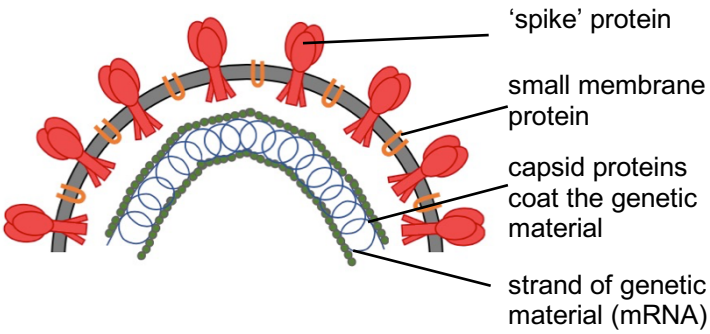
21 More vaccines & COVID-19

Vaccines



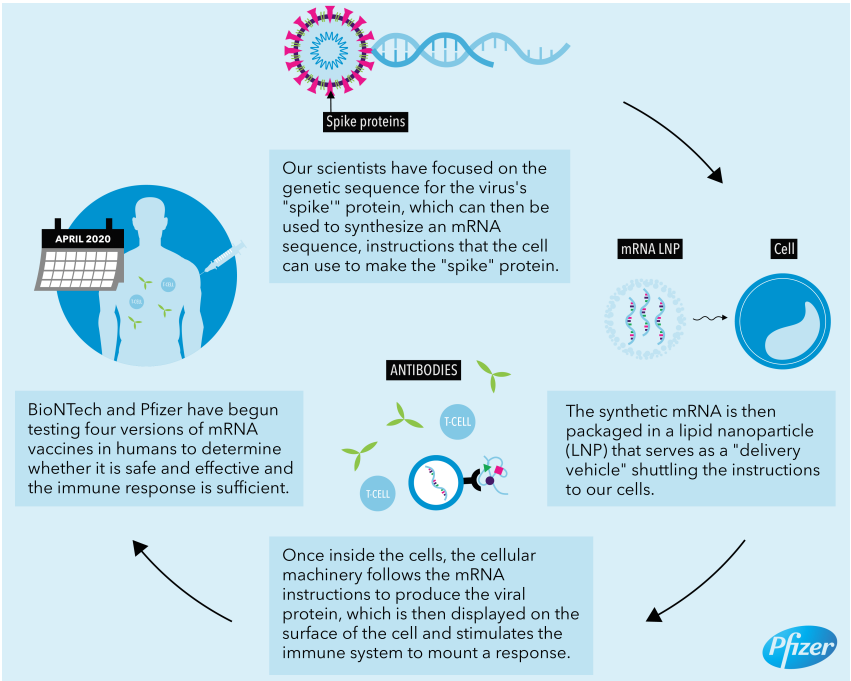
A **vaccine** can stop someone getting a certain **communicable disease**. Many vaccines work by putting part of a disease-causing organism into the body. This part is an **antigen**. For the SARS-CoV-2 virus (in the diagram) the 'spike' protein is a good antigen to use in a vaccine.

Different vaccines

One type of vaccine, called a 'subunit vaccine', just contains many antigen molecules. Other vaccines get the body's own cells to produce the antigen, using genetic material from the virus. Genetic material contains instructions for producing proteins. In humans it is DNA. In a human cell nucleus, the instructions on DNA molecules are copied onto strands of a similar substance called mRNA. The mRNA leaves the nucleus and enters the cytoplasm where its instructions are used to make proteins.

The genetic material of SARS-CoV-2 is mRNA. When a SARS-CoV-2 virus particle enters a human cell, the virus mRNA in the cytoplasm fools the cell into mass producing the virus proteins and new copies of its mRNA. These are assembled into new virus particles, which burst out of the cell.

Pfizer and BioNTech have made an 'mRNA vaccine'. They make copies of the section (gene) of the virus mRNA with the spike protein instructions. They then coat the mRNA copies in cell membrane. When injected, the membrane combines with a human cell membrane and the spike protein mRNA enters the cell.



A vaccine made by the University of Oxford and AstraZeneca uses an adenovirus as a **vector**. Adenoviruses contain DNA. When they infect a cell, their DNA enters the nucleus of the cell. mRNA is then produced, with the instructions for the virus proteins. For this 'vector vaccine', the scientists genetically modified the adenovirus so that it cannot cause disease. They then made DNA with instructions for the SARS-CoV-2 spike protein. This artificial DNA was then genetically engineered into the adenovirus DNA.

Find out

I. 1. What disease do adenoviruses commonly cause in humans? _____

2. Go to https://bit.ly/2KPw6MF. This shows a 'map' of the genetic material from SARS-CoV-2 that has been converted from mRNA to DNA. Scroll over the diagram to find the answers.

a. What letter is given to the section of DNA (the gene) for the spike protein. _____

b. DNA is made of pairs of substances called bases (bp). How many base pairs (bp) are in the spike protein gene. _____

c. DNA contains four bases, each represented by a letter. What are the letters? _____

d. mRNA contains a base that is not found in DNA. What is its name? _____

Test yourself

3. a. Where is DNA found in human cells? _____

b. What do human cells use mRNA for? _____

4. Compare the genetic material in SARS-CoV-2 and an adenovirus. _____

_____

5. A **vector** transfers material from place to place. Explain why the adenovirus is a vector.

_____

6. Explain why the Pfizer vaccine cannot cause COVID-19. _____

_____

7. Suggest what would be found in a subunit vaccine against COVID-19. _____

_____

8. The SARS-CoV-2 mRNA contains a gene for the spike protein. Describe two other genes that the virus must contain.

_____

_____

Check-up

I. Check your answers.

II. Companies often produce 'infographics', such as the one from Pfizer shown above. These are simple diagrams to explain their products. Design an infographic for the University of Oxford/AstraZeneca vaccine.

Answers

Note to home educators

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

- Describe the relationship between genes and DNA (KS3)
- 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 how information from genes is translated into proteins. (Higher Tier GCSE)

To access this sheet, students will need a knowledge of white blood cells and immunity. It may be helpful for students to use Worksheets 7, 8, 9 and/or 10 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 - 8 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. Students in Years 8 and 9 should be able to access the material with guidance and support.

I.
1. Common cold is the most obvious (and common) but others include bronchitis, viral pneumonia and conjunctivitis.
2. Note that this is a website used by scientists.
   a. S
   b. 3822 bp
   c. A, T, G, C
   d. uracil
3. a. nucleus (There is also some DNA in mitochondria.)
   b. making proteins / carrying instructions from DNA into the cytoplasm
4. • They both contain the instructions for proteins.
   • SARS-CoV-2 contains mRNA, adenoviruses contain DNA.
5. It carries the virus gene into the human cell.
6. It does not contain all the genes needed to make the virus.
7. spike proteins (from the virus)
8. Two from: for the small membrane proteins / for the capsid proteins / for making copies of the mRNA.

II. Infographics should explain that the adenovirus has its genetic material changed to stop it causing a disease, and that it has the gene for the SAR-CoV-2 spike protein inserted. The infographic should show the virus vector vaccine getting into a human cell and the DNA entering its nucleus, then making mRNA and spike proteins.

The University of Oxford has produced an infographic, which students could compare to their own.
https://www.research.ox.ac.uk/Article/2020-07-19-the-oxford-covid-19-vaccine