Vaccine

Vaccine

- Vaccine, suspension of weakened, killed, or fragmented microorganisms or toxins or other biological preparation, such as those consisting of antibodies, lymphocytes, or messenger RNA (mRNA), that is administered primarily to prevent disease.
- A vaccine can confer active immunity against a specific harmful agent by stimulating the immune system to attack the agent. Once stimulated by a vaccine, the antibody-producing cells, called B cells (or B lymphocytes), remain sensitized and ready to respond to the agent should it ever gain entry to the body.
- A vaccine may also confer passive immunity by providing antibodies or lymphocytes already made by an animal or human donor.
- Vaccines are usually administered by injection (parenteral administration), but some are given orally or even nasally (in the case of flu vaccine). Vaccines applied to mucosal surfaces, such as those lining the gut or nasal passages, seem to stimulate a greater antibody response and may be the most effective route of administration. (For further information, *see* immunization.)

TABLE 12.2 Human disease agents for which recombinant vaccines are currently being developed

Pathogenic agent	Disease
Viruses	
Varicella-zoster viruses	Chicken pox
Cytomegalovirus	Infection in infants and immunocompromised patients
Dengue virus	Hemorrhagic fever
Hepatitis A virus	High fever, liver damage
Hepatitis B virus	Long-term liver damage
Herpes simplex virus type 2	Genital ulcers
Influenza A and B viruses	Acute respiratory disease
Japanese encephalitis	Encephalitis
Parainfluenza virus	Inflammation of the upper respiratory tract
Rabies virus	Encephalitis
Respiratory syncytial virus	Upper and lower respiratory tract lesions
Rotavirus	Acute infantile gastroenteritis
Yellow fever virus	Lesions of heart, kidney, and liver
Human immunodeficiency virus	AIDS

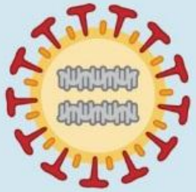
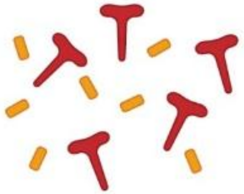
Coronavirus 2 (SARS-CoV-2): COVID-19

Vaccine

Bacteria	
Vibrio cholerae	Cholera
E. coli enterotoxin strains	Diarrheal disease
Neisseria gonorrhoeae	Gonorrhea
Haemophilus influenzae	Meningitis, septicemic conditions
Mycobacterium leprae	Leprosy
Neisseria meningitidis	Meningitis
Bordetella pertussis	Whooping cough
Shigella strains	Dysentery
Streptococcus group A	Scarlet fever, rheumatic fever, throat infection
Streptococcus group B	Sepsis, urogenital tract infection
Streptococcus pneumoniae	Pneumonia, meningitis
Clostridium tetani	Tetanus
Mycobacterium tuberculosis	Tuberculosis
Salmonella enterica serovar Typhi	Typhoid fever
Parasites	
Onchocerca volvulus	River blindness
Leishmania spp.	Internal and external lesions
Plasmodium spp.	Malaria
Schistosoma mansoni	Schistosomiasis
Trypanosoma spp.	Sleeping sickness
Wuchereria bancrofti	Filariasis

Types of coronavirus vaccine approaches

Scientists are casting a wide net to see what works best against the novel coronavirus.

Types of vaccines	DNA and RNA	Live attenuated	Inactivated	Subunit	Viral vector
					
How it works	This vaccine uses DNA or RNA molecules to teach the immune system to target key viral proteins.	This is a weakened version of the actual virus.	An inactivated vaccine uses the whole virus after it has been killed with heat or chemicals.	This vaccine uses a piece of a virus' surface to focus your immune system on a single target.	This approach takes a harmless virus and uses it to deliver viral genes to build immunity.
Advantages	Easy and quick to design.	Stimulates a robust immune response without causing serious disease.	Safe because the virus is already dead and is easy to make.	Focuses the immune response on the most important part of the virus for protection and cannot cause infection.	Live viruses tend to elicit stronger immune responses than dead viruses or subunit vaccines.
Disadvantages	Never been done before. There are no licensed DNA or RNA vaccines currently in use.	May not be safe for those with compromised immune systems.	Not as effective as a live virus. Some previous inactivated vaccines have made the disease worse; safety for the novel coronavirus needs to be shown in clinical trials.	May not stimulate a strong response, other chemicals may need to be added to boost long-term immunity.	Important to pick a viral vector that is truly safe. An immune response to the viral vector could make the vaccine less effective.
Existing examples	• None	• Measles, Mumps and Rubella • Chickenpox	• Polio	• Pertussis • Hepatitis B • Human papillomavirus (HPV)	• Ebola • Veterinary medicine
Group testing this approach for COVID-19	• Moderna (RNA) • Inovio (DNA)	• Codagenix • Indian Immunologicals Ltd.	• Sinovac • Sinopharm	• Novavax • AdaptVac	• University of Oxford & AstraZeneca • CanSino Biologics • Johnson & Johnson

Sources: CDC; NIAID; FDA

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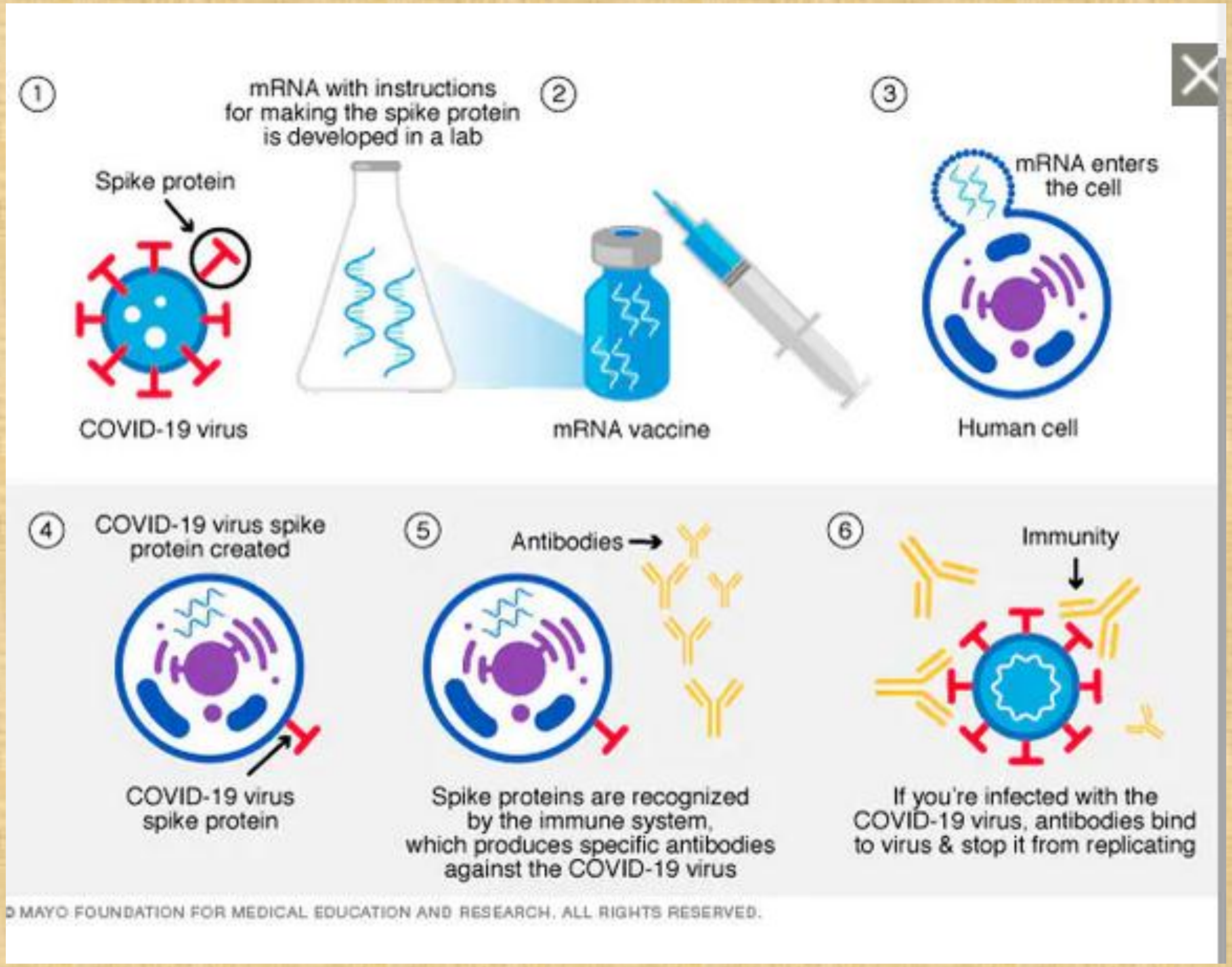


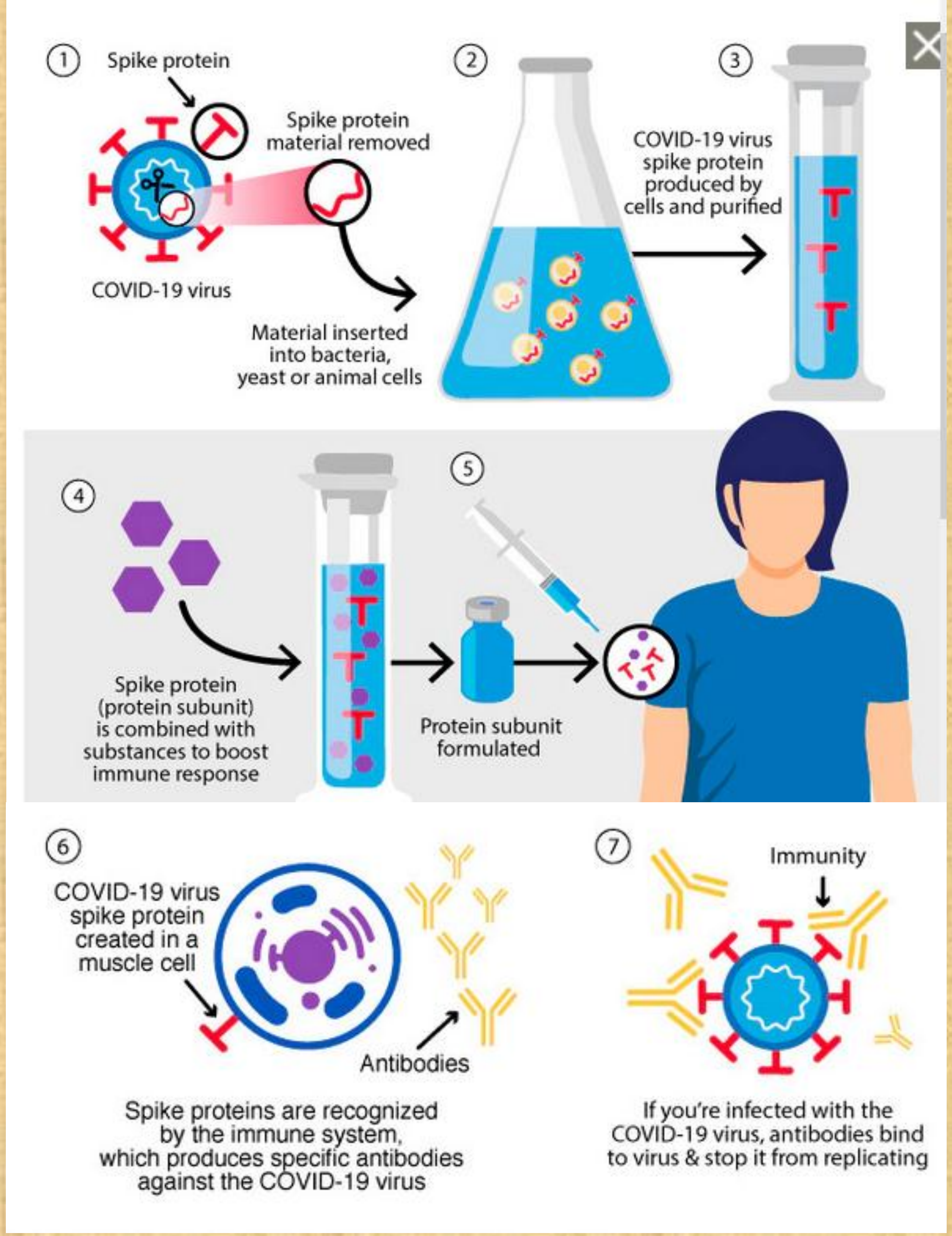
•**Messenger RNA (mRNA) vaccine.** This type of vaccine uses genetically engineered mRNA to give your cells instructions for how to make the S protein found on the surface of the COVID-19 virus.

After vaccination, your muscle cells begin making the S protein pieces and displaying them on cell surfaces.

This causes your body to create antibodies. If you later become infected with the COVID-19 virus, these antibodies will fight the virus.

After delivering instructions, the mRNA is immediately broken down. It never enters the nucleus of your cells, where your DNA is kept.

Both the Pfizer-BioNTech and the Moderna COVID-19 vaccines use mRNA.



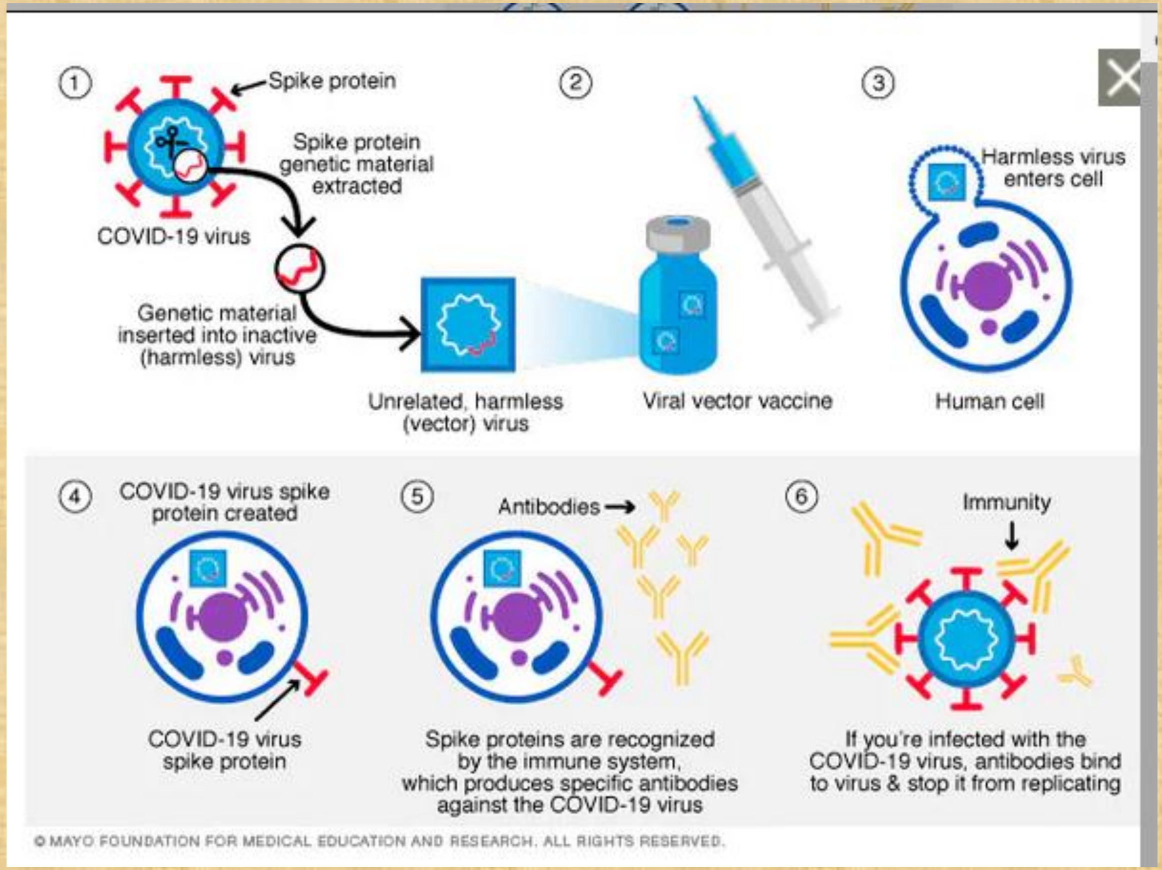
Protein subunit vaccine.

Subunit vaccines include only the parts of a virus that stimulate your immune system.

This type of COVID-19 vaccine contains harmless S proteins.

Once your immune system recognizes the S proteins, it creates antibodies and defensive white blood cells. If you later become infected with the COVID-19 virus, the antibodies will fight the virus.

Viral vector vaccine



A viral vector vaccine is made when genetic material from a COVID-19 virus is inserted into a unrelated, harmless virus. When the viral vector gets into your cells, it delivers genetic material from the COVID-19 virus that gives your cells instructions for how to make the spike protein found on the surface of the COVID-19 virus. Once your cells displace the spike proteins on their surfaces, your immune system creates antibodies that can fight the COVID-19 virus.

Types of SARS-CoV-2 vaccines for COVID-19

Viral vector vaccines

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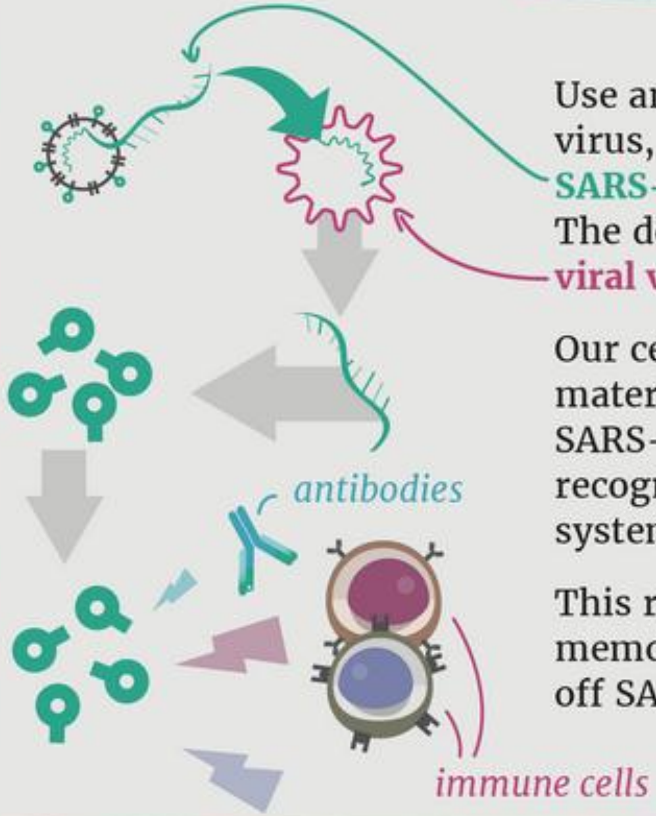

Use an unrelated harmless virus, modified to deliver **SARS-CoV-2 genetic material**. The delivery virus is known as a **viral vector**.

Our cells use the genetic material to make a specific SARS-CoV-2 protein, which is recognised by the immune system to trigger a response.

This response builds immune memory, so your body can fight off SARS-CoV-2 in future.

Considerations

Generate strong immune response.

May need to be stored at specific low temperatures.

Examples in human use for other diseases

Ebola vaccine

Approved in the UK for COVID-19

AstraZeneca/Oxford

Approved elsewhere in the world for COVID-19

Jannsen, CanSino, Gamaleya

Types of SARS-CoV-2 vaccines for COVID-19

Genetic vaccines
(nucleic acid vaccines)

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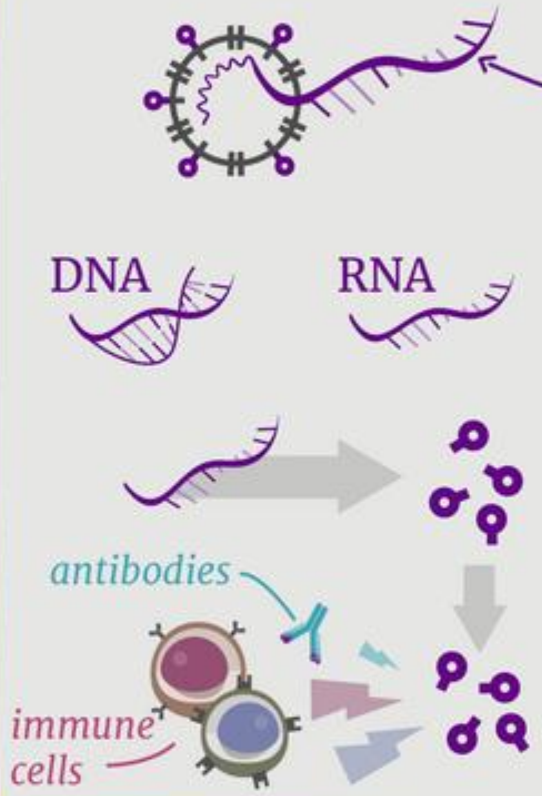

Contain a segment of **SARS-CoV-2 virus genetic material** that codes for a specific protein. Can be DNA or RNA.

Our cells use the genetic material to make the SARS-CoV-2 protein, which is recognised by the immune system to trigger a response.

This response builds immune memory, so your body can fight off SARS-CoV-2 in future.

Considerations

Low cost and fast to develop.

May need to be stored at specific low temperatures.

Approved in the UK for COVID-19

Pfizer/BioNTech & Moderna

In clinical trials for COVID-19

CureVac, Inovio Pharmaceuticals

Types of SARS-CoV-2 vaccines for COVID-19

Inactivated vaccines

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Contain **killed SARS-CoV-2 virus**.

The killed virus is recognised by the immune system to trigger a response without causing illness.

This response builds immune memory, so your body can fight off SARS-CoV-2 in future.

Considerations

May need to be administered with an adjuvant to boost immune response.

Examples in human use for other disease

Influenza vaccine

Approved elsewhere in the world for COVID-19

Sinovac, Sinopharm, Bharat Biotech

In clinical trials for COVID-19

Shifa-Pharmed, Chinese Academy of Medical Sciences

Types of SARS-CoV-2 vaccines for COVID-19

Attenuated vaccines

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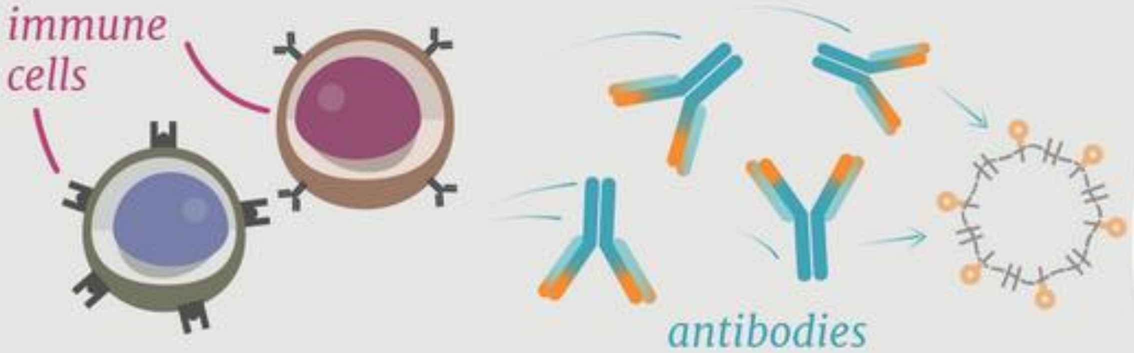
Contain **weakened SARS-CoV-2 virus**.

The weakened virus is recognised by the immune system to trigger a response without causing illness.

This response builds immune memory, so your body can fight off SARS-CoV-2 in future.



Considerations

A well-known approach which requires time and extensive testing.

The immune response resembles the natural infection.

Examples in human use for other disease

Oral Polio vaccine

In clinical trials for COVID-19

Codagenix

Types of SARS-CoV-2 vaccines for COVID-19

Protein vaccines

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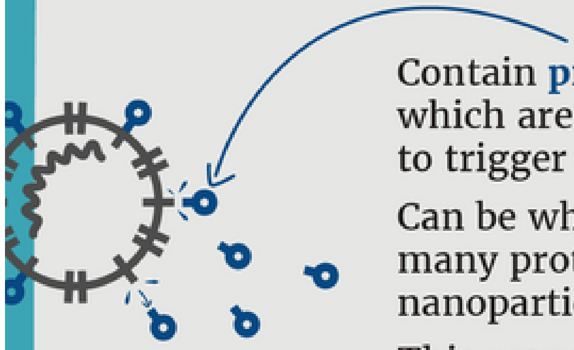
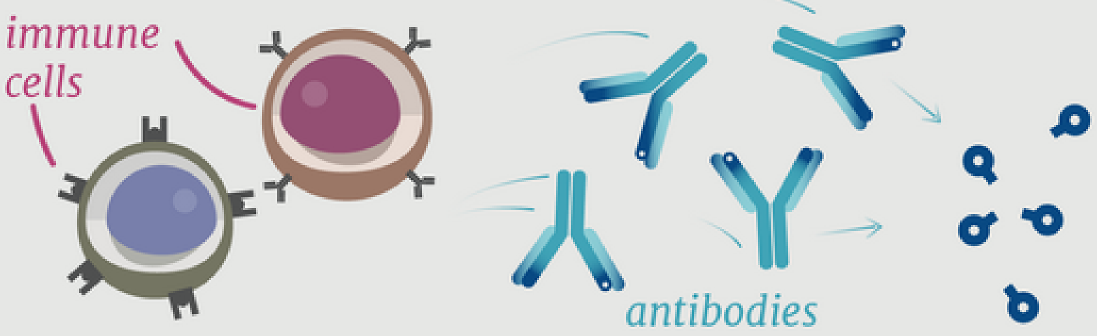


Contain **proteins** from the SARS-CoV-2 virus, which are recognised by the immune system to trigger a response.

Can be whole proteins, protein fragments, or many protein molecules packed into nanoparticles.

This response builds immune memory, so your body can fight off SARS-CoV-2 in future.



Considerations

Have good previous safety records.

Usually administered with an adjuvant to boost immune response.

Examples in human use for other diseases

Hepatitis B vaccine

In clinical trials for COVID-19

Novavax, Sanofi/GSK

Subunit Vaccine

- Vaccines that use components of a pathogenic organism rather than the whole organism are called “subunit” vaccines; recombinant DNA technology is very well suited for developing new subunit vaccines.
- There are advantages and disadvantages to the use of subunit vaccines.
- On the positive side, using a purified protein(s) as an immunogen ensures that the preparation is stable and safe, is precisely defined chemically, and is free of extraneous proteins and nucleic acids that can initiate undesirable side effects in the host organism.
- On the negative side, purification of a specific protein can be costly, and in certain instances, an isolated protein may not have the same conformation as it does in situ (within the viral capsid or envelope), with the result that its antigenicity is decreased.

Subunit Vaccine: For Herpes Simplex Virus (HSV)

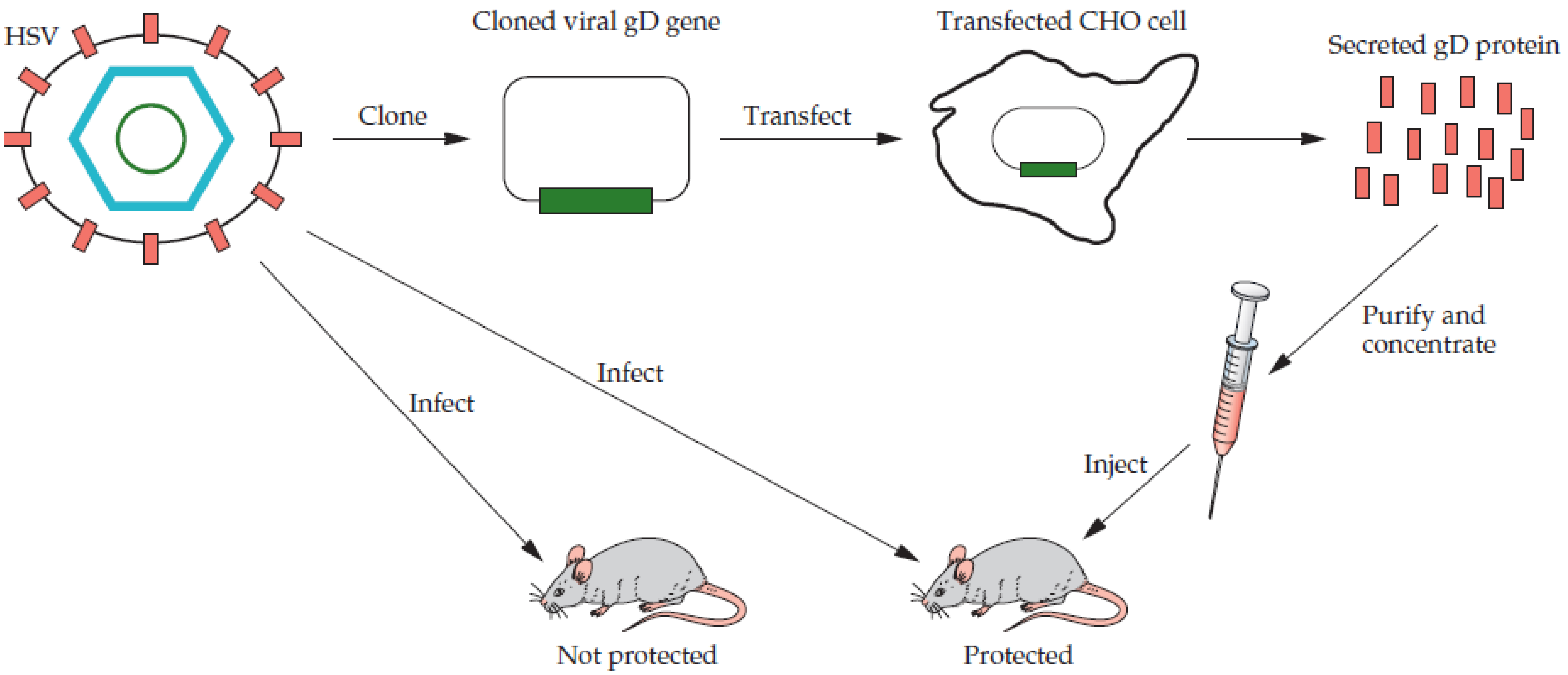


FIGURE 12.2 Schematic representation of the development of a subunit vaccine against HSV. The isolated HSV gD protein gene is used to transfect CHO cells. Then, the transfected cells are grown in culture and produce gD protein. Mice inoculated with the purified gD protein are protected against infection by HSV.

References

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Types of vaccines for COVID-19

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