

Limiting factors, and tomorrow's air

60 minutes • C1.3.7 and C1.3.8 • Chapters 6, 7 • The dry lab

Light, carbon dioxide and temperature as limiting factors, how to vary each, and greenhouse against FACE experiments

BY THE END, STUDENTS CAN

- ☐ Suggest and test hypotheses about light, carbon dioxide and temperature as limiting factors, naming the variables C1.3.7
- ☐ Compare greenhouse and FACE experiments as ways of predicting how plants will grow in tomorrow's air C1.3.8

TIMING

0-5	5 min	Do now: sketch it	
5-17	12 min	Leaf discs, set going	
17-27	10 min	Sketch, then check	
27-35	8 min	Which question is better?	
35-47	12 min	Greenhouse against FACE	
47-55	8 min	Leaf discs: the last counts	
55-60	5 min	Exit	
	60 min	One lesson	

STARTER

5
min

Do now: sketch it

Rate of photosynthesis against light intensity, with no help (the first stage of [chapter 6's](#) sketches).

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.

06 Whatever runs short sets the pace

CHAPTER 06 IN THE SLIDES

Show the figure: Sketch a hypothesis as a graph, then check it. Three stages: light, then temperature, then carbon dioxide at high and low light.

Predict box: A plant at 15 °C is given more and more light until its rate levels off. Then it is warmed to 25 °C. What happens to the rate? Hands up or mini whiteboards first.

Answer B: It rises to a higher plateau

Remember it: Lazy Cats Toast (Light intensity, Carbon dioxide concentration, Temperature).

07 Tomorrow's air, today

CHAPTER 07 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.

- Two ways to grow plants in **tomorrow's air**.
- A greenhouse **controls** more variables; a **FACE** ring keeps real field conditions.
- In the field, the gain in yield was smaller.

Predict box: Crops given extra carbon dioxide gained less yield in FACE rings than in enclosures. What is the most likely reason? Hands up or mini whiteboards first.

Answer C: In fields, another factor soon limits

THE LESSON

- 12 min**

Leaf discs, set going

The leaf disc practical below, set going in groups at three hydrogencarbonate concentrations. One student in each group counts the floating discs every minute through the next steps.
- 10 min**

Sketch, then check

Chapter 6: Sketch, then check, stages 2 and 3 on the board against the students' own sketches. Then the predict, then the Lazy Cats Toast tiles.
- 8 min**

Which question is better?

The activity below, then the leaf disc lab's variables: how is each varied, why, and in what units?
- 12 min**

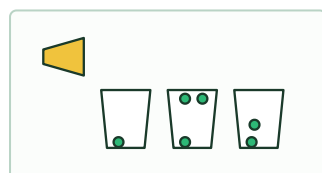
Greenhouse against FACE

Chapter 7: the predict, then the figure. Students fill a two-column table, greenhouse and FACE, with one controlled variable for each.
- 8 min**

Leaf discs: the last counts

Last counts, then each group's time for half the discs to float goes on the board. The dry lab (the pondweed bench) is shown on the board with one distance series, and set for homework, written up with the coach.

ACTIVITIES

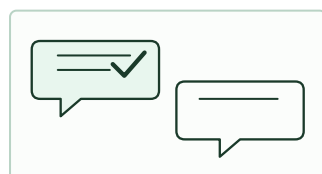


PRACTICAL

Leaf discs

Punch ten discs from a spinach leaf (avoiding veins) for each cup (chapter 6). Draw the air out of them in a 10 cm³ plastic syringe of the cup's solution with a drop of washing-up liquid (a finger on the nozzle, pull the plunger, release, repeat until they sink). Tip them into a cup of the same solution: 0 %, 0.2 % and 0.5 % sodium hydrogencarbonate (1 g in 100 cm³ is 1 %). Stand each cup the same distance from a lamp. Count the discs floating every minute for 15 to 20 minutes, and find the time for half to float.

Needs: spinach, a hole punch, 10 cm³ plastic syringes, sodium hydrogencarbonate, washing-up liquid, clear cups, a lamp, a metre rule, timers.



WRITE

Which question is better?

Two research questions for the leaf disc lab: one names the independent variable with its range and units, the dependent variable and how it is measured, and the organism; the other does not. Students say which is better and why, then write their own for the dry lab.

Needs: the two questions on the board.

○	_____
→	_____
⊥	_____

TABLE

Three ways to measure it

A three-row table: oxygen given off, carbon dioxide taken up, gain in mass. For each, how it is measured and the theory behind the method. If there is time, or set it with the dry lab homework: lesson 3's minutes have no slot for it.

Needs: a printed table.



PRACTICAL

Algal balls

An alternative to the leaf discs, if there is time or in another lesson. Algae trapped in alginate beads sit in bottles of red hydrogencarbonate indicator, the bottles along a metre rule from a lamp. After an hour or so the indicator turns purple where carbon dioxide is taken up (photosynthesis faster than respiration) and yellow where it is added. Make the beads with sodium alginate and calcium chloride, by the SAPS method; compare with a colour chart or a colorimeter at 550 nm.

Needs: concentrated algae, 2 % sodium alginate, 2 % calcium chloride, hydrogencarbonate indicator, small bottles with lids, a lamp, a metre rule.

PLENARY

5
min

Exit

Name the limiting factor at three points on a sketch graph.

WHAT STUDENTS GET WRONG

A limiting factor stops photosynthesis. It sets the rate; it is the one in shortest supply.

More light always means a faster rate. Only while light is limiting.

The plateau means the plant is "full". It means another factor now limits.

Lamp distance is the light intensity. Intensity falls about as $1 \div \text{distance}^2$: measure it, and watch for heat.

STRETCH AND SUPPORT

Support: chapter captions as cut-up cards to put in order; the dotted key terms as a glossary; a writing frame for "explain the effect of light intensity" (rise, why, plateau, why).

Stretch: in the dry lab, plot rate against $1 \div \text{distance}^2$ and find where the straight line ends. What does that point tell you?

Stretch: a greenhouse grower can add carbon dioxide, light or heat. Using a sketch graph, which should she add first on a dull winter day, and why?

IN THE GUIDE

- 6** [Whatever runs short sets the pace](#)
- 7** [Tomorrow's air, today](#)
- Lab** [Dry lab: Pondweed and the lamp](#)
- All** [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 C1.3, 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.

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on C1.3 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=C1.3&level=SL&paper=quiz&marks=15&src=ep

