Viruses aren't always harmful. Six ways they're used in health care and pest control

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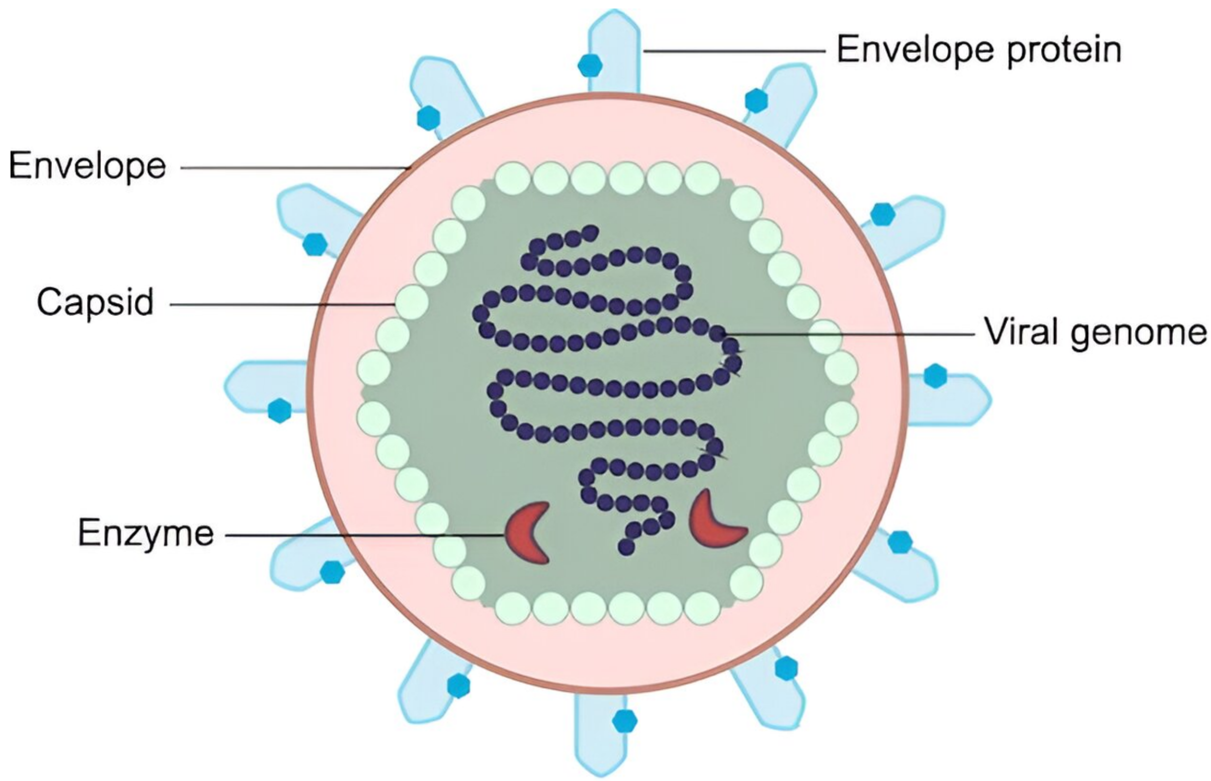

Viruses consist of a piece of RNA or DNA enclosed in a protein coat called the capsid. Credit: DEXi

We tend to just think of viruses in terms of their damaging impacts on human health and lives. The 1918 flu pandemic killed around 50 million people. Smallpox claimed 30% of those who caught it, and survivors were often scarred and blinded. More recently, we're all too familiar with the health and economic impacts of COVID.

But viruses can also be used to benefit human health, agriculture and the environment.

Viruses are comparatively simple in structure, consisting of a piece of genetic material (RNA or DNA) enclosed in a protein coat (the capsid). Some also have an outer envelope.

Viruses get into your cells and use your cell machinery to copy themselves. Here are six ways we've harnessed this for health care and pest control.

1. To correct genes

Viruses are used in some gene therapies to correct malfunctioning genes. Genes are DNA sequences that code for a particular protein required for cell function.

If we remove viral genetic material from the capsid (protein coat) we can use the space to transport a "cargo" into cells. These modified viruses are called "viral vectors".

Viral vectors can deliver a functional gene into someone with a genetic disorder whose own gene is not working properly.

Some genetic diseases treated this way include hemophilia, sickle cell disease, and beta-thalassemia.

2. Treat cancer

Viral vectors can be used to treat cancer.

Healthy people have p53, a tumor-suppressor gene. About half of cancers are associated with the loss of p53.

Replacing the damaged p53 gene using a viral vector stops the cancerous cell from replicating and tells it to suicide (apoptosis).

Viral vectors can also be used to deliver an inactive drug to a tumor, where it is then activated to kill the tumor cell.

This targeted therapy reduces the side effects otherwise seen with cytotoxic (cell-killing) drugs.

We can also use oncolytic (cancer cell-destroying) viruses to treat some types of cancer.

Tumor cells have often lost their antiviral defenses. In the case of melanoma, a modified herpes simplex virus can kill rapidly dividing melanoma cells while largely leaving non-tumor cells alone.

3. Create immune responses

Viral vectors can create a protective immune response to a particular viral antigen.

One COVID vaccine uses a modified chimp adenovirus (adenoviruses cause the common cold in humans) to transport RNA coding for the SARS-CoV-2 spike protein into human cells.

The RNA is then used to make spike protein copies, which stimulate our immune cells to replicate and "remember" the spike protein.

Then, when you are exposed to SARS-CoV-2 for real, your immune system can churn out lots of antibodies and virus-killing cells very quickly to prevent or reduce the severity of infection.

4. Act as vaccines

Viruses can be modified to act directly as vaccines themselves in several ways.

We can weaken a virus (for an attenuated virus vaccine) so it doesn't cause infection in a healthy host but can still replicate to stimulate the immune response. The chickenpox vaccine works like this.

The Salk vaccine for polio uses a whole virus that has been inactivated (so it can't cause disease).

Others use a small part of the virus such as a capsid protein to stimulate an immune response (subunit vaccines).

An mRNA vaccine packages up viral RNA for a specific protein that will stimulate an immune response.

5. Kill bacteria

Viruses can—in limited situations in Australia—be used to treat antibiotic-resistant bacterial infections.

Bacteriophages are viruses that kill bacteria. Each type of phage usually infects a particular species of bacteria.

Unlike antibiotics—which often kill "good" bacteria along with the disease-causing ones—phage therapy leaves your normal flora (useful microbes) intact.

6. Target plant, fungal or animal pests

Viruses can be species-specific (infecting one species only) and even cell-specific (infecting one type of cell only).

This occurs because the proteins viruses use to attach to cells have a shape that binds to a specific type of cell receptor or molecule, like a specific key fits a lock.

The virus can enter the cells of all species with this receptor/molecule. For example, rabies virus can infect all mammals because we share the right receptor, and mammals have other characteristics that allow infection to occur whereas other non-mammal species don't.

When the receptor is only found on one cell type, then the virus will infect that cell type, which may only be found in one or a limited number of species. Hepatitis B virus successfully infects liver cells primarily in humans and chimps.

We can use that property of specificity to target invasive plant species (reducing the need for chemical herbicides) and pest insects (reducing the need for chemical insecticides). Baculoviruses, for example, are used to control caterpillars.

Similarly, bacteriophages can be used to control bacterial tomato and grapevine diseases.

Other viruses reduce plant damage from fungal pests.

Myxoma virus and calicivirus reduce rabbit populations and their environmental impacts and improve agricultural production.

Just like humans can be protected against by vaccination, plants can be " immunized " against a disease-causing virus by being exposed to a milder version.

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