SCIENCE AT HOME

# MEASURING VITAL CAPACITY

GRADE: **10**

**SNC2D, SNC2P**
**SUBJECT:** SCIENCE
**STRAND:** BIOLOGY
**TOPIC:** THE RESPIRATORY SYSTEM
**EXPECTATIONS:** SNC2D: A1.1, A1.5, B3.3, B3.4, B3.5; SNC2P: A1.1, A1.5, B3.3, B3.4, B3.5
**VIDEO:** youtu.be/HQ7quumtFLU

## INTRODUCTION:

There are 11 organ systems in the human body working together to keep you alive, and the respiratory system is one. It helps provide the cells in your body with the oxygen they need to survive.

When you breathe in, air travels into your mouth or nose and down a tube called the "trachea." This tube divides into two narrower tubes, called "bronchi," which further divide into multiple small, narrow tubes, known as "bronchioles." When it reaches tiny air sacs called "alveoli," a gas exchange takes place: oxygen, needed by your cells, is traded for carbon dioxide, a waste product. The oxygen enters your bloodstream and 25 trillion red blood cells in your circulatory system then carry it to each of the other five trillion cells throughout your body.

Your diaphragm controls inspiration, or breathing in, and expiration, breathing out. A "spirometer" is a device that can be used to measure the volume of air that is inspired or expired. Spirometers are commonly used to measure "vital capacity," the maximum volume of air that you can exhale in one breath. In a normal breath — your "tidal volume" — you exchange approximately 500 millilitres of air.

## ACTIVITY: Build a model respiratory system

Use balloons, straws and a bottle to explore how the contraction and relaxation of your diaphragm muscle is connected to inhalation and exhalation.

## TIME: 10 minutes

## SAFETY:

Be careful when you are using scissors to cut the plastic bottle and when making a hole in the bottle cap.

Choose latex-free balloons if you have an allergy.

## WHAT YOU NEED:

- Empty plastic bottle (500 mL to 710 mL is best)
- Scissors
- 3 round 12"/ 30 cm balloons
- Plastic or paper straw
- Tape
- Hot glue gun and glue (optional)

## WHAT YOU DO:

- Cut the bottom off the pop bottle.
- Make a hole in the bottle cap large enough to fit a straw. (Be very careful when doing this.)

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## WHAT YOU DO (continued):

- Cut your straw approximately five centimetres from one end, on an angle.
- Create a hole in the side of the straw about five centimetres from the end where you made the angled cut.
- Use tape or hot glue to attach the short piece you cut from your straw over the hole you created in its side. This should give you a Y-shaped straw.
- Tape one balloon to each of the two branches of your Y-shaped straw.

- Insert the free end of your straw into the bottom of the bottle and up through the mouth. The Y-shaped part of the straw and the balloons are now inside the bottle. Keep pushing the free end of the straw through the underside of the bottle cap and out through the top. Hot glue or tape it in place.
- Knot the neck of your third balloon, and cut the balloon in half through its widest part.
- Attach the bottom half of this balloon over the bottom of your bottle using tape.

- You now have a model of your respiratory system:
  - The bottle represents your chest, or "thoracic," cavity.
  - The straws represent your trachea and primary bronchi.
  - The balloons on the straws represent the elastic tissue of the lungs, which contain narrower branches of bronchi, bronchioles, and alveoli (but your simple model doesn't show these separately). This is where gas exchange occurs, in conjunction with the circulatory system.
  - The balloon stretched across the bottom of the bottle represents your diaphragm.
- Force the diaphragm to contract by pulling down on the balloon's knot. What happens to the lungs?
- Allow the diaphragm to relax. What happens to the lungs now?
- Does all of the air ever leave the lungs, bronchi and trachea in your model? Why do you think this is?

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## WHY THIS MATTERS:

Inhale. Now, exhale. Have you been remembering to breathe while reading? No? No worries — breathing is involuntary. Our nervous, circulatory and respiratory systems work together to ensure muscles like the diaphragm contract and relax, bringing air into and out of the lungs.

## ACTIVITY: Measuring vital capacity

Measure vital capacity using either a balloon spirometer or a water displacement spirometer. Feel free to try both.

## TIME: 20 minutes

## SAFETY:

If you have a respiratory condition, you should avoid this activity.

Choose latex-free balloons if you have an allergy.

Use fresh tubing or straws for each participant (or wash these thoroughly with warm soapy water between participants).

Do this activity under the supervision of an adult.

## WHAT YOU NEED:

**Water displacement method**

- Empty bottle or bottles, with a minimum combined volume of 4 L
- Clean, flexible tubing or bendy straws
- Basin of water or a sink (large enough to hold the volume of your bottles)
- Measuring cup
- Marker
- Water

**Balloon method**

- Balloon
- Piece of string
- Ruler

## WHAT YOU DO:

**Water displacement method**

- Create 250 mL markings on each bottle by filling them in 250 mL increments and marking the water level after each addition.
- Completely fill your bottle with water and seal the mouth with the palm of your hand. Tip the bottle upside down and submerge the opening in the basin water. Don't let any water escape. Take your hand away, but keep holding the bottle upright. Do this with all the bottles you're using.
- Slip one end of your tubing under the water and into the mouth of a bottle. The other end has to remain outside the basin — you will be exhaling into it.

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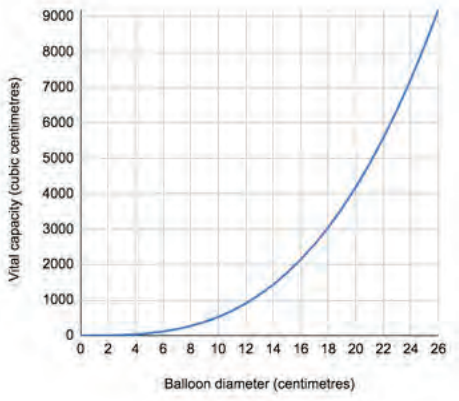
## WHAT YOU DO (continued):

- Inhale maximally: take the deepest breath you can.
- Then exhale completely into the tube. This will displace a volume of water equivalent to the volume of air you blew out. If one bottle is not enough you will need to move your tube to a second bottle after the first is emptied. Don't exhale while you're transferring the straw or tube.
- Measure the volume of gas exhaled using your 250 mL markings. This is your vital capacity.
- Repeat your measurement three times and take an average.

**Balloon method**

- Stretch out your balloon very well.
- Take a deep breath and exhale completely into the balloon. Force out as much air as you can with one breath.
- The volume of air in the balloon is your vital capacity. To calculate this volume, find the diameter of the balloon. To do this, lay the balloon on its side on a flat surface. Stand a ruler up beside the breath-filled balloon and measure the height at the widest part.

- Then use the graph below to determine your vital capacity.
- Repeat your measurement three times and take an average.




- Age, size, biological sex and genetic factors — many variables may account for differing vital capacities. Choose a variable that could be related to a person's vital capacity, make a hypothesis and test members of your household to see how your hypothesis stands up. (Remember to use fresh or clean tubing for each person.)

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## WHAT YOU DO (continued)

- Were you correct? Do you have enough data to draw any significant conclusions?
- Share your data with your class. What conclusions can you draw when you pool your data?

## WHY THIS MATTERS:

Vital capacities differ between people for all sorts of reasons. A person's usual vital capacity can also change because of illness. Vital capacity is often measured by a medical professional to help diagnose and monitor diseases such as asthma or chronic obstructive pulmonary disease (COPD).

## TAKING IT FURTHER:

The respiratory and circulatory systems are tightly connected and are always adapting to your body's needs. Changes in heart rate and breathing rate often happen at the same time.

Measure your pulse and number of breaths per minute while you are lying down, sitting and standing.

Did you notice any differences based on your body position?

Test other members of your household. How do their measurements differ from yours? Why do you think that is?

Design an experiment to test other factors that may affect heart rate and breathing rate. For example, you may choose to look at the effect of temperature, emotion, time of day — or anything else you can think of.

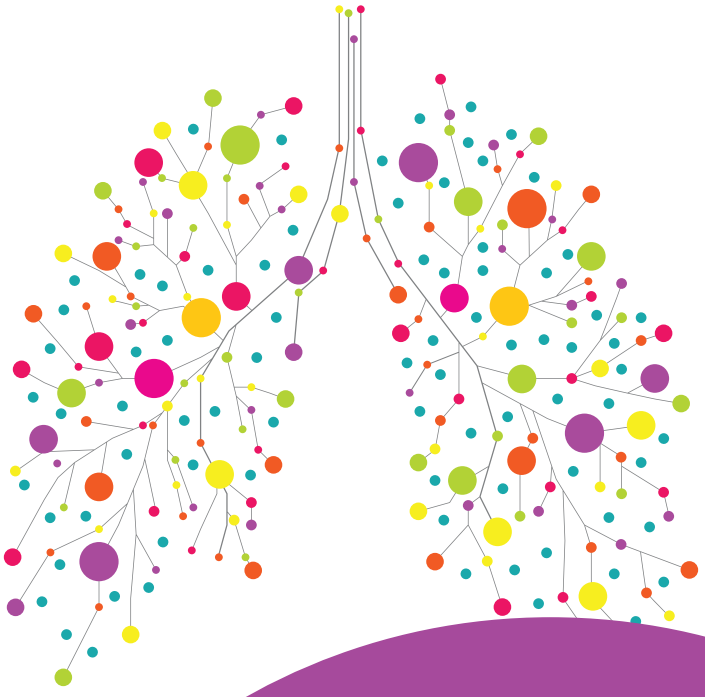
## HINT:

Your body automatically adjusts your breathing based on how much oxygen you need. Running up ten flights of stairs? Your breathing rate will speed up. Sleeping? Your breathing rate will slow down.

## MORE ONLINE:

Respiratory system
https://www.lung.ca/lung-health/lung-info/respiratory-system

Gasp! 11 Surprising Facts About the Respiratory System
https://www.livescience.com/44105-respiratory-system-surprising-facts.html



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