Vaccination

4.3.1.7 · Infection and response · revision notes

How a vaccine makes you immune to a disease before you catch it, and why vaccinating a large proportion of a population also protects people who are not vaccinated. Expect 'explain how vaccination prevents illness' (3 to 4 marks) and graphs or data on antibody levels.

Key facts

- Vaccine = small quantity of a dead or inactive pathogen
- Re-infection → white blood cells respond quickly → correct antibodies made → pathogen destroyed before illness
- Immune = able to destroy the pathogen before it causes illness
- MMR vaccine protects against measles, mumps and rubella
- Vaccine → white blood cells produce specific antibodies
- Second response: faster and much bigger than the first
- Vaccinate a large proportion of a population → the pathogen spreads much less (herd immunity)

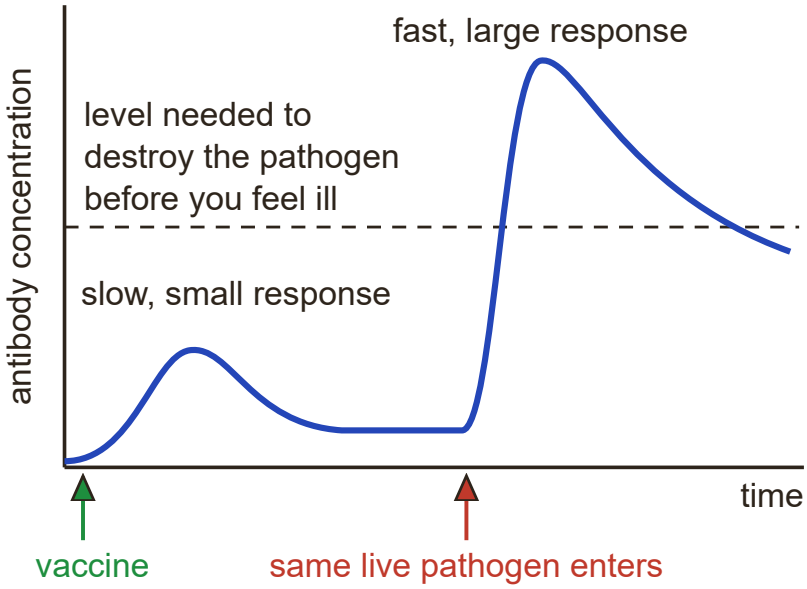
Notes

What a vaccine is

- A vaccine contains small quantities of a **dead or inactive** form of a pathogen. It is often given by injection.
- It cannot cause the disease, but it still carries the pathogen's **antigens**.

How vaccination protects you

- The vaccine stimulates your **white blood cells** to produce **antibodies** specific to that pathogen.
- Your white blood cells 'remember' the pathogen: some of them stay in your blood as memory cells.
- If the same live pathogen enters your body later, your white blood cells respond **quickly**, producing the correct antibodies in large amounts.
- The pathogens are destroyed before they can reproduce enough to make you ill. You are **immune**.
- Without the vaccine, the first response to a pathogen is slow, so the pathogen has time to reproduce and make you ill.



Memory cells make the second response faster and much bigger.

Protecting the population

- If a large proportion of a population is vaccinated, most people cannot be infected, so they cannot pass the pathogen on.
- So the pathogen is unlikely to reach the few people who are not immune, e.g. babies too young to be vaccinated or people who cannot have the vaccine.
- This is called **herd immunity**. It greatly reduces the spread of the disease.

Benefits and drawbacks

- Benefits: prevents illness and deaths, and can stop epidemics. Smallpox has been wiped out worldwide by vaccination.
- Drawbacks: a vaccine does not always make a person immune, and some people have side effects, which are usually mild.
- A vaccine protects only against the pathogen(s) it was made from (the MMR vaccine contains three: measles, mumps and rubella). Some pathogens, such as the flu virus, change their antigens, so a new vaccine is needed.

How to answer each type of question

Explain how vaccination prevents illness

3 to 4 marks **Grade 5**

1. Say what is in the vaccine: a dead or inactive form of the pathogen.
2. Say that it stimulates white blood cells to produce antibodies.
3. Say that if the live pathogen enters later, white blood cells respond quickly.
4. Finish: the correct antibodies destroy the pathogen before it causes illness.

Example. Young children in the UK are vaccinated against measles.
Explain how the vaccine protects a child from becoming ill with measles later.

Model answer. The vaccine contains a dead or inactive form of the measles virus (1). This stimulates white blood cells to produce antibodies against the virus (1). If the live measles virus enters the body later, the white blood cells respond quickly (1), producing the correct antibodies, which destroy the virus before it can cause illness (1).

Explain why vaccinating most people protects others

2 to 3 marks **Grade 5**

1. Vaccinated people are immune, so they are not infected.
2. So they cannot pass the pathogen on.
3. So unvaccinated people are unlikely to meet the pathogen.

Example. Some children cannot be vaccinated because they have a weak immune system.
Explain why it is important for as many other children as possible to be vaccinated.

Model answer. If most children are vaccinated, they are immune and will not be infected (1). So there are very few infected people to pass the pathogen on (1). So the children who cannot be vaccinated are unlikely to come into contact with the pathogen (1).

Interpret antibody data

3 to 4 marks | Grade 7

1. Compare the two responses: how quickly each starts and how high each peak is.
2. Quote numbers from the data.
3. Explain: the white blood cells had met the antigen before, so the second response is faster and bigger.

Example. A person was vaccinated on day 0. Their antibody concentration peaked at 20 arbitrary units on day 14. On day 60 the live pathogen entered their body. Their antibody concentration then peaked at 180 arbitrary units on day 66.
(a) How many times greater was the second peak than the first?
(b) Explain why the person did not become ill after day 60.

Model answer.

(a) 180 ÷ 20 = 9 times (1)

(b) The white blood cells had already been stimulated by the vaccine (1). So they responded faster: the peak came after 6 days instead of 14 (1). They made far more antibodies, so the pathogens were destroyed before they could cause illness (1).

Suggest why a new vaccine is needed

2 marks | Grade 7

1. Say that the pathogen changes its antigens.
2. Link to specificity: the old antibodies no longer fit the new antigens.

Example. A new flu vaccine is made every year.
Suggest why.

Model answer. The flu virus changes, so new strains with different antigens appear (1). Antibodies made in response to last year's vaccine are specific, so they do not bind to the new antigens (1).

Don’t lose marks

- Saying the vaccine contains antibodies. It contains a dead or inactive pathogen; your white blood cells make the antibodies.
- Saying vaccines cure a disease or kill the pathogen. They prevent illness; they do not treat an infection you already have.
- Saying the antibodies from the vaccine stay in the blood for life. What lasts is the ability to make the correct antibodies quickly.
- Writing 'the body becomes immune' without saying why: the white blood cells respond quickly and make the correct antibodies.
- Writing 'antibiotics' when you mean 'antibodies'.

More tips

Memory tricks

- Vaccine chain: dead or inactive pathogen → antibodies made → body 'remembers' → fast response next time → not ill.
- Graph check: the second peak comes sooner, rises more steeply and goes much higher.
- Herd immunity: the more people are immune, the fewer 'stepping stones' the pathogen has to spread.

Exam technique

- A full answer on how vaccination works includes: dead or inactive pathogen, white blood cells, antibodies, a quick response on re-infection, and the pathogen destroyed before illness.
- For antibody graphs, quote values: when each response starts and how high each peak is.
- For the population, describe the effect on the unvaccinated: the pathogen is unlikely to reach them.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

State what a vaccine contains

Small quantities of a dead or inactive form of a pathogen.

Grade 4

Describe what a vaccine makes the body do

It stimulates white blood cells to produce antibodies against the pathogen.

Grade 5

Explain how vaccination prevents illness

If the live pathogen enters later, white blood cells quickly make the correct antibodies and destroy it before it causes illness.

Grade 5

Explain how vaccination reduces spread in populations

If most people are immune, the pathogen is unlikely to reach unvaccinated people, so it spreads much less.

Grade 7

Interpret graphs of antibody concentration

After a second exposure, antibodies are made faster and in much larger amounts than after the first.

Grade 8

Evaluate the benefits and drawbacks of vaccination

Weigh the protection of individuals and populations against the fact that vaccines do not always work and can cause mild side effects.

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