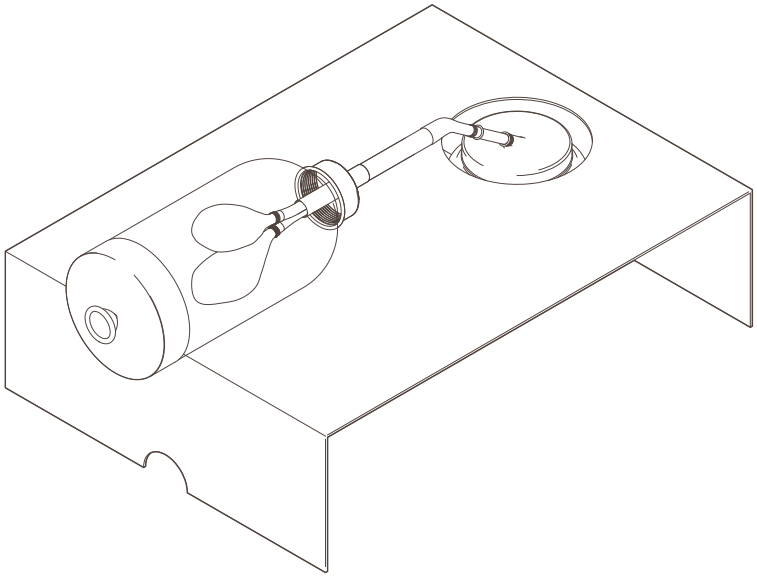


BREATHING SIMULATOR WORKSHEET

GETTING STARTED

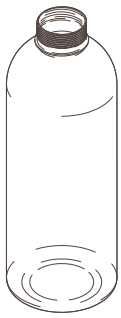
5-10m

Did you know that everyday functions of our body, such as digesting food, moving muscles or even just thinking, all require oxygen?

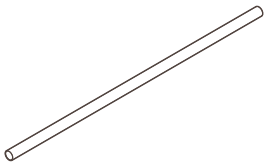
Sometimes when people are unwell they need help getting oxygen into their bodies. Biomedical engineers design and make all sorts of essential medical equipment that doctors can use to treat their patients.

This session will show you how to make model lungs that simulate the action of breathing, as well as a pump, which models how a ventilator can provide oxygen when someone is unwell.

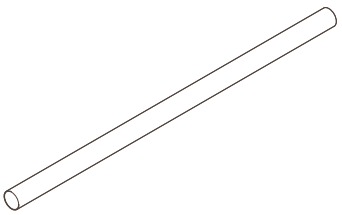
YOU WILL NEED



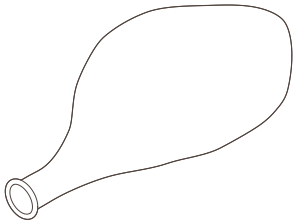
1L Plastic bottle
1



Drinking straws
2

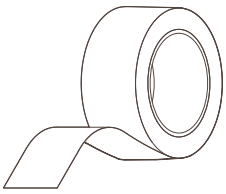


Smoothie straw
1

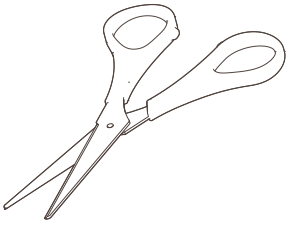


Large balloons
4

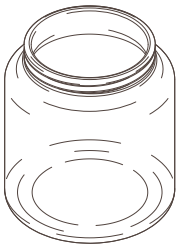
Small elastic bands
4



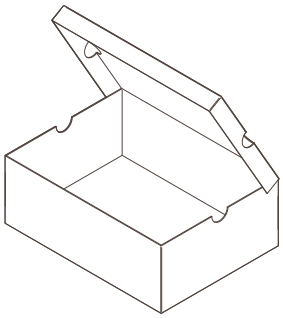
Sticky tape
10cm



Scissors
1



Jar
1



Shoe box
1

VOCABULARY

Respiratory system - The respiratory system is the group of tissues and organs in your body that allow you to breathe.

Diaphragm - A dome-shaped sheet of muscular tissue, which extends across the body below the chest cavity.

Intercostal muscles - Muscles that run between the ribs and help form and move the chest wall.

Volume - The amount of space an object takes up.

Pressure - The force over a given area.

Contract (muscle) - When a muscle becomes shorter and tighter.

Inhalation - The movement of air into the lungs, during breathing.

Exhalation - The movement of air out of the lungs, during breathing.

Diffusion - The movement of a substance from an area of higher concentration to an area of lower concentration.

WARM-UP ACTIVITIES

A

5-10m

Draw a diagram of the human lungs. Begin using your existing knowledge, then research further to add more detail.

Can you label these parts of the respiratory system?

- Trachea
- Bronchi
- Bronchiole
- Alveoli
- Diaphragm
- Nasal Cavity
- Mouth Cavity

Thinking about the structure of the lungs will help you to make links between the mechanical processes of inhaling and exhaling and the workings of the model you build.

B

10-15m

When somebody gets sick or hurt, they often need the help of doctors and nurses to make them feel better. However, those same doctors and nurses depend on biomedical engineers for help.

Think about all the different technologies that are used in hospitals to treat patients. For example, x-ray machines, prosthetic limbs and pacemakers.

Work with your team to make a list of as many different types of technology found in hospitals as you can.

Now think about health problems that currently do not have any solutions. Do you think that biomedical engineers might be able to design solutions to help people with these conditions in the future?

MAIN CHALLENGE

30-40m

Building this model is a great way to help you understand the mechanical process of breathing.

It will also give you some insight into the important work engineers do, designing solutions that help doctors to treat their patients.

We have provided you with an example of how to build the model and suggested some materials to use, but if you are feeling creative we encourage you to design your own.

Every time an engineer is faced with a problem, they approach it using the Engineering Design Process:

Ask - What's the problem?

Imagine - Choose a solution.

Plan - Design and choose materials.

Create - Make it.

Test - Test your creation.

Improve - Redesign as needed.

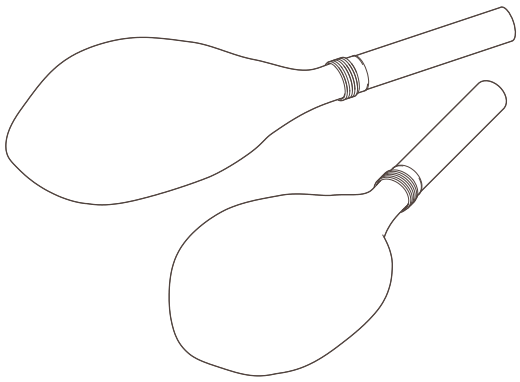
Using this design process, see if you can create the most efficient ventilation system for your model lungs. Good luck!

BUILDING THE BREATHING SIMULATOR

Follow these steps to build a breathing simulator that demonstrates how humans breathe naturally and a ventilator that models how doctors can help people who are unable to breathe for themselves.

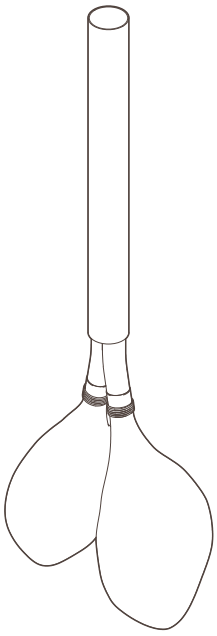
A

Firstly, construct the part of the model that represents the lungs. Cut one of the drinking straws into two 5cm long pieces. Then, cut the ends off two large balloons (keep these ends, as they will be used in later stages of the build). Connect the balloons to the ends of the straws, using small elastic bands. Make sure they are tightly attached to prevent air from escaping.



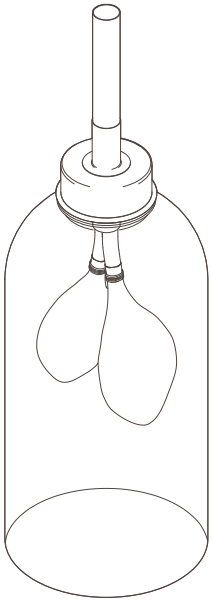
B

Next, make the trachea using the thicker smoothie straw. Trim the straw, so it is 10cm long, then push the two thinner straws inside of it. Take care not to crush them, as this will prevent air passing through. Test the flow of air, by blowing into the straw and checking if both balloons inflate, before sealing any gaps at the end of the smoothie straw with some tape.



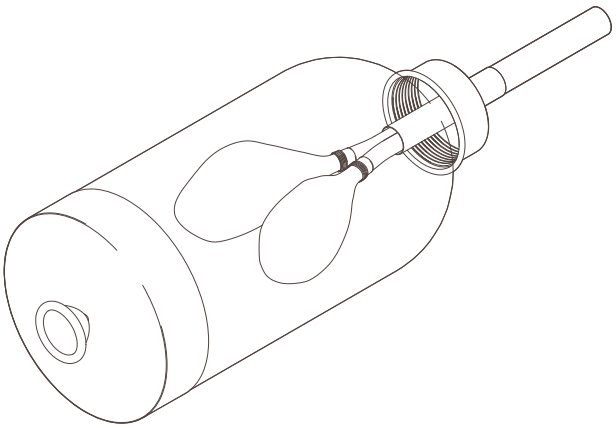
C

Now, take the plastic bottle, which will act like the chest cavity in this model, and cut off the bottom. Then, pull one of the ends of the balloon, which was cut off in Step A, over the neck of the bottle. Tape the rubber from the balloon around the trachea to create an airtight seal.



D

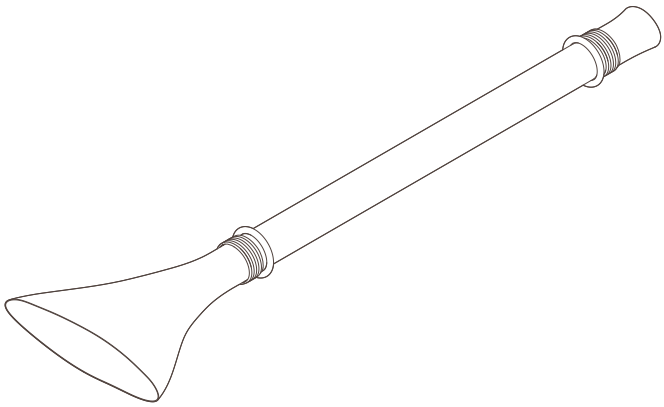
Complete the lung model by adding a diaphragm. Take another balloon, tie a knot in the end and then cut it across the middle. Stretch the balloon over the end of the bottle. When the knotted end of the balloon (diaphragm) is pulled down, it creates more space inside the bottle. Air then comes down the straw (trachea) and fills the balloons (lungs) with some air to fill the space. When the knot is released, the space no longer exists, so the air from the balloons (lungs) is expelled, causing them to deflate.



E

To make the pump for the ventilator, take another balloon, and cut it in half.

Trim the other drinking straw to 8cm and connect it to the cut balloon using a small elastic band. Connect one of the ends of the balloon, cut off in Step A, to the other end of the straw using another elastic band. This will create the connector between the pump and the trachea.

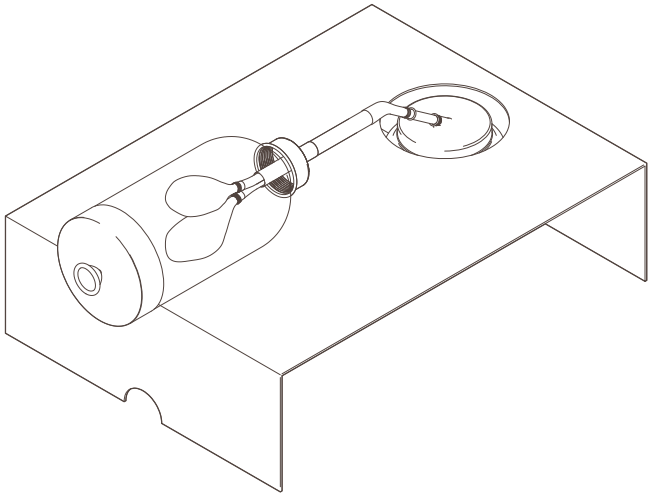


F

Now, stretch the larger section of balloon over a jar to trap air inside. When the balloon on top is pressed down, the volume inside the jar is decreased, which increases air pressure and forces air out of the jar down the straw to the trachea. This air then inflates the balloon lungs.

G

Finally, use a shoe box to house the pump so it can easily be connected to the lung model. Cut off one side of the box, then cut a hole in the top, the same diameter as the jar. The pump can be accessed through the hole and the lung model can rest on top.



DID YOU KNOW?

Bioengineers are developing technology to make it possible to grow a new lung in a laboratory for a patient who needs a lung transplant.

BREATHING SIMULATOR

THE MECHANICS OF BREATHING

KS2/3

UNDERSTAND THE SCIENCE

10-15m

The Mechanical Process Of Breathing

Human lungs fill the chest cavity between the neck and the bottom of the rib cage. The lungs themselves contain no muscles and are not able to expand and contract on their own. The size of the lungs is controlled by two different muscle groups:

- The diaphragm - a dome-shaped sheet of muscles that forms the floor of the chest cavity.
- The intercostal muscles - located between each pair of ribs.

When inhaling, the diaphragm contracts and drops down, whilst the ribs expand outward, making the chest cavity larger (Diagram 1). Therefore, the pressure in the cavity decreases. This results in air being drawn into the lungs causing them to expand.

During exhalation, the diaphragm relaxes and moves up whilst the ribs settle down (Diagram 2). This means the chest cavity is made smaller. Therefore, pressure increases and forces air out of the lungs.

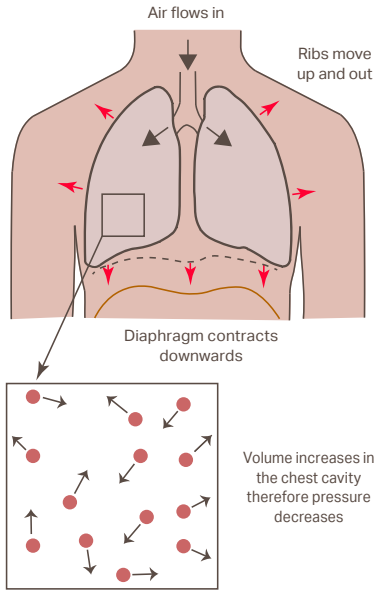


Diagram 1

Gas Pressure And Volume

Gas pressure is linked to the volume of its container because gases will always fill the space they occupy. It doesn't matter how big the container is, the molecules always spread out to fill the whole space equally.

The particles in a gas move quickly in all directions, but they do not get far before they bump into each other or the walls of their container. When gas particles hit the walls of their container, they cause pressure. If the volume of the container is decreased, the particles hit the walls of the container more often. This causes the pressure to rise.

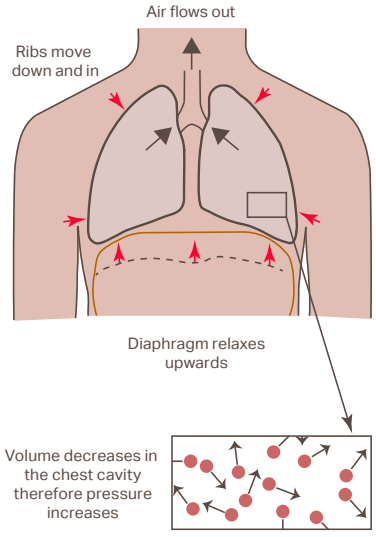


Diagram 2

KS3
DEEPER LEARNING

10-15m

Gas Exchange

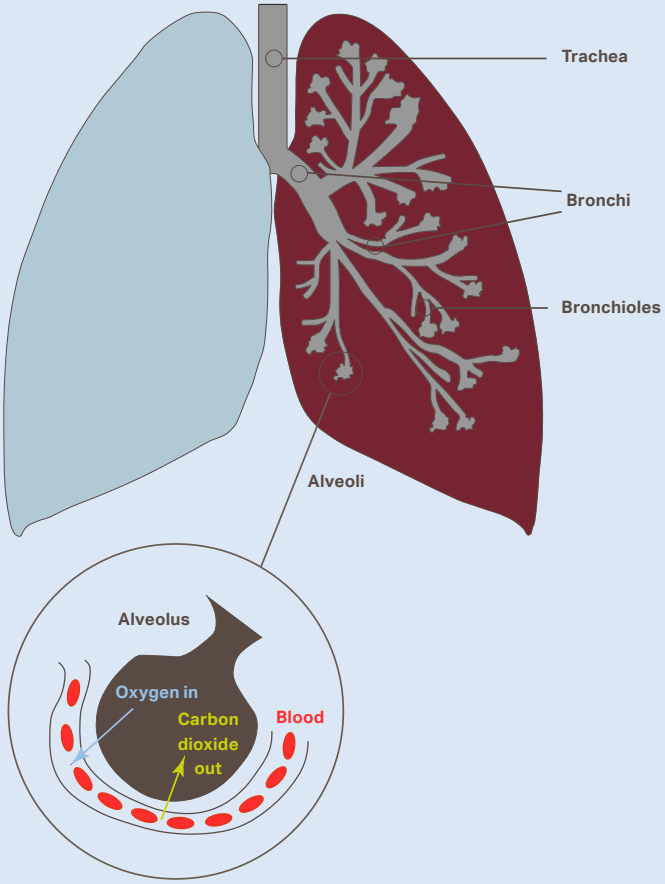
Humans need to breathe to get oxygen from the air into their blood, as well as to remove the waste carbon dioxide from their blood into the air. Moving gases like this is called gas exchange.

Gas exchange takes place in the lungs. To begin the process, air passes from the mouth into the trachea. The trachea divides into two bronchi, which then divide further into smaller tubes called bronchioles. Each bronchiole has a group of tiny air sacs on its end. These air sacs are covered in tiny bulges called alveoli which increase their surface area giving the maximum space for gas exchange to take place.

Each lung contains 300 million alveoli. Incredibly, if the surface of all the alveoli were spread out flat they would cover a tennis court!

It is the alveoli that allow oxygen from the air to pass into the blood and travel around the body. Each alveolus has a mesh-like covering of very small blood vessels called capillaries. Oxygen passes through the walls of each alveolus into the tiny capillaries that surround it through the process of diffusion.

Diffusion is a physical process where molecules of a material move from an area of high concentration (where there are many molecules) to an area of low concentration (where there are fewer molecules). Oxygen diffuses from the air in the alveoli into the blood whilst carbon dioxide diffuses from the blood into the air in the alveoli.



DID YOU KNOW?

The lungs are not equal in size. The right lung is shorter, because the liver sits high, tucked under the ribcage, but it is broader than the left. The left lung is smaller because of the space taken up by the heart.

QUIZ

10-15m

In the breathing simulator, which part of the respiratory system do the drinking straws represent?

.....

.....

Name some technology used to treat patients that could have been developed by biomedical engineers.

.....

.....

What properties does the rubber balloon have that make it good for simulating the movement of the lungs and diaphragm in this model?

.....

.....

Why does pressure increase in the lungs when we exhale?

.....

.....

Which gas do we exhale as a waste product?

.....

.....

QUIZ

Which muscles control the size of the lungs?

.....

.....

Are both sides of the lungs the same size?

.....

.....

Which part of the respiratory system does the balloon stretched across the bottom of the bottle represent?

.....

.....

What is diffusion?

.....

.....

How is surface area for diffusion maximised in the lungs?

.....

.....