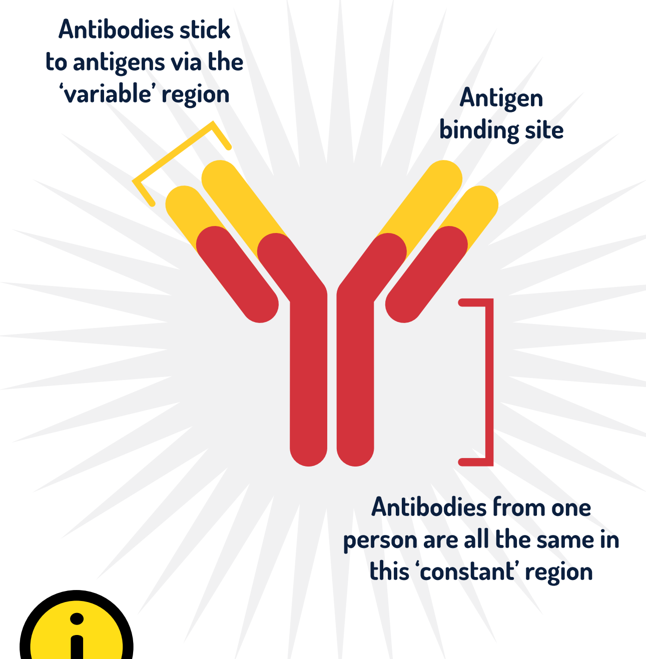
Antibody production before an attack...

Our immune system has the potential to produce 10 billion different antibodies, even before it meets an invader! Antibody generation starts in developing B cells, beginning before you are born and continuing throughout life. Each antibody has a different 'variable' region, the top of the 'Y' shape, where antigen-recognition and binding takes place.

A process used to create variation in antibodies is called 'V(D)J' recombination. This involves shuffling of different variable (V), diversity (D) and joining (J) genes. Because there are hundreds of V genes, tens of D genes and only a few J genes there is huge potential to create a range of antibodies.

Ask about our 'V(D)J' jigsaw games to learn more about antibody production.



- Other autoimmune diseases include multiple sclerosis, rheumatoid arthritis and type-1-diabetes

- Antibodies are specific to one antigen – they fit with only one antigen like a key fits only one lock

What happens to our immune system as we get older?

Your immune system protects you from diseases. It changes throughout your life; getting stronger and stronger from birth to becoming an adult. Vaccinations against diseases work by teaching your immune system to recognise a pathogen without having to suffer from the disease.

As we go beyond middle-age, our immune system has trouble defending against attack, so we are more likely to catch infections. This happens because the thymus shrinks and produces fewer T cells with diverse antigen receptors; also fewer B cells are made, reducing the range of antibodies produced, therefore vaccinations are less effective.

At the Babraham Institute we're trying to work out why the immune system changes as we get older – once we know, we hope to be able to add something to vaccines for older people so they will be more effective.

What happens when your immune system goes wrong?

If something goes wrong with your immune system you may suffer from immunodeficiencies or autoimmune disease. Immunodeficiency occurs when your immune system becomes compromised or it is not present at all; this means that the body is very vulnerable to infections. Some people are born with immunodeficiency; others become immune deficient following treatment for other diseases or after organ transplant.

Autoimmunity is when your immune cells recognise your body's cells as pathogens and attack. Rheumatoid arthritis is an example of an autoimmune disease – it occurs in the joints and causes pain and impaired movement.

- The flu virus continually changes and evolves, so scientists have to re-develop the flu vaccine and we have to have another jab each winter

This image shows the effect of the ageing process on the mouse thymus. As the mouse ages the thymus shrinks, and changes in its structure occur which means that fewer T cells are produced. (image from Frontiers in Bioscience 16, 2461 – 2477, June 1, 2011)

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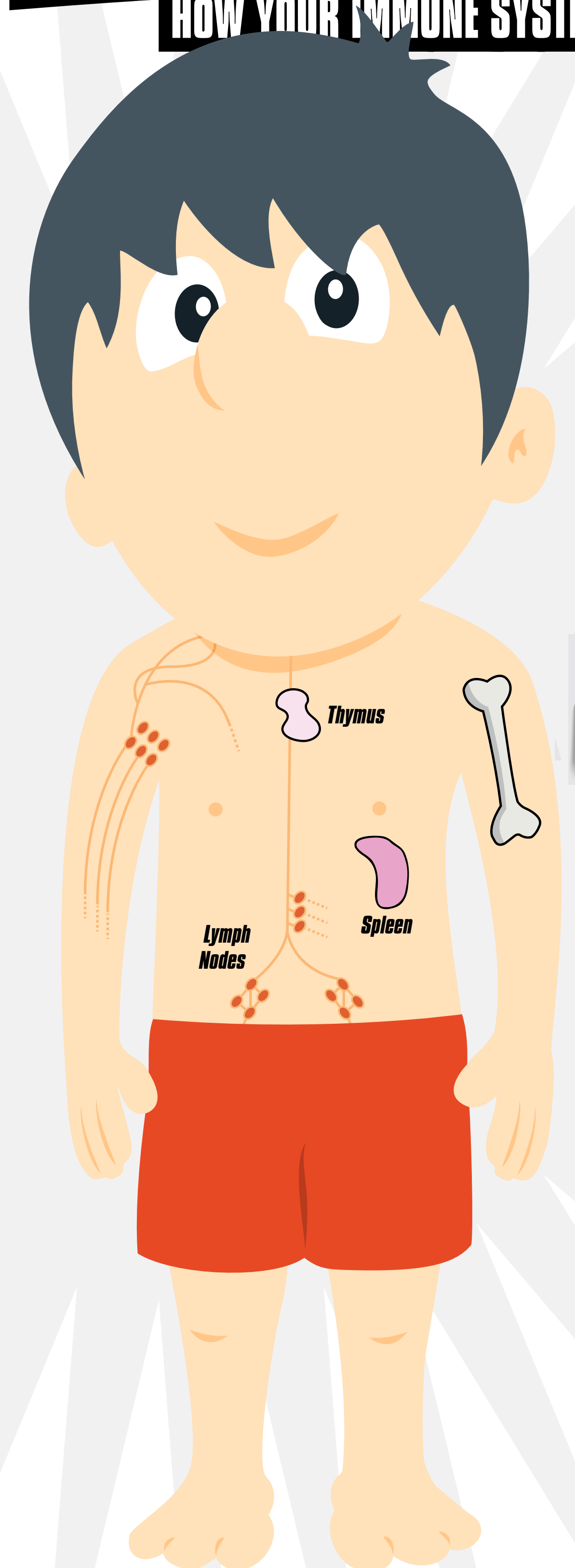

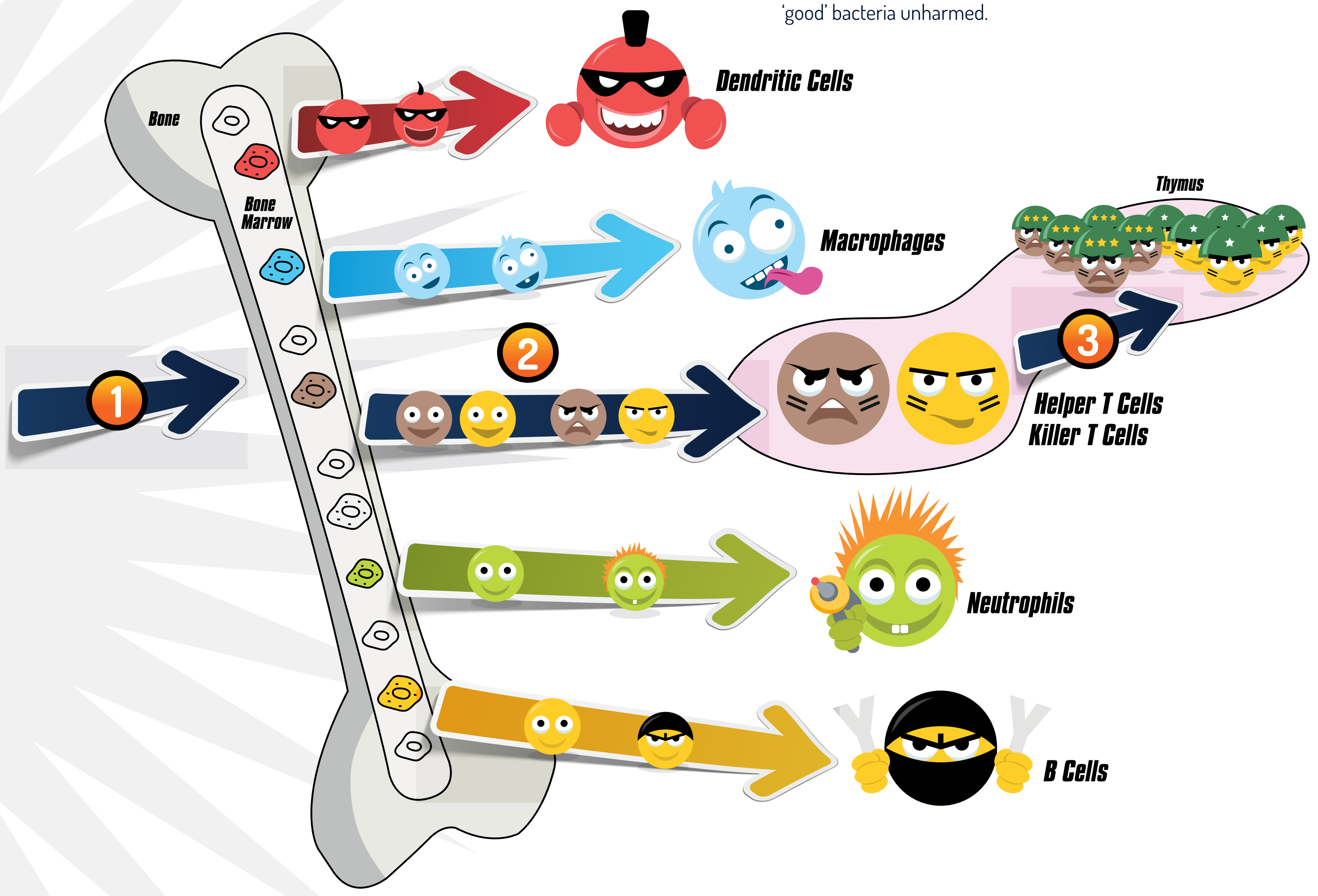

1 Immune cells are white blood cells which are made in your bone marrow from haematopoietic stem cells

2 One stem cell can make any of the immune cells, which cell they become depends on what cells are needed or what invader is attacking

3 T cells are further developed in the thymus, hence the name 'T cells'

Why do we need an immune system?

Your body is under attack! All around you are pathogens – or germs – that cause disease: bacteria, viruses, fungi and parasites are in the air we breathe, the food we eat and on the surfaces we touch. Colds, flu and chicken pox are caused by viruses, tiny particles that enter healthy cells. Bacteria are larger than viruses, but still smaller than a human cell. Some bacteria are harmless or even helpful; the 'bad' bacteria can cause stomach upsets and other diseases. **But don't panic!** Your immune system works day and night to defend your body.

In response to the threats of attack your body has developed an immune system, an army of specialist cells equipped with high-tech weapons (e.g. **antibodies**) and sophisticated communication systems ready for battle. The immune system army is always on patrol, particularly at the sites where we are most exposed to the environment, such as our skin, lungs, and intestinal tract (gut). The specialist cells of the immune system identify and target invaders, destroying them whilst leaving your own cells and other 'good' bacteria unharmed.

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- The surface of your mobile phone holds about 4,000 bacteria per cm²; the total population of your smartphone could be roughly 700,000 bacteria!
- There are billions of bacteria in your gut – they help to digest vegetables and make some vitamins like Vitamin K

Your Immune System Army

Your immune system is a huge army of defender cells – these cells are white blood cells and are known as **leukocytes**. You make over a billion of them every day. These cells develop in your bone marrow from **'haematopoietic'** (he-ma-toe-po-etic) stem cells; just one of these cells can make any type of immune cell such as:

Macrophages – the clean-up crew – 'eat' any bacteria, pollen and even bits of our own damaged cells.

Dendritic Cells – the detectives – 'collect' parts of pathogens and show them to T cells and B cells, helping them to identify which pathogen to destroy.

Neutrophils – the body's rapid response force – first on the scene when you graze your knee or cut your finger; neutrophils travel through your blood and destroy the pathogens by 'eating' them.

B Cells – the ninjas – create weapons called 'antibodies', these are 'Y' shaped and stick specifically to a pathogen, helping other immune cells recognise and destroy it.

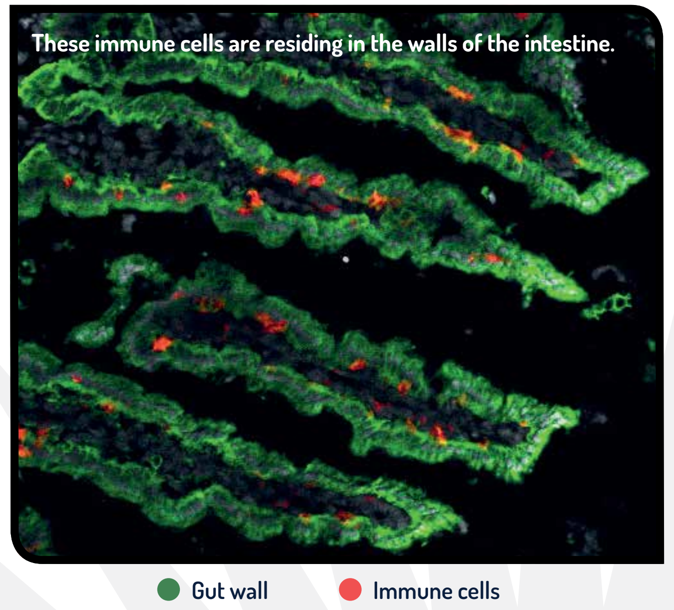
Helper T Cells – the sergeant majors – coordinate an attack by secreting molecules to boost antibody production and activate macrophages.

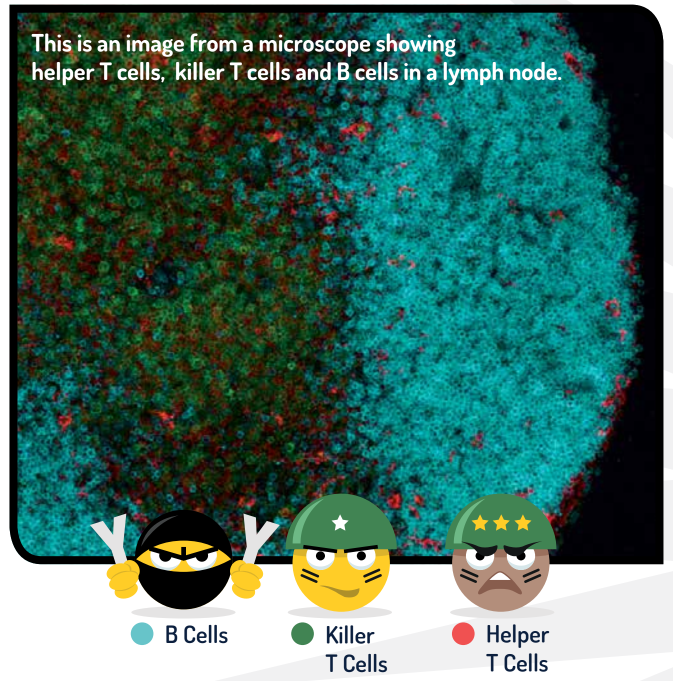
Killer T Cells – the soldiers of the immune system – recognise our cells that have been invaded by viruses and destroy them; they also recruit more macrophages to the site of an infection.

Where is our immune system? How do the cells know where to go?

Some immune cells reside in our tissues, but others travel around your body using two main routes; the circulatory system (your blood) and the lymphatic system. Both of these networks are made up of many tiny vessels allowing the cells to reach every nook and cranny of your body.

Within these networks there are meet-up points (like a base camp!) where your immune cells interact. The spleen and lymph nodes are examples of these meet-up points where immune cells share information they have found on their travels and instruct each other to help in the fight against an infection. Immune cells use signalling molecules, such as **cytokines**, to exchange information.





How does our immune system destroy invaders?

Your immune system has two strategies for destroying pathogens, **innate** and **adaptive** immunity. The cells of the innate immune system respond quickly within hours of infection; adaptive immunity is much slower and can take up to 1 week to reach full force.

Key players in innate immunity are always on guard and ready for action, they include: **epithelial barriers** – cells on our skin, in our gut and respiratory tract which act as physical barriers for pathogens – macrophages, neutrophils, natural killer cells and dendritic cells.

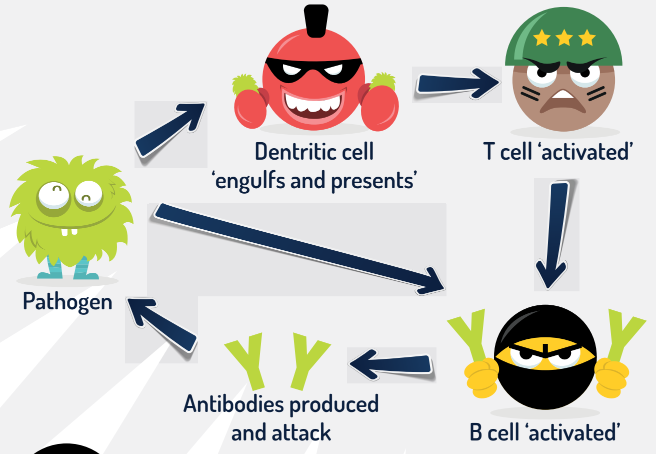
B cells, antibodies, T helper and T killer cells make up the adaptive immune response. After an attack some T cells and B cells become memory cells and act as scouts looking for the same pathogen in the future - this is called **immunological memory**. This allows you to mount a quicker and more effective immune response the next time around.

How does our immune system tell the good from the bad?

Our own cells, as well as the invaders, have unique identifiers which are recognised by immune cells and antibodies – these identifiers are called antigens.

A single invader can have hundreds of antigens, this allows many immune cells or antibodies to identify and start a counter-attack on the invader. T cells have **antigen receptors** which recognise one specific antigen, so they can identify a certain invader and decide how to deal with it. This is called **antigen specificity.**

Dendritic cells help T cells recognise pathogens by engulfing the pathogen and presenting parts of it to the T cells – this is called **antigen presentation.**



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- Antibodies bind invaders neutralising them, so they are unable to multiply or enter a cell, and marking them as meals for macrophages
- Vaccines are how we use immunological memory in medicine to give us immunity against a disease we haven't yet come across