How Vaccines Work

by Matt Boucher

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Infectious Disease

An infectious disease is a set of symptoms caused by **micro-organisms** such as bacteria and viruses. (A non-infectious disease, such as asthma, is caused by a person's environment, diet, lifestyle, or genes they inherit from their parents.) Micro-organisms are found all around us. Some even live on or in us. Normally they're harmless, but under certain conditions, they can cause disease. Then we call them **pathogens**.

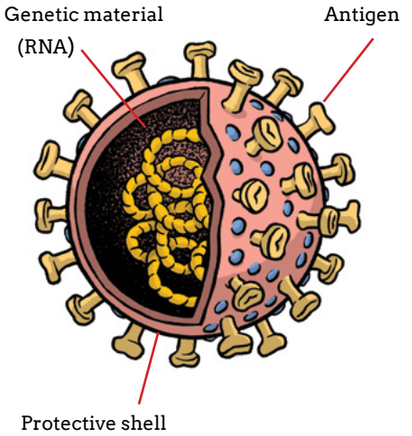
Many of the more common infectious diseases, including colds and chicken pox, are caused by a virus, and we all know about COVID-19 and its later **variants**. These viral super-spreaders resulted in chaos, lockdowns, and millions of deaths around the world. Viruses don't eat, grow, or reproduce on their own. Instead, they find a **host** and take over …

Virus Factories

Because viruses need a living thing to survive, they've become expert colonisers of cells. Take the virus that causes COVID-19. It's made up of genetic material covered in a protective shell – but this shell has a secret weapon. It contains a special protein, called an antigen, that mimics a signal the host cell recognises, a bit like wearing a disguise. Expecting the virus is one of the usual things that's allowed to enter, the host cell opens up, and the virus moves in.

Once inside, the virus gets to work. It uses its RNA to reprogramme the host cell to become a COVID-19 factory. The now infected cell copies the virus over and over. Eventually, the virus spreads to other cells, and if enough healthy cells are infected, the host becomes sick. Their immune system will either fight off the infection – and gain immunity – or the host will stay sick for longer or even die.

A COVID-19 VIRUS



micro-organism: a living thing that can only be seen through a microscope

pathogen: a virus, bacteria, or other micro-organism that causes disease

variant: a subtype of a micro-organism, which is slightly different from the first

host: a living organism (like you) that's been invaded by a pathogen

The Immune System

Your body has an answer to infectious diseases: the immune system. This vast network is divided into two parts: the innate immune system and the adaptive immune system. These parts work separately and together to fight infection within hours of a pathogen entering your body.

Once a pathogen has made its way past your skin, your body's first line of defence is the innate immune system. Cells in the innate immune system are constantly on the lookout. If they spot anything unfamiliar, they capture it and take samples. Although innate immune cells can work quickly to stop an invasion, they aren't specialists. There are some pathogens they can't recognise, and they can only respond in a limited way.

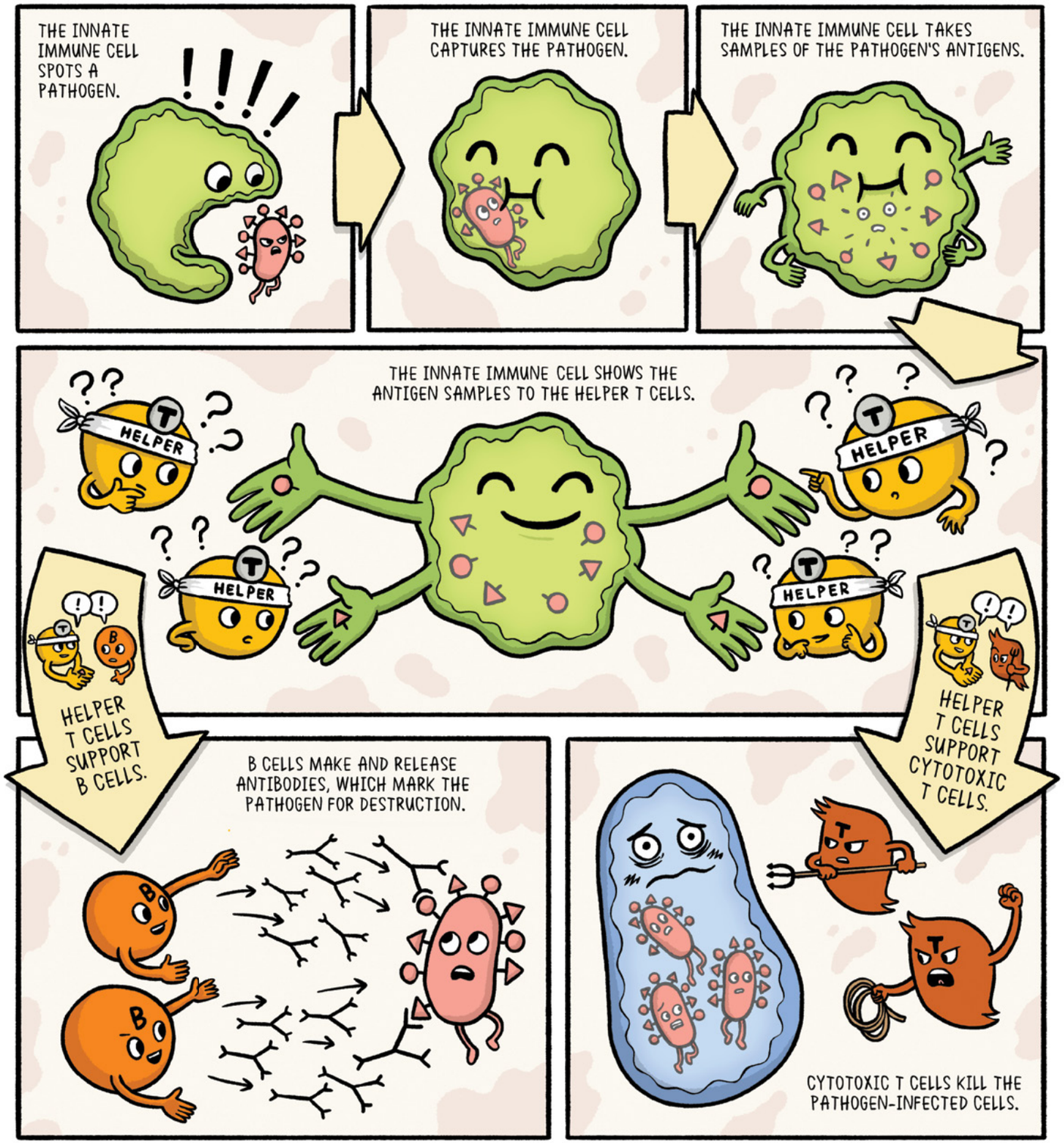
If the intruder isn't beaten back, the adaptive immune system joins the fight. The adaptive immune system contains cells that *are* specialists. Helper T cells recognise and use the samples of the pathogen's antigens to help B cells make **antibodies**, which stick to the pathogen and make it easier to target. Helper T cells also support another kind of T cell (called cytotoxic T cells) to hunt down and destroy any infected cells.

If things go to plan, the intruder is defeated, and the infected person and their immune system recover. But what if the pathogen re-attacks? To help the body stay on guard, the immune system makes **memory cells**. These stay in the body so that if the pathogen *does* return, the body will remember it and mount a more effective attack. The immune system can then work faster, the pathogen will be quickly defeated, and the person won't get as sick – if at all. We call this **immunity**.

antibody: a protein produced by the immune system to fight antigens

memory cell: a cell that stays in the body for a long time to "remember" a pathogen so it can help fight it

immunity: the ability to fight off an infectious disease



Training Your Immune System

Getting sick and recovering is one way to gain immunity. But it can be an unpleasant (and sometimes dangerous) experience. Luckily, scientists have found a much safer way to help your immune system deal with infectious diseases: vaccines. These train your body to fight off a pathogen quickly and effectively before it has the chance to take hold and make you sick – or spread to others.

A vaccine works by showing a pathogen's antigens to your immune system. This can be done in different ways. Some vaccines contain the dead or weakened pathogen; others contain just the pathogen's antigens. But a newer kind of vaccine uses a code called mRNA. This code tells your body to make copies of the antigens in order to train the immune system. In all of these cases, the immune system remembers this information and uses it to respond to an attack.

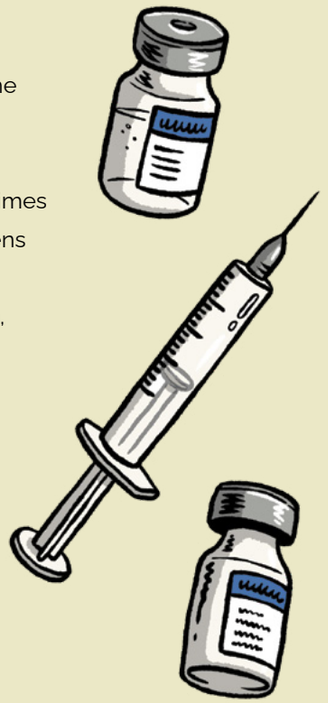
Memory cells can fade over time, especially with certain diseases. That's why some vaccines have a second or third dose – and even a booster shot. These vaccines keep your immune system trained and ready at all times.

Variants and Vaccines

Infectious diseases are often changing. We all know about the many faces of COVID-19 (including Delta and Omicron), and each winter, there always seems to be a different kind of flu.

Because all pathogens replicate themselves, they sometimes mutate. A mutation is a chance event (or mistake) that happens when genetic material is copied. Some mutations give a pathogen an advantage, and if that advantage is big enough, the mutation will take over and become a new variant.

A new variant can be good news for a pathogen. Sometimes, a vaccine won't work as well against it; other times, it won't work at all. Scientists keep a close eye on the most common and trickiest diseases so they can improve the vaccines we use to fight them, which is why we have a different vaccine for the flu each season.

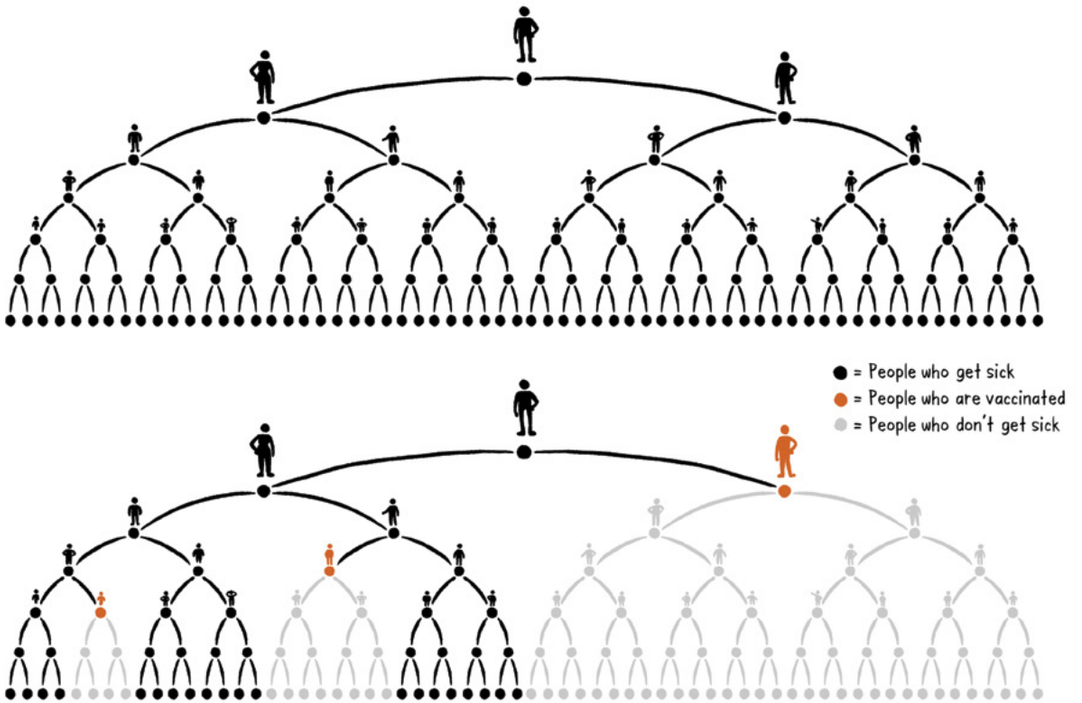


Protecting Our Communities

A vaccine doesn't protect only you. Getting vaccinated also protects the people around you because the disease has less chance to spread. If enough of us are immune, the disease can't spread at all. We call this herd immunity. Some diseases, such as polio, need 80 percent of people to be vaccinated to have herd immunity. Scientists now think that COVID-19 needs over 95 percent.

Herd immunity takes time. Sometimes, it can be difficult to achieve at all. However, the spread of infectious diseases can be slowed if enough people get vaccinated. Being vaccinated also helps protect vulnerable people in the community. Small children, the elderly, and people with health problems often have a weaker immune system, which makes it harder for them to fight disease. Other people can't be vaccinated, or a vaccine might not work as well for them. Being vaccinated helps you to care for everyone in your community.

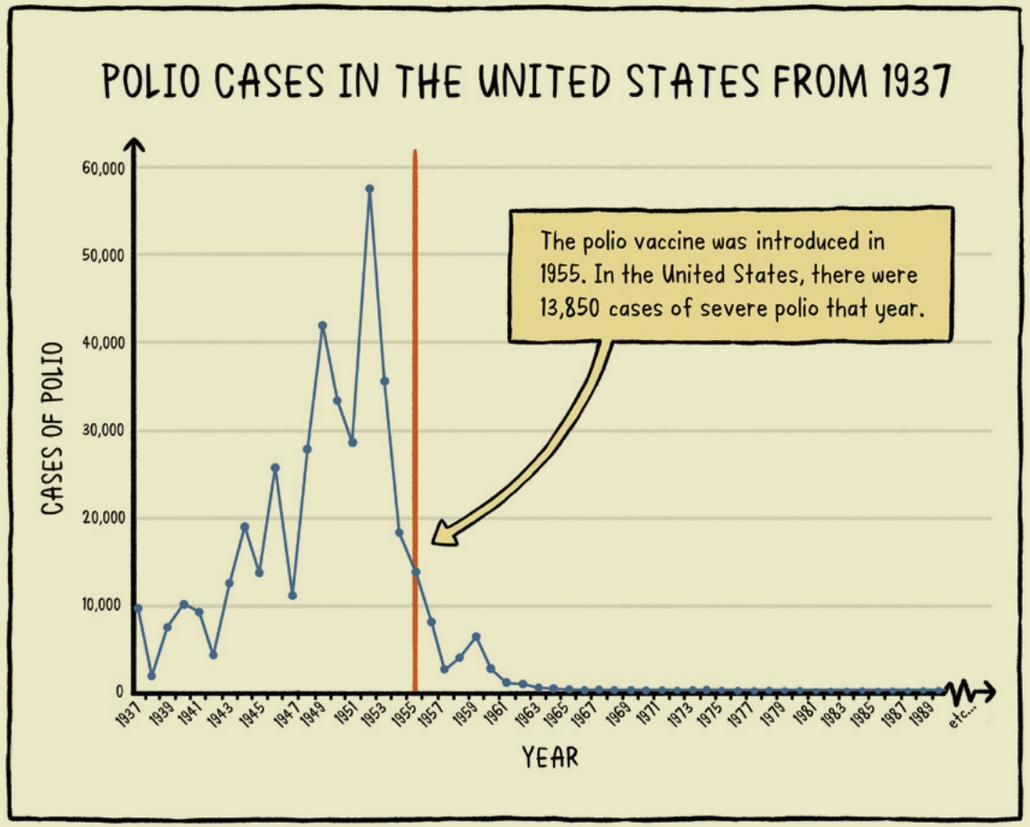
HERD IMMUNITY

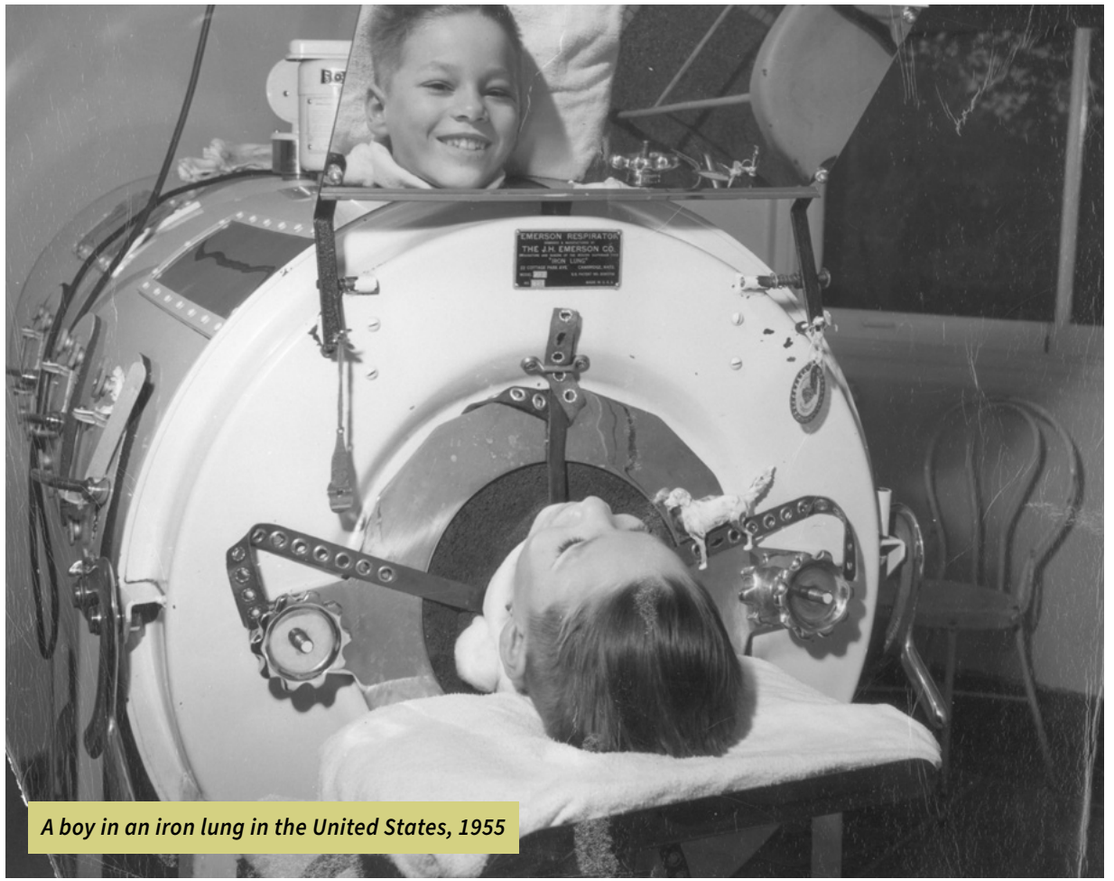


Polio: A Disease Almost Defeated

Polio was once a common infectious disease. It was spread through contaminated food and water or by contact with a person already infected with the polio virus. In severe cases, people with polio couldn't breathe on their own and had to spend time in an iron lung, a machine that breathed for them. The disease especially affected children and young people and sometimes caused permanent paralysis.

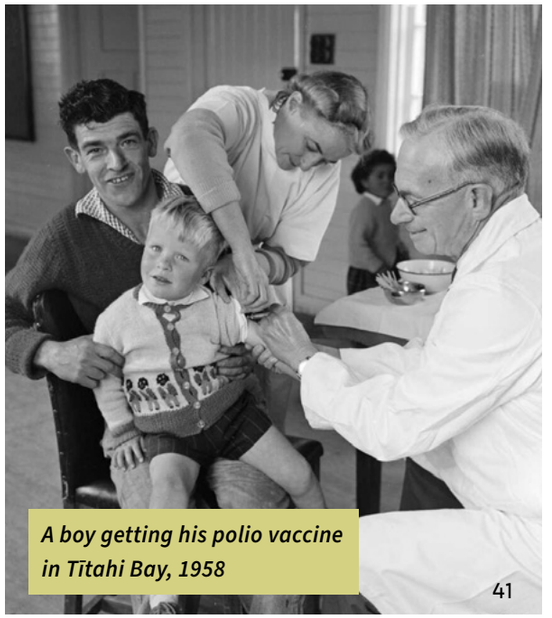
By the mid-twentieth century, the number of polio cases around the world began to fall as people got better access to good sanitation. Then in 1955, a polio vaccine was invented. In countries where many people got the vaccine, including the United States and New Zealand, the disease quickly disappeared. In 1988, the World Health Organization made it a goal to eliminate polio from the entire planet. Now, through vaccination, that goal is on track.





A boy in an iron lung in the United States, 1955

Children with polio in Auckland, 1943



A boy getting his polio vaccine in Titahi Bay, 1958

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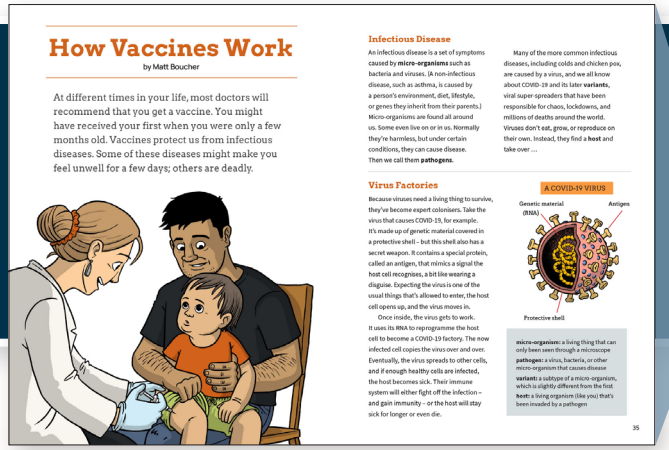
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Antigen

Protective shell

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