

The thylakoid at work HL

60 minutes • C1.3.12, C1.3.13 and C1.3.14 • Chapters 10, 11

Chemiosmosis in the thylakoid, cyclic and non-cyclic photophosphorylation, NADP reduced at photosystem I, and where each step happens

BY THE END, STUDENTS CAN

- ☐ Explain how a proton gradient and ATP synthase make ATP in the thylakoid, by cyclic and non-cyclic photophosphorylation C1.3.12
- ☐ Explain how photosystem I reduces NADP, and where in a thylakoid each light-dependent step happens C1.3.13, C1.3.14

TIMING

0-5	5 min	Do now: where do protons collect?	
5-17	12 min	The thylakoid, step by step	
17-32	15 min	Act it out	
32-42	10 min	NADP and the map	
42-55	13 min	Plan a 7-mark answer	
55-60	5 min	Exit	
60 min		One lesson	

STARTER

5
min

Do now: where do protons collect?

In a mitochondrion, where do protons collect, and where is ATP made? Now guess for a chloroplast ([chapter 10's](#) predict).

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.

10 Protons downhill make ATP

CHAPTER 10 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. The thylakoid membrane: **photosystems**, a **chain of carriers** and **ATP synthase**.
2. Electrons give up energy along the chain, which **pumps protons** into the lumen.
3. Protons pile up in the small lumen: a **proton gradient**.
4. They flow back through **ATP synthase**, which makes **ATP** in the stroma: **chemiosmosis**.
5. **Non-cyclic**: on to NADP. **Cyclic**: back round the chain, for more ATP.

Predict box: In a working chloroplast, where do protons build up? Hands up or mini whiteboards first.

Answer C: In the lumen, inside each thylakoid

11 NADP reduced, and the thylakoid as a system

CHAPTER 11 IN THE SLIDES

Tap the parts of the figure in turn: Stroma, Envelope, Granum, Granum, Granum, Thylakoid lumen, Stroma, Photosystem II, Chain of carriers, Photosystem I, NADP and ATP synthase.

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

1. Light energy is passed through an **array of pigments** to the **reaction centre**, a special chlorophyll, which gives off an **excited electron**.
2. The reaction centre replaces its lost electrons by **splitting water** (photolysis). The protons stay in the lumen; the **oxygen** is a waste product.
3. The electron passes along a **chain of carriers**, which uses its energy to **pump protons** from the stroma into the lumen.
4. At **photosystem I** light lifts the electron again. Two electrons and a proton from the stroma **reduce NADP**.
5. Protons flow out of the lumen through **ATP synthase**, making **ATP** in the stroma, where the Calvin cycle will use it.
6. The thylakoid as a system: water split on the lumen side, **ATP** and **reduced NADP** made on the stroma side.

Predict box: On which side of the thylakoid membrane is NADP reduced, and why does that side make sense?
Hands up or mini whiteboards first.

Answer A: The stroma side, where the Calvin cycle uses it

Remember it: Loads Spends (Lumen, Stroma).

THE LESSON

12
min

The thylakoid, step by step

Chapter 10's figure step by step. Switch to Cyclic: what stops?

15
min

Act it out

Act it out (below): the light-dependent reactions modelled in plasticine on an A3 thylakoid.

10
min

NADP and the map

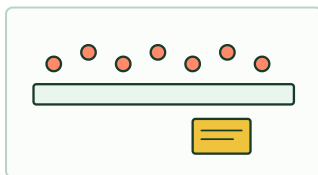
Chapter 11: the predict, then Map the thylakoid with the labels hidden and the Loads and Spends tiles. Then the chemiosmosis film (thylakoid), with the light off.

13
min

Plan a 7-mark answer

Plan a 7-mark answer (below) on the light-dependent reactions, then write it.

ACTIVITIES

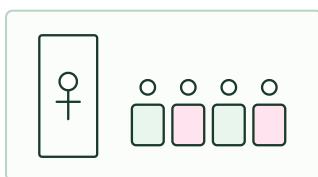


MODEL

Act it out

On an A3 drawing of a thylakoid membrane (stroma below, lumen above), pairs model the light-dependent reactions (chapters 10 and 11). Plasticine balls are protons. A sticky note stands for NADP, which turns into reduced NADP only once it holds two electron tokens and one proton. ADP and phosphate balls are joined at ATP synthase only as protons pass through it. Then one partner narrates while the other moves the pieces, using a markscheme's points as the script.

Needs: A3 thylakoid drawings, plasticine in two colours, sticky notes and tokens.



ROLE PLAY

Meet the membrane

If there is time. One student is the host at the door of the thylakoid; each other student is a part (photosystem II, photosystem I, a carrier, ATP synthase, ATP, ADP, NADP, reduced NADP, a proton, an electron, water, the lumen, the stroma) and introduces themselves to the host: where they live and who they work with.

Needs: name cards.



WRITE

Plan a 7-mark answer

The C1.3 exam maker's higher level extended question on how the light-dependent reactions produce ATP and NADPH (7 marks; the question says NADPH where this guide says reduced NADP). Students list the points they will make (photosystems, photolysis, chain, pumping, gradient, ATP synthase, photosystem I, NADP, cyclic), then write. Peer mark against the exam maker's markscheme.

Needs: lined paper.

PLENARY

5
min

Exit

Where in a thylakoid are water split, ATP made and NADP reduced?

WHAT STUDENTS GET WRONG

Protons collect in the stroma, or in the "intermembrane space". They collect in the lumen.

Cyclic photophosphorylation makes reduced NADP. It makes ATP only.

ATP and reduced NADP "move to the stroma". They are made on the stroma side.

STRETCH AND SUPPORT

Stretch: compare a mitochondrion's chain with the thylakoid's in a table: source of electrons, last acceptor, where protons collect, where ATP is made.

Stretch: make a respiration and photosynthesis Tarsia puzzle in the Tarsia builder, ticking C1.2 and C1.3 together.

IN THE GUIDE

- 10** [Protons downhill make ATP](#)
- 11** [NADP reduced, and the thylakoid as a system](#)
- 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 C1.3 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=C1.3&level=HL&paper=quiz&marks=15&src=ep



PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- [Tarsia puzzle](#), [dominoes](#) and [picture reveal](#) on C1.3, built from its key terms and ready to print
- A [pub quiz](#) with rounds on C1.3, to present or run with no projector
- An [escape room](#) built from the [question bank](#) on C1.3

ALREADY ON THE SITE FOR C1.3

- Quiz: [Photosynthesis](#)
- Quiz: [Photosynthesis \(HL\)](#)
- Revision map: [C1.3 Photosynthesis](#), to fill in
- Exam questions: [C1.3 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.

- [C1.3 Photosynthesis \(SL\)](#)
- [C1.3 Photosynthesis \(HL\)](#)

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.