

Enzymes and metabolism

Three one-hour lesson plans, and two more at higher level

Five one-hour lessons: three at standard level and two more at higher level (the guide gives C1.1 three hours at SL and two at HL). They follow Adam's teaching order: why life needs enzymes, how an enzyme fits and what changes its rate, and a lesson on measuring it that ends on [the dry lab](#) with the coach; then two higher level lessons, one on pathways, places and heat and one on stopping enzymes. The plan follows the chapters, so a class can read the guide for homework and use the lesson for the activities. Every figure plays on a projector: step through it with the arrow keys and stop on each caption.

LESSON	COVERS	FOCUS	CHAPTERS
1 Why life needs enzymes	C1.1.1, C1.1.2, C1.1.3, C1.1.10	What enzymes are for, metabolism as a web, anabolic and catabolic, and the activation energy hill	1, 2, 3
2 Fit, collisions and shape	C1.1.4 to C1.1.8	The active site and induced fit, collisions, specificity and denaturation, and the three graphs	4, 5, 6, 7
3 Measuring a rate	C1.1.9	How to measure an enzyme's rate, the initial rate, and planning, running and evaluating the catalase investigation	7, 8, lab
4 Pathways, places and heat HL	C1.1.11 to C1.1.14	Enzymes inside and outside cells, linear and cyclical pathways, heat from metabolism, and the allosteric site	9, 10, 11
5 Stopping enzymes HL	C1.1.15 to C1.1.17	Competitive inhibition and statins, feedback inhibition of the isoleucine pathway, and penicillin	12, 13, 14

The guide, for the class to read and play: biologybybradford.com/guides/ib-biology-c1-1-enzymes-and-metabolism

Why life needs enzymes

60 minutes • C1.1.1, C1.1.2, C1.1.3, C1.1.10 • Chapters 1, 2, 3

What enzymes are for, metabolism as a web, anabolic and catabolic, and the activation energy hill

BY THE END, STUDENTS CAN

- ☐ Explain why cells need catalysts, and what an enzyme's speed does for digestion, growth and keeping cool enough to live C1.1.1
- ☐ Describe metabolism as a web of linked reactions, and sort reactions into anabolic and catabolic with an example of each C1.1.2, C1.1.3
- ☐ Read an energy diagram and explain how an enzyme lowers the activation energy without changing the energy released C1.1.10

TIMING

0-6	6 min	Do now: how long without an enzyme?	
6-16	10 min	Why speed matters	
16-28	12 min	Build or break?	
28-42	14 min	Draw the hill	
42-54	12 min	Enzymes and their substrates	
54-60	6 min	Exit: label the diagram	
	60 min	One lesson	

STARTER

- 6 min** **Do now: how long without an enzyme?**
- Put [chapter 1](#)'s predict box on the board and take a vote with fingers, 1 to 4. Leave the votes up, then play [chapter 1](#)'s figure: the same bond in starch, broken two ways. Students call out the gap between the two clocks.

ON THE BOARD, FROM THE GUIDE

Open the guide on the projector at each chapter (the links work in this PDF). Every figure plays from its own buttons, and the lesson's slides have the same figures, step by step, in the order of this plan.

01 Seconds, not millions of years

CHAPTER 01 IN THE SLIDES

Step through the figure (3 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

- The same bond in starch, broken two ways.
- With water alone at room temperature, half the bonds take **millions of years** to break.
- Amylase breaks each one in about **a thousandth of a second**, at body temperature.

Predict box: With no enzyme at all, how long would water at room temperature take to break half the bonds between the glucose units in starch? Hands up or mini whiteboards first.

Answer C: About five million years

Step through the figure (3 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. One reaction, one enzyme.
2. The product of one reaction is the substrate of the **next**.
3. Thousands of linked reactions make **metabolism**. Switch off one enzyme and one step stops.

Show the figure: Six reactions in a cell or an organism. Is a bigger molecule being made, or a big one being taken apart?

Play the animation, Build glycogen, then break it down. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. Glucose units join one at a time; a **water** molecule leaves at each link.
2. Amylose **coils** into a helix: a lot of glucose in a small space.
3. Amylopectin and glycogen **branch**, so they have many ends.
4. Enzymes take glucose off the **ends**, using a water molecule each time.

Predict box: A liver cell makes thousands of different enzymes. Why so many? Hands up or mini whiteboards first.

Answer A: Each enzyme catalyses one kind of reaction

Remember it: Add Cut (Anabolic, Catabolic).

03 **A lower hill to climb**

Step through the figure (5 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. A substrate, before it reacts.
2. Breaking its bonds needs energy first: the **activation energy**.
3. Making new bonds releases energy. Here more comes out than went in.
4. With an **enzyme**, the hill is lower. Start and end do not move.
5. A building reaction ends higher than it starts. An enzyme lowers its hill too.

Predict box: An enzyme lowers the activation energy of a reaction that releases energy. What happens to the energy released overall? Hands up or mini whiteboards first.

Answer D: Nothing: the start and end levels stay put

THE LESSON

10 **Why speed matters**

min

Pairs list what would go wrong in a body with no enzymes. Take three answers and land on digestion in the hours food spends in the gut, copying all the DNA before a cell divides, and working at 37 °C. Then chapter 1's points: a catalyst is not used up, and heat is not an option for a cell.

12 **Build or break?**

min

Chapter 2: step through the figure, from one reaction to a web. Then Build or break? in pairs, with the card sort below, and the chapter's own sorter on the board for the two cards the class argued over most. Finish with the Add and Cut tiles.

14 **Draw the hill**

min

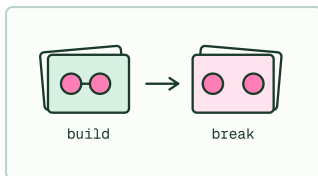
Mini whiteboards, alongside chapter 3's figure, one step at a time. Stop before step 4 and take the predict: what happens to the energy released overall? Students redraw the diagram with the lower hill and check the start and end levels against the figure.

12 **Enzymes and their substrates**

min

The card match below, in groups. Then ask which of the seven reactions are anabolic, and which of the enzymes would have to be present in a liver cell.

ACTIVITIES

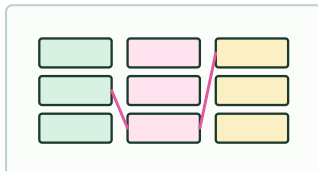


CARD SORT

Build or break?

Twelve cards, two headings: anabolic and catabolic. The six reactions of [chapter 2](#)'s sorter, plus DNA replication, making a phospholipid from glycerol and fatty acids, lipid digestion in the small intestine, breaking glycogen down to glucose in the liver, starch made in a potato, and protein broken down to amino acids in a cell. Each card is placed with the reaction type written under it: condensation, hydrolysis, oxidation or photosynthesis.

Needs: printed card sets, one per pair.

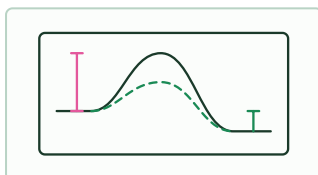


CARD GAME

Enzymes and their substrates

Triples to match, in three colours: amylase, starch, maltose; lipase, triglycerides, fatty acids and glycerol; pepsin, proteins, shorter peptides; catalase, hydrogen peroxide, water and oxygen; lactase, lactose, glucose and galactose; sucrase, sucrose, glucose and fructose; DNA polymerase, nucleotides, a DNA strand. Then ask: which are anabolic? Link the names to [chapter 2](#) and to the specificity of [chapter 6](#).

Needs: triples of cards in three colours.



DRAWING

Draw the hill

Students draw an energy diagram on a mini whiteboard for a reaction that releases energy, with and without an enzyme. They label the two activation energies and the energy released overall, then draw a second diagram for a reaction that takes energy in. Check each step against [chapter 3](#)'s figure.

Needs: mini whiteboards and pens.

PLENARY

6
min

Exit: label the diagram

On a sketch of an energy diagram, students label the activation energy with and without an enzyme, and the energy released overall.

WHAT STUDENTS GET WRONG

Enzymes are used up. They come out unchanged and work again.

Enzymes make reactions happen that otherwise could not. They speed up reactions that are possible but slow.

An enzyme changes the energy released. It lowers only the activation energy.

Breaking bonds releases energy. Breaking takes energy in; making bonds releases it.

All catabolism is hydrolysis. Respiration is an oxidation.

STRETCH AND SUPPORT

Support: the figures' captions as cut-up cards to put in order; the dotted key terms as a glossary; a writing frame for "explain the effect of temperature" (rise, optimum, fall, each with its reason).

Stretch: some enzymes speed reactions up more than a million million times. Why might the slowest reactions without enzymes be the ones cells most need enzymes for?

IN THE GUIDE

- 1 [Seconds, not millions of years](#)
- 2 [A web of reactions, an enzyme for each](#)
- 3 [A lower hill to climb](#)
- A11 [The whole guide, with the figures that play](#)
- PPTX [This lesson's slides, in the order of this plan](#)

PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- [Tarsia puzzle](#), [dominoes](#) and [picture reveal](#) on C1.1, built from its key terms and ready to print
- A [pub quiz](#) with rounds on C1.1, to present or run with no projector
- An [escape room](#) built from the [question bank](#) on C1.1

ALREADY ON THE SITE FOR C1.1

- Lesson: [Enzymes & Metabolism HL \(HL\)](#)
- Lab: [The Enzyme in Your Spit](#)
- Summary doodle: [Enzymes & Metabolism](#)
- Quiz: [Enzymes](#)
- Quiz: [Enzymes & Metabolism \(HL\)](#)
- Revision map: [C1.1 Enzymes and metabolism](#), to fill in
- Exam questions: [C1.1 in the exam maker](#), a paper with its markscheme

CARD SETS ON SPLYCR

- Open a set to host it as a class game, or make a copy to edit.
- [C1.1 Enzymes and Metabolism](#)

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on C1.1 at standard level each time, marked as students go and saved to their Exam practice when they are signed in.

biologybybradford.com/exam-maker/sit?topics=C1.1&level=SL&paper=quiz&marks=15&src=ep



Fit, collisions and shape

60 minutes • C1.1.4 to C1.1.8 • Chapters 4, 5, 6, 7

The active site and induced fit, collisions, specificity and denaturation, and the three graphs

BY THE END, STUDENTS CAN

- ☐ Explain how a few amino acids, held in place by the whole folded protein, make an active site, and how induced fit works C1.1.4, C1.1.5
- ☐ Explain why substrate and active site must collide, and how enzymes fixed in membranes still meet their substrates C1.1.6
- ☐ Explain how the shape of the active site makes an enzyme specific, and why denaturation stops it working C1.1.7
- ☐ Sketch and explain the effects of temperature, pH and substrate concentration on the rate, using collision theory and denaturation C1.1.8

TIMING

0–5	5 min	Do now: what is wrong with this?	
5–17	12 min	Lock and key, then induced fit	
17–23	6 min	Who moves?	
23–31	8 min	Fit, or no fit	
31–45	14 min	Sketch, then check	
45–55	10 min	Timed written question	
55–60	5 min	Exit	
	60 min	One lesson	

STARTER

5 min Do now: what is wrong with this?

"The enzyme was killed by the heat, and it died in the fridge too." Students write two corrections each, then compare. Keep the corrections for the end of the lesson.

ON THE BOARD, FROM THE GUIDE

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04 A pocket held in shape

CHAPTER 04 IN THE SLIDES

Step through the figure (5 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

- Only a few amino acids will form the site, far apart in the chain.
- Folding brings them together: the **active site**.
- The substrate binds: an **enzyme-substrate complex**.
- Both change shape: **induced fit** strains the substrate's bonds.
- Products leave; the enzyme is unchanged.

Predict box: An enzyme has 300 amino acids, and only about six touch the substrate. A mutation changes one amino acid far from the active site, and the enzyme stops working. How? Hands up or mini whiteboards first.

Answer B: It changed how the chain folds, so the site lost its shape

Remember it: Bind Bend Break Bye (Binding, Induced fit, Reaction, Release).

05 Meeting by chance

CHAPTER 05 IN THE SLIDES

Switch the figure through In solution, Enzyme fixed in a membrane and Substrate held still, and have the class say what will change before each.

Predict box: Lactase sits fixed in the membrane of cells lining your small intestine. It cannot move. How does lactose reach its active site? Hands up or mini whiteboards first.

Answer D: Lactose molecules move at random and collide with it

06 Lose the shape, lose the fit

CHAPTER 06 IN THE SLIDES

Switch the figure through Its substrate, A different molecule, Too hot and Wrong pH, and have the class say what will change before each.

Predict box: Pepsin digests protein in the stomach at about pH 2. Carried on into the small intestine at about pH 8, what happens to it? Hands up or mini whiteboards first.

Answer A: It denatures: its active site changes shape and charge

07 Three graphs to know

CHAPTER 07 IN THE SLIDES

Step through the figure (4 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. Temperature: faster collisions, then **denaturation**.
2. pH: each enzyme has its own **optimum**.
3. Substrate: the rate rises, then **levels off**.
4. More enzyme raises the maximum.

Play the animation, Watch it happen: collisions, substrate and heat. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. Molecules move at **random**, and most collisions miss the active site.
2. A **successful collision**: it binds and reacts, and the enzyme is unchanged.
3. Too hot: enzymes **denature**. Active sites lose their shape, and the rate falls.

Predict box: On a graph of rate against substrate concentration, the curve levels off. Why? Hands up or mini whiteboards first.

Answer C: Nearly every active site is already busy

Remember it: Tigers Prefer Steak (Temperature, pH, Substrate concentration).

THE LESSON

12 min Lock and key, then induced fit

The plasticine models below, then [chapter 4's](#) figure and predict. Students first make a rigid site and a key, then a soft site that closes and pinches the substrate. Finish with the Bind, Bend, Break, Bye tiles.

6 min Who moves?

[Chapter 5](#): the lactase predict first, then the three states of the figure. Students say who moves in each state before the readout appears.

8 min Fit, or no fit

[Chapter 6's](#) states, then the pepsin predict. Link back to what students saw in B1.2 when a protein unfolded, and name the two causes: heat and pH.

14

min

Sketch, then check

Chapter 7: students sketch all three graphs before the figure plays (Sketch, then check, below) and mark their own sketches against it. Take the plateau predict on whiteboards with a one-sentence reason. Then the collisions film, which sits after chapter 7: students call out what will happen before each slider move. Tigers Prefer Steak. Set Make a gif for homework.

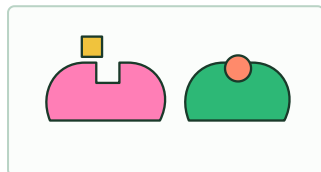
10

min

Timed written question

A written question on the effect of temperature or pH from the C1.1 exam maker, timed at 7 minutes, peer-marked against the markscheme.

ACTIVITIES

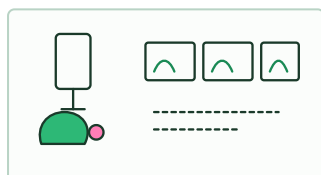


MODEL

Lock and key, then induced fit

Pairs make an enzyme and its substrate twice from plasticine. The first time, a rigid notch and a key that slots in. The second time, a soft site that closes round the substrate and pinches it at the bond to break. A photo of each for notes, and one sentence each on what the second model explains that the first does not. Keep the enzyme: an allosteric site is added to it in lesson 4.

Needs: plasticine in two colours, a plastic knife, phones for photos.

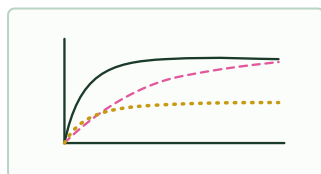


ANIMATION

Make a gif

Homework, from chapter 7. Pairs make a 10 to 20 second stop-motion or gif of one factor: temperature, pH or substrate concentration. It shows enzymes and substrate interacting, how the factor changes the collisions, the shape or the saturation, and ends with the sketch graph. A good one has short sentences with the key words, sums up the point at the end, leaves time to read each frame and looks clear. Plasticine, paper cut-outs or doodles, and any free gif or stop-motion app.

Needs: phones, plasticine or paper.



DRAWING

Sketch, then check

Lesson 2: students sketch the three graphs of chapter 7 from memory, then play the figure and correct their sketches in another colour.

Lesson 5: on one set of axes, draw rate against substrate concentration with no inhibitor, then a line for something competing for the active site, then one for something changing the active site's shape. Check against chapter 12's graph.

Needs: mini whiteboards, two colours of pen.

PLENARY

5

min

Exit

One sentence each: why the rate rises as an enzyme warms towards its optimum, and why it falls beyond it.

WHAT STUDENTS GET WRONG

The active site is the whole enzyme, rigid like a lock. It is a few amino acids, and they move (induced fit).

Enzymes are alive and are killed by heat; cold denatures them. They denature with heat; cold only slows them.

The optimum is always 37 °C. It depends on the enzyme.

The rate levels off because the substrate runs out. The active sites are busy: saturation.

Higher temperature always means faster. Only up to the optimum.

STRETCH AND SUPPORT

Support: the figures' captions as cut-up cards to put in order; the dotted key terms as a glossary; a writing frame for "explain the effect of temperature" (rise, optimum, fall, each with its reason).

Support: the Tigers Prefer Steak and Bind, Bend, Break, Bye tiles as starters.

Stretch: the DNA polymerase used in PCR comes from a bacterium of hot springs (D1.1). Predict its temperature curve, and say what about its structure might keep it folded.

IN THE GUIDE

- 4 [A pocket held in shape](#)
- 5 [Meeting by chance](#)
- 6 [Lose the shape, lose the fit](#)
- 7 [Three graphs to know](#)
- A11 [The whole guide, with the figures that play](#)
- PPTX [This lesson's slides, in the order of this plan](#)

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biologybybradford.com/exam-maker/sit?topics=C1.1&level=SL&paper=quiz&marks=15&src=ep



Measuring a rate

60 minutes • C1.1.9 • Chapters 7, 8 • The dry lab

How to measure an enzyme's rate, the initial rate, and planning, running and evaluating the catalase investigation

BY THE END, STUDENTS CAN

☐ Work out a rate from your own results or from secondary data, including the initial rate from a tangent C1.1.9

TIMING

0-5	5 min	Do now: elephant's toothpaste	
5-15	10 min	Chapter 8: read the rate	
15-25	10 min	Catalase over water	
25-55	30 min	The dry lab with the coach	
55-60	5 min	Exit	
60 min		One lesson	

STARTER

5
min

Do now: elephant's toothpaste

The demonstration below. Ask: "How could you measure how fast that happened?" Collect the measures students suggest: foam height, time, mass lost, volume of gas.

ON THE BOARD, FROM THE GUIDE

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07 Three graphs to know

CHAPTER 07 IN THE SLIDES

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2. pH: each enzyme has its own **optimum**.
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Play the animation, Watch it happen: collisions, substrate and heat. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. Molecules move at **random**, and most collisions miss the active site.
2. A **successful collision**: it binds and reacts, and the enzyme is unchanged.
3. Too hot: enzymes **denature**. Active sites lose their shape, and the rate falls.

Predict box: On a graph of rate against substrate concentration, the curve levels off. Why? Hands up or mini whiteboards first.

Answer C: Nearly every active site is already busy

Remember it: Tigers Prefer Steak (Temperature, pH, Substrate concentration).

Step through the figure (4 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. Oxygen collected every 10 seconds.
2. Fast at first, then slower as the **substrate** runs out.
3. The **initial rate** is the gradient of a tangent at the start.
4. Warmer: a steeper start, the same total.

Predict box: A drop of a starch and amylase mixture stops turning iodine blue-black after 40 s at 30 °C and after 80 s at 20 °C. Compare the rates. Hands up or mini whiteboards first.

Answer B: The rate at 30 °C is double: rate is $1 \div \text{time}$

THE LESSON

10

min

Chapter 8: read the rate

Product made or substrate used. Step through the figure: the points, the curve, the tangent and its gradient. At step 4, students draw their own gradient triangle on the 35 °C tangent and work out its initial rate before reading the label, then the predict (rate is $1 \div \text{time}$).

10

min

Catalase over water

The demonstration below: how much of the oxygen made do you think ends up in the cylinder, and what could lose it? Pairs fill one row of the evaluation table: a weakness, its effect on the results, and an improvement.

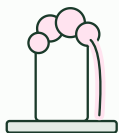
30

min

The dry lab with the coach

In pairs on [the dry lab](#). Start with How? Why? Units? in the coach, then run a temperature series with three repeats, find the means and standard deviations and draw the graph with error bars. Ask pairs to compare their curve with [chapter 7's](#) sketch graph.

ACTIVITIES

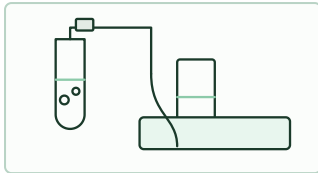


DEMONSTRATION

Elephant's toothpaste

A safe version: in a 250 cm³ measuring cylinder on a tray, put 30 cm³ of 6% (20 volume) hydrogen peroxide, a squirt of washing-up liquid and a few drops of food colouring. Tip in a tablespoon of dried yeast stirred into warm water. Foam rises, because the catalase in the yeast speeds up the breakdown of the peroxide to water and oxygen. Wear eye protection: 6% hydrogen peroxide irritates eyes and skin, so rinse splashes at once. The 30% peroxide and potassium iodide version is for the teacher alone.

Needs: the above, a tray, eye protection, gloves for the teacher.



PRACTICAL

Catalase over water

A demonstration, or pairs if there is time. A level spatula of dried yeast (weighed once, about 0.1 g) goes into 5 cm³ of 3% hydrogen peroxide in a boiling tube, and the bung is pushed in at once. A delivery tube leads to an upturned 100 cm³ measuring cylinder full of water in a trough; read the gas every 10 seconds. (5 cm³ of 3% can give about 53 cm³ of oxygen, so a 25 cm³ cylinder would overflow.) [The dry lab](#) uses potato extract and this uses yeast: two sources of one enzyme, so say so. Then the evaluation table: a weakness, its effect on the results, and an improvement. Weaknesses: gas lost before the bung goes in, reading the meniscus in a moving cylinder, the yeast at room temperature while the peroxide sits in a bath, and only one run. The improvements lead to [the dry lab's](#) gas syringe and water bath.

Needs: dried yeast, 3% (10 volume) hydrogen peroxide, boiling tubes, bungs with delivery tubes, measuring cylinders, a trough, a stopwatch, eye protection.

How	Why	Units
✓ ✓	✓	✓

PLANNING

How? Why? Units?

Before running the dry lab, pairs fill the coach's variables table: for each variable, how it is set or measured, why it matters, and its unit. The planning questions become the coach's checklist: the range of values, time for the reaction, controlled variables, a negative control with no enzyme, a positive control, bringing the enzyme to temperature first, the precision of the measurement, and safety.

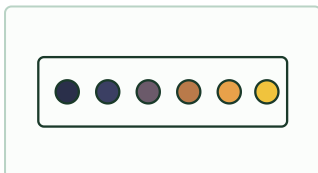
Needs: a device per pair.

DRY LAB

Catalase and hydrogen peroxide

The [dry lab](#) above, with the tasks and questions under it and the coach beneath. Results go to a CSV for a class graph, and the coach's write-up is copied into notes.

Needs: one device per pair.



PRACTICAL

The enzyme in your spit

Optional, for a practical lesson outside the three hours. The site's own lab, [the enzyme in your spit](#), with its sheet: salivary amylase and starch at cold, room and warm temperatures, iodine as the end point, and the rate worked out as $1 \div \text{time}$.

Needs: as the lab page lists.

PLENARY

5
min

Exit

Write your research question, and one weakness of the method with its improvement.

WHAT STUDENTS GET WRONG

The amount of product at the end measures the rate. It measures how much substrate went in; use the initial rate.

A longer time means a faster rate. Rate = $1 \div \text{time}$.

STRETCH AND SUPPORT

Support: the figures' captions as cut-up cards to put in order; the dotted key terms as a glossary; a writing frame for "explain the effect of temperature" (rise, optimum, fall, each with its reason).

Stretch: in [the dry lab](#), find the temperature at which half the enzyme is lost within the run. How would you design a run to separate the effect of heat on collisions from its effect on denaturation?

IN THE GUIDE

- 7** [Three graphs to know](#)
- 8** [Measuring a rate](#)
- Lab** [Dry lab: Catalase and hydrogen peroxide](#)
- A11** [The whole guide, with the figures that play](#)
- PPTX** [This lesson's slides, in the order of this plan](#)

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- An [escape room built from the question bank](#) on C1.1

ALREADY ON THE SITE FOR C1.1

- Lesson: [Enzymes & Metabolism HL \(HL\)](#)
- Lab: [The Enzyme in Your Spit](#)
- Summary doodle: [Enzymes & Metabolism](#)
- Quiz: [Enzymes](#)
- Quiz: [Enzymes & Metabolism \(HL\)](#)
- Revision map: [C1.1 Enzymes and metabolism](#), to fill in
- Exam questions: [C1.1 in the exam maker](#), a paper with its markscheme

CARD SETS ON SPLYCR

- Open a set to host it as a class game, or make a copy to edit.
- [C1.1 Enzymes and Metabolism](#)

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on C1.1 at standard level each time, marked as students go and saved to their Exam practice when they are signed in.

biologybybradford.com/exam-maker/sit?topics=C1.1&level=SL&paper=quiz&marks=15&src=ep



Pathways, places and heat HL

60 minutes • C1.1.11 to C1.1.14 • Chapters 9, 10, 11

Enzymes inside and outside cells, linear and cyclical pathways, heat from metabolism, and the allosteric site

BY THE END, STUDENTS CAN

- ☐ Compare enzymes at work inside cells and outside them, and linear pathways with cycles C1.1.11, C1.1.13
- ☐ Explain why metabolism always releases heat, and how mammals and birds use it C1.1.12
- ☐ Explain how a molecule binding an allosteric site stops an enzyme, and why the binding can be undone C1.1.14

TIMING

0-5	5 min	Do now: Inside or outside?	
5-20	15 min	Chapter 9: chains and cycles	
20-32	12 min	Chapter 10: warm from the inside	
32-45	13 min	Chapter 11: a second site	
45-55	10 min	Timed written question	
55-60	5 min	Exit	
60 min		One lesson	

STARTER

- 5 min** **Do now: Inside or outside?**
- The card sort below, as a first look: students place each process inside or outside a cell on an A3 outline. Come back to it at the end of [chapter 9](#).

ON THE BOARD, FROM THE GUIDE

Open the guide on the projector at each chapter (the links work in this PDF). Every figure plays from its own buttons, and the lesson's slides have the same figures, step by step, in the order of this plan.

09 Chains, cycles, inside and out

CHAPTER 09 IN THE SLIDES

Tap the parts of the figure in turn: The gut contents, Duct from the pancreas, Inside a cell, The cell's own membrane and An organelle inside the cell.

Play the animation, Three pathways on one map. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

- Glycolysis**, in the cytoplasm: glucose is changed a step at a time, each step by its own enzyme.
- A **linear** pathway: what goes in at one end leaves at the other as something else, pyruvate.
- Back where it started: the last step remakes the molecule the first step needs. A **cycle**.

Predict box: Glycolysis runs in the cytoplasm, the Krebs cycle inside mitochondria, and protein digestion in your stomach. Which are intracellular? Hands up or mini whiteboards first.

Answer D: Glycolysis and the Krebs cycle: both inside cells

10 Warm from the inside

CHAPTER 10 IN THE SLIDES

Switch the figure through Energy from glucose and Body against air temperature, and have the class say what will change before each.

Predict box: A mouse and a lizard of the same mass sit at 20 °C for a day. Which needs more food, and why? Hands up or mini whiteboards first.

Answer C: The mouse: heat from respiration keeps it at 37 °C

11 A second site

CHAPTER 11 IN THE SLIDES

Step through the figure (4 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. An active site, and a second site elsewhere: the **allosteric site**.
2. Only a specific molecule fits the allosteric site.
3. Binding changes the enzyme's shape, and with it the **active site**.
4. The binding is **reversible**: the inhibitor leaves, the enzyme works again.

Predict box: An allosteric inhibitor binds nowhere near the active site. How can it stop the enzyme? Hands up or mini whiteboards first.

Answer A: Binding changes the enzyme's shape, active site included

THE LESSON

15 Chapter 9: chains and cycles

min

Chapter 9: the predict, then the figure, tapping each part of the gut wall. Then the metabolism map on the board: run each pathway and ask whether its starting molecule comes back round. Teach the mnemonic: "Glycolysis goes; Krebs and Calvin come round."

12 Chapter 10: warm from the inside

min

Chapter 10: the predict (mouse or lizard), then both states of the figure. Ask: why does a bird need a warm body?

13 Chapter 11: a second site

min

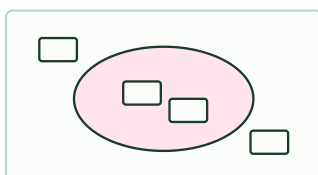
Chapter 11: the predict, then the figure. Students add an allosteric site to the plasticine enzyme from lesson 2 and show the active site changing shape.

10 Timed written question

min

A short written question on C1.1.1 to C1.1.13 from the exam maker, timed and marked.

ACTIVITIES



CARD SORT · HL

Inside or outside?

Cards: glycolysis, the Krebs cycle, the Calvin cycle, DNA replication, protein synthesis, starch digestion in the mouth, protein digestion in the stomach, lipid digestion in the small intestine, and lysozyme breaking bacterial walls in tears. Sort them onto a drawing of a cell with its outside marked. Then ask which are linear and which cyclical.

Needs: the cards and an A3 cell outline per group.

PLENARY

5 Exit

min

One difference between a linear and a cyclical pathway, with an example of each.

WHAT STUDENTS GET WRONG

Intracellular means in the cytoplasm. It means anywhere inside the cell, an organelle included.

Heat from respiration is waste with no use. Mammals and birds depend on it.

All inhibitors block the active site. Non-competitive ones bind elsewhere.

STRETCH AND SUPPORT

Stretch: make a Tarsia puzzle on C1.1 better than the site's own, in the Tarsia builder.

IN THE GUIDE

- 9** [Chains, cycles, inside and out](#)
- 10** [Warm from the inside](#)
- 11** [A second site](#)
- A11** [The whole guide, with the figures that play](#)
- PPTX** [This lesson's slides, in the order of this plan](#)

PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- [Tarsia puzzle, dominoes and picture reveal](#) on C1.1, built from its key terms and ready to print
- A [pub quiz](#) with rounds on C1.1, to present or run with no projector
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EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on C1.1 at higher level each time, marked as students go and saved to their Exam practice when they are signed in.

biologybybradford.com/exam-maker/sit?topics=C1.1&level=HL&paper=quiz&marks=15&src=ep

Stopping enzymes HL

60 minutes • C1.1.15 to C1.1.17 • Chapters 12, 13, 14

Competitive inhibition and statins, feedback inhibition of the isoleucine pathway, and penicillin

BY THE END, STUDENTS CAN

- ☐ Explain how statins inhibit an enzyme competitively, and contrast competitive and non-competitive inhibition on a graph C1.1.15
- ☐ Explain how isoleucine controls its own pathway by feedback inhibition C1.1.16
- ☐ Explain how penicillin inhibits transpeptidase for good, and how a changed transpeptidase makes bacteria resistant C1.1.17

TIMING

0-6	6 min	Do now: Sketch, then check	
6-18	12 min	Chapter 12: statins	
18-30	12 min	Chapter 13: the pathway valve	
30-40	10 min	Chapter 14: a trap that springs once	
40-55	15 min	Plan an 8-mark answer	
55-60	5 min	Exit	
	60 min	One lesson	

STARTER

6 Do now: Sketch, then check

The higher level version, below: three lines on one graph. Students draw their prediction before [chapter 12](#).

ON THE BOARD, FROM THE GUIDE

Open the guide on the projector at each chapter (the links work in this PDF). Every figure plays from its own buttons, and the lesson's slides have the same figures, step by step, in the order of this plan.

12 [A look-alike in the active site](#)

CHAPTER 12 IN THE SLIDES

Step through the figure (4 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. HMG-CoA reductase: an early step on the way to **cholesterol**.
2. Part of a **statin** looks like the substrate and binds the active site.
3. It binds and leaves: **competitive** and **reversible**.
4. Less cholesterol is made, and blood cholesterol falls.

Switch the figure through No inhibitor, Competitive, Non-competitive and All three, and have the class say what will change before each.

Step through the figure (2 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. Relenza: a competitive inhibitor designed to fit a virus's enzyme.
2. Cyanide: a poison that takes the place where oxygen binds.

Play the animation, Add an inhibitor. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. Molecules move at **random**, and most collisions miss the active site.
2. A **successful collision**: it binds and reacts, and the enzyme is unchanged.
3. Plenty of substrate outcompetes it, so the rate climbs back near its **maximum**.

Predict box: Two samples of an enzyme: one with a competitive inhibitor, one with a non-competitive inhibitor. You add far more substrate to both. In which does the inhibitor's effect fade? Hands up or mini whiteboards first.

Answer D: The competitive one: substrate wins the site back

13 The end product shuts the gate

CHAPTER 13 IN THE SLIDES

Switch the figure through Slow, Normal and Fast, and have the class say what will change before each.

Predict box: Isoleucine inhibits the first enzyme of its five-step pathway, not the last. Why the first? Hands up or mini whiteboards first.

Answer B: So no threonine is spent on intermediates nobody needs

14 A trap that springs once

CHAPTER 14 IN THE SLIDES

Step through the figure (5 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. **Transpeptidase** cross-links the wall's sugar chains.
2. Penicillin looks like the peptide the enzyme joins.
3. The enzyme starts to act on it, and is trapped by a **covalent bond**: irreversible.
4. Without cross-links, the wall gives way and the cell bursts.
5. A changed transpeptidase binds penicillin poorly: **resistance**.

Predict box: A strain of bacteria keeps building strong walls in penicillin. Its transpeptidase still makes cross-links. What has most likely changed? Hands up or mini whiteboards first.

Answer C: Its transpeptidase's active site binds penicillin poorly

Remember it: Copycat Nudge Mousetrap (Competitive, Non-competitive, Mechanism-based).

THE LESSON

12

min

Chapter 12: statins

Chapter 12: the statins figure, the predict, then the graph's states against their sketches. Then the collisions film with each inhibitor.

12

min

Chapter 13: the pathway valve

Chapter 13: the predict, then the Pathway valve. Set Fast, then Slow, then untick the allosteric site. Ask what would happen to a bacterium with that mutation.

10

min

Chapter 14: a trap that springs once

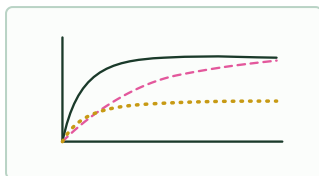
Chapter 14: the predict, then the figure. Finish with Copycat, Nudge, Mousetrap.

15

min

Plan an 8-mark answer

The writing task below: plan in keywords, then write.



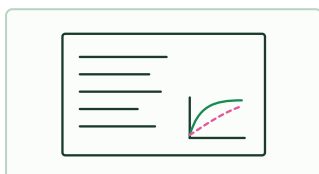
DRAWING

Sketch, then check

Lesson 2: students sketch the three graphs of [chapter 7](#) from memory, then play the figure and correct their sketches in another colour.

Lesson 5: on one set of axes, draw rate against substrate concentration with no inhibitor, then a line for something competing for the active site, then one for something changing the active site's shape. Check against [chapter 12](#)'s graph.

Needs: mini whiteboards, two colours of pen.



WRITING · HL

Plan an 8-mark answer

"Three molecules stop three enzymes: a statin, isoleucine and penicillin. Compare how each one does it, and say which can be undone. [8]" Plan in keywords first (competitive: binds the active site, resembles the substrate, reversible, more substrate overcomes it, statins; non-competitive: allosteric site, shape change, reversible, more substrate does not help; mechanism-based: covalent, irreversible, penicillin and transpeptidase; feedback with isoleucine; a sketch graph), then write. Peer mark against the points the class agrees.

Needs: lined paper.

PLENARY

5
min

Exit

Why can more substrate overcome a statin but not penicillin?

WHAT STUDENTS GET WRONG

All inhibitors block the active site. Non-competitive ones bind elsewhere.

More substrate overcomes any inhibitor. Only a competitive one.

Feedback inhibits the last enzyme. It inhibits the first, at the start of the pathway.

Penicillin is a competitive inhibitor. It binds covalently, for good.

Bacteria become resistant because penicillin changes them. The changed transpeptidase arose by mutation; penicillin selects it.

STRETCH AND SUPPORT

Stretch: methanol poisoning can be treated with ethanol, which competes with methanol for the active site of the same liver enzyme. Explain why a large dose of ethanol is needed, and has to be kept up, using [chapter 12](#)'s graph.

Stretch: why might the isoleucine pathway's first enzyme respond to isoleucine in a switch-like way rather than gradually, and what would that give the cell? (Beyond the guide; for discussion only.)

Stretch: make a Tarsia puzzle on C1.1 better than the site's own, in the Tarsia builder.

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- 13** [The end product shuts the gate](#)
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biologybybradford.com/exam-maker/sit?topics=C1.1&level=HL&paper=quiz&marks=15&src=ep



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.