

Oxygen Used by Sprouting Seeds, and Energy per Gram of Food: Two Datasets

Learning target: I can graph and calculate from data to show that living seeds use oxygen faster when warmer, and use real energy-per-gram values to explain why fat is the body's long-term energy store.

Data and graphing

About 45 min

Individual

MS-LS1-7 · practice

MS-LS1-6 · supports

data analysis

independent practice

Name

Date

Period

Directions

This sheet has two parts. Part A uses a teaching dataset about sprouting pea seeds in a gas-measuring tube; the numbers were invented to be realistic, not measured in a real lab. Part B uses real, rounded values for the energy in food. Graph with a ruler, label units on every number, and show every calculation so a partner could check it.

You will need: This worksheet, Pencil, Ruler, Calculator

Part A: How fast do sprouting seeds use oxygen?

A class placed 25 sprouting pea seeds in a sealed glass tube with a thin side tube marked in milliliters. A small packet inside the tube soaked up any carbon dioxide the seeds released, so the only gas change left to measure was the oxygen the seeds used. As the seeds used oxygen, a drop of colored water in the side tube moved inward, and the class read how many milliliters of oxygen had been used every five minutes. They ran the test in the dark in water baths at three temperatures, and they ran one more tube with boiled (killed) seeds as a comparison.

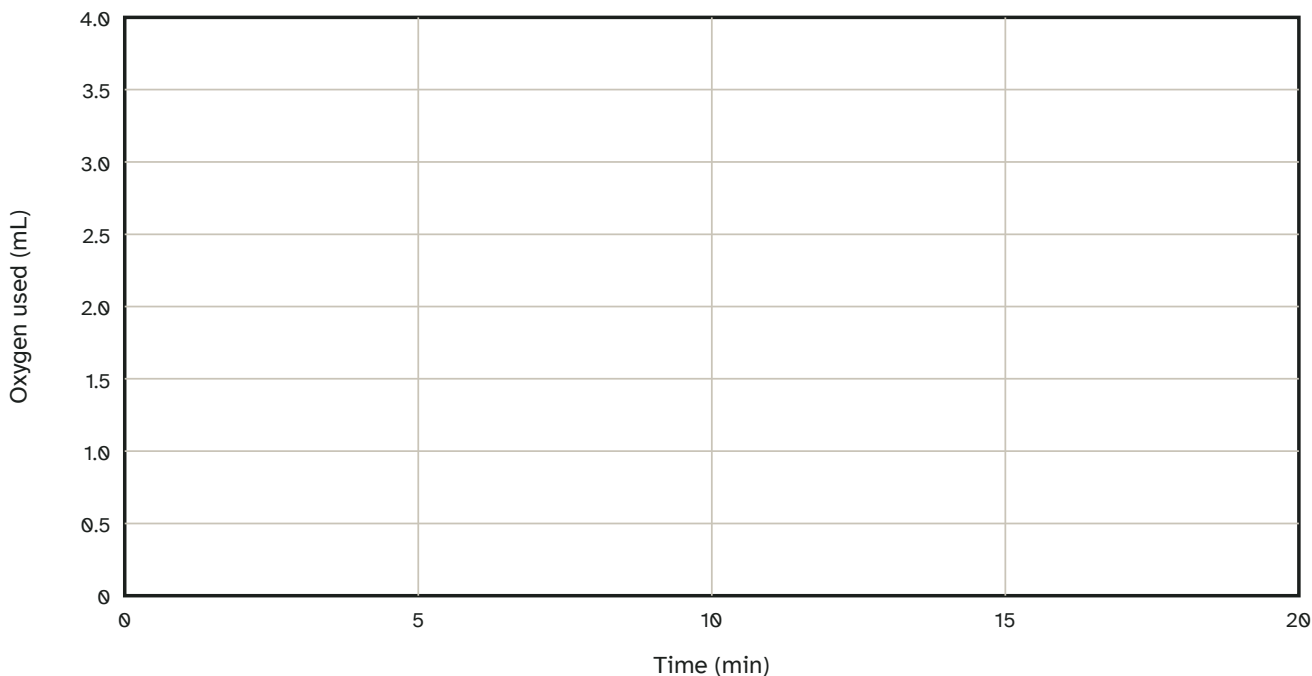
Oxygen used by 25 pea seeds in a sealed tube (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Time (min)	Sprouting seeds, 10 °C (mL)	Sprouting seeds, 20 °C (mL)	Sprouting seeds, 30 °C (mL)	Boiled seeds, 20 °C (mL)
0	0.0	0.0	0.0	0.0
5	0.2	0.5	0.9	0.0
10	0.4	1.1	1.9	0.1
15	0.7	1.5	2.8	0.1
20	0.8	2.0	3.8	0.1

Simulated data for teaching. The tubes were kept in the dark. Values are the total milliliters of oxygen used since the start.

Oxygen used versus time



1. Calculate the rate at which the sprouting seeds used oxygen at 20 °C, in milliliters per minute, using the total after 20 minutes. Show the division.

2. Complete the table for all four tubes. Round rates to the nearest hundredth.

Oxygen used in 20 min (mL)	Rate (mL per min)
Sprouting, 10 °C	
Sprouting, 20 °C	
Sprouting, 30 °C	
Boiled, 20 °C	

3. Describe the pattern in the rates for the sprouting seeds as temperature rises from 10 °C to 20 °C to 30 °C. Use the numbers.

4. Why did the class include the tube of boiled seeds? What would it have meant if that tube had also used 2.0 mL of oxygen?

5. Predict how much oxygen the 30 °C seeds would have used after 40 minutes if the pattern continued. Show the calculation. Then give one reason the real reading might be lower.

6. The seeds were in the dark the whole time. Using the words **reactant**, **product** and **energy**, explain where the oxygen went, what the seeds gave off (even though the packet hid it), and why the seeds needed to do this at all.

Part B: How much energy is in each kind of food molecule?

Scientists measure the energy a food can release by burning a weighed sample and measuring the heat, much as Lavoisier did. The table gives real, rounded values. A kilocalorie (kcal) is the unit printed as 'Calories' on food labels in the United States; 1 kcal is about 4.2 kilojoules (kJ).

Energy released per gram of food molecule (real rounded values)

Food molecule	Energy per gram (kcal)	Energy per gram (kJ)	Main role in the body
Carbohydrate (sugar, starch)	4	17	quick fuel; short-term storage as glycogen
Fat	9	37	long-term energy storage; part of cell membranes
Protein	4	17	building material for muscle and other structures; can be used as fuel

A trail-mix serving contains 18 g of carbohydrate, 8 g of fat and 5 g of protein (these amounts are typical for a small handful; treat them as the serving for the questions below).

7. Calculate the total energy in the trail-mix serving in kilocalories. Show the three multiplications and the sum.

8. What percentage of the serving's energy comes from fat? Show the calculation and round to the nearest whole percent.

9. A songbird stores energy for migration as fat, not as glycogen. Using the table, explain why fat is the better choice for an animal that has to carry its energy store while flying.

10. Look at both parts of this sheet. The sprouting seeds in Part A were using up starch that the parent plant stored in them. If the class had dried and weighed the seeds before and after the test, what would have happened to the dry mass, and where did that mass go? Connect your answer to the oxygen the seeds used and to the energy values in Part B.

Rates are 'how much per how long'

A rate is an amount divided by a time. For q1 and q2, write the amount used in 20 minutes on top, the 20 minutes on the bottom, and divide: for example, $1.0 \text{ mL} \div 20 \text{ min} = 0.05 \text{ mL per minute}$. The unit of your answer is always 'mL per min.' For the percentage in q8, divide the part (energy from fat) by the whole (total energy) and multiply by 100.

How much sugar did the seeds use?

In the overall reaction, six oxygen molecules are used for every sugar molecule, and in gas form 1 mL of oxygen at room conditions holds about 2.5×10^{19} molecules. Use the 20 °C data to estimate how many oxygen molecules the seeds used in 20 minutes, then how many sugar molecules that corresponds to. One sugar molecule has a mass of about 3.0×10^{-22} g; estimate the mass of sugar used in 20 minutes and explain why a balance that reads to 0.01 g could not have detected this change.