**ANSWER KEY.**

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# The Break-Even Light: A Photosynthesis Lab

Biology | ANSWER KEY

Sample answers and data. Accept answers that match the group's own data and reasoning.

**Draft lab.** This lab has not been tested in a classroom yet. Your teacher may change some steps, times or amounts.

## The Puzzle

Leaf disks with the air pulled out of them sink. In light, photosynthesis makes oxygen that collects inside the leaf, and the disks float back up. But leaves also use oxygen for cellular respiration, all the time. If you dim the light enough, there must be a point where the leaf makes oxygen only as fast as it uses it. That is the **break-even light**, also called the **compensation point**. You will dim the light with layers of window screen.

## Question

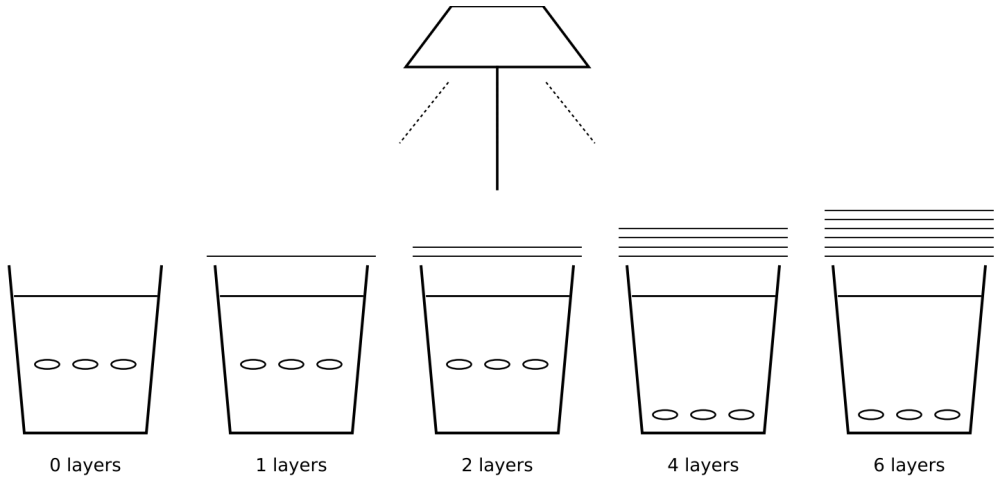
How dim can the light get before spinach leaf disks stop making extra oxygen?

## Safety

- Syringes have no needles. Never point them at anyone.
- Lamps get hot. Do not touch the bulb or shade.
- Wipe up spills. Do not eat the spinach.

## Materials (per group)

- Fresh spinach leaves, hole punch or straw
- 10 mL syringe (no needle)
- 5 cups of bicarbonate solution (0.2% baking soda with 1 drop of dish soap per 300 mL)
- Window screen squares: stacks of 0, 1, 2, 4, and 6 layers
- Foil, LED lamp, timer




*Foil around each cup blocks side light. The only light comes through the screen on top.*


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## Before the Lab

**1.** Predict how many disks will float after 20 minutes in each cup. At which cup do you think floating will stop? Explain.

**Answers vary. Expected: fewer disks float under more layers, and none float at the dimmest light, where oxygen is used as fast as it is made.**

## Procedure

**1.** Punch 50 disks from spinach leaves, avoiding the big veins.

**2.** Put 10 disks in the syringe, draw in 5 mL of bicarbonate solution, and push out the air. Cover the tip with a finger and pull the plunger back for 10 seconds. Repeat 2 or 3 times until the disks sink.

**3.** Drop the 10 sunken disks into a cup. Repeat for all five cups.

**4.** Wrap the side of each cup in foil. Cover each cup's top with its screen stack (0, 1, 2, 4, or 6 layers).

**5.** Place all five cups the same distance (about 15 cm) under the lamp. Start the timer.

**6.** Peek through the screen and count floating disks every 5 minutes for 20 minutes.

## Data

**Table 1. Number of disks floating (out of 10)**

| Screen layers | 5 min | 10 min | 15 min | 20 min |
|---|---|---|---|---|
| 0 | **2** | **6** | **9** | **10** |
| 1 | **1** | **4** | **8** | **9** |
| 2 | **0** | **2** | **5** | **7** |
| 4 | **0** | **0** | **1** | **2** |
| 6 | **0** | **0** | **0** | **0** |

**2.** Graph the number of disks floating at 20 minutes (y) against the number of screen layers (x).

**Expected graph: 10 floating at 0 layers, 9 at 1, 7 at 2, 2 at 4, and 0 at 6 layers. The curve drops steeply between 2 and 6 layers (sample).**

## Analysis

**3.** Why did the disks sink after you used the syringe, and why did some float later?

**The syringe pulled the air out of the leaf's air spaces and replaced it with solution, so the disks sank. In light, photosynthesis made oxygen gas that filled the air spaces again, so the disks floated.**

**4.** What is the baking soda for?

**It adds dissolved $CO_2$ (as bicarbonate), the carbon source the leaf needs for photosynthesis.**


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**5.** No disks floated under 6 layers. Does that prove the leaf did no photosynthesis? Explain.

**No. The leaf can still photosynthesize in dim light, but respiration used the oxygen as fast as it was made. With no extra (net) oxygen, the disks could not float.**

**6.** Between which screen layers is the break-even light for spinach? Use your data.

**Between 4 and 6 layers. Some disks still floated at 4 layers; none floated at 6 (sample).**

**7.** Plants on a forest floor live in dim light. Would you expect their break-even light to be higher or lower than spinach's? Explain.

**Lower. Shade plants need to make more oxygen and sugar than they use even in dim light, so they tend to have lower respiration rates and break even at lower light.**

**8.** Claim, evidence, reasoning: What happens to a leaf's net oxygen production as light gets dimmer?

| **Claim** |
| --- |
| **Net oxygen production drops as light dims and reaches zero at the break-even light.** |

| **Evidence** |
| --- |
| **After 20 minutes, 10 disks floated with no screen, 2 with 4 layers, and 0 with 6 layers (sample).** |

| **Reasoning** |
| --- |
| **Photosynthesis makes oxygen faster in brighter light, while respiration uses oxygen at a steady rate. Disks float only when photosynthesis makes more oxygen than respiration uses.** |


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