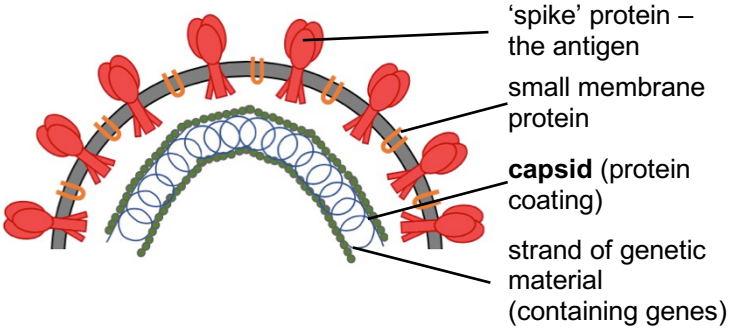
10 New vaccines & COVID-19

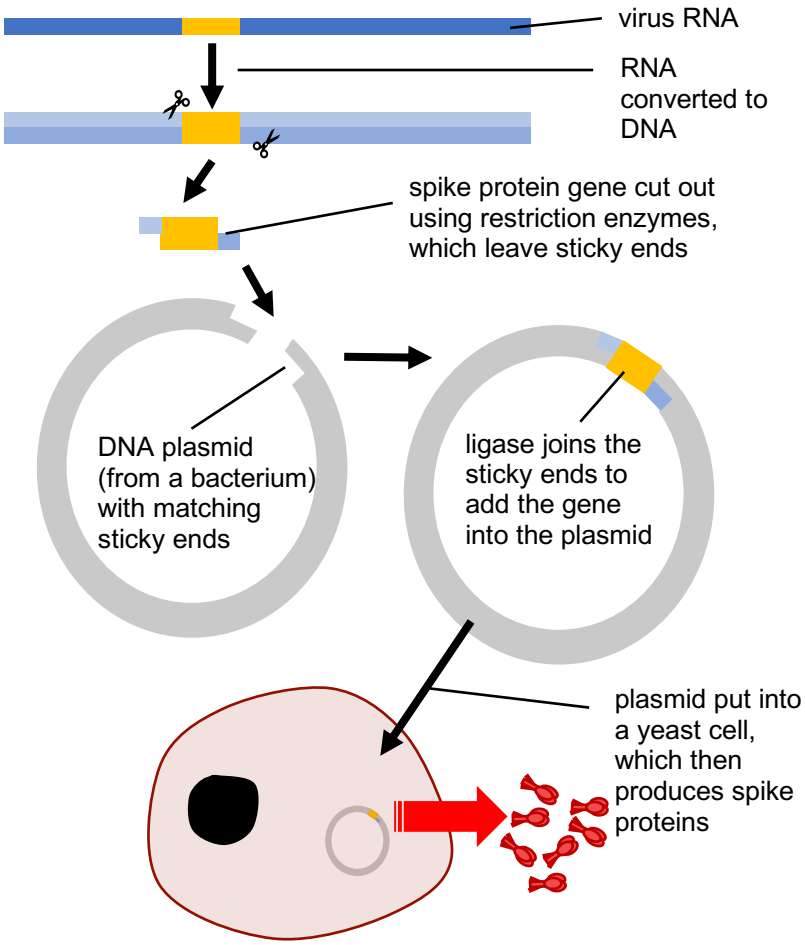
Vaccines



A **vaccine** makes someone immune to a certain **communicable disease.** 'Subunit vaccines' only contain the **antigens** from the pathogen. The 'spike' proteins on the SARS-CoV-2 virus are antigens. **Lymphocytes** in the body detect these antigens as being foreign. This triggers some lymphocytes to make specific **antibodies** that lock onto the antigens and inactivate the virus.

Genetic Engineering

A subunit vaccine for COVID-19 may just contain spike protein molecules. These vaccines are very safe and can be given to people with weak immune systems. They can be made by changing the **genome** (genetic material) of a yeast to form a **GMO**.



The genetic material in SARS-CoV-2 is a long molecule of RNA. This is similar to DNA but needs to be converted into DNA for **genetic engineering**. The **gene** for the spike protein is then cut out of the DNA using **restriction enzymes**, which leave jagged ends on the DNA (**sticky ends**).

A small loop of DNA (a **plasmid**) is then taken from a bacterium. A restriction enzyme cuts the plasmid open, giving it matching sticky ends to the gene. Another enzyme (**ligase**) joins the gene to the plasmid. This plasmid is now a new combination of DNA (**recombinant DNA**). It is then put into a yeast cell, where it causes the yeast to make spike proteins.

Recombinant subunit vaccines are cheap to produce but vaccines using only one antigen do not always work. Scientists are not sure that lymphocytes can be activated by the spike protein on its own (other parts of the virus may be needed). Yeast cells may not manufacture the spike protein in the same way as a human cell, so these spike proteins may not activate the correct lymphocytes.

Find out

I. 1. a. What does GMO stand for? _____

b. In which year was genetic engineering technology invented? _____

2. Go to https://bit.ly/2KPw6MF to see a 'map' of the genetic material from SARS-CoV-2 (after conversion into DNA). The parts of a DNA molecule that different restriction enzymes cut are shown when you hover over them (the enzymes have names like BamHI). The large solid red arrows indicate the positions of the genes. The gene for the spike protein is S.

a. Identify one restriction enzyme that does not produce sticky ends. _____

b. Name two restriction enzymes you would use to cut out gene S. _____

c. Give the name of another gene with a single letter. _____

d. Find out what it does. _____

Test yourself

3. a. A **vector** transfers material from place to place. Explain why the plasmid is a vector.

_____

b. Give the reason that the plasmid on page 1 is described as 'recombinant'.

_____

4. Human insulin is needed by people who have type 1 diabetes. It is produced using a genetically modified bacterium. Sketch a flow chart to show how this GMO was made.

5. Compare the advantages and disadvantages of creating a vaccine in this way.

_____

_____

_____

_____

Check-up

I. Check your answers.

II. Use an app to create a stop motion animation showing how genetic engineering is used to create a subunit vaccine. Include a voice-over.

Answers

Note to home educators

The worksheet is designed to support understanding of immunity, immunisation and genetic engineering. You may wish to share these objectives with students:

- Explain the body's response to immunisation using an inactive form of a pathogen (GCSE)
- Describe what is meant by a 'genetically modified organism'. (GCSE)
- Recall some uses of genetically engineered organisms (e.g. in medicine). (GCSE)
- Describe the main stages of genetic engineering. (GCSE Higher Tier)

To access this sheet, students will need a knowledge of white blood cells, molecules, proteins, enzymes and DNA. It may be helpful for students to use Worksheets 8 and 9 before this one (available at https://shwca.se/covid19science).

It is suggested that students complete the worksheet independently, using the internet for questions 1 & 2. Questions 3 - 5 should be completed without help from additional sources.

This sheet is designed for students in Years 10 and 11, and the material is drawn from the GCSE 9-1 Science specifications (Combined Science and Single Science Biology). Some of the material is Higher Tier.

If you wish to check the answers, keep this part of the sheet away from the questions!

I.
1. a. genetically modified organism
   b. 1973 (by Herbert Boyer and Stanley Cohen)
2. Note that this is a website used by scientists.
   a. One of: NruI, SfoI, SmaI, PmeI, Eco53kI, SwaI, BsrBI, StuI. (When you hover over the name of the enzyme, the places where it cuts each strand of a DNA molecule are shown. The arrows mark those cuts. If the two arrows are one above the other, they will not produce a sticky end.)
   b. NgoMIV and BanHI (Accept BspEI to be on the safe side, but SwaI cuts into the S protein gene. Do not accept NaeI which does not produce sticky ends.)
   c. One of: E, M or N
   d. One of: E = envelope protein, M = Membrane glycoprotein, N = nucleocapsid phosphoprotein
3. a. It carries the virus gene into the yeast cell.
   b. It contains DNA that has been artificially combined in a new way.
4. A flow chart (or diagram) showing the insulin gene being cut from human DNA, being added into a bacterial plasmid (using restriction enzymes and ligase) and being put into a bacterium.
5. Advantages: cheap production, very safe, suitable for people with very weak immune systems
   Disadvantages: spike protein on its own may not activate lymphocytes (so vaccine may not work well), yeast-produced proteins may not be the same as natural spike proteins (so vaccine may not work well).

II. Stop motion animation showing the procedure in the large graphic on page one, with a voice-over to explain what is happening. The lengths of genetic material could be modelled using string, coloured wool or drawings. Restriction enzyme action could be represented by scissors, and ligase by glue.