Control of blood glucose concentration

4.5.3.2 · Biology · revision notes

How the pancreas uses insulin, and at Higher tier glucagon, to keep blood glucose within narrow limits, and the causes and treatments of Type 1 and Type 2 diabetes. Expect graph questions on glucose levels after a meal, 'compare Type 1 and Type 2 diabetes', and 6-mark negative feedback explanations.

Key facts

- The pancreas monitors and controls blood glucose
- Grade 7+ only Glucose too low → glucagon → glycogen converted to glucose → released into the blood
- Type 2: cells no longer respond to insulin → carbohydrate-controlled diet and exercise
- Glucose = the sugar; glycogen = the store; glucagon = the hormone
- Glucose too high → insulin → glucose moves into cells → stored as glycogen in liver and muscle cells
- Type 1: pancreas makes too little insulin → insulin injections
- Obesity is a risk factor for Type 2 diabetes

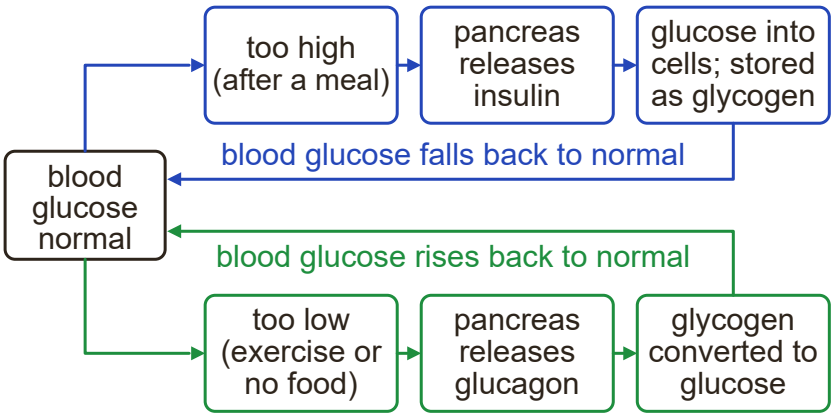
Notes

Insulin

- Blood glucose concentration is **monitored and controlled by the pancreas**.
- If blood glucose is **too high** (e.g. after a meal), the pancreas releases the hormone **insulin** into the blood.
- Insulin causes glucose to **move from the blood into the cells**.
- In **liver and muscle cells**, excess glucose is converted into **glycogen** for storage. Blood glucose falls back to normal.

Glucagon and negative feedback Grade 7+ only

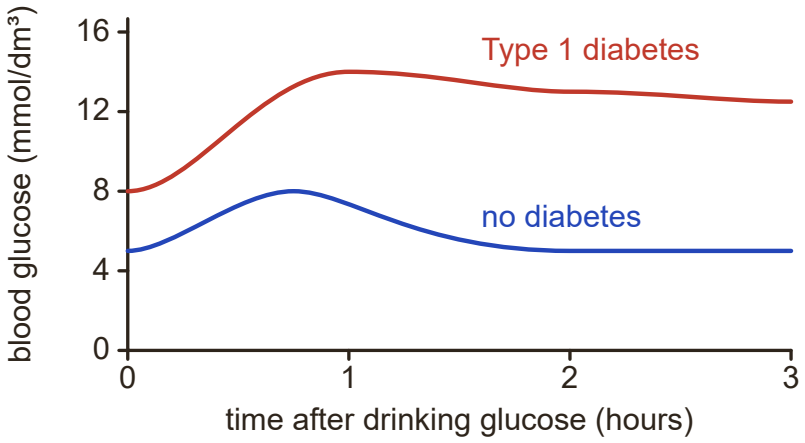
- If blood glucose is **too low** (e.g. after exercise or a long time without food), the pancreas releases the hormone **glucagon**.
- Glucagon causes **glycogen to be converted into glucose**, which is released into the blood, so blood glucose rises.
- Insulin and glucagon work together in a **negative feedback** cycle: a rise triggers insulin, which brings the level down; a fall triggers glucagon, which brings it back up.



Insulin and glucagon: negative feedback keeps blood glucose within narrow limits.

Diabetes

- **Type 1 diabetes**: the pancreas fails to produce enough insulin, so blood glucose is uncontrolled and can rise to dangerously high levels. It is normally treated with **insulin injections**.
- **Type 2 diabetes**: the body cells **no longer respond** to the insulin produced by the pancreas. Common treatments are a **carbohydrate-controlled diet** and an **exercise regime**.



Without enough insulin, blood glucose rises higher and stays high.

- **Obesity** is a risk factor for Type 2 diabetes.
- Data show Type 2 diabetes is more common in people with a higher BMI. This is a correlation: it shows a link but does not prove obesity is the only cause.
- Recommendations to cut obesity (healthy eating advice, sugar taxes, more exercise) must weigh cost, freedom of personal choice and fairness to people on low incomes.

How to answer each type of question

Describe how blood glucose returns to normal after a meal 3 marks **Grade 5**

1. The pancreas detects the high glucose level and releases insulin.
2. Insulin makes glucose move from the blood into cells.
3. Liver and muscle cells convert excess glucose to glycogen.

Example. After a meal, a person's blood glucose concentration increases.
Describe how the body brings the blood glucose concentration back to normal.

Model answer. The pancreas detects the high blood glucose concentration and releases insulin (1). Insulin causes glucose to move from the blood into cells (1). In liver and muscle cells, excess glucose is converted to glycogen for storage (1).

Compare Type 1 and Type 2 diabetes 2 to 4 marks **Grade 5**

1. Give the cause of each type, linked with 'whereas'.
2. Give the treatment of each type, linked with 'whereas'.

Example. Compare the causes and treatments of Type 1 and Type 2 diabetes.

Model answer. In Type 1 the pancreas does not produce enough insulin (1), whereas in Type 2 the body cells no longer respond to insulin (1). Type 1 is treated with insulin injections (1), whereas Type 2 is usually treated with a carbohydrate-controlled diet and exercise (1).

Interpret blood glucose data

3 to 4 marks | **Grade 5**

1. Read values carefully, with units.
2. For a percentage change: change ÷ starting value × 100.
3. Explain the pattern using insulin: with Type 1 diabetes too little insulin is made, so glucose stays high.

Example. Two people each drink a glucose solution. Person A does not have diabetes. Person B has Type 1 diabetes. The table shows their blood glucose concentrations.

Person	Before the drink (mmol/dm^3)	Peak (mmol/dm^3)	2 hours after the drink (mmol/dm^3)
A	5	8	5
B	8	14	13

(a) Calculate the percentage increase in person B's blood glucose concentration, from before the drink to the peak.
(b) Explain why person B's blood glucose concentration stays high.

Model answer.

(a) 14 − 8 = 6 (1); 6 ÷ 8 × 100 = 75% (1)
(b) Person B's pancreas does not produce enough insulin (1), so glucose is not moved from the blood into cells / not converted to glycogen (1).

6-mark: explain how insulin and glucagon control blood glucose

6 marks | **Grade 8**

1. Deal with the rise first: pancreas, insulin, glucose into cells, glycogen.
2. Then the fall: pancreas, glucagon, glycogen to glucose, released into the blood.
3. Use the term negative feedback and say each response returns the level to normal.

Example. A person eats a large meal and then goes without food for several hours.
Explain how their body keeps their blood glucose concentration within normal limits over this time.

Model answer.

Indicative content: glucose from the digested meal is absorbed and blood glucose rises; the pancreas detects the rise and releases insulin; insulin causes glucose to move from the blood into cells; in liver and muscle cells excess glucose is converted to glycogen; blood glucose falls back to normal; later, glucose is used in respiration and blood glucose falls below normal; the pancreas releases glucagon; glucagon causes glycogen to be converted into glucose, which is released into the blood; blood glucose rises back to normal; the two hormones work in a negative feedback cycle.
Level 3 (5 to 6 marks): clear, logically linked explanation of both the insulin and the glucagon responses.
Level 2 (3 to 4 marks): one response explained in detail, or both with gaps.
Level 1 (1 to 2 marks): simple statements, e.g. 'insulin lowers blood glucose'.

Don’t lose marks

- Mixing up glucagon (the hormone) and glycogen (the storage carbohydrate).
- Saying insulin turns glucose into glycogen in the blood. Insulin makes glucose move into cells; the conversion happens in liver and muscle cells.
- Saying people with Type 2 diabetes make no insulin. They do make it; their cells no longer respond to it.
- Dividing by the final value instead of the starting value in percentage change calculations.
- Describing a graph without quoting any values from it.

More tips

Memory tricks

- Glucagon is released when glucose is gone (too low).
- Insulin puts glucose IN to cells.
- Type 1: the pancreas is the problem. Type 2: the cells are the problem.
- Insulin and glucagon are opposites, like a heater and a fan controlled by the same thermostat.

Exam technique

- Spell glucagon and glycogen carefully: a spelling that could be either word may not get the mark.
- In 6-mark answers, cover both directions (too high and too low) and use the term negative feedback.
- When describing graphs, quote values with units and times, e.g. 'rises to a peak of 8 $mmol/dm^3$ at 30 minutes'.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Name the organ that controls blood glucose**
The pancreas monitors and controls blood glucose concentration.

Grade 4 — **Describe how insulin lowers blood glucose**
Insulin makes glucose move from the blood into cells; liver and muscle cells store it as glycogen.

Grade 5 — **Compare the causes of Type 1 and 2**
Type 1: the pancreas does not make enough insulin. Type 2: body cells stop responding to insulin.

Grade 5 — **Describe treatments for each type of diabetes**
Type 1: insulin injections. Type 2: a carbohydrate-controlled diet and an exercise regime.

Grade 5 — **Interpret blood glucose graphs**
Describe and explain the rise and fall of glucose after a meal, with and without diabetes.

Grade 7 — **Describe how glucagon raises blood glucose**
Glucagon causes glycogen to be converted into glucose, which is released into the blood.

Grade 8 — **Explain insulin and glucagon in negative feedback**
The two hormones act in opposite directions, returning glucose to normal whenever it rises or falls.

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