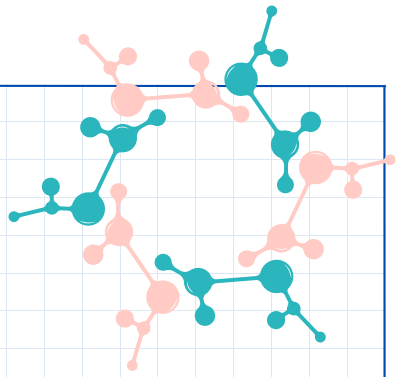
WE DISCOVER, WE GROW
Girlguiding
North West England

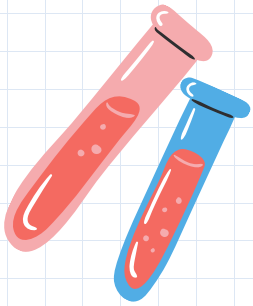
BAE SYSTEMS

CLEVER COGS CHALLENGE

ON THE MEND

CONTENTS





INTRODUCTION

This challenge is an extension of the popular Clever Cogs Engineering Challenge, which is part of the BAE Systems and Girlguiding North West England Partnership and is themed around Biomedical Engineering. Biomedical Engineering is a type of engineering which solves problems in a medical environment. Biomedical Engineers use their technological background and problem-solving skills to improve or invent medical technology to make people better when they get sick or help people who have an impairment.

This Clever Cogs Challenge is a little shorter than the previous packs; you should be able to complete this challenge pack in one or two unit meetings.

Each activity will give you a taste of a different kind of engineering that you might find within the field of biomedical engineering. After each activity you'll read about some incredible female engineers who have achieved something amazing in their field!

We'd love to see your creations! Ask your leader for some help taking some photos as you complete the activities and share them on social media using the hashtags #CleverCogs and #GGNWE. Make sure you gain permission of anyone in your photos before posting!

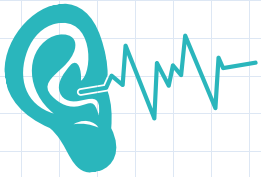
This is a fun badge, not a qualification, therefore a flexible approach is required. As long as you have taken a full and active part in the challenge, then you should receive your badge.

Badges can be ordered by visiting the region shop at https://shop.girlguidingnwe.org.uk/

LOOK OUT!

This activity is all about eyes and ears, and how engineers have developed solutions to allow people with sight or hearing impairments to see and hear better. The activity will teach you about how light can be bent and how sound is amplified (made louder). The experiments will let you try this out for yourself to see how it works, and understand how engineers have contributed to the development of glasses and hearing aids as we know them today.

HEARING



EQUIPMENT:

- Piece of card per pair
- Sticky tape
- A device to play music (a mobile phone would be fine!)
- Measuring tape
- Pens and paper to record results

DID YOU KNOW?

AS YOU GET OLDER, YOU STOP BEING ABLE TO HEAR VERY HIGH-PITCH SOUNDS. IF YOU PLAY A VERY HIGH-PITCH SOUND, THE ADULTS PROBABLY WON'T BE ABLE TO HEAR IT! THIS IS BECAUSE AS WE DO GET OLDER, THE TINY HAIRS INSIDE OUR EARS GET WORN DOWN AND THIS AFFECTS OUR ABILITY TO HEAR SOME SOUNDS (ESPECIALLY AT VERY HIGH FREQUENCIES).

METHOD:

Estimated Time: 20 Minutes

- Roll up a piece of card, starting with one of the corners, so that you form a cone shape.
- Make sure you leave a small opening at the narrow end for you to hear through.
- Tape it to keep it together. This is your “trumpet hearing aid”.
- Now position a phone/speaker somewhere in your meeting place, and measure out 3 different distances (1m, 2m, 3m for example) from the music source with your measuring tape. Mark the 3 points out on the floor so you know roughly where to stand.
- Play some music and stand at the first marker (closest to the music). How well can you hear the music? Now put your cone to your ear. Can you hear the music any louder?
- Next, step back to the next marker and repeat the above. Can you notice a difference in the volume of the music when you put the cone to your ear?
- Repeat this again for the third marker and then note down your results. If you find you can’t tell the difference, try turning the music down and repeating the experiment. If the music is too loud to start with, you will struggle to notice a difference as you move away from the music.
- Ideally, you want to be able to barely hear the music on you furthest away marker (without the cone).

Q1: What difference did you notice in the sound with or without the cone?
Q2: Why do you think this is?
Q3: What do you know about how modern hearing aids work?
Q4: How have engineers been involved in developing hearing aids?

TAKE IT FURTHER:

Why not do some more research about trumpet hearing aids and how they have been developed into hearing aids that we have today.

HOW THIS RELATES TO ENGINEERING:

When people with hearing loss first started using hearing aids, they used animal horns placed to their ears, which improved hearing. Eventually, the ear trumpet was invented which is similar to what you have created today. Ear trumpets worked by collecting sound from a bigger area and channelling it into the ear canal. The idea of electronic hearing aids was introduced when the telephone was invented, and since then, has gradually been developed by engineers to become what we have today. Hearing aids today are very clever; they can be programmed to different environments and linked to other electric devices (such as phones, laptops etc.). Engineers are still working to improve hearing aids; mainly they are looking at improving directionality, which means that people with hearing loss would be better able to tell which direction a sound is coming from.

EYES

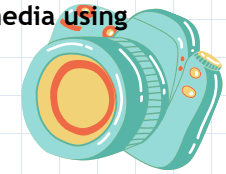
EQUIPMENT:

- 5 x pipe cleaners per girl
- Pens and paper to record research

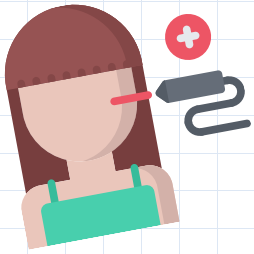
METHOD:

Estimated time: 10 minutes

- Take a pipe cleaner and make it into a circle, attach the two ends together by overlapping them slightly and twisting them together. Do this with 2 pipe cleaners so that you have 2 circles.
- Attach your two circles together using a third pipe cleaner - this is the nosepiece of your glasses. You might want to fold your pipe cleaner in half first and twist it together to shorten its length.
- Now attach a pipe cleaner to each circle, opposite to where you've just attached the two circles together - these are legs for your glasses. Bend the end of each pipe cleaner at the ends so that they will fit nice and snug around your ears.
- Try your new glasses on! You can adjust the fit of them by bending the pipe cleaners into place.
- Once you are happy with your glasses, ask your leader to take a picture and share it on social media using #CleverCogs and #GGNWE



Q1: Why do you think some people need to wear glasses?
Q2: How do glasses make it easier for people to see?
Q3: What's the difference between long-sighted and short-sighted?
Q4: How have engineers been involved in developing glasses?



TAKE IT FURTHER:

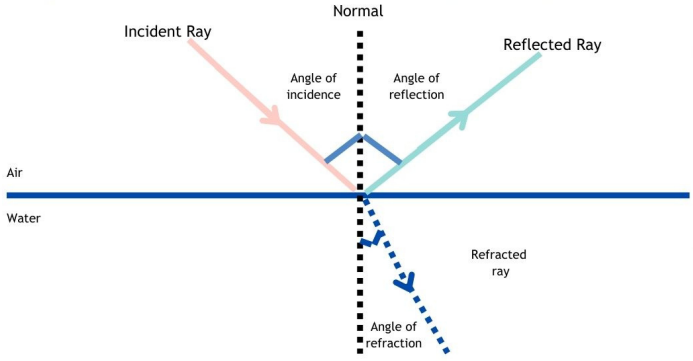
Why not do some research about how laser eye surgery works?

HOW THIS RELATES TO ENGINEERING:

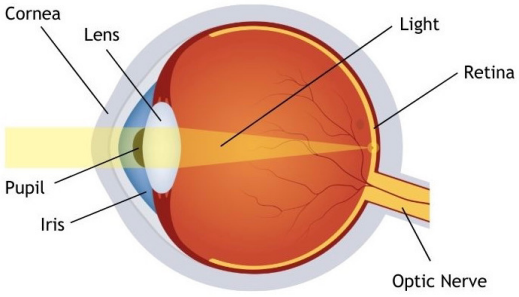
Reflection is when light changes direction by bouncing off a surface (like a mirror). Refraction is when light changes direction as it passes through a surface (like glass). The diagram on the next page shows how this works. When people's vision is blurry, it means that either the light coming into the eye is focussed just in front of the retina, or the light is focussed just behind the retina. One is called 'short-sighted' and one is called 'long-sighted'.

To help people to see better, light coming into the eye needs to be bent so that it focusses properly on the retina. Eye glasses have different lenses in them to bend the light according to how much the person needs it. Diagram 1. below shows how light is bent by eye glasses.

1.



2.

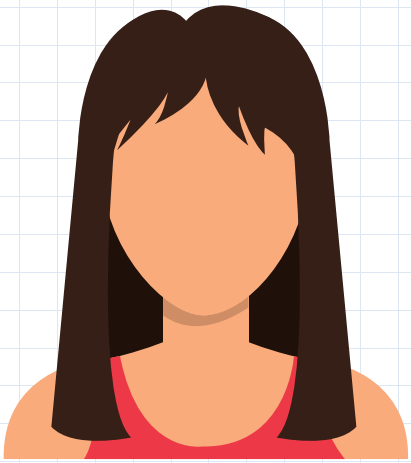


The kind of engineers who would be involved in developing eye glasses and the technology around vision are called Optical Engineers. Optical Engineers work in laser eye technology, telescopes and optical systems for developing cameras and lenses.

Laser eye surgery works by using lasers to reshape the cornea of the eye (labelled in diagram 2. above) to refract the light correctly to the retina. This means that the people no longer need to wear glasses to correct their vision.

INSPIRING FEMALE ENGINEER: INGEBORG HOCHMAIR-DESOYER

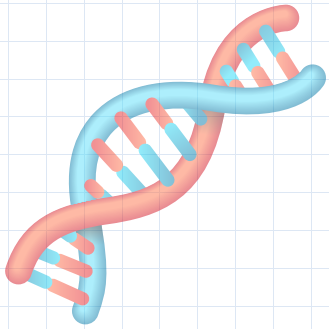
Ingeborg Hochmair-Desoyer is an electrical engineer, originally from Vienna, Austria. She grew up with a very inspiring family - her grandmother was one of the very first female chemical engineers in Austria; her mother was a physicist; and her father was the Dean of Mechanical Engineering at the Vienna University of Technology.
In the 1970s, Ingeborg and her husband developed the world's first electronics cochlear implant (internal hearing aid). This cochlear impact was able to allow the user to hear sounds and also understand some speech.
Ingeborg achieved "Venia Legendi" (which is a qualification allowing her to teach in Austria) in Biomedical Engineering. In the early 1980s, Ingeborg partnered up with her husband, Erwin, to co-found a medical device company. She has since developed many inventions for people who suffer from hearing loss.



SPILL THE GENES!

With this activity you will create a DNA helix out of sweets. The activity will teach you about DNA and how engineers are involved in gene-mapping. You can also go into a basic activity around dominant and recessive genes (like why a baby might have brown or blue eyes based on parents)

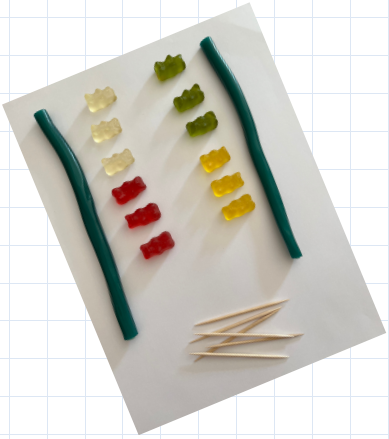
EQUIPMENT:



- Thick strawberry laces or pencils
- 12 x small soft sweets (ie jelly tots, midget gems or gummy bears) 3 of each colour
- 6 x cocktails sticks
- Print out of appendix A (punnet squares) for Guides & Rangers only, they can work as pairs or small groups if needed

Estimated time: 10-30 minutes

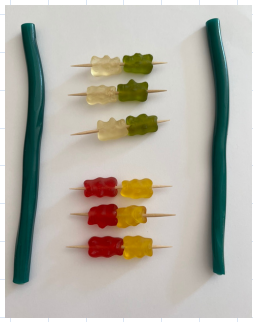
METHOD:

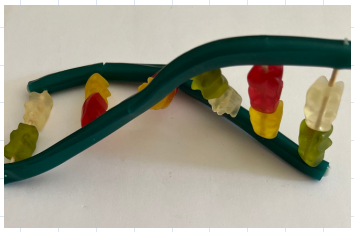


- Collect your sweets and lay them out in front of you - you should have two laces, six cocktail sticks, and 12 small sweets. Split out your small sweets into four different colours (you should have 3 of each colour).
- DNA is made up of four different chemicals - adenine; guanine; thymine; and cytosine. We will be representing these chemicals with the different coloured sweets. Pick a colour of sweet to represent each of these chemicals (they don't have to be the same for everyone, just as long as you are consistent). For example:
  a. Yellow = Adenine (A)
  b. Clear = Guanine (G)
  a. Red = Thymine (T)
  b. Green = Cytosine (C)
- The chemicals listed above pair up with each other in specific ways. A pairs up with T, and C pairs up with G. So by using the colours given in the example above, we will be pairing the green sweets with the yellow sweets, and the red sweets with the clear sweets. Use your cocktail sticks to pair your sweets up.
- Put a sweet which represents A on the cocktail stick with a sweet which represents T.
- Put a sweet which represents G on the cocktail stick with a sweet which represents C.
- Do this for all of your sweets. You should end up with 6 cocktail sticks, each with 2 sweets on each.

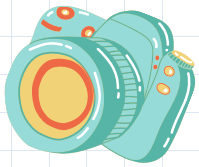
(remember your colours might be different - this is okay as long as you are pairing them up correctly!).

- Remember it's important to match up the right sweets - A can only be paired with T, and G can only be paired with C. These can't be paired in any other way! For real DNA in your body, the chemicals aren't coloured like this, and they are much, much smaller. Your real DNA in your body has about 3 billion pairs - today we are only modelling a very small part of it!
- To create your DNA model, lay your two laces out, with your cocktail sticks in between, so that it looks a bit like a ladder. Now you need to attach the cocktail sticks to the laces. You can choose which order to put your cocktail sticks in - this determines your DNA's sequence.



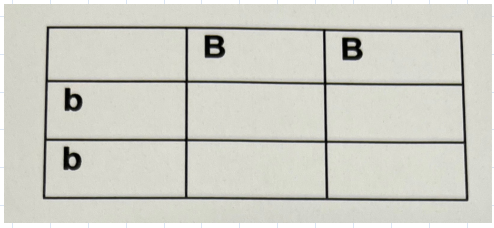


- Now that your DNA is assembled, you need to twist it, because in real life your DNA is called a double helix - see 'How This Relates to Engineering' for more information on this!
- Once you are happy with your creation, ask your leader to take a picture of your DNA helix and share it on social media using #CleverCogs and #GGNWE.



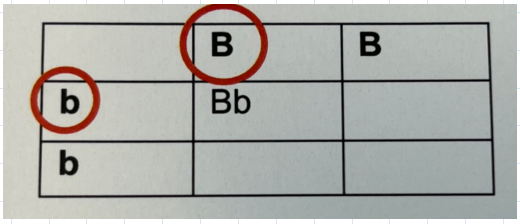
Take it Further:

Now that you've created the DNA helix, have a look at the punnett square examples in Appendix A, which you can print off. A punnett square is a tool that scientists can use to predict certain characteristics of babies. In this example we'll use the letter 'B' to represent the eye colour gene. The capital letter B means it is a dominant gene, and the lowercase 'b' means it is a recessive gene. If we use eye colour as an example, B represents brown and b represents blue. In this example, both parents have 2 genes each. So, the combinations of the genes could be BB, Bb, or bb. Anytime that capital B is there (which is brown), the overall eye colour will be brown because it is the dominant gene and therefore overrules the small b (for blue). So a parent with BB or Bb genes will have brown eyes, and a parent with bb genes will have blue eyes. For our punnett square example, one parent has brown eyes, 'BB', and one parent has blue eyes, 'bb'.



	B	B
b		
b		

To fill in the punnett square, we combine the gene in the row with the corresponding gene in that column as detailed here;



	B	B
b	Bb	
b		

So your completed punnett square will look like this

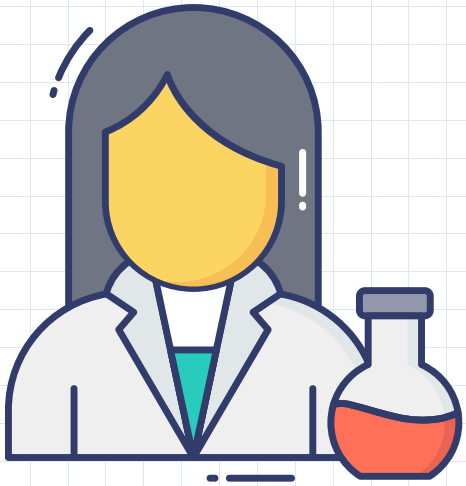
	B	B
b	Bb	Bb
b	Bb	Bb

This is telling us that all combinations of the parents' genes will end up with any baby that they have having brown eyes (because the big B is dominant over the little b). Let's do another example and see if you can fill it out by yourself (print-out version in Appendix A). In this punnett square, one parent has brown eyes and one parent has blue eyes, but this time the parent with brown eyes has the 'Bb' gene (see how the top row is different?). Try and fill this one out yourself and see what outcome you get. Can you predict what colour eyes the babies might have in this family? See if you can fill out the other punnett squares from the print-out too!

HOW THIS RELATES TO ENGINEERING:

Genetic Engineering is a related field within Biomedical Engineering, and involves working with genes and DNA. These kinds of engineers can be involved in changing the genetic structure of living things to give it different characteristics. For example, changing the genetic structure of farmers' crops - perhaps they want to try and make some types of crops bigger or more resistant to the cold. Genetic Engineering can also be used to improve different types of medicine, and to cure some genetic diseases.

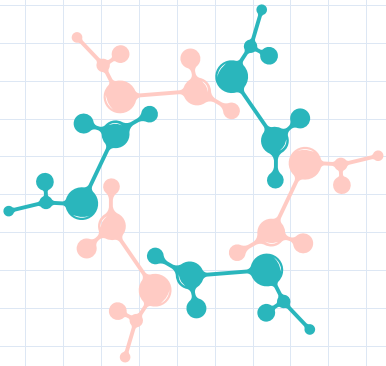
INSPIRING FEMALE ENGINEER: ROSALIND FRANKLIN



Rosalind Franklin was from London, England, and was a chemist. She had various degrees, including one in Natural Sciences and one in Physical Chemistry. She later went on to study a PhD with Cambridge University. The work she did was fundamental to how we understand the structure of DNA today.

Rosalind is best known for her work in X-Ray diffraction of DNA, which led to her contribution to discovering the DNA double helix, like the one you've made today with your sweets!

Later in her career, Rosalind worked on the molecular structure of viruses, and was due to present this work in Brussels. One of her team members continued with the research she was doing and ended up winning the Nobel Prize in Chemistry in 1982.

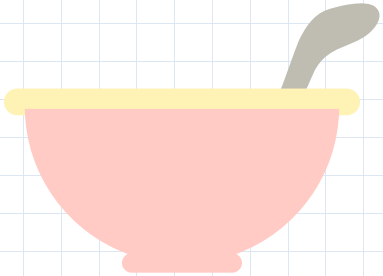


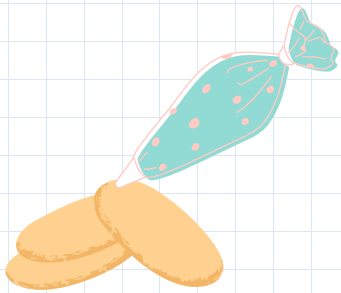
BUILD-A-BISCUIT

The possibilities of 3D printing are endless! In this activity you will learn more about how 3D printing works whilst creating a tasty treat. Using 3D printing in a biomedical setting is relatively new, but it's something that lots of scientists and doctors are very excited about. Traditionally 3D printers use very fine lines of plastic or other building materials to create complex structures. Lots of experiments are now going on, however, to see whether we can use human tissue as the building material, rather than plastic. Human tissue is mostly made up of cells, held together by tiny structures called polymers and cross-links.

EQUIPMENT:

- Plain Biscuits e.g. digestives
- Icing Piping Bags
- Icing Sugar
- Water
- Food Colouring
- Spoon
- Bowls
- Scissors



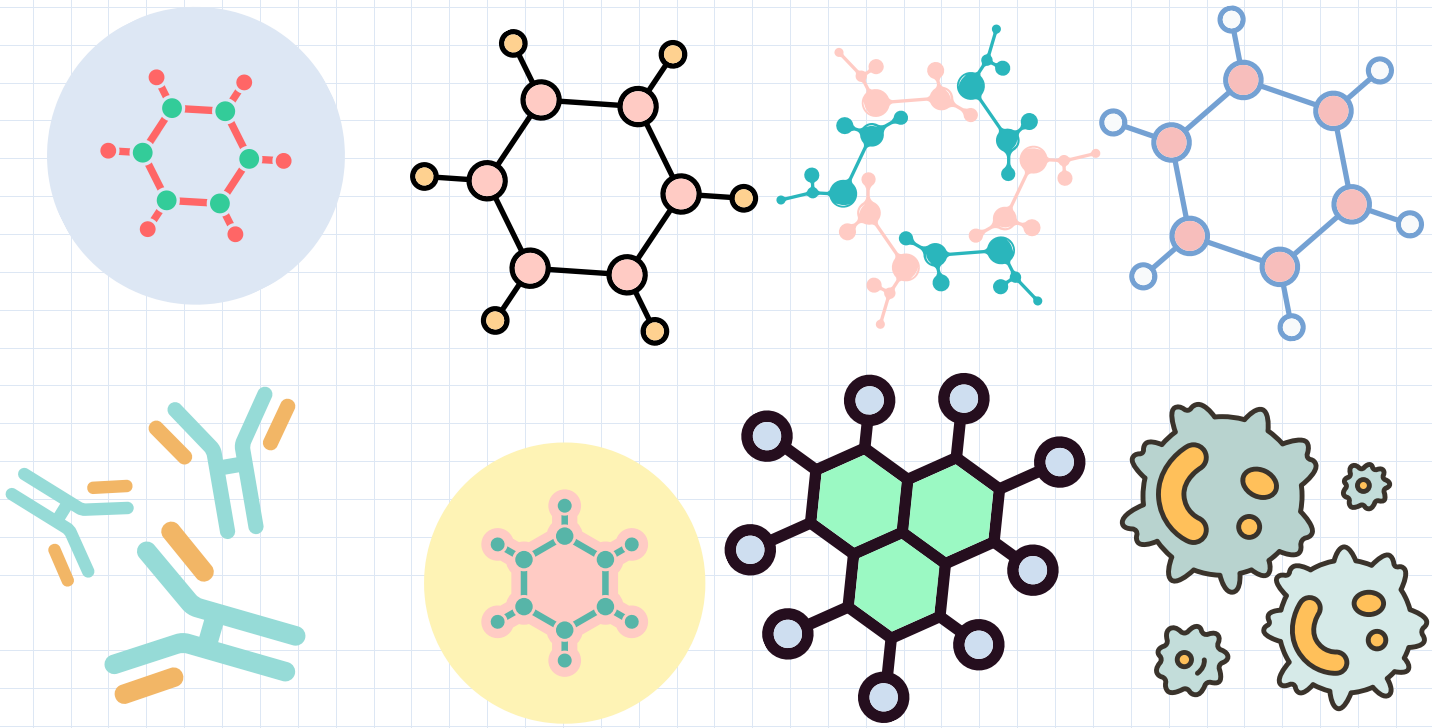


Estimated Time: 30 Minutes

METHOD:

- Before you start this activity, it would be useful to see a 3D printer in action, if this isn't something you are already familiar with. Ask your leader if they can help you to find a video online showing a 3D printer at work!
- Prepare your icing following the instructions on the back of the icing sugar packet. Generally, you will only need to add a very small amount of water to your icing sugar, so be carefully not to put too much in at once!
- Your icing should be thick and not too runny. Once you are happy with the consistency of your icing, split it into the bowls and add a few drops of different food colouring to each bowl.
- Choose which colour icing you would like to start with and spoon the icing into the piping bag; pushing it down so that it is sitting in the point of the bag.
- Cut the tip of the point off your piping bag. You only want to make a very small opening, so that you can produce a thin line of icing. If you cut too much off the end of your piping bag you will end up with an icing blob!

- Now you're ready to start icing your biscuits! The way that 3D printers work is by building up layers of material to create a 3D construction. When 3D printing human tissue, this material is a mix of cells, polymers and cross links.
- Take a look at the diagram below for some inspiration on what these could look like!



- Using your icing, start to build up cells, polymers and cross-links on the surface of your biscuit. Remember the aim is to get lots and lots of layers so that it looks like your icing has been built by a 3D printing machine.
- Once you are happy with your creation, ask your leader to take a picture of your biscuits and share it on social media using #CleverCogs and #GGNWE.

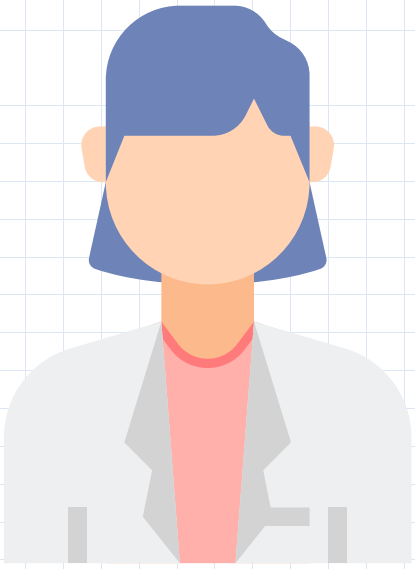
HOW THIS RELATES TO ENGINEERING:

Although you might not have been actually 3D printing your biscuits, the process of icing them is very similar to 3D printing. 3D printers use something called additive manufacturing, this means adding lots of tiny layers of material on top of each other to create a finished product. The limits of 3D printing are endless - and recently engineers and scientists have been exploring using 3D printing to create human tissue. This means the 3D printer would add lots of tiny layers of individual cells together to create something which could be used in a medical treatment, for example creating a new kidney for someone who is suffering with kidney failure.

INSPIRING FEMALE ENGINEER: WAI YEE YEOUNG

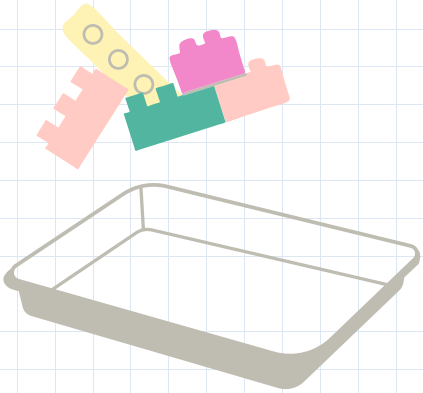
Wai Yee Yeong is the programme director at the Singapore Centre for 3D printing. She completed a PhD all about creating scaffolds for tissue manufacturing using 3D printing techniques. Wai Yee used her experience and qualifications as a mechanical engineer in order to achieve this. You can learn more about Wai Yee in this article by 'Women in 3D Printing' in which Wai Yee talks about the joy she gets from using her imagination to engineer new 3D printed solutions to problems.

https://womenin3dprinting.com/wai-yee-yeong-it-is-the-curiosity-to-see-the-limit-of-3d-printing-that-drives-me/

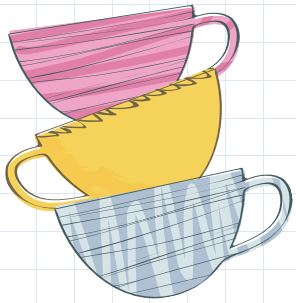


OH SUGAR!

Have you ever thought about why you get a sugar rush when you eat something really sweet?! In this activity you will learn more about how our bodies process sugar; what this can mean to someone with Type 1 diabetes; and what role engineers play in making day-to-day life easier for people managing medical conditions such as Type 1 diabetes. You'll have a go at creating a simple model of human tissue, with cells and something called interstatial fluid which surrounds the cells in our bodies. You'll then play a quick game to see how sugar moves through interstatial fluid at different concentrations, and think about how this creates an opportunity for engineers to design something called continuous glucose monitoring systems.



EQUIPMENT:

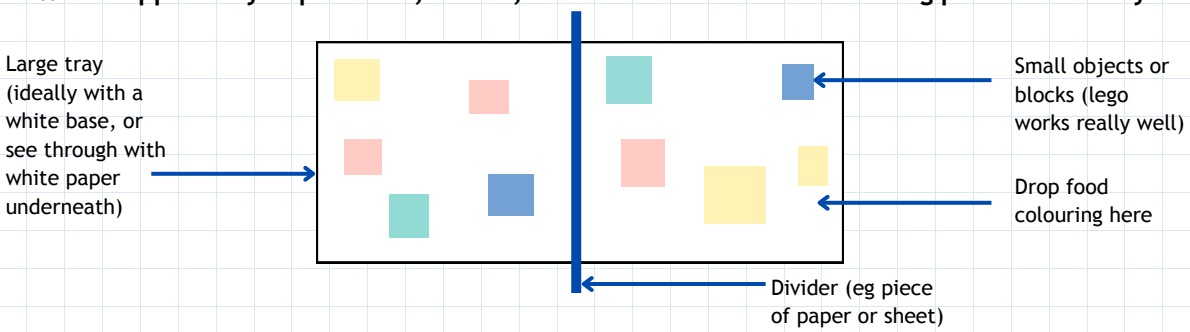


- Food colouring
- Sugar
- Water
- Cups/Bowls
- Blocks or small objects (e.g. lego bricks)
- Large tray with a white base or see through base
- Paper
- Pens
- Something to use as a divider, so that you can't see both sides of the tray at once. Depending on the size of your tray, this could be a piece of paper, a pillowcase, a sheet or anything else that works for you!
- A timer (you could use a watch or a phone)

METHOD:

Estimated Time: 10 Minutes

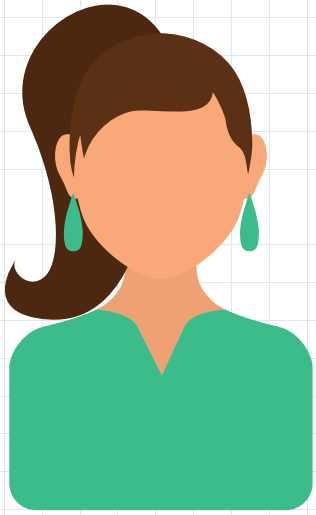
- Mix up three sugar solutions of different strengths in your cups/bowls.
- Add a few drops of food colouring to each solution, using a different colour for each strength of solution. For example, in the first cup you might add one teaspoon of sugar and a few drops of blue food colouring; the second cup you might add three teaspoons of sugar and red food colouring and so on.
- Lay the tray on a flat surface eg a table and fill with a shallow amount of water (a couple of centimetres should be fine).
- Place the objects or blocks in random places within the tray. These represent your cells. The water in the tray represents something called interstatial fluid.
- Put your divider in the middle of the tray, so that it blocks the line of sight from one side of the tray to the other.
- Split your group into 2 teams and have team 1 stand on one side of the divide, and team 2 stand on the other side. No peeking!
- On one side of the divider, team 1 should add a few droplets of one of the coloured sugar solutions. Start the timer when you put the droplets in.
- Team 2 need to keep a close eye on the water in the tray. As soon as you can see coloured water appearing past the divider shout out!
- Stop the stopwatch as soon as you hear them!
- Repeat the activity using the different strengths of sugar solution. Is there any difference between the solutions? What happens if you put more, or less, coloured solution in the starting point of the tray?



HOW THIS RELATES TO ENGINEERING:

Our body has lots of different ways to break down the food we eat into useful parts, often called 'molecules'. Our body can then use these molecules for lots of different jobs, for example as a source of energy. One type of molecule which we consume regularly is sugar, although in scientific terms this is usually called 'glucose' or 'fructose'. When we eat food containing sugar, our bodies break it down into molecules and it enters our bloodstream, and the fluid that sits between the cells in our body. People who have Type One Diabetes struggle to naturally regulate their body sugar. This can be dangerous, so they have to take a type of medication called 'insulin' to manage the amount of sugar in their bodies. This can interrupt their daily lives, as they have to regularly measure their blood sugar and inject themselves with the right amount of insulin. Engineers have been working on a solution to this though, there are now machines called 'continuous glucose monitors' which involve a tiny sensor being put under the skin of the person with diabetes. The sensor checks how much sugar is in the fluid between their cells and alerts them when this starts to get too low or too high (a bit like how you shouted out when you could see the sugar solution reach your side of the tray!). This can make the condition a lot easier to manage!

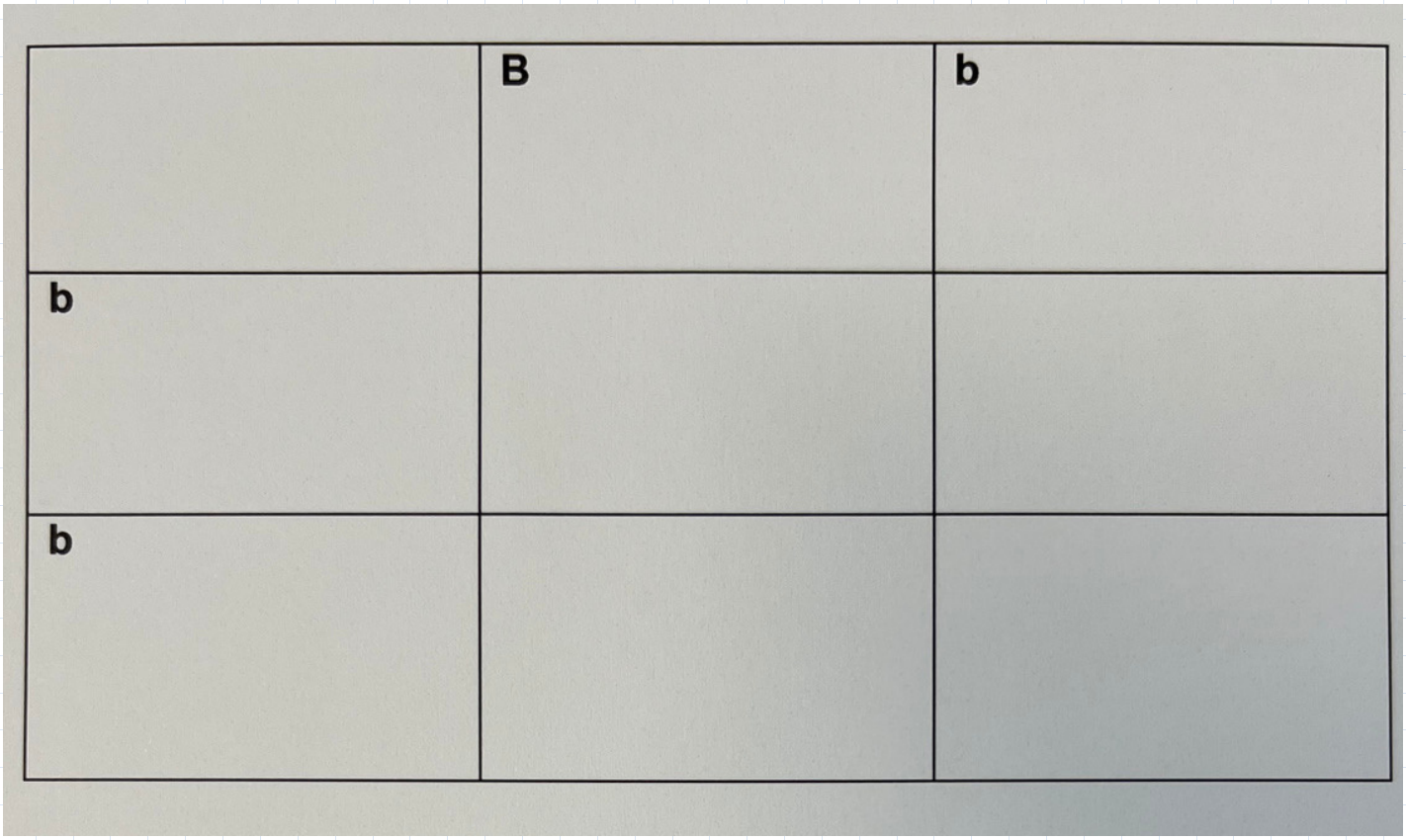
INSPIRING FEMALE ENGINEER: SIERRA SANDISON



Sierra Sandison is a Mechanical and Biomechanical engineer from the USA who also has type 1 diabetes. Sierra has an insulin pump to help her manage her condition, and takes part in beauty contests where she wears her insulin pump clipped to the side of her bikini. Sierra has achieved lots of amazing things in recent years, from biking across America to helping to spark a global hashtag where people could share pictures of their insulin pumps. Sierra has also talked about her passion in raising awareness of engineering and STEM topics amongst girls and young women.

You can read more about Sierra in this interview with HealthLine:
https://www.healthline.com/diabetesmine/sierra-sandison-diabetes-stem#Calling-out-diabetes-orgs

APPENDIX A - SPILL THE GENES



	B	b
b		
b		