REVISION GUIDE

Fats that shun water, and the molecule that *remembers*

Lipids and nucleic acids

Butter is solid and olive oil is not, a membrane builds itself in water, and a strand of DNA always grows from the same end. Two very different classes of molecule, and the structures that explain what each does.

6 chapters · a dry lab

The interactive guide, with every animation:

biologybybradford.com/guides/ap-biology-unit-1-lipids-and-nucleic-acids

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By the end you can

- [ ] Explain why lipids are nonpolar and hydrophobic, and describe a triglyceride and the water released in making one 1.5.A
- [ ] Explain how saturated and unsaturated fatty acids differ in structure, and how that sets the melting point of a fat 1.5.A
- [ ] Explain how the polar head and nonpolar tails of phospholipids make them form a bilayer in water 1.5.A
- [ ] Describe the three parts of a nucleotide and the sugar-phosphate backbone with its 5′ and 3′ ends 1.6.A
- [ ] Describe complementary base pairing, its hydrogen bonds, and the antiparallel strands of the double helix 1.6.A
- [ ] Compare DNA and RNA: sugar, bases, and number of strands 1.6.A

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

1.5.A LIPIDS

01 The molecules water will not *touch*

Lipids are not grouped by a shared monomer, as the other three classes are. They are grouped by how they behave: they are **nonpolar**, so they mix with oils and solvents such as hexane but not with water. The reason is their atoms. Lipids are mostly carbon and hydrogen, and C–H bonds share electrons almost evenly, so water molecules have nothing to attract. They bond to each other and squeeze the lipid out into droplets or a layer: lipids are **hydrophobic**.

Fats and oils are mostly **triglycerides**: one **glycerol** joined to three **fatty acids**. Each fatty acid joins glycerol by dehydration synthesis, a water molecule leaving at each join, so making one triglyceride releases three waters. It is big, but it is not a polymer: four parts joined, not a chain of repeats.

Lipids do several jobs. Gram for gram a fat stores about twice the energy of a carbohydrate, and stores it without the water that glycogen holds, so it is the long-term store of animals and of many seeds (the figure under this chapter). Fat under the skin insulates, and wax on a leaf or a feather keeps water off. Phospholipids make every membrane (chapter 3), and steroids such as cholesterol and the sex hormones are lipids too.

KEY POINTS

- Nonpolar and hydrophobic, because they are mostly C–H.
- A triglyceride: glycerol and three fatty acids, three waters released.

KEY TERMS

lipids
Molecules made by living things that are mostly carbon and hydrogen, nonpolar and hydrophobic: fats, oils, phospholipids, steroids and waxes.

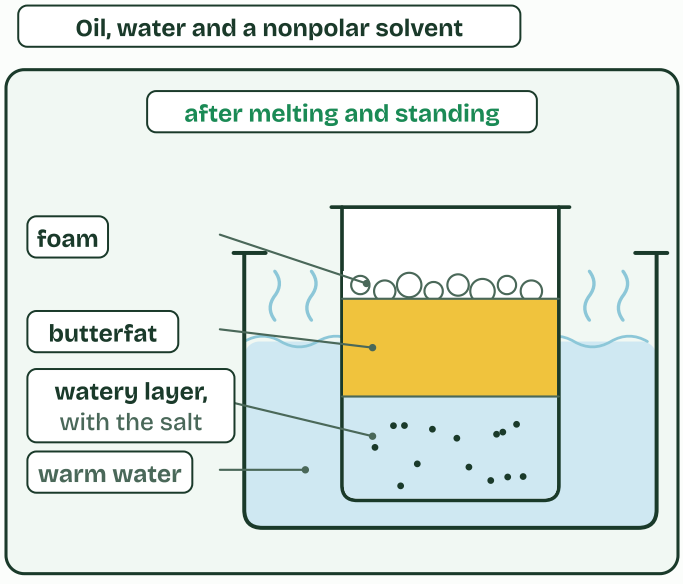
nonpolar
Having no partial charges, because electrons are shared evenly, as in C–H bonds.

hydrophobic
Not attracted to water; nonpolar substances are hydrophobic.

triglycerides
A lipid of one glycerol joined to three fatty acids.

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

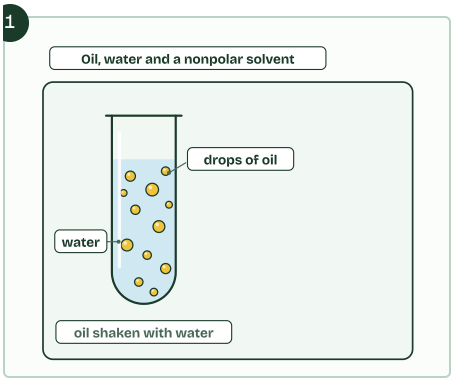
fatty acids
A long hydrocarbon chain with a carboxyl group, COOH, at one end.



STEP BY STEP

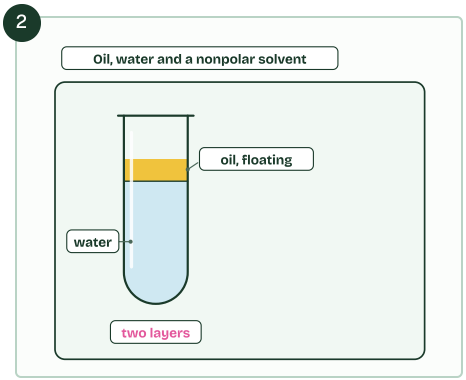
5 STEPS

1



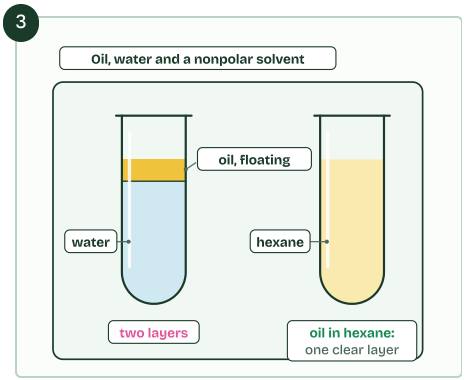
Shake oil with **water**,

2



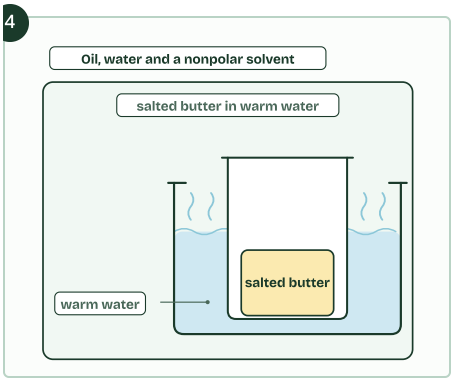
and it separates and floats: it does not dissolve.

3



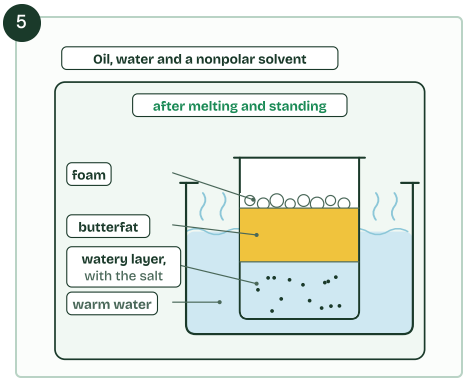
In a **nonpolar solvent** such as hexane, it dissolves.

4

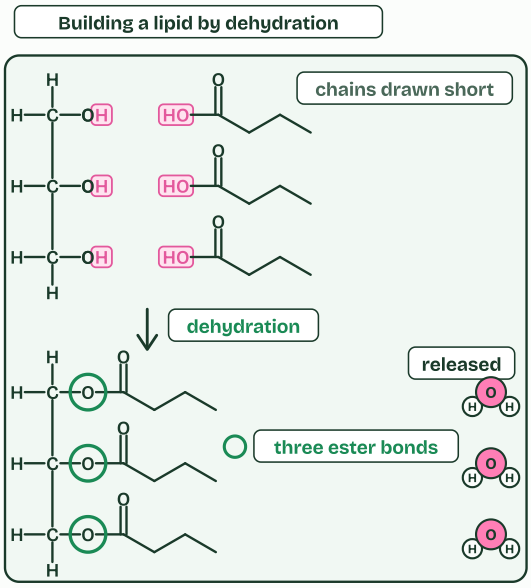


Butter is mostly fat, with some water and, in salted butter, salt.

5

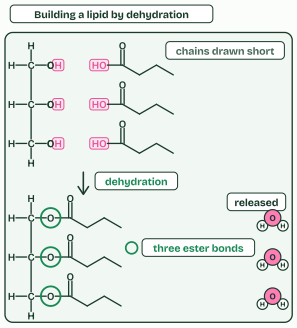


Melted, the **fat** separates from the watery layer, and the salt stays dissolved in the water.



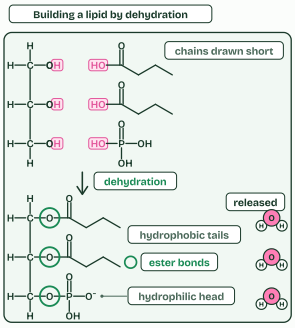
Each join releases one water molecule: an OH from the acid group and an H from glycerol. Switch between the two products and count the waters.

1

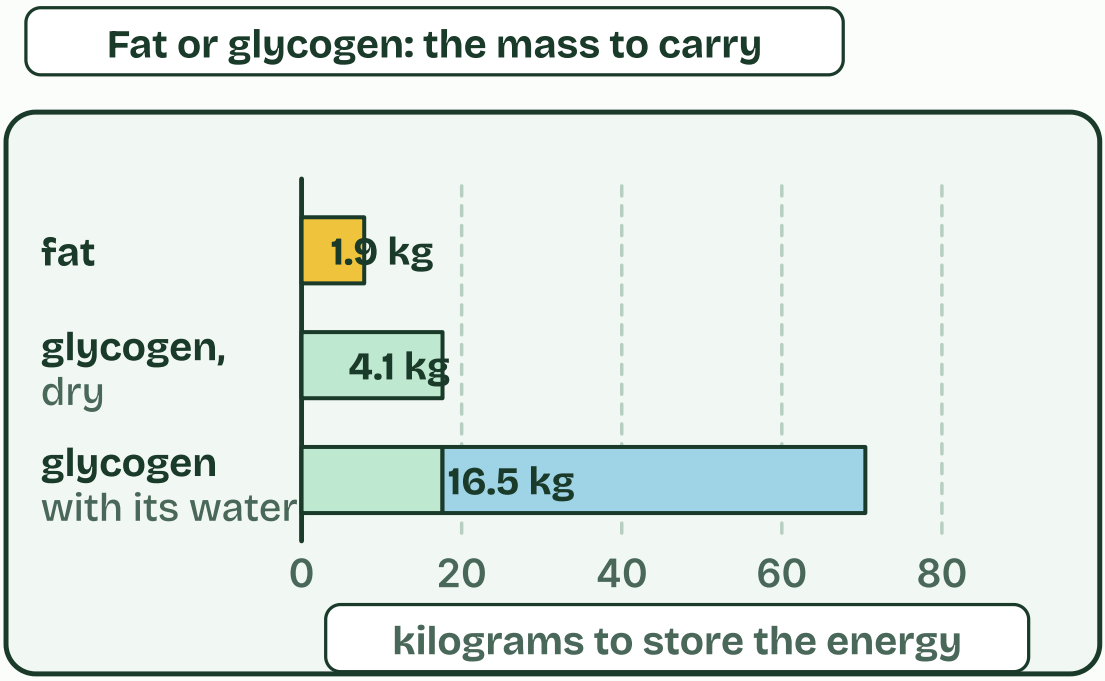


Triglyceride

2



Phospholipid



Assumes 10 000 kJ a day, 37 kJ g^{-1} for fat, 17 kJ g^{-1} for glycogen, and 3 g of water stored with every gram of glycogen.

WATCH OUT

"A fat is a polymer of fat molecules." It is one glycerol carrying three fatty acids, not a chain of repeating units.

PREDICT

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

(A) Stir it into plenty of water so the salt dissolves, then filter the fat off

(B) Melt it, leave it to settle, then pour the fat off the watery layer

(C) Heat it hard until all of the salt evaporates and only the fat is left

Decide before you look. Answer on page 24.

02

1.5.A SATURATED AND UNSATURATED

Every double bond puts a kink in the *tail*

The tail of a fatty acid is a chain of carbons. In a **saturated** fatty acid every bond between carbons is single, so each carbon holds as many hydrogens as it can: the chain is saturated with hydrogen. An **unsaturated** fatty acid has one or more C=C double bonds.

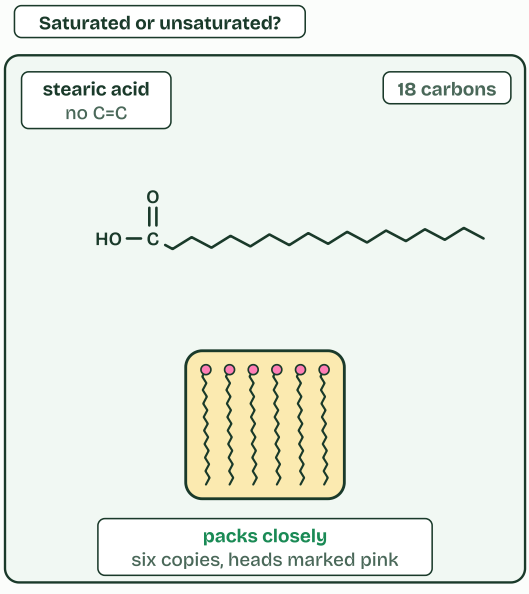
In natural fats, nearly every double bond bends the chain. Straight saturated tails pack closely side by side, the attractions between them add up, and it takes more heat to pull them apart: a high melting point, a fat that is solid at room temperature, like butter or lard. Kinked unsaturated tails cannot pack closely, so they attract each other less and melt at a lower temperature: an oil, like olive or sunflower oil. The more double bonds, the lower the melting point.

That difference in structure is a difference in function. Plants and fish in cold water store oils that stay liquid when cold; mammals, kept at about 37 °C, can store harder fats. In membranes (chapter 3), the share of unsaturated tails sets how fluid the membrane is.

KEY TERMS

saturated
A fatty acid with no C=C double bonds: every carbon holds as many hydrogens as it can.

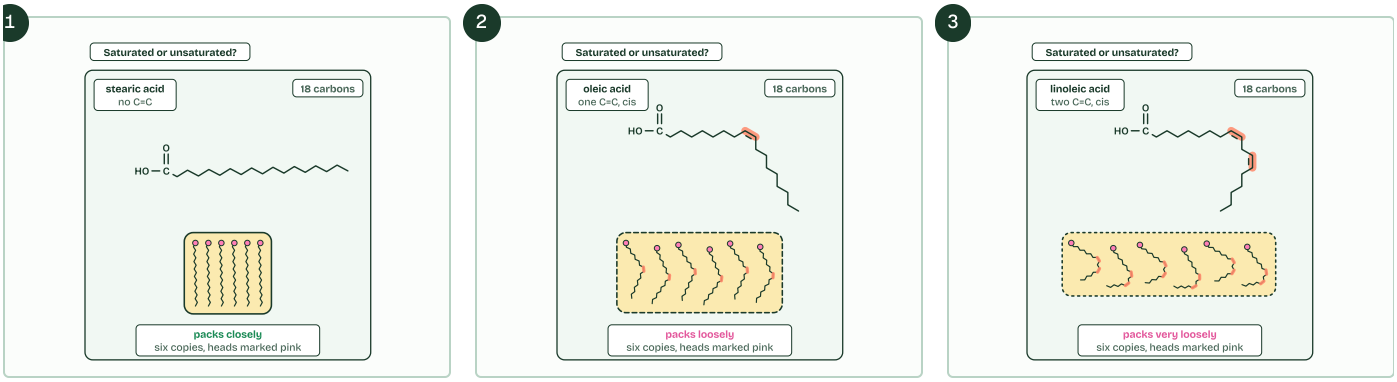
unsaturated
A fatty acid with one or more C=C double bonds in its chain.



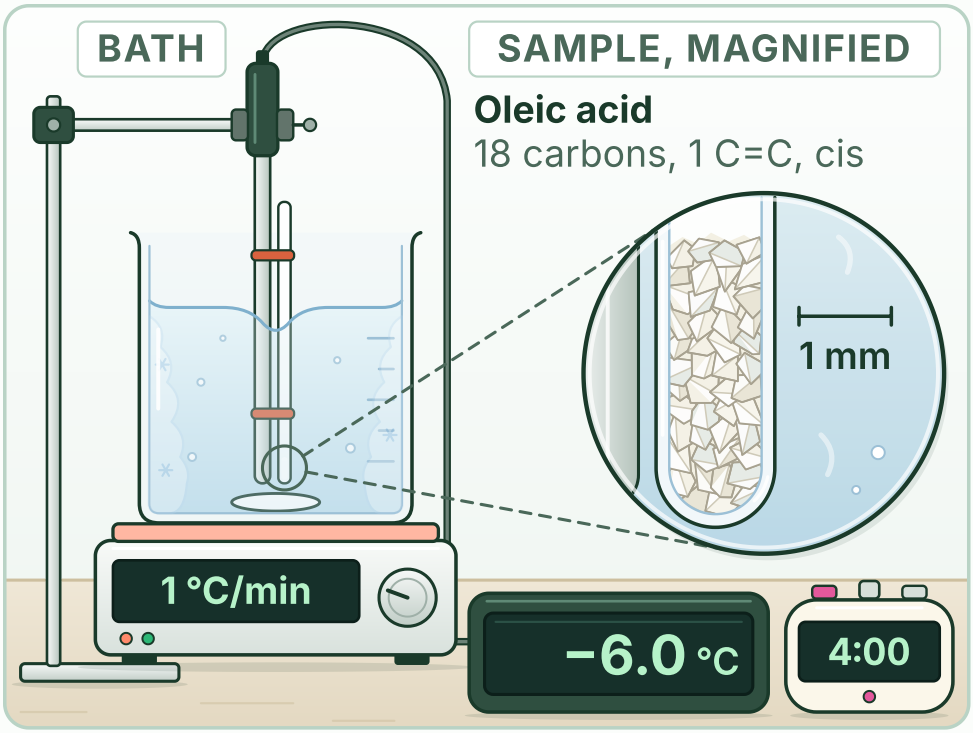
Coral marks each C=C double bond. Under each fatty acid, six copies of it packed as they would sit in a fat or oil.

SWITCH IT

3 SETTINGS



Saturated **Monounsaturated** **Polyunsaturated**



The bench: a frozen sample in a capillary tube, banded to the tip of a probe in a bath that warms slowly. Watch the tube under the lens, and read the probe when the first liquid shows and when the last crystal goes.

REMEMBER IT

Why unsaturated fats are oils

D Double	K Kinks	L Leave	L Liquids
C=C double bond at least one in an unsaturated tail	**Kinked chain** each double bond bends the tail	**Loose packing** bent tails cannot lie close	**Low melting point** an oil at room temperature

WATCH OUT

Melting a fat breaks no covalent bonds, double or single: it only separates whole molecules from each other.

PREDICT

Olive oil's fatty acids mostly have one double bond, and sunflower oil's mostly two or more. 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, because the extra double bonds in its chains make it the first of the two to freeze solid

(B) Olive oil, because with fewer double bonds its chains pack better, so its melting point is higher

(C) Neither, because oils are liquid fats and never turn solid however cold the fridge is set

Decide before you look. Answer on page 24.

03 Half loves water, half does *not*

1.5.A PHOSPHOLIPIDS

A **phospholipid** is built like a triglyceride, but one fatty acid is replaced by a phosphate group. That changes everything. The phosphate end is charged and polar, a **hydrophilic head** that water is drawn to. The two fatty acid tails stay non-polar and **hydrophobic**. A molecule with a part of each kind is **amphipathic**.

Drop phospholipids into water and nothing has to arrange them. Water bonds to the heads and pushes the tails together, so the molecules gather into a **bilayer**: two sheets, heads out toward the water on both sides, tails in, out of the water's way. Every cell membrane is built on this sheet, and the film below shows it forming.

The tails form a nonpolar core that ions and most polar molecules cannot cross, which is how a membrane holds a cell's dissolved contents in (Unit 2). Unsaturated tails, kinked, keep the bilayer fluid.

Steroids are lipids of another shape: four carbon rings joined together, nonpolar enough to pass through the bilayer. Cholesterol sits among the phospholipid tails of animal membranes; testosterone and estrogen are steroid hormones made from it.

KEY TERMS

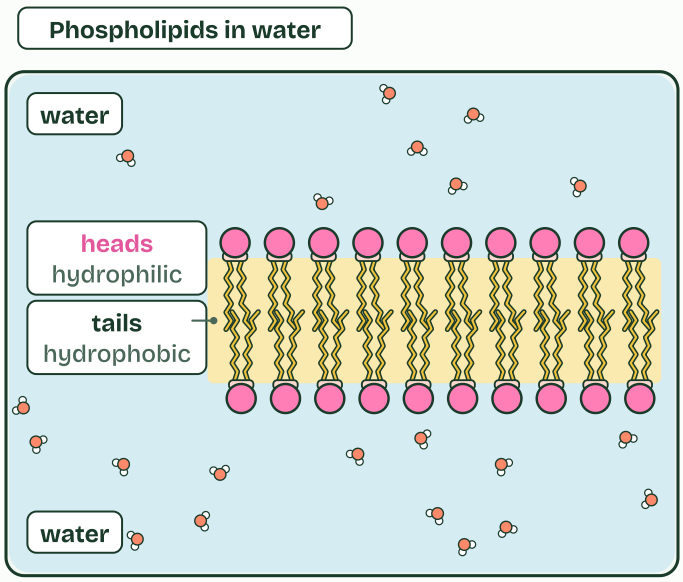
phospholipid
A lipid of glycerol joined to two fatty acids and a phosphate group: a polar head and two nonpolar tails.

hydrophilic head
The phosphate end of a phospholipid, which is polar and attracts water.

hydrophobic
The two fatty acid chains of a phospholipid, which are nonpolar and avoid water.

amphipathic
Having a hydrophilic part and a hydrophobic part.

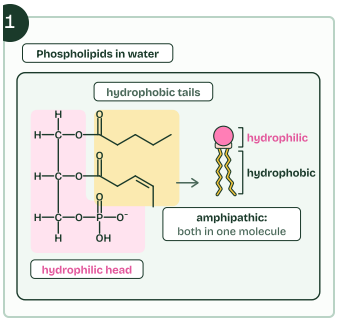
bilayer
Two layers of phospholipids, tails pointing in toward each other and heads facing the water on either side.



STEP BY STEP

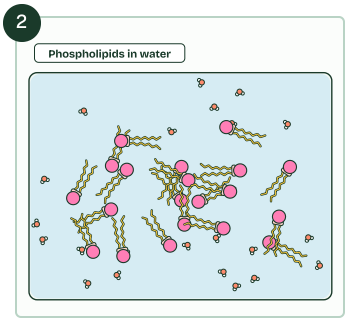
4 STEPS

1



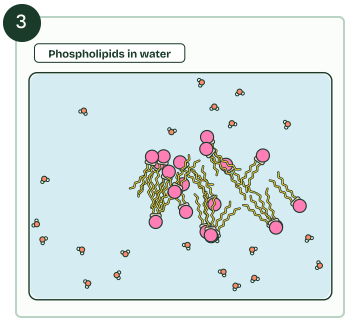
One molecule, two natures: **amphipathic**.

2



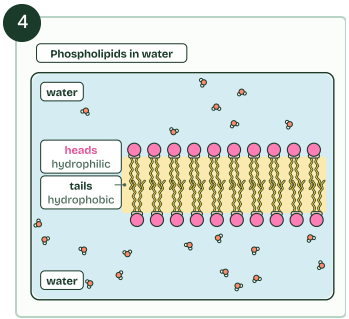
Mixed into water,

3



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

4

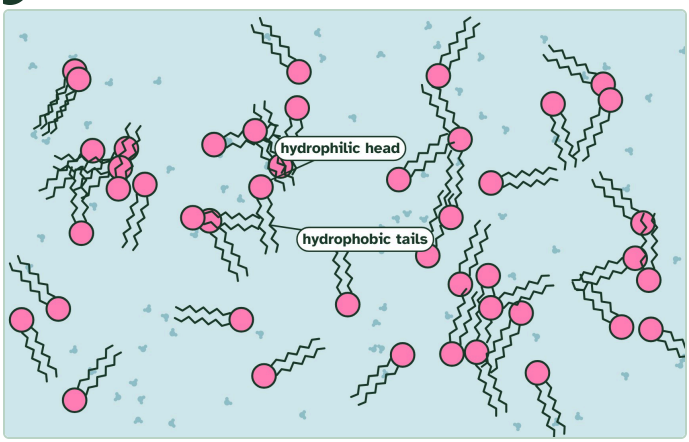


forming a **bilayer**, with water on both sides.

ANIMATION · WATCH IT HAPPEN: A BILAYER BUILDS ITSELF

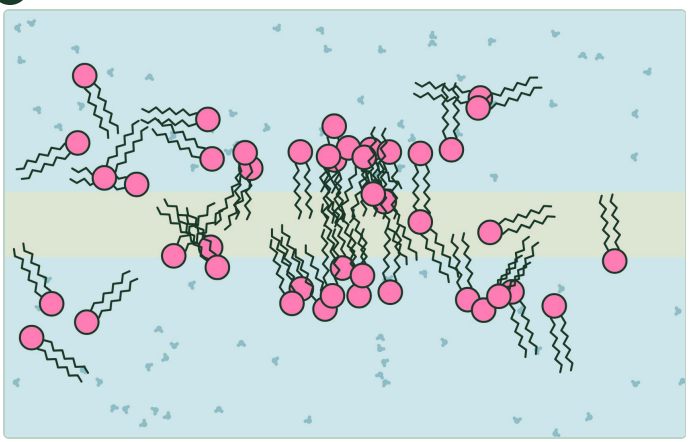
3 MOMENTS

1 IN THE BILAYER: 0 OF 44



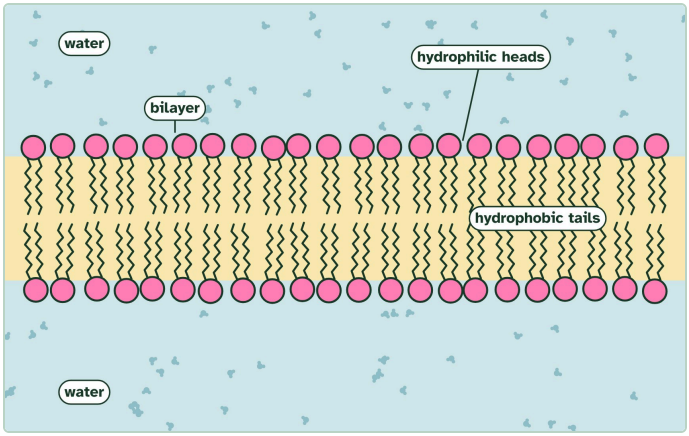
Phospholipids stirred into water point every which way.

2 IN THE BILAYER: 6 OF 44



The tails cannot form hydrogen bonds with water, so water crowds the **tails** together.

3 IN THE BILAYER: 44 OF 44



No enzyme placed them and no energy was spent: **water** arranged them.

Watch it move, and change it as it runs: biologybybradford.com/guides/ap-biology-unit-1-lipids-and-nucleic-acids#phospholipids

WATCH OUT

The bilayer is not held together by covalent bonds between the phospholipids: it holds because water keeps pushing the tails together, which is why a membrane can flow and seal over a small tear.

PREDICT

Phospholipids are shaken in oil instead of water. Which way do they turn?

(A) They form the same bilayer as in water, because a phospholipid always takes that shape whatever it is in

(B) They dissolve completely and spread evenly through the oil, because they are lipids and lipids dissolve in oil

(C) Tails out into the oil and heads gathered together inside, the reverse of how they sit in water

Decide before you look. Answer on page 24.

04 A sugar, a phosphate and a *base*

1.6.A NUCLEOTIDES AND THE BACKBONE

Nucleic acids, DNA and RNA, carry the instructions for building every protein. Their monomers are **nucleotides**, and every nucleotide has three parts: a five-carbon sugar in the middle, a phosphate group on one side and a **nitrogenous base** on the other. The sugar is deoxyribose in DNA and ribose in RNA.

Nucleotides join by dehydration synthesis: the phosphate of one bonds to the sugar of the next and a water leaves. Repeat it and a chain grows with a **sugar-phosphate backbone** of strong covalent bonds, and the bases stick out to one side of it, at right angles. The bases are the message; the backbone holds them in order.

The chain has two different ends. The carbons of the sugar are numbered 1′ to 5′, and each phosphate links the **5′** carbon of one sugar to the **3′** carbon of the one before. So one end of a strand has a free phosphate on a 5′ carbon, the **5′ end**, and the other a free OH on a 3′ carbon, the **3′ end**. When DNA or RNA is made, new nucleotides are added only to the 3′ end, so a strand always grows 5′ to 3′.

KEY POINTS

- Nucleotide: five-carbon sugar, phosphate, base.
- Backbone: sugar, phosphate, sugar, phosphate, joined covalently.
- A strand has a 5′ end and a 3′ end, and grows at the 3′ end.

KEY TERMS

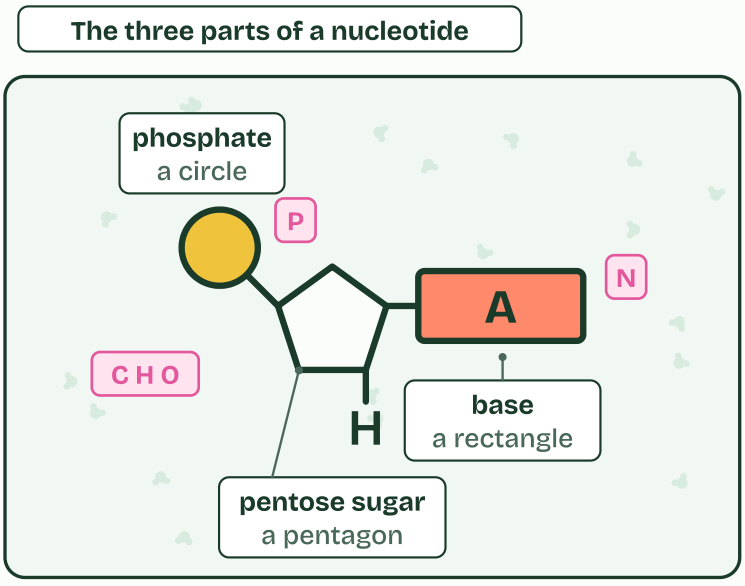
nucleotides
The monomer of nucleic acids: a five-carbon sugar, a phosphate group and a nitrogenous base.

nitrogenous base
A ring-shaped, nitrogen-containing part of a nucleotide: A, T, G or C in DNA, and A, U, G or C in RNA.

sugar-phosphate backbone
The chain of alternating sugars and phosphates, joined by covalent bonds, that runs along a strand of DNA or RNA.

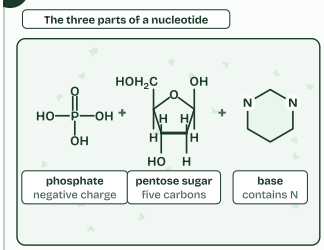
5′ end
The end of a strand of DNA or RNA with a free phosphate on the 5′ carbon of the last sugar.

3′ end
The end of a strand with a free OH group on the 3′ carbon of the last sugar. New nucleotides are added here.



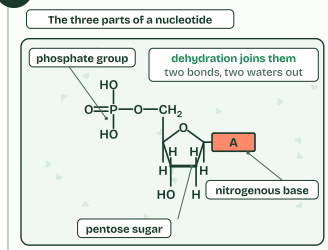
STEP BY STEP
4 STEPS

1



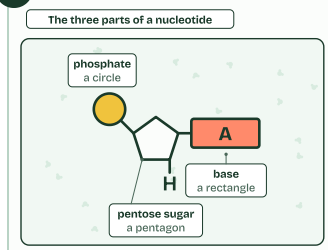
A nucleotide is built from **three parts**.

2



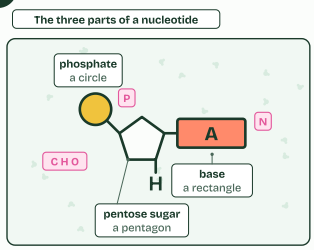
The **sugar** sits in the middle, bonded to both of the others.

3

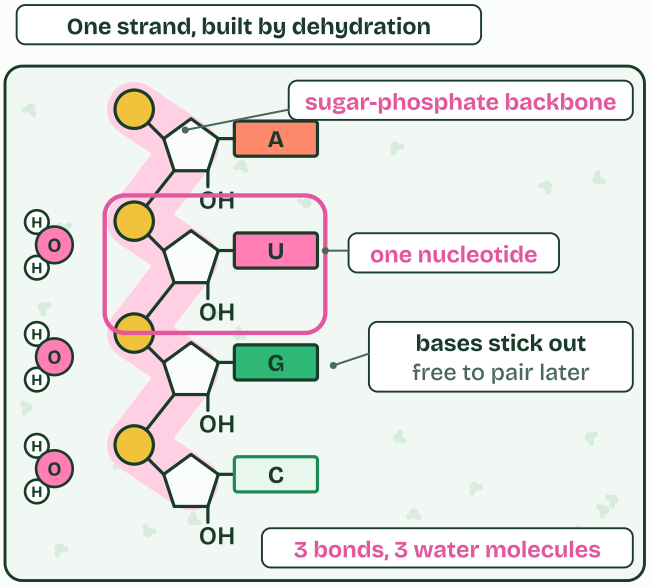


Diagrams draw them as a **circle**, a **pentagon** and a **rectangle**, in these positions.

4



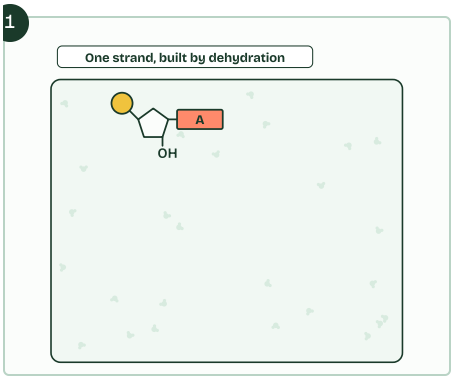
Nitrogen comes from the base and **phosphorus** from the phosphate.



STEP BY STEP

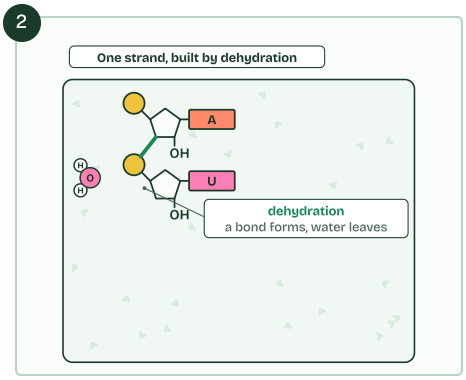
5 STEPS

1



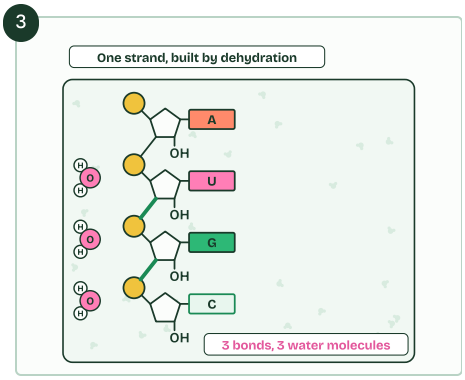
One **nucleotide**.

2



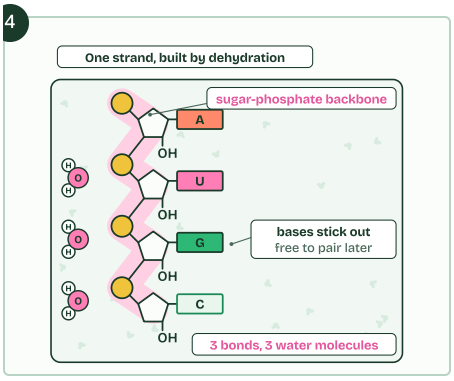
Dehydration synthesis: the phosphate bonds to the sugar above, and water leaves.

3



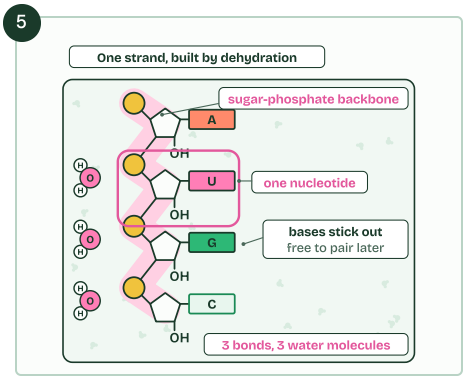
Each new bond releases one **water** molecule.

4



Sugar, phosphate, sugar, phosphate: a covalently bonded **backbone**.

5



One nucleotide is a circle, a pentagon and a rectangle **together**.

WATCH OUT

"5′ and 3′ are the first and last bases." They are carbons of the sugar: the prime marks a sugar carbon, not a base.

PREDICT

A strand of RNA 50 nucleotides long is made. How many water molecules are released?

(A) 50

(B) 49

(C) 100

(D) 51

Decide before you look. Answer on page 24.

05 Two strands, running opposite *ways*

1.6.A BASE PAIRING AND ANTIPARALLEL STRANDS

DNA is usually two strands, held together by their bases. The bases pair by **complementary base pairing**: adenine (A) with thymine (T), and cytosine (C) with guanine (G). The pairs are held by **hydrogen bonds**: two between A and T, three between C and G. Each is weak, but there are millions along a chromosome, so the strands hold together firmly and can still be unzipped for copying.

The two strands are **antiparallel**: one runs 5′ to 3′, and its partner, beside it, runs 3′ to 5′. Only that way do the bases face each other at the right angle to bond. Together the pair twists into a **double helix**, with the backbones on the outside and the base pairs stacked like rungs inside.

Pairing is what lets DNA be copied. Separate the strands and each one is a template: its bases decide which nucleotide joins opposite each, so the new strand is complementary to the old (Unit 6). Try it in the pairing figure.

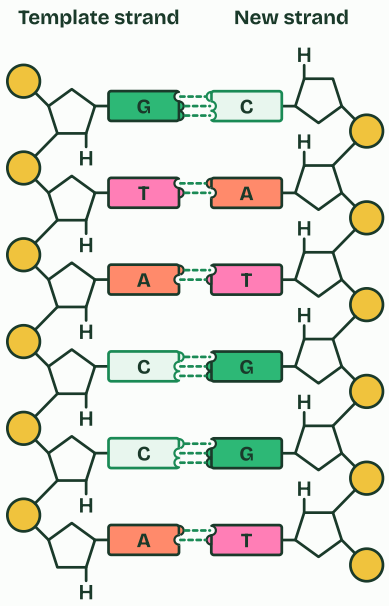
KEY TERMS

complementary base pairing
The rule that A pairs with T (or U in RNA) and C pairs with G.

hydrogen bonds
Weak attractions between a slightly positive hydrogen on one base and a slightly negative atom on the base opposite.

antiparallel
Running in opposite directions: one strand 5′ to 3′, its partner 3′ to 5′.

double helix
The shape of DNA: two antiparallel strands wound round each other, the backbones outside and the paired bases inside.

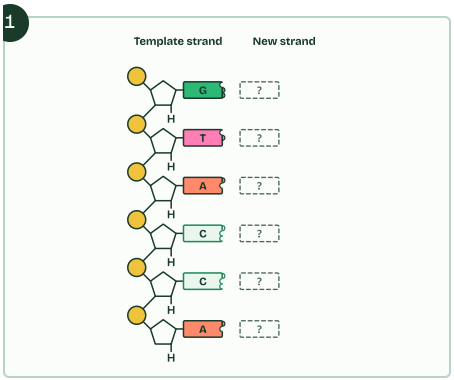


The knobs and notches stand for the atoms that form hydrogen bonds: a knob is a hydrogen that can be shared, a notch an atom that can take it. Real bases are flat rings.

SWITCH IT

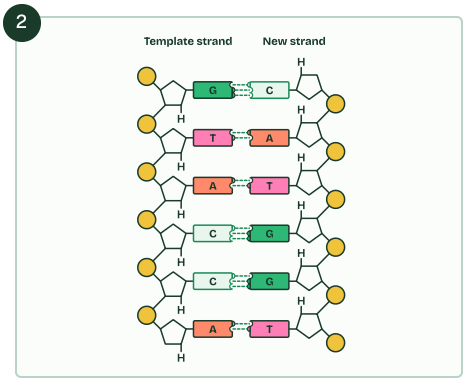
4 SETTINGS

1



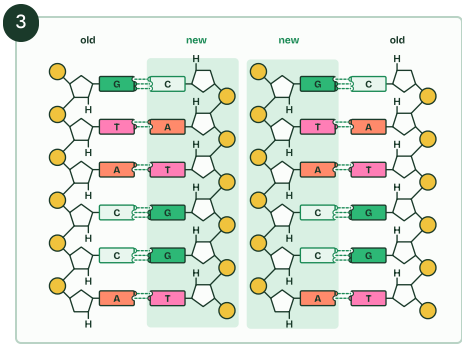
Which base fits each slot?

2



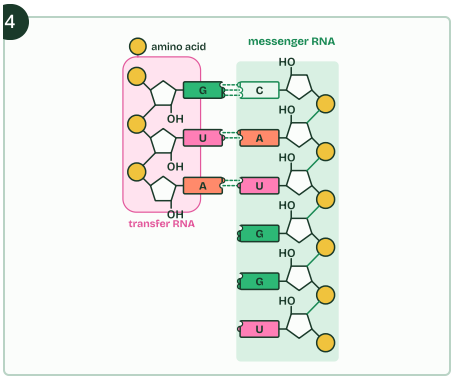
Paired: only A with T and G with C form hydrogen bonds

3

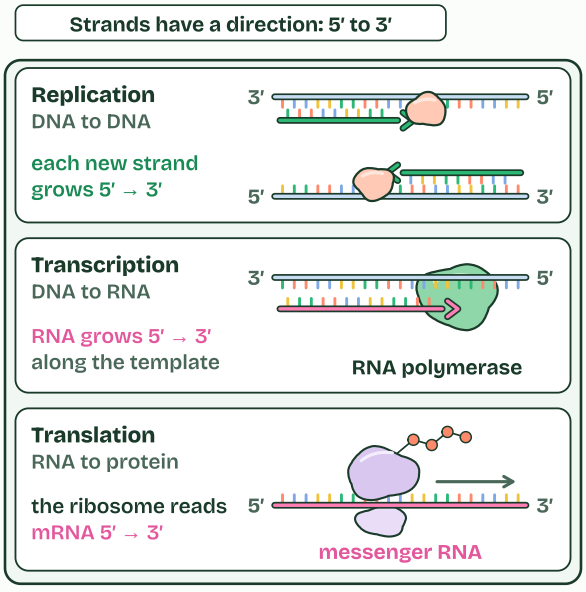


Copy it: two molecules with the same sequence

4



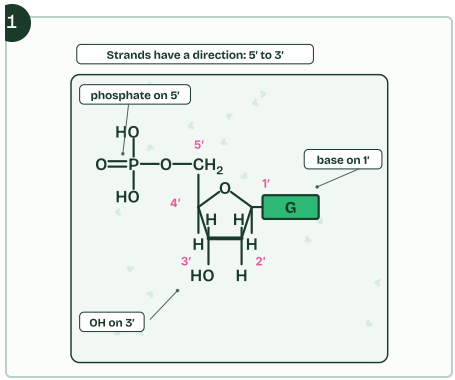
Read it: messenger RNA, read by a transfer RNA



STEP BY STEP

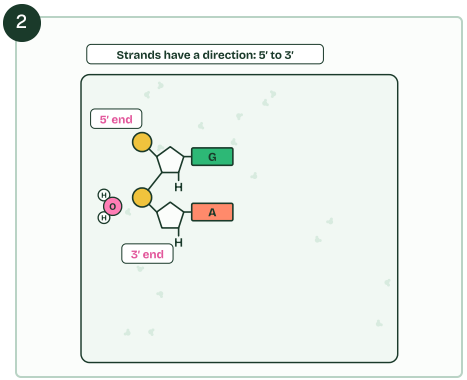
5 STEPS

1



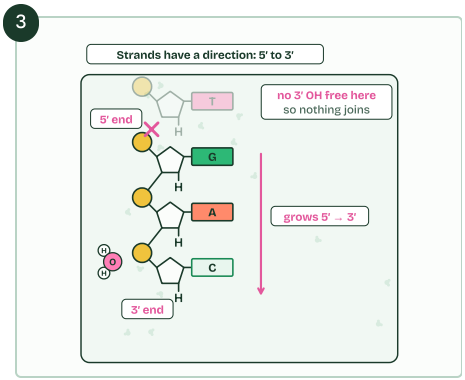
Carbons **1′ to 5′**.

2



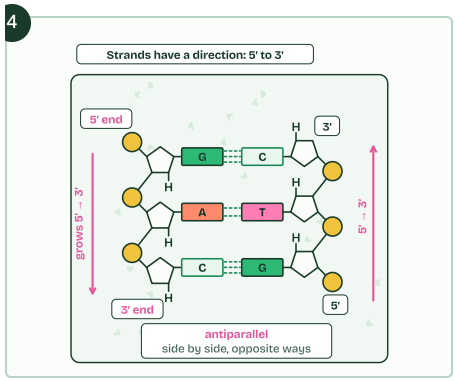
Each phosphate links a **5′** carbon to the **3′** carbon before it.

3



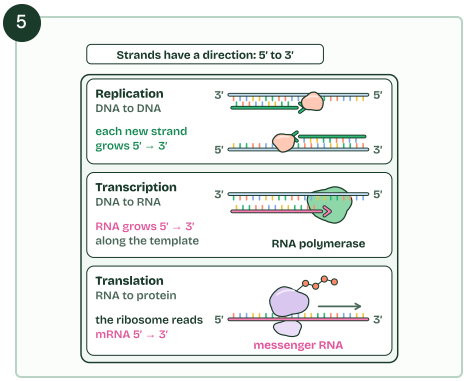
New nucleotides join only at the **3′ end**.

4

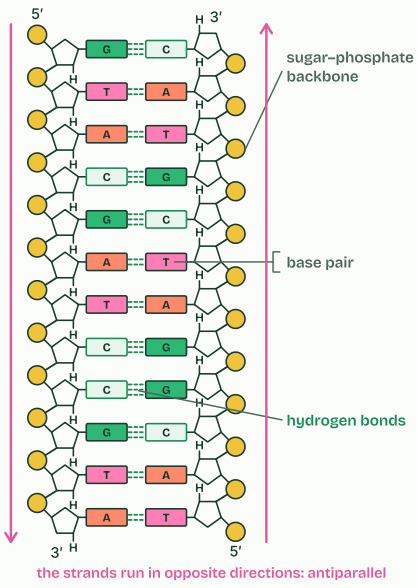


The strands are **antiparallel**: one runs 5′ to 3′, the other 3′ to 5′.

5



So DNA is copied, transcribed and read in **one direction**.

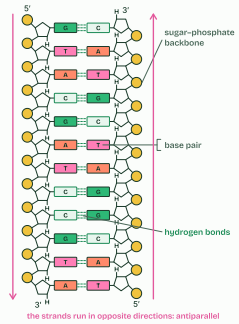


Twelve base pairs. Slide Twist to wind the ladder into a double helix, about ten base pairs a turn, then Turn it, or drag it sideways. Real DNA is about 2 nm across, with 0.34 nm between base pairs.

SWITCH IT

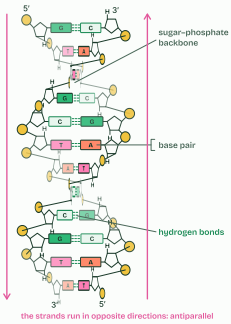
2 SETTINGS

1



Flat: the ladder the exam asks for

2



Twisted into a double helix

REMEMBER IT

Which base pairs with which

A	T	C	G
Apples	**Tree**	**Cars**	**Garage**
A pairs with T	**T in DNA only**	**C pairs with G**	**G pairs with C**
two hydrogen bonds	U takes its place in RNA	three hydrogen bonds	the stronger pair

WATCH OUT

The two strands of one molecule are complementary, not identical. And the bonds between base pairs are hydrogen bonds; the bonds along each backbone are covalent.

PREDICT

Two stretches of DNA are the same length. One is 60% C and G, the other 60% A and T. Which needs more heat to separate its strands?

(A) The A and T rich one, because adenine and thymine are the larger bases and hold on to each other more strongly

(B) The C and G rich one, because each C and G pair is held by three hydrogen bonds instead of two

(C) Both the same, because separating the strands breaks the covalent backbone, which is the same in both

Decide before you look. Answer on page 24.

06 Two nucleic acids, two *jobs*

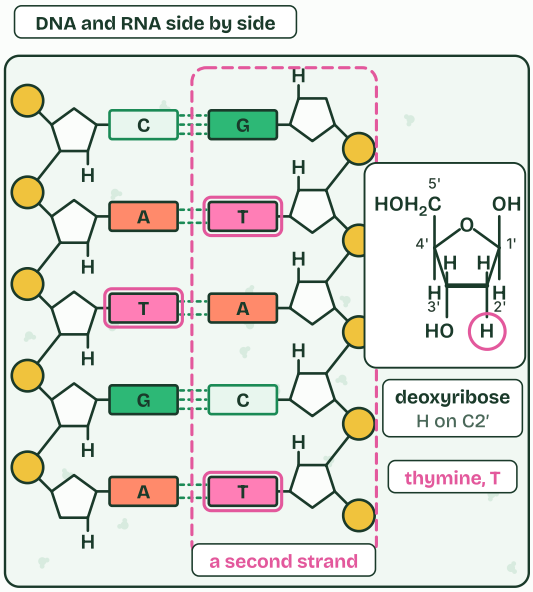
1.6.A DNA AND RNA

DNA and RNA are built the same way, nucleotides joined into a strand with a 5′ and a 3′ end and the bases at right angles to the backbone. They differ in three ways, and each fits its job.

KEY POINTS

- **The sugar.** DNA has deoxyribose, which has one oxygen fewer than RNA's ribose.
- **One base.** RNA has uracil (U) where DNA has thymine (T); U pairs with A.
- **Strands.** DNA is usually double stranded, its two strands antiparallel; RNA is usually a single strand.

DNA is the long-term store of genetic information. Two strands protect the code, since the bases are tucked inside the helix, and each strand can repair or copy the other. RNA is a working copy: a cell makes it from one gene when it needs the protein, uses it, and breaks it down. Being single stranded, RNA can also fold back on itself into shapes that do jobs, as in the ribosome (Unit 6).

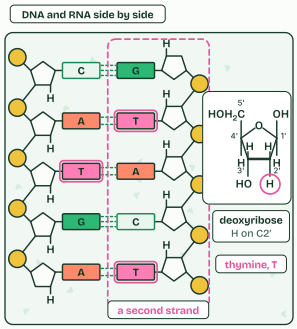


Switch between them. What differs from the other nucleic acid is outlined in pink.

SWITCH IT

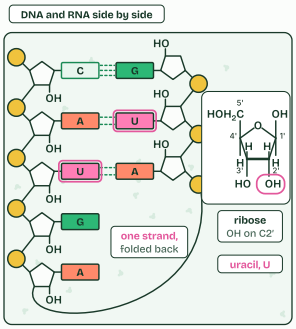
2 SETTINGS

1



DNA

2



RNA

WATCH OUT

"RNA has uracil instead of adenine." Uracil replaces thymine, and it pairs with adenine.

PREDICT

A sample of nucleic acid contains uracil, and its A and U are not present in equal amounts. What is it most likely to be?

(A) Double-stranded DNA, because every A in a DNA molecule is always paired with a U on the other strand

(B) Single-stranded RNA, because uracil is found only in RNA and a single strand has no partner to match its bases

(C) Double-stranded RNA, because uracil can only be found in molecules where two strands are paired together

Decide before you look. Answer on page 24.

Key terms

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

3′ end 04
The end of a strand with a free OH group on the 3′ carbon of the last sugar. New nucleotides are added here.

5′ end 04
The end of a strand of DNA or RNA with a free phosphate on the 5′ carbon of the last sugar.

amphipathic 03
Having a hydrophilic part and a hydrophobic part.

antiparallel 05
Running in opposite directions: one strand 5′ to 3′, its partner 3′ to 5′.

bilayer 03
Two layers of phospholipids, tails pointing in toward each other and heads facing the water on either side.

complementary base pairing 05
The rule that A pairs with T (or U in RNA) and C pairs with G.

double helix 05
The shape of DNA: two antiparallel strands wound round each other, the backbones outside and the paired bases inside.

fatty acids 01
A long hydrocarbon chain with a carboxyl group, COOH, at one end.

glycerol 01
A small molecule of three carbons, each with an OH group, that fatty acids join to.

hydrogen bonds 05
Weak attractions between a slightly positive hydrogen on one base and a slightly negative atom on the base opposite.

hydrophilic head 03
The phosphate end of a phospholipid, which is polar and attracts water.

hydrophobic 01
Not attracted to water; nonpolar substances are hydrophobic.

lipids 01
Molecules made by living things that are mostly carbon and hydrogen, nonpolar and hydrophobic: fats, oils, phospholipids, steroids and waxes.

nitrogenous base 04
A ring-shaped, nitrogen-containing part of a nucleotide: A, T, G or C in DNA, and A, U, G or C in RNA.

nonpolar 01
Having no partial charges, because electrons are shared evenly, as in C–H bonds.

nucleotides 04
The monomer of nucleic acids: a five-carbon sugar, a phosphate group and a nitrogenous base.

phospholipid 03
A lipid of glycerol joined to two fatty acids and a phosphate group: a polar head and two nonpolar tails.

saturated 02
A fatty acid with no C=C double bonds: every carbon holds as many hydrogens as it can.

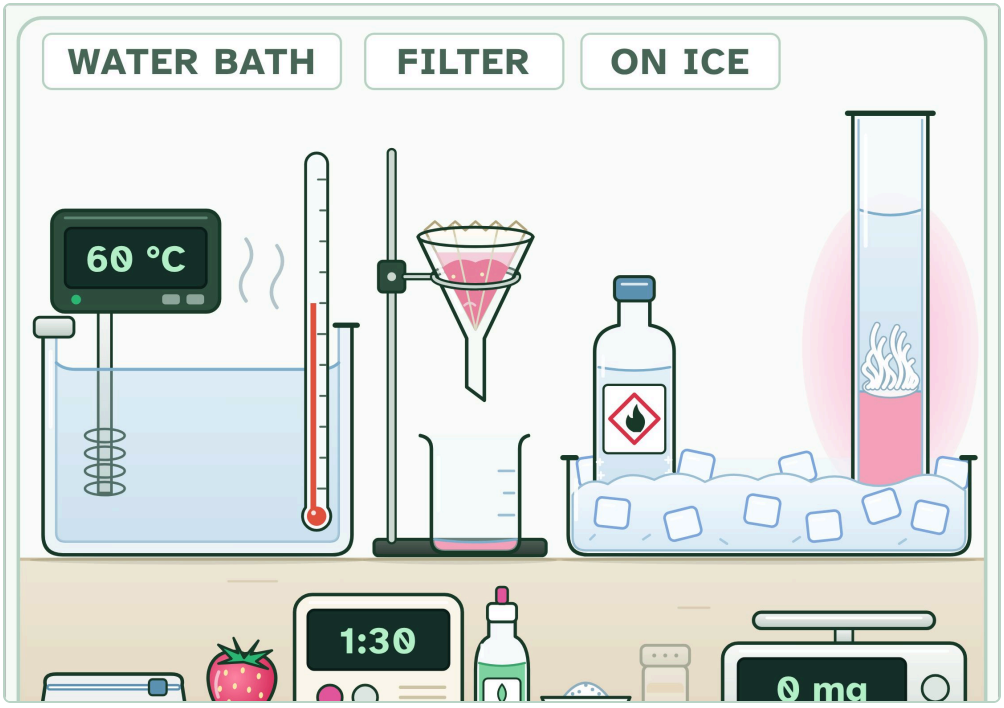
sugar-phosphate backbone 04
The chain of alternating sugars and phosphates, joined by covalent bonds, that runs along a strand of DNA or RNA.

triglycerides 01
A lipid of one glycerol joined to three fatty acids.

unsaturated 02
A fatty acid with one or more C=C double bonds in its chain.

Dry lab: *Getting DNA out*

Mash, dissolve, warm, filter and pour on cold ethanol. Leave a step out or change it, run it three times, and find out what each step is for.



Run it online: change the variables, run the trials, and the table and graph fill in as you go. `biologybybradford.com/guides/ap-biology-unit-1-lipids-and-nucleic-acids#lab`

Your question

Which steps of a DNA extraction matter most for how much DNA you get, and why does each one work?

What you can change

The fruit or vegetable, how long you mash it, whether you add dish soap, how much salt, the temperature and time of the warm bath, a protease, and the ethanol: ice-cold, at room temperature, or none.

What to record

The mass of DNA you wind out on each run. Repeat each set-up three times and compare the means.

Find out

- **The full method first.** Run every step with strawberries, three times. That mean is the yield to beat.
- **Leave the soap out.** Predict, then run it three times. What does dish soap do to a cell, and why does that matter for the DNA?
- **Room temperature ethanol.** Swap the ice-cold ethanol for ethanol at room temperature. What changes, and why?
- **Add protease.** What is the DNA wrapped round in the nucleus, and what happens to the threads when that is digested?

Record

- Every run's settings and the mass of DNA wound out.
- Change one step at a time, three runs each, and compare the means with the full method.
- For each step, one sentence: what it does to the cell or to the DNA.

Your question Which steps of a DNA extraction matter most for how much DNA you get, and why does each one work?**What you can change**The fruit or vegetable, how long you mash it, whether you add dish soap, how much salt, the temperature and time of the warm bath, a protease, and the ethanol: ice-cold, at room temperature, or none.**What to record**The mass of DNA you wind out on each run. Repeat each set-up three times and compare the means.

Back to the molecules

Soap got the DNA out of the cells, and ethanol got it out of the water. Use the structure of a phospholipid and of a nucleotide to explain why each step works.

QUESTIONS ON THE LAB

QUESTION 1

Without the dish soap, far less DNA came out. Why?

(A) Dish soap is what makes the DNA molecules stick together into threads, so without it they stay too thin to see

(B) Soap breaks up the lipid bilayers of the cell and nuclear membranes, so without it most DNA stays shut inside

(C) Dish soap is what turns the DNA white, so without it the DNA is still there but cannot be seen in the tube

Answer on page 24.

QUESTION 2

DNA dissolves in the watery extract but comes out as white threads where the ethanol meets it. What does that tell you about DNA?

(A) DNA is a lipid, because it moves from the water layer into the ethanol, which is the less polar of the two liquids

(B) DNA reacts with ethanol, which joins its nucleotides into much longer chains that are too big to stay dissolved

(C) Its charged phosphate backbone keeps DNA dissolved in water, but it is insoluble in ethanol, so it comes out of solution there

Answer on page 25.

Check yourself

The check for this guide is online: a fresh paper of past-paper style questions from the exam bank on 1.5 and 1.6 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?program=ap&units=U1&ced=1.5,1.6&paper=quiz&marks=15&src=ep

Answers

PREDICTIONS IN THE CHAPTERS

01 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 watery layer**

Melt it and let it settle. Butter is 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 melted fat floats above: clarified butter. Stirring cold butter into water fails because the fat does not dissolve or let go of its water droplets, and salt does not evaporate at kitchen temperatures.

02 Olive oil's fatty acids mostly have one double bond, and sunflower oil's mostly two or more. 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, because with fewer double bonds its chains pack better, so its melting point is higher**

Olive oil. With mostly one kink per chain, its chains pack better than sunflower oil's, so it begins to solidify at fridge temperatures while sunflower oil stays clear. The fats dry lab below lets you measure the pattern.

03 Phospholipids are shaken in oil instead of water. Which way do they turn?

C **Tails out into the oil and heads gathered together inside, the reverse of how they sit in water**

Turned inside out. The tails now mix with the nonpolar oil, and the polar heads, with nothing to attract them, cluster together away from it, around any trace of water. The shape a phospholipid takes is set by what it sits in: the bilayer is what water makes it do.

04 A strand of RNA 50 nucleotides long is made. How many water molecules are released?

B **49**

49, one for each bond in the backbone. It is the same rule as for any polymer built by dehydration synthesis.

05 Two stretches of DNA are the same length. One is 60% C and G, the other 60% A and T. Which needs more heat to separate its strands?

B **The C and G rich one, because each C and G pair is held by three hydrogen bonds instead of two**

The C and G rich one. Each C–G pair has three hydrogen bonds and each A–T pair two, so more C and G means more bonds to break. Separating the strands breaks only hydrogen bonds: the backbones stay whole.

06 A sample of nucleic acid contains uracil, and its A and U are not present in equal amounts. What is it most likely to be?

B **Single-stranded RNA, because uracil is found only in RNA and a single strand has no partner to match its bases**

Single-stranded RNA. Uracil means RNA. In a double strand every A has a partner opposite it, so A and its partner come in equal amounts; in a single strand nothing forces them to match.

QUESTIONS ON THE DRY LAB

Q1 Without the dish soap, far less DNA came out. Why?

B **Soap breaks up the lipid bilayers of the cell and nuclear membranes, so without it most DNA stays shut inside**

The membranes stay whole. Soap molecules, like phospholipids, have a hydrophobic tail and a hydrophilic head. They push in among the phospholipids and break the bilayer into small droplets, opening the cell and its nucleus. Mashing alone tears some cells open, but leaves most nuclei closed.

Q2 DNA dissolves in the watery extract but comes out as white threads where the ethanol meets it. What does that tell you about DNA?

C Its charged phosphate backbone keeps DNA dissolved in water, but it is insoluble in ethanol, so it comes out of solution there

DNA is soluble in water and not in ethanol. The negatively charged phosphates of its backbone attract water molecules. Ethanol is less polar, and with salt shielding those charges, the long molecules clump together and come out of solution as threads you can wind up. Ice-cold ethanol works better because it mixes more slowly and DNA is even less soluble in it.

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.