Hello, I'm Dr Alex Lathbridge and this is Bitesize Biology.

This is episode three in a six-part series about Infection and Response. In this episode we're going to talk about vaccination, antibiotics and painkillers.

So vaccines are key to having a healthy population. Why are vaccines so important? Well, here's a little history lesson that'll make the rest of this episode a breeze, and it's one of my favourites.

There's a disease called smallpox, honestly, one of the deadliest diseases known to humans and been around for thousands of years. This isn't just like chicken pox. We're talking vomiting, fever, rashes that turned into fluid-filled blisters, scabbing, scarring and even blindness. 1 in 3 people would die, look up smallpox online and you'll see how bad it is. Well, how bad it was, because smallpox is, as of now, the only human disease to have been completely eradicated.

How? Let's go back to the 1500s in China. People would pick bits of smallpox scabs from an infected person. They would dry them, grind them up, and blow them into a healthy person's nostril using a pipe. The idea was that exposing patients to small amounts of the smallpox would make them immune to it later. Similarly in India, they would use a needle to transfer material from smallpox blisters to the skin of healthy children. And West Africans had long practiced the technique and, when enslaved and taken to America, their knowledge was taken with them.

But Europeans were relatively late to the game, only learning about it in the 18th century.

However, instead of using smallpox scabs, a man in the UK called Dr Edward Jenner did something different. He'd heard from communities that milkmaids who got the milder disease of cowpox never got smallpox. So he inserted the pus from a cowpox blister into the arm of a young healthy boy, who felt unwell for about a week or so, but then made a full recovery. Two months later, the boy had matter from a smallpox sore put into his arm and, as Jenner thought, the boy remained perfectly healthy.

This experiment is the one that has gone down in history, meaning that Dr Jenner gets called the father of vaccinations (apparently India and Africa and China don't count. I hope that your history teachers have taught you that achievements outside of the Western world do get overlooked a fair bit.)

In fact, the word vaccine comes from the Latin word for cow, vacca. Less than 200 years later after his experiment, with advances in medicine, smallpox was completely eradicated.

But why did this work? Let's break it down, so grab a pen:

Vaccines allow us to be protected from a specific disease in advance, protecting us from becoming ill, if our cells are invaded by that pathogen.

In the last episode, we talked about how our body has defence systems that can protect us from infection. (You should go back and listen if you don't know) but quick summary: antibodies are proteins produced by white blood cells, known as lymphocytes, to bind to specific antigens found on the surface of foreign cells (these are like ID cards to show which cells are yours and which are not).

After infections, memory lymphocytes are stored in the body (which is like having a database of pathogen ID cards) and so if you get infected by the same pathogen again, you can very quickly mass-produce the correct antibody. This makes us immune so the pathogen can't infect us.

So vaccines allow us to do the same thing, in a more controlled way. Basically, it's like having a tutorial level of a game, or instead of playing online with your friends, playing against bots.

Instead of blowing scabs up your nose or pricking you with pus, a small amount of a dead or inactive pathogen enters your body, usually via injection.

The pathogen still has its antigens all over so, despite it being weak or dead, the immune system still gets triggered, and it is GO TIME.

So first up, your lymphocytes produce the specific antibodies which target and bind to the antigen.

Other white blood cells called phagocytes then engulf and digest the pathogens (remember: this is phagocytosis).

And then memory lymphocytes that make the antibodies are stored in the spleen for many years.

So if you get exposed to the live version of the same pathogen, your lymphocytes can produce lots of antibodies really quickly and destroy the pathogen easily. Meaning you aren't going to get ill and are immune.

Remember, pathogens have their own specific antigens (those ID cards). Antibodies are very specific to one pathogen's antigens. So a vaccine for the virus that causes Measles can't also protect against the flu virus.

Speaking of which, some vaccinations, like the one that you have for the flu virus, wear off over time. I get my flu jab every year to stay immune. Basically, it's because some viruses replicate really fast and can mutate into new strains (remember not species, because viruses aren't alive like bacteria.)

And with a new strain comes new antigens, so new antibodies are required. Whereas other viruses, like smallpox or measles, are more stable and less likely to change.

But health doesn't start and end at one person, it's about community.

The majority of a population needs to be vaccinated against very serious diseases, like smallpox, as this means people are less likely to come into contact with disease-causing pathogens. This helps protect people who are more at risk or who are unable to be vaccinated.

This concept of a population being protected against a specific disease by a high percentage of them being vaccinated is called herd immunity.

Alright, that’s vaccines over but there aren’t vaccines for every type of pathogen. However, there are different types of medicines that can treat diseases: painkillers and antibiotics.

Painkillers are chemicals that reduce symptoms from pathogens but they don’t kill the pathogens themselves. It’s in the name: pain killer. These drugs help you deal with the symptoms of the illness, such as headaches, that occur while your immune system is fighting the pathogens.

Now, antibiotics are drugs that kill or stop the growth of one type of pathogen: bacteria.
They don’t work on viruses, like flu, only bacterial diseases.

Penicillin is a great example of an antibiotic. They destroy bacterial cells without killing your own body cells.

Antibiotics target specific bacteria, so it's important that you get prescribed the right antibiotic.

Since the introduction of antibiotics they had have a huge influence on the health of the world’s population. Lots of bacterial diseases that previously killed people are now able to be treated with antibiotics.

But there is one problem though: antibiotic resistance.

No, that isn’t the bacteria rioting or something. It’s when bacteria randomly mutate and become resistant to some antibiotics.

This happens in three ways:

1. Overuse of antibiotics, especially for conditions that don’t need them.

2. Patients not taking the full course of antibiotics that they’ve been prescribed, so some bacteria aren’t destroyed and have the opportunity to mutate

3. Antibiotics are overused in farming, to prevent disease in animals, but this can lead to resistant bacteria building up in the environment and spreading.

All of this behaviour combined can increase the likelihood of mutations leading to resistance, meaning that infections and diseases that we can treat today, might not be treatable in the future. Because recently we’ve not found many new antibiotics.

MRSA is a type of bacteria resistant to more than one type of antibiotic, so it's really hard to treat.

Viruses are not cured by antibiotics, so scientists develop anti-viral drugs to treat viruses.

But it is really difficult to develop successful anti-viral drugs, as viruses hide inside cells so they are hard to treat.

Before you go, I have a personal plea:

What I really want you to take away from today is that it's down to all of us to change the way we think about antibiotics. Because if we can limit their use to only when they're necessary, and everyone makes sure that they do finish a course of antibiotics when they're given them, we can keep the diseases of today treatable and make it easier to find even better treatments for diseases in the future.

I'm Dr Alex Lathbridge and this is Bitesize Biology – all episodes available on BBC Sounds