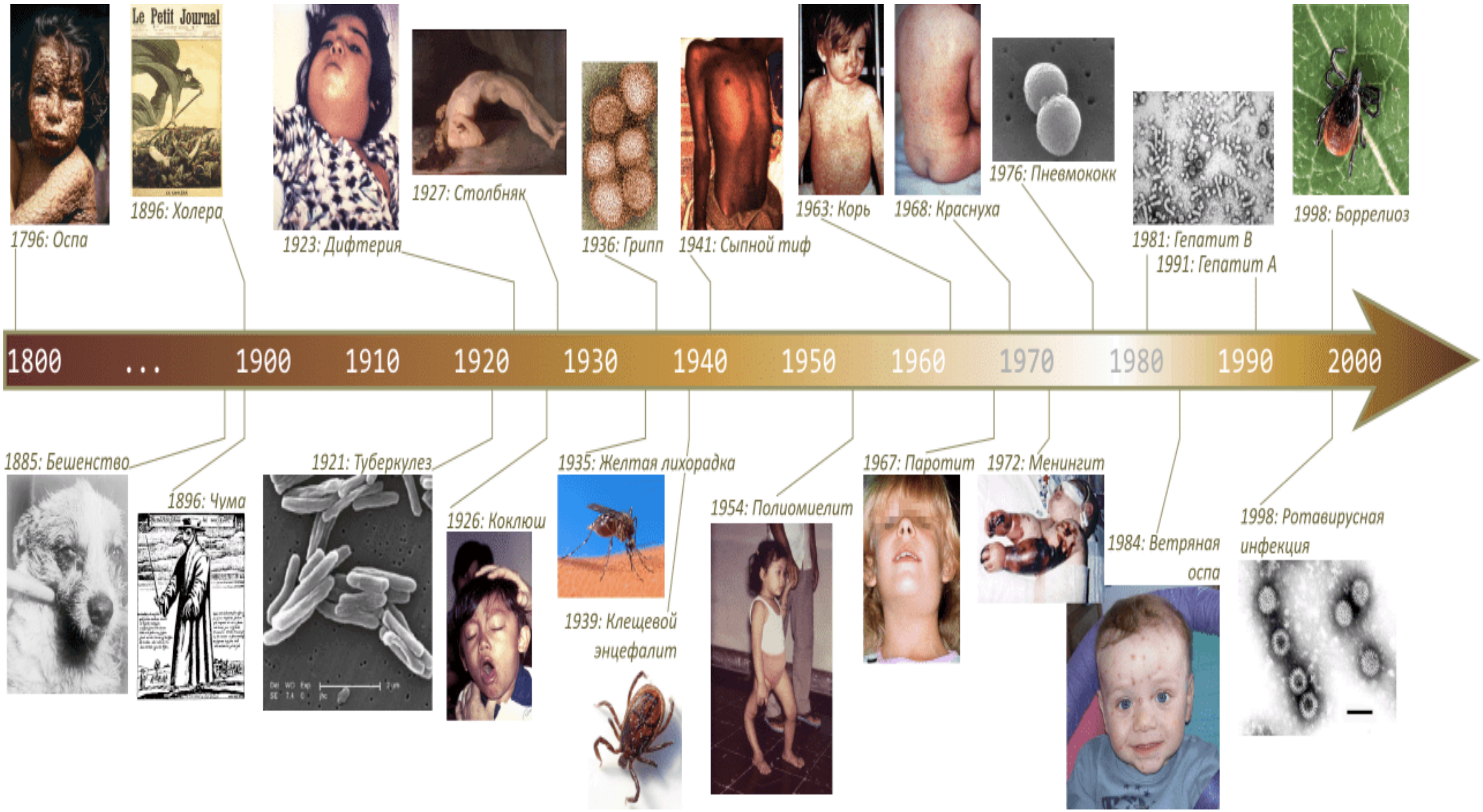
Immunobiological drugs. Classification, immunological bases of vaccination. Vaccines, serums, toxoids and immunoglobulins.

Chronology of vaccine development



Vaccines. History of vaccination. Main types of vaccines

The history of vaccination dates back to the late 18th century, when Edward Jenner's work appeared. Vaccination is one of the most important discoveries in human history.

The main types of vaccines are:

• Using a specific antigen
• Using fragments of a bacterium or virus
• Using a killed bacterium
• Using live versions, but weakened so that the actual disease does not occur
• Using bacterial toxins • Using recombinant DNA

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Классификация вакцин

- **Live attenuated vaccines In particular**,

this is the Calmette-Guérin vaccine - BCG, created on the basis of mycobacterium tuberculosis bovis - bovine tuberculosis. The live vaccine is also used against poliomyelitis, measles, mumps, rubella, chickenpox/shingles and viral hepatitis A.

- **Killed whole cell vaccines**

The human body receives a large number of antigens, very different. As a result, a large number of clones (b and t-cells) are activated, since this is a whole viral particle or bacterium. Total activation of the immune system occurs, the body is tuned to foreign molecules. Such a vaccine is used against whooping cough, typhoid fever, rabies, cholera, plague, etc.

- **Vaccines based on microbial cell fragments**

In this case, they take, for example, only the bacterial cell wall, the protein shell of the virus. This includes hepatitis B.

- **Toxin-based vaccines**

Used against tetanus, diphtheria, cholera, gas gangrene. Antigens produced by bacteria can be toxins that attack the immune system. Therefore, it is sometimes important to work specifically on toxins, neutralizing them, thereby creating anatoxins.

- **Recombinant DNA vaccines**

This method involves genetic modification of a virus that is obviously harmless and artificially grown.

Classification of vaccines
(depending on the nature of the vaccine immunogen)

1. **whole-microbial or whole-virion**, consisting of microorganisms, bacteria or viruses respectively, that maintain their integrity during the manufacturing process;
2. **chemical vaccines** from the products of the vital activity of a microorganism (toxoids) or its integral components, including submicrobial or subvirion vaccines;
3. **genetically engineered vaccines** containing expression products of individual genes of a microorganism, produced in special cellular systems;
4. **chimeric or vector vaccines**, in which the gene that controls the synthesis of a protective protein is inserted into a harmless microorganism in the expectation that the synthesis of this protein will occur in the body of the vaccinated person.
5. **synthetic vaccines**, where a chemical analogue of a protective protein obtained by direct chemical synthesis is used as an immunogen

Comparison of different types of vaccines

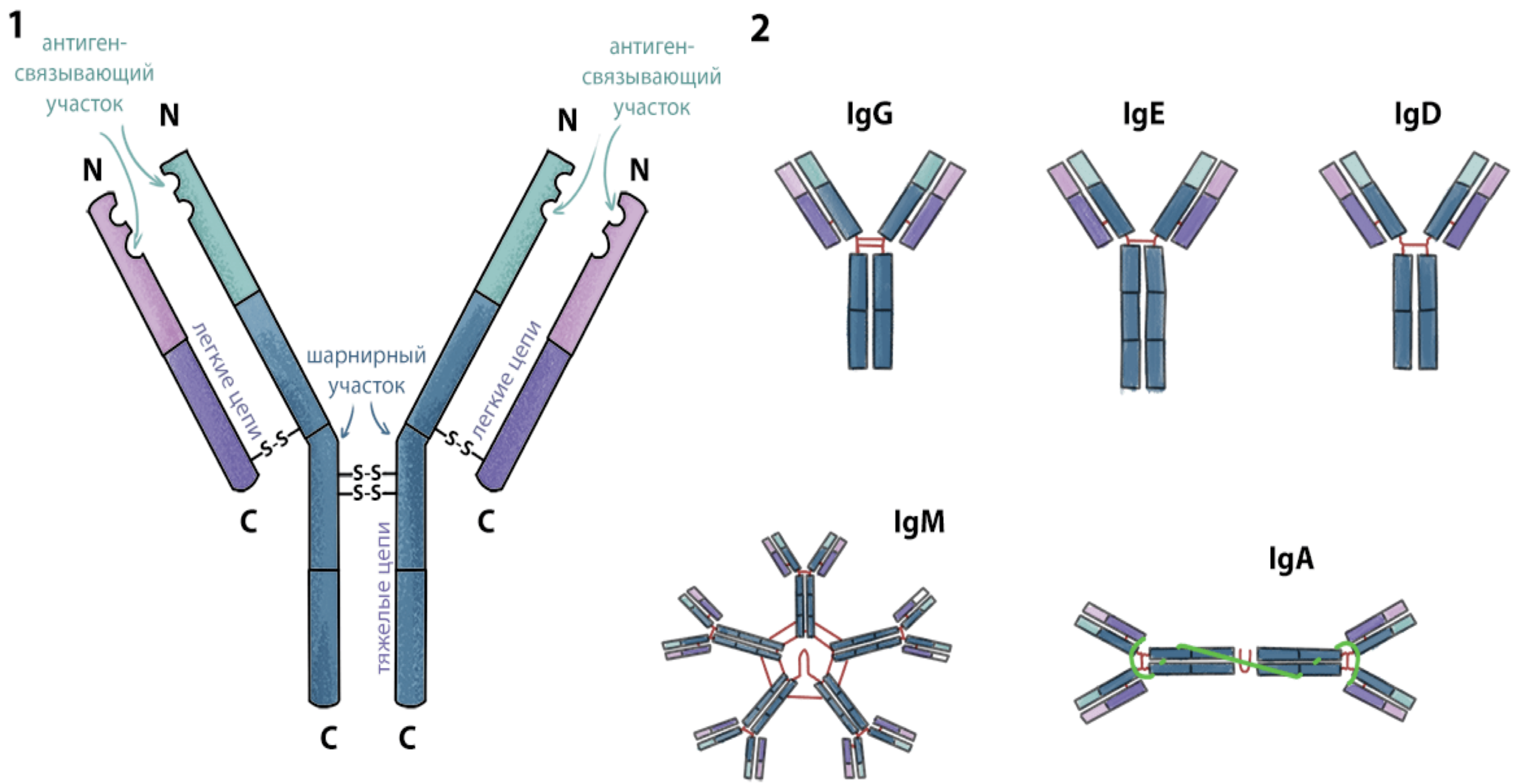
Type of vaccine	Antigen source	**positiv**	**negativ**
Live vaccine	Live attenuated pathogens	•Typically stronger, more effective and longer lasting immune response	•Risk of vaccine-associated diseases •Small number of suitable infectious agents
Inactivated vaccine	Killed whole pathogens	•Almost any infectious agent is suitable	•weaker immune response
Subunit vaccine; toxoid	Pathogen fragments and individual proteins, inactivated toxins	•Precise targeting of antibodies •Protection against toxins, not just bacteria or viruses •Possibility of scaling up production	•Some vaccines require periodic re-administration •Complex development
Gene vaccine	Patient's cells into which individual pathogen genes have been introduced	•Ease of production •Low cost	•Ethical issues •Complexity of delivery

Vaccines: disease's imitation

Molecular signals for activation of B-lymphocytes producing antibodies:

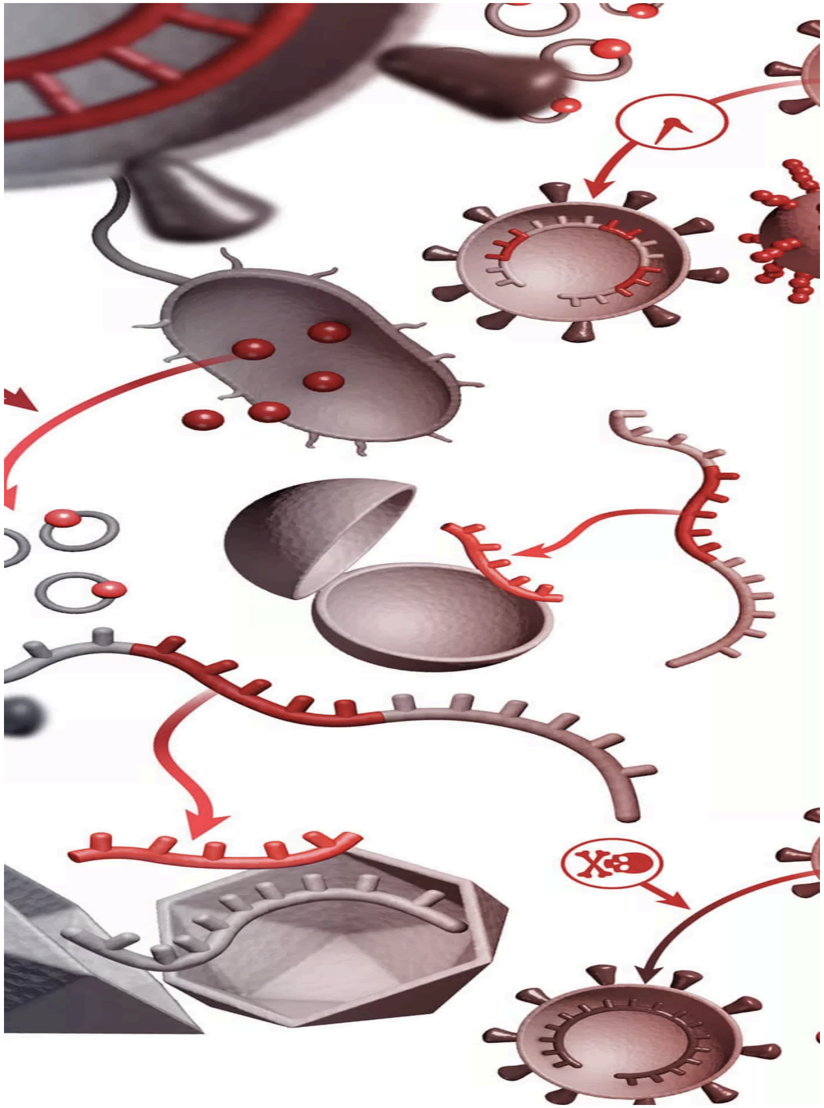
- Antigens is **the first signal** (fragments of the surface of a virus or bacteria). They enter the lymph nodes with immune system cells, lymph and blood, which get there from the inflamed tissue.
- The Inflammation in the area from which the antigens come is **the second signal** A lot of factors (molecules) of inflammation indicate that the source of antigens is dangerous for the body. If there are antigens, but no inflammation, then there is a risk that the immune system will treat these proteins as it usually treats, for example, food components. Then, instead of immunization, tolerance will arise. The immune system will recognize these proteins as safe and will not attack them.

Structure and classes of antibodies.



Regardless of class, antibodies have two main areas. The antigen-binding area is “selected” by lymphocytes for each specific antigen and sticks to it upon contact. The constant area ensures binding to receptors and proteins of the organism itself.

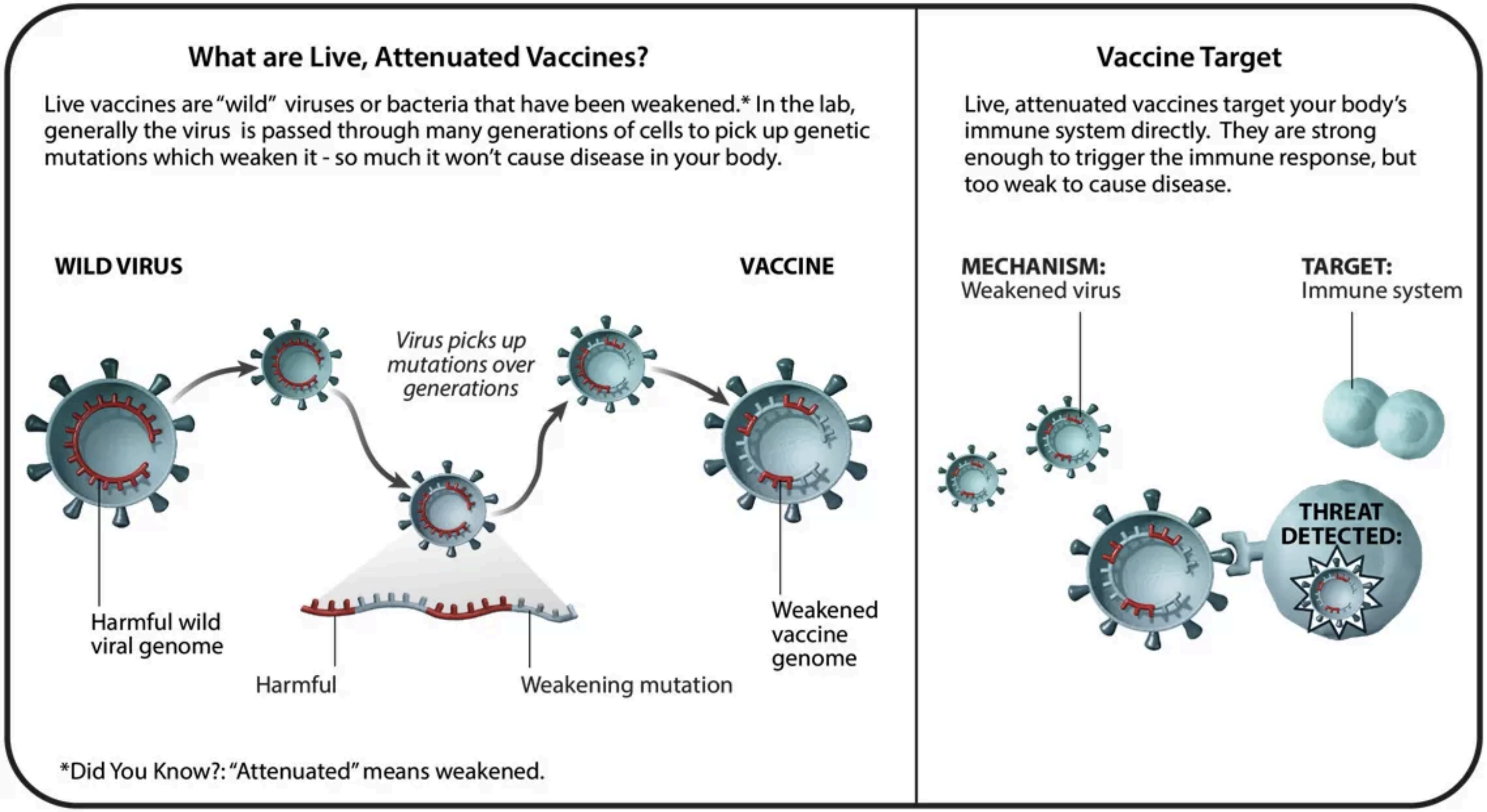
Six Vaccine Technology Platforms



Since the first vaccine was developed to treat smallpox in 1796, vaccine technology has become more advanced and uses the latest technology to help protect the world from preventable diseases.

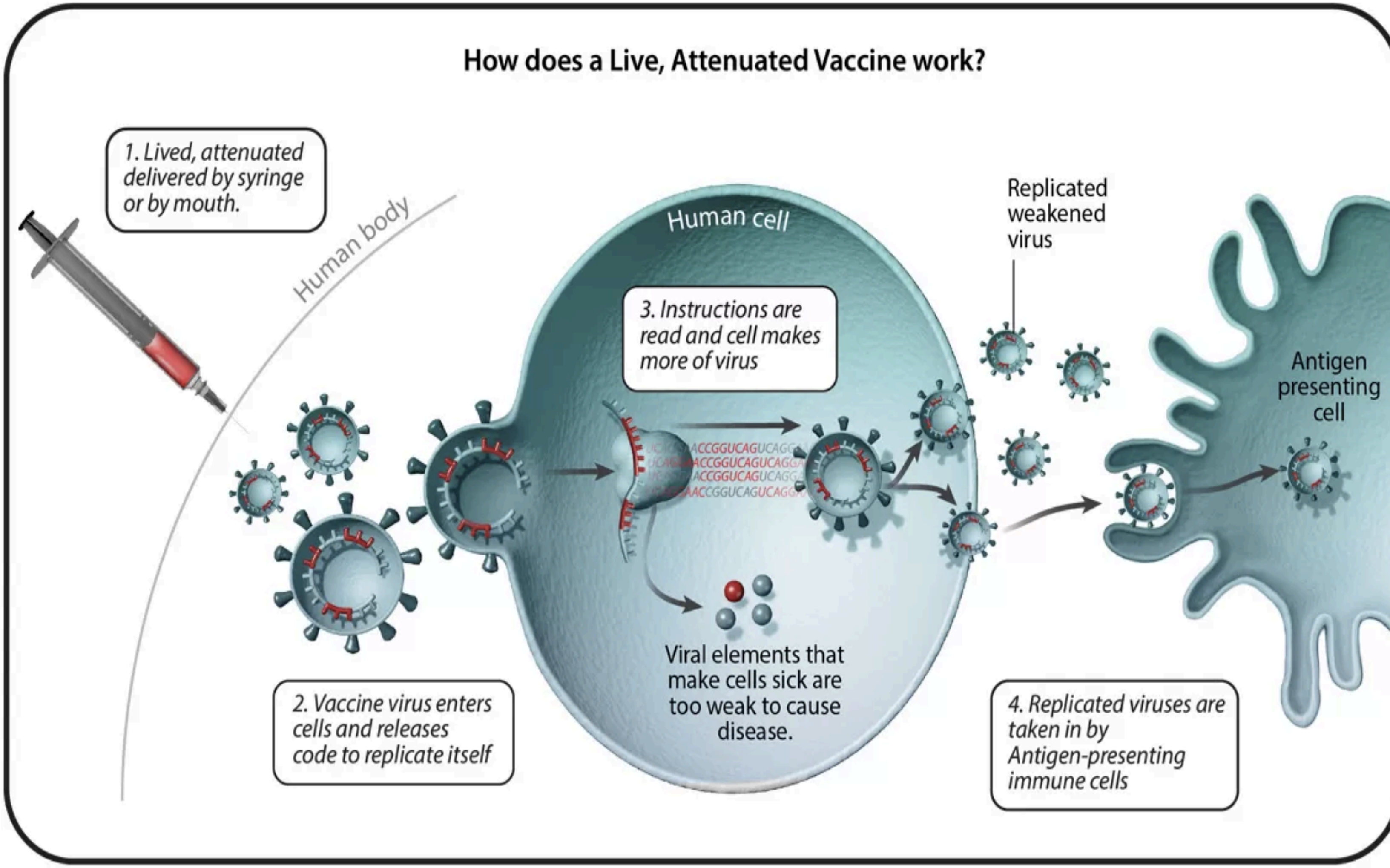
Depending on the pathogen (bacteria or virus) being targeted, different vaccination technologies are used to create an effective vaccine. Just as there are many ways to develop a vaccine, they can also take many forms, from injections and nasal sprays to oral forms.

Live attenuated vaccines



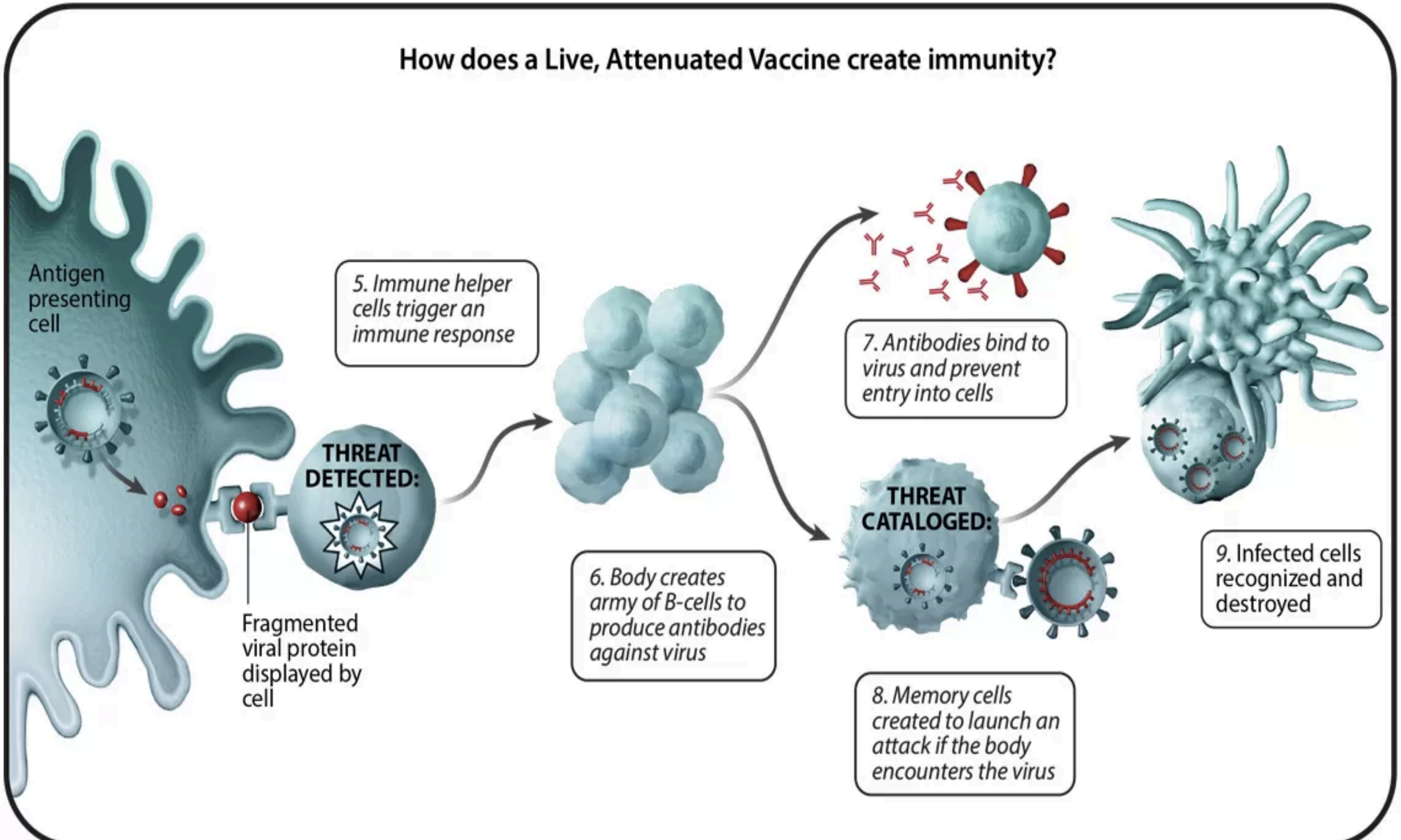
Live attenuated vaccines contain live pathogens from bacteria or viruses that have been "attenuated," or weakened. These vaccines are made by selecting strains of bacteria or viruses that still produce a strong enough immune response but do not cause disease. Attenuated viruses were one of the earliest methods of eliciting protective immune responses. "Vaccinia," the world's first vaccine, protected against smallpox, and where the term "vaccination" came into common usage.

Live attenuated vaccines



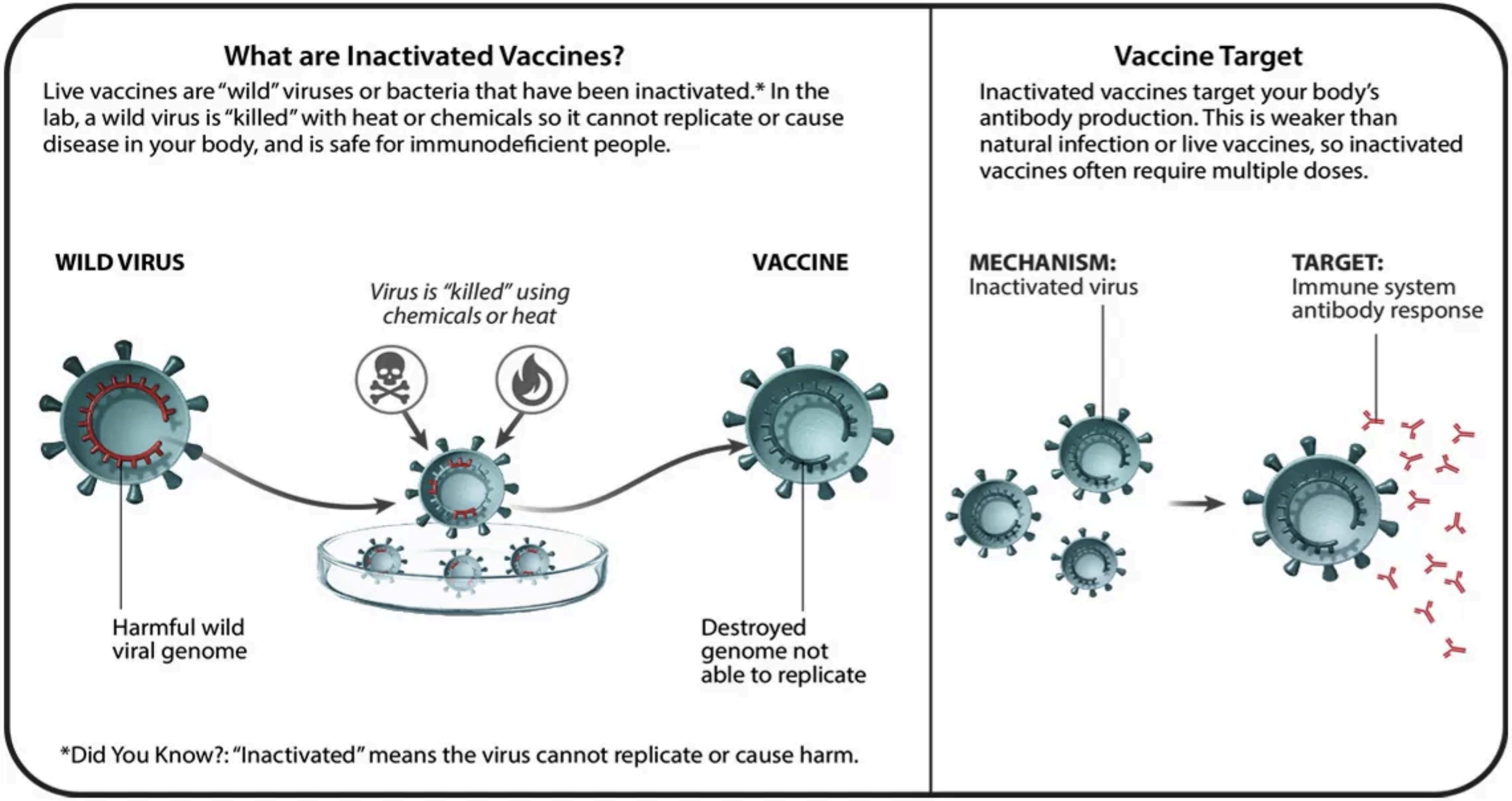
Advantages: Because these types of vaccines contain a live pathogen, the immune system responds to them very well and usually remembers the pathogen for a very long time. Additional doses or boosters are not always necessary.

Live attenuated vaccines



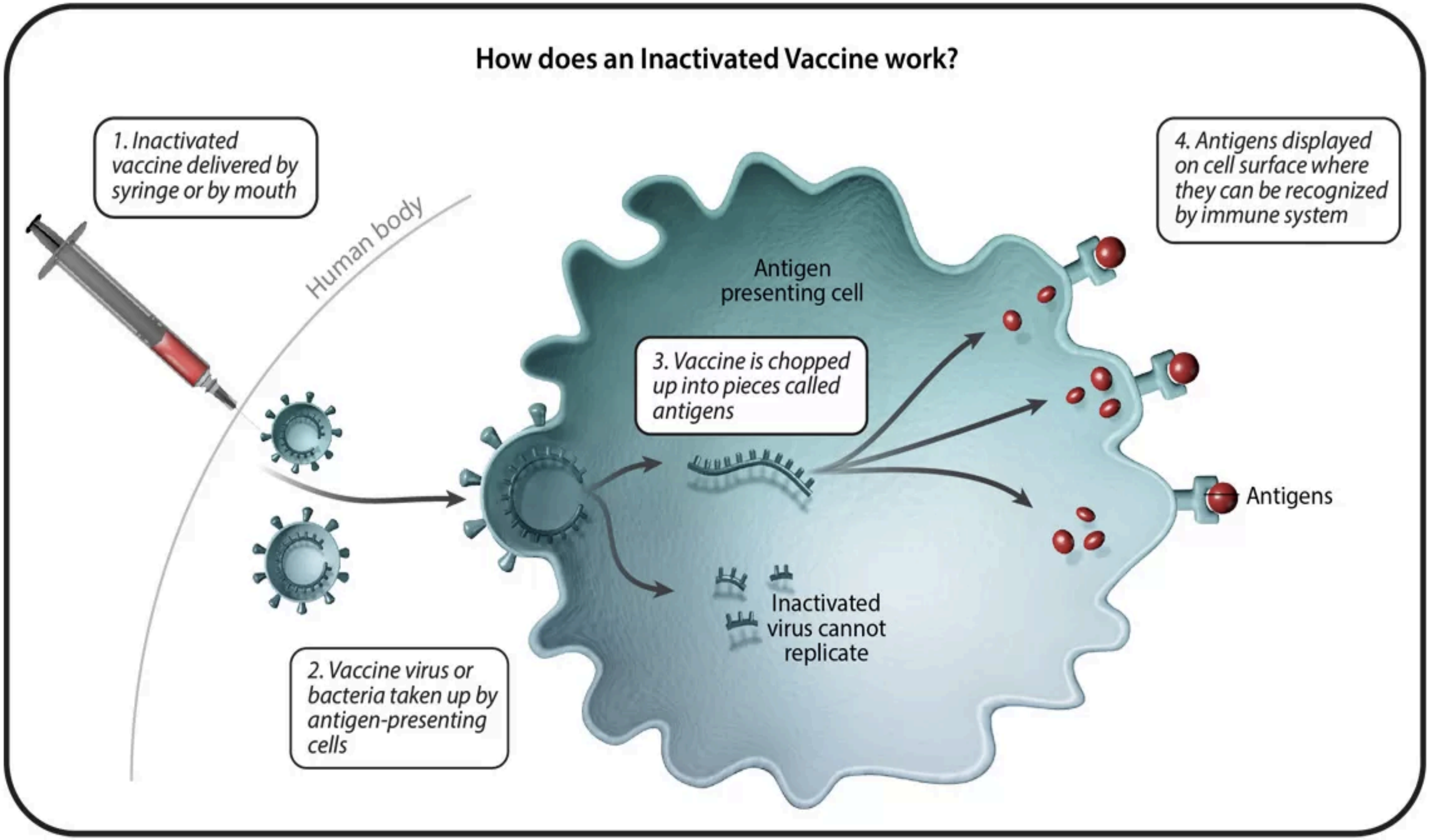
Examples: measles, mumps, and rubella (MMR) vaccine, chickenpox vaccine.

Inactivated vaccines



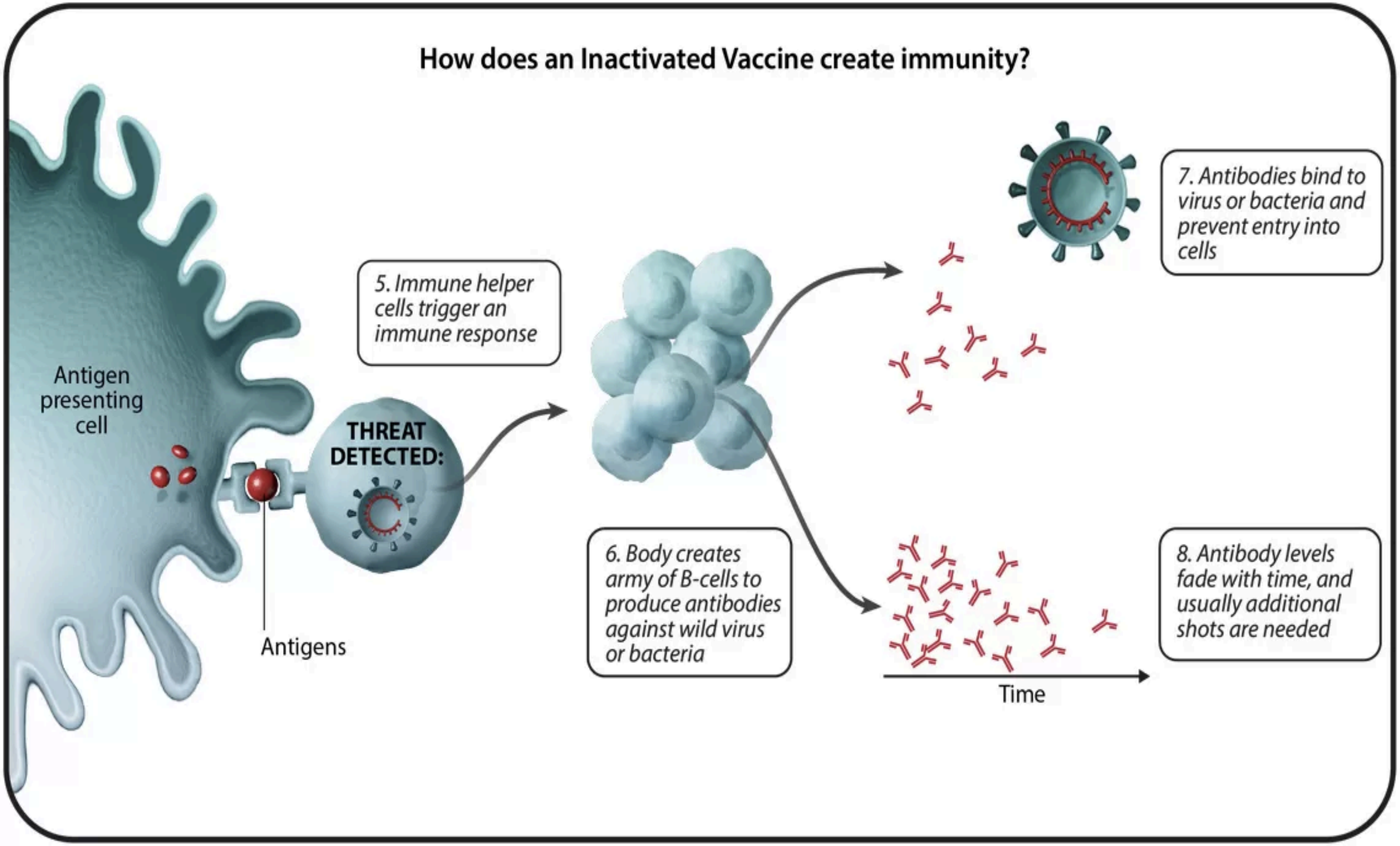
Inactivated vaccines take a live pathogen and inactivate or kill it. When the vaccine is then given to a person, the inactivated pathogen is strong enough to create an immune response, but is not capable of causing disease. It often takes multiple doses to build immunity and provide full protection.

Inactivated vaccines



Advantages: Inactivated vaccines can be mass-produced and are relatively is not expensive to produse

Inactivated vaccines



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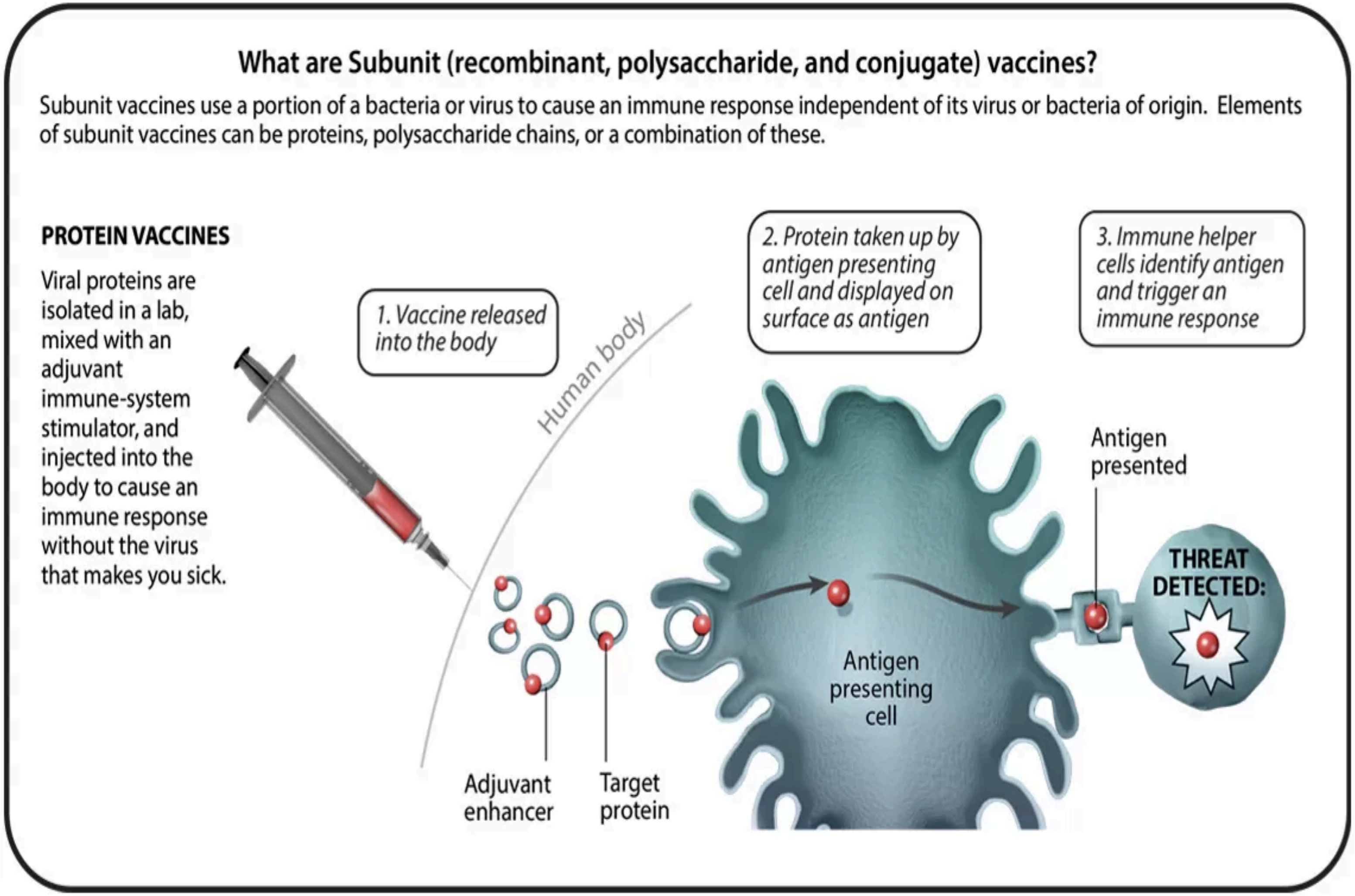
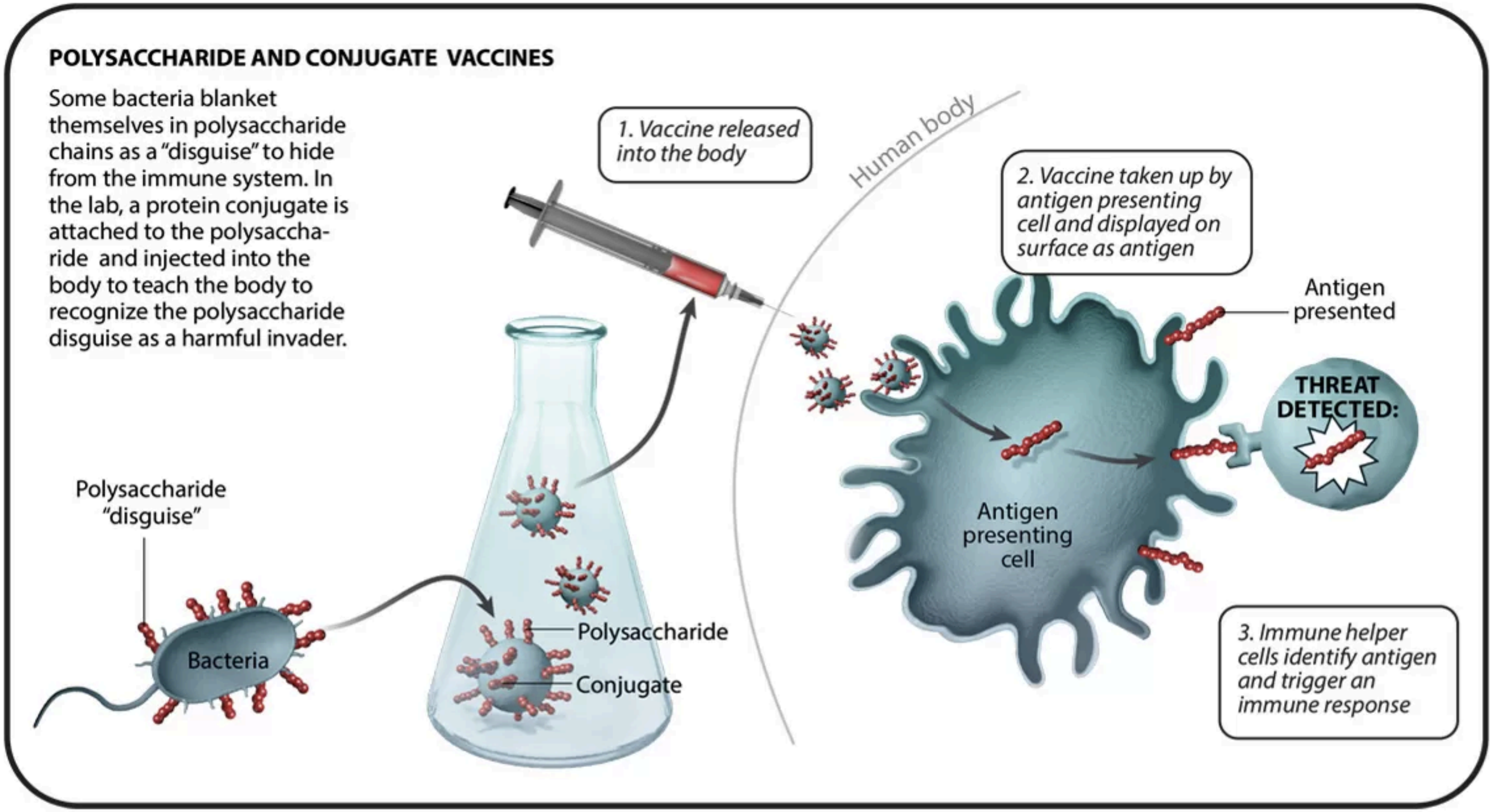
Examples: polio vaccine, influenza vaccine.

Subunit vaccines



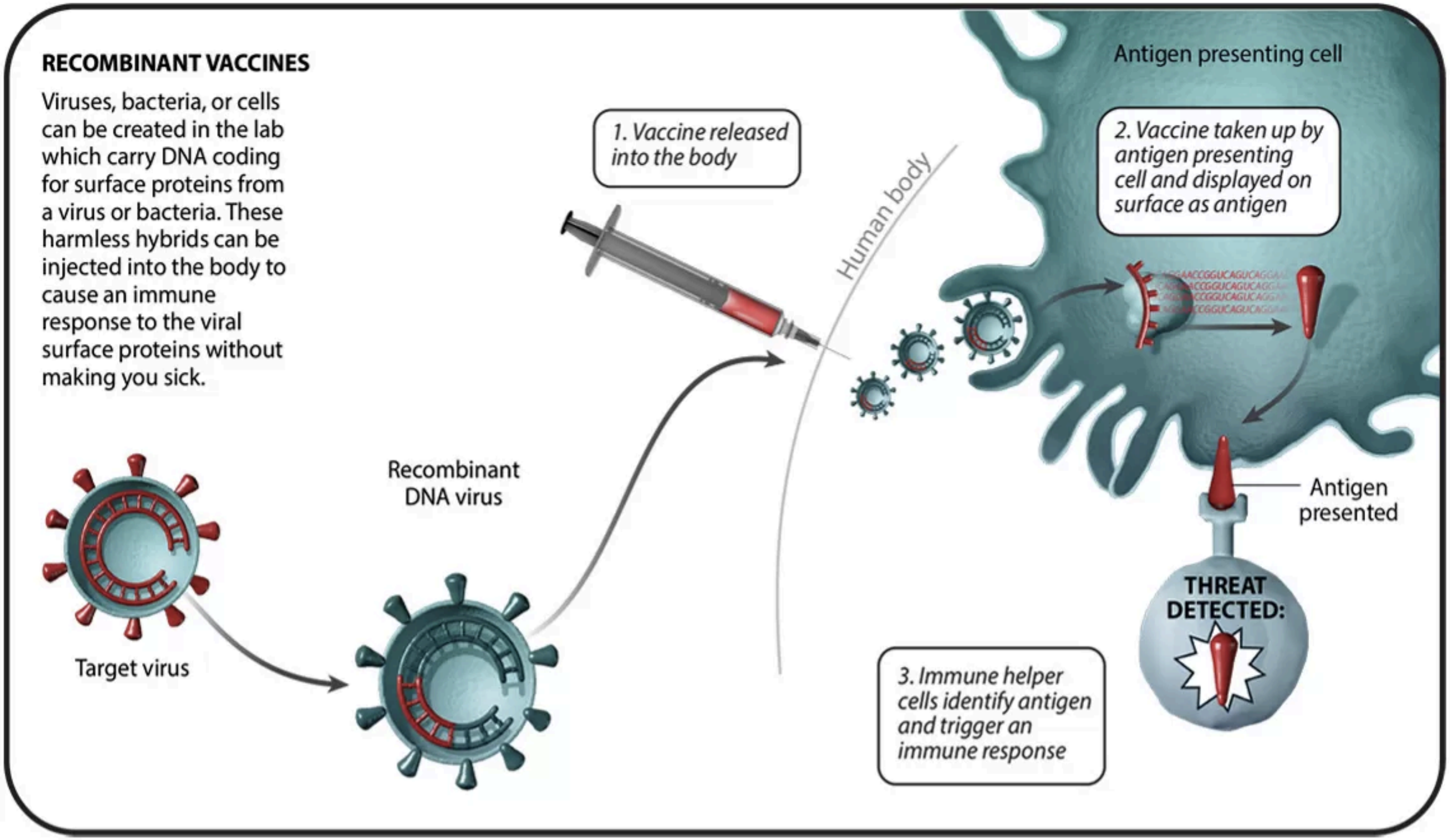
Subunit vaccines are made from part of a pathogen rather than the whole organism, so they do not contain live pathogens. Some important subunit vaccines are polysaccharide vaccines, conjugate vaccines, and protein-based vaccines.

Subunit vaccines



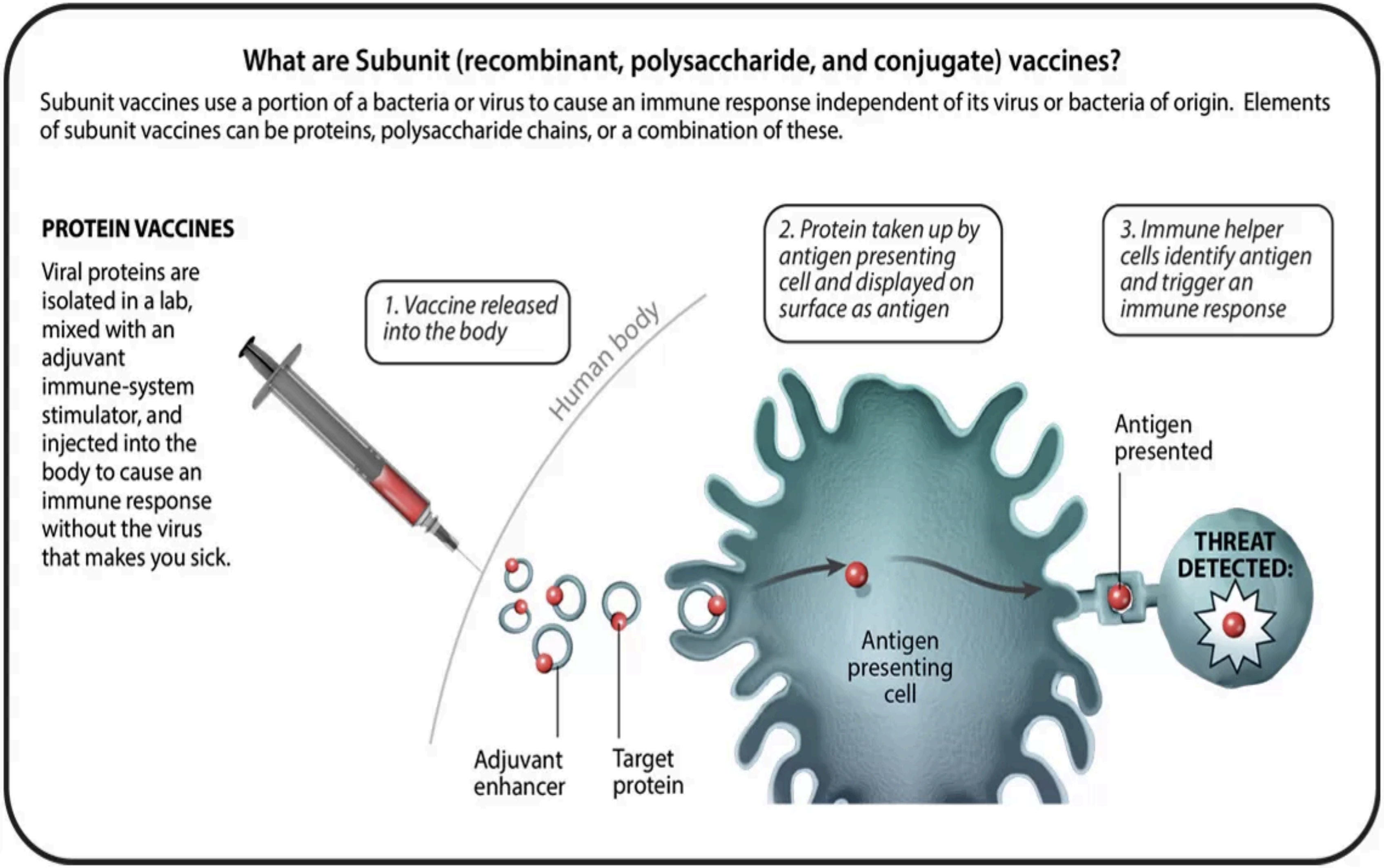
Advantages: Subunit vaccines contain only parts of a pathogen, not the whole organism, so they can't make you sick or cause an infection. This makes them suitable for people who shouldn't get "live" vaccines, such as young children, older adults, and people with weakened immune systems.

Recombinant and conjugate vaccines

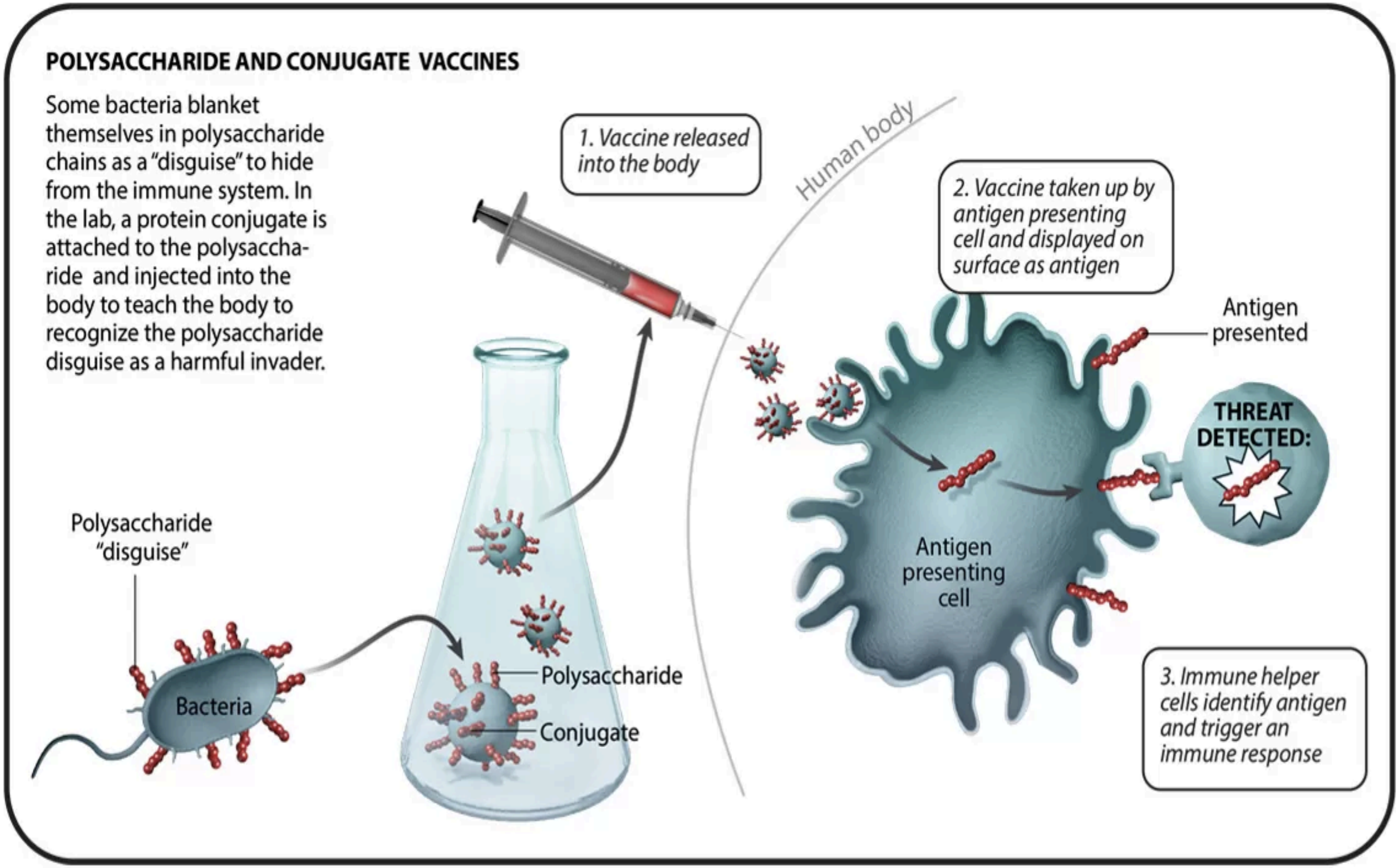


Examples: Haemophilus influenzae type B (Hib) vaccine (conjugate), pneumococcal vaccine (polysaccharide or conjugate), shingles vaccine (recombinant protein), hepatitis B vaccine (recombinant protein), acellular pertussis vaccine, MenACWY (conjugate).

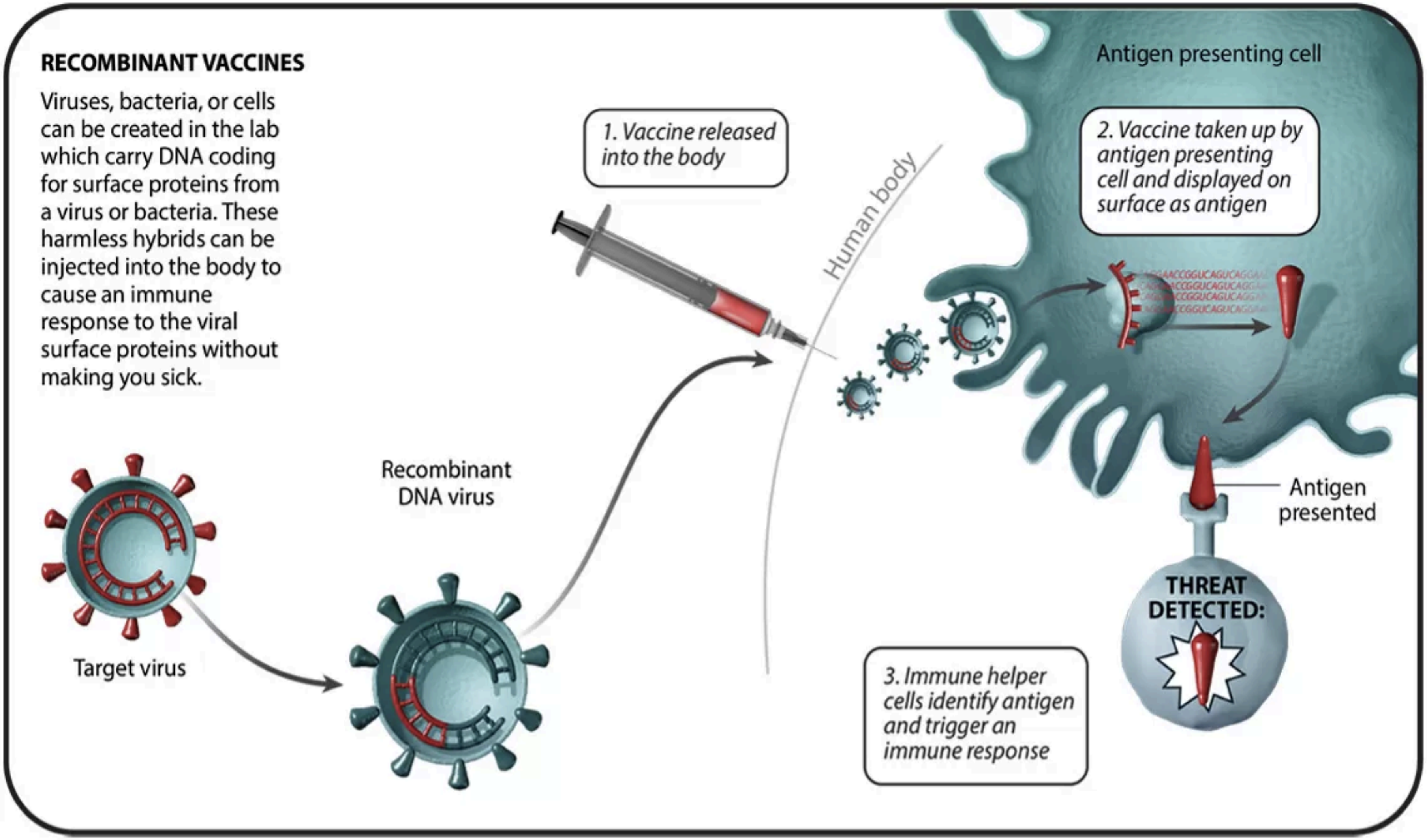
Recombinant and conjugate vaccines



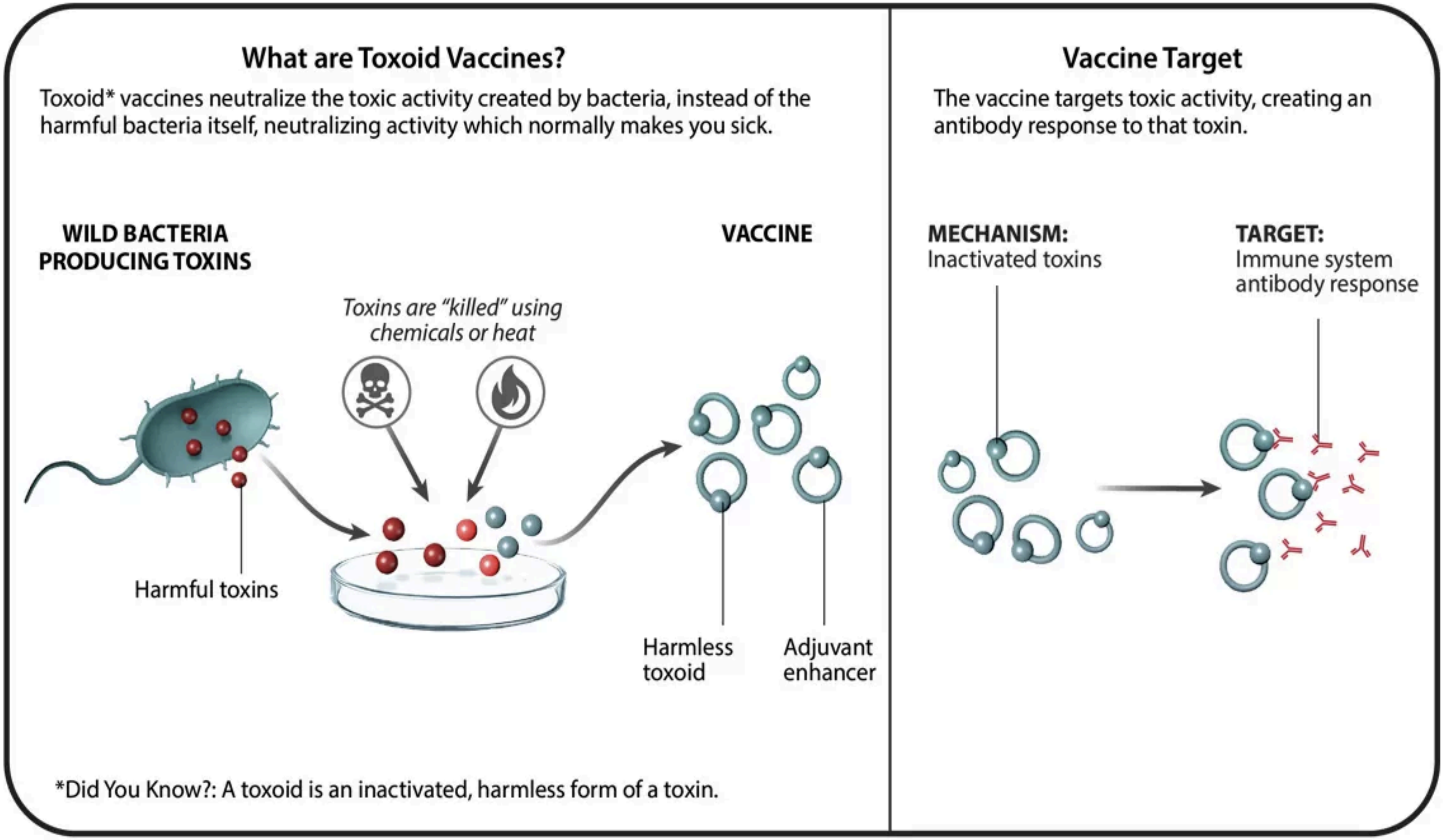
Recombinant and conjugate vaccines



Recombinant and conjugate vaccines

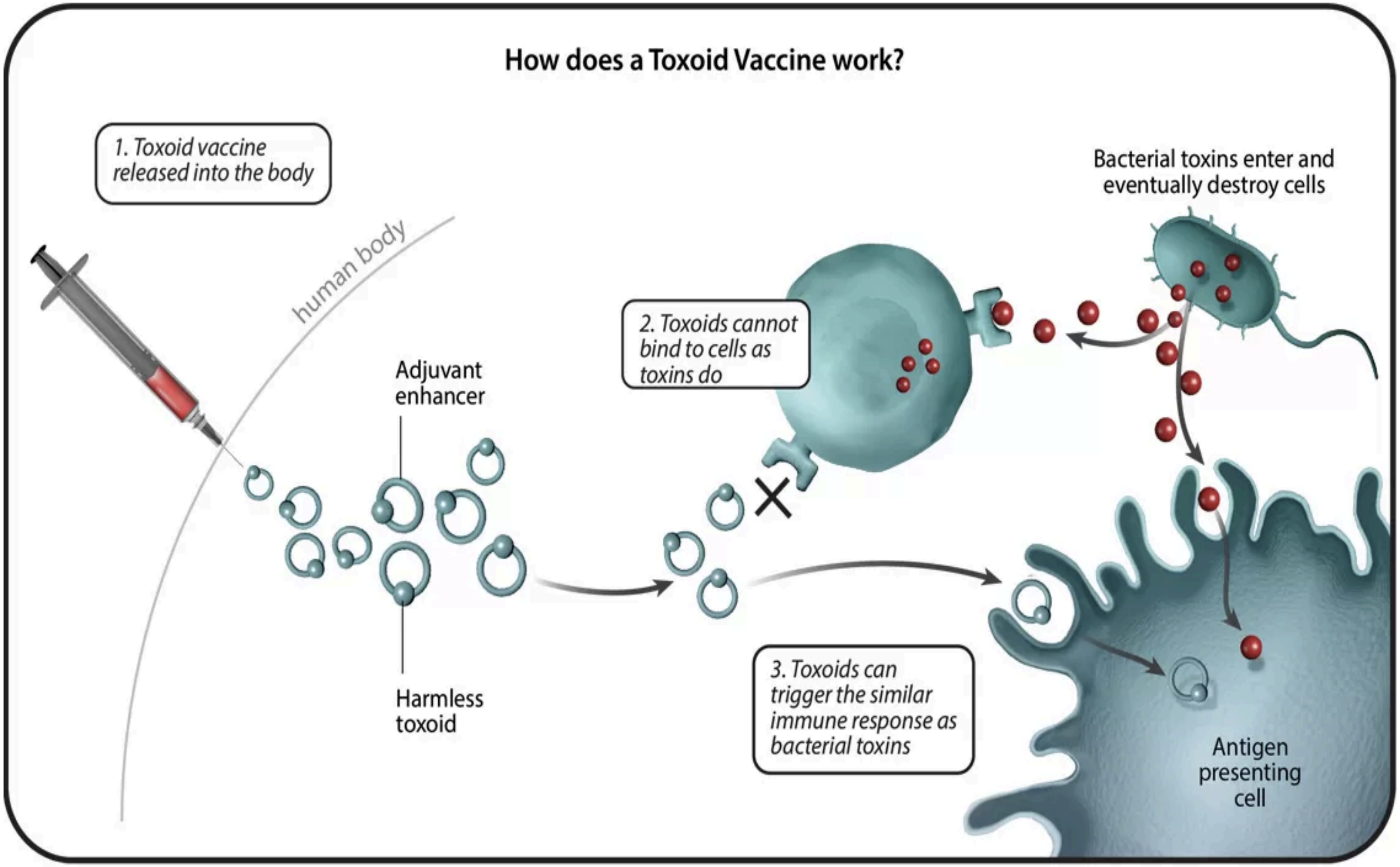


Anatoxin vaccines



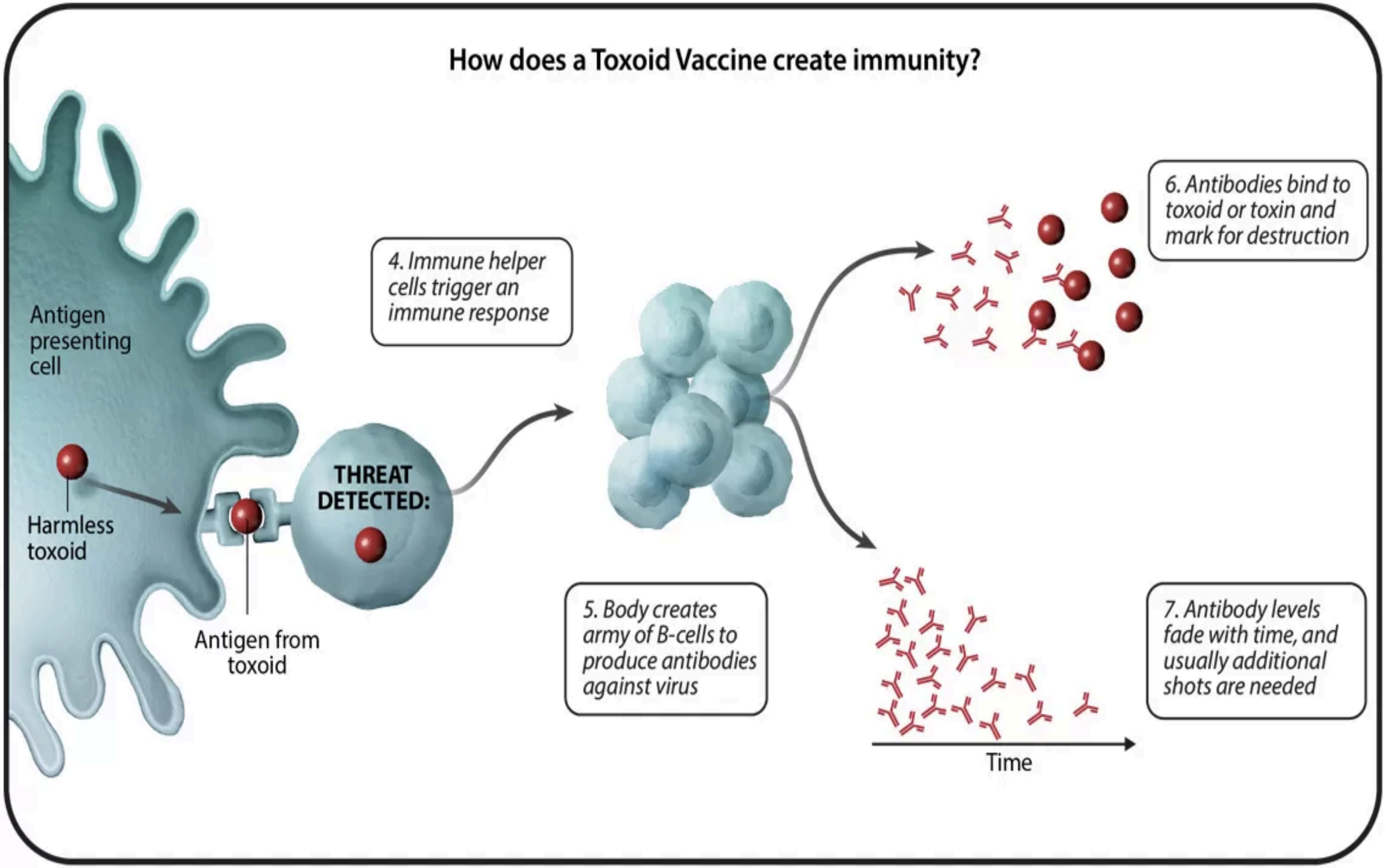
Toxoid vaccines use inactivated toxins to target the toxic activity produced by bacteria, rather than the bacteria themselves. "The goal of toxoid vaccines is to enable people to neutralize these toxins with antibodies through vaccination."

Anatoxin vaccines



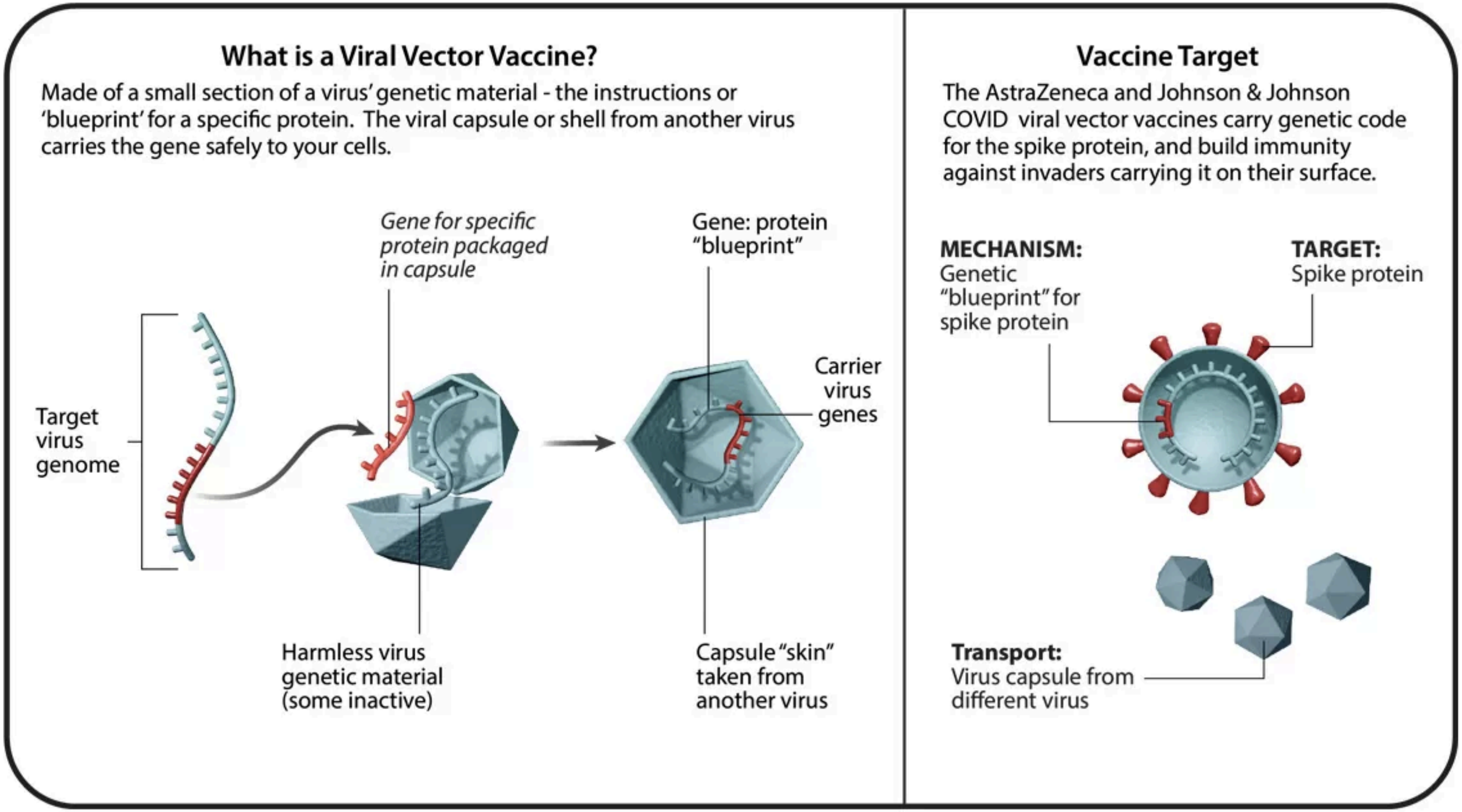
Advantages: Toxoid vaccines are especially good for preventing certain diseases caused by toxins, such as tetanus, diphtheria, and whooping cough. Boosters are usually recommended every 10 years.

Anatoxin vaccines



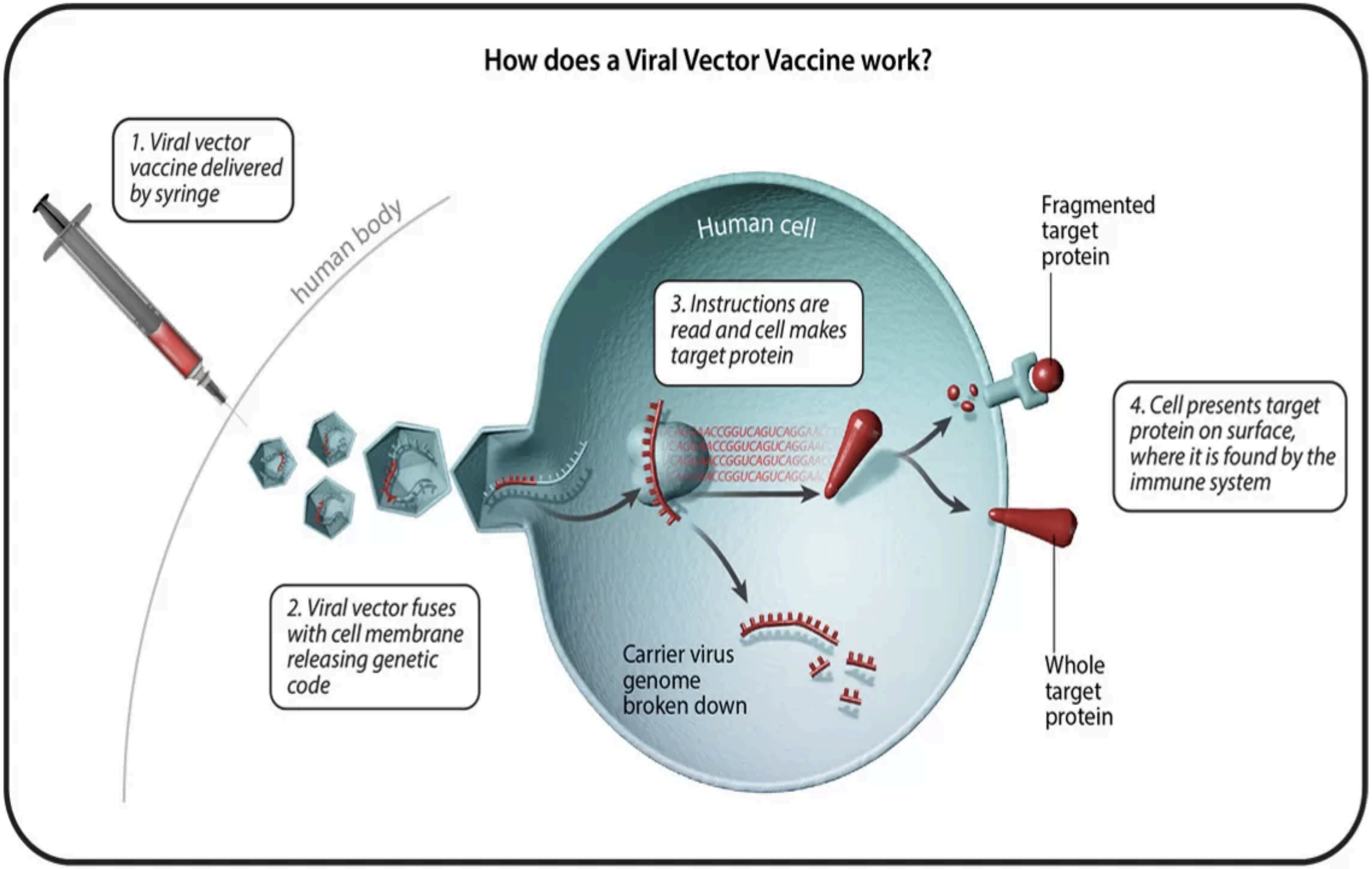
Examples: tetanus vaccine, diphtheria vaccine.

Viral vector-based vaccines



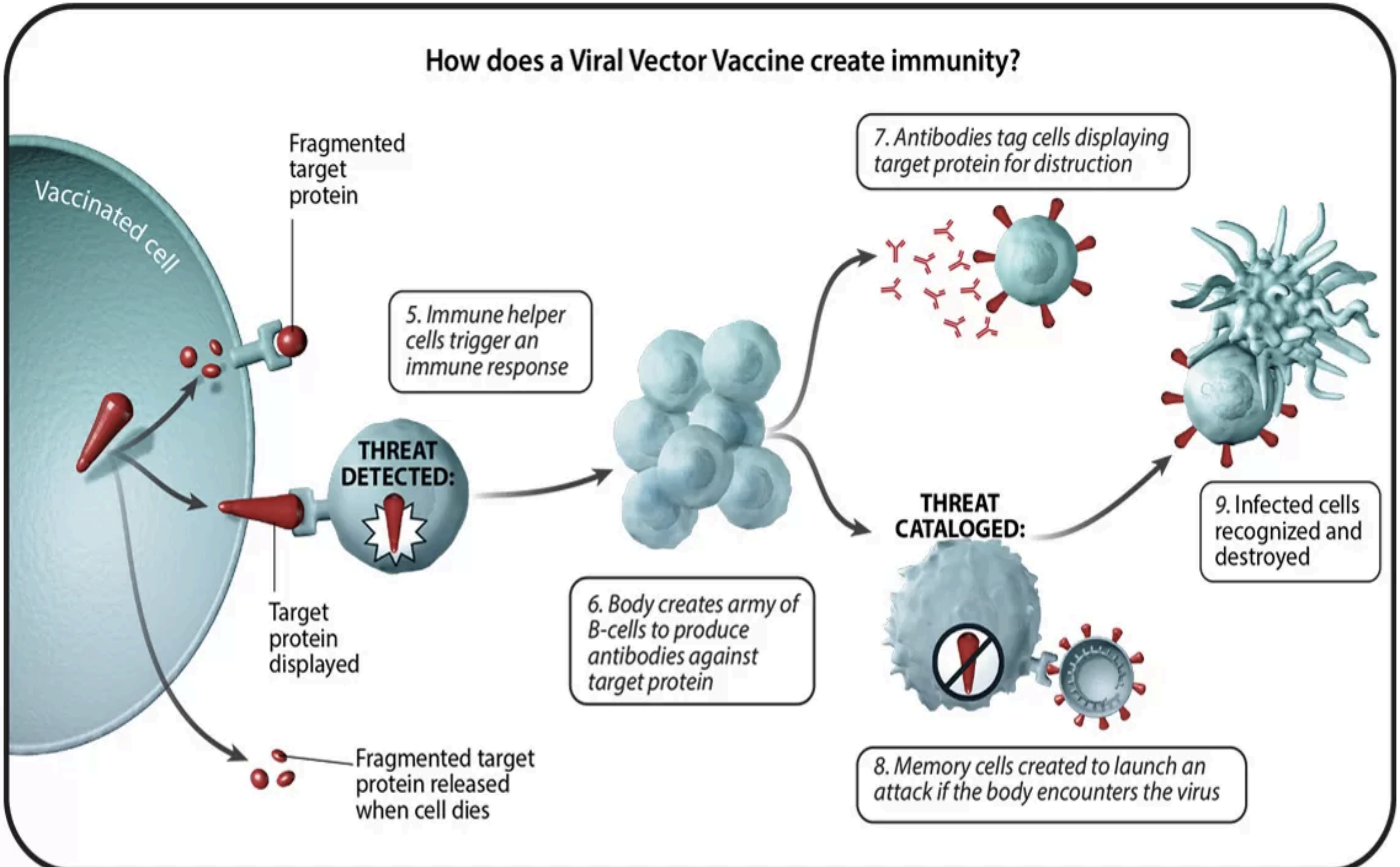
Viral vector vaccines use a harmless virus to deliver the genetic code for an antigen that the immune system must fight into the host's cells. They are essentially a gene delivery system. They deliver information about the antigen that triggers the body's immune response.

Viral vector-based vaccines



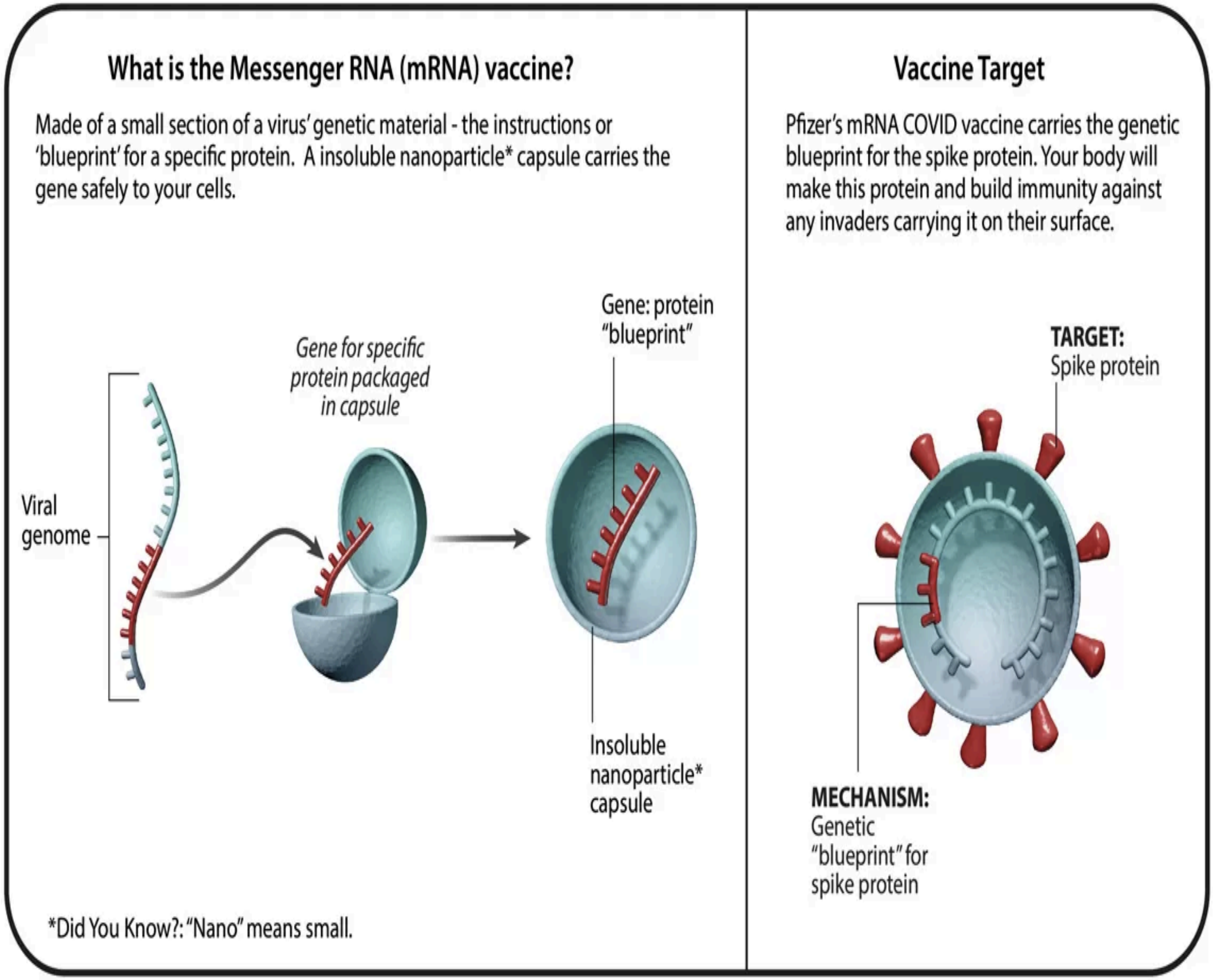
Advantages: Viral vector vaccines generally produce a strong immune response. One dose of the vaccine is usually enough to develop immunity. Booster shots may be needed to maintain immunity.

Viral vector-based vaccines



Examples: Ebola vaccine, HIV vaccine against COVID-19 (AstraZeneca и Johnson & Johnson)

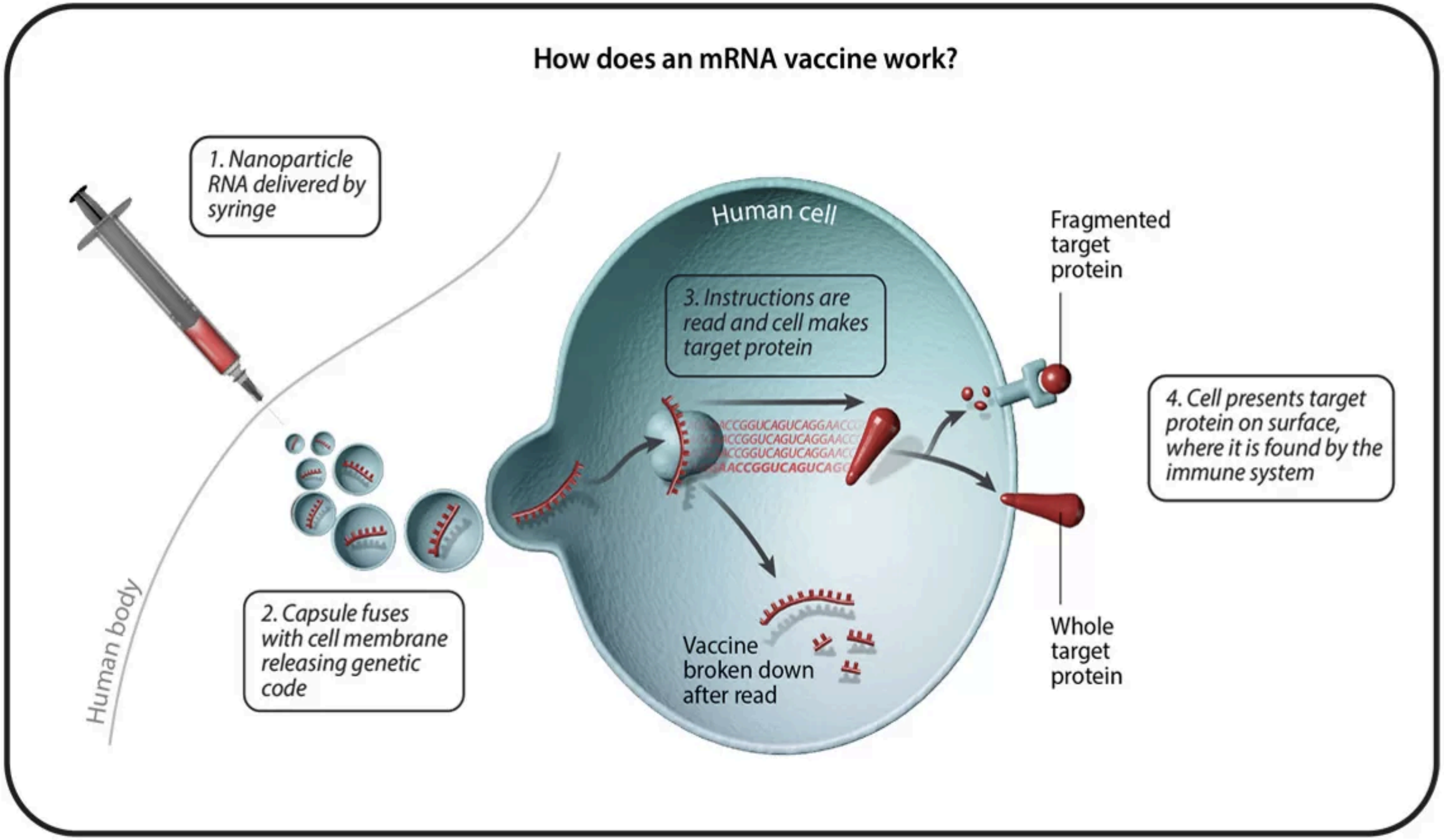
Messenger RNA vaccines



One of the newest and most exciting areas in vaccine technology is the use of mRNA vaccines. Unlike conventional vaccines, which can take many months or even years to grow, mRNA vaccines can be developed quickly using the genetic code of a pathogen.

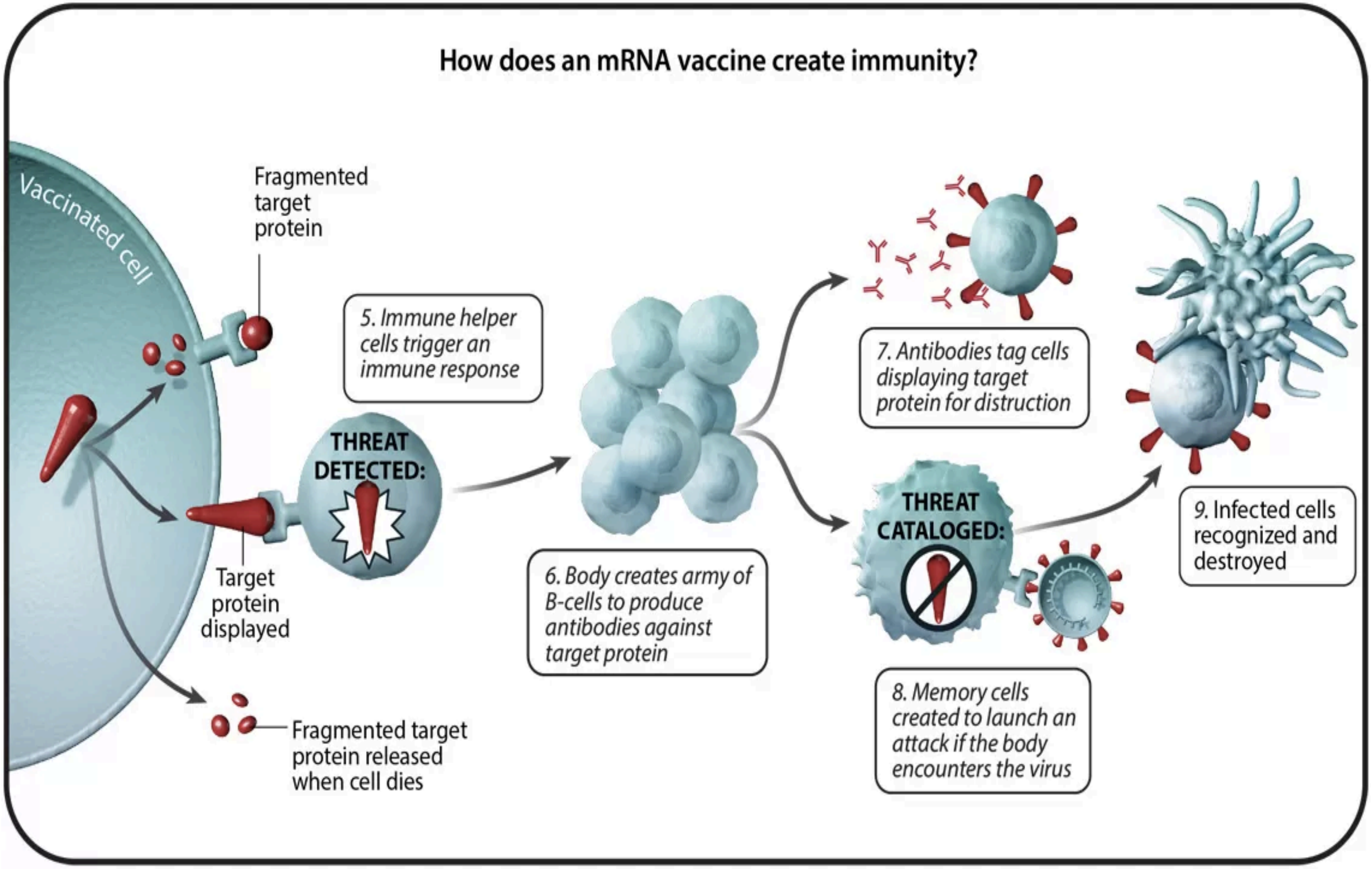
When an mRNA vaccine is given, the RNA material "teaches" our body how to make a specific type of protein that is unique to the virus but does not make the person sick. The protein triggers an immune response that involves producing antibodies that recognize the protein. That way, if a person is ever exposed to that virus in the future, the body will have antibodies ready to go.

Messenger RNA vaccines



Advantages: “It’s a very powerful technology that can make a lot of vaccines quickly. The advantage is that the technology is very adaptable. We can potentially go in and change the mRNA in the formula to target a new antigen, and we can make a lot of high-quality vaccine material relatively quickly.”

Messenger RNA vaccines



The Future of Vaccination

Vaccination is the main way to fight pathogens. It is the only way we know to create protection in a person who has not yet been ill. Mass vaccination opens up opportunities not only to prevent epidemics, but also to completely eradicate the disease.

New targets for vaccine prevention include HIV and the Zika virus.

New methods of delivering antigens to the body:

- the concept of DNA vaccines, which involves introducing into the patient's body not the proteins themselves, but the genes encoding them. Some of the cells of the immune system begin to independently produce the necessary antigens and activate the immune response to them.
- development of therapeutic oncovaccines that make it possible to combat malignant neoplasms in the same way as infections. Methods are used to load immune cells with tumor proteins outside the body and then return them to circulation.

Myth #1: Vaccines themselves cause diseases

In reality, most of these reports are myths. Vaccines almost never cause serious complications. Side effects are rare and include signs of an immune reaction, such as fever or weakness. The use of live vaccines in immunodeficiency can provoke serious diseases, so vaccination of sick people should be strictly controlled. Modern research shows that vaccines are one of the safest means of protection against infections.

Myth #2:
Vaccination against several diseases at the same time can lead to negative consequences, especially for the child

In fact, nature in this same year of life provides the infant's immune system with far more tasks than any vaccine. The colonization of its body with microorganisms alone reduces the burden of all "calendar" vaccines to the level of statistical error: thousands of new types of microbes constantly penetrate the infant's intestines, which the immune system must sort out, expel pathogenic ones, and take control of beneficial ones.

In addition, it is important to understand that the immune response to each antigen occurs independently. A B-lymphocyte that selects an antibody to the measles pathogen membrane will not do its job worse if another lymphocyte next to it is practicing with rubella virus antigens. The use of combination vaccines allows you to reduce the number of visits to the doctor, painful injections and financial costs.

Myth #3.
We could do without vaccines; diseases would be defeated by hygiene anyway.

If you look at historical data on disease incidence, it is easy to see that its intensity falls as the quality of life improves. But if you plot the start of full-scale vaccination programs on these graphs, it becomes clear how big this qualitative leap is. Hygiene helped suppress infections, but it was vaccines that really drove them underground.

Infectious diseases for which there are no vaccines

- HIV,
- herpes,
- syphilis,
- leprosy,
- malaria,
- chlamydia, etc.

Causes:

- Variability of the pathogen (HIV)
- Genetic diversity of the pathogen - HIV is characterized by a very fast mutation rate. It mutates in the body in two weeks, the immune system cannot keep up with it. A virus or bacterium can have multiple serotypes.
- Vaccines can cover only part of this diversity. There are bacteria that do not secrete almost any antigens. This applies to single-celled fungi, such as candidiasis or pneumococcus.