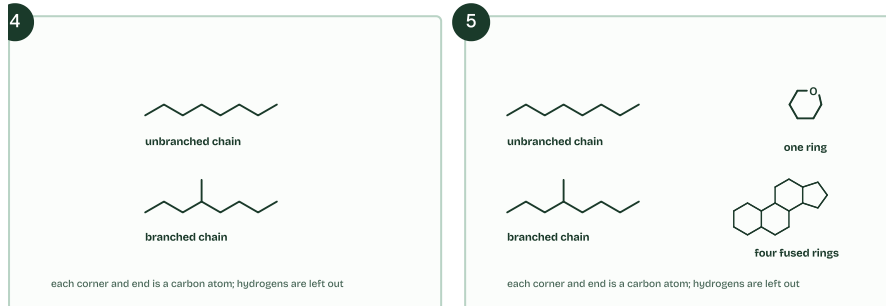
5 STEPS



A **covalent bond** is a pair of electrons shared by two atoms.

Carbon has four electrons to share, so it makes **four** bonds.

A **double bond** shares two pairs: it uses two of carbon's four.



Carbon bonds to carbon, so it builds **chains**, straight or branched,

and **rings**, one or several fused together.

kilo	k × 1000		a food label
centi	c ÷ 100		a potato, about 10 cm
milli	m ÷ 1000		the tube's bore
micro	μ ÷ 1 000 000		starch grain and red blood cell
nano	n ÷ 1 000 000 000		microfibril and glucose molecule

Five prefixes biology uses all the time, from a food label to a molecule.

kilo (k), × 1000. A food label gives energy in kilojoules (kJ). One kilojoule is a thousand joules.

milli (m), ÷ 1000. A thin glass tube used for melting point tests is about 1 mm across the bore.

nano (n), ÷ 1 000 000 000. A cellulose microfibril is about 3 nm wide. One glucose molecule is under 1 nm across.

centi (c), ÷ 100. A potato is about 10 cm long: ten centimetres.

micro (μ), ÷ 1 000 000. A starch grain from a potato cell is tens of micrometres across. A red blood cell is about 8 μm.

WHY EVERY LAB AGREES ON A NANOMETRE

Scientists can compare measurements only if a unit means the same everywhere. The SI, the international system of units, was adopted by agreement in 1960. Its prefixes scale a unit up or down in powers of ten: kilo, centi, milli, micro and nano. Biology uses all five, as the ladder below shows.

WATCH OUT

A double bond is not one bond: it uses two of carbon's four. Count it twice when you check a drawing.

PREDICT

A drawing shows a carbon atom with a double bond to an oxygen, a single bond to another carbon and single bonds to two hydrogens. What is wrong with it?

- ☐ (A) Nothing: carbon can form as many bonds as it has neighbours
- ☐ (B) It has five bonds' worth: the double bond counts as two
- ☐ (C) Oxygen can never form a double bond with carbon

Decide before you look. Answer on page 42.

02

B1.1.2 B1.1.3 CONDENSATION AND HYDROLYSIS

Water out to *build*, water in to *break*

Many of life's large molecules are **polymers**: long chains of similar small units called **monomers**. Very large molecules like these are **macromolecules**.

Monomers are joined by a **condensation reaction**. An OH group from one monomer and an H from the other leave together as a molecule of water, and a covalent bond forms between the two monomers. One water molecule is released for every bond made.

Three families of polymer are built this way. **Polysaccharides** are monosaccharides joined by **glycosidic bonds**. Polypeptides are chains of amino acids (B1.2) and nucleic acids are chains of nucleotides (A1.2).

Hydrolysis runs the other way: hydro means water and lysis means splitting. A water molecule is split, its H joins one monomer and its OH joins the other, and the bond between them breaks. Digestion is hydrolysis: it turns the polymers in food back into monomers. In the amylase lab you can watch an enzyme hydrolyse starch.

In cells, enzymes catalyse both reactions. Building polymers by condensation is part of anabolism, and breaking them down by hydrolysis part of catabolism (C1.1). Not every large molecule is a polymer: triglycerides are also made by condensation, but they are not chains of repeating units (chapter 7). Why water behaves as it does is in A1.1.

KEY TERMS

polymers

A molecule made of many similar small units, the monomers, joined in a chain by covalent bonds.

monomers

The small units that join together to make a polymer, such as a glucose molecule in starch.

macromolecules

Very large molecules, such as starch, proteins and DNA.

condensation reaction

A reaction that joins two molecules and releases a molecule of water. An OH group from one and an H from the other leave together as water.

polysaccharides

Polymers of monosaccharides: starch, glycogen and cellulose are examples.

glycosidic bonds

The covalent bond between two sugar units, with an oxygen atom bridging the two rings.

hydrolysis

A reaction that splits a molecule by adding water. The water is split: its H goes to one product and its OH to the other.

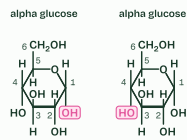


water is split: its OH goes to one end and its H to the other

STEP BY STEP

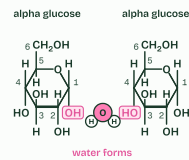
5 STEPS

1



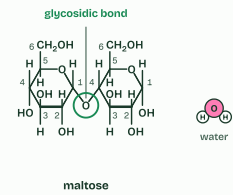
Two **monomers**: alpha glucose. Watch the OH groups that face each other.

2



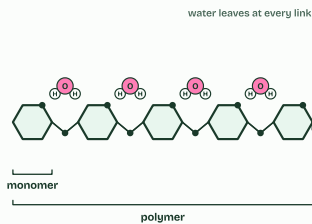
Condensation: an OH and an H leave together as a molecule of water.

3



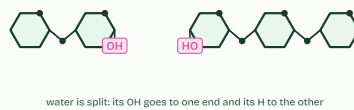
A covalent **glycosidic bond** now joins them.

4

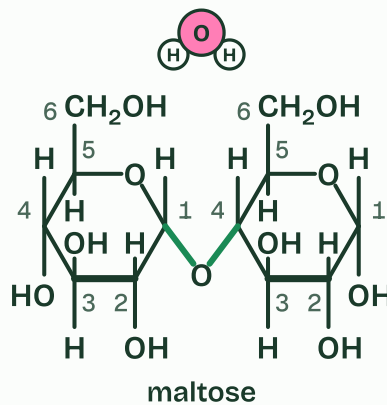


Repeat it and a chain grows: a **polymer**.
Polysaccharides, polypeptides and nucleic acids are all built like this.

5



Hydrolysis runs it backwards: water is split, its H to one monomer and its OH to the other.

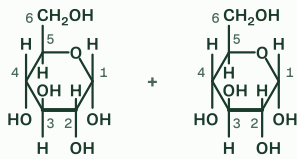


Join two alpha (α) glucose, then add a third. Then split one bond with water.

STEP BY STEP

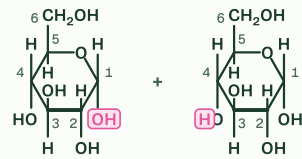
4 STEPS

1



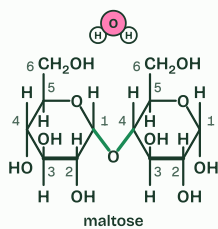
Two **alpha glucose** molecules, their carbons numbered.

2



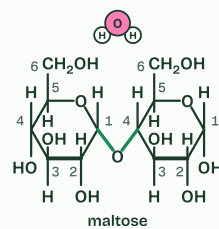
The OH on **carbon 1** of one and the H from the OH on **carbon 4** of the other face each other.

3



They leave as **water**, and a **1,4 glycosidic bond** joins the rings: **condensation**, making maltose.

4



Add water and the bond splits again, the H to one sugar and the OH to the other: **hydrolysis**.

WATCH OUT

Condensation releases water and hydrolysis uses it. And in hydrolysis the water is not simply added: it is split, and its H and OH end up in the two new ends.

PREDICT

Ten glucose molecules are joined into one unbranched chain. How many water molecules were released?

- (A) 10
(B) 11
(C) 9
(D) 20

Decide before you look. Answer on page 42.

03

B1.1.4 MONOSACCHARIDES

Glucose: small, soluble and *stable*

A **monosaccharide** is one sugar unit, the monomer of carbohydrates. In cells most monosaccharides exist as rings. They are named by their number of carbon atoms: a **pentose** has five (ribose, deoxyribose) and a **hexose** has six (glucose, fructose).

To recognise one from a ring diagram, count every carbon atom, including any outside the ring in CH_2OH groups. The ring also holds one oxygen atom, which is not a carbon.

Glucose comes in two forms with the same formula, $\text{C}_6\text{H}_{12}\text{O}_6$: **alpha (α) glucose** and **beta (β) glucose**. They are **isomers**. They differ only in the OH on carbon 1: it is below the ring in α -glucose and above it in β -glucose, on the same side as the CH_2OH . That one difference decides whether glucose is built into starch or into cellulose, as the next two chapters show.

Glucose is the sugar cells run on, and four properties explain why:

KEY POINTS

- **Soluble.** Its many OH groups form hydrogen bonds with water (A1.1), so it dissolves in cytoplasm and in blood plasma.
- **Transportable.** Dissolved in plasma, it is carried to every cell.
- **Chemically stable.** It does not react or break down by itself, so it keeps while it is stored and carried, until an enzyme acts on it.
- **Yields energy.** Oxidised in respiration to carbon dioxide and water, it releases about 16 kJ per gram (C1.2).

KEY TERMS

monosaccharide

A single sugar unit, the monomer of carbohydrates. Glucose, fructose and ribose are monosaccharides.

pentose

A monosaccharide with five carbon atoms, such as ribose and deoxyribose.

hexose

A monosaccharide with six carbon atoms, such as glucose and fructose.

alpha (α) glucose

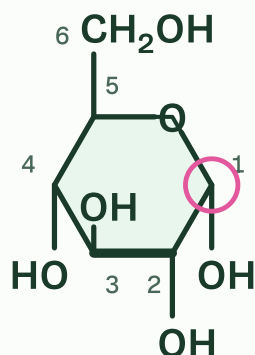
The form of glucose with the OH on carbon 1 below the ring, opposite the CH_2OH group. It makes starch and glycogen.

beta (β) glucose

The form of glucose with the OH on carbon 1 above the ring, on the same side as the CH_2OH group. It makes cellulose.

isomers

Molecules with the same atoms arranged differently, so they have the same formula but different structures.



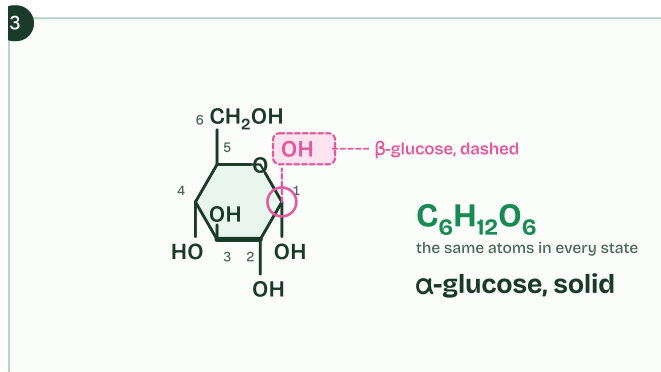
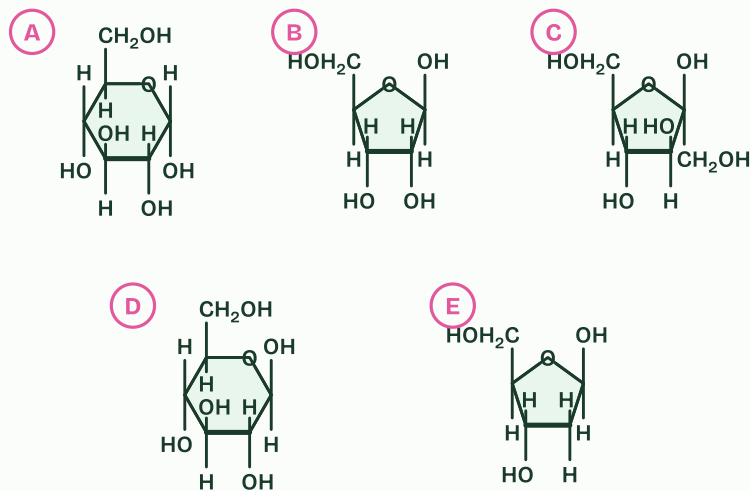
the same atoms in every state

α -glucose

One glucose ring, with carbon 1 ringed in pink. Switch between the two forms, or lay one over the other.

SWITCH IT

3 SETTINGS

 **α -glucose** **β -glucose****Both**

Count every carbon, the ones outside the ring too. The ring itself holds one oxygen.

α -glucose A hexose: six carbons, five in the ring and one in the CH_2OH group. It is the sugar dissolved in your blood, the one cells use for energy.

Fructose A hexose: six carbons, four in the ring and two in CH_2OH groups outside it. It is found in fruit and, joined to glucose, in sucrose.

Deoxyribose A pentose: five carbons, like ribose, but with an H where ribose has an OH on carbon 2. It is the sugar in DNA.

Ribose A pentose: five carbons, four in the ring and one in the CH_2OH group. It is the sugar in RNA.

β -glucose A hexose: the same six carbons as sugar A, but the OH on carbon 1 points the other way. Its units make up cellulose.

SWITCH IT

2 SETTINGS

1

Plain

2

Number the carbons

REMEMBER IT

ABBA: which way carbon 1's OH points

A Alpha	B Beta
Below the OH on carbon 1 points down, away from the CH ₂ OH	Above the OH on carbon 1 points up, on the same side as the CH ₂ OH

REMEMBER IT

Why glucose is the sugar on the move

S Sweet	T Treats	S Stay	E Energetic
Soluble its OH groups hydrogen-bond with water	Transportable dissolved, it travels in blood plasma	Stable it keeps until an enzyme acts on it	Energy yield oxidised in respiration, it releases energy

WATCH OUT

α -glucose and β -glucose are not different sugars with different formulas. Both are $C_6H_{12}O_6$: only the OH on carbon 1 differs.

PREDICT

Sugar C in the second figure has a five-sided ring. Is it a pentose or a hexose?

- (A) A hexose: four ring carbons and two outside it make six
- (B) A pentose: a five-cornered ring means five carbons in all
- (C) Neither: you cannot tell without its molecular formula

Decide before you look. Answer on page 42.

04

B1.1.5 STARCH AND GLYCOGEN

Starch and glycogen: energy packed *tight*

Plants store energy as **starch** and animals (and fungi) store it as **glycogen**. Both are polymers of α -glucose, built by condensation.

Starch is a mixture of two polysaccharides. **Amylose** is an unbranched chain that coils into a helix. **Amylopectin** is a coiled chain with **branches** coming off it. Glycogen is built like amylopectin, but it branches far more often.

Coiling and branching make both stores compact: a great deal of glucose in a small space. Starch is packed into grains inside plant cells, and glycogen into granules in liver and muscle cells.

Each molecule is also huge, thousands to tens of thousands of glucose units, so it barely dissolves. Being relatively insoluble, a store stays where it is put. It does not draw water into the cell, as the same glucose dissolved in the cytoplasm would (osmosis, B2.1).

α -glucose is easy to add by condensation, to build the store, and easy to take off by hydrolysis, to use it. Enzymes do both at the ends of the chains, one glucose unit at a time.

KEY TERMS

starch

The energy store of plants: a mixture of amylose and amylopectin, both polymers of α glucose.

glycogen

The energy store of animals and fungi: a highly branched polymer of α glucose, found in liver and muscle cells.

amylose

An unbranched chain of α glucose that coils into a helix. One of the two polysaccharides in starch.

amylopectin

A chain of α glucose that coils and also has branches. The other polysaccharide in starch.

branches

Side chains of glucose units coming off the main chain of a polysaccharide.

working ends: 1



○ one glucose unit ● a working end, where glucose goes on or comes off

real molecules: thousands of glucose units

Each bead is one glucose unit. Switch between the three stores and compare their shapes and their ends.

SWITCH IT

3 SETTINGS

1

working ends: 1

○ one glucose unit ● a working end, where glucose goes on or comes off
real molecules: thousands of glucose units

Amylose

2

working ends: 5

○ one glucose unit ● a working end, where glucose goes on or comes off
real molecules: thousands of glucose units

Amylopectin

3

working ends: 18

○ one glucose unit ● a working end, where glucose goes on or comes off
real molecules: thousands of glucose units

Glycogen

ANIMATION · WATCH IT HAPPEN: BUILDING AND USING A STORE

4 MOMENTS

1

WATER RELEASED: 1

Glucose units join one at a time; a **water** molecule leaves at each link.

2

ENDS: 1

Amylose **coils** into a helix: a lot of glucose in a small space.

3

ENDS: 18

Amylopectin and glycogen **branch**, so they have many ends.

4

ENDS: 8, GLUCOSE RELEASED: 43

Enzymes take glucose off the **ends**, using a water molecule each time.

Watch it move, and change it as it runs: biologybybradford.com/guides/ib-biology-b1-1-carbohydrates-and-lipids#stores

WATCH OUT

Insoluble does not mean hydrophobic. Starch and glycogen are covered in OH groups: they barely dissolve because each molecule is so large.

EXAMPLE

A potato tuber is roughly a sixth starch by mass. An adult human liver holds about 100 g of glycogen and the muscles about 400 g more, roughly a day's energy.

PREDICT

An amylose molecule and a glycogen molecule hold the same number of glucose units. A sprinter's muscles suddenly need glucose. Which store can release it faster?

- ☐ (A) Amylose: its single coiled chain is easier for enzymes to unwind
- ☐ (B) Both the same: they hold the same number of glucose units
- ☐ (C) Glycogen: its many branches give enzymes many ends to work on

Decide before you look. Answer on page 42.

05 Turn every other glucose over and the chain runs *straight*

Cellulose is an unbranched polymer of β -glucose and the main material of plant **cell walls**. β -glucose does not join to itself the way α -glucose does. Try it in the bond builder under this chapter, then read on.

In β -glucose the OH on carbon 1 points up, but the OH on carbon 4 points down. To join two of them, the second must be turned over, so in the chain each unit is upside down compared with the one before it: alternate units point opposite ways.

The alternation keeps the chain straight rather than coiled. Straight chains lie side by side, and OH groups on neighbouring chains form **hydrogen bonds** that cross-link them into bundles called **microfibrils**.

One hydrogen bond is weak, but there are thousands along every chain, and together they make a microfibril very strong when pulled: it has high **tensile strength**. In a cell wall, layers of microfibrils lie at different angles. The wall resists the pressure of the cell's contents and helps hold the plant up (D2.3).

Few organisms make an enzyme for the β links, and humans do not, so cellulose passes through us as fibre. Amylase cannot hydrolyse it (C1.1).

KEY TERMS

cellulose

An unbranched polymer of beta glucose, and the main material of plant cell walls.

cell walls

The tough layer outside the plasma membrane of a plant cell. Its main material is cellulose.

hydrogen bonds

Weak attractions between a slightly positive hydrogen and a slightly negative atom such as oxygen on a neighbouring molecule or chain (A1.1).

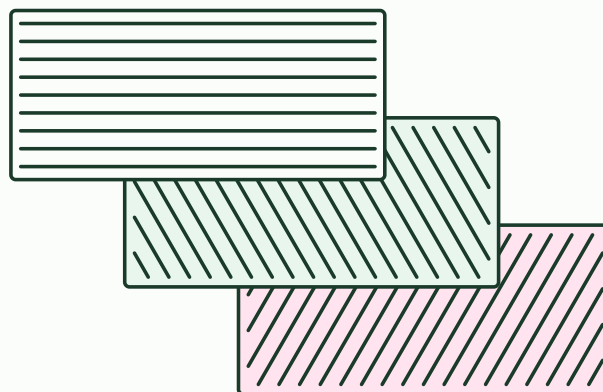
microfibrils

Bundles of cellulose chains held together by hydrogen bonds. They are very strong when pulled.

tensile strength

How much pulling force a material can withstand before it breaks.

cell wall, cut away



each layer: microfibrils side by side, all in one direction

STEP BY STEP

6 STEPS

1

Two **beta glucose** molecules. Their OH groups point opposite ways.

2

Turn one **over** and they can join: water leaves and a bond forms.

3

Every other unit is turned over, so the chain runs **straight**.

4

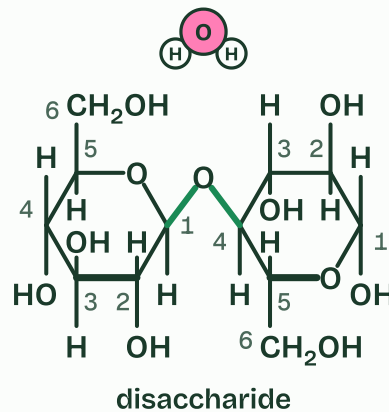
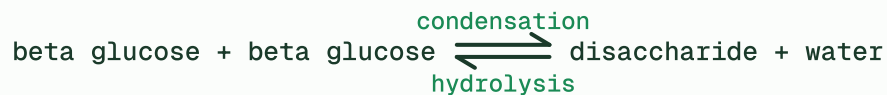
Neighbouring chains are linked by many **hydrogen bonds**.

5

Bundles of chains form **microfibrils**.

6

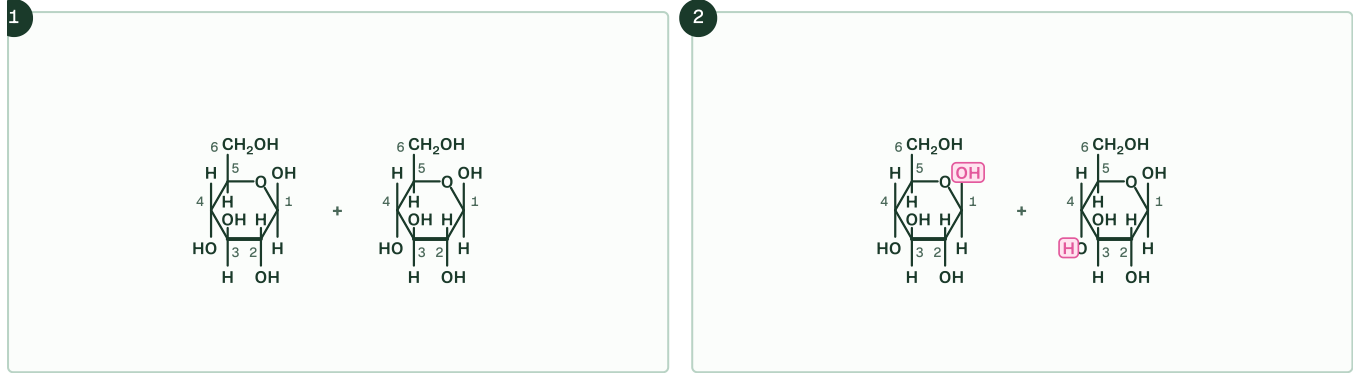
Layers of microfibrils give the **cell wall** its strength.



Try to join them. What has to change?

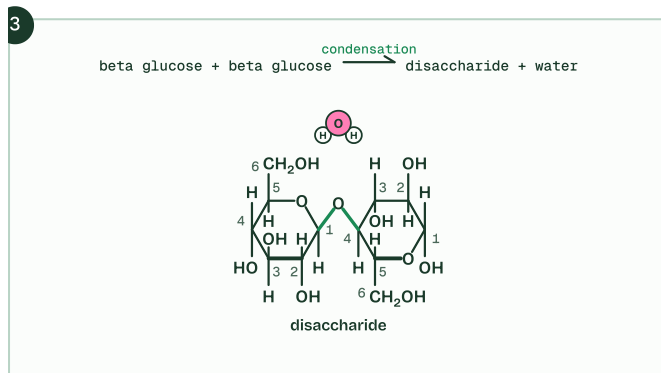
STEP BY STEP

4 STEPS

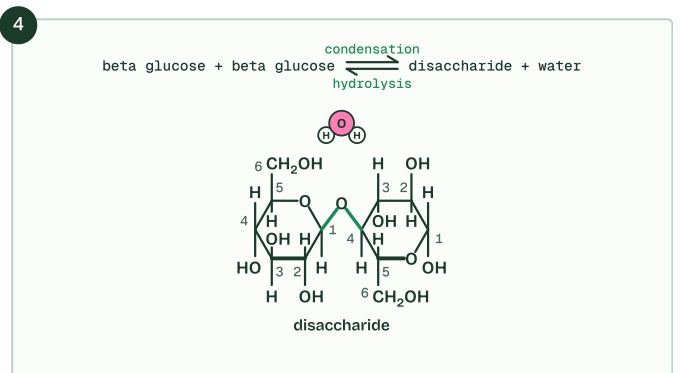


Two **beta glucose** molecules, their carbons numbered.

The OH on **carbon 1** of one points up, and the OH on **carbon 4** of the other points down: they cannot meet.



Turn the second over and they meet. They leave as **water**, and a **1,4 glycosidic bond** joins the rings, as in **cellulose: condensation**.



Add water and the bond splits again, the H to one sugar and the OH to the other: **hydrolysis**.

WHERE IT LEADS

Because cellulose is so hard to break down, wood and peat store carbon for centuries or longer, and coal formed from ancient plant matter. Stores like these are carbon sinks (C4.2, D4.3).

WATCH OUT

Cellulose is the plant's structure, not its energy store: it is built to stay in the wall.

PREDICT

Cellulose chains lie side by side in bundles. What holds neighbouring chains together?

- (A) Glycosidic bonds between the glucose units of neighbouring chains
- (B) Hydrogen bonds between OH groups on neighbouring chains
- (C) Ionic bonds between charged groups on neighbouring chains

Decide before you look. Answer on page 42.

06

B1.1.7 GLYCOPROTEINS

Sugar name tags on the cell *surface*

A **glycoprotein** is a protein with carbohydrate chains attached. In the plasma membrane the protein sits in the membrane and its sugar chains face outwards, away from the cell.

Carbohydrate chains can differ in which monosaccharides they contain, in the order of those sugars and in how the chain branches, so they can take a huge number of forms. That makes them good identity tags, and other cells read them: this is **cell-cell recognition**. Cells of one tissue recognise each other and stick together, and immune cells tell the body's own cells from foreign ones.

The ABO blood groups are the standard example. Red blood cells carry a short sugar chain on glycoproteins in their membrane. In group O the chain ends at its base. Group A cells add one extra sugar to its tip, group B cells add a different extra sugar, and group AB cells carry both kinds, on different chains. The A and B forms are **antigens**. A person whose cells lack one of them treats it as foreign, which is why transfused blood must match the recipient's group (the antibody side is C3.2).

Which extra sugar a person adds depends on the alleles they inherit, I^A , I^B and i (D3.2). Glycoproteins also take part in the structure of the plasma membrane (B2.1).

KEY TERMS

glycoprotein

A protein with carbohydrate chains attached to it. In the plasma membrane its carbohydrate chains face outwards.

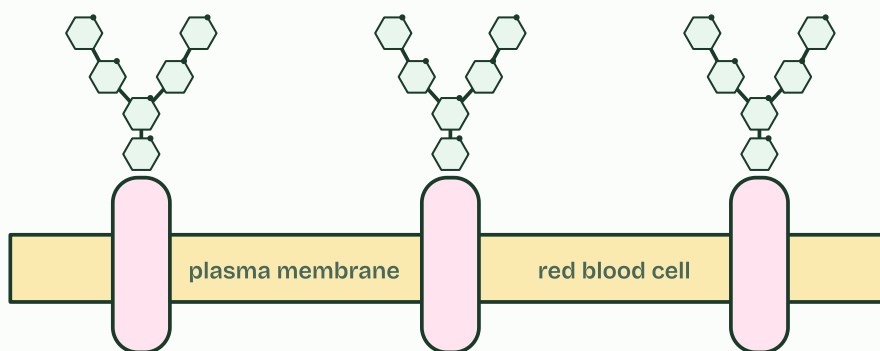
cell-cell recognition

One cell identifying another by the molecules on its surface, such as the sugar chains of glycoproteins.

antigens

Molecules that the immune system can recognise. The A and B sugars on red blood cells are antigens.

outside the cell



inside the cell

Part of a red blood cell membrane. Pick a blood group, then tap the tips of the sugar chains.

Protein part Through the membrane.

A antigen One extra sugar on the tip of the chain. (The sugar is N-acetylgalactosamine.)

A antigen One extra sugar on the tip of the chain. (The sugar is N-acetylgalactosamine.)

No A or B sugar This chain stops at its base. (Its last sugar is fucose.)

B antigen A different extra sugar on the tip of the chain. (The sugar is galactose.)

No A or B sugar This chain stops at its base. (Its last sugar is fucose.)

A antigen One extra sugar on the tip of the chain. (The sugar is N-acetylgalactosamine.)

B antigen A different extra sugar on the tip of the chain. (The sugar is galactose.)

No A or B sugar This chain stops at its base. (Its last sugar is fucose.)

B antigen A different extra sugar on the tip of the chain. (The sugar is galactose.)

No A or B sugar This chain stops at its base. (Its last sugar is fucose.)

B antigen A different extra sugar on the tip of the chain. (The sugar is galactose.)

Protein part Through the membrane.

A antigen One extra sugar on the tip of the chain. (The sugar is N-acetylgalactosamine.)

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Protein part Through the membrane.

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B antigen A different extra sugar on the tip of the chain. (The sugar is galactose.)

No A or B sugar This chain stops at its base. (Its last sugar is fucose.)

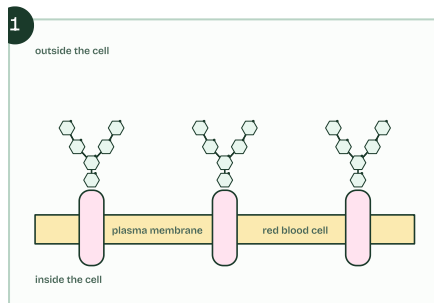
B antigen A different extra sugar on the tip of the chain. (The sugar is galactose.)

No A or B sugar This chain stops at its base. (Its last sugar is fucose.)

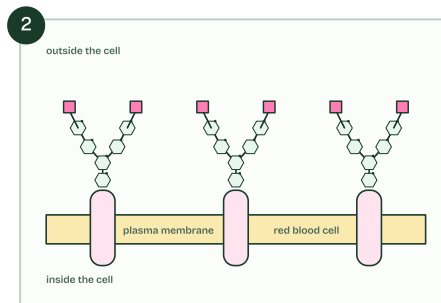
B antigen A different extra sugar on the tip of the chain. (The sugar is galactose.)

SWITCH IT

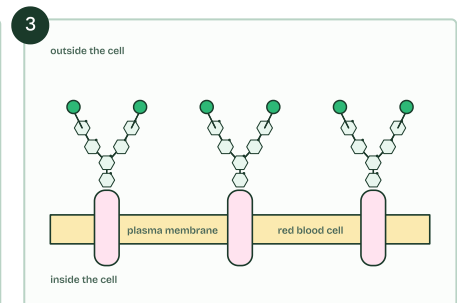
4 SETTINGS



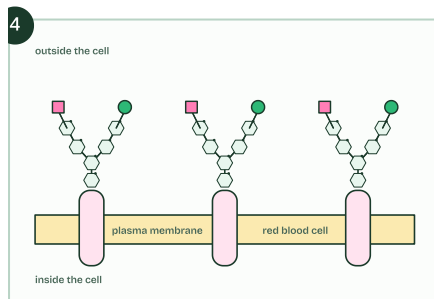
O



A



B



AB

WATCH OUT

Group O cells are not bare. They carry the same base sugar chain: they only lack the extra A or B sugar on its tip.

PREDICT

What makes a group A red blood cell different from a group B one?

- (A) Its membrane holds a completely different kind of protein
- (B) Group A cells keep their nuclei and group B cells lose theirs
- (C) One different sugar at the tip of each sugar chain

Decide before you look. Answer on page 42.

07

B1.1.8

B1.1.9

LIPIDS, TRIGLYCERIDES AND PHOSPHOLIPIDS

Lipids keep their distance from *water*

Lipids are substances made by living things that dissolve in **non-polar solvents**, such as hexane, but only sparingly in water. They are grouped by this behaviour, not by a shared monomer. Lipids include **fats, oils, waxes** and steroids.

The reason is in their atoms. Lipids are mostly carbon and hydrogen, and C–H bonds are non-polar, so there are no partial charges for water to attract (A1.1). Water molecules stay bonded to each other and push the lipid out into droplets or a separate layer: lipids are **hydrophobic**. Wax on a leaf and oil on a feather keep water off for this reason. A wax is a fatty acid joined to a long-chain alcohol, and its long hydrocarbon chains make a waterproof coat, as on a leaf surface or in beeswax.

Fats and oils are mostly **triglycerides**: one **glycerol** (three carbons, each with an OH group) joined to three **fatty acids**. A fatty acid is a hydrocarbon chain with a **carboxyl group**, COOH, at one end. Each one joins glycerol by condensation: the OH of the carboxyl group and the H of one of glycerol's OH groups leave as water, and an **ester bond** forms. Three fatty acids mean three ester bonds and three molecules of water.

A **phospholipid** is glycerol joined to two fatty acids and one **phosphate group**, also by condensation. (In most phospholipids a further small polar group is attached to the phosphate, which we leave out.)

A triglyceride is not a polymer: it is three fatty acids on one glycerol, not a chain of repeating units.

KEY TERMS

lipids

Substances made by living things that dissolve in non-polar solvents such as hexane but only sparingly in water. Fats, oils, waxes and steroids are lipids.

non-polar solvents

Solvents such as hexane whose molecules have no partial charges. Lipids dissolve in them.

fats

Lipids, mostly triglycerides, that are solid at room temperature.

oils

Lipids, mostly triglycerides, that are liquid at room temperature.

waxes

Lipids that form a waterproof coating, such as the wax on a leaf.

hydrophobic

Not attracted to water. Non-polar substances such as lipids are hydrophobic.

triglycerides

Lipids made of one glycerol molecule joined to three fatty acids by ester bonds.

glycerol

A small molecule of three carbon atoms, each with an OH group, that fatty acids join to.

fatty acids

Molecules with a long hydrocarbon chain and a carboxyl group at one end.

carboxyl group

The group COOH, found at one end of a fatty acid. It is the part that joins to glycerol.

ester bond

The covalent bond between a fatty acid and glycerol, formed by condensation.

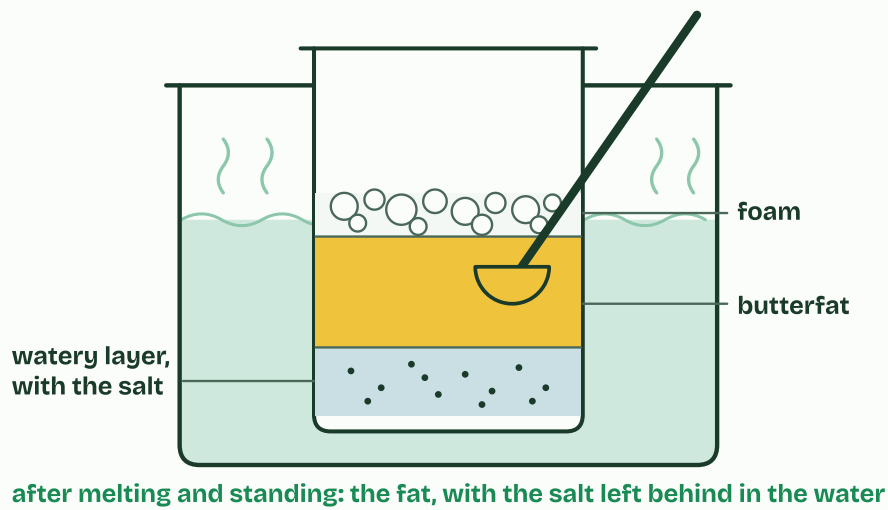
phospholipid

A lipid made of glycerol joined to two fatty acids and one phosphate group.

phosphate group

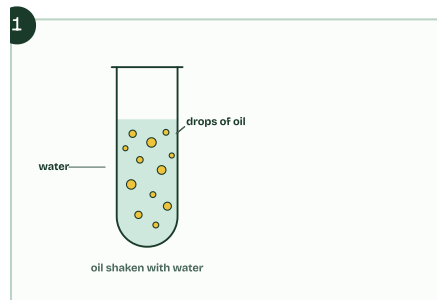
A group of one phosphorus atom and four oxygen atoms. It carries

a negative charge and attracts water.

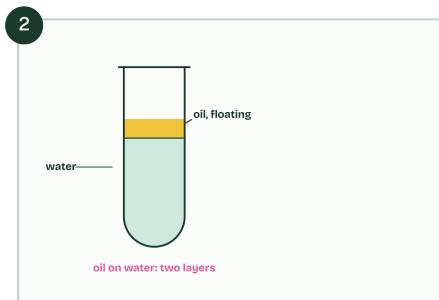


STEP BY STEP

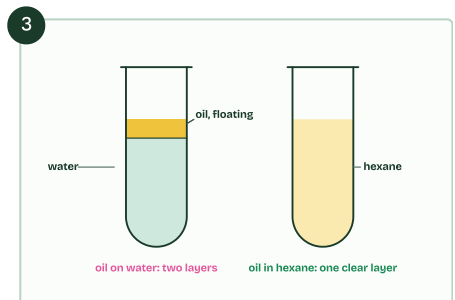
5 STEPS



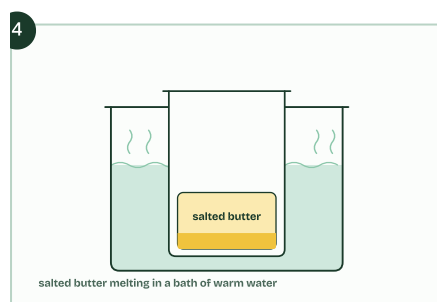
Shake oil with **water**,



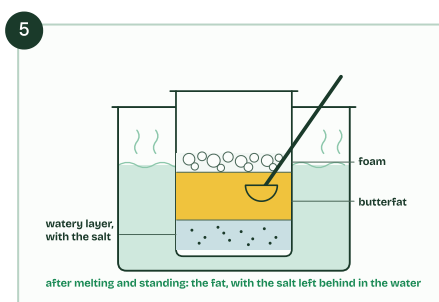
and it separates and floats: it does not dissolve.



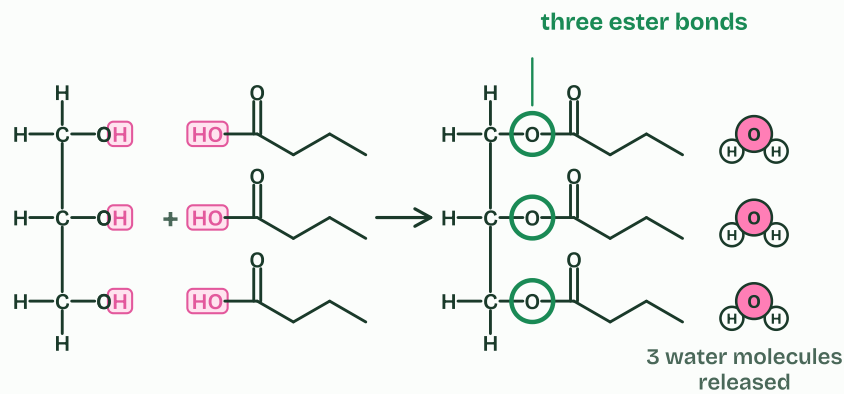
In a **non-polar solvent** such as hexane, it dissolves.



Butter is mostly fat, with some water and, in salted butter, salt.



Melted, the **fat** separates from the watery layer, and the salt stays dissolved in the water.

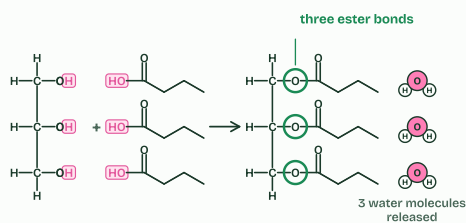


chains drawn short: most real fatty acids have 14 to 20 carbons

Each join releases one water molecule: an OH from the acid group and an H from glycerol. Switch between the two products and count the waters.

SWITCH IT

1



chains drawn short: most real fatty acids have 14 to 20 carbons

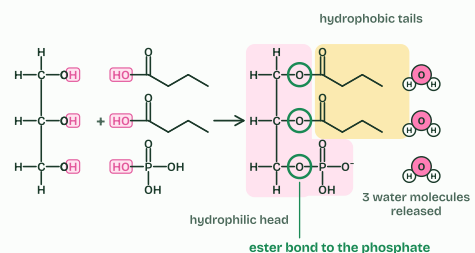
Triglyceride

WATCH OUT

A fat is not a chain of “fat molecules”, and it is not a polymer: it is one glycerol carrying three fatty acids.

2 SETTINGS

2



chains drawn short: most real fatty acids have 14 to 20 carbons

Phospholipid

PREDICT

You have salted butter but need it unsalted. What could you do?

- (A) Stir it into plenty of water and filter the salt out of the butter
- (B) Melt it, leave it to settle, then pour the fat off the water
- (C) Heat it hard until the salt evaporates and only the fat is left

Decide before you look. Answer on page 42.

08

B1.1.10 SATURATED AND UNSATURATED FATTY ACIDS

Every double bond puts a kink in the *tail*

The hydrocarbon tail of a fatty acid may or may not contain C=C double bonds. A **saturated** fatty acid has none: each carbon holds as many hydrogen atoms as it can, so the chain is saturated with hydrogen. An **unsaturated** fatty acid has at least one C=C. With one it is **monounsaturated**, and with two or more it is **polyunsaturated**.

In natural fatty acids the double bonds are almost all **cis**: the chain continues on the same side at both ends of the double bond, so it bends there, by about 30°. Every double bond puts one more kink in the tail. (A trans double bond, made when oils are partially hydrogenated, leaves the chain almost straight, so trans fats pack and melt much like saturated ones.)

Kinks decide the **melting point**. Straight saturated chains pack closely side by side, so the attractions between neighbouring molecules are strong and more heat is needed to pull them apart: a higher melting point, and a fat that is solid at room temperature. Kinked chains cannot pack closely, the attractions are weaker and the melting point is lower: an oil, liquid at room temperature. The more double bonds, the lower the melting point. Melting only separates whole molecules from each other. No covalent bond breaks.

The guidance asks about plants and endotherms. A plant is the temperature of its surroundings, and its seeds may sit in cold soil, so plants store oils rich in unsaturated fatty acids. These stay liquid when cold, so the store can still be used. An **endotherm** keeps its body warm, about 37 °C in a mammal, so its fat can hold a far larger share of saturated fatty acids: often a third to a half, against about a tenth in plant oils. Solid at room temperature, it is still soft at body temperature.

The rule is really about temperature. Tropical plants such as coconut and cocoa store more saturated fat, which is liquid in the tropics, and fish in cold seas, which are not endotherms, store very unsaturated oils.

KEY TERMS

saturated

A fatty acid with no C=C double bonds in its chain. Every carbon holds as many hydrogen atoms as it can.

unsaturated

A fatty acid with at least one C=C double bond in its chain.

monounsaturated

A fatty acid with one C=C double bond.

polyunsaturated

A fatty acid with two or more C=C double bonds.

cis

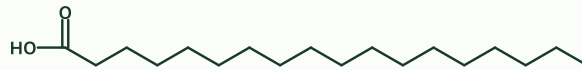
A double bond with the two parts of the chain on the same side of it, so the chain bends there.

melting point

The temperature at which a solid turns to a liquid.

endotherm

An animal that keeps its body warm with heat made inside it, such as a bird or a mammal.



stearic acid
no C=C

packs closely
six copies



Coral marks each C=C double bond. Under each fatty acid, six copies of it packed as they would sit in a fat or oil.

SWITCH IT

3 SETTINGS

1 stearic acid no C=C packs closely six copies	2 oleic acid one C=C packs loosely six copies	3 linoleic acid two C=C packs very loosely six copies
Saturated	Monounsaturated	Polyunsaturated

REMEMBER IT

Why unsaturated fats are oils

D Double	K Kinks	L Leave	L Liquids
C=C double bond one in a monounsaturated chain, two or more in a polyunsaturated one	Kinked chain each cis double bond bends the chain	Loose packing bent chains cannot lie close, so they attract each other less	Lower melting point less heat separates them: an oil at room temperature

WATCH OUT

Melting does not break double bonds or any other covalent bond: it separates whole molecules.

WATCH OUT

Saturated means saturated with hydrogen, not with fat.

PREDICT

Olive oil's fatty acids are mostly monounsaturated, and ordinary sunflower oil's are mostly polyunsaturated. Both are liquid at room temperature. You put a bottle of each in the fridge at 5 °C. Which turns cloudy and thick?

- ☐ (A) Sunflower oil: its chains have more double bonds, so it freezes first
- ☐ (B) Olive oil: fewer double bonds per chain, so a higher melting point
- ☐ (C) Neither: oils are liquid fats and never go solid, however cold

Decide before you look. Answer on page 43.

09

B1.1.11 ADIPOSE TISSUE

Fat: the lightest way to carry *energy*

Adipose tissue is made of cells that each hold a large droplet of triglyceride, under the skin and round organs. Four properties suit triglycerides to long-term energy storage.

KEY POINTS

- **Energy dense.** Fat releases about twice the energy of carbohydrate for the same mass: about 37 kJ a gram, against about 17 kJ.
- **Stored without water.** Triglycerides are hydrophobic, so fat is stored dry. Glycogen is stored with about three times its own mass of water, so the same energy in fat weighs several times less. That matters to anything that moves, flies or migrates.
- **Insoluble.** Even a large store has no osmotic effect on the cell.
- **Chemically stable.** Fat keeps for months.

Why keep glycogen at all? Glucose can be released from glycogen quickly, carried in the blood and respired with or without oxygen. Fat is mobilised more slowly, and fatty acids are respired only with oxygen. Glycogen suits quick, short-term needs, and fat the long term.

Triglycerides also give **thermal insulation**. Fat conducts heat only about half as well as muscle. An **endotherm** loses heat to colder surroundings faster the bigger the difference, and far faster in water than in air (A1.1, the ringed seal). So endotherms in cold habitats, above all in polar seas, have thick layers of fat called **blubber**, and tropical mammals have thin ones. An ectotherm makes too little heat for insulation to be worth much.

KEY TERMS**adipose tissue**

Tissue made of cells that each hold a large droplet of triglyceride, under the skin and round organs.

thermal insulation

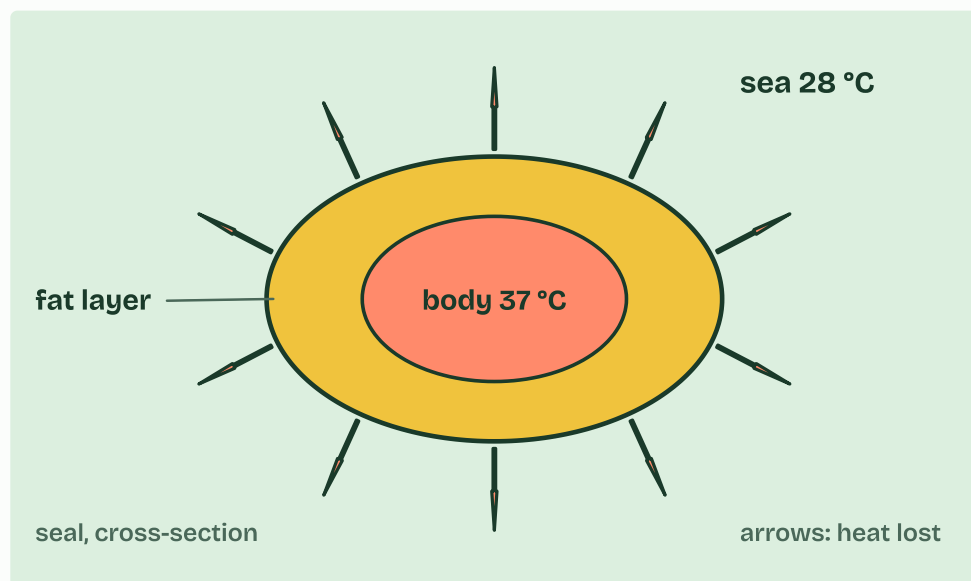
A layer that slows the loss of heat from the body.

endotherm

An animal that keeps its body warm with heat made inside it, such as a bird or mammal.

blubber

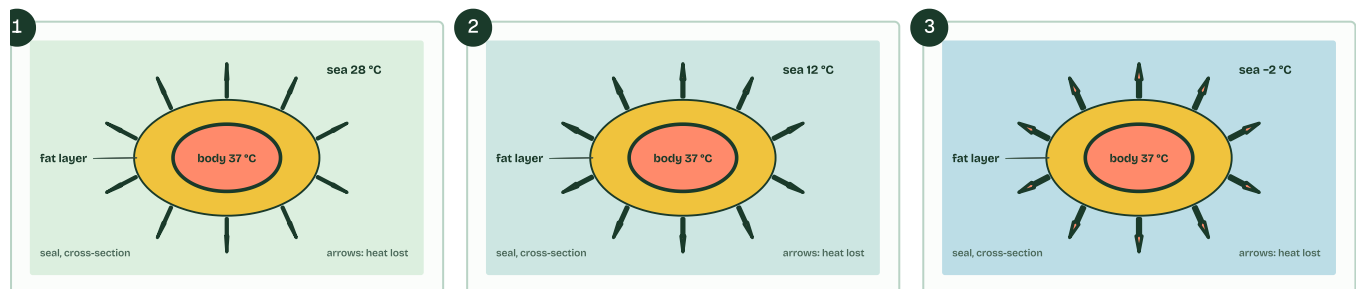
The thick layer of fat under the skin of seals and whales. It insulates them in cold water.



The wider the arrow, the faster the heat leaves. Change the sea, then thicken the fat.

SWITCH IT

3 SETTINGS



Tropical sea 28 °C

Temperate sea 12 °C

Polar sea -2 °C

WHY MORE ENERGY A GRAM?

A fatty acid chain is almost all C–H bonds, with very little oxygen, so there is more to oxidise. Glucose already carries an oxygen on almost every carbon: it is partly oxidised before respiration starts (C1.2).

CARBOHYDRATE OR LIPID?

How the two stores compare.

	Glycogen	Triglyceride
Energy per gram	about 17 kJ	about 37 kJ
Water stored with it	about 3 g for every gram	none
Release	quick	slower
Respired without oxygen	yes, as glucose	no
Usual role	short-term store in animals	long-term store, insulation

WATCH OUT

Not every carbohydrate store is short-term. Plants keep starch for months in seeds and tubers: “short-term” describes glycogen in animals.

EXAMPLE

A camel's hump is fat, not water.

PREDICT

A seal and a cod swim in the same polar sea. Which needs a thick layer of fat to insulate it?

- (A) The seal: its body stays near 37 °C, much warmer than the water
- (B) The cod: it is far smaller than the seal, so it loses heat faster
- (C) Both equally: they swim in the same water at the same temperature

Decide before you look. Answer on page 43.

10

Half loves *water*, half does not

B1.1.12 THE PHOSPHOLIPID BILAYER

A phospholipid is **amphipathic**: one part of the molecule is attracted to water and another part is not. The phosphate group carries a negative charge and attracts water, and with the glycerol it forms the **hydrophilic head**. The two fatty acid tails are non-polar, so they are the **hydrophobic tails**.

In water, phospholipids arrange themselves so that their tails avoid water and their heads touch it. The result is two layers, with the tails pointing inwards and the heads facing the water on both sides: a **phospholipid bilayer**.

Nothing places the molecules. No enzyme arranges them and no energy is spent: the bilayer is simply what happens when molecules with hydrophilic and hydrophobic regions meet water. Its core is hydrophobic, so it is a barrier to ions and polar molecules (chapter 11 and B2.1), and it is the basis of every cell membrane (B2.1).

KEY TERMS

amphipathic

Having one part that is attracted to water and another part that is not.

hydrophilic head

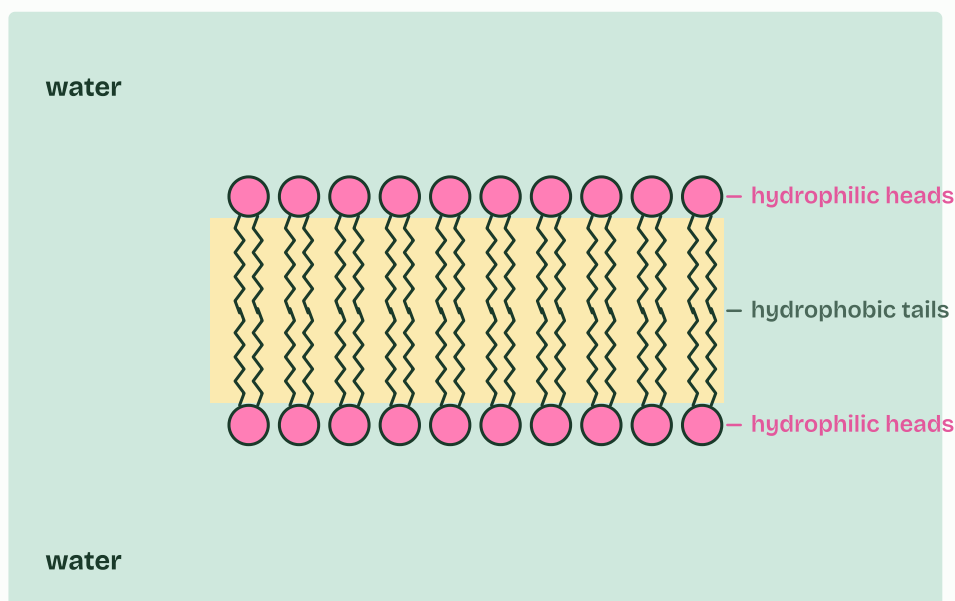
The part of a phospholipid that is attracted to water: the phosphate group and glycerol.

hydrophobic tails

The two fatty acid chains of a phospholipid. They are non-polar and are pushed away by water.

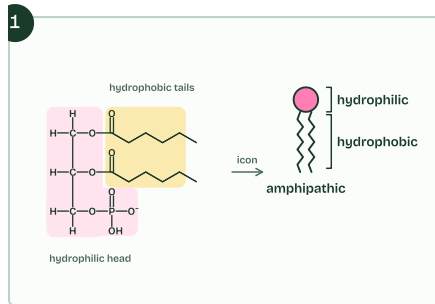
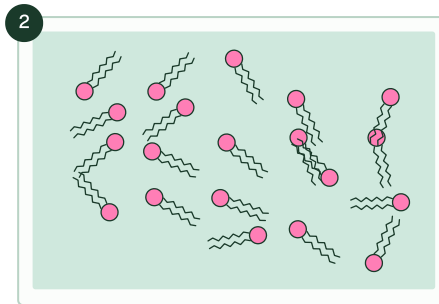
phospholipid bilayer

A double layer of phospholipids, with the hydrophobic tails inside and the hydrophilic heads facing the water on both sides.

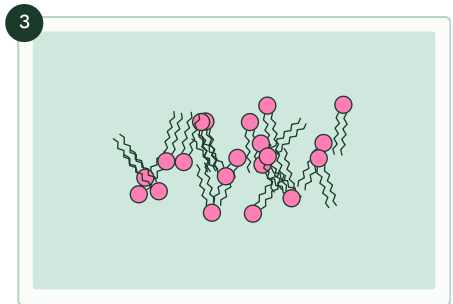


STEP BY STEP

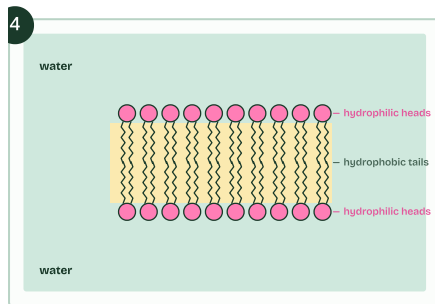
4 STEPS

One molecule, two natures: **amphipathic**.

Mixed into water,

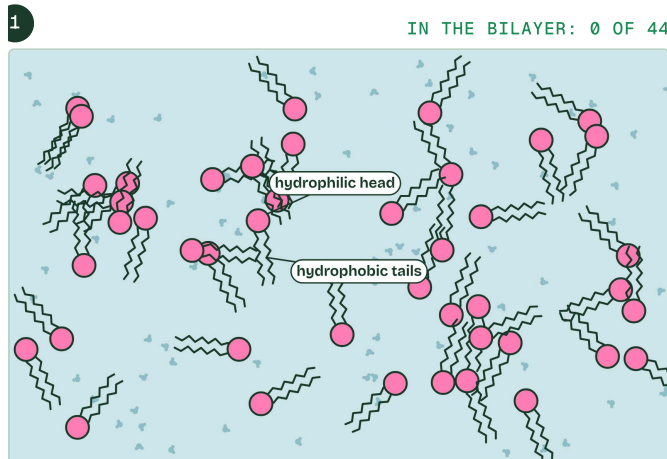


the tails turn away from water and the heads face it,

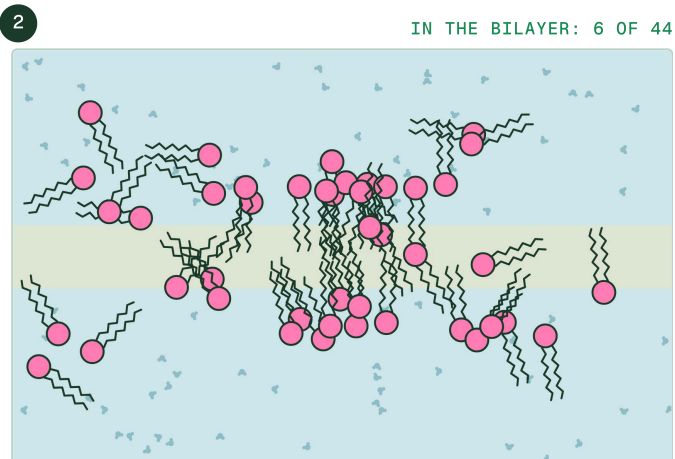
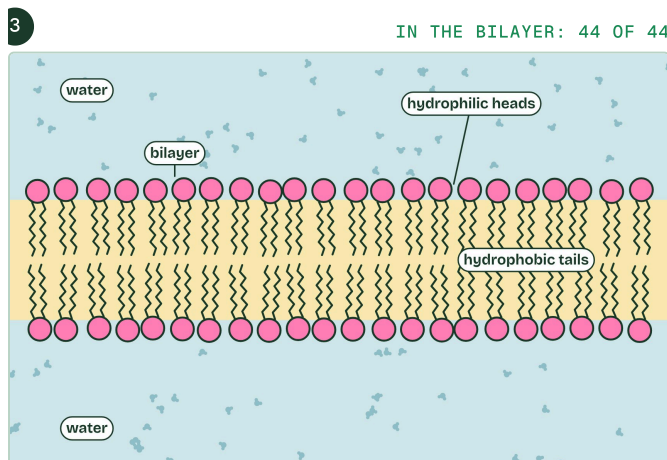
forming a **bilayer**, with water on both sides.

ANIMATION · WATCH IT HAPPEN: A BILAYER BUILDS ITSELF

3 MOMENTS



Phospholipids stirred into water point every which way.

The tails cannot form hydrogen bonds with water, so water crowds the **tails** together.No enzyme placed them and no energy was spent: **water** arranged them.Watch it move, and change it as it runs: biologybybradford.com/guides/ib-biology-b1-1-carbohydrates-and-lipids#bilayer

WATCH OUT

Cells do not build the bilayer by placing each phospholipid with an enzyme. Once the molecules are made, water arranges them.

PREDICT

Phospholipids are stirred into a beaker of water, well below the surface. What do they form?

- Ⓐ A solid clump with the heads hidden inside and the tails facing the water
- Ⓑ Nothing: they all dissolve as separate molecules in the water
- Ⓒ A double layer: tails inside, heads facing the water on both sides

Decide before you look. Answer on page 43.

11

B1.1.13 STEROIDS

Four rings, and straight through the *membrane*

Steroids are lipids built on four fused rings: three rings of six carbons and one of five, sharing edges. Different groups attached to the rings make different steroids. To identify a steroid from a diagram, look for that four-ring block, whatever is attached to it.

Cholesterol, which sits in animal cell membranes (B2.1), is a steroid, and so are the sex hormones **oestradiol** and **testosterone**. The hormones are made from cholesterol.

Steroids are mostly hydrocarbon, so they are non-polar. Oestradiol has two OH groups and testosterone an OH and a C=O, but the rings dominate. They dissolve into the hydrophobic core of the bilayer and diffuse straight through it, with no transport protein. (In blood they travel bound to carrier proteins, because they barely dissolve in plasma.) Glucose and ions, although smaller, are polar or charged. They cannot cross the core and need proteins (B2.1).

Inside the target cell these hormones bind receptors that act on genes (C2.1), and oestradiol takes part in the menstrual cycle (D3.1).

KEY TERMS

steroids

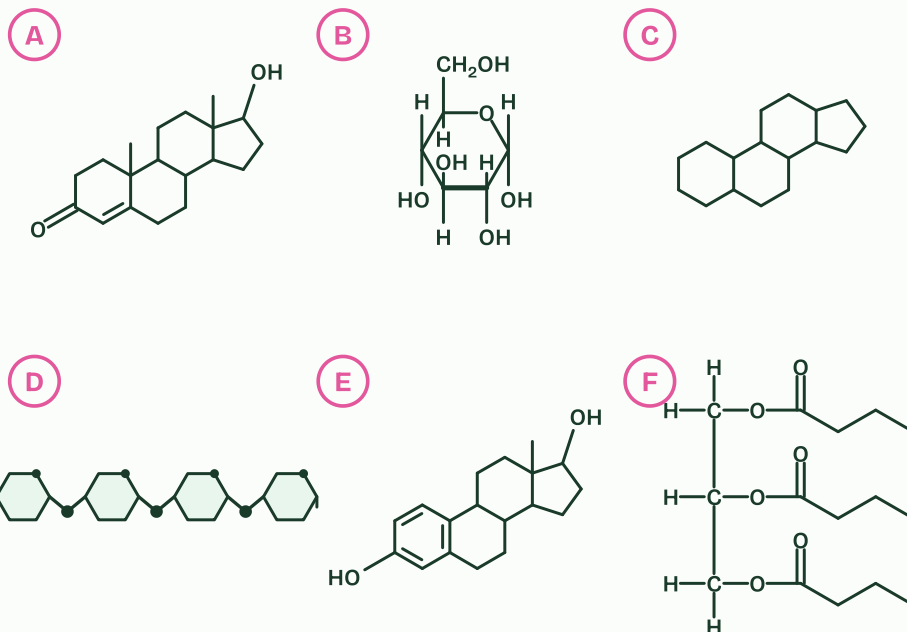
Lipids built on four fused rings of carbon atoms: three rings of six carbons and one of five, sharing edges.

oestradiol

A steroid sex hormone, the main oestrogen. It has two OH groups on its four rings.

testosterone

A steroid sex hormone, mainly made in the testes. It has an OH group and a C=O group on its four rings.



Look for the four-ring block, three rings of six and one of five, sharing edges.

Testosterone A steroid: four fused rings, three of six carbons and one of five, sharing edges.

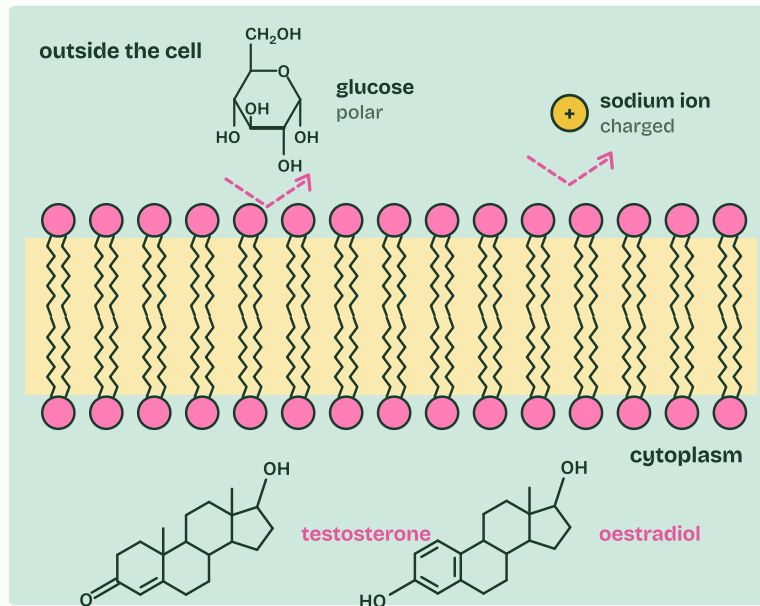
A steroid skeleton A steroid: four fused rings, three of six carbons and one of five. Nothing is attached, but the block is what makes it a steroid. Cholesterol and the sex hormones are this block with groups added.

α -glucose Not a steroid: it has a single ring, of five carbons and an oxygen, with groups attached.

Part of an amylose chain Not a steroid: it has four rings, but they are joined by oxygen bridges, not fused. Each ring is a whole glucose unit.

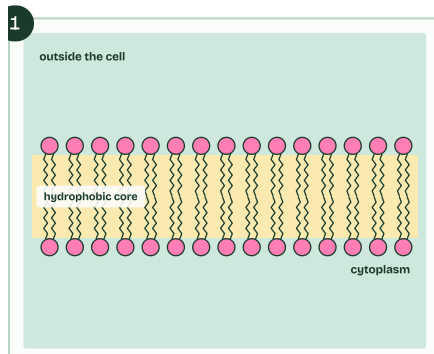
Oestradiol A steroid: four fused rings, three of six carbons and one of five. The first ring is drawn with three double bonds.

A triglyceride Not a steroid: one glycerol carrying three fatty acid chains. It is a lipid, but it has no fused rings.

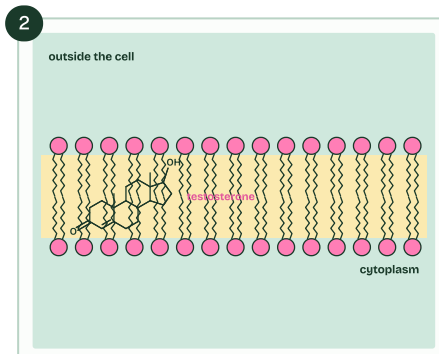


STEP BY STEP

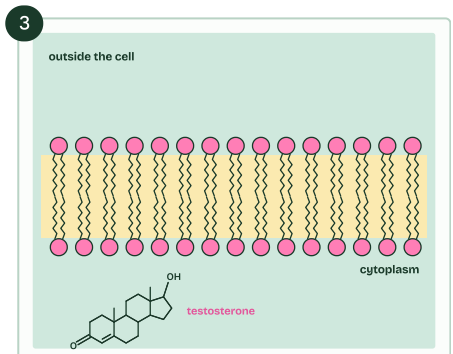
5 STEPS



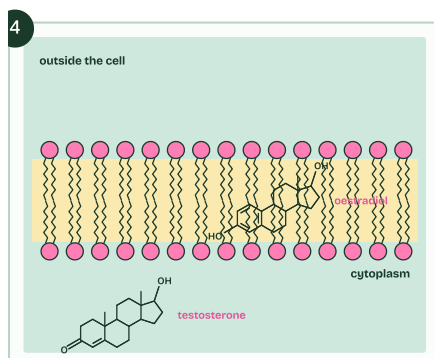
The bilayer's core is **hydrophobic**.



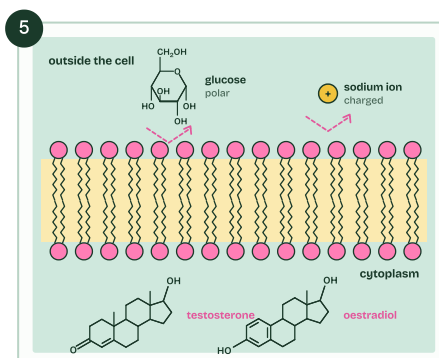
Non-polar **testosterone** dissolves into the core,



and diffuses out the other side.



Oestradiol crosses the same way.



Polar glucose and charged ions cannot cross the core: they need proteins (B2.1).

WATCH OUT

Not every lipid is a steroid, and not every steroid is a hormone: cholesterol is a steroid that sits in membranes.

PREDICT

Testosterone crosses a membrane with no transport protein. Glucose cannot. Why?

- Ⓐ Testosterone is the smaller molecule, so it slips between the heads
- Ⓑ Testosterone is non-polar, so it dissolves in the bilayer's core
- Ⓒ Testosterone is pumped across the membrane by a protein using ATP

Decide before you look. Answer on page 43.

Key terms

Every term this guide defines, A to Z, with the chapter it is in. Cover the right-hand side and test yourself.

adipose tissue 09

Tissue made of cells that each hold a large droplet of triglyceride, under the skin and round organs.

alpha (α) glucose 03

The form of glucose with the OH on carbon 1 below the ring, opposite the CH₂OH group. It makes starch and glycogen.

amphipathic 10

Having one part that is attracted to water and another part that is not.

amylopectin 04

A chain of alpha glucose that coils and also has branches. The other polysaccharide in starch.

amylose 04

An unbranched chain of alpha glucose that coils into a helix. One of the two polysaccharides in starch.

antigens 06

Molecules that the immune system can recognise. The A and B sugars on red blood cells are antigens.

beta (β) glucose 03

The form of glucose with the OH on carbon 1 above the ring, on the same side as the CH₂OH group. It makes cellulose.

blubber 09

The thick layer of fat under the skin of seals and whales. It insulates them in cold water.

branches 04

Side chains of glucose units coming off the main chain of a polysaccharide.

carbon compound 01

A molecule built on a skeleton of carbon atoms, with other atoms attached to it.

carboxyl group 07

The group COOH, found at one end of a fatty acid. It is the part that joins to glycerol.

cell walls 05

The tough layer outside the plasma membrane of a plant cell. Its main material is cellulose.

cell-cell recognition 06

One cell identifying another by the molecules on its surface, such as the sugar chains of glycoproteins.

cellulose 05

An unbranched polymer of beta glucose, and the main material of plant cell walls.

chain 01

A row of carbon atoms joined end to end. It is unbranched if it is a single row, and branched if a side chain comes off it.

cis 08

A double bond with the two parts of the chain on the same side of it, so the chain bends there.

condensation reaction 02

A reaction that joins two molecules and releases a molecule of water. An OH group from one and an H from the other leave together as water.

covalent bond 01

A bond in which two atoms share a pair of electrons. The shared pair holds the atoms together.

double bond 01

Two pairs of electrons shared between the same two atoms. It uses two of a carbon atom's four bonds.

endotherm 08

An animal that keeps its body warm with heat made inside it, such as a bird or a mammal.

ester bond 07

The covalent bond between a fatty acid and glycerol, formed by condensation.

fats 07

Lipids, mostly triglycerides, that are solid at room temperature.

fatty acids 07

Molecules with a long hydrocarbon chain and a carboxyl group at one end.

glycerol 07

A small molecule of three carbon atoms, each with an OH group, that fatty acids join to.

glycogen 04

The energy store of animals and fungi: a highly branched polymer of alpha glucose, found in liver and muscle cells.

glycoprotein 06

A protein with carbohydrate chains attached to it. In the plasma membrane its carbohydrate chains face outwards.

glycosidic bonds 02

The covalent bond between two sugar units, with an oxygen atom bridging the two rings.

hexose 03

A monosaccharide with six carbon atoms, such as glucose and fructose.

hydrogen bonds 05

Weak attractions between a slightly positive hydrogen and a slightly negative atom such as oxygen on a neighbouring molecule or chain (A1.1).

hydrolysis 02

A reaction that splits a molecule by adding water. The water is split: its H goes to one product and its OH to the other.

hydrophilic head 10

The part of a phospholipid that is attracted to water: the phosphate group and glycerol.

hydrophobic 07

Not attracted to water. Non-polar substances such as lipids are hydrophobic.

hydrophobic tails 10

The two fatty acid chains of a phospholipid. They are non-polar and are pushed away by water.

isomers 03

Molecules with the same atoms arranged differently, so they have the same formula but different structures.

lipids 07

Substances made by living things that dissolve in non-polar solvents such as hexane but only sparingly in water. Fats, oils, waxes and steroids are lipids.

macromolecules 02

Very large molecules, such as starch, proteins and DNA.

melting point 08

The temperature at which a solid turns to a liquid.

microfibrils 05

Bundles of cellulose chains held together by hydrogen bonds. They are very strong when pulled.

monomers 02

The small units that join together to make a polymer, such as a glucose molecule in starch.

monosaccharide 03

A single sugar unit, the monomer of carbohydrates. Glucose, fructose and ribose are monosaccharides.

monounsaturated 08

A fatty acid with one C=C double bond.

non-polar solvents 07

Solvents such as hexane whose molecules have no partial charges. Lipids dissolve in them.

oestradiol 11

A steroid sex hormone, the main oestrogen. It has two OH groups on its four rings.

oils 07

Lipids, mostly triglycerides, that are liquid at room temperature.

pentose 03

A monosaccharide with five carbon atoms, such as ribose and deoxyribose.

phosphate group 07

A group of one phosphorus atom and four oxygen atoms. It carries a negative charge and attracts water.

phospholipid 07

A lipid made of glycerol joined to two fatty acids and one phosphate group.

phospholipid bilayer 10

A double layer of phospholipids, with the hydrophobic tails inside and the hydrophilic heads facing the water on both sides.

polymers 02

A molecule made of many similar small units, the monomers, joined in a chain by covalent bonds.

polysaccharides 02

Polymers of monosaccharides: starch, glycogen and cellulose are examples.

polyunsaturated 08

A fatty acid with two or more C=C double bonds.

ring 01

Carbon atoms (sometimes with an oxygen atom) joined in a closed loop, as in glucose.

saturated 08

A fatty acid with no C=C double bonds in its chain. Every carbon holds as many hydrogen atoms as it can.

starch 04

The energy store of plants: a mixture of amylose and amylopectin, both polymers of alpha glucose.

steroids 11

Lipids built on four fused rings of carbon atoms: three rings of six carbons and one of five, sharing edges.

tensile strength 05

How much pulling force a material can withstand before it breaks.

testosterone 11

A steroid sex hormone, mainly made in the testes. It has an OH group and a C=O group on its four rings.

thermal insulation 09

A layer that slows the loss of heat from the body.

triglycerides 07

Lipids made of one glycerol molecule joined to three fatty acids by ester bonds.

unsaturated 08

A fatty acid with at least one C=C double bond in its chain.

waxes 07

Lipids that form a waterproof coating, such as the wax on a leaf.

Dry lab: *Fats on the bench*

Freeze fatty acids and kitchen fats, warm them slowly in a bath and catch the moment each one melts. Then find out what double bonds do to the melting point.

Bench Pure fatty acids Fats and oils from the kitchen

Set up a run

Sample

- Lauric acid
12:0 (carbons : C=C)
- Myristic acid
14:0 (carbons : C=C)
- Palmitic acid
16:0 (carbons : C=C)
- Stearic acid
18:0 (carbons : C=C)**
- Arachidic acid
20:0 (carbons : C=C)
- Oleic acid
18:1 cis (carbons : C=C)
- Linoleic acid
18:2 cis (carbons : C=C)
- α -Linolenic acid
18:3 cis (carbons : C=C)
- Mystery acid
?:? (carbons : C=C)

Bath at the start

-25 °C -10 °C 0 °C 10 °C 20 °C **40 °C**

Heating rate °C min⁻¹

0.5 1 2 4

Diagram: A beaker containing a liquid bath sits on a stirring hotplate. A thermometer is in the bath, showing 40.0 °C. A small vial of solid stearic acid is being heated. A magnified view of the stearic acid shows a regular, crystalline structure of triangles.

Buttons: First liquid, Clear

Choose a sample and the settings, then press **Run**.



Run it online: change the variables, run the trials, and the table and graph fill in as you go.
biologybybradford.com/guides/ib-biology-b1-1-carbohydrates-and-lipids#lab

Your question

How does the number of C=C double bonds in a fatty acid affect its melting point? And do the fats that plants and endotherms store fit the same pattern?

What you can change

The sample (four fatty acids with 18 carbons and 0 to 3 double bonds, saturated fatty acids with 12 to 20 carbons, a mystery acid, and eight fats and oils from the kitchen), the bath's starting temperature, how fast it warms, whether it is stirred, and how many repeats you do.

What to record

For each run: the sample, the settings, the temperature at which the first liquid appears and the temperature at which the sample turns completely clear, its melting point. Repeat each sample at least three times and take a mean.

Find out

- **Double bonds.** Stearic, oleic, linoleic and α -linolenic acid, three runs each at 1 °C a minute, stirred. Plot the mean melting point against the number of C=C.
- **Chain length.** Lauric to arachidic acid, three runs each at the same settings. Plot the mean melting point against the number of carbons. Which matters more: one double bond, or two extra carbons?
- **Heating rate.** Stearic acid at 0.5, 1, 2 and 4 °C a minute, three runs each, stirred and then unstirred. What happens to the readings?
- **The mystery acid.** It has 16 carbons and one C=C. Predict its melting point from your two graphs, then measure it.
- **Kitchen fats.** All eight, three runs each. Plot the melting point against the mean C=C per fatty acid, and compare the plant and animal fats.

Record

- For every run: the sample, the starting temperature, the heating rate, stirring, and the first liquid and clear temperatures.
- Change one setting at a time and keep the rest the same.
- Repeat each sample at least three times and take a mean; give the range as its uncertainty.
- Use **Graph your results** under the lab, or download the CSV and plot it yourself.

QUESTIONS ON THE LAB

QUESTION 1

Heating at 4 °C a minute gave readings about 1.5 °C higher than at 0.5 °C a minute, every time. What kind of error is this?

- (A) Random error: it varies from run to run, so enough repeats will average it out
- (B) Systematic error: the sample lags behind the probe, so every reading is high
- (C) No error: a fatty acid really does melt higher when heated fast

Answer on page 43.

QUESTION 2

Coconut oil is about 90 % saturated, yet it melts lower than butter or lard. Why?

- (A) Coconut oil holds water among its fats, and the water lowers its melting point
- (B) Plant fats always melt at lower temperatures than animal fats, whatever their fatty acids
- (C) Its fatty acids are mostly short, 12 and 14 carbons, so they attract each other less

Answer on page 43.

QUESTION 3

Olive, rapeseed and sunflower oil come from plants of cool and temperate climates; coconut and cocoa from the tropics. What explains the difference in their fats?

- (A) A store must stay liquid at the plant's own temperature to be used: cold climates favour unsaturated oils
- (B) Tropical plants are endotherms: they keep their seeds warm, so a solid fat there can still be used
- (C) Unsaturated oils store far more energy per gram, which seeds waiting in cold soil need most

Answer on page 43.



Check yourself

The check for this guide is online: a fresh paper of past-paper style questions from the exam bank on B1.1 each time, marked as you go, and saved to your Exam practice progress when you are signed in. Scan the code, or type the link.

[biologybybradford.com/exam-maker/sit?
topics=B1.1&level=HL&paper=quiz&marks=15&src=ep](https://biologybybradford.com/exam-maker/sit?topics=B1.1&level=HL&paper=quiz&marks=15&src=ep)

Answers

PREDICTIONS IN THE CHAPTERS

- 01** A drawing shows a carbon atom with a double bond to an oxygen, a single bond to another carbon and single bonds to two hydrogens. What is wrong with it?
- B It has five bonds' worth: the double bond counts as two**
- Count the double bond as two: $2 + 1 + 1 + 1 = 5$, one more than carbon can make. Take away one hydrogen and every carbon has exactly four. Checking each carbon for four bonds is the quickest way to catch an error in any molecule you draw.
-
- 02** Ten glucose molecules are joined into one unbranched chain. How many water molecules were released?
- C 9**
- Nine. One water leaves for every bond, and a chain of ten units has nine bonds between them. Digesting it back to glucose by hydrolysis uses nine water molecules.
-
- 03** Sugar C in the second figure has a five-sided ring. Is it a pentose or a hexose?
- A A hexose: four ring carbons and two outside it make six**
- A hexose. Its ring is four carbons and an oxygen, and two more carbons sit outside the ring as CH_2OH groups: six in all. It is fructose. Count carbons, not corners: ribose also has a five-sided ring, but only one carbon outside it, so it is a pentose.
-
- 04** An amylose molecule and a glycogen molecule hold the same number of glucose units. A sprinter's muscles suddenly need glucose. Which store can release it faster?
- C Glycogen: its many branches give enzymes many ends to work on**
- Glycogen. Enzymes take glucose off the ends of chains, one unit at a time. A heavily branched molecule has many ends, so many enzymes can work on it at once. That suits animals, which may need glucose in seconds.
-
- 05** Cellulose chains lie side by side in bundles. What holds neighbouring chains together?
- B Hydrogen bonds between OH groups on neighbouring chains**
- Hydrogen bonds. Each is weak, but there are thousands along every chain, so together they hold the bundle firmly. Glycosidic bonds link glucose units within a chain, not chain to chain.
-
- 06** What makes a group A red blood cell different from a group B one?
- C One different sugar at the tip of each sugar chain**
- One sugar. Both carry the same glycoprotein chains. The enzyme a person's alleles make adds one sugar to the tip, a different one for A and for B. That single sugar is enough for immune cells to tell the cells apart.
-
- 07** You have salted butter but need it unsalted. What could you do?
- B Melt it, leave it to settle, then pour the fat off the water**
- Melt it and let it settle. Butter is a mixture: mostly fat, with some water. Salt dissolves in water but not in fat, so it stays in the watery layer at the bottom while the fat floats above. Pour or ladle the fat off and it is almost salt-free: this is clarified butter. Stirring into water fails because the fat does not dissolve, and salt does not evaporate at kitchen temperatures.
-

- 08** Olive oil's fatty acids are mostly monounsaturated, and ordinary sunflower oil's are mostly polyunsaturated. Both are liquid at room temperature. You put a bottle of each in the fridge at 5 °C. Which turns cloudy and thick?

B Olive oil: fewer double bonds per chain, so a higher melting point

Olive oil. With mostly one double bond per chain, its chains pack better than sunflower oil's, so it starts to solidify at fridge temperatures while sunflower oil stays clear. More double bonds, lower melting point. The dry lab lets you measure it.

- 09** A seal and a cod swim in the same polar sea. Which needs a thick layer of fat to insulate it?

A The seal: its body stays near 37 °C, much warmer than the water

The seal. It is an endotherm, holding its body near 37 °C in water close to freezing, and water draws heat away fast, so without blubber it would lose heat faster than it could make it. The cod is an ectotherm: its body sits at about the water's temperature, so there is no warmth to keep in.

- 10** Phospholipids are stirred into a beaker of water, well below the surface. What do they form?

C A double layer: tails inside, heads facing the water on both sides

A bilayer. The tails cannot hydrogen-bond with water, so water molecules crowd them together, and the charged heads are attracted to water. Two layers, tails to tails, is the arrangement in which every head touches water and no tail does.

- 11** Testosterone crosses a membrane with no transport protein. Glucose cannot. Why?

B Testosterone is non-polar, so it dissolves in the bilayer's core

Polarity, not size. Testosterone (Mr 288) is bigger than glucose (Mr 180), but it is mostly hydrocarbon, so it mixes into the hydrophobic core. Glucose's many OH groups bind water and are repelled by the core.

QUESTIONS ON THE DRY LAB

- Q1** Heating at 4 °C a minute gave readings about 1.5 °C higher than at 0.5 °C a minute, every time. What kind of error is this?

B Systematic error: the sample lags behind the probe, so every reading is high

Systematic error. The sample in its glass tube warms more slowly than the probe beside it, so by the time the sample melts the probe already reads higher, and the faster the bath warms the bigger the gap. It shifts every reading the same way, so more repeats cannot remove it. Heat slowly near the melting point, and stir, so the bath, probe and sample stay at one temperature.

- Q2** Coconut oil is about 90 % saturated, yet it melts lower than butter or lard. Why?

C Its fatty acids are mostly short, 12 and 14 carbons, so they attract each other less

Chain length is the other variable. Shorter chains have less length along which to attract their neighbours, so less heat separates them. Your chain-length series shows it, and it is why a fair test of double bonds keeps every chain at 18 carbons.

- Q3** Olive, rapeseed and sunflower oil come from plants of cool and temperate climates; coconut and cocoa from the tropics. What explains the difference in their fats?

A A store must stay liquid at the plant's own temperature to be used: cold climates favour unsaturated oils

A plant is at the temperature of its surroundings, and its store must stay usable there. Seeds in cool soils store oils rich in double bonds, which stay liquid when cold; tropical seeds can store saturated fat, which is liquid in the heat. Endotherms keep their own heat, so their stores can be more saturated (chapter 8).

How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.

Written and drawn for Biology by Bradford, biologybybradford.com. Free to print and share with a class.