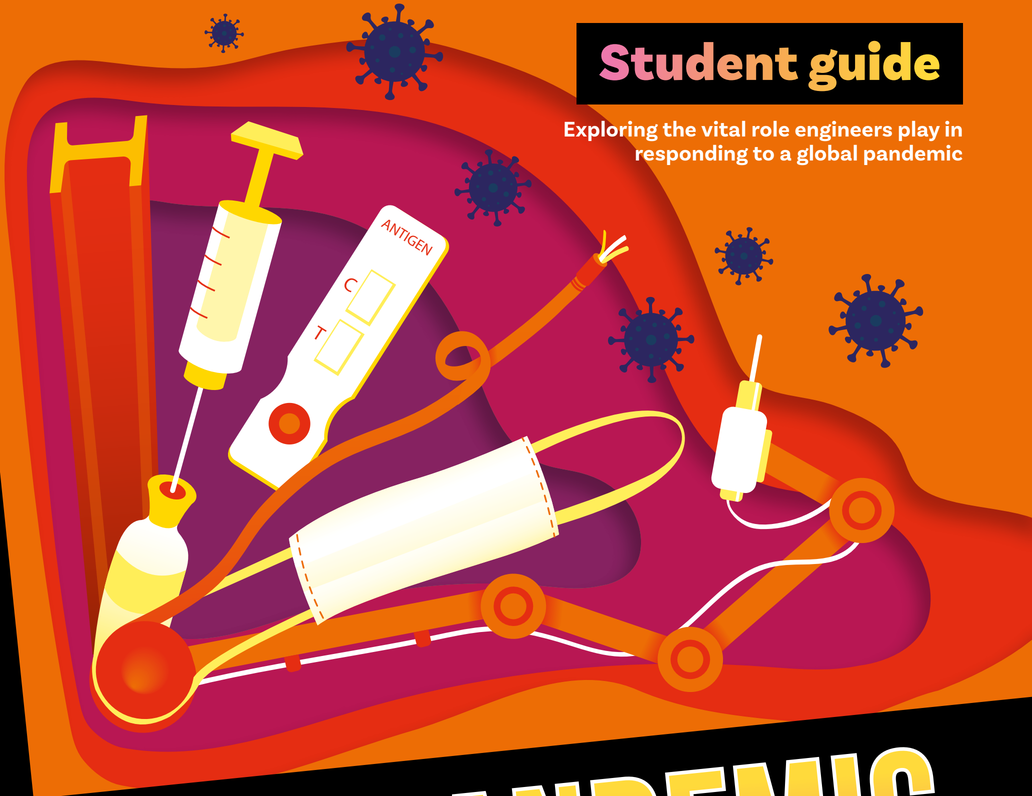
Royal Academy of Engineering

Student guide

Exploring the vital role engineers play in responding to a global pandemic

THIS IS ENGINEERING



ENGINEERING IN A PANDEMIC

ENGINEERING IN A PANDEMIC

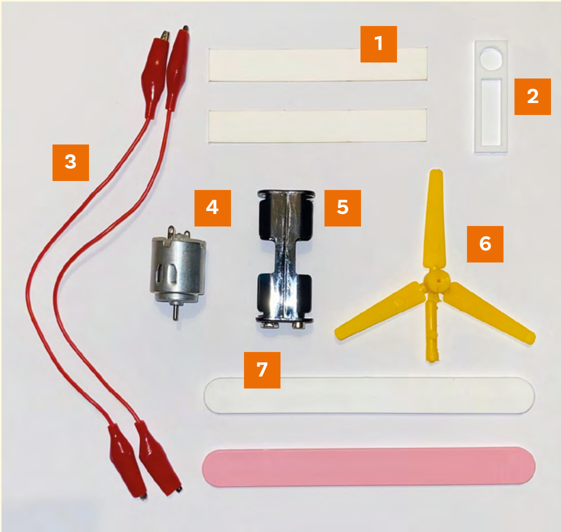
The engineering community plays a vital role in our daily lives and engineers were essential in responding to the COVID-19 pandemic.

While the pandemic has had devastating global effects, the engineering community worked together to quickly respond to the sudden demands of coronavirus, even finding opportunities for positive change.

Engineers have created emergency ventilators, diagnostic tests and manufacturing methods, helped increase hospital capacity, ensured that vulnerable people can safely get supplies and helped us all stay in touch with friends and family while social distancing.

What's in the pack?

1. Two pieces of chromatography paper
2. Chromatography paper holder
3. Croc leads
4. Motor
5. Battery pack (batteries not included)
6. Fan blades
7. Two moulding sticks



Find this resource on our STEM resource hub at: https://stemresources.raeng.org.uk/engineering-in-a-pandemic/

CHOOSE YOUR CHALLENGE

ENGINEERING HABITS

Engineers make 'things' that work or make 'things' work better. They do this in particular ways.

The engineering habits describes the way engineers think and act.

How do you think and act like an engineer?

Take the quiz on our the Engineering in a pandemic page on our STEM resource hub to discover your engineering habits.

But remember – results are not fixed! Take the quiz several times. You might find that different engineering habits are stronger depending on the type of activity or challenge you are doing.

Engineering is all about having a diverse group of people and skills so having different engineers with different habits of mind in any team is always important.

I am good at...

Creative problem-solving	Improving	Problem-finding	Adapting	Visualising	Systems thinking
Coming up with lots of new and good ideas	Making what I have done better	Thinking about the world around me and how it could be better	Deciding how something could be done differently	Thinking out loud when I am being imaginative	Using ideas from one subject in another
Working successfully in a group	Experimenting with things just to see what happens	Finding out why something does not work	Explaining how well I am doing to my teachers and friends	Making a plan before I start work	Putting things together to make something new

Find the quiz on the Engineering in a pandemic page on our STEM resource hub or visit: https://stemresources.raeng.org.uk/stem-at-home/engineering-habits-quiz/.

STEM BADGES

Digital STEM badges reward you for your commitment to STEM.

For each activity you complete from this booklet, think about which engineering habits you were using and mark it on the STEM badge record sheet.

Once you have completed enough of the activities and challenges, cash them in for your STEM badges!

The badges are digital so you can link them to your online profiles and applications and you won't lose them!

How do you collect your badges?

Show and tell your teacher what challenge(s) you have been working on and answer these questions:

- What problem did you solve?
- What did you discover from working on this challenge?
- Which engineering habits did you use?
- Did you work in a team or independently?
- What worked well?
- How could you improve it?

Your teacher will then share your work with us and claim digital badges on your behalf.

Complete SEVEN challenges

Complete FOUR challenges

Complete TWO challenges

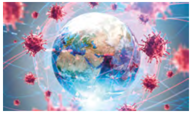
STEM BADGE TRACKER

Name:

Challenge one
Post-pandemic world

Challenge two
Model your own virus

Challenge three
Outbreak



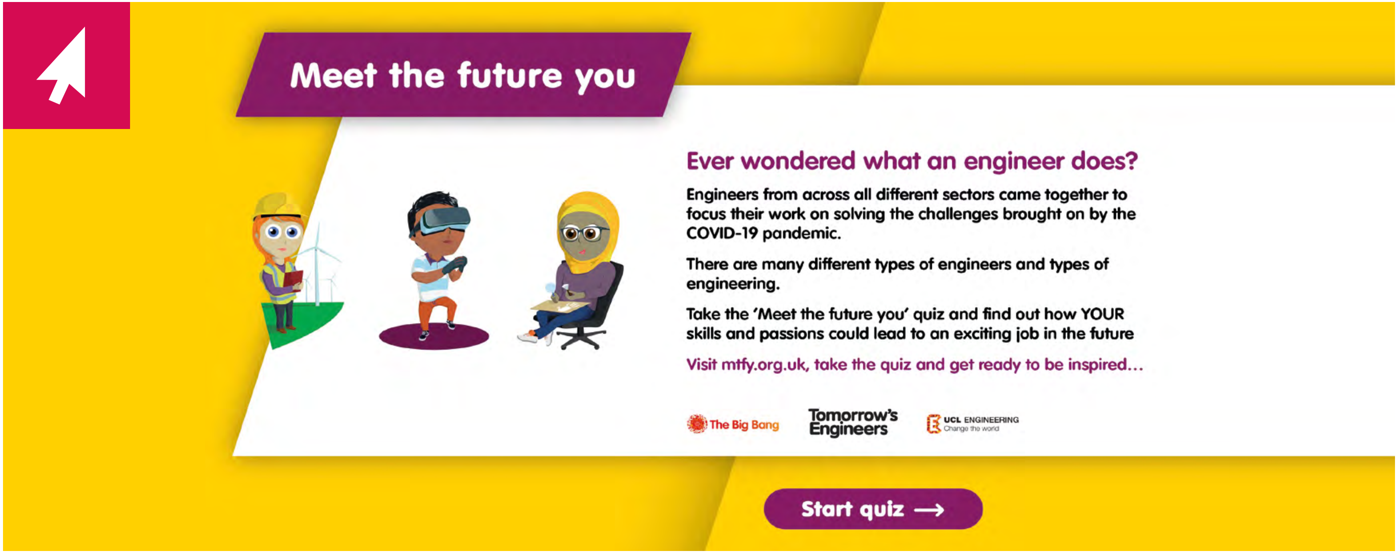
Challenge four
Testing, testing, testing...

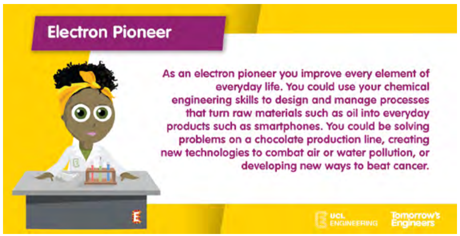
Challenge five
Block the way

Challenge six
Tech4pandemics

Challenge seven
Respirator challenge

MEET THE FUTURE YOU QUIZ





Setting the scene

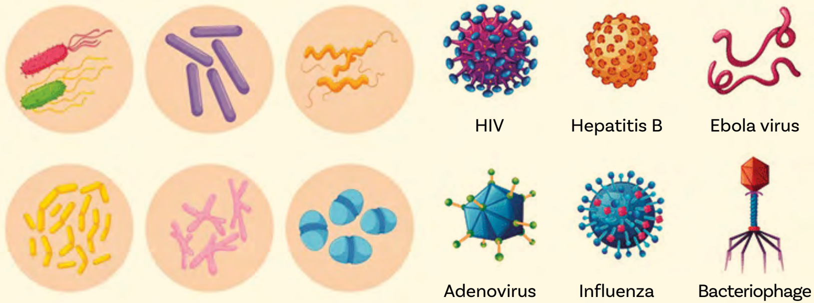
WHAT IS A PANDEMIC?

When a large number of people become seriously ill due to the same **bacteria** or **virus** (types of **pathogens**), it is called an **epidemic**. If the disease spreads globally, it becomes a **pandemic**.

The World Health Organization (WHO) lists six stages of a pandemic virus:

1. The virus is found in animals, but not in humans.
2. The virus has been found in humans.
3. There are small clusters of the disease found, but it is not spreading rapidly.
4. The virus is being passed from human-to-human and there are community outbreaks of the disease.
5. The virus has spread to at least two countries. A full-fledged pandemic is imminent.
6. The disease is now classified as a full-fledged pandemic.

Bacteria vs virus



Mini-glossary

Bacteria are microscopic one-celled (uni-celled) organisms. Thousands of bacteria live almost everywhere. Bacteria can multiply (by reproducing themselves). Some are helpful and some make us sick.

Viruses are even smaller than bacteria and often have a spiny outside layer. They can't reproduce on their own, so they infect cells and take them over in order to multiply.

Communicable diseases are diseases that can be transferred from one person to another.

A **pathogen** is an organism that causes disease.

Pandemics throughout history:

- **1300s – Bubonic plague.** This is caused by *Yersinia pestis* bacteria. There are still a few cases each year but it is now treatable by antibiotics and a vaccine is available.
- **1918 to 1919 – Spanish (Avian) Flu.** It was caused by a virus in the H1N1 influenza family. Spanish Flu was one of the deadliest pandemics in human history. The pandemic ended after a series of social distancing measures, lockdowns and push on hygiene measures. Eventually, after more than 50 million deaths, society developed a collective immunity.
- **Ancient times to 1970s – Smallpox.** This was caused by the variola virus. The revolutionary Edward Jenner developed the world's first vaccination and we eliminated the disease by 1979.
- **1980s to today: HIV/Aids.** This is caused by a human immunodeficiency virus, a different type of virus that attacks the cells of the immune system. Thanks to scientific advances, such as the development of the antiretroviral drugs, people with access to treatment are able to live long and healthy lives with HIV.
- **2019 to today: COVID-19.**

What is the COVID-19 pandemic?

COVID-19 pandemic, also known as the **coronavirus pandemic**, is an ongoing pandemic of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The World Health Organization declared the outbreak a Public Health Emergency of International Concern in January 2020 and a pandemic in March 2020. In November 2020, a vaccine was approved and vulnerable people and frontline workers started receiving the vaccine.

But what is COVID-19?

Watch the TED-Ed COVID-19 YouTube video to find out: https://www.ted.com/talks/elizabeth_cox_what_is_a_coronavirus?language=en (Video duration 05:15)

Spotlight

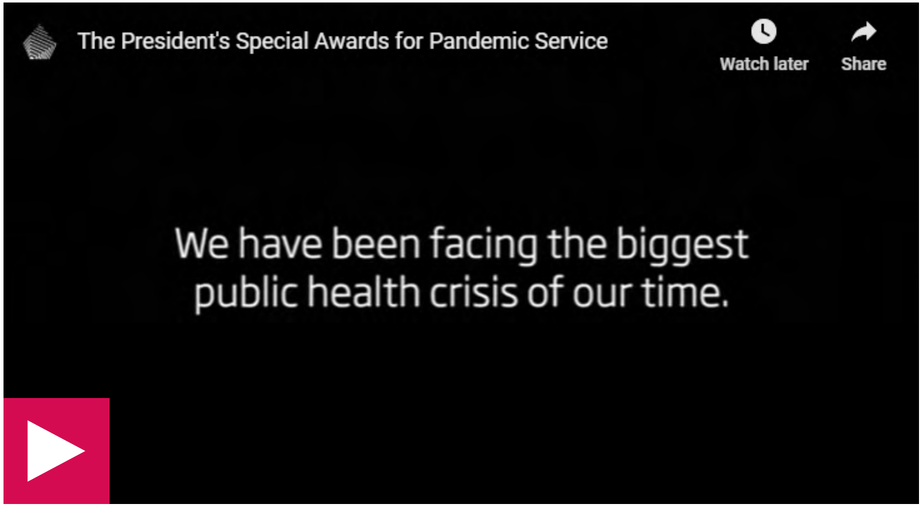
INNOVATION IN A CRISIS

Engineers and the engineering community have made and continue to make vital contributions to the global fight against pandemics throughout history, and COVID-19 is no exception.

What do you think?

- How have engineers and the engineering community worked together to fight against the devastating effects of COVID-19?
- How has engineering supported our healthcare system during the pandemic?
- How has engineering contributed to the economy during the pandemic?
- How has engineering supported our wellbeing during the pandemic?
- Where else do you think engineering has played a role in responding to COVID-19?

Watch this short film by the Royal Academy of Engineering to get a glimpse of some of the teams of engineers and innovators who have led the way in the response to COVID-19, and before you start exploring answers to the questions.



These engineers and innovators are also being recognised at the Science and Media Museum's online exhibition, Engineering a response to COVID-19.

Here is a sneak preview:

Dr Dominic Pimenta, a heart doctor at one of London's busiest hospitals worked with a team from Makerversity to design and manufacture 100,000 reusable face shields as well as thousands of reusable gowns and scrubs (see **page 28** for weird and wonderful facemask challenge).

All photos

A team of young engineers from the National Physical Laboratory (NPL) took a central role in building and testing prototype ventilators.

A team led by Professor Rebecca Shipley, Professor Tim Baker and Mercedes AMG High Performance Powertrains delivered 10,000 breathing aids to UK hospitals and shared the designs with governments from 105 other countries at no cost.

Dick Elsy CBE led the initiative to combine the knowledge and skills of 33 UK technology and engineering businesses across aerospace, automotive and medical sectors to produce more than 13,000 ventilators for the NHS.

Engineers at Mott MacDonald had the NHS Nightingale London and NHS Nightingale North West field hospitals up and running ready to care for parents shortly after the announcement of the pandemic.

Check out the full exhibition on the Science and Media museum website.

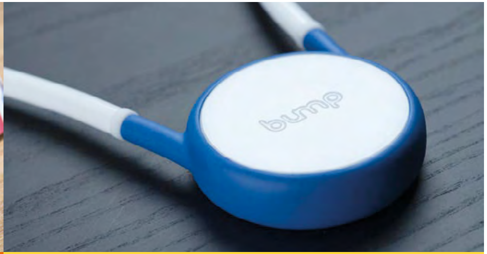
Challenge one

POST-PANDEMIC WORLD

As we learn more about different diseases, how to manage their spread and eventually limit their harmful effects, changes are made to society and how we live to ensure that history does not repeat itself and so that we can continue living in a safe, sustainable and equal society.

Check out these creative innovations from teams of engineers who have been working hard to solve many of the new problems that the pandemic has brought with it.

This environmentally-friendly **face shield** has been manufactured from recycled materials that are compostable or recyclable at the end of life.



Tharsus Bump is a **social distancing system** providing real-time alerts when wearers get too close.

The **Handy Hook** was initially developed for front line NHS staff, to limit their interaction with surfaces that might be carrying the virus.

A rapid, affordable **COVID-19 test** based on a lab in a cartridge technology that provides test results in just over an hour.

Image from:
http://designatmnblog.com/2020/09/design-in-a-post-pandemic-world/

Design and prototype a sustainable product, technology or system that meets the changing needs of our society in one of these areas:

- Enabling people to enjoy some form of entertainment such as going to gigs or watching sports
- Remote learning during and after a pandemic
- Healthy habits during and after a pandemic
- Protecting and enhancing the lives of vulnerable communities
- Supporting essential workers.

Getting started:

- Brainstorm lots of ideas – every idea counts, no matter how strange it might seem.
- What social distancing problem are you trying to solve?
- Who are you solving this problem for?
- Get inspiration from other people's work.
- Start sketching, modelling, making, tinkering!

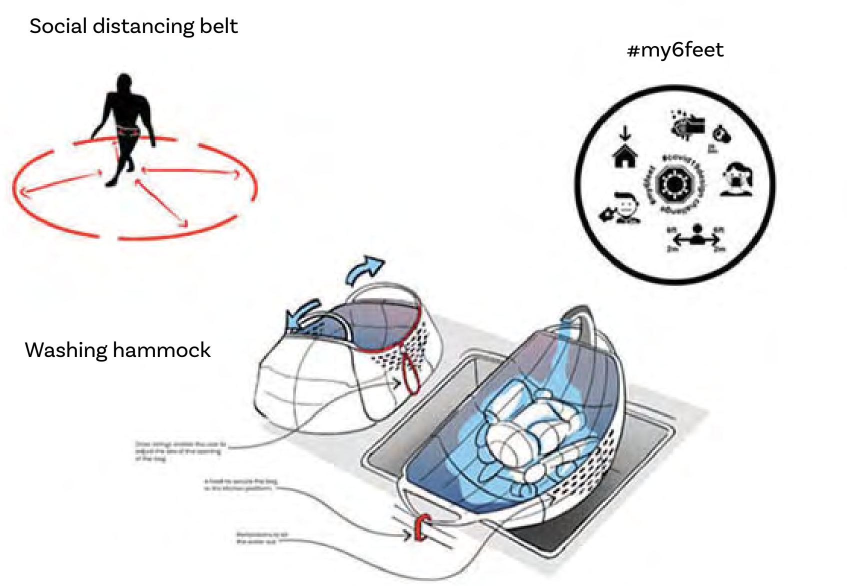


Image taken from:
https://newsroom.ibm.com/covid19designchallenge

Ideas for devices submitted for the IBM Design Challenge:
a social distancing belt, a sticker reminding people of safe behaviour and hammock to wash produce.

Challenge two

VIRUS BIOART

Viruses as far as the eye can see...

There are more viruses on Earth than stars in the visible universe. If we could lay all the viruses end-to-end they would stretch 100,000 light years (one light year is equal to 9.46 trillion kilometres!).

Most viruses are harmless to humans. Others cause diseases, such as influenza, the common cold, smallpox, measles, mumps, chickenpox, AIDS, hepatitis and some kinds of cancer. Viruses reproduce fast when conditions are right for them.

Your body can contain 100 trillion influenza viruses when you suffer from flu. That's over 10,000 times more viruses than there are people on the planet.

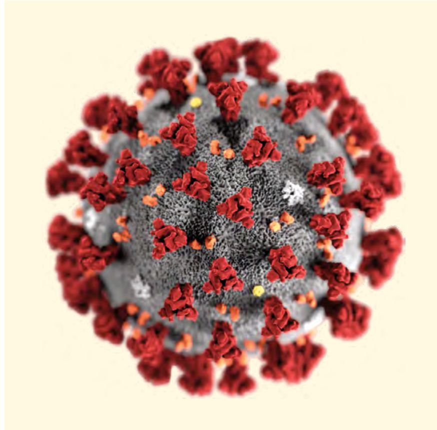
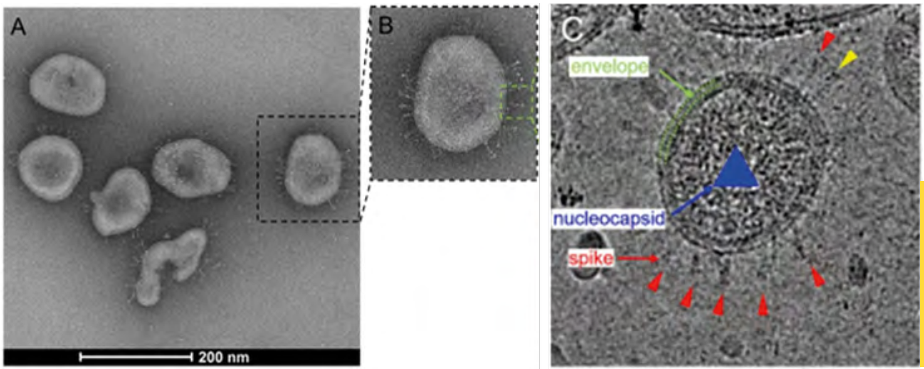


Illustration of SARS-Cov-2 created at the Centers for Disease Control and Prevention (CDC),



Electron microscopy visualisation of SARS-CoV-2 particles taken from 'The Conversation: Five techniques we're using to uncover the secrets of viruses'.

What does a virus look like?

Viruses are not made of cells, unlike all other forms of life. They consist of **proteins** and **nucleic acids** and surrounded by a protective shell called a **capsid**. They are so small that they are not visible with a standard optical microscope. To put it into perspective, most of our cells are around 100 micrometres (0.1 millimetres) in diameter. Viruses are about 1,000 times smaller than this, averaging 150 nanometres (0.00015 millimetres)*.

So how do we know they exist or what they look like?

Standard light microscopes allow us to see our cells clearly. However these microscopes do not allow us to see anything smaller than half the wavelength of a visible light* – and viruses are much smaller than this!

Biochemical engineers have been developing tools and methods to allow us to visualise viruses. One technique is called electron microscopy, which produces images at the nanometre scale.

We can use this information to work out how to use drugs to block the virus and produce more precise and effective vaccines.

*__Have a look at our__ Light Saver resource for more activities exploring nanometres and the visible light spectrum.

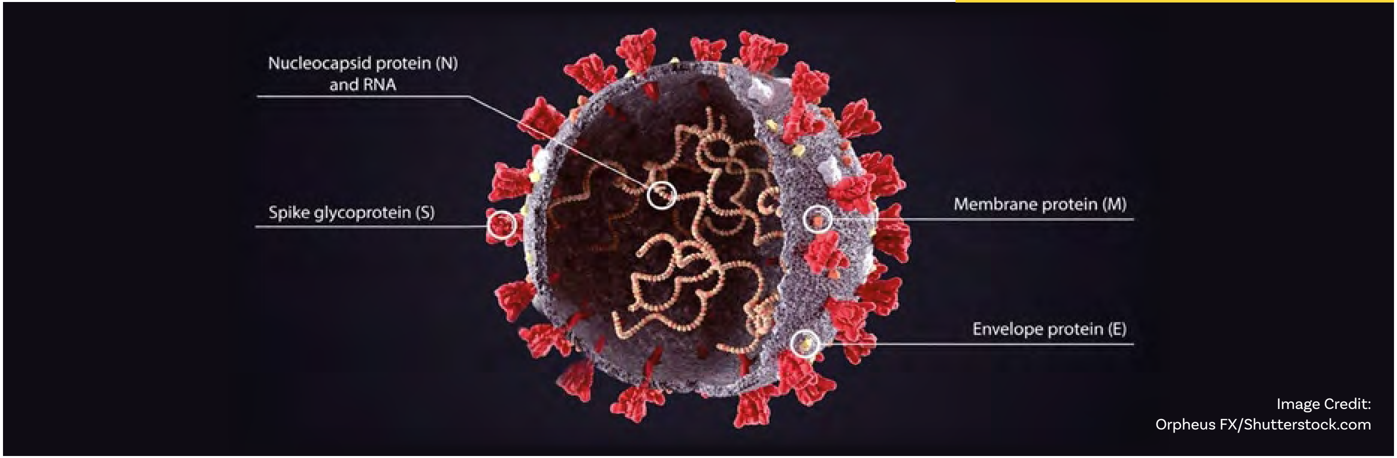


Image Credit: Orpheus FX/Shutterstock.com

Virus show and tell

Create a 3D model of a virus (your choice, some ideas are shown below) that can be used to help teach others about what a virus looks like and how it works.

Take pictures of your virus model and use this as a part of a presentation/poster/booklet that you can use to explain to a friend or family member what a virus looks like, how it interacts with the body and what infection it might cause.

Handy hint:

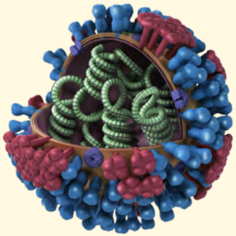
The information on **pages 7, 8, 13 and 14** might help you with your presentation.

This interactive 3D representation of SARS-CoV-2 (the virus that causes Covid-19) gives you a good look in and around the virus: https://www.scientificamerican.com/interactive/inside-the-coronavirus/

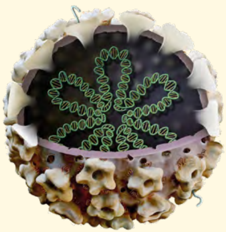
Stretch and challenge

Create a model and presentation for one more than one type of virus to compare their characteristics.

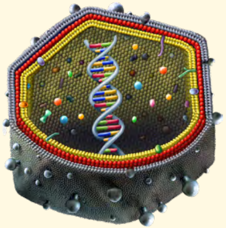
Research how **antibodies** work and what they look like and include this in your presentation.



Influenza virus

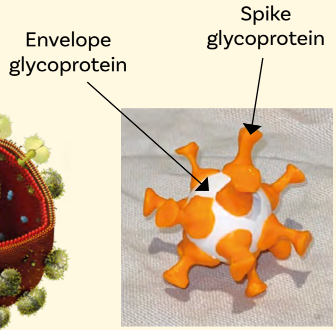


Human papillomavirus (HPV)



Emiliania huxleyi virus (EhV)

Human immunodeficiency virus (HIV)



Model of a virus made using moulding sticks

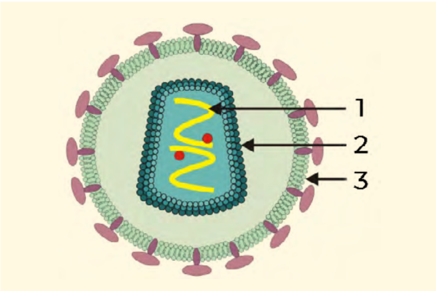
Images of viruses from https://worldofviruses.unl.edu/category/inside-viruses/

Be careful when using hot water. Do not put your hand in water that has just been boiled. Work with a teacher/parent/guardian when dunking the sticks in the hot water.

Make a 3D model of a virus

Which parts of the virus can you include?

1. **Nucleic acid.** This is a set of genetic material known as either DNA or RNA.
2. **Capsid.** This is the protein coat that surrounds the DNA or RNA to protect it.
3. **Envelope.** A covering for the capsid. This includes the spike proteins that allow viruses to penetrate host cells and cause infections.



For more on different types of viruses and how they work, visit [letstalkscience.ca, Introduction to viruses].

Materials

- Moulding sticks (included in pack)
- Bowl or cup of hot water for melting the sticks (speak to a parent, carer, or activity leader before using hot water)
- Sharpies/acrylic paints for colouring your stick
- Anything you have at home or school that could be used for your model.

What is happening?

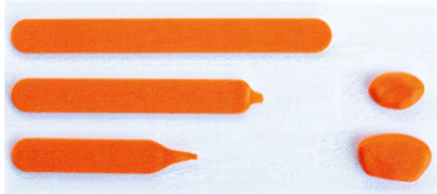
The moulding sticks are made from a thermoplastic material. It has all the characteristics of tough materials such as nylon, yet it can be reheated and remoulded as often as is needed.

Fixit sticks – heat it to shape it!

Dunk the sticks into hot water (60°C+). Remove it and pinch off the section you want to work and mould.

The stick moulds will stick together when they are hot.

Keep them in a bowl of warm/hot water so they stay **malleable** while you mould.



Mini-glossary

A material is **malleable** if it can be hammered or pressed into shape without breaking.

Changed your mind about your design or want to try a different virus model?

Fixits are endlessly reusable. Just put them back in hot water and remould them.

Model of DNA made using moulding sticks.

Challenge three

CLASSROOM OUTBREAK

Outbreaks can spread from just one person with an infection.

Simulate how an infection can spread with your class or group through a multiplication game.

This challenge will work best once you are back in school!

Your teacher or activity leader will allocate each of you a number. Anyone with the number 0 is carrying the virus. Do not tell anyone your number.

1. You will each receive a sheet to track the results of the game.
2. You will each be given a secret number which will be already filled in on your record sheet.
3. You will play several rounds of this game. Each new round starts once you have a new number after interacting with another student.

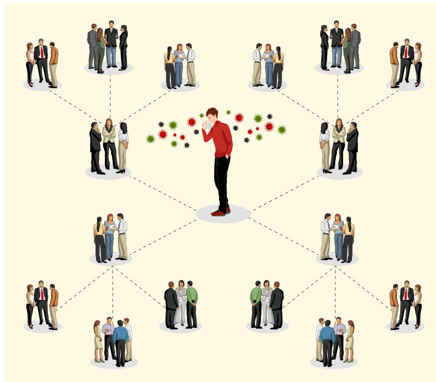
Round one

4. In the first round, find another student and quietly tell each other your numbers.
5. Then, on your own, secretly multiply your two numbers together and record the product on the next line of your sheet. This will be your number for the next round. For example, if you have two and the other student has a three, your number will be 2 x 3 = **6**

Round two

6. Find another student, quietly exchange numbers.
7. On your own, secretly multiply your two numbers together and record the product on the next line of your sheet.

Continue to do this until your teacher, or activity leader ends the game.



Time to discuss

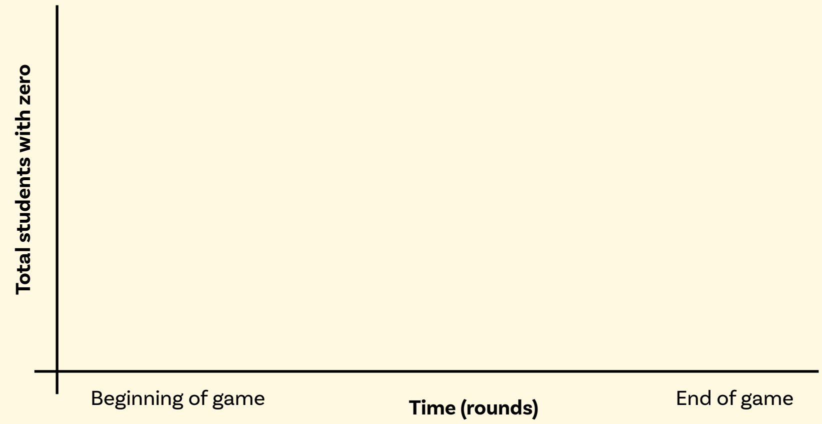
- What do you notice about the last number on your record sheet?
- How many people do you think started with this number?
- How does this game represent how an infection can spread?

As a group, investigate how the number of people carrying the virus, or with the number 'zero' grows.

Graphs are often used by scientists, engineers and anyone investigating infection rates as a way to show how an epidemic spreads through a populations and make future predictions. Can you show how the 'infection' has spread through your group on a graph?

Time to analyse

- What do the different stages of your graph represent?
- How is this simulation NOT realistic?
- What measures could be put in place to change how the game develops and whether all students become infected?

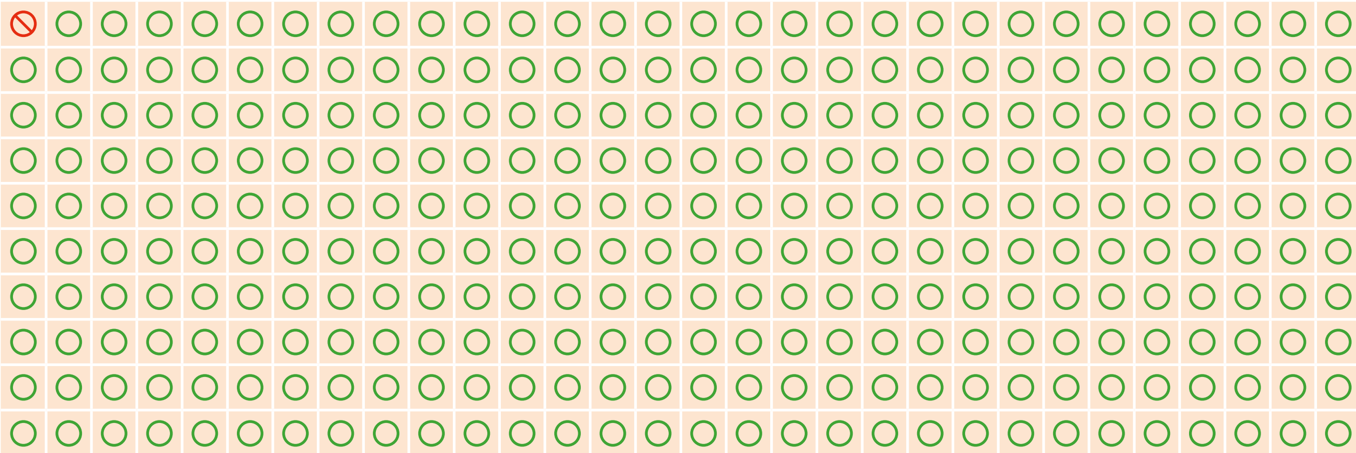


Round	Number of new infections	Total number of infections

VILLAGE OUTBREAK

In a small village of 300 people, one person is infected with a contagious virus, and anyone infected with the virus spreads it to one new person each week.

Using the table below, show how the infected and healthy populations change during the first 10 weeks of the outbreak.



Week	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Infected	1																				
Healthy	299																				

There are approximately 7.8 billion humans on Earth. If the virus spreads beyond the 300-person town, how long will it be until the entire global population is infected?

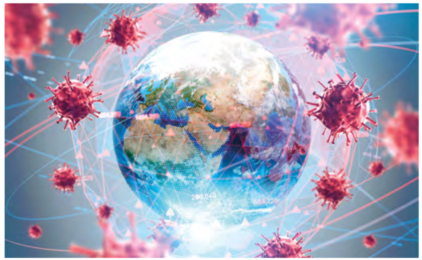
Some viruses are more contagious than others, instead of passing the virus to one new person, each infected person now passes it to three. How would the number of infected and healthy people change in a village of 400 people with this new variant? How long would it take for the global population to be infected?

Slow the spread

Many factors influence how a virus spreads. What measures could be put in place to slow the spread of a virus? Is this the same for all different types of virus (see **page 8** to find out about other viruses).

An extension of this activity can be found at [Mathalicous, Pandemic activity] where this activity has been adapted from.

NOTES



Spotlight

VACCINE FACTORY-IN-A-BOX

In order to control the COVID-19 pandemic with a vaccine, we need to vaccinate about 60% of the nearly 8 billion people on earth.

With current manufacturing capacity, we can make up to five billion vaccines every year, but at least 1.5 billion of these are set aside to tackle the flu.

A team of engineers at Kings College London have been working on a solution to enable vaccine manufacture at a large scale: a factory-in-a-box.

The factory-in-a-box minimises the space and equipment needed for making lots of vaccine doses. This means that they can make many RNA-based vaccines, one of the vaccines that is being developed to combat COVID-19, almost anywhere around the world, at a much faster pace than would otherwise be possible.

Find out more about the Factory-in-a-box by visiting the Google Museum of Engineering Innovation.

Time to discuss

Being efficient with space and being able to design and make things to fit smaller spaces is important for many reasons.

- **What reasons could there be for this is?**

Professor Harris Makatsoris from King's College London is developing a 'factory-in-a-box' that allows the rapid manufacture of synthetic RNA vaccines against the SARS-CoV-2 virus and minimises the space required for high-volume vaccine production.

Challenge four

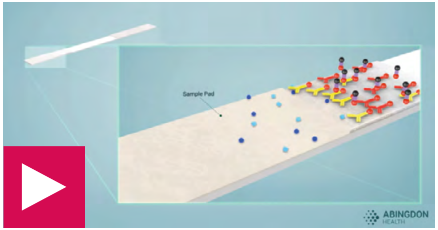
TESTING, TESTING, TESTING

Finding out if people have been infected or are infected with a virus or disease plays a critical role in a government's efforts to manage a pandemic and to work towards allowing people to continue with their lives as safely and as normal as possible.

During the COVID-19 pandemic, lateral flow tests were used across the UK. Lateral flow tests detect active infections and provide results in minutes. Antibody tests were also used to detect whether people had previously been infected, and results could be given in less than an hour.

Scientist and bioengineers use what they know about the make-up of SARS-CoV-2 to develop these tests. Both tests use **lateral flow assay** platforms.

This YouTube video from Abingdon Health shows how a lateral flow assay works.



Chromatography lab

Chromatography is a way to look at mixtures by separating them into their components. They are used in biochemical tests to identify different substances such as proteins.

These tests are also used to separate the components in inks. Different inks have different properties, which is shown by how they dissolve in solvents. When you place chromatography paper into the solvent, the solvent begins to move up the paper. As the solvent rises, it dissolves the ink on the paper and separates the ink into its components. The further the ink travels, the more it is attracted to the solvent.

Mini-glossary

Antibodies are produced by the immune system to identify and destroy harmful foreign substances (antigens), such as bacteria and viruses.

Materials

- Two strips of the chromatography paper
- Three different coloured felt tip pens or other washable ink (cyan, magenta, red, yellow and blue work well)
- Black ink pen
- One clear beaker
- Pencil
- Test holder

Time to investigate

- Take a thin strip of chromatography paper approximately the height of the beaker you are using.

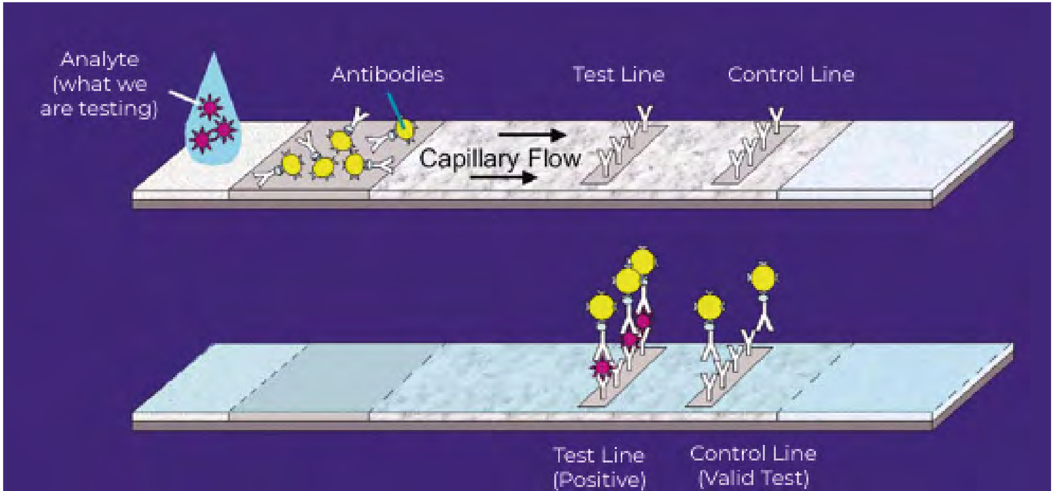


Image adapted from a NASA illustration of a lateral flow assay test.

- Using one coloured pen, mark a line or large dot at one end of your paper, approximately 1cm from the edge.
- Using two different coloured pens, draw a line/dot over your line/dot.
- Add a small amount of water to one beaker.
- Drop the chromatography paper into the beaker.

Watch what happens!

Time to discuss

- How do you know when the test is complete?
- What **solvent** is being used?
- Try this using just **primary colours**. What happens? Why do you think this is?
- What happens if you use black ink?
- What colours are present in black ink? What do you think these colours represent?
- You can try this test with other absorbent paper such as coffee filters.
- How does this affect the outcome?

Create a control line

To check that a lateral flow test has worked a control line is used.

The control line will change colour once the sample has passed through it.

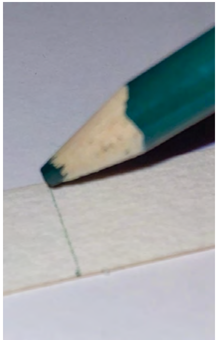
This is known as a **reactive zone**.

Create a simulation to show the control line works on a lateral flow test.

Materials to use

- Lateral flow test holder (in pack)
- Strip of chromatography paper to fit the test holder
- Ink to use as your sample
- Ink to use on your control line
- A pencil

Handy hint: graphite in pencils is not attracted to water.



Professor Zhanfeng Cui FREng and his team from the University of Oxford for the Oxford rapid viral RNA test for COVID-19. It can detect SARS-CoV-2 infection in 30 minutes and could be invaluable in developing countries because no specialist equipment is needed.

Challenge five

BLOCK THE WAY

Viruses do not move by themselves. They are carried. Coughs, sneezes, digestive waste, water, touch and biting insects can all carry and spread viruses.

Antibiotics do not work against viruses. Vaccination does. People who receive a vaccine protect themselves and others. Smallpox was ended by vaccination and other viruses such as influenza and measles are controlled through the use of vaccines.

When we get a virus, our body learns how to make antibodies to fight it and we start building immunity. Some vaccines imitate this process by using a weakened, dead, or part of a virus injected into our body so that our immune system can learn which antibodies to make to fight the virus without us getting sick. Every vaccine is different depending on the virus.

What about COVID-19?

As we are writing this activity, vaccines for COVID-19 had started to be rolled out. Each of the vaccines that are being developed work in slightly different ways.

Time to research

Investigate one of the vaccines that has been developed to protect against COVID-19. How does it work?

Time to vaccinate

You do not need to vaccinate a whole population in order to stop a future outbreak of a virus. If a certain proportion of the population has been vaccinated, the whole population can be protected. This is known as **herd immunity**.

- **Who might a government decide to prioritise when deciding how to vaccinate a population?**

Working individually, in pairs, or in small groups, you have been asked to control the spread of a virus within an unvaccinated population. The diagram on **page 26** shows a section of your 'population'. The person in the top left can infect people to the right and below. They can infect one person every three seconds.

Watch this YouTube video created by the Oxford VaccineGroup to find out more about how vaccines work.

Materials

- 5 x 8 grid handout
- Three different coloured counters
- Stopwatch

Using the 5 x 8 grid handouts (which can be found on **page 33** (support sheet one) and on the Engineering in a pandemic page on the resource hub), fill every space except for the top left corner with the same colour counter (for example blue).

Use a different coloured counter (for example green) for the space on the top left corner. The green counter represents someone carrying the virus.

Start a timer. Every three seconds, one new person becomes infected, either to the left, right, above or below an already infected person.

- **How long does it take for the whole population to be infected?**

A new vaccination has been developed and needs to be given out to the population to block the spread of the virus.

Swap ten of the blue (healthy) counters with a different colour (for example red).

The red counter will represent people who have had the vaccine. **They cannot catch or transmit the virus**.

Randomly place the red and blue counters on the grid.

Start the timer again with one infected person in the top left corner who will infect one person every three seconds.

- How long does it now take for the whole population to be carrying the virus?

This time, use 30 red and 10 blue counters. Randomly place the counters on the gird.

- How long does it now take for the whole unvaccinated population to be infected?

Time to discuss

What else do we need to think about when putting together a vaccination strategy?

This challenge has been adapted from British Society for Immunology 'Going Viral' activity pack.

Spotlight

TECH4PANDEMICS

The COVID-19 pandemic has affected people all over the world.

How has technology been used to help us manage and overcome the virus?

How could technology be used to avoid future pandemics having such an impact on our lives?

Technology plays a key role during pandemics. Technology can help us to:

- control the spread of viruses
- detect people who have the virus
- treat people who are unwell
- monitor the spread and effect of a virus
- allow people to continue learning, working and communicating safely.

Tech during COVID-19

More than 90% of countries around the world implemented some sort of remote/online learning for school children during 2020.

Over 1.5 billion children relied on some form of technology to stay in contact with their teachers. Unfortunately, at least a third of the world's school children didn't have access to technology and were unable to complete their remote learning.

The pandemic triggered changes in online shopping behaviours that are likely to have lasting effects. In order to meet the growing demands of delivery services, and to continue to keep people safe, contactless delivery methods are being developed, such as using robots for deliveries.

3D printing technology was used to manage the huge increase in demand for personal protective equipment, as it offers flexibility in production: the same printer can produce different products.

© David Philogene / Shutterstock.com

https://www.acs-schools.com/hillingdon/acs-international-schools-designs-new-3d-printed-parts-convert-snorkels-emergency

Challenge six

WEIRD AND WONDERFUL FACE MASKS

More than 50 countries asked people to cover their faces when leaving their homes in 2020 to try and slow the spread of COVID-19.

Face coverings and masks came in all shapes and sizes and many people and companies used their creativity to design and produce different types of face coverings.

We challenge you to design an innovative face mask with additional tech features to help control the spread of future viruses.

Things to consider in your design:

- How is the tech in your mask used to keep the wearer safe? Check out this example on Design Boom about masks that use heat to kill the virus.
- How will you make the design of your mask appealing and stand out from others? Check out this example on Design Book of a mask with sunglasses build in.
- Could your mask be multi purpose? Check out this example on Design Boom of a mask that gives the wearer privacy, but can also reflect their mood.
- How sustainable is the design of your mask? Check out this example on Design Boom of a biodegradable face mask.
- Why will people choose your mask over others?

Go to page 34 for a face template (support sheet two) to use for this challenge.

Challenge seven

RESPIRATOR CHALLENGE

A team at the University of Southampton developed a personal respirator for local healthcare workers, PeRSo.

Hospital staff treating an influx of patients with COVID-19 were, at the beginning of the crisis, concerned about risk of infection due to shortages of personal protective equipment (PPE).

To keep them safe, engineers at the University of Southampton created PeRSo (the Personal Respirator Southampton), trialling devices on the wards of its local hospital within 10 weeks.

The respirator is designed to deliver a much higher level of protection than surgical masks and can be worn for a full 12-hour shift.

Find out more about PeRSo in the President's Special Awards for Pandemic Service, on the Royal Academy of Engineering's website.

The PeRSo works using a powered air purifying system. Air can be purified using filters.

However different types of filters will be more effective than others as acting as a barrier to stopping particles moving in and out.

Challenge

Air filters are used to block unwanted particles from travelling through, but they must still allow air through to make it comfortable for a user to breathe.

Design and make a device that will test the level of airflow through different materials.

Time to test

After engineers have created a product, they have to **test** it out. Tests are often carried out on models of a product, or

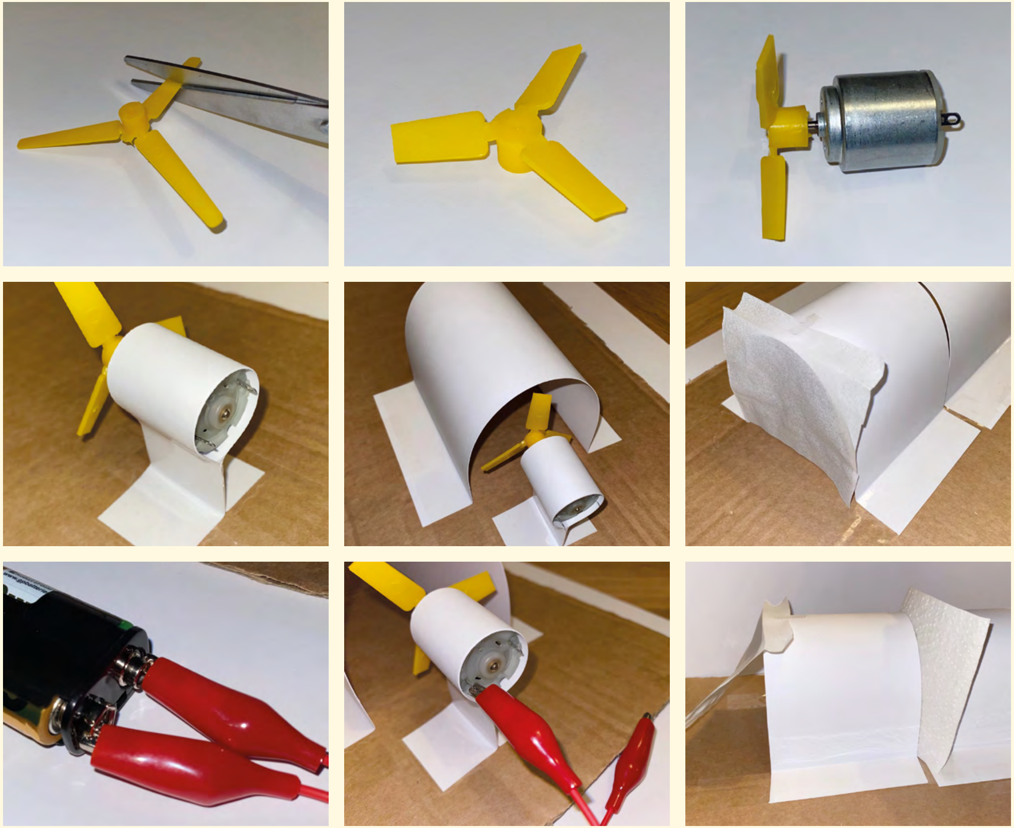
a specific part of a product that might need **improving** (remember those engineering habits!).

Test different materials to discover which one you think would be the most effective as a filter to purify air, but not block all air flow.

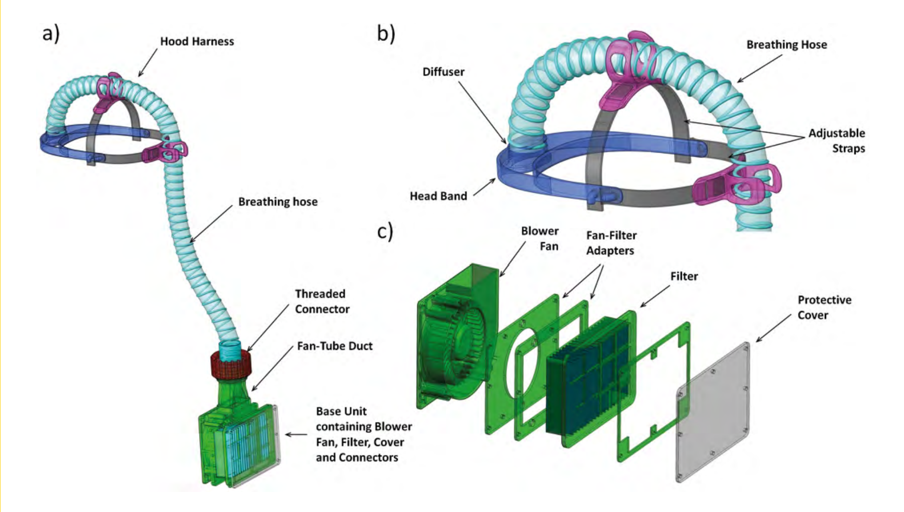
You will need to make a device to test your different materials.

Materials

- Shoebox, circular tube or card that you can roll into a tube.
- Selection of materials to test. For example:
  - Kitchen roll/tissue
  - Cotton
  - Muslin cloth
  - Tissue paper
- Adhesive tape
- Motor (in the pack)
- Fan blades (in the pack)
- Battery pack (in the pack)
- Crocodile clips (in the pack)
- 2 x AA Batteries
- Card



1. Build a testing device that has an opening at two ends.
2. Build a stand to hold your fan.
3. Stick a piece of aluminium foil or tissue paper at the open end. This is to show you that there is airflow.
4. Create a filter slot using card, tape and anything else you think might be useful. This slot will need to secure the filter material that you will be testing in place, but also allow you to swap the different filters in and out.
5. Secure the material you are testing in the filter slot.
6. **Test the airflow of the material**. Turn on the fan. Does the aluminium foil or tissue paper move with the airflow through your filter?



The second prototype for the PeRSo was presented to University Hospital and pilot testing led to further modifications © University of Southampton

Find out more about their work in the *Ingenia* article, Responding to a global pandemic.

Image of your testing device

Materials you are testing

1. ....
2. ....
3. ....
4. ....

What will make a good filter? What are you looking for?

....

....

....

....

....

From your testing, which material do you think would make the best air filter? Why?

....

....

....

....

....

Support sheet one

BLOCK THE WAY GRID

Use three different coloured counters to represent:

- Infected people
- Healthy people
- People who have received a vaccine

Go to page 25 to find this challenge.

Support sheet two

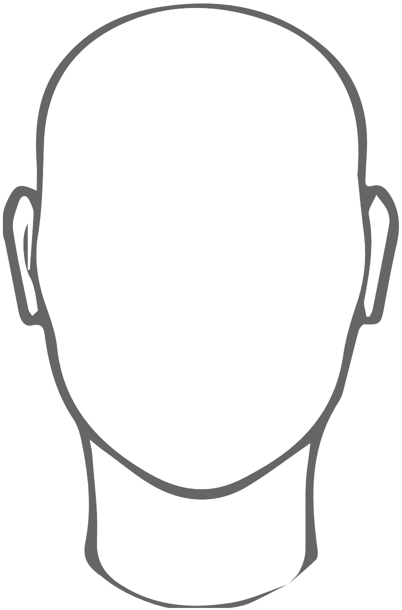
FACE MASKS TEMPLATE

- **Draw** a front view and side view of your mask so that we can see your design in detail.
- **Label** your mask to explain how the tech works.

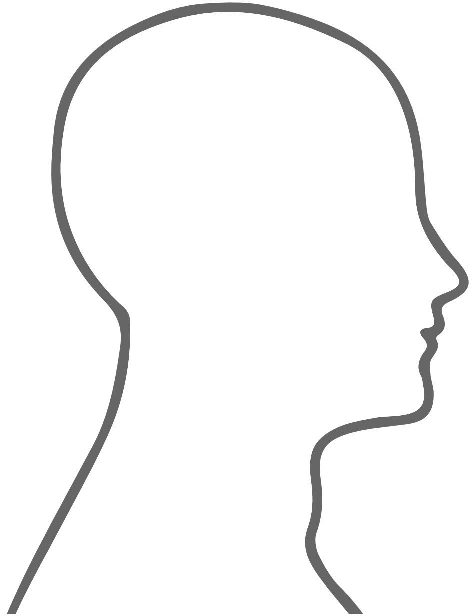
If you would like feedback on your mask design then please email them to uk_techshecan@pwc.com.

To find out more about careers in technology visit https://techwecan.org/tech-tuesdays/ to watch the Tech for Pandemic lesson and many more.

Front view



Side view



Go to page 28 to find this challenge.

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Together we're working to tackle the greatest challenges of our age.

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