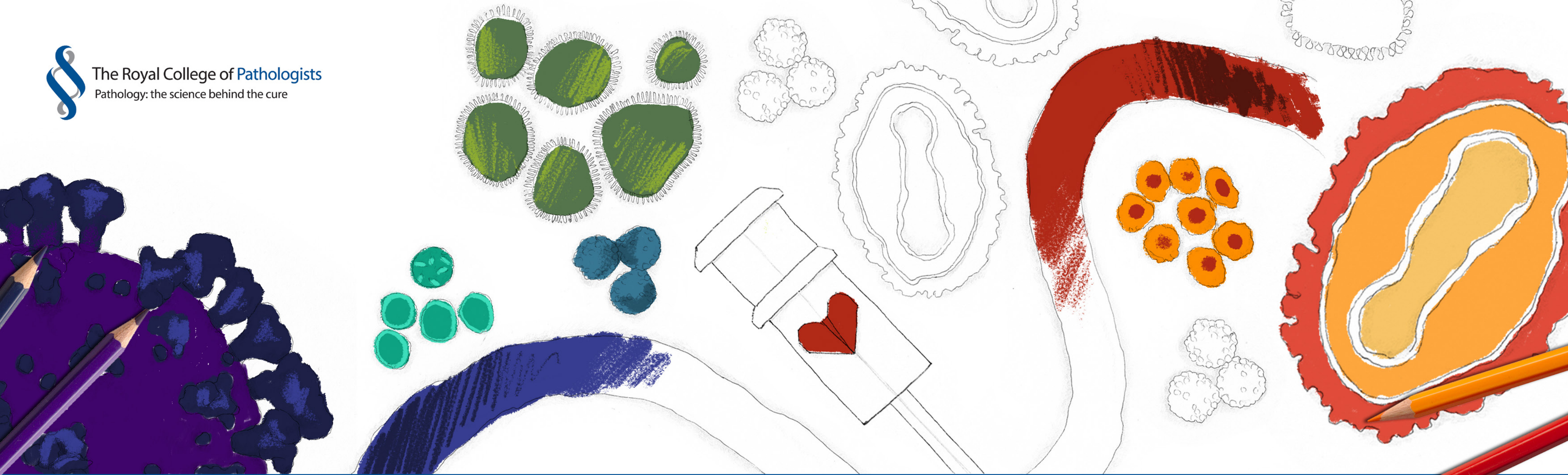
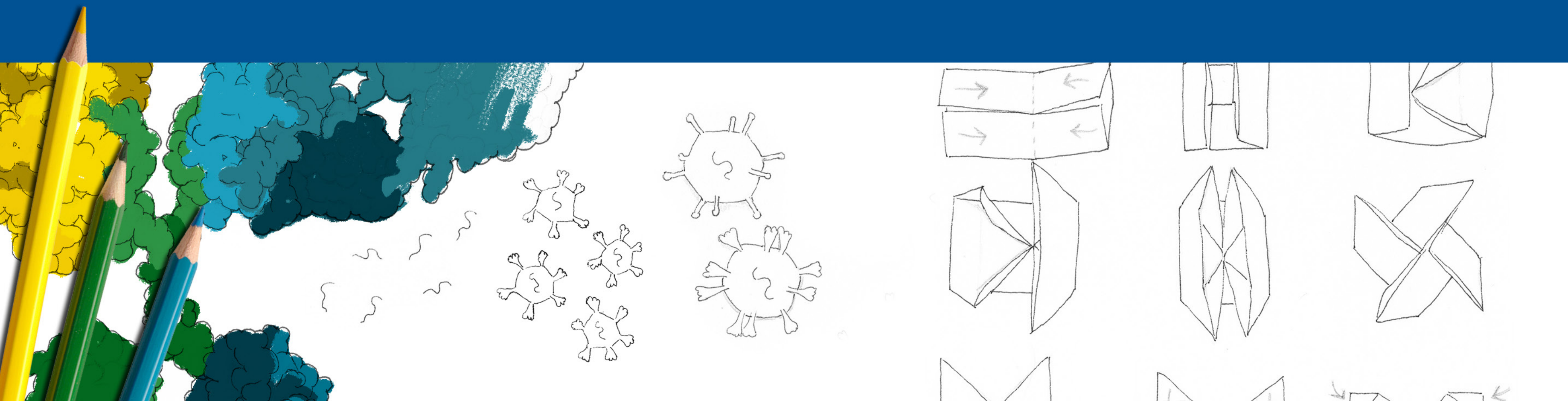
The Royal College of Pathologists
Pathology: the science behind the cure



Viruses and Vaccines



Viruses & Vaccines

Viruses and Vaccines

Our lives have been changed by one little virus. This collection of drawings and origami activities have been created to celebrate science, which brings hope that we can safely be with loved ones again. Science comes from our innate curiosity for wanting to understand ourselves and the world around us. Learning and creativity allow scientists to come up with practical ways to overcome real world problems we face, including the SARS-CoV-2 virus (which causes COVID-19).

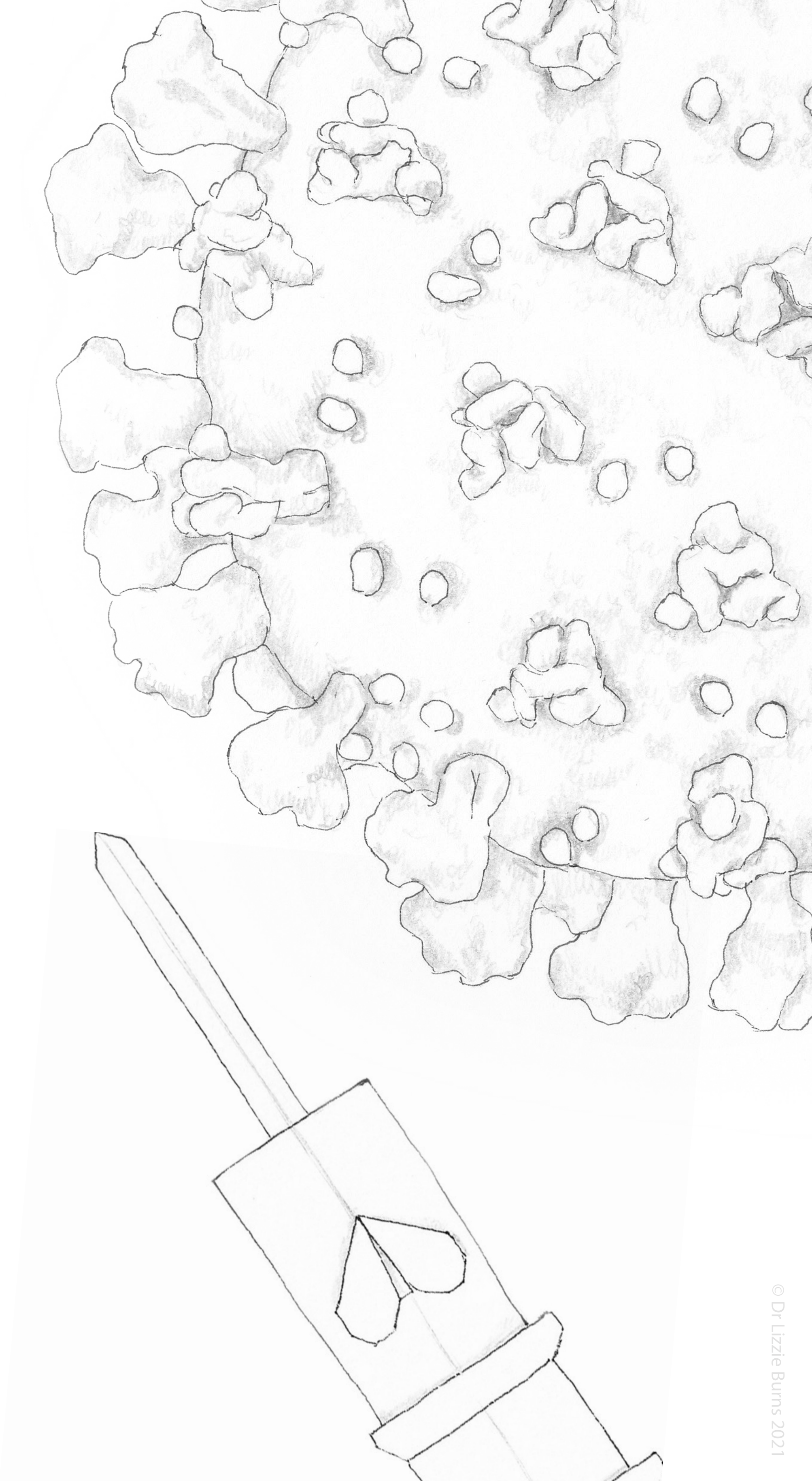
I hope this collection will get you marvelling at the surprising beauty of viruses, how they work and how our body responds to fight off disease. This resource is for all ages – join me and enjoy getting creative through colouring and folding while learning about science. If you haven't got a printer then create your own drawings or take a look at the scientific images which accompany this resource. No special paper is needed for origami; any paper will do. Follow along with me in videos where I will show you how to fold. You will soon find yourself folding viruses and vaccines, and making antibodies.

While we need to keep apart, we hope this creative resource can help you feel connected with others. Please share your creations using hashtag #VirusesAndVaccines.

This collection is dedicated to all those working in healthcare, and comes from the Royal College of Pathologists. Pathology is the study of disease. Pathologists are doctors and scientists who help diagnose disease and suggest the best treatments. Their aim is to help make people better. Thanks to scientists collaborating across the world, vaccines have been developed, with the chance to protect ourselves and each other. For many diseases this has not been possible, but researchers continue to try and develop vaccines to prevent infectious diseases. Find out how vaccines work, fold yourself a vaccine decoration and celebrate science. #OrigamiVaccine

Drawings and writing: scientist-turned-artist, Dr Lizzie Burns, in collaboration with the Royal College of Pathologists. Lizzie is also a member of the British Origami Society. For more folds: ***www.youtube.com/DrLizzieBurns***
Twitter: @DrLizzieBurns. These resources can be printed and used by anyone for educational purposes.

Each activity is accompanied by a video including conversations with pathologists.
Visit ***www.youtube.com/ilovepathology*** *and find the Viruses and Vaccines playlist.*



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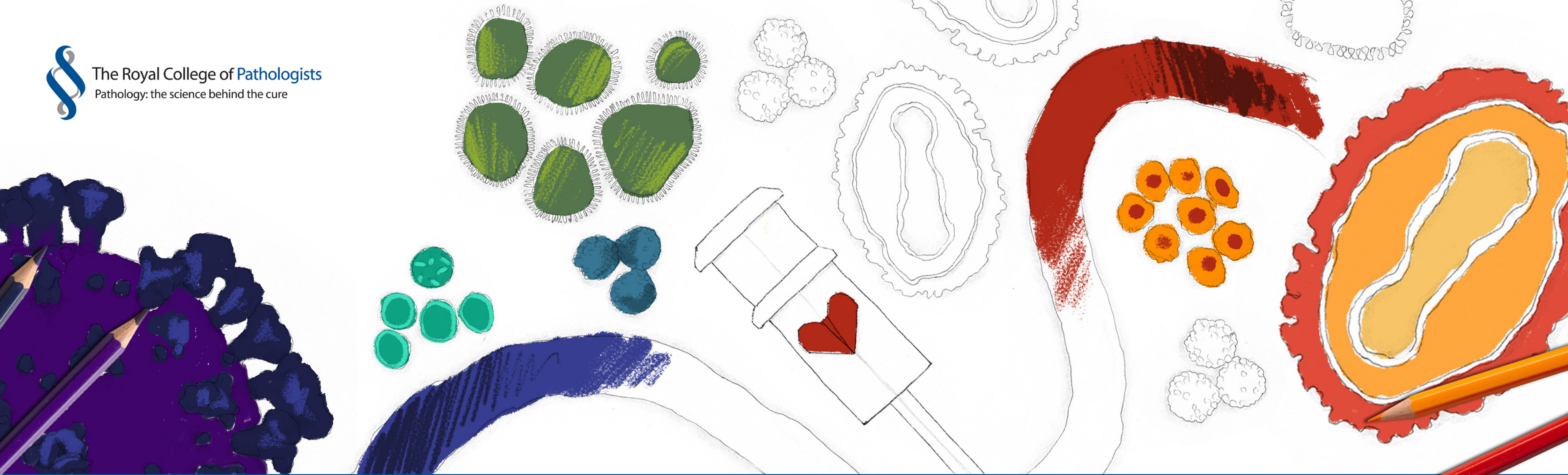
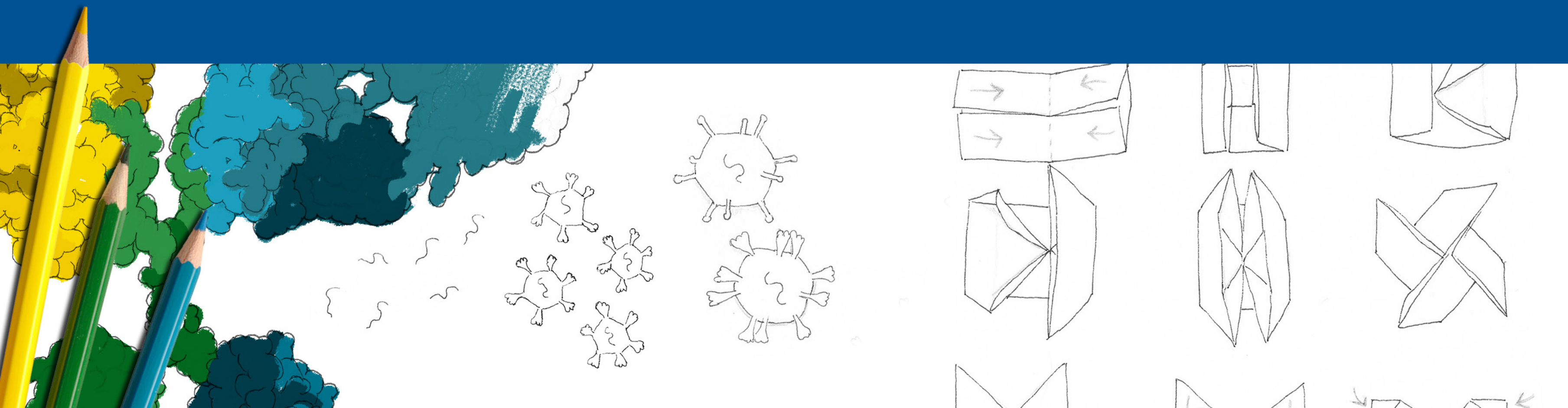
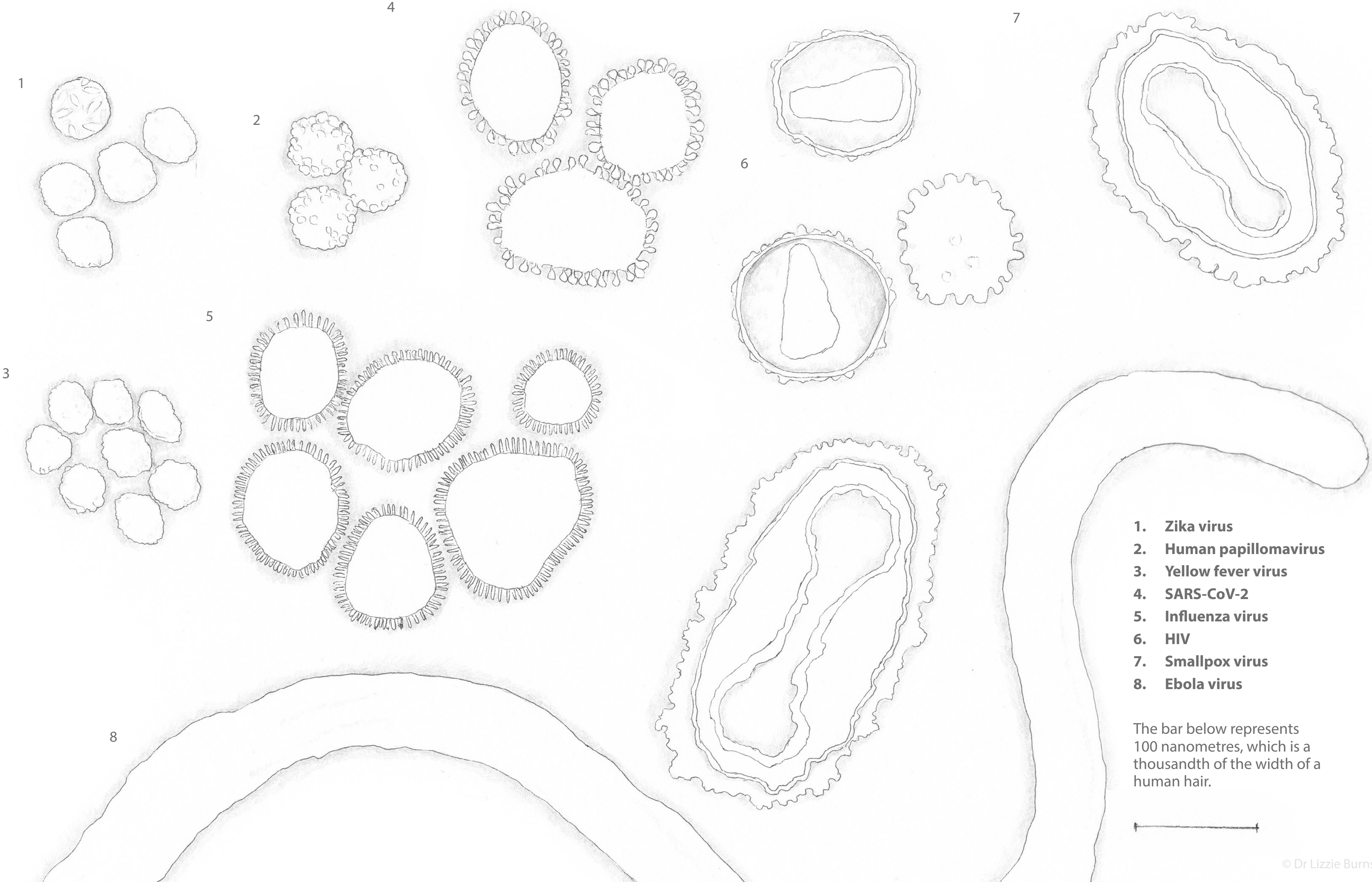


Virus collection



Viruses & Vaccines

Virus collection



1. **Zika virus**
2. **Human papillomavirus**
3. **Yellow fever virus**
4. **SARS-CoV-2**
5. **Influenza virus**
6. **HIV**
7. **Smallpox virus**
8. **Ebola virus**

The bar below represents 100 nanometres, which is a thousandth of the width of a human hair.

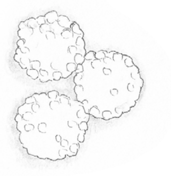
Zika virus

Caught: from mosquito bites

Where: South East Asia, Africa, Americas, Pacific Islands, Caribbean

Symptoms: can be without symptoms; or a skin rash and raised temperature; can be harmful to developing babies in pregnant women

Vaccine: None – but clinical trials are taking place for a possible vaccine



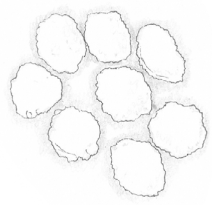
Human papillomavirus (HPV) Types 16 and 18

Caught: from sexual contact

Where: across the world

Symptoms: there are many types of HPV (some cause warts/verrucas); types 16 and 18 can cause development of cervical cancer and some types of head and neck cancer

Vaccine: Yes – for the virus that can cause cervical cancer



Yellow fever virus

Caught: from mosquito bites

Where: tropical areas of Africa, Central and South Americas

Symptoms: can be without symptoms; or fever, muscle pains, nausea; may feel better for 48 hours then unwell again. Approximately 5% can become very ill and develop liver damage (jaundice), bleeding or kidney damage

Vaccine: Yes

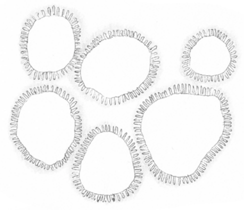
SARS-CoV-2

Caught: from air droplets and touch

Where: across the world

Symptoms: can be without symptoms; or mild with fever, continuous cough and change/loss of smell and taste; or severe leading to breathing difficulty, blood clots, organ damage and death. Some may experience long COVID with symptoms including fatigue

Vaccine: Yes



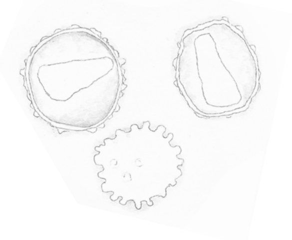
Influenza virus

Caught: from air droplets and touch

Where: across the world

Symptoms: can be without symptoms; or fever, muscle aches, fatigue, headache; or severe leading to death

Vaccine: Yes – as the virus changes, vaccines need updating



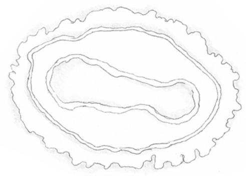
HIV

Caught: from contact with infected fluids such as blood; including through sexual contact (not sweat, urine or saliva)

Where: across the world

Symptoms: initial infection can be without symptoms or with sore throat, fever and rash. Without treatment infection severely weakens the immune system and leads to death

Vaccine: None – but effective treatments allow a near-normal life



Smallpox virus

Caught: from air droplets and contact with infected fluids

Where: nowhere anymore

Symptoms: caused pustules across the body and killed around 30% of those who caught it; those who survived were scarred and could lose their sight

Vaccine: Yes – thanks to vaccines, it has been made extinct

Ebola virus

Caught: from contact with blood or body fluids from an infected person

Where: West and Central Africa

Symptoms: causing fever, fatigue and bleeding; severe disease causing death

Vaccine: Yes – two vaccines and thanks to quickly isolating areas, epidemics were brought under control

This activity is accompanied by a video. Visit ***https://youtu.be/DvQ7wtXKCE4***

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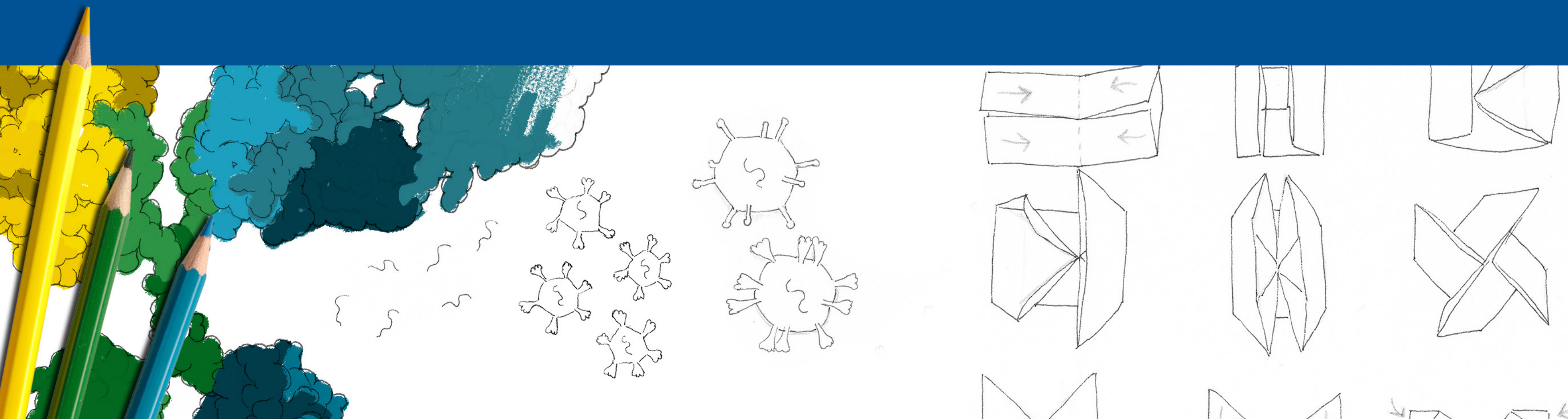
Coronavirus: inside & out



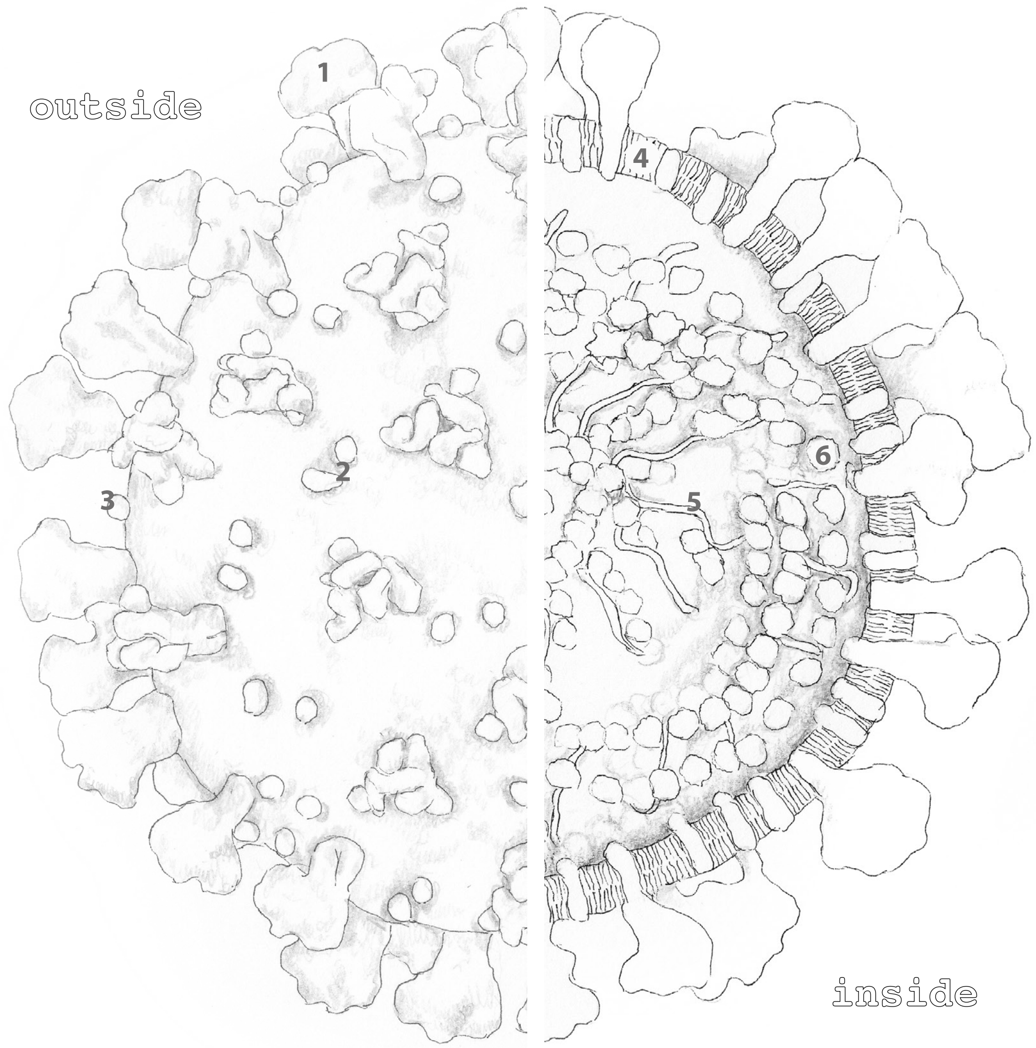
Viruses & Vaccines

Coronavirus: inside & out

Everyone's life has been affected by SARS-CoV-2, the virus that causes COVID-19. Some people carry it without realising and can pass it to another person who can become seriously unwell. We all need to look after each other through distancing and wearing masks. Thankfully, scientists across the world have worked together to find a way to create vaccines to protect us. Learn about this fascinating virus and how vaccines work. We hope this resource will inspire you to get creative, learn and have fun.

Viruses are so small they can usually only be seen with a special microscope using electrons to take pictures. The 'Virus collection' drawings are based on electron microscope images but they are quite fuzzy. These more detailed drawings of the virus are based on computer models where scientists have worked out the structure of each part. We enter a tiny world.

SARS-CoV-2



1. Spike (S) protein – the virus uses this to attach and enter a cell (the basic unit of our body). Seen from above, they are a triangular shape.

2. Membrane (M) protein – they come in pairs

3. Envelope (E) protein – forms a pore with a five-fold symmetry

4. Membrane – a fatty outer layer, which means this virus can be damaged by soap

5. Genetic material (RNA) – instructions to make the virus

6. Nucleoprotein (N) – may help with the structure for spacing out spikes and packing the RNA

*This activity is accompanied by a video. Visit **https://youtu.be/Pk_4nFROxns***

Coronavirus: outside

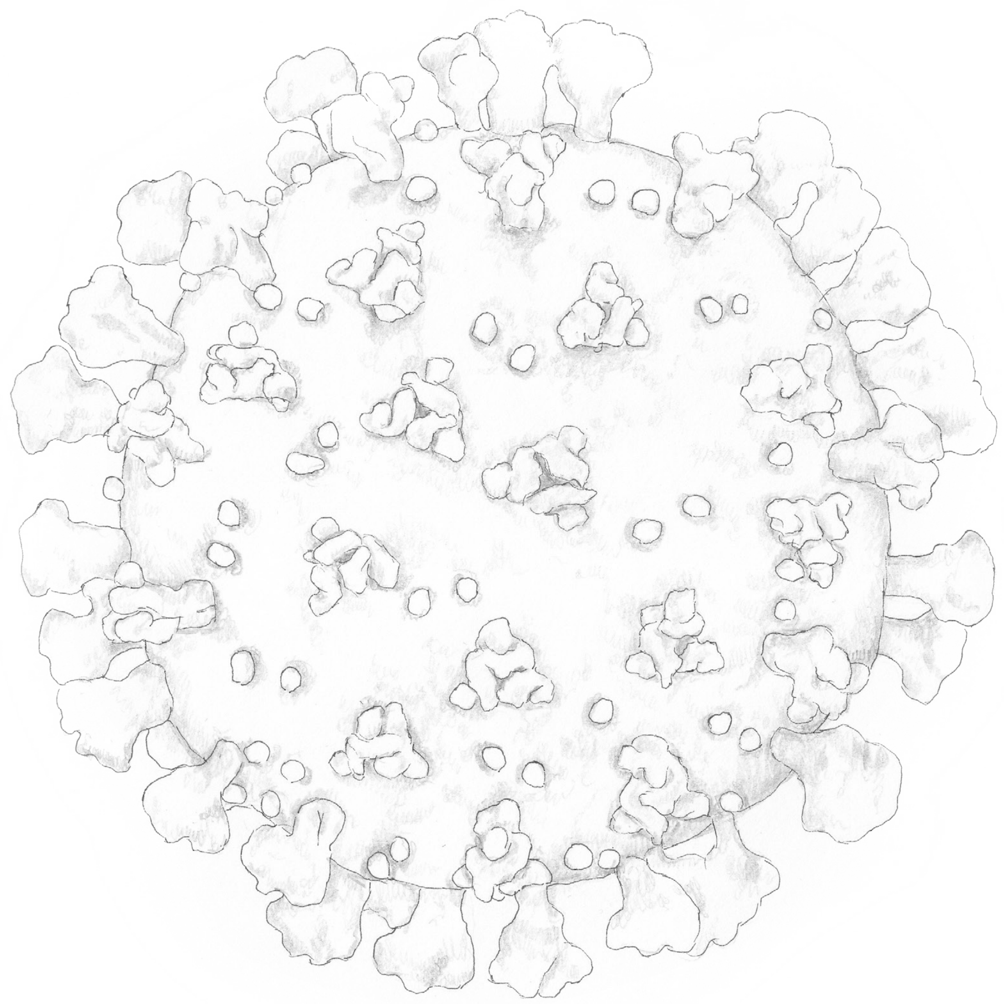
'Corona' comes from Latin meaning 'garland, wreath, crown' and is used to describe sun rays – 'solar corona'. Under the microscope, the spikes of the coronavirus look a bit like sun rays. Around a fifth of colds are caused by coronaviruses, but this novel coronavirus (SARS-CoV-2) is different and causes COVID-19.

Add colour and decorate the outside of this virus. The drawing can be cut out and matched up to the next picture showing the inside of the virus. The drawings could be hung up and spun to see the inside and outside of this virus.

In more detail: The distinctive crown-like spikes allow the virus to attach to a cell (building block of our body) and enter it. SARS-CoV-2 attaches to a protein on the outside of cells called ACE2.

The virus is surrounded by a fatty membrane called an envelope, which wraps around its viral genetic material (RNA). Soap dissolves fat and therefore can dissolve the virus's fatty membrane and destroy the virus.

SARS-CoV-2 can be caught from droplets in the air from the breath of someone who is infected, through speaking or coughing. Any one of us can be infected without realising, so it's important we keep a two metre distance and wear masks. Coronavirus can also be caught from touching a surface touched by someone who is infected. It can then infect someone after unclean fingers touch eyes, nose or mouth. This is why it's important to wash our hands.



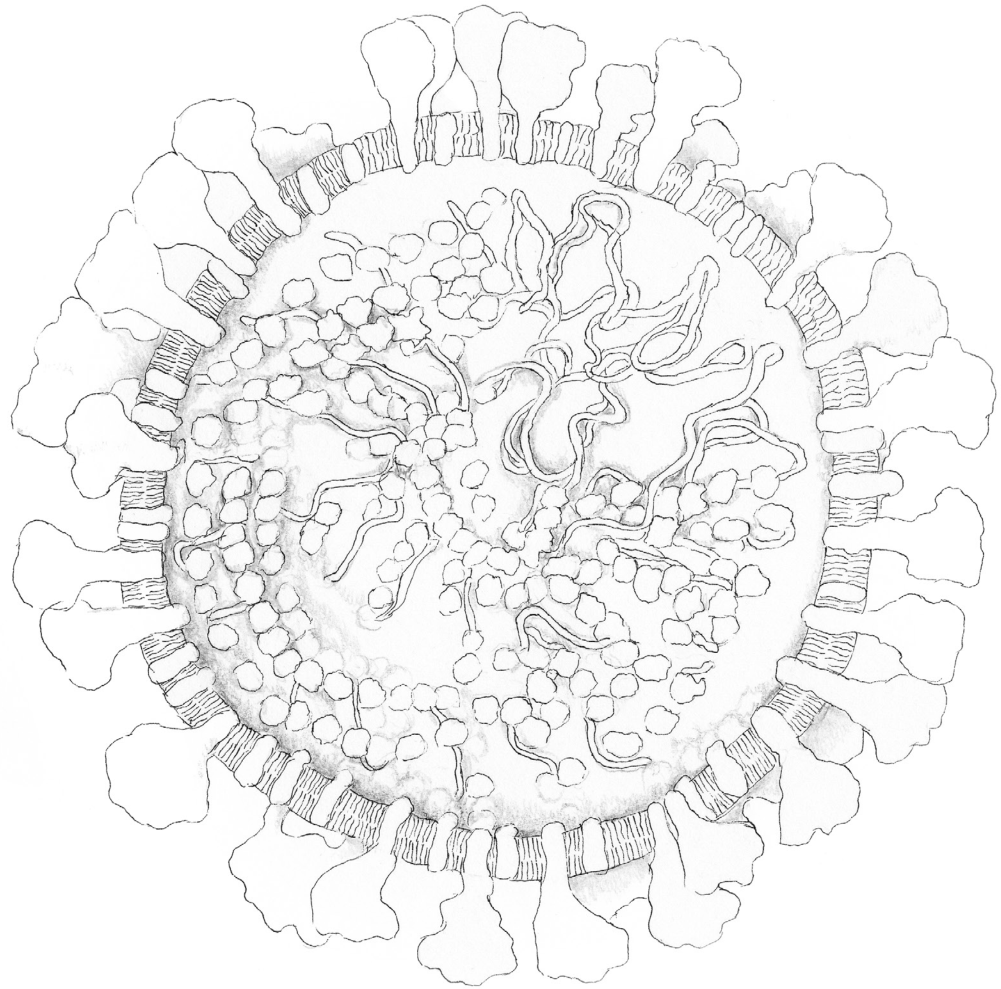
This activity is accompanied by a video. Visit ***https://youtu.be/Pk_4nFROxns***

Coronavirus: inside

Inside a virus is genetic material containing instructions to make more viruses after hijacking a cell. The information for making viruses can be in the form of DNA or RNA. Coronaviruses are RNA viruses.

Add colour and decorate the inside of the virus. This drawing can be cut out and stuck back to back to show the inside and outside of the virus.

In more detail: The RNA inside this novel coronavirus is close to 30,000 bases or letters, which is quite big for an RNA virus. The genome encodes at least 29 proteins. Any changes (mutations) in the letters encoding proteins can lead to new variants, which may affect how a virus is transmitted or how it affects a person.



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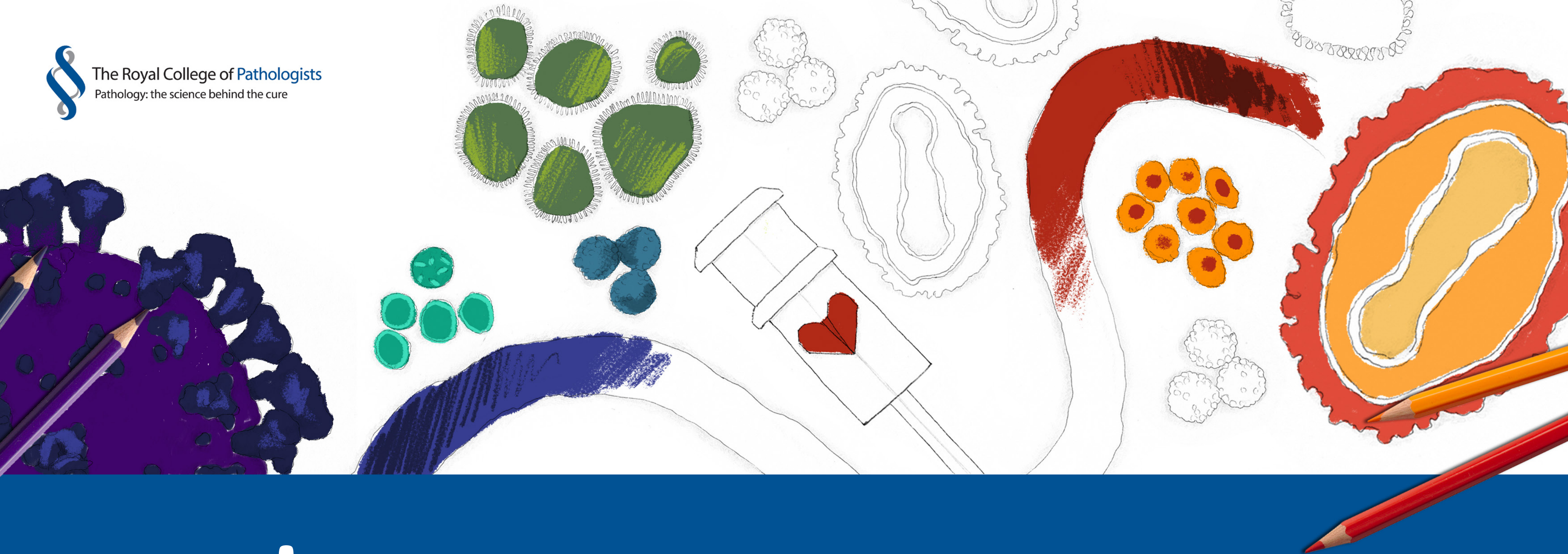
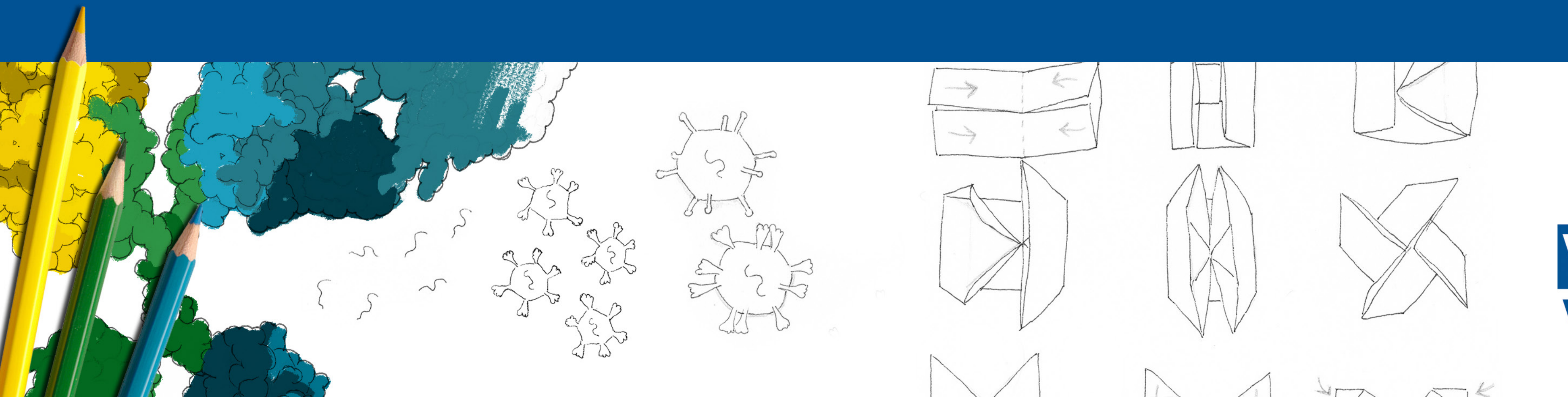


A virus flick-book



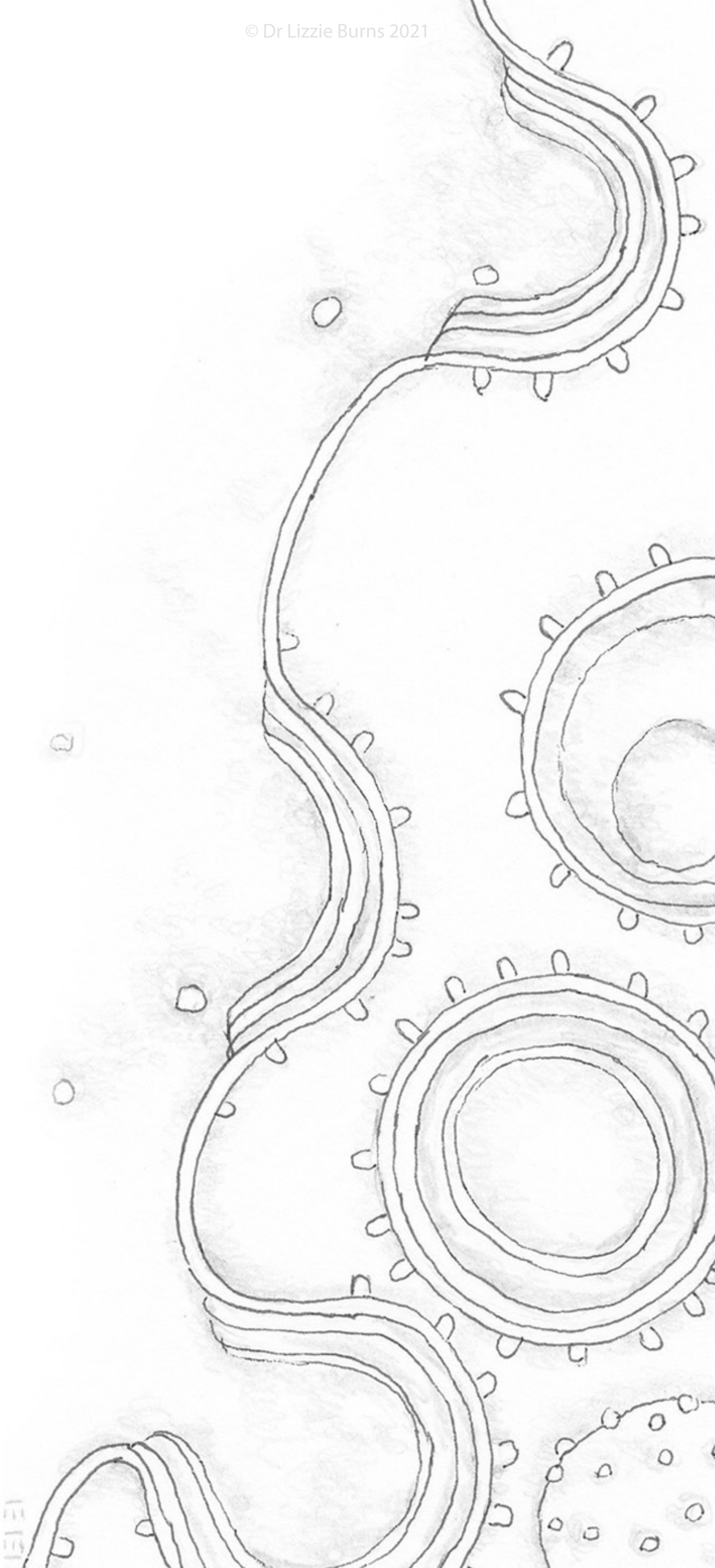
Viruses & Vaccines

A virus flick-book

Make yourself a little flick-book showing the 'life' of a virus. Colour in the boxes, cut out and put in order, then staple on the left. Flick the pages to see the adventure of a little virus.

These drawings are based on images of real specimens taken using an electron microscope. Can you use the 'Virus collection' resource to identify this virus? It's a really distinctive virus and as yet a vaccine has not been developed.

You will see a tiny bit of the surface of a cell (a cell is the basic building block of any living organism). Cells are tiny, measuring less than the width of a human hair, so we need a microscope to look at them. Viruses are hundreds of times smaller, and are so tiny that normal microscopes won't show any of their details; we need an electron microscope for this. The drawings show a virus landing on the surface of a cell and attaching through its spikes. The inside of the virus (genetic material, which can be DNA or RNA) can then enter the cell and will start to be copied. The genetic material inside the virus contains instructions for making proteins, including the spikes. Once taken over, the cell starts to make more viruses which burst out ready to attack other cells. We would quickly get unwell if it wasn't for our own body's hero: antibodies.



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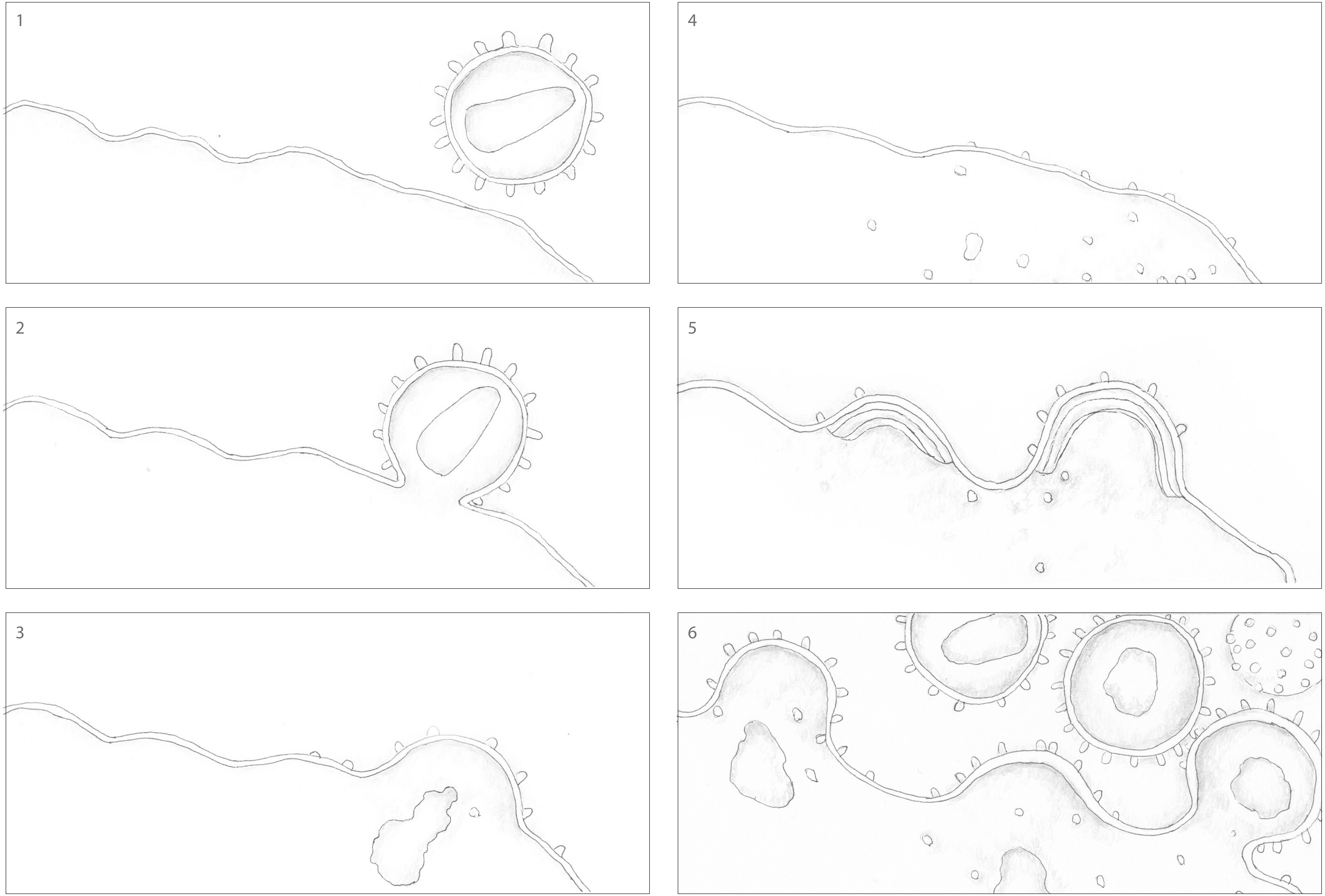

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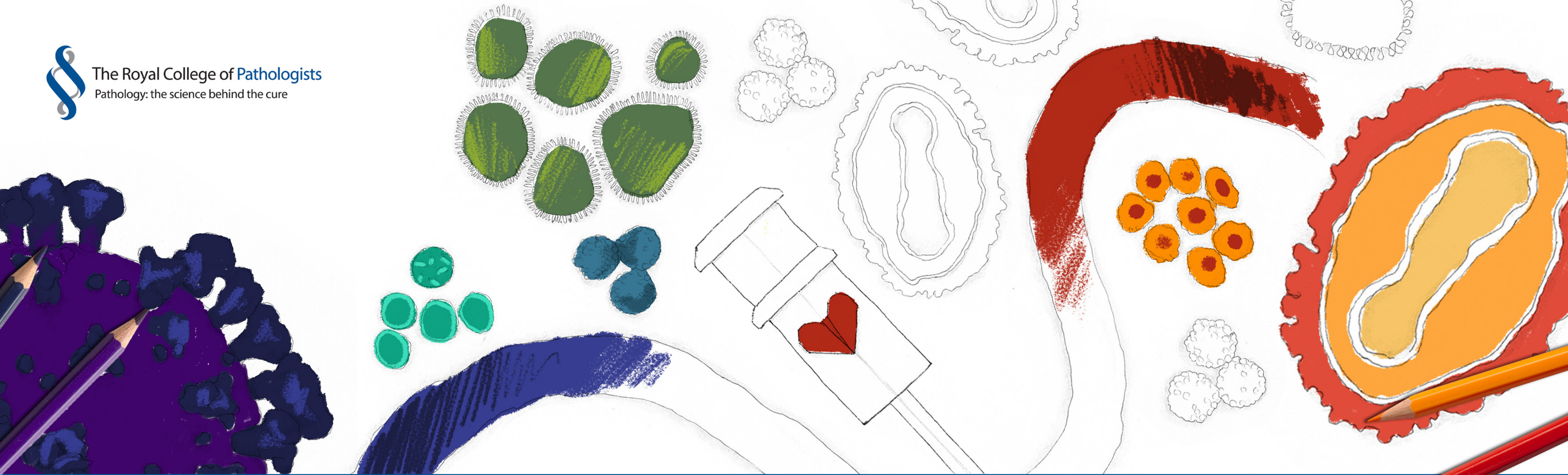
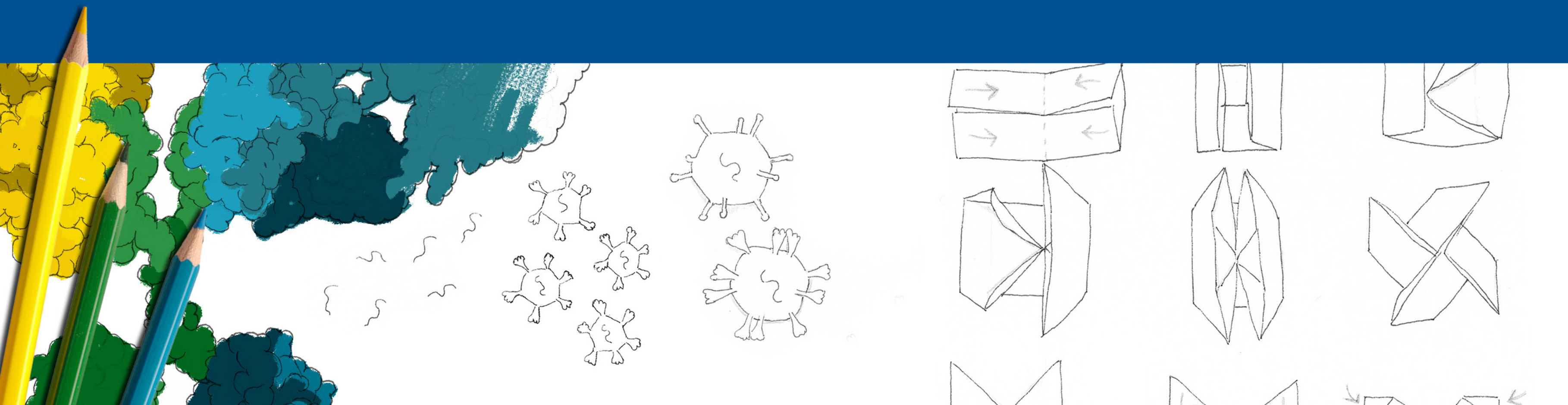


Our hero: the antibody



Viruses & Vaccines

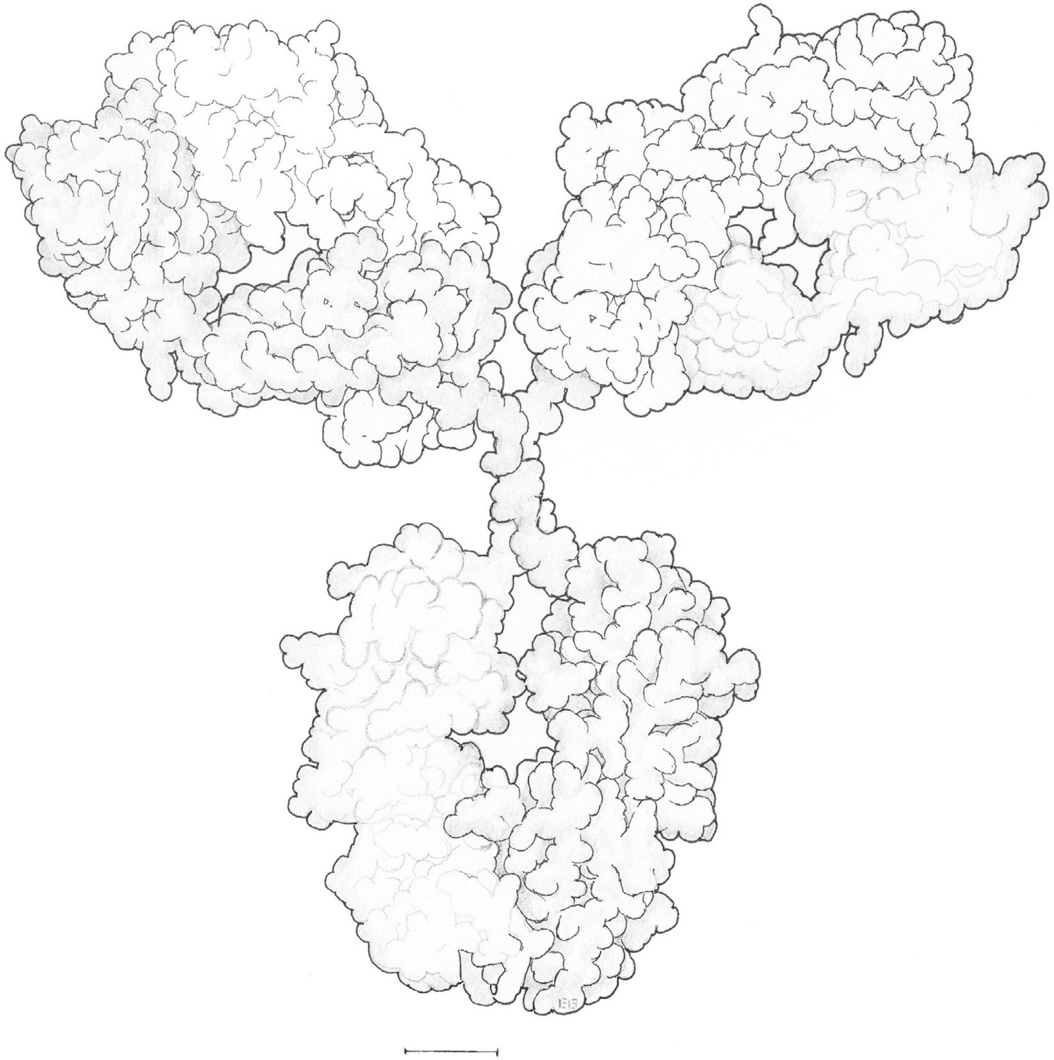
Our hero: the antibody

Our body is extraordinary, constantly defending itself from viruses and bacteria that can make us unwell. Most of the time our body works so well we would never realise how much we constantly save ourselves from disease.

The way our body can spot an invader is through a special protein called an antibody. This 'Y' shaped protein has two arms, each of which can stick to an intruder. When an antibody sticks onto a virus spike, the virus can't bind to a cell to infect it and is left powerless, waiting to be destroyed by our immune system. Colour in your own heroic antibody.

In more detail: Antibodies are made by white blood cells (B cells). Once a B cell starts to make an antibody specific to an intruder, it can 'remember' the intruder, so in future it can make more antibodies quickly (called 'adaptive immunity'). When we have a vaccine, we encourage our body to form memory B cells so we make antibodies quickly. Vaccines also encourage memory T cells which encourage B cells to make antibodies (T helper cells) and directly kill infected cells (killer T cells). It is utterly remarkable that the body can generate enough different antibodies to recognise so many viruses.

The bar represents 1 nanometre (millionth of a millimetre). Around 10,000 antibodies would fit across the width of a human hair.



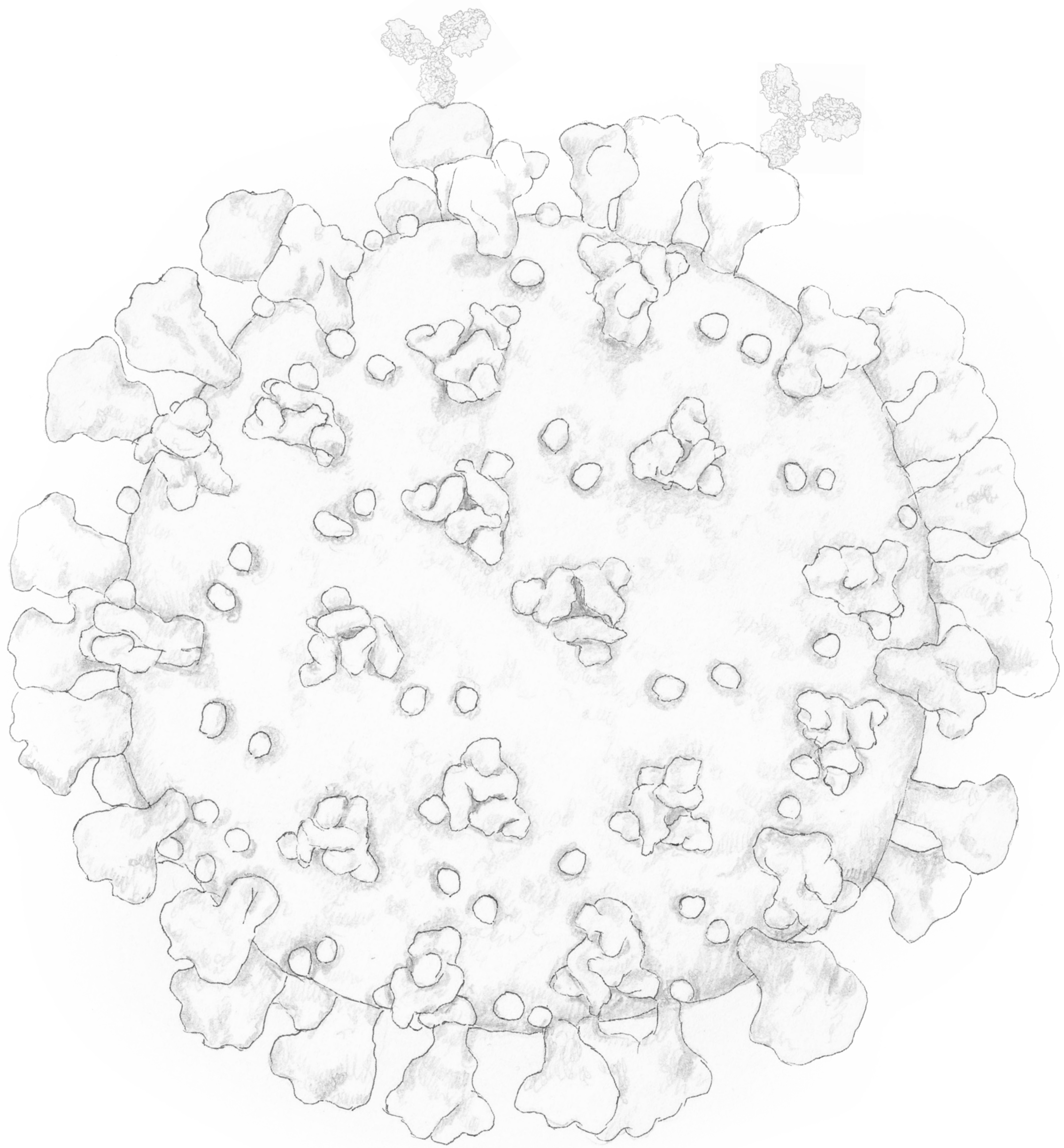
This activity is accompanied by a video. Visit ***https://youtu.be/Glaoc2YdaGI***

Add antibodies

Antibodies can stop a virus by sticking to its spikes.
Once disabled, the virus cannot infect a cell.

Decorate this drawing of a coronavirus with more antibodies.
Cut out the antibodies below and use glue to stick them onto the spikes. Add bright colours to make a colourful picture celebrating the body stopping a virus in its tracks.

In more detail: Antibodies recognise spike proteins.
Here, they are seen to scale.



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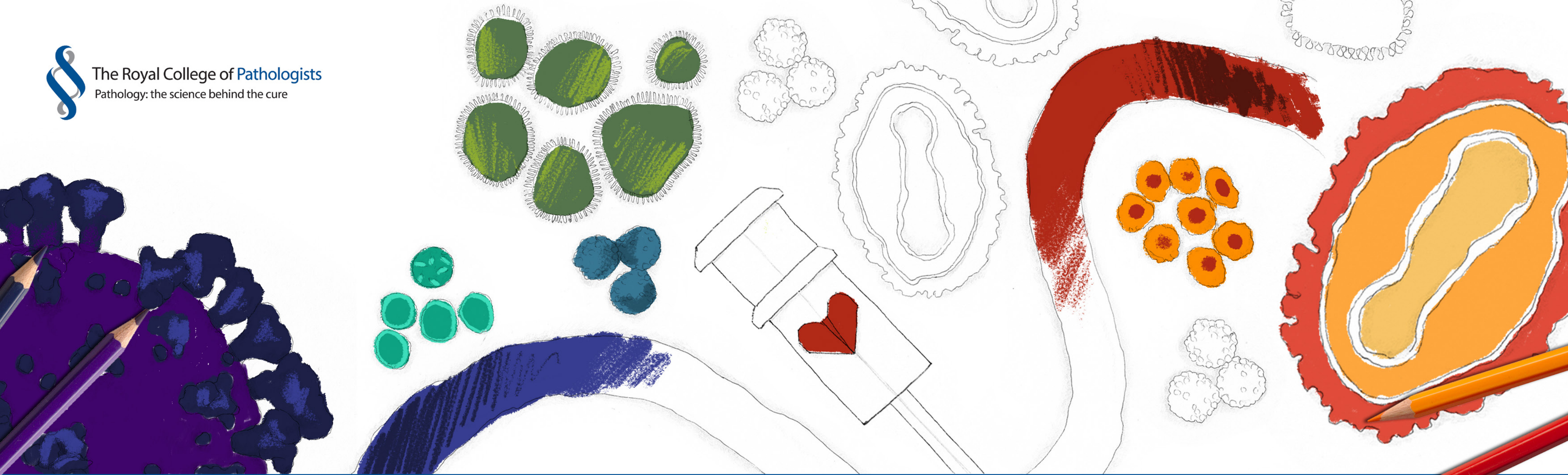
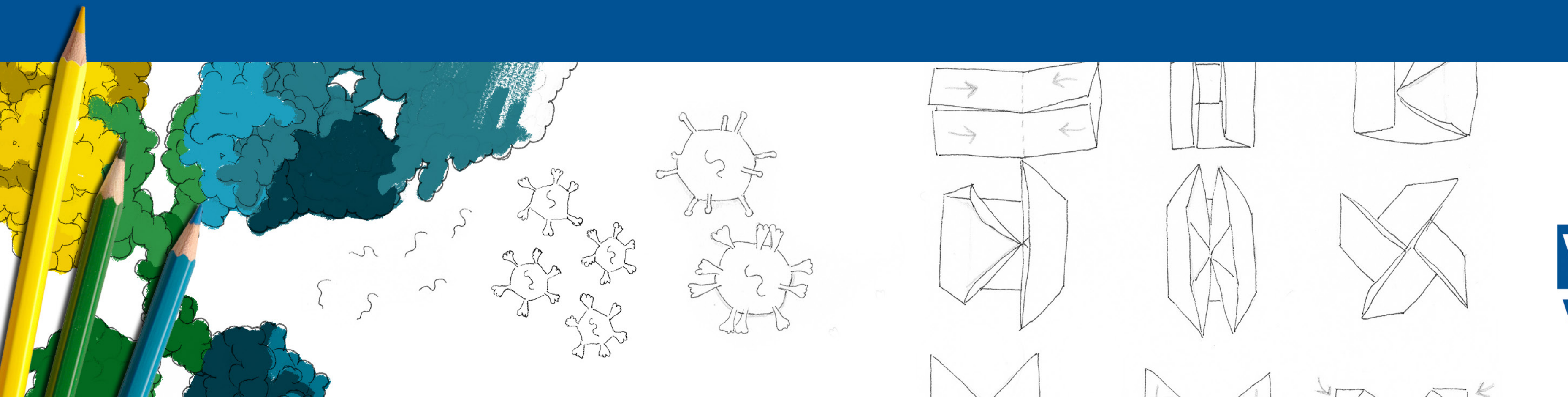
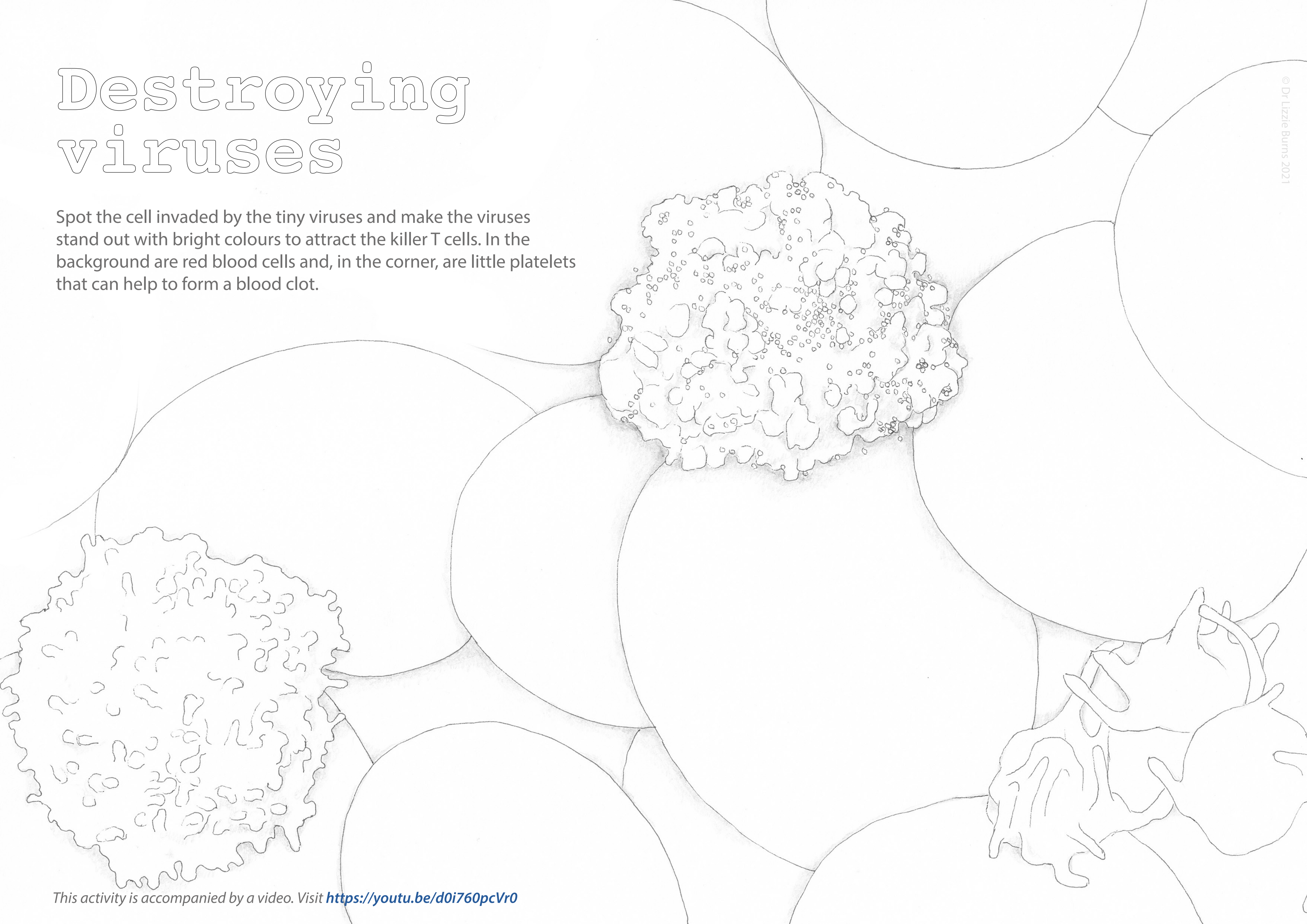


Destroying viruses



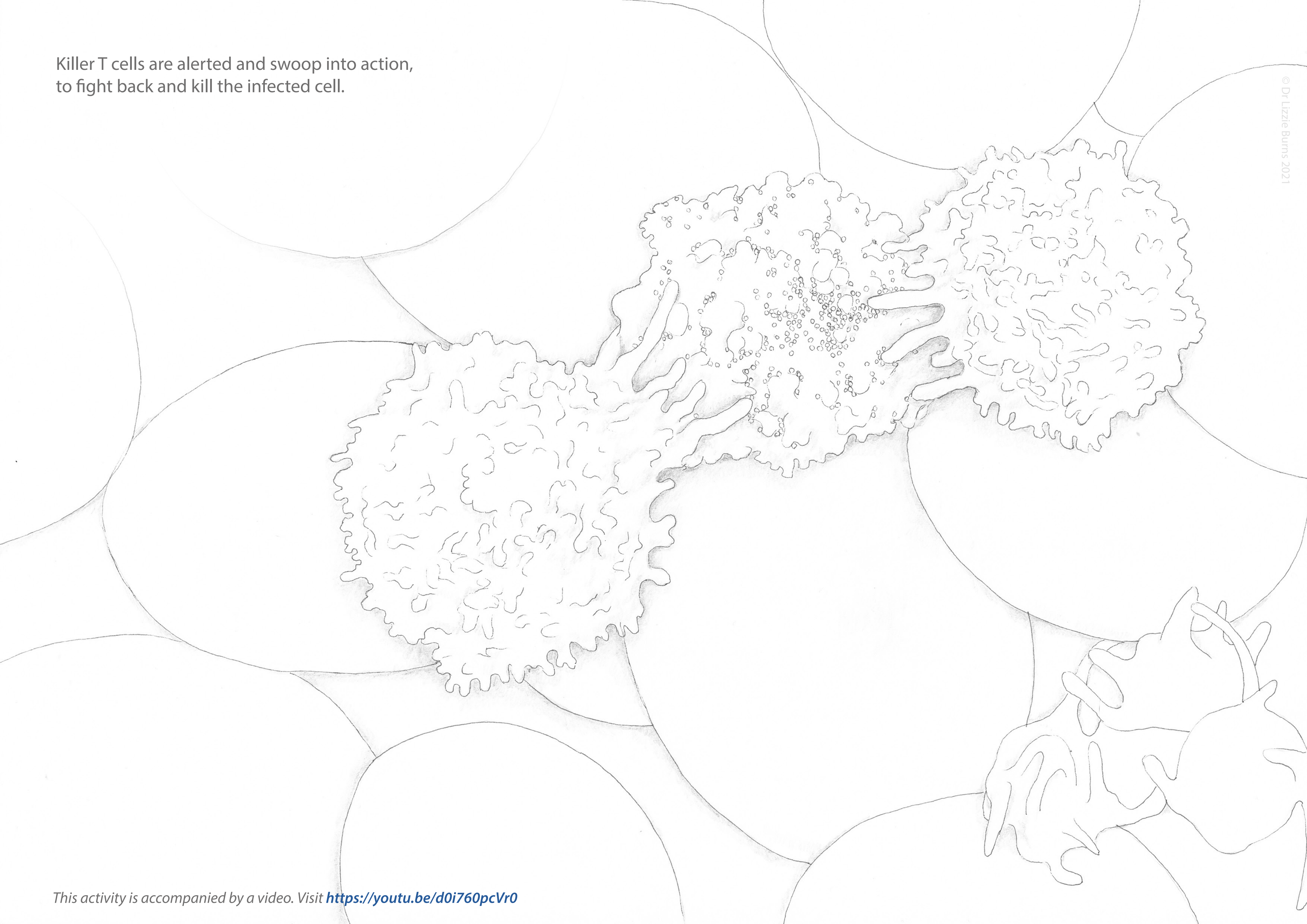
Destroying viruses

Spot the cell invaded by the tiny viruses and make the viruses stand out with bright colours to attract the killer T cells. In the background are red blood cells and, in the corner, are little platelets that can help to form a blood clot.



This activity is accompanied by a video. Visit ***https://youtu.be/d0i760pcVr0***

Killer T cells are alerted and swoop into action, to fight back and kill the infected cell.



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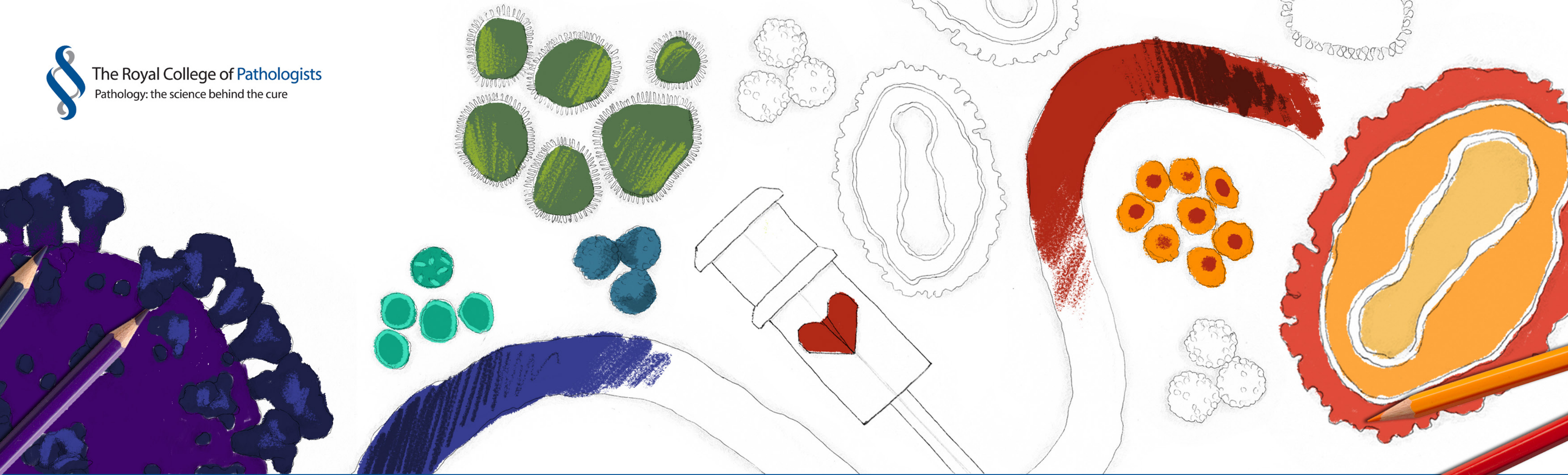
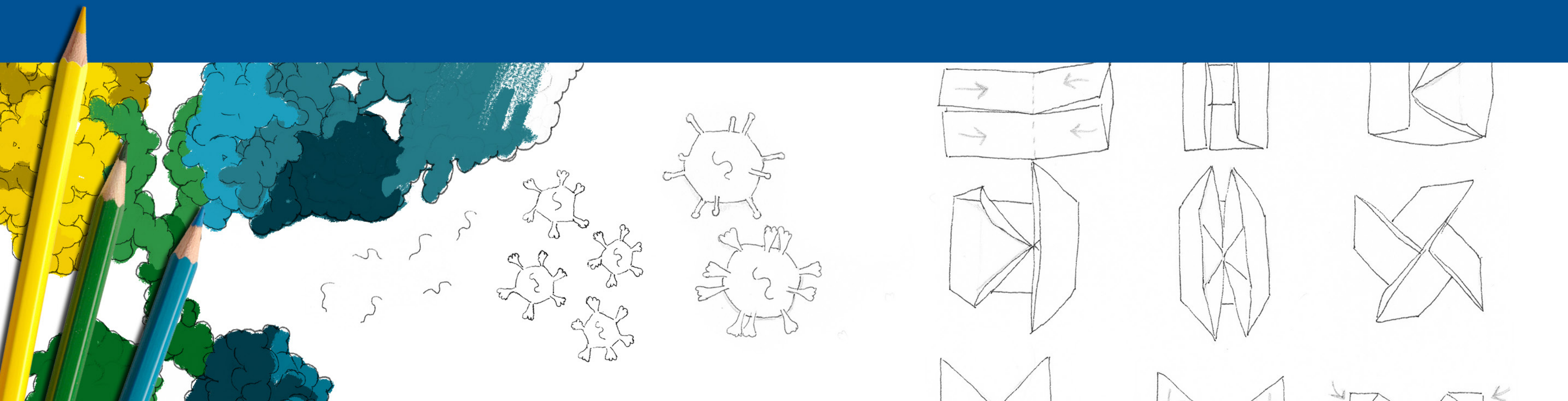


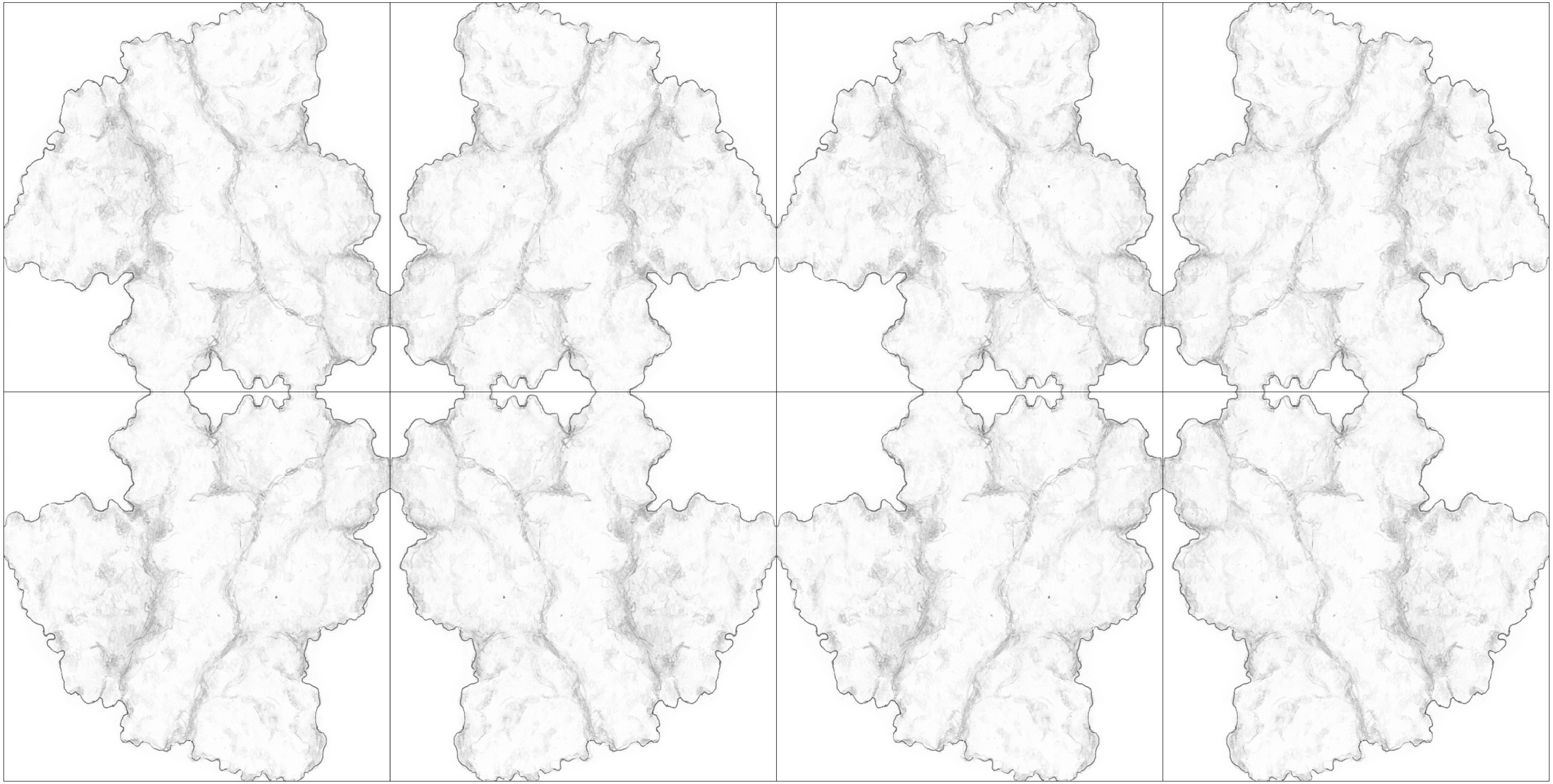
Fold a virus



Viruses & Vaccines

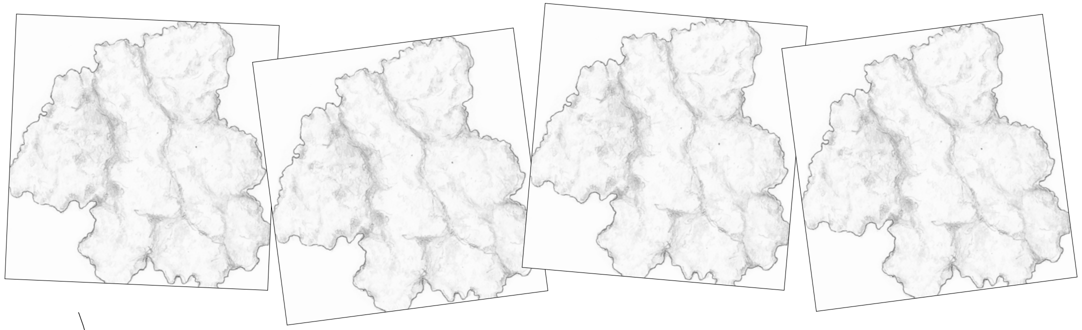
Fold a virus

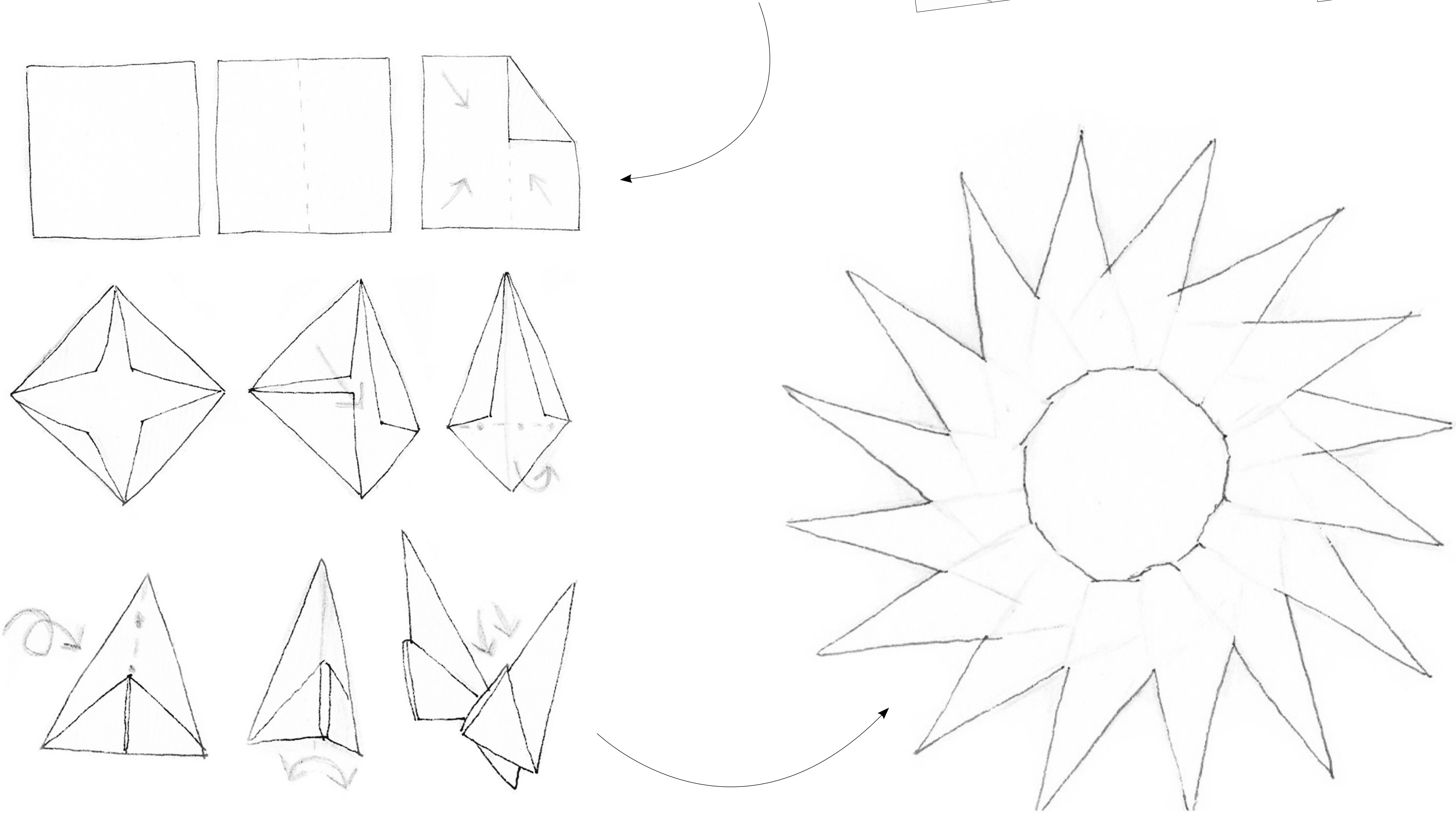
For the purposes of this activity, print this page twice to get 16 squares. Then, cut them out individually.



This activity is accompanied by a video. Visit ***https://youtu.be/kAYmpnYsZ98***

To make your own spiky virus, use the 16 little squares you have cut out. See below for how to fold each square into a spike or better still, follow along with me in the ***'How to fold an origami virus'*** video. All 16 spikes will create a spiky modular outside but a virus needs instructions to be complete so it can be transmitted to someone else.



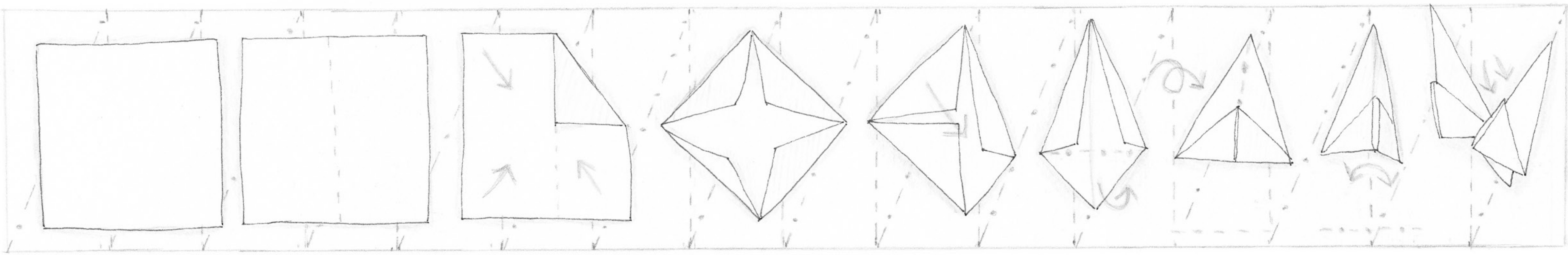


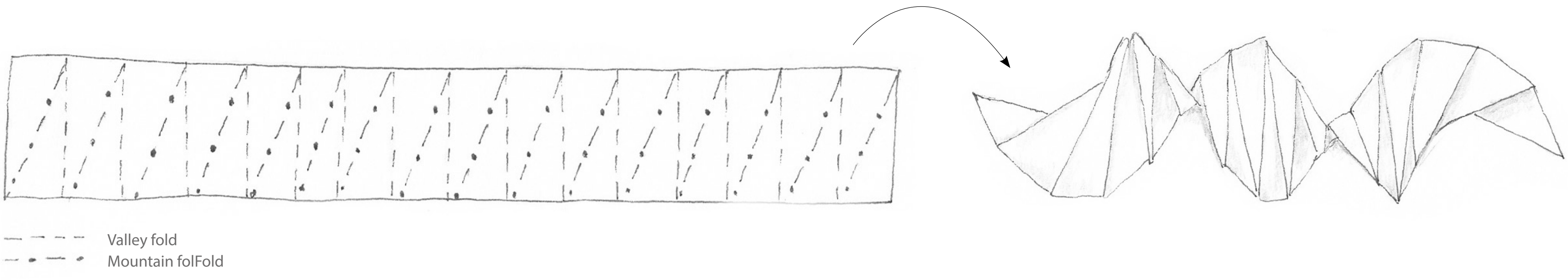
This activity is accompanied by a video. Visit ***https://youtu.be/kAYmpnYsZ98***

Fold DNA (or RNA)

Viruses are tiny. Each contains genetic information (DNA or RNA) to make more viruses. This genetic material includes instructions for proteins, which are like tiny strings of beads that fold up to make pieces of the virus, including spikes.

Next, cut out the instructions for making the spikes on the previous page. Fold along the tiny lines (or follow the video) and it will become a helix-like structure (like the SARS-CoV-2's RNA). If you gave your virus with instructions to someone else, they could start making viruses too!





Valley fold
Mountain folFold

This activity is accompanied by a video. Visit ***https://youtu.be/SlJC69ozRJQ***

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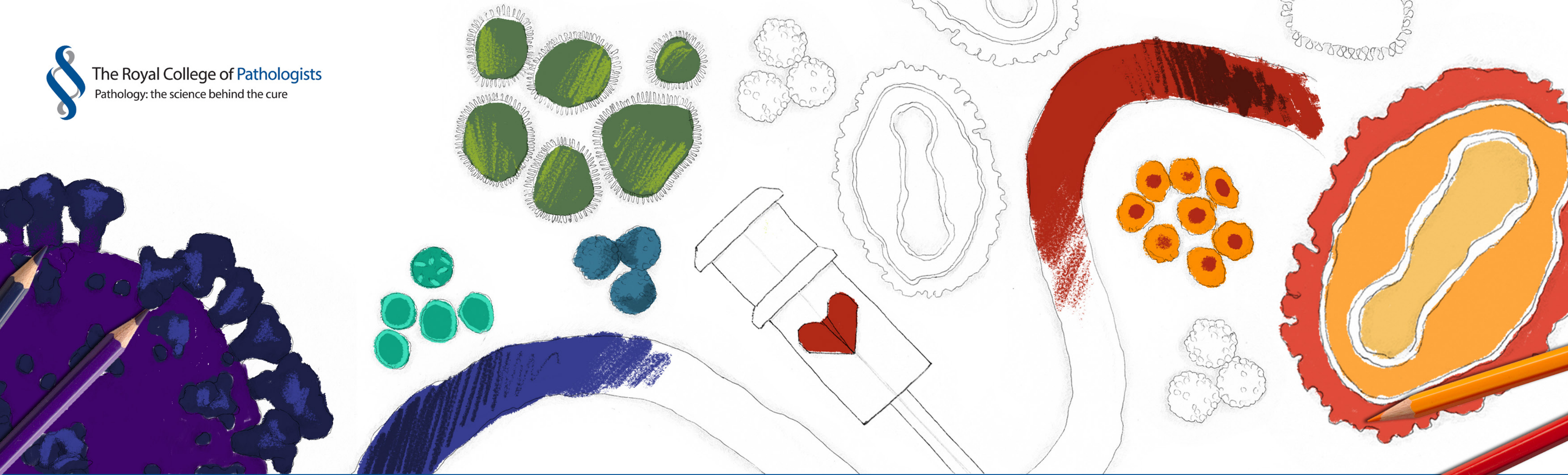
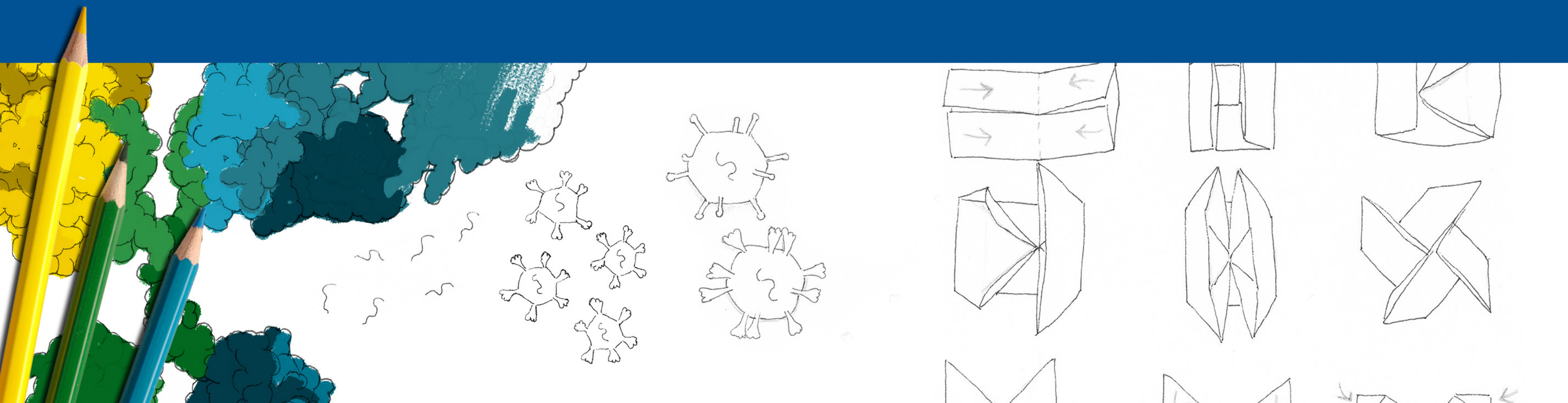


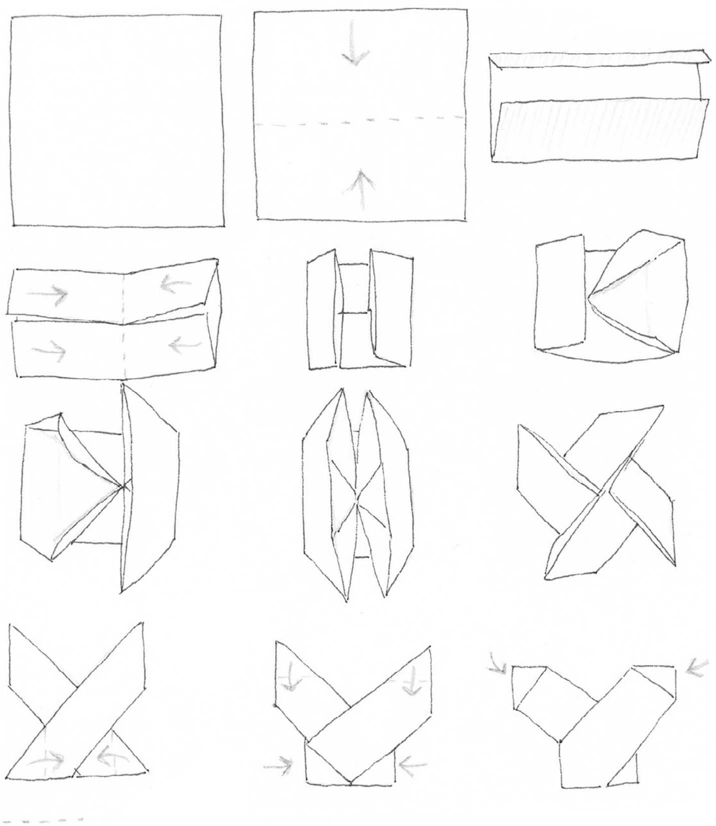
Make an antibody & vaccine

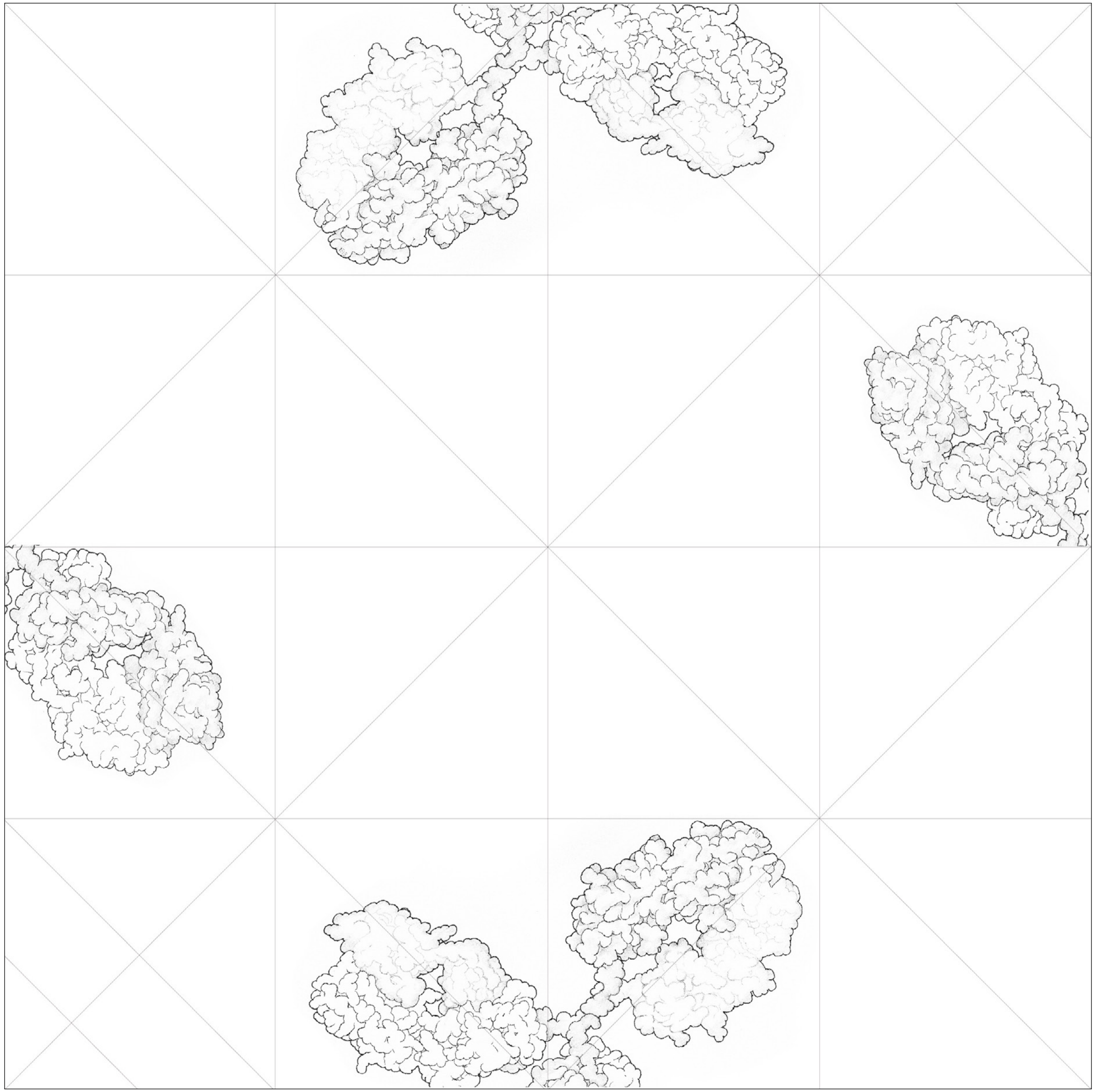


Viruses & Vaccines

Make an antibody

Your body makes antibodies. These 'Y' shaped proteins protect us from disease. Little grooves in the end of the arms can stick to a virus spike to stop it infecting a cell. Colour in the patterns and cut out the square to fold an antibody or ***watch our video*** to learn how to fold an origami antibody.



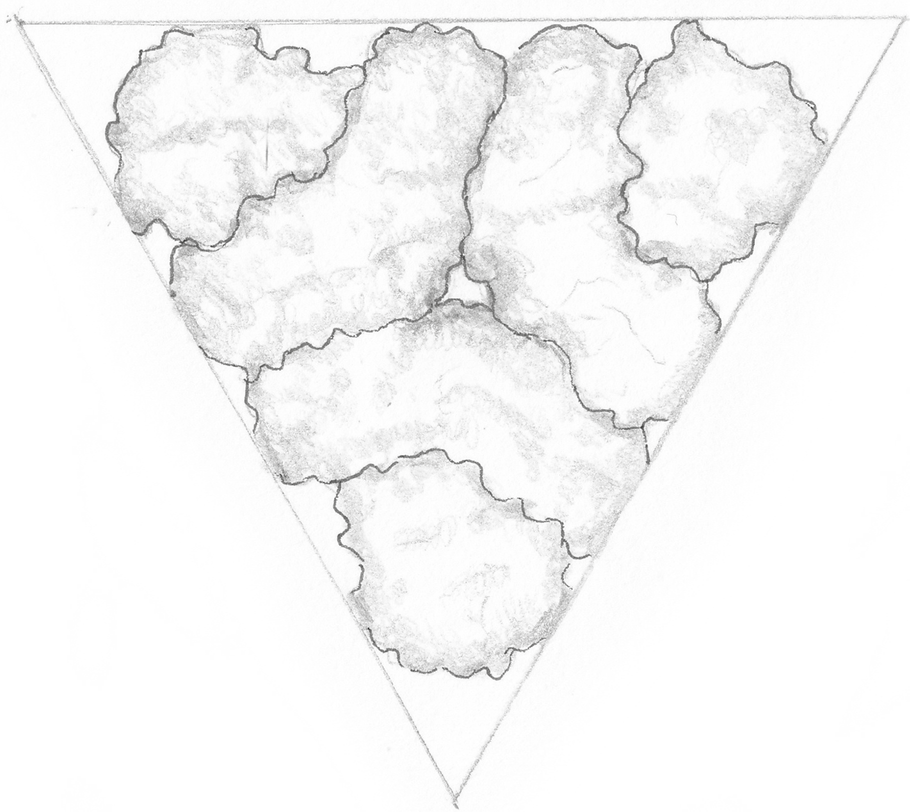


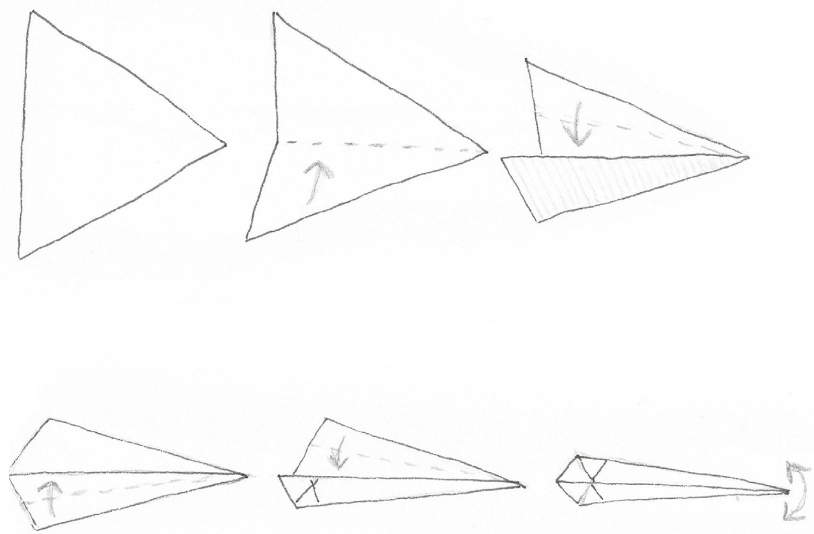
*Two videos accompany this activity. Visit **https://youtu.be/C2yFNIK_RS0** and **https://youtu.be/r3rK2qrsxjo***

Make a vaccine

Vaccines work by showing your body a little bit of spike protein from the virus in a form that isn't harmful. This means a vaccine boosts antibodies to protect you from the disease. Cut out the large triangle (right) and fold it into a spike as shown below, ready to stick into the antibody you just made.

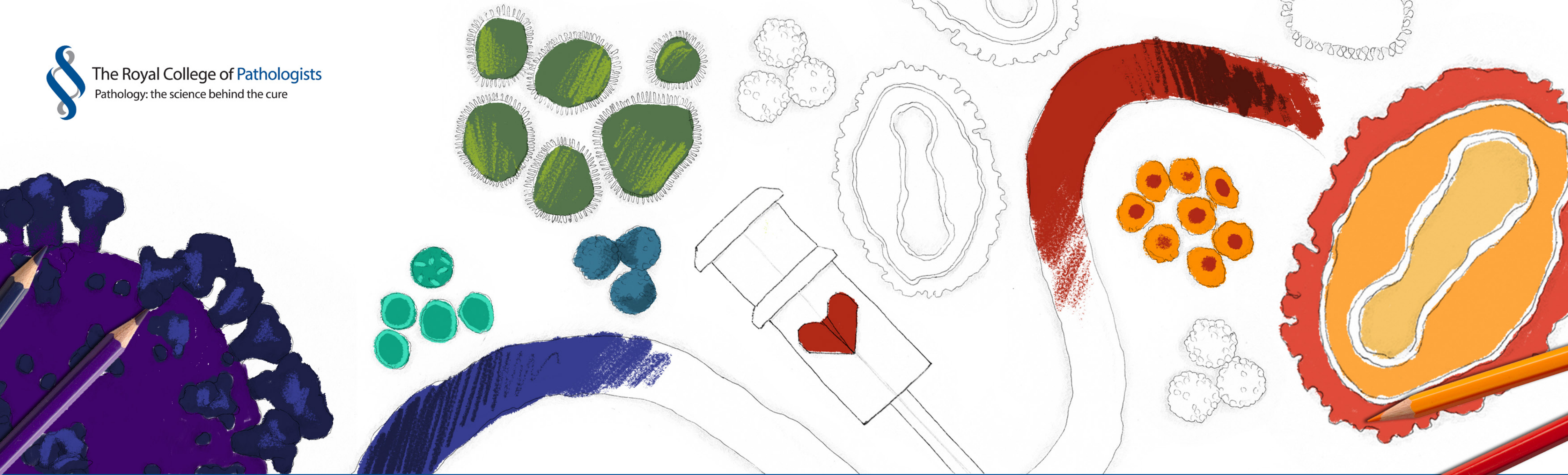
This spike is based on the SARS-CoV-2 spike, which has a distinctive triangular shape.



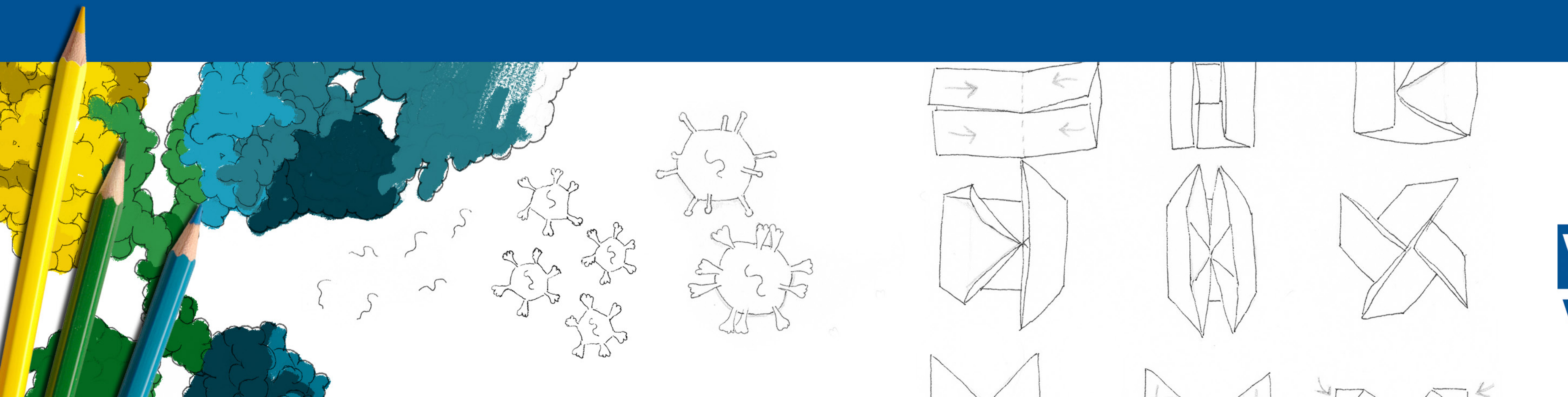


*Two videos accompany this activity. Visit **https://youtu.be/C2yFNIK_RS0** and **https://youtu.be/r3rK2qrsxjo***

The Royal College of Pathologists
Pathology: the science behind the cure

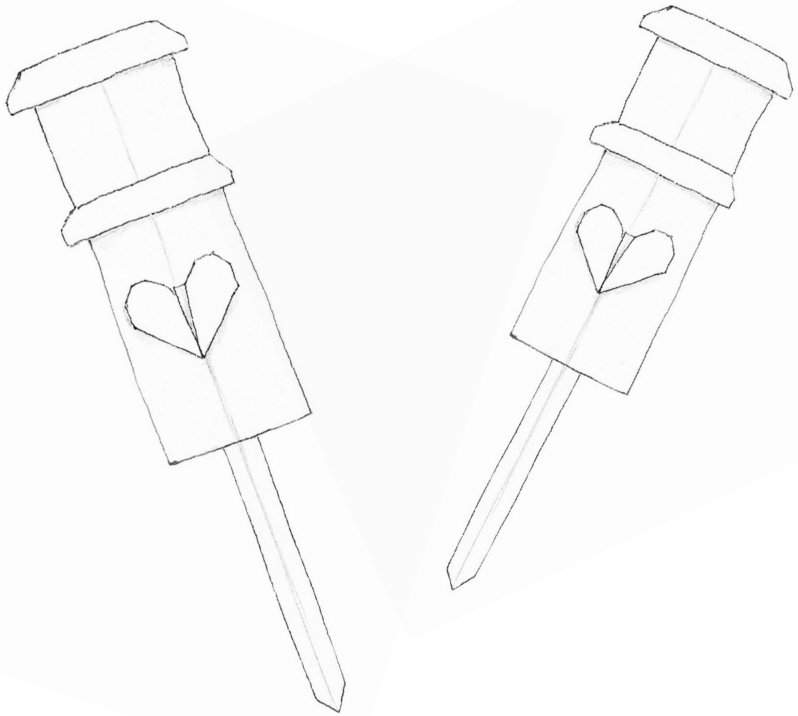


Origami syringe

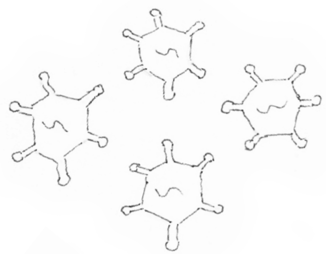


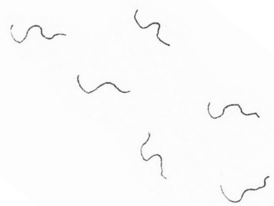
Viruses & Vaccines

Origami syringe



Vaccines encourage our body to make antibodies and immune memory cells (B and T cells) to protect us from diseases. By showing the body a tiny bit of protein spike from the coronavirus (SARS-CoV-2), we encourage our natural defences to be prepared if the same virus attacks us again. Scientists around the world have worked hard, collaborating to create vaccines to protect us against SARS-CoV-2 and COVID-19. To celebrate the hope this brings, either draw a syringe or cut out the Oxford/AstraZeneca vaccine on top, or the Pfizer/BioNTech on the bottom, follow along with me in an ***online video*** to fold the strips into origami syringes.





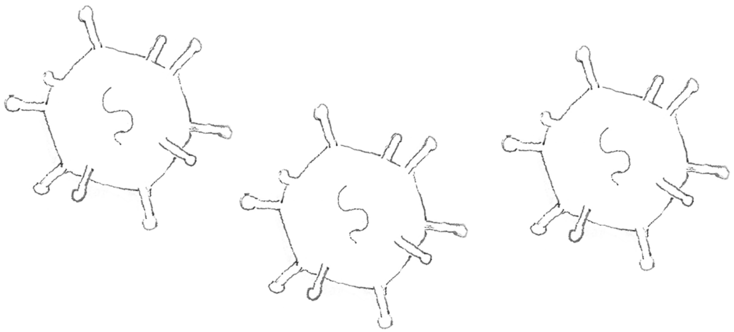
*Two videos accompany this activity. Visit **https://youtu.be/9tK2rV9Cszw** and **https://youtu.be/pWV57aY8Uvo***

Oxford/AstraZeneca vaccine

Oxford University scientists have spent many years studying viruses and vaccines, so quickly got to work designing one to tackle SARS-CoV-2.

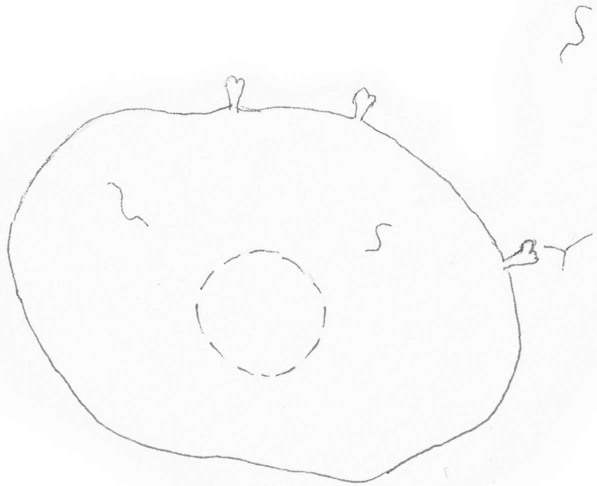
The vaccine is based on a weakened version of a common cold virus (adenovirus). It has been modified with instructions for cells to make coronavirus spikes, but can't cause illness.

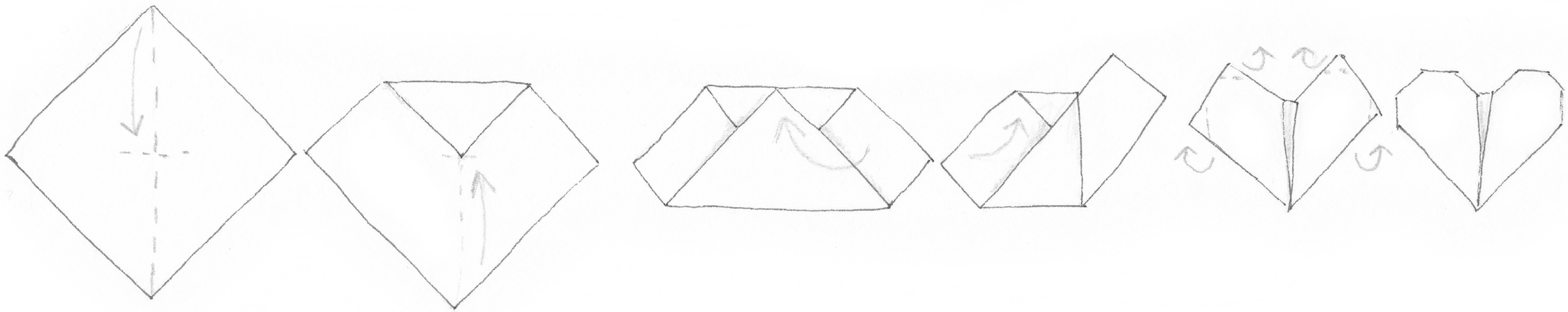
The vaccine encourages the immune system to make antibodies, priming it to attack a SARS-CoV-2 infection. It can be kept in the fridge, so is suitable for use around the world.



Pfizer/BioNTech vaccine

Scientists in the United States developed a different type of vaccine. The genetic information (messenger RNA) can be given directly inside oily drops. Once cells take up the mRNA, they get instructions to make a little bit of the protein spike to safely encourage the production of antibodies.





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