

BREATHING OUT CARBON DIOXIDE

TOPIC:

Respiration

SCIENTIST:

Joseph Black 1728–1799

INTRODUCTION:

We need energy to stay alive. The way we obtain energy is through the process of respiration. When we breathe in, oxygen is taken into the bloodstream through the lungs. It is transported to the cells where it is used to release energy from glucose. Carbon dioxide, produced as waste, is transported to the lungs, and is removed from the body when we breathe out. Although respiration is understood clearly now, it has not always been. According to the second-century Greek physician Claudius Galen (129–201), air was breathed in and out to ventilate the *flamma vitalis*—the vital flame of life that burned in the heart. Galen's views were accepted without question until the seventeenth century, when a number of scientists challenged his theories. In the 1660s, English scientist Robert Boyle (see 1.009) showed that air was necessary for life. John Mayow (see 1.032) found that only a small part of the air (later shown to be oxygen) was required to keep animals alive. In the 1750s, Joseph Black showed that carbon dioxide was present in much larger amounts in air that was breathed out than air that was breathed in. He did this by sucking, then blowing, air through limewater, a solution which turns milky in the presence of carbon dioxide. This experiment showed that carbon dioxide was a waste product of respiration. Over the years these pieces of evidence were brought together to provide us with our present-day understanding of respiration.

TIME NEEDED:

45 minutes

MATERIALS:

2 test tubes	2 teaspoons
test tube rack	safety goggles
felt-tip marker	filter funnel
4 flexible drinking straws	250-ml Erlenmeyer flask
modeling clay	stopper to fit Erlenmeyer flask
limewater (calcium hydroxide solution)	filter paper
250-ml beaker	metric ruler
distilled water	

Original Materials:

Black evidently used much the same apparatus as that used here but all pieces were constructed from glass. He referred to carbon dioxide (the gas he discovered) as “fixed air.”

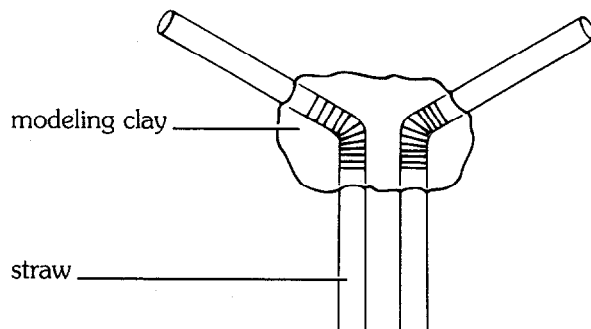
Safety Precautions

Please read and copy the safety precautions at the beginning of this book. Wear safety glasses, and follow the instructions carefully when handling calcium hydroxide solution (limewater). Be careful not to suck too strongly on the apparatus when carrying out the experiment. In the unlikely event of swallowing limewater, wash your mouth out well and drink plenty of water.

PROCEDURE:

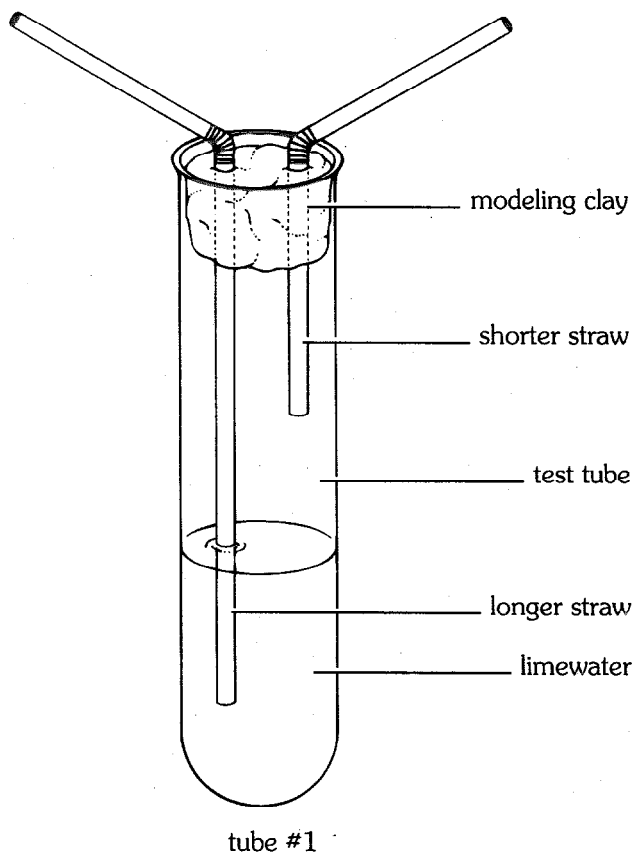
1. Take the two test tubes. Use the felt-tip marker to label one tube "1" and the other tube "2."
2. Pour limewater into both test tubes until they are both one-third full.
3. Take the drinking straws. Cut 7 cm from the ends of two of the straws.
4. Take a piece of modeling clay about the size of a large strawberry. Mold it around the flexible sections of one of the long straws and one of the short straws, joining the two straws together (see figure 1).

Figure 1



5. Insert the straws and modeling clay into test tube #1 as shown in figure 2. Use extra modeling clay to seal the top of the test tube. Be careful not to flatten the straws.

Figure 2

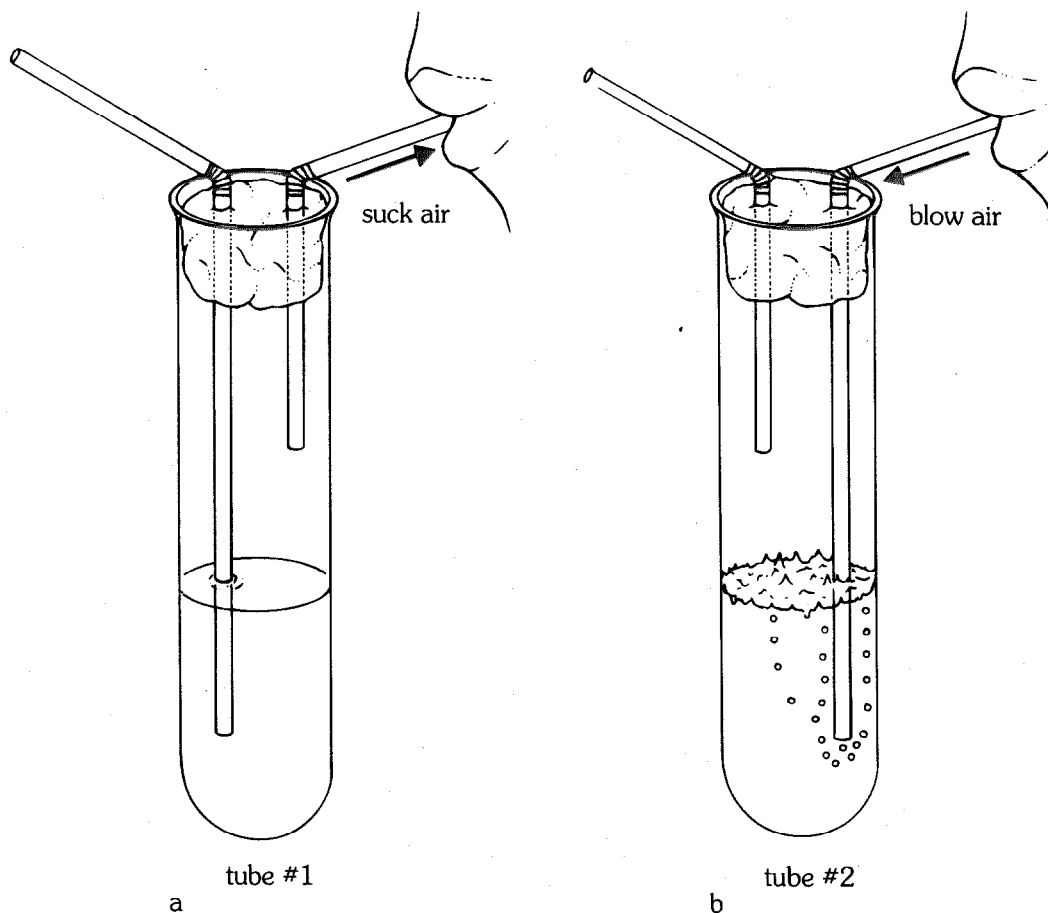


6. Repeat steps 4 and 5 with the other drinking straws and tube #2.
7. Hold tube #1 in your left and tube #2 in your right hand. Record the appearance of the limewater in both tubes.

8. Lift up tube #1. Put the end of the SHORTER straw (see figure 3a) into your mouth and suck GENTLY. Record what happens.

9. Now lift up tube #2. Put the end of the LONGER straw into your mouth (see figure 3b). Blow gently down the straw. Record what happens.

Figure 3



10. Repeat steps 8 and 9 five more times. Look at the limewater in both tubes. Record the appearance of the limewater in both.

ANALYSIS:

1. What did the limewater look like at the beginning of the experiment?
2. What did you observe when you a) sucked air through tube #1 and b) blew air through tube #2?
3. Describe the appearance of the limewater in the two tubes at the end of the experiment.
4. Do some research. What chemical reaction is occurring here?
5. What conclusion can you draw from this experiment?
6. Do some research. Is it correct to say that air breathed in contains no carbon dioxide?

OUR FINDINGS:

See Section VIII.

SPECIAL SAFETY NOTE TO EXPERIMENTERS

Each experiment includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are performing the experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each experiment you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say **BE CAREFUL WITH HOT LIQUIDS** or **DON'T CUT YOURSELF WITH THE KNIFE** does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:

- Clear all surfaces before beginning experiments
- Read the instructions before you start
- Know the hazards of the experiments and anticipate dangers

PROTECTING YOURSELF:

- Follow the directions step-by-step; do only one experiment at a time
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
- Make sure there is adequate ventilation
- Do not horseplay
- Wear an apron and goggles
- Do not wear contact lenses, open shoes, loose clothing, or loose hair
- Keep floor and work space neat, clean, and dry
- Clean up spills immediately
- Never eat, drink, or smoke in laboratory or work space
- Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:

- Set up apparatus far from the edge of the desk
- Use knives and other sharp or pointed instruments with caution
- Pull plugs, not cords, when removing electrical plugs
- Don't use your mouth to pipette; use a suction bulb
- Clean glassware before and after use
- Check glassware for scratches, cracks, and sharp edges
- Clean up broken glassware immediately
- Do not use reflected sunlight to illuminate your microscope
- Do not touch metal conductors
- Use only low voltage and current materials such as lantern batteries
- Be careful when using stepstools, chairs, and ladders

USING CHEMICALS:

- Never taste or inhale chemicals
- Label all bottles and apparatus containing chemicals
- Read labels carefully
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
- Do not touch chemical solutions
- Wash hands before and after using solutions
- Wipe up spills thoroughly

HEATING SUBSTANCES:

- Use goggles, apron, and gloves when boiling water
- Keep your face away from test tubes and beakers
- Never leave apparatus unattended
- Use safety tongs and heat-resistant mittens
- Turn off hot plates, bunsen burners, and gas when you are done
- Keep flammable substances away from heat
- Have fire extinguisher on hand

FINISHING UP:

- Thoroughly clean your work area and glassware
- Be careful not to return chemicals or contaminated reagents to the wrong containers
- Don't dispose of materials in the sink unless instructed to do so
- Wash your hands
- Clean up all residue and put in proper containers for disposal
- Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES