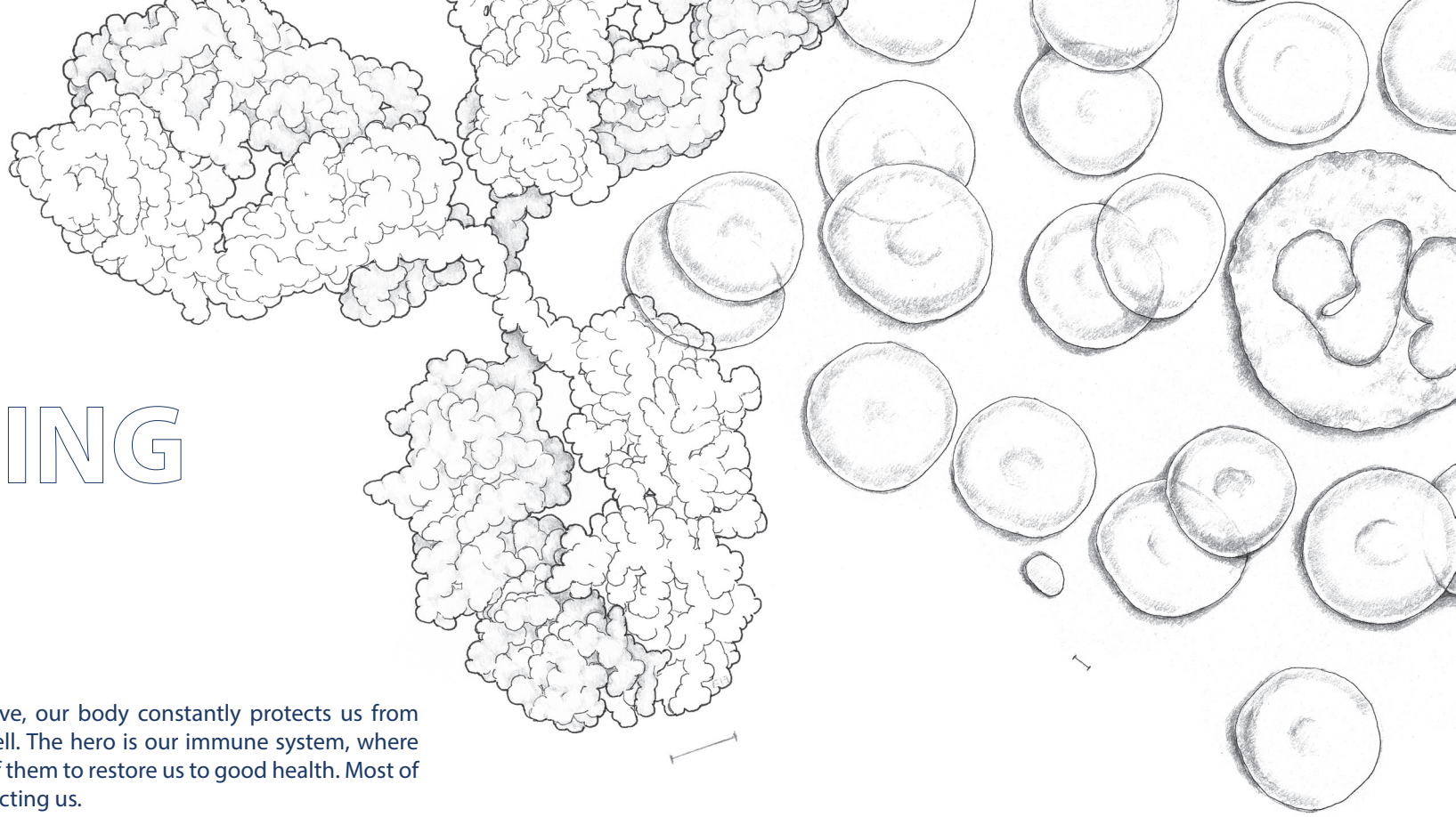
OUR HEROIC BODIES PROTECTING US



Our body is astonishing. As well as being alive, our body constantly protects us from bacteria and viruses that could make us unwell. The hero is our immune system, where white blood cells detect invaders and get rid of them to restore us to good health. Most of the time we never know that our body is protecting us.

This collection of drawings celebrates the unexpected beauty of our body at a tiny scale, starting with blood cells, including our protective heroic white blood cells. Most of the time they do a brilliant job but just occasionally it takes longer for our body to react which means we can get unwell. Drawings reveal some of the bacteria and viruses that can make us unwell. The collection includes celebrating how an unexpected finding by Edward Jenner in 1798 led to one of the greatest discoveries in medicine to help protect us from illness.

Drawings reveal a tiny world from the building blocks of our body, cells, to bacteria, viruses and molecules. Take a moment to ponder how beautiful we are, and the intricacy of life at a tiny scale. To explain how small these subjects are a scale is included, and compared to the width of a human hair. Scientists need to add colours and dyes to reveal structure and patterns. This collection of drawings is for all ages, to take time out to relax, chat, learn about ourselves and add colour to bring drawings to life.

About the author: Drawings and writing have been created for the British Society for Immunology by Dr Lizzie Burns. Following a doctorate, and research fellowship at the University of Oxford in cancer research, Dr Burns became a science-based artist in 2002 exploring the beauty and wonder of life. Lizzie runs workshops and events to inspire people of all ages to learn about the body as astonishing.

"I hope these drawings can inspire you to discover how extraordinary you are, and how medicines can help boost how we naturally protect ourselves from illness" – Dr Lizzie Burns

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OUR HEROIC BODIES

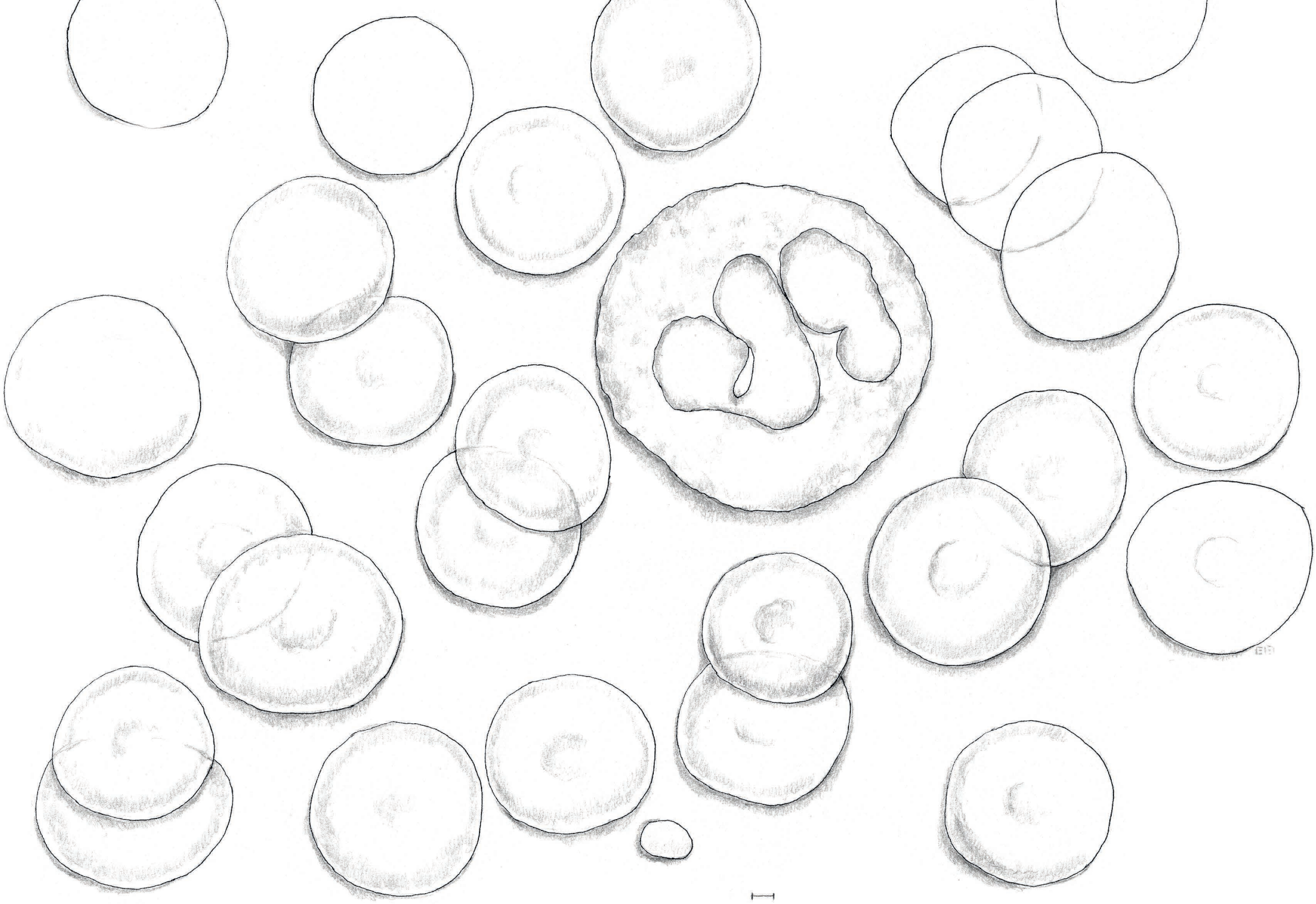
Blood Cells

Our body is made of tiny building blocks, called cells, which can be seen using a microscope. This drawing shows cells in our blood which keep us alive through carrying oxygen and food. Round cells called red blood cells carry oxygen around our body. They are bright red as they are packed full of a protein called haemoglobin which contains iron and can change colour. When haemoglobin is holding oxygen from the air these cells are an orange-red colour and when they lose it they look a more red-purple colour. Add reds and enjoy shading some red blood cells.

A smaller structure at the bottom of the drawing is a platelet which can help trigger a blood clot. We need this to happen when we have a cut so as not to lose too much blood.

In the middle is a different sort of cell, called a white blood cell, which look out for any bacteria or viruses that could make us unwell. There are lots of types of white blood cells that carry out different types of jobs to keep you well. White blood cells are our heroes. The most common type of white blood cell is called a neutrophil – seen in this drawing – which can help eat up intruders.

The line is a scale and represents one micrometre (thousandth of a millimetre). More than ten red blood cells would fit across the width of a human hair.



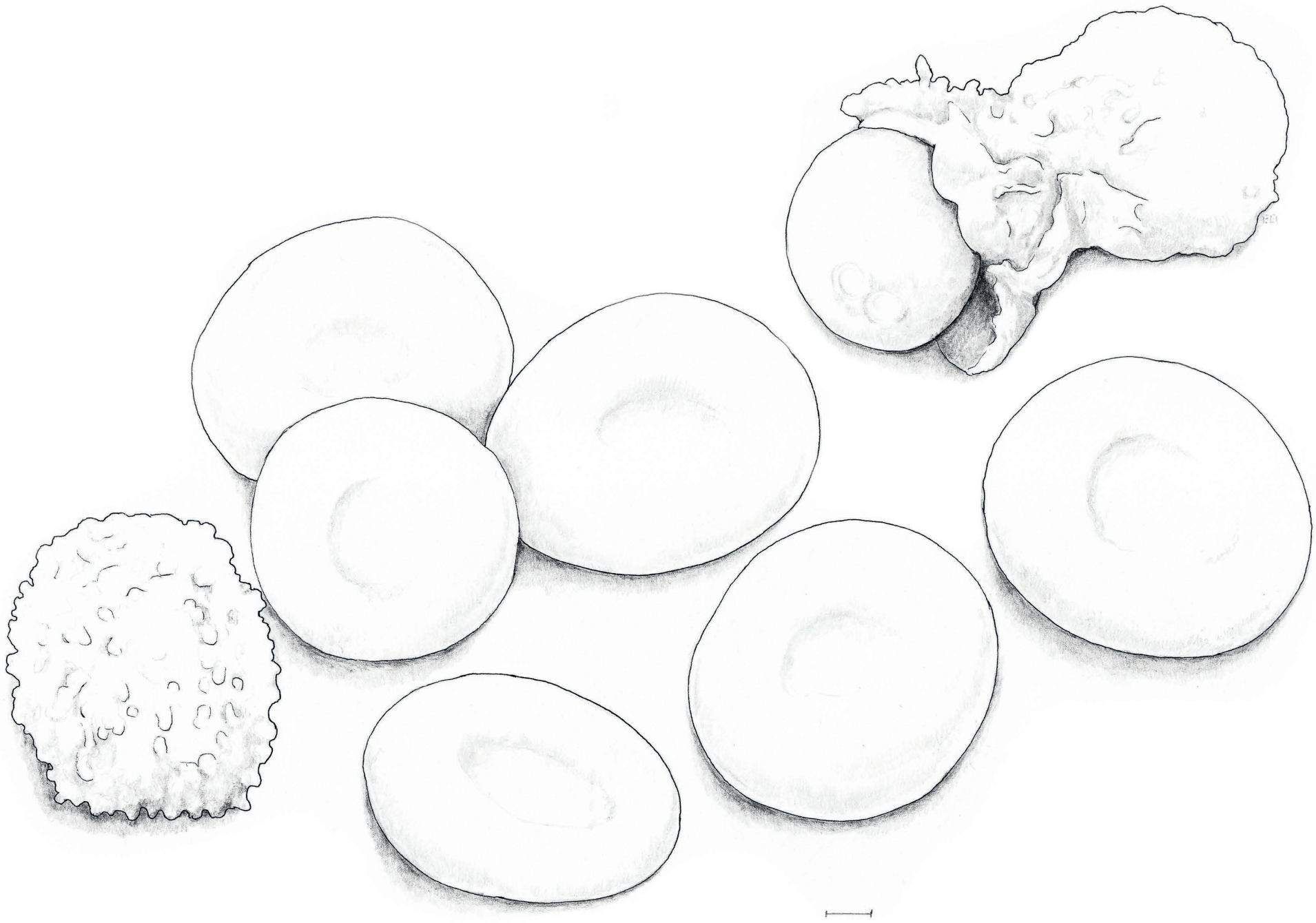
OUR HEROIC BODIES

Phagocytosis

The most common type of white blood cell is seen in the drawing – called a neutrophil; it has spotted an intruder, in this case a type of yeast. At a tiny microscopic scale these remarkable cells can swallow up and eat up invaders and so protect us from getting unwell. This process is called 'phagocytosis' where 'phago' means to eat in Greek.

In the drawing other cells are seen including red blood cells that carry oxygen. These cells should be red in colour but experiment with shading and adding other colours to bring them to life. In the bottom corner is another type of white blood cell called a T cell. T cells can produce toxic chemicals to kill infected cells, and help attract other killer cells.

The line is a scale and represents one micrometre (thousandth of a millimetre). More than ten red blood cells would fit across the width of a human hair.



OUR HEROIC BODIES

White Blood Cells

Our white blood cells protect us from illness. There are different types of white blood cells, including neutrophils and macrophages which can eat up invaders that are tagged by antibodies, while T cells can directly kill infected cells through toxic chemicals.

This drawing shows another type of white blood cell in our immune system; B cells. On the left a B cell is resting, while on the right a B cell has become active and is busy making antibodies after recognising the intruder.

Take a look at the insides of both cells. Each cell contains a nucleus where DNA is found. The cell on the right is full of lines (endoplasmic reticulum) where copies of genes are used as instructions to make proteins, in this case antibodies. Antibodies will stick to one specific invader to mark it for destruction by neutrophils or macrophages so as to get us better again.

The line is a scale and represents one micrometre (thousandth of a millimetre). About ten white blood cells would fit across the width of a human hair.

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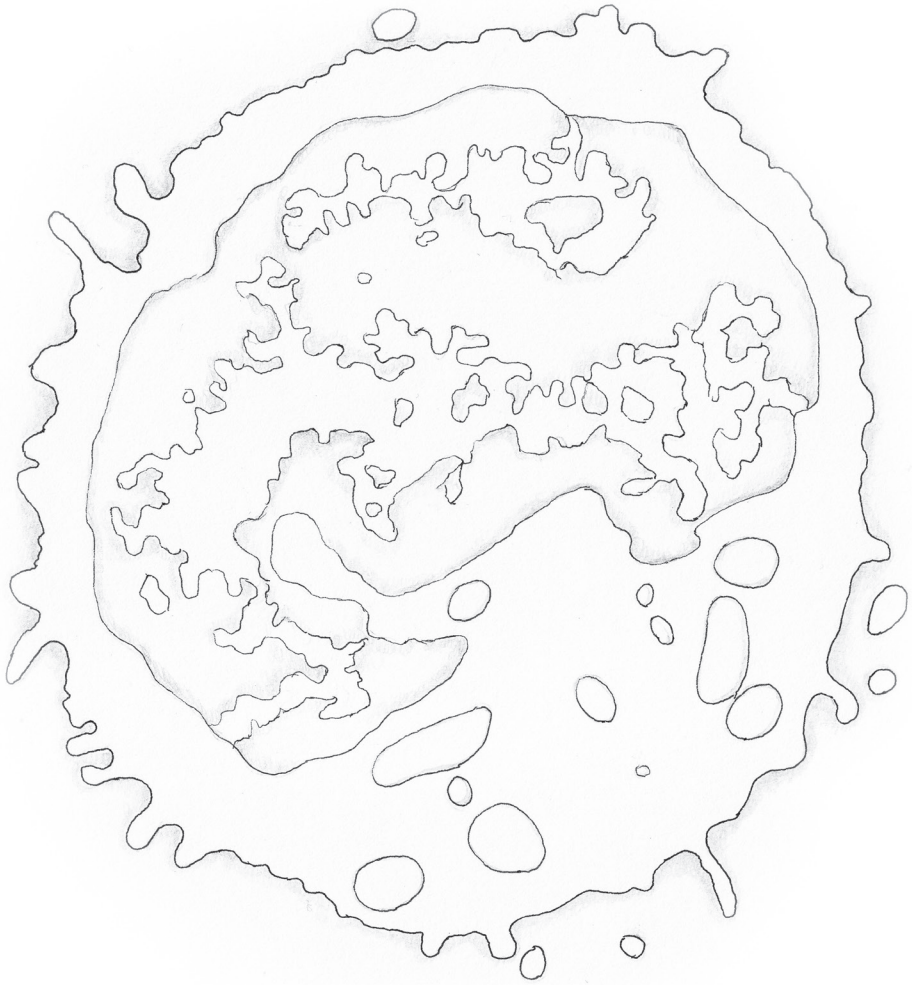


OUR HEROIC BODIES

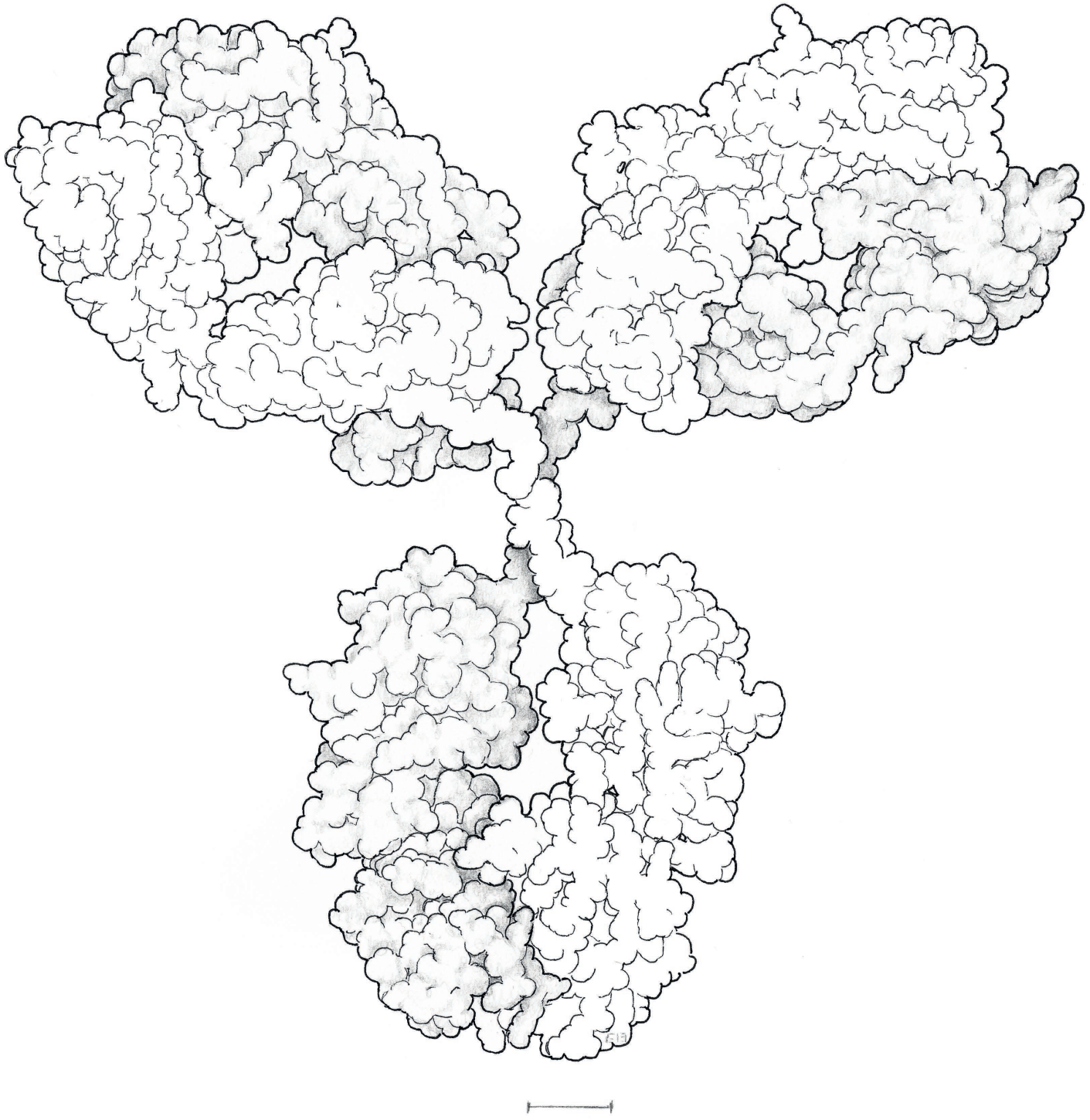
Antibody

Our white blood cells protect us from bacteria and viruses that could make us unwell. Once a white blood cell spots an invader they can eat it up (neutrophils or macrophages) or kill the infected cell through toxic chemicals (T cells) to keep us well.

White blood cells detect intruders (pathogens) when they get decorated by tiny Y-shaped molecules called antibodies. As their name suggests antibodies stick to things that are not from our body. Antibodies are made by B cells. These cells detect pathogens and make very specific antibodies to tag them and mark them for destruction. The tagged pathogens are then eaten up (phagocytosis) by other specialised white blood cells including neutrophils and macrophages.

Add colour to this Y-shaped molecule. The tips of the arms at the top will stick to an intruder and mark them out for destruction. These molecules are remarkable in being so diverse and specific to each pathogen we encounter. This is possible because our B cells can generate endless possibilities for the tips of the arms and create novel antibodies against any new pathogen to keep us well.

The line is a scale and represents one nanometre (millionth of a millimetre). About 10,000 antibodies would fit across the width of a human hair.



OUR HEROIC BODIES

Bacteria: Diphtheria

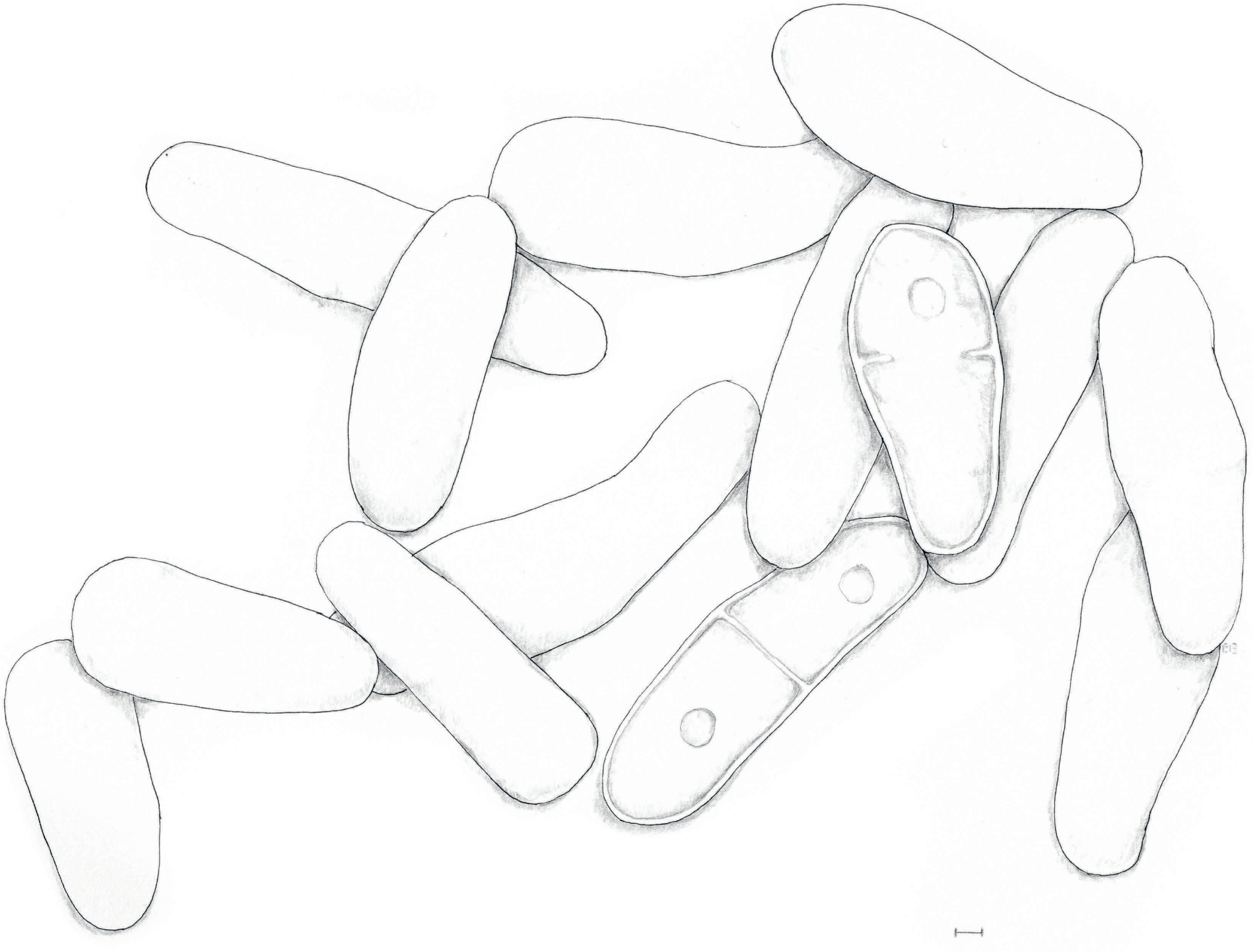
Our immune system protects us from illness. Most bacteria are not harmful and help us in so many ways such as helping to digest food in our guts.

Some bacteria that can make us unwell are caught from other people. When we are young our immune system is only just starting to get good at spotting intruders. If our white blood cells are unable to destroy an intruder fast enough, we can quickly become unwell and need help. A vaccine contains a safe form of the bacteria to encourage our body to make antibodies. Once exposed to the bacteria from the vaccine our immune system 'remembers'. This means our body is ready to recognise the bacteria and destroy it before it can make us unwell. This means you will have immunity to this bacteria.

What is diphtheria?

This bacteria (*Corynebacterium diphtheriae*) can be caught from other people who have it through touch or coughs. Most of the time we would never know about this illness as we are protected by our immune system. When young our immune system is only just learning and without a vaccine we can become unwell. Symptoms include high temperatures, difficulty breathing and swallowing, ulcers and it can even cause death. With bacteria, antibiotics can help but the best way to protect ourselves is through a vaccine so our immune system is prepared. In 1990 about 8,000 people worldwide died from diphtheria who were mostly children. By 2015 this was down to 2,100 due to more vaccines being available.

Take a look at the drawing to see the surprising beauty of diphtheria. Bacteria are smaller cells than our own. The inside of a couple of bacteria can be seen with their own nuclei. The line is a scale and represents a tenth of a micrometre (ten thousandths of a millimetre). Around 30 diphtheria bacteria cells lined up lengthwise would fit across the width of a human hair.



Bacteria: Diptheria

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OUR HEROIC BODIES

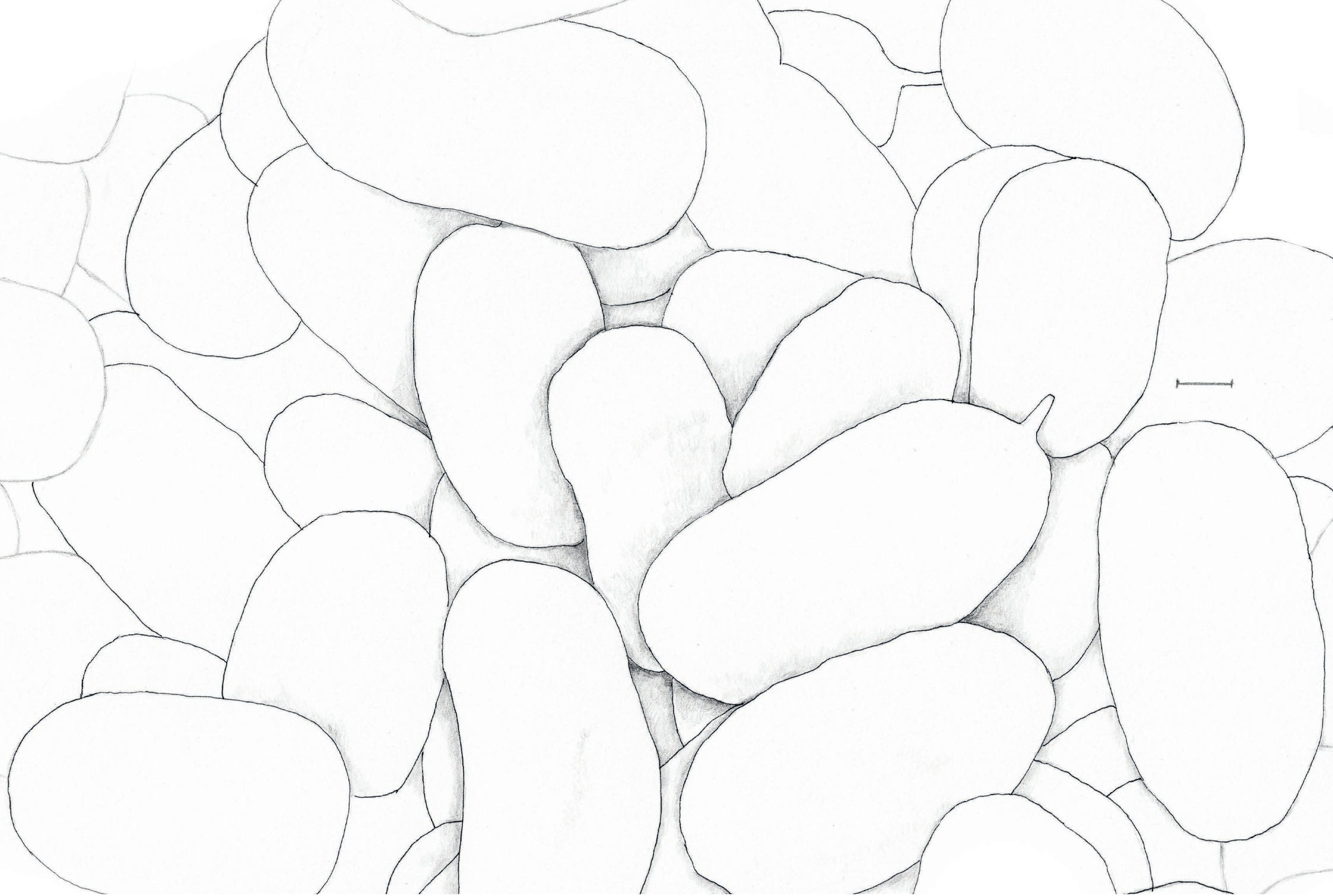
Bacteria: Whooping Cough

Our immune system protects us from illness. Most bacteria are not harmful and help us in many ways.

Some bacteria that can make us unwell are caught from other people. When we are young our immune system is only just starting to get good at spotting intruders. If our white blood cells are unable to destroy an intruder fast enough, we can quickly become unwell and need help. A vaccine contains a safe form of the bacteria to encourage our body to make antibodies. Once exposed to the bacteria from the vaccine our immune system 'remembers'. This means our body is ready to recognise the bacteria and destroy it before it can make us unwell. This means you will have immunity to this bacteria.

What is whooping cough?
This illness is caused by a bacteria also known as pertussis (*Bordetella pertussis*) that can be caught from other people who have it through touch or coughs. Most of the time we would never know about this illness as we are protected by our immune system. When young our immune system is only just learning and without a vaccine we can become unwell. Symptoms include a severe 'whooping' cough with problems breathing, which can develop into pneumonia. With bacteria, antibiotics can help but the best way to protect ourselves is through a vaccine so our immune system is prepared. In 1990 about 138,000 people worldwide died from whooping cough who were mostly children. By 2015 this was down to 58,700 due to more vaccines being available.

Take a look at the drawing to see the surprising beauty of pertussis. Bacteria are smaller cells than our own. The line is a scale and represents a tenth of a micrometre (ten thousandths of a millimetre). Over 100 pertussis bacterial cells lined up lengthwise would fit across the width of a human hair.



OUR HEROIC BODIES

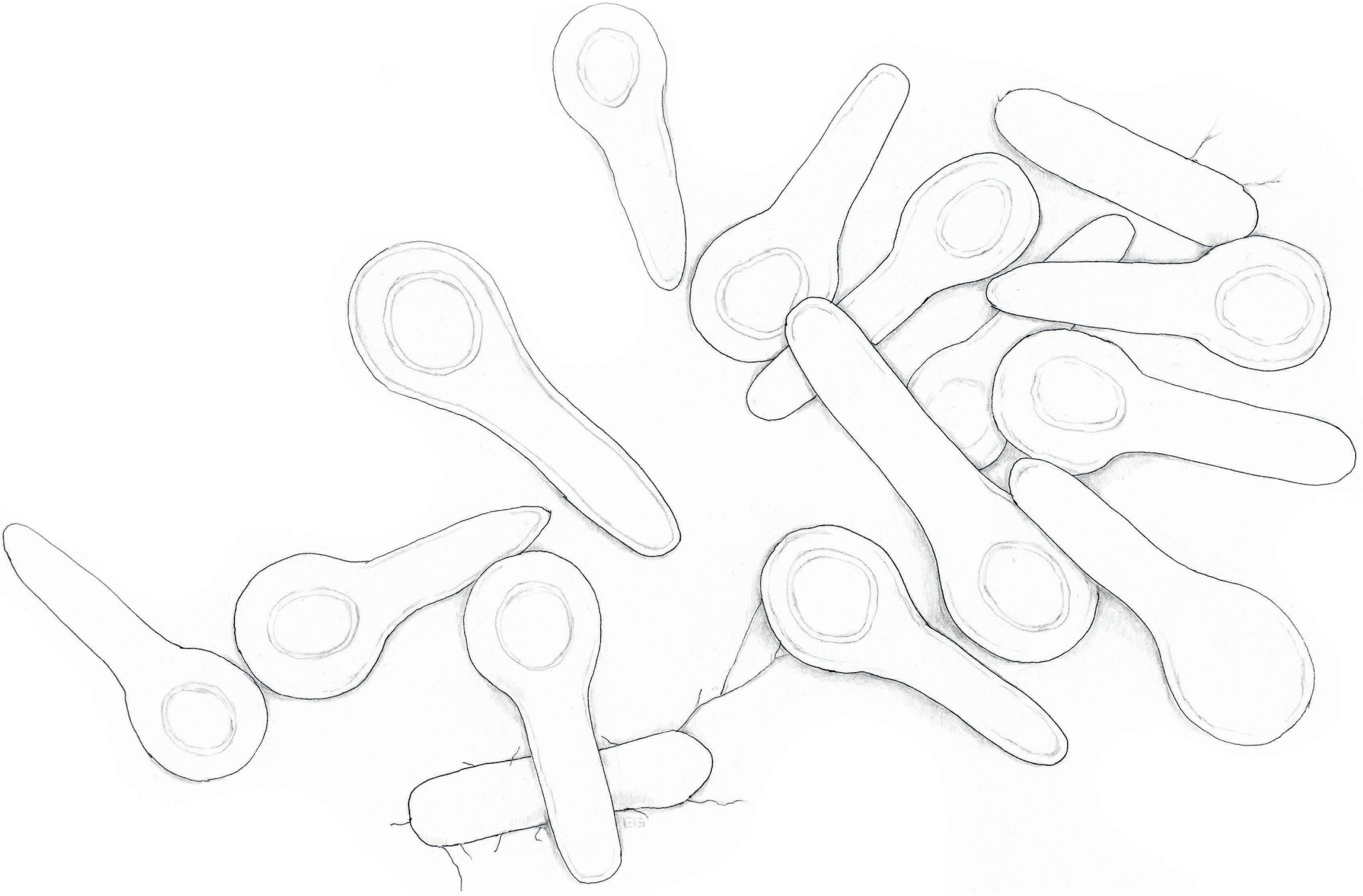
Bacteria: Tetanus

Our immune system protects us from illness. Most bacteria are not harmful and help us in many ways.

Some bacteria can make us unwell. When we are young our immune system is only just starting to get good at spotting intruders. If our white blood cells are unable to destroy an intruder fast enough, we can quickly become unwell and need help. A vaccine contains a safe form of the bacteria to encourage our body to make antibodies. Once exposed to the bacteria from the vaccine our immune system 'remembers'. This means our body is ready to recognise the bacteria and destroy it before it can make us unwell. This means you will have immunity to this bacteria.

What is tetanus?
This bacteria (*Clostridium tetani*) naturally lives in soil and can make us seriously unwell. The bacteria makes a toxin that affects our nervous system leading to painful muscle contractions across the body, including jaw and neck, and interferes with being able to breathe. Known as 'lockjaw', this is a very serious illness. With bacteria, antibiotics can help but the best way to protect ourselves is through a vaccine to help our immune system to be prepared. In 1990 about 356,000 people worldwide died from tetanus who were mostly children. By 2015 this was down slightly to 209,000 due to more vaccines being available.

Take a look at the drawing to see the surprising beauty of tetanus which is quite distinctive. A single spore can be seen at the end of the cell giving it a drumstick-like shape. Spores are tough and can be resistant to heat and antiseptics. The line is a scale and represents a tenth of a micrometre (ten thousandths of a millimetre). About 40 tetanus bacteria cells lined up lengthwise would fit across the width of a human hair.



OUR HEROIC BODIES

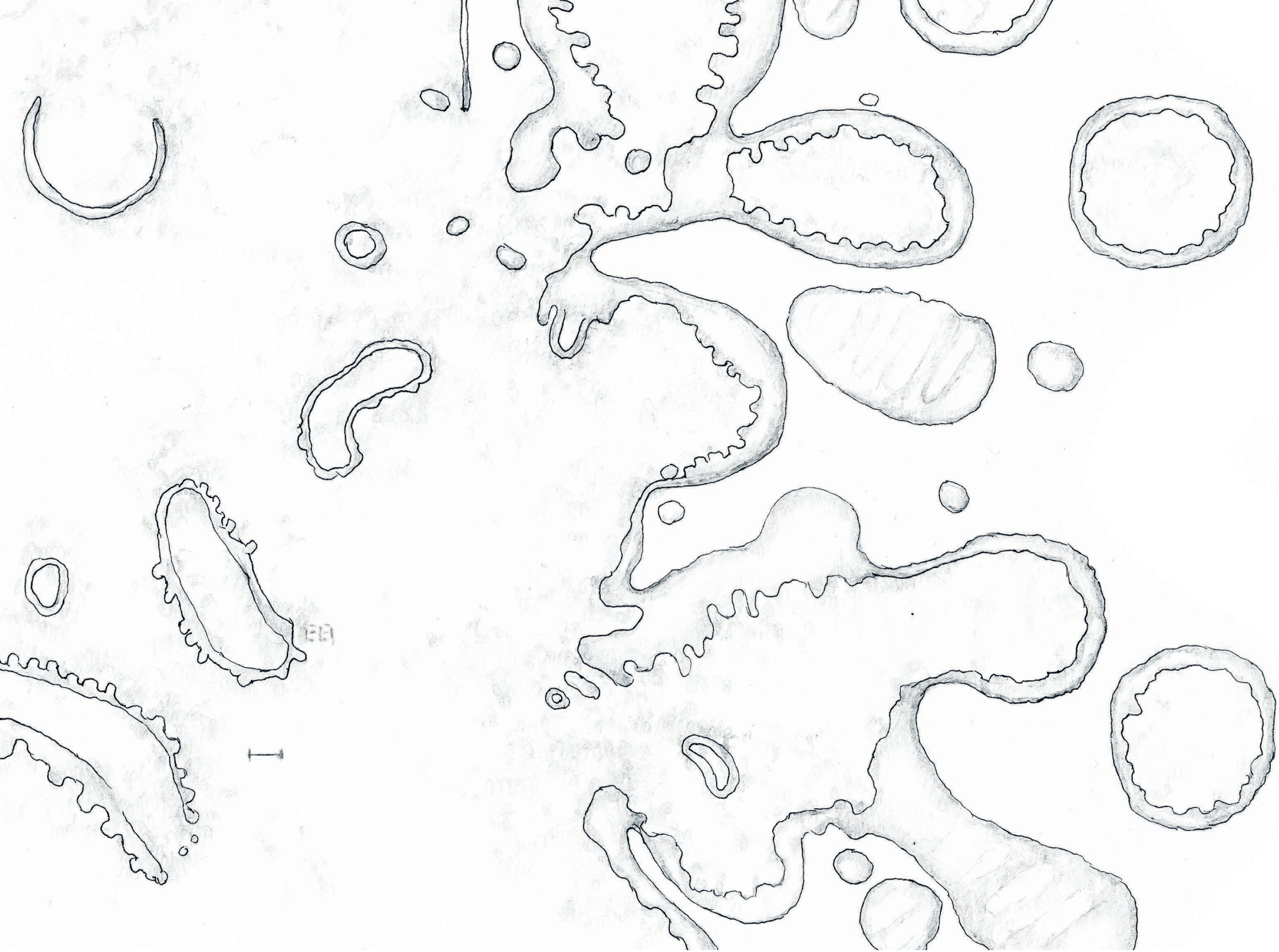
Virus: Measles

Our immune system protects us from illness. Most viruses are not harmful but some are contagious and can make us unwell.

When we are young our immune system is only just starting to get good at spotting intruders. If our white blood cells are unable to destroy an intruder fast enough, we can quickly become unwell and need help. A vaccine contains a safe form of the virus to encourage our body to make antibodies. Once exposed to the virus from the vaccine our immune system 'remembers'. This means our body is ready to recognise the virus and destroy it before it can make us unwell. This means you will have immunity to this virus.

What is measles?
This illness is caused by a virus that can be caught from other people through touch or the air. Measles can bring on a fever, and can result in an itchy rash. For some people it can become more serious with life-threatening complications with infection in the lungs (pneumonia) and the brain (encephalitis). With viruses, antibiotics will not work, so the only way we can protect ourselves and others is through a vaccine. In 1980 2.6 million people worldwide died from measles who were mostly children. By 2014 this was down to 73,000 deaths due to more vaccines being available.

Take a look at the drawing to see the surprising beauty of measles. Viruses are tiny and take over our cells with instructions to make more viruses. They can be seen here emerging and bursting out like bubbles from an infected cell on the left. Each virus particle can infect other cells and spread, making us unwell. The line is a scale and represents 100 nanometres (ten thousandths of a millimetre). About 1,000 measles viruses would fit across the width of a human hair.



OUR HEROIC BODIES

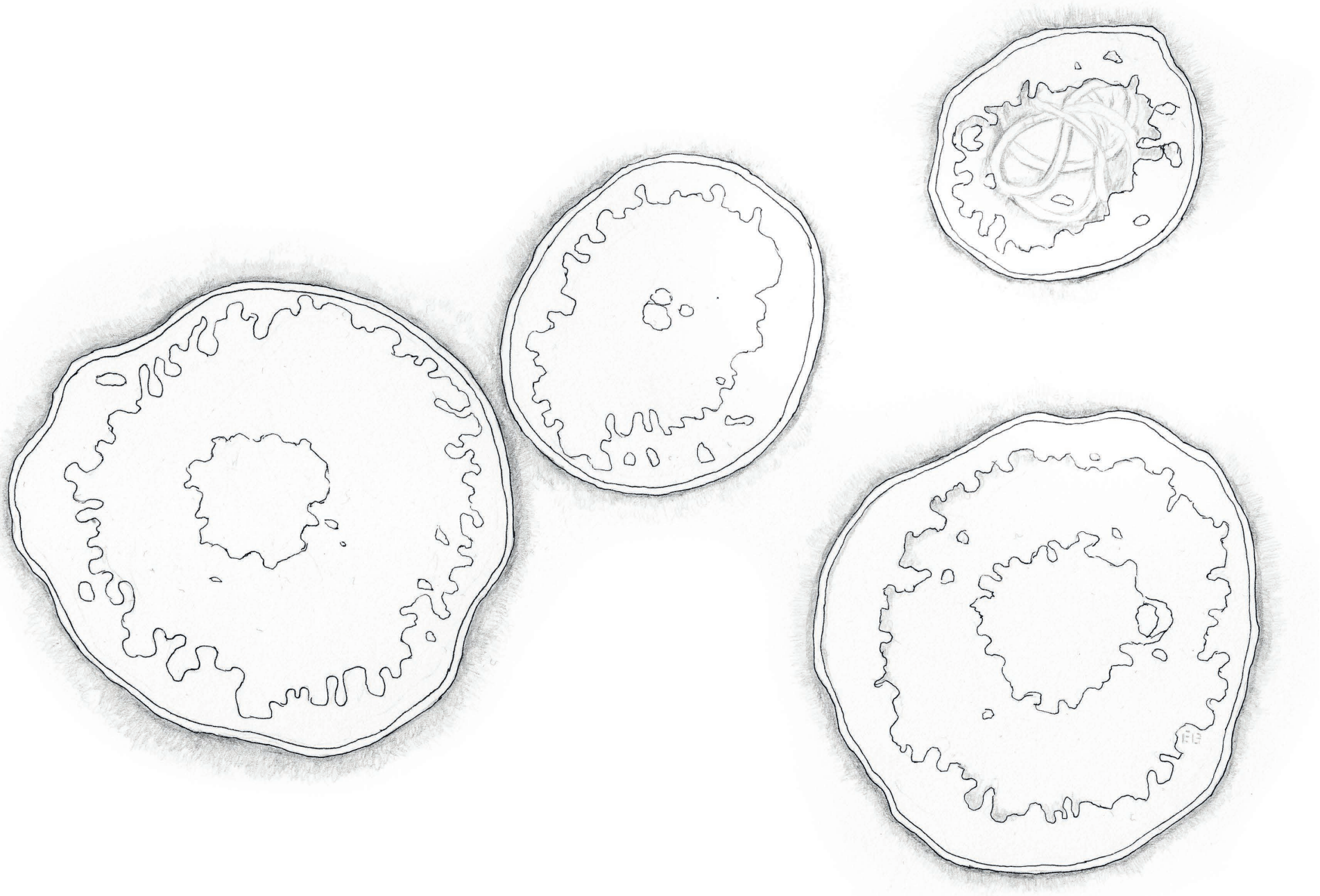
Virus: Mumps

Our immune system protects us from illness. Most viruses are not harmful but some are contagious and can make us unwell.

When we are young our immune system is only just starting to get good at spotting intruders. If our white blood cells are unable to destroy an intruder fast enough, we can quickly become unwell and need help. A vaccine contains a safe form of the virus to encourage our body to make antibodies. Once exposed to the virus from the vaccine our immune system 'remembers'. This means our body is ready to recognise the virus and destroy it before it can make us unwell. This means you will have immunity to this virus.

What is mumps?
This illness is caused by a virus that can be caught from other people through touch or the air. Mumps is associated with headaches, joint pains, and swelling of the face and glands in the neck. In some rare cases it can develop into meningitis, or lead to deafness or inflammation of the testes, and in some cases infertility. With viruses, antibiotics will not work, so the only way we can protect ourselves and others is through a vaccine. Where most people are vaccinated within a community, protection for everyone – including those who cannot be vaccinated – is high. This is called 'herd immunity'. Where fewer people have been vaccinated, the whole community becomes vulnerable to developing the disease and passing it on to others. This can be especially dangerous for the very young, old or those with weak immune systems.

Take a look at the drawing to see the surprising beauty of mumps. They are quite variable in size and like many viruses are so small they can only be seen using an electron microscope – but even then, are not clearly seen. Viruses have an outside called a capsid to attach and enter cells with genetic material to direct the cell to make more viruses. The line is a scale and represents 100 nanometres (ten thousandths of a millimetre). About 500 mumps viruses would fit across the width of a human hair.



Virus: Mumps

OUR HEROIC BODIES

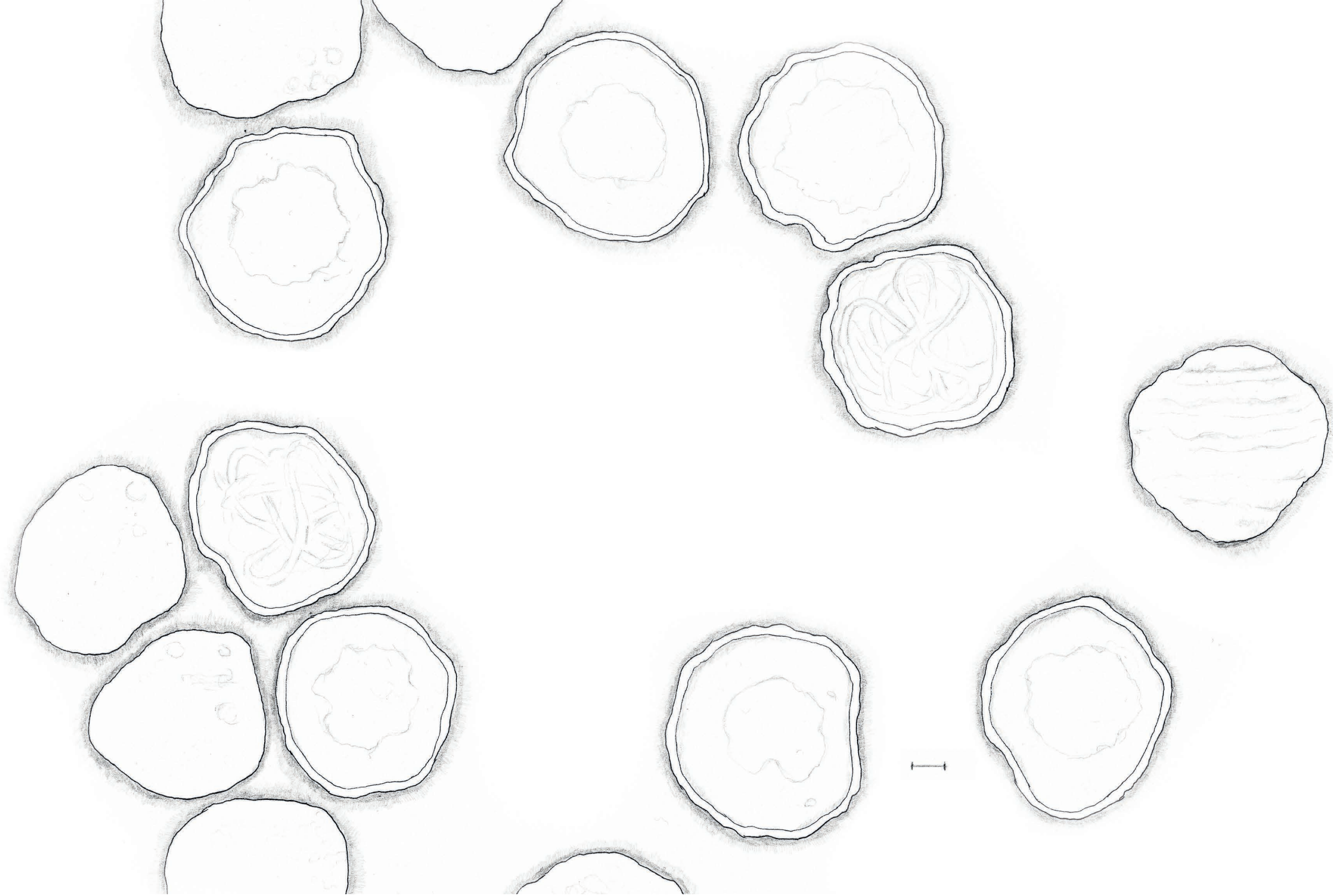
Virus: Rubella

Our white blood cells protect us from illness. Most viruses will not harm us but we know about them when we get unwell.

When we are young our immune system is only just starting to get good at spotting intruders. If our white blood cells are unable to destroy an intruder fast enough, we can quickly become unwell and need help. A vaccine contains a safe form of the virus to encourage our body to make antibodies. Once exposed to the virus from the vaccine our immune system 'remembers'. This means our body is ready to recognise the virus and destroy it before it can make us unwell. This means you will have immunity to this virus.

What is rubella?
This illness is caused by a virus that can be caught from other people through touch or the air. Rubella is associated with fever, joint pains and swelling. In some rare cases it can develop into meningitis. For women who are pregnant this can affect their developing baby leading to problems with their heart, brain, vision and hearing, or lead to a miscarriage. With viruses, antibiotics will not work, so the only way we can protect ourselves and others is through a vaccine.

Take a look at the drawing to see the surprising beauty of rubella. At such a tiny scale viruses are so small they can only be seen using an electron microscope – but even then, are not clearly seen. Viruses have an outside called a capsid to attach and enter cells with genetic material to direct the cell to make more viruses. The line is a scale and represents 100 nanometres (ten thousandths of a millimetre). More than 1,000 viruses would fit across the width of a human hair.



Virus: Rubella

British Society for immunology

OUR HEROIC BODIES

Virus: Flu & Edward Jenner's Discovery

Our immune system protects us from illness. In most cases it keeps us healthy, but particularly when we are very young or old our immune system may be unable to act fast enough and we become unwell. A surprise observation by English doctor and scientist, Edward Jenner, in 1796 led to a revolutionary finding and way to help our immune system protect us even more.

Helping our body help itself

In Edward Jenner's time there was an outbreak of smallpox with more than a third of people dying from this virus or left severely scarred or blind. Edward noticed most milkmaids were well and appeared protected from the disease. Jenner had an idea (hypothesised) that milkmaids caught a different sort of pox, called cowpox from the cows, which was a less severe virus and meant they were protected from catching the more serious smallpox virus. Jenner found that taking a sample from a cowpox blister from one person could help another person become protected from the disease. This led to the invention of vaccines to protect us from serious illness.

Jenner's legacy

In most cases when we are unwell it is our own body that helps us get better. Jenner's discovery led to a way we can help prepare our body so our white blood cells are ready if ever we encounter the virus or bacteria again. These days there are different types of vaccines which help boost our body's immune system including showing our body just a tiny bit of the outside of a virus, or bacteria, or a more complete version that is harmless to us. Thanks to Jenner's discovery leading to vaccinations, the last person diagnosed with smallpox was in 1977, and by 1980 this disease was completed eradicated as a cause of human suffering.

Take a look at the drawing to see the surprising beauty of flu virus. At this scale the virus particles are so small they cannot be seen well even using the most powerful microscopes. Increasingly scientists are using more detailed understanding of the components of viruses, including computer models, to help create new vaccines. The flu virus can evade our immune system through evolving and so scientists need to continually create new vaccines for each new virus strain. The line is a scale and represents 10 nanometres (one hundred thousandths of a millimetre). More than 1,000 flu viruses would fit across the width of a human hair.

While some of us may not enjoy having an injection, vaccines are the safest and the most effective way to protect ourselves and those around us from serious diseases. When most people are vaccinated within a community, protection for everyone, including those who cannot be vaccinated, is high. This is called 'herd immunity'. Where fewer people have been vaccinated the whole community becomes vulnerable to developing the disease and passing it on to others. This can be especially dangerous for the very young, old or those with weak immune systems. Vaccines help each other and our body do its wonderful thing. We will never know all the diseases our immune system has saved us from; it is our everyday hero. We hope you have enjoyed finding out more about your amazing body, vaccines, bacteria and viruses while getting creative at the same time.