Cambridge IGCSE · Biology 0610 · Notes

Biological molecules

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What you need to know

Living things are built from a few kinds of large molecule. This topic is about what they are made of and how to test a food for them. The part marked **Extended only** is tested on Papers 2 and 4 only. By the end of it you should be able to:

1. **List the chemical elements** in carbohydrates, fats and proteins.
2. **State that large molecules are made from smaller molecules**, for these three cases only:
   - starch, glycogen and cellulose are made from glucose;
   - proteins are made from amino acids;
   - fats and oils are made from fatty acids and glycerol.
3. **Describe the five food tests**: iodine solution for starch, Benedict's solution for reducing sugars, the biuret test for proteins, the ethanol emulsion test for fats and oils, and the DCPIP test for vitamin C. Know how each is carried out and what a positive and a negative result look like.
4. **Extended only:** describe the structure of DNA: two strands coiled together to make a double helix; each strand contains chemicals called bases; bonds between pairs of bases hold the two strands together; and the bases always pair the same way, A with T and C with G (you don't need the full names of the bases).

Understand it

Elements: what the molecules are made of

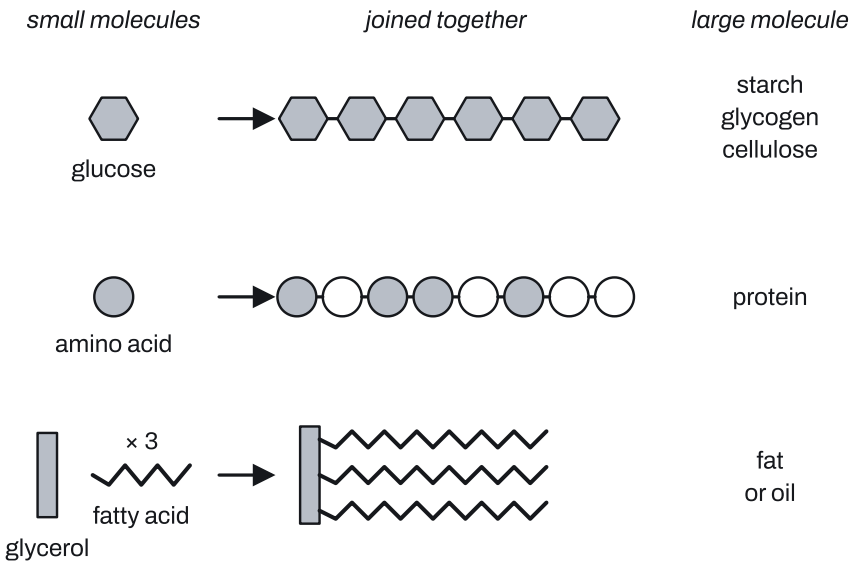
Nearly everything in a cell is built from just a few chemical elements.

- **Carbohydrates** (sugars such as glucose, and starch, glycogen and cellulose) contain **carbon, hydrogen and oxygen** only: C, H, O.
- **Fats and oils** also contain **carbon, hydrogen and oxygen** only: C, H, O. (They have much less oxygen than carbohydrates, but the elements are the same.)
- **Proteins** contain **carbon, hydrogen, oxygen and nitrogen**: C, H, O, N. Some proteins also contain sulfur, but the four you must list are C, H, O and N.

So **nitrogen is the element that is in proteins but not in carbohydrates or fats**. That one fact answers a lot of questions. Enzymes and haemoglobin are proteins, and amino acids are the units of proteins, so they all contain nitrogen too. Iron, calcium and magnesium are not in any of these three types of molecule: they are mineral ions, a different part of the diet.

Large molecules from small ones

Large molecules are made by joining many small molecules together, like beads on a string. Digestion does the reverse: it breaks the large molecules back down into their small units.



Large molecule	Made from	Where you meet it
Starch	glucose	the energy store in plant cells
Glycogen	glucose	the energy store in animal cells (liver and muscles)
Cellulose	glucose	plant cell walls
Protein (including enzymes and haemoglobin)	amino acids	enzymes, muscle, membranes, antibodies
Fats (solid) and oils (liquid)	fatty acids and glycerol	energy store, insulation

Three things to notice:

- **Starch, glycogen and cellulose are all made of glucose.** They are different because the glucose units are joined in different ways, but you only need to know that glucose is the unit of all three.
- **A protein is a chain of amino acids.** There are about twenty kinds of amino acid, and the order they are joined in makes each protein different. A diagram of a protein as a chain of small circles shows amino acids.

- **Fats and oils have two different units**: fatty acids and glycerol. Glycerol is **not** a sugar, and fats contain no glucose.

Don't confuse the names: **glycogen** is the large molecule made of glucose; **glycerol** is one of the small units of fat; **glucagon** is a hormone (a different topic).

The five food tests

Each test uses a chemical that changes colour when a particular nutrient is present. For each test, a solid food is first crushed or ground with a little water to make a solution or suspension. The first colour is the colour of the reagent; the colour change is what shows the nutrient is there.

Nutrient	Test	Heat?	Negative result (nutrient absent)	Positive result (nutrient present)
Starch	a few drops of **iodine solution**	no	stays yellow-brown (orange-brown)	**blue-black**
Reducing sugars (such as glucose)	add **Benedict's solution**, heat in a water-bath at about 80 °C for a few minutes	**yes**	stays blue	green, yellow, orange or **brick-red**
Protein	add **biuret** solution	no	stays blue	**purple** (lilac)
Fats and oils	shake with **ethanol**, then pour the ethanol into water	no	stays clear	**cloudy white** (a milky emulsion)
Vitamin C	add the food solution drop by drop to **DCPIP**	no	DCPIP stays blue	DCPIP turns **colourless**

How each one works:

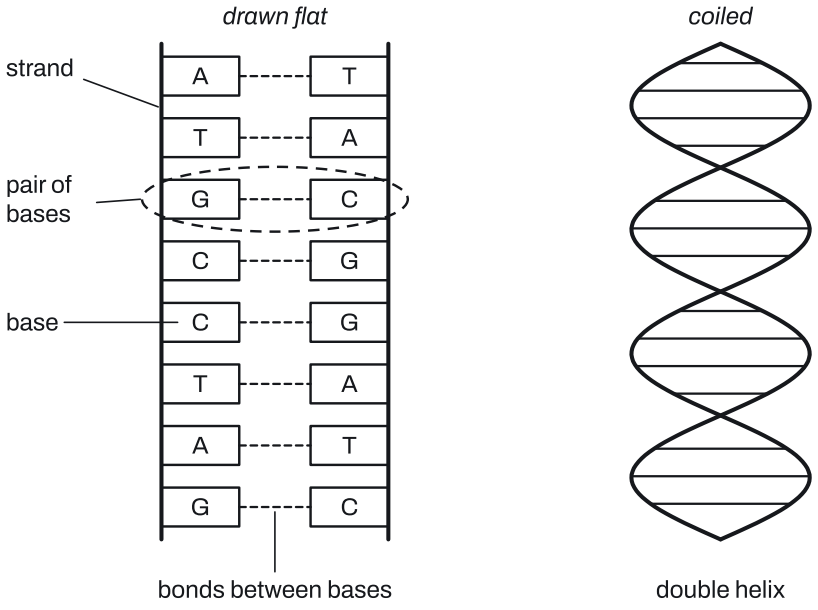
- **Iodine solution** is yellow-brown. Starch makes it go blue-black. This is the test used on leaves in photosynthesis experiments, after the leaf has been boiled and the chlorophyll removed with ethanol.
- **Benedict's solution** is blue. It only reacts when **heated**. With a reducing sugar, such as glucose or maltose, it turns green, then yellow, then orange, then brick-red. The more reducing sugar there is, the further along it goes: green means a little, brick-red means a lot. Sucrose (ordinary sugar) is **not** a reducing sugar, so it gives a negative Benedict's test.
- **Biuret** solution is blue. With protein it turns purple, with no heating.
- **Ethanol emulsion test**: fats dissolve in ethanol but not in water. Shake the food with ethanol so any fat dissolves, then pour the ethanol into water. The fat comes out of solution as tiny droplets, which make the water look milky white. The order matters: ethanol first, then water.
- **DCPIP** is a blue dye. Vitamin C makes it lose its colour. To compare the vitamin C in two juices, count how many drops of each juice it takes to decolourise the same volume of DCPIP. **Fewer drops means more vitamin C**, because each drop carries more.

Iodine solution, Benedict's solution and DCPIP all start blue or brown and change; the colour at the **end** is what you read. A food can contain several nutrients, so it can give several positive tests. Always read each test on its own.

DNA (Extended only)

DNA is the molecule that genes are made of. It is found in the chromosomes in the nucleus. Its structure is described in four points:

1. It has **two strands** coiled around each other to form a **double helix** (a twisted ladder).
2. Each strand contains chemicals called **bases**. There are **four** kinds: **A, T, C and G**.
3. The bases on one strand pair with bases on the other strand, and **bonds between the pairs of bases** hold the two strands together. They are the rungs of the ladder.
4. The bases **always pair the same way: A with T, and C with G.** These are called complementary base pairs.



DNA is **not** a protein and is **not** made of amino acids. It carries the code (the order of its bases) that the cell uses to make proteins, but that is another topic.

The complementary strand. If you know one strand, you can write the other: swap every A for T, every T for A, every C for G and every G for C, keeping the order. For A–C–G–T–T–A the other strand is T–G–C–A–A–T.

Counting bases. Because every A is paired with a T, a DNA molecule always has **the same number of A as T**, and **the same number of C as G**. This lets you work out all four from one:

- If 30% of the bases are A, then T is also 30%. A and T together are 60%, so C and G share the other 40%: **C = G = 20%**.
- The same works with numbers of bases instead of percentages.

A C–G pair is held together more strongly than an A–T pair, so DNA with more C and G needs a higher temperature to separate its strands. Questions sometimes give you this fact to use.

Key facts and formulas

There is no formula list in the IGCSE Biology exam. Everything below must be learnt.

Formula	Status
Carbohydrates and fats: C, H, O. Proteins: C, H, O, N	Learn it
Starch, glycogen, cellulose ← glucose; protein ← amino acids; fats and oils ← fatty acids and glycerol	Learn it
Iodine: yellow-brown → blue-black (starch). Benedict's + heat: blue → brick-red (reducing sugar). Biuret: blue → purple (protein). Ethanol then water: clear → cloudy white (fat). DCPIP: blue → colourless (vitamin C)	Learn it
Extended: A pairs with T, C pairs with G	Learn it
Extended: $\%A = \%T$, $\%C = \%G$, and $\%A + \%T + \%C + \%G = 100\%$, so $\%G = \dfrac{100 - 2 \times \%A}{2}$	Learn it
Extended: in numbers of bases, $A = T$, $C = G$, $G = \dfrac{\text{total bases} - 2A}{2}$ (and $\text{total bases} = 2\times$ number of base pairs)	Learn it

How to do it

In the questions we have tagged for this topic (113 questions, 2021–2025, on Papers 1–4), the types came up this often. 12 of the 113 questions mix types, so the counts add up to more than 113.

Question type	Questions
Name a food test, its reagent or its colours, or read a table of food-test results	35
State the elements in carbohydrates, fats or proteins	31
Match large molecules to the small molecules they are made from	30
Extended: describe DNA structure, base pairing or the complementary strand	24
Extended: work out base percentages or numbers of bases in DNA	6

Most are one-mark multiple choice on Papers 1 and 2. On Papers 3 and 4 the topic comes as short parts (elements, matching lines, a food test) inside a longer question about digestion, photosynthesis, enzymes or genetics.

1. Food tests (35 questions)

1. **Learn the table** in "Understand it": nutrient, reagent, heat or not, start colour, positive colour.
2. **"Which test for …?" or "What colour?"**: give the reagent's full name (iodine **solution**, **Benedict's** solution, **biuret**, **ethanol**, **DCPIP**) and the exact colour (blue-black, brick-red, purple, cloudy white, colourless).
3. **A table of results**: go through the columns one at a time. For each test, write "present" or "absent" next to it, using the positive colours only. Then read off the answer. For example, iodine yellow-brown (no starch), Benedict's blue (no reducing sugar), biuret purple (protein), DCPIP colourless (vitamin C): the food contains protein and vitamin C.

Variations you will meet:

- **"Describe how you would test for …"** (usually Benedict's or the emulsion test): give the reagent, what you do (heat in a water-bath for Benedict's; ethanol first, then water, for fats), and the positive colour. For starch or protein there's no heating.
- **Two nutrients in one question**, such as "reducing sugars and vitamin C in lemon juice": Benedict's for the sugar, DCPIP for the vitamin C.
- **A starch test on a leaf** in a photosynthesis experiment: parts that made starch go blue-black; parts that didn't (white parts of a variegated leaf, or leaves kept in the dark or without carbon dioxide) stay yellow-brown.
- **An indicator you haven't met** (for example, "turns brown when glucose is present"): use the rule the question gives, in the same way.
- **Comparing amounts**: Benedict's colour (green < yellow < orange < brick-red means more sugar), or drops of juice to decolourise DCPIP (fewer drops = more vitamin C).

2. Chemical elements (31 questions)

1. Carbohydrates: C, H, O. Fats and oils: C, H, O. Proteins: C, H, O, N.
2. **"Which element is in proteins but not carbohydrates?"** Nitrogen.
3. **A table of ticks**: tick C, H, O for carbohydrate and fat; tick all four for protein.

Variations you will meet:

- **Named examples**: starch, glucose, cellulose, glycogen and sucrose are carbohydrates (C, H, O). Enzymes, haemoglobin and amino acids are proteins or their units (C, H, O, N).
- **"Circle the elements present in all proteins"** from a list that includes calcium, iron, magnesium or iodine: circle only carbon, hydrogen, oxygen and nitrogen.
- **"Which structure is an amino acid?"** from drawn formulas: the amino acid is the one with a nitrogen (an NH_2 group) as well as C, H and O. The others (glucose and other sugars) have no N.

3. Large molecules and their small units (30 questions)

1. Glucose makes **starch, glycogen and cellulose**.

2. Amino acids make **proteins** (including enzymes).
3. Fatty acids **and** glycerol make **fats and oils**.

Variations you will meet:

- **Draw lines** from small to large molecules: amino acid → protein, glucose → glycogen (or starch, cellulose), fatty acid and glycerol → fat.
- **"Which statement is correct?"**: check each option against the three rules. Wrong options usually swap units, such as "glycogen is made of glycerol" or "protein is made of fatty acids".
- **Name one large molecule containing** glucose (starch, glycogen or cellulose), amino acids (protein) or glycerol (fat or oil).
- **Two carbohydrates other than starch**: glycogen and cellulose.
- **Digestion tables**: the products of digesting a large molecule are its small units. Protein → amino acids; starch → (maltose, then) glucose; fat or oil → fatty acids and glycerol; glycogen → glucose.
- **A diagram of a protein** as a chain of beads: each bead is an amino acid.

4. DNA structure and base pairing, Extended only (24 questions)

1. **"Describe the structure of DNA"**: give the four points: two strands, coiled into a double helix; bases on each strand; bonds between pairs of bases hold the strands together; A with T and C with G.
2. **"Which pair of bases is correct?"** A–T or C–G. Every other pair (A–G, A–C, C–T, G–T) is wrong.
3. **The complementary strand**: write the partner of each base, in the same order. For C–A–T–G–G the other strand is G–T–A–C–C.

Variations you will meet:

- **"Circle one pair of bases"** on a diagram: circle the two bases that face each other across the strands, one from each strand, not two bases next to each other on one strand.
- **Sticky ends** (single-strand bases left after cutting DNA): the bases that stick to them are the complementary ones, in the same order, found the same way.
- **Fill-in sentences**: "two strands", "bases", "cross-links" or "bonds" between pairs of bases.
- **Wrong statements to reject**: DNA made of amino acids, DNA with three strands, DNA with six bases, or A paired with G.

5. Base percentages and numbers, Extended only (6 questions)

1. Write down the base you are given. Its partner has the **same** value (A = T, C = G).
2. Double it and subtract from the total (100% or the total number of bases).
3. Halve what is left: that is each of the other two bases.

For example, in a DNA sample 20% of the bases are T. Then A = 20%, A + T = 40%, C + G = 60%, so G = 30%.

Variations you will meet:

- **Numbers of bases**: "A length of DNA has 2000 bases; 560 are C." Then G = 560, C + G = 1120, A + T = 880, so A = 440.
- **Pairs of bases**: if you are told the number of **pairs**, double it first to get the number of bases.
- **Which DNA separates at the lowest temperature?** The one with more A and T (fewer C–G pairs), because C–G pairs are held together more strongly.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1

(a) Complete the table to show which chemical elements are found in each type of molecule. Use a tick for present and a cross for absent. **[3]**

Molecule	Carbon	Hydrogen	Nitrogen	Oxygen
Starch				
Oil				
Enzyme				

(b) State the name of the smaller molecules that each of these large molecules is made from: cellulose, protein, oil. **[3]**

(a)

Molecule	Carbon	Hydrogen	Nitrogen	Oxygen
Starch	✓	✓	✗	✓
Oil	✓	✓	✗	✓
Enzyme	✓	✓	✓	✓

B1 for each correct row. Starch is a carbohydrate and oil is a fat, so neither has nitrogen; an enzyme is a protein, so it has all four.

(b) Cellulose: glucose. **B1** Protein: amino acids. **B1** Oil: fatty acids **and** glycerol. **B1** (both are needed for the mark).

Example 2

A student tested four foods, W, X, Y and Z. The table shows the colours at the end of each test.

Food	Iodine solution	Benedict's solution (heated)	Biuret	Ethanol emulsion	DCPIP
W	blue-black	blue	blue	clear	blue
X	yellow-brown	brick-red	blue	clear	colourless
Y	yellow-brown	blue	purple	cloudy white	blue
Z	blue-black	orange	purple	clear	blue

(a) State which food contains starch and nothing else that was tested for. **[1]**

(b) State which food contains protein and fat. **[1]**

(c) State the nutrients that food Z contains. **[2]**

(d) Describe how the student tested the foods for reducing sugars. **[3]**

(a) W: only the iodine test is positive. **B1**

(b) Y: biuret purple and a cloudy emulsion. **B1**

(c) Starch (iodine blue-black) and reducing sugar (Benedict's orange) **B1**; protein (biuret purple) **B1**. Food Z has no fat and no vitamin C.

(d) Add Benedict's solution to a solution of the food **B1**; heat it in a water-bath (about 80 °C) for a few minutes **B1**; a colour change from blue to green, yellow, orange or brick-red shows a reducing sugar **B1**.

Example 3

Two fruit juices were tested for vitamin C. The same volume of blue DCPIP solution was put into each of two test-tubes. Each juice was added one drop at a time until the DCPIP turned colourless. Juice P needed 8 drops and juice Q needed 20 drops.

(a) State which juice contains more vitamin C, and explain your answer. **[2]**

(b) Calculate how many times more concentrated the vitamin C is in the richer juice. **[1]**

(c) State one variable that must be kept the same to make this a fair comparison. **[1]**

(a) Juice P **B1**: it needed fewer drops to decolourise the same volume of DCPIP, so each drop carries more vitamin C **B1**.

(b) $20 \div 8 = 2.5$ times. **B1**

(c) The volume (or concentration) of DCPIP, the size of the drops, or the temperature. **B1** for any one, stated in full: "the volume of DCPIP", not just "DCPIP".

Example 4 (Extended)

(a) The bases on one strand of a length of DNA are A–T–G–C–C–T–A–G. State the sequence of bases on the other strand. **[1]**

(b) In the DNA of one organism, 18% of the bases are C. Calculate the percentage of the bases that are A. **[2]**

(c) A section of DNA contains 3000 bases, and 840 of them are T. Calculate the number of G bases. **[2]**

(d) Describe the structure of a DNA molecule. **[3]**

(a) T–A–C–G–G–A–T–C. **B1** (this is the molecule drawn in the second diagram).

(b) G = C = 18%, so C + G = 36% **M1**. A + T = 100 − 36 = 64%, so A = **32% A1**.

(c) A = T = 840, so A + T = 1680 **M1**. C + G = 3000 − 1680 = 1320, so G = **660 A1**.

(d) Any three of: two strands coiled to form a double helix **B1**; each strand contains bases **B1**; bonds between pairs of bases hold the strands together **B1**; A always pairs with T and C with G **B1**.

Common mistakes

- **Leaving nitrogen out of proteins**, or adding it to carbohydrates or fats. Examiners see both every year. Proteins: C, H, O, N; the others: C, H, O.
- **Writing a molecule instead of an element**: "carbon dioxide" or "water" instead of carbon or hydrogen, or "amino acids" when asked for an element. Elements are single names from the periodic table.
- **Mixing up glycogen, glycerol and glucagon.** Glycogen is made of glucose; glycerol is part of a fat; glucagon is a hormone.
- **Forgetting one of the units of fat.** Fats are made of fatty acids **and** glycerol; one alone doesn't get the mark.
- **Missing the heating step in the Benedict's test**, or saying "put it in a water-bath" without saying it is hot. Only Benedict's needs heat.
- **Swapping the protein and sugar tests.** Biuret → purple is protein; Benedict's → brick-red is reducing sugar.
- **Vague names and colours**: "iodine" instead of iodine solution, "black" or "dark blue" instead of blue-black, "burette" instead of biuret.
- **Giving the name of the test when asked for the colour** (for example "biuret" when the question asks for the positive result). Read what the question asks for.
- **Doing the emulsion test in the wrong order**: the food goes into ethanol first, then into water. No heat.
- **Not knowing DCPIP** for vitamin C, or thinking a juice that takes more drops has more vitamin C. Fewer drops means more.
- **Extended: calling DNA a protein** or a chain of amino acids, or writing "two chains" without the double helix and bases.

- **Extended: base-pair sums done with one strand in mind.** If T is 27%, G is not 73% or 27%: A = 27%, so C + G = 46% and G = 23%.
- **Extended: circling two bases on the same strand** instead of a pair across the strands.

How to get the marks

- **"List" or "state" the elements**: write all of them, as element names (carbon, hydrogen, oxygen, nitrogen). Write the names in full to be safe, and don't leave one out: a missing element loses the mark.
- **Food tests**: a full answer has three parts: the named reagent, what you do (heat for Benedict's; ethanol then water for fats), and the colour of a **positive** result. The mark scheme wants the exact colour words.
- **"Describe"** a test or DNA: give the separate points, one per mark. **"Explain"** a result: say what the colour shows (for example, "no reducing sugar, because the Benedict's solution stayed blue").
- **Tables of results**: work column by column and only then choose. Tick boxes: one tick per box, and don't tick two options when the question wants one.
- **Draw lines**: draw exactly the number of lines asked for, from each box on the left.
- **Constant variables** in a food-test investigation must be stated in full: "the volume of Benedict's solution", "the temperature of the water-bath", not just "Benedict's".
- **Extended calculations**: show the steps (partner base, total for the pair, what's left, halve it). A working line can earn a mark even if the final answer slips.
- **Extended: "Describe the structure of DNA"**: the four points are the mark scheme; a labelled sketch of a double helix with paired bases also earns credit.

Quick check

1. Name the element that is found in proteins but not in carbohydrates or fats.
2. State the small molecules that make up (a) glycogen and (b) oils.
3. A food sample is tested. Biuret turns purple, heated Benedict's solution stays blue, and iodine solution stays yellow-brown. State what the food contains and what it does not contain.
4. Describe how to test a food for fat, and give the result if fat is present.
5. **Extended:** (a) State the complementary strand to G–G–A–T–C–A. (b) A DNA molecule contains 5000 bases, of which 1300 are A. Calculate the number of G bases.

Answers

1. Nitrogen.
2. (a) Glucose. (b) Fatty acids and glycerol.
3. It contains protein (biuret purple). It contains no reducing sugar (Benedict's stayed blue) and no starch (iodine stayed yellow-brown).
4. Shake (or mix) the food with ethanol, then pour the ethanol into water. A cloudy white emulsion shows fat is present; if it stays clear, there is no fat.
5. (a) C–C–T–A–G–T. (b) T = A = 1300, so A + T = 2600. C + G = 5000 − 2600 = 2400, so G = 1200.

Past questions to try

- **0610/32/M/J/21 Q2**: elements in carbohydrates and proteins, and matching large molecules to what they are made of.
- **0610/13/M/J/23 Q9**: reading a table of food-test results.
- **0610/42/M/J/23 Q2**: circling a base pair and working out a base percentage (Extended).
- **0610/22/M/J/22 Q8**: counting bases from a number of base pairs (Extended).