

Inside the matrix, and which fuel HL

60 minutes • C1.2.11, C1.2.12 and C1.2.17 • Chapters 9, 12

The link reaction and the Krebs cycle, counting carbons and carriers, and fat against sugar as fuels

BY THE END, STUDENTS CAN

- ☐ Outline the link reaction and the Krebs cycle: where the carbon dioxide and the reduced NAD come from C1.2.11, C1.2.12
- ☐ Compare lipids and carbohydrates as fuels: energy per gram, and which routes each can take C1.2.17

TIMING

0-5	5 min	Do now: draw a mitochondrion	
5-15	10 min	The link reaction	
15-30	15 min	Build the Krebs cycle	
30-38	8 min	Name the reaction	
38-55	17 min	Fat or sugar?	
55-60	5 min	Exit	
	60 min	One lesson	

STARTER

5
min

Do now: draw a mitochondrion

From memory, with no notes (activity below), and label it. Keep the drawings: they are used again in lesson 5.

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 The carbon leaves as carbon dioxide

CHAPTER 09 IN THE SLIDES

Step through the figure (6 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. Pyruvate goes into the **matrix**.
2. **Link reaction**: a carbon off as CO₂ (**decarboxylation**), hydrogen to NAD (**oxidation**). The **acetyl group** goes on with **coenzyme A**.
3. Acetyl (2C) + **oxaloacetate** (4C) → **citrate** (6C).
4. Two decarboxylations, four oxidations, one ATP.
5. Oxaloacetate is **remade**: a cycle.
6. Two turns per glucose: all six carbons gone as CO₂.

Show the figure: Name the reaction: eight steps of respiration and four kinds of reaction. Which bin does each belong in, and what tells you?

Predict box: Each turn of the Krebs cycle takes in a 2-carbon acetyl group. Why does the cycle not fill up with carbon? Hands up or mini whiteboards first.

Answer B: Two carbons leave as carbon dioxide each turn

12 Fat or sugar?

CHAPTER 12 IN THE SLIDES

Switch the figure through What is in them and How they are respired, and have the class say what will change before each.

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

1. Inside a muscle fibre, one **mitochondrion**: the folded inner membrane (**cristae**), the **matrix** inside it.
2. Net from one glucose: **2 ATP, 2 reduced NAD** and **2 pyruvate**.
3. The **link reaction**, in the **matrix**: pyruvate loses a carbon as CO_2 (**decarboxylation**) and hydrogen to NAD (**oxidation**).
4. One **ATP** is made, and a fourth oxidation passes hydrogen to another carrier.
5. Protons flow back through **ATP synthase**, turning it: most of the ATP is made here. **Oxygen** takes the electrons at the end, making water.
6. From one glucose: **6 CO_2** , water, and **about 30 to 32 ATP**, nearly all of it from the chain.

Predict box: Gram for gram, fat releases about twice the energy of carbohydrate when respired. Why? Hands up or mini whiteboards first.

Answer C: Fat holds less oxygen and more hydrogen to oxidise

THE LESSON

10

min

The link reaction

Chapter 9: students draw the link reaction from a written summary (activity below), then play the first two steps of the figure to check it.

15

min

Build the Krebs cycle

Pairs build the cycle with hexagon cards (below), then play the rest of [chapter 9's](#) figure and make its predict. Count the carbons out loud.

8

min

Name the reaction

Chapter 9's sorter in pairs, then on the board for the two cards most argued over.

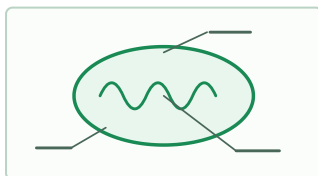
17

min

Fat or sugar?

Chapter 12: the predict, then Count the oxygen (below), then the figure's two settings. The chain is lesson 5, so here say only that fat enters at the Krebs cycle, which runs only while oxygen is there; the chapter's watch-out is read again in lesson 5.

ACTIVITIES

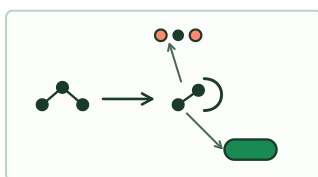


DRAWING · HL

Draw a mitochondrion

From memory: the outer membrane, the inner membrane folded into cristae, the matrix, the intermembrane space, and ribosomes and DNA. Then add where the link reaction, the Krebs cycle and the chain happen.

Needs: paper.

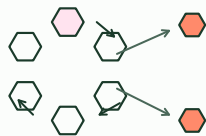


DRAWING · HL

The link reaction as a diagram

From a written summary, draw the link reaction: pyruvate in, carbon dioxide out, hydrogen to NAD, and the acetyl group onto coenzyme A.

Needs: paper.

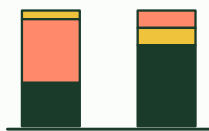


CARD MODEL · HL

Build the Krebs cycle

Hexagon cards to arrange in a ring: acetyl group (2C), oxaloacetate (4C), citrate (6C), decarboxylation (twice), oxidation (four times) and ATP, with arrows drawn between them. The rule: only citrate and oxaloacetate are named.

Needs: printed hexagon sets, A3 paper.



CALCULATION · HL

Count the oxygen

From the formulae $C_6H_{12}O_6$ and $C_{16}H_{32}O_2$, work out the percentage of each that is oxygen by mass, and the oxygen needed to respire one of each (6 and 23 O_2). Then: which gives more energy per gram, and why?

Needs: calculators.

PLENARY

5
min

Exit

One reason fat gives more energy per gram, and one thing fat cannot do that glucose can.

WHAT STUDENTS GET WRONG

The Krebs cycle makes most of the ATP. It makes reduced NAD; the chain makes most of the ATP.

The carbon dioxide breathed out comes from the oxygen breathed in. It comes from the fuel's carbon, in the link reaction and the Krebs cycle.

Fat gives more energy because its molecules are bigger. A fatty acid holds less oxygen and more oxidisable hydrogen and carbon per gram.

Fat can be respired anaerobically. It enters at the Krebs cycle, so it needs oxygen.

STRETCH AND SUPPORT

Stretch: the respiratory quotient (carbon dioxide given out divided by oxygen taken up) for glucose is 1.0 and for palmitic acid 16 divided by 23. Work out what an athlete's breath would show as they switch from fat to carbohydrate.

Stretch: make a Tarsia puzzle on C1.2 that is better than the site's own, in the Tarsia builder.

Consequences for ecosystems: respiration returns carbon dioxide to the air and releases heat at every transfer. Use both to start the energy flow of C4.2: where does the energy of a food chain go?

IN THE GUIDE

9 [The carbon leaves as carbon dioxide](#)

12 [Fat or sugar?](#)

A11 [The whole guide, with the figures that play](#)

PPTX [This lesson's slides, in the order of this plan](#)

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on C1.2 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=C1.2&level=HL&paper=quiz&marks=15&src=ep



PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- [Tarsia puzzle, dominoes and picture reveal](#) on C1.2, built from its key terms and ready to print
- A [pub quiz](#) with rounds on C1.2, to present or run with no projector
- An [escape room](#) built from the [question bank](#) on C1.2

ALREADY ON THE SITE FOR C1.2

- Lesson: [Cell Respiration HL \(HL\)](#)
- Lesson: [Cell Respiration](#)
- Quiz: [Cell Respiration](#)
- Quiz: [Cell Respiration \(HL\)](#)
- Revision map: [C1.2 Cell respiration](#), to fill in
- Exam questions: [C1.2 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.

- [C1.2 Cell Respiration](#)
- [B3.2–C2.2 Plant Transport, Respiration & Neural Signalling](#)

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.