



MICROBE WARS



*Humanity's biggest battles with
the world's smallest life-forms*

Gill Arbuthnott • Marianna Madriz

MEET MORE MICROBES

You didn't think that was all of them, did you? The show goes on! These are the real A-Listers; you've probably heard about some before, or seen others on TV. But you wouldn't want to see them *all* performing live...

BACTERIA

All the world's a stage for bacteria: these single cells are found almost everywhere, including your skin and guts! In fact, you have at least as many bacteria cells in your body as human cells — so who's really in charge? Some bacteria make their own food, while many feed like fungi. Luckily, most bacteria are harmless or even super helpful, but others live as parasites in other living things and these can cause diseases like sore throats and food poisoning.

Help is at hand!
I'm *Bifidobacterium* and I'm a hero. I live in your gut and fight off invaders like *Clostridium*.
BIFF POW!

Everyone loves a villain, and I'm the worst of all! I'm *Clostridium botulinum* and I could end the world! But I probably won't.

HERO OR VILLAIN?

Clostridium botulinum bacteria live in soil, but occasionally gets into damaged tins of food. This bacteria makes the most toxic substance of any living thing — botulinum toxin. Less than 100 grams of it could kill everyone in the world, and people inject it into their faces! If you make it very dilute, it's called Botox and smooths out skin wrinkles, and can also help patients with chronic pain.

VIRUSES

Viruses aren't alive. They aren't even cells. They're just bits of DNA or RNA with instructions for making — you guessed it — more viruses, all wrapped up in protein and sometimes fat. They hijack cells, breaking in and making them produce more viruses. This damages the cells and causes diseases like flu and Covid-19. Viruses attack every living thing: even bacterial!

I'm avian influenza, the bird flu virus, and I'm always lurking in the wings!

I can pass between birds easily but I'm not good at infecting humans yet. Scientists are keeping an eye on me — and I love an audience!

I hope they throw these after the show!

I'm Potyvirus, the tulip-breaking virus. I can really ruin them, but I also give them amazing straggly flowers!

THE INVISIBLE THREAT

Although people have known since 1898 that viruses existed, they are so small that you can't see them with an ordinary microscope, which shines light through glass lenses. It wasn't until the invention of the powerful electron microscope in the 1930s that scientists saw a virus for the first time.

THE BLACK DEATH

You've probably heard of the plague, one of the scariest sicknesses in human history, but do you know the full story?

Ring a ring o' roses, a pocket full of posies, atishoo, atishoo, we all fall down!

In 1347, trading ships arrived in Sicily. Many of the sailors were dead or dying. The 'death ships' had brought Black Death (sometimes called plague) from Asia to Europe. It killed between a quarter and a third of Europe's population, then went very quiet from 1770.

When you sang 'Ring a ring o' roses, I bet you didn't know you were singing about *that!* The 'ring o' roses' rash and 'atishoo' sneezing were early symptoms. The 'pocket full of posies' was because people thought sniffing a bunch of flowers or herbs would protect them (it didn't).

We finally got the hang of London life, and we're beaten by a baker with an over-eager oven!

It's almost worth it to see them so miserable!

This is God's anger! You have sinned too much and prayed too little.

SMELLS, SPELLS & SPECULATION

In medieval Europe, nobody knew about microbes. So when they were struck with diseases for no clear reason, they looked for answers in religion and superstition. Here are some theories of the day...

I'm a good man, so it won't harm me. Just to make sure, I will donate this image of St. Sebastian to the church.

They say in London that wearing sapphires or amber will prevent this illness. Rich people are always right!

My friends told me it's caused by witches, so we're going to burn down Granny Ogg's cottage to stop her evil ways. I've never liked Ogg.

BUT WHAT REALLY CAUSED IT?

We're not absolutely sure, even now. Most scientists think it was caused by bacteria carried by fleas which live on rats. It's still around today and causes a disease called bubonic plague, but we can treat it now with antibiotics.

Other scientists think Black Death was caused by a virus that died out completely when Black Death vanished in the 17th century. If a virus kills almost everyone it infects, in the end it runs out of places to reproduce and fizzles out.

I've heard that bad smells cause it. If I smell this pot of sweet herbs, it might protect me.

Wear this around your neck. It's powdered toad, mixed with toad vomit. Trust me.

You're all idiots. It's the flea's fault.

No it isn't! It's the bacteria. You all need to learn some science.

LONDON BURNING!

The Great Fire of London in 1665 began in a bakery in Pudding Lane, in the midst of a plague outbreak that had killed one in seven Londoners. The flames destroyed most of the city, but it did destroy enough of the germs to end the wave of sickness.

SIGNS AND SYMPTOMS

The disease sometimes started with the rash and sneezing, then you would develop painful lumps called buboes in your armpits and groin and purple spots on your skin. The lumps, which were full of bacteria, turned black (hence the name) and if they burst, you were doomed...

We travelled around wherever people went, and if they couldn't find us, they couldn't stop us!

THE PLAGUE VILLAGE

In September 1665, fleas in a bale of cloth that had been sent to the Derbyshire village of Eyam from London started to bite people. Those people started to die of plague.

Somehow, the village rector, William Mompesson, persuaded most of the villagers to quarantine themselves, so they wouldn't spread plague to other towns. No one went in or out of Eyam. By November 1666, when the outbreak ended, 260 villagers had died, out of a population of fewer than 800, but their sacrifice had saved hundreds of other people.

200 YEARS OF HIDE & SEEK

Enough horror stories! Here are the lives of five intrepid intellectuals who put the 'search' into 'research'!



More like 200 years of you hunting us down and kicking us out! You're the worst housemates ever.



Wash your hands!

Why bother?

I have the cleanest hands in town. I wash them every week!

A WEISS DECISION

Before the mid-19th century, no one knew what caused infections like sepsis (blood poisoning from bacteria), so no one knew how to prevent them. This made hospitals incredibly dangerous. Doctors carrying out operations just wore their normal clothes, maybe an apron to catch bloodstains, walked from patient to patient and stuck their dirty hands straight in!

In 1847 a Hungarian doctor, Ignaz Semmelweis, started making medical students wash their hands after examining corpses. The death rate from infections in his hospital dropped from eighteen percent to one percent, but it still didn't catch on. Finally, in 1864 a French scientist, Louis Pasteur, proved that bacteria and viruses caused infections, and hospitals finally turned hygienic! You'll hear more about him in a minute...

SNOW VS. WATER

In the 19th century, people thought cholera was caused by miasma (bad air). But when John Snow (1813–1858) traced an outbreak in London to a public water pump, he found evidence that microbes in the water were behind it all! When the pump was closed, cholera cases fell sharply.

Not in the air, but perhaps in the water?

Crumb, he's onto us!

NOTHING GETS PAST PASTEUR

Louis Pasteur (1822–95) studied fermentation (the process that produces wine — see p. 43) and why wine spoiled, and he believed that it was all down to microbes. He discovered you could avoid wine spoiling by heating it up between 60 and 100 Celsius, killing the microbes off. Nowadays pasteurisation is used worldwide to destroy microbes in milk, fruit juice and beer.

But how did he prove Semmelweis right? Well, Pasteur also developed vaccines which would only have worked if Semmelweis' theories were correct. In 1881 he developed one against anthrax bacteria, and in 1885 he was working on one against the rabies virus, and tested it when nine-year-old Joseph Meister faced certain death after being mauled by a rabid dog. Luckily, the vaccine worked, saving Joseph's life.

Eugh, why do the humans always win?



LISTER'S LAST RESORT

Even with basic hygiene and anaesthetics, surgery was very risky. Surgeon Joseph Lister (1817–1912) knew about Pasteur's work and finally went to war with microbes, cleaning surgical instruments, wounds, and even surgeons' hands with carbolic acid. Lister's antiseptic system has saved countless lives.

It's okay, we'll only start chopping when you start napping.

You guys have washed that needle, right?

Quick, jab him!



Now surgery is carried out in aseptic conditions, by cleaning the room with antiseptics, filtering the air, heating up surgical instruments — and always washing hands!

FAR-FLUNG FRIEDMANN

Roseli Ocampo-Friedmann (1937–2005) was a Filipino-American scientist who wanted to find out how tough microbes are, and the extreme conditions they might be able to survive. She discovered microbes in areas presumed to be totally lifeless like the deserts of Antarctica, where Friedmann Peak has been named in her honour. Her work has even been used by NASA to theorise about microbes on Mars!

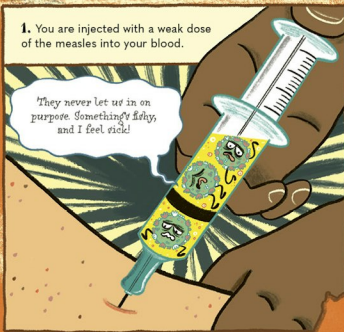


HOW VACCINATION WORKS

Immunisation is the effect of a successful vaccination. It tricks your immune system into making memory cells without you getting ill first. You're injected with a tiny dose of a bacteria or virus that has been killed or weakened. Vaccines cannot hurt you, but they still have antigens, so the immune system leaps into action. Let's try it with measles...

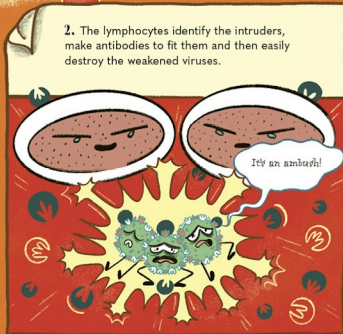
1. You are injected with a weak dose of the measles into your blood.

'They never let us in on purpose. Something's fishy, and I feel sick!



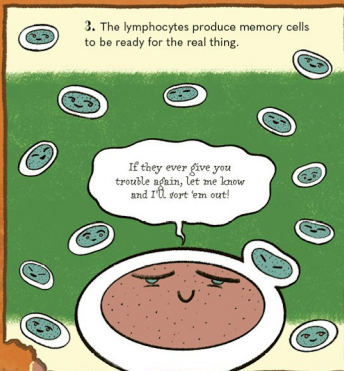
2. The lymphocytes identify the intruders, make antibodies to fit them and then easily destroy the weakened viruses.

It's an ambush!



3. The lymphocytes produce memory cells to be ready for the real thing.

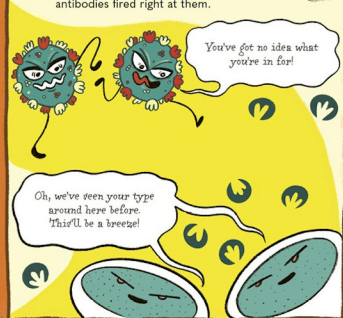
If they ever give you trouble again, let me know and I'll sort 'em out!



4. Now, if strong measles viruses ever enter your system, the memory cells can get antibodies fired right at them.

You've got no idea what you're in for!

Oh, we've seen your type around here before. This'll be a breeze!



Polio (virus)



Tetanus (bacteria)



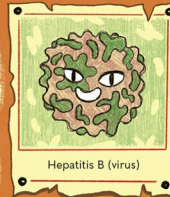
Measles (virus)



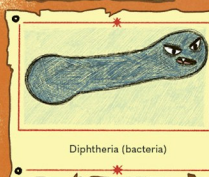
Rubella (virus)

Immunisation programmes now exist in every country in the world, and vaccines have saved millions of lives by protecting us against polio, diphtheria, tetanus, pertussis, measles, the Hib virus, rubella, hepatitis B and more.

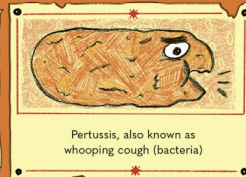
Still, we're always on the look-out for the worst offenders!



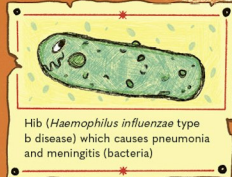
Hepatitis B (virus)



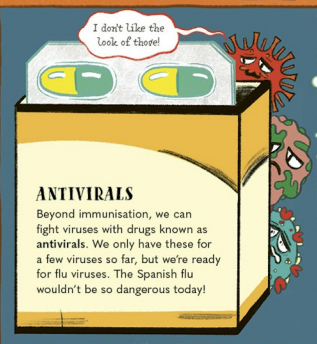
Diphtheria (bacteria)



Pertussis, also known as whooping cough (bacteria)



Hib (*Haemophilus influenzae* type b disease) which causes pneumonia and meningitis (bacteria)



I don't like the look of those!

ANTIVIRALS

Beyond immunisation, we can fight viruses with drugs known as antivirals. We only have these for a few viruses so far, but we're ready for flu viruses. The Spanish flu wouldn't be so dangerous today!



You can wash your hands, you can wear your masks, but you'd better get to work if you really want to stop us!

WHAT ABOUT NEW VIRUSES?

For new viruses, like COVID-19 (see p. 20), the effects can be disastrous if it's never infected humans before and spreads rapidly. After all, nobody has memory cells for a new virus, and we certainly don't have vaccines. We can only stave the virus off with antivirals and treatments to help with symptoms while scientists run to the labs!