Why leaves are flat

60 minutes • B3.1.1, B3.1.2, B3.1.7, B3.1.8 • Chapters 1, 2, 3

Why gas exchange gets harder as organisms grow, what makes a good exchange surface, and how a leaf is built for gas exchange and drawn in plan

BY THE END, STUDENTS CAN

- [ ] Explain why every organism exchanges gases, and why being bigger makes it harder B3.1.1
- [ ] Describe the four properties of a gas-exchange surface and why each one matters B3.1.2
- [ ] Explain how a leaf's waxy cuticle, epidermis, air spaces, spongy mesophyll, guard cells and veins suit it to gas exchange B3.1.7
- [ ] Draw and label a plan diagram of a leaf in transverse section from a micrograph B3.1.8

TIMING

0–6	6 min	**Do now: three cubes**
6–16	10 min	**Bigger is harder**
16–22	6 min	**Four properties**
22–34	12 min	**Parts and jobs**
34–52	18 min	**Draw it in plan**
52–60	8 min	**Exit**
	60 min	**One lesson**

STARTER

6 min

Do now: three cubes

Three cubes on the board, with sides of 1, 2 and 4 cm. Students work out each one's surface area, volume and surface area to volume ratio, then say what happens to the ratio as the cube grows. Keep the answers up for the figure.

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 Every cell needs a way in

CHAPTER 01 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. A 1 cm cube: a surface of **6 cm²** round a volume of **1 cm³**, a ratio of 6 : 1. Its centre is 0.5 cm from the nearest face.
2. Double the side to 2 cm. The surface grows four times, to 24 cm², but the volume grows eight times, to 8 cm³: the ratio halves, to **3 : 1**.
3. Double it again, to 4 cm: 96 cm² round 64 cm³, a ratio of **1.5 : 1**. The centre is now 2 cm from the outside.
4. As a cube grows, each square centimetre of its surface has more volume to supply, from further away: the ratio **falls** as the distance **rises**.

Play the animation, Bigger bodies, slower supply. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. A **model** cube, not a real cell: 1 cm on each side, with 6 cm^2 of surface around 1 cm^3 of volume.
2. Three cubes **soak in a dye** for the same time: just long enough for it to reach the centre of the 1 cm cube.
3. **Cut open**, the 1 cm cube is dyed right through. The 4 cm cube is still **pale** in the middle, 2 cm from the nearest face.
4. The 4 cm cube's 64 cm^3 squashed into a sheet 0.25 cm thick: after the same soak it is dyed right through, as no part is more than 0.125 cm from a surface.

> **Predict box:** The 4 cm cube is squashed into a sheet 16 cm by 16 cm and 0.25 cm thick, with the same volume. Compared with the cube, how quickly is every part of it supplied? Hands up or mini whiteboards first.
>
> **Answer B: Quickly everywhere: there is far more surface for the volume, and no part is far from it**

> **Remember it:** Too Many Pink Leaves (Thin, Moist, Permeable, Large surface area).

02 A leaf is built for gas exchange

CHAPTER 02 IN THE SLIDES

Tap the parts of the figure in turn: Air spaces, Spongy mesophyll, Palisade mesophyll, Vein, Xylem, Phloem, Upper epidermis, Lower epidermis, Guard cells, Waxy cuticle, Air spaces, Spongy mesophyll, Palisade mesophyll, Vein, Xylem, Phloem, Upper epidermis, Lower epidermis, Guard cells and Waxy cuticle.

> **Predict box:** Why are most of a leaf's stomata in its lower surface? Hands up or mini whiteboards first.
>
> **Answer C: The underside is shaded and cooler, so less water evaporates out through its open pores**

> **Remember it:** Cats Usually Purr Softly Lazily (Cuticle, Upper epidermis, Palisade mesophyll, Spongy mesophyll, Lower epidermis).

03 Drawing a leaf in plan

CHAPTER 03 IN THE SLIDES

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. A light micrograph, drawn: a transverse section of a leaf through its midrib, every cell in view. Lignified walls are pink, as the stain colours them; the cuticle is shown yellow and thicker than true scale.
2. Its plan diagram: one clean outline for each tissue, in the micrograph's proportions, no cells and no shading; ruled label lines, a title and a scale bar.

> **Predict box:** A plan diagram shows where each tissue of an organ is. A student draws every palisade cell in their plan of a leaf. What is wrong? Hands up or mini whiteboards first.
>
> **Answer D: A plan shows the outline of each tissue, and none of the separate cells inside it at all**

THE LESSON

10 min — Bigger is harder

Chapter 1's figure, step by step, checked against the Do now; then the film under it. Take the predict box on the squashed cube before anyone touches the film's shape control. Land the point: diffusion through the outside alone cannot supply a large body.

6 min — Four properties

The four properties of a gas-exchange surface, with chapter 1's Remember it tiles (Too Many Pink Leaves). For each, students finish the sentence "this helps because..." in one clause.

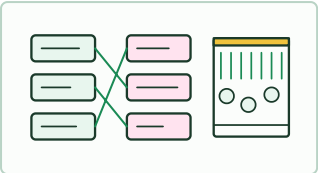
12 min — Parts and jobs

Chapter 2's leaf: tap each part, then its Match it. Then the card match below, in pairs, finishing on the big drawn section. Take the predict box on the lower surface's stomata before moving on, and press for the reason: the underside is shaded and cooler, so open pores there lose less water.

18 min — Draw it in plan

Chapter 3: each student draws a plan diagram of a leaf from a micrograph or a prepared slide, keeping to the six rules. Then the plan diagram tool's Spot the faults, and pairs swap drawings and mark each other's against the rules.

ACTIVITIES



CARD MATCH

Parts and jobs

Twelve cards for pairs: six parts of a leaf (waxy cuticle, upper epidermis, palisade mesophyll, spongy mesophyll, guard cells, xylem) and six jobs in plain words (keeps water in; lets the light through to the cells below; catches most of the light; the wet surface where gases dissolve; opens and shuts the pores; brings water in). Pairs match them, then lay each pair on a big drawn section of a leaf, and add the air spaces and the phloem with jobs of their own. Finish by asking which two jobs pull against each other: keeping water in, and letting gases in.

Needs: a set of cards for each pair, an A3 outline of a leaf section for each pair.

PLENARY

8 min

Exit

Two sentences: why a large organism cannot rely on its outer surface for gas exchange, and how the shape and the inside of a leaf get round the problem.

WHAT STUDENTS GET WRONG

"A bigger organism has a bigger surface area to volume ratio." Both grow, but the volume grows faster, so the ratio falls. Have them work out 6 : 1, 3 : 1 and 1.5 : 1 themselves before the figure does.

"Plants respire only at night." Every living cell respires all the time. By day, a leaf in bright light photosynthesises faster, which hides its respiration in the overall exchange.

Gas exchange across the whole leaf surface. The cuticle stops almost all of it: the gases go through the stomata, then across the wet walls of the mesophyll cells.

Drawing cells in a plan diagram. A plan shows the outline of each tissue, never its cells, and is never shaded.

STRETCH AND SUPPORT

Stretch: check the sheet in chapter 1's predict box (528 cm^2 of surface for 64 cm^3, 8.25 : 1), then design a shape with the same volume and an even higher ratio. What would it be like to live in?

Support: a printed, labelled leaf section (chapter 2's figure) to copy from before drawing a plan of their own.

IN THE GUIDE

1 Every cell needs a way in

2 A leaf is built for gas exchange

3 Drawing a leaf in plan

All 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 B3.1 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=B3.1&level=SL&paper=quiz&marks=15&src=ep

PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- Tarsia puzzle, dominoes and picture reveal on B3.1, built from its key terms and ready to print
- A pub quiz with rounds on B3.1, to present or run with no projector
- An escape room built from the question bank on B3.1

ALREADY ON THE SITE FOR B3.1

- Quiz: Gas Exchange (HL)
- Quiz: Gas Exchange
- Revision map: B3.1 Gas exchange, to fill in
- Exam questions: B3.1 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.

- B3.1 Gas Exchange: Humans
- B2.2–B3.2 Organelles, Gas Exchange & Transport

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.