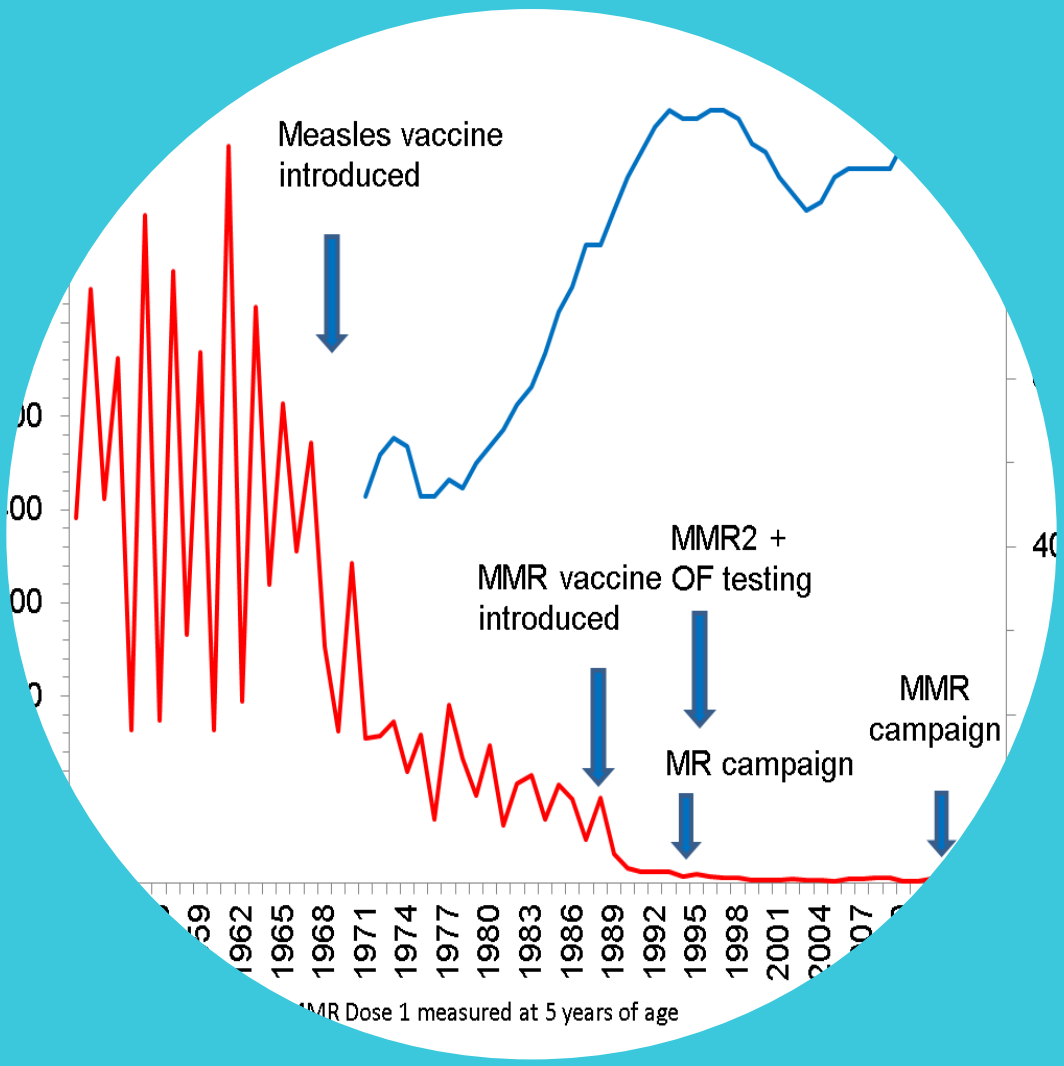

Vaccination

Key Stage 4 Revision Programme

Pupil Name

Handbook Designed by Dr J Bell

Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1 (Baseline assessment)	December 11, 2019	15:20	Ark Alexandra
2	January 8, 2020	15:20	Ark Alexandra
3	January 22, 2020	15:20	Ark Alexandra
4	January 29, 2020	15:20	Ark Alexandra
5	February 5, 2020	15:20	Ark Alexandra
6 (Final assessment)	February 12, 2020	15:20	Ark Alexandra
7 (Feedback)	March 11, 2020	15:20	Ark Alexandra

Timetable – Homework Assignments

Tutorial 1		
Tutorial 2		
Tutorial 3		
Tutorial 4		
Tutorial 5		

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Course Rationale

This course is based on the concept of deliberate practice, which means learning a topic by systematically practicing exercises on it, just as you would practice for a sport. The theory behind it is that if you actually have to do exercises, rather than just reading about a topic, you are forced to think about it, and if you think about it you will remember it.

The topic of infectious disease, the immune response and vaccination is a key part of the GCSE syllabus. It is one on which many misconceptions arise: for example, students don't always understand the difference between bacteria and viruses, and antibodies and antibiotics are confused. It will also be very useful to know about this topic in everyday life.

In this course the topic will be broken down into small parts and you will get opportunities to practice thinking about each part. Also the practice covers application of the knowledge in a wide variety of situations, so you are less likely to be presented with a situation you are unfamiliar with in the exam.

The skills you will practice can also be applied to many other topics in the exams, so the course will help you do well on other topics as well as this one.

In this workbook words given in **bold** are defined in the glossary.

Glossary of keywords

Word	Definition	In a sentence
Antibiotic	A medicine used that kills bacteria and is used to treat bacterial diseases.	Antibiotics are used to treat bacterial diseases.
Antigen	A molecule on the outside of a pathogen which is recognised by the immune system	The immune system responds to an antigen on a virus.
Antibody	A protein produced by white blood cells which can neutralise a pathogen by binding with a specific antigen	Antibodies provide protection against infection by pathogens.
Gene	A section of DNA that codes for a protein	Viruses have only a few genes.
Immunity	A state of protection against infectious diseases mediated by specialised white blood cells	Vaccination can give immunity against yellow fever.
Pathogen	A disease causing microorganism.	Pathogens can be viruses, bacteria, fungi or protists.
Vaccination	Creation of immunity by the artificial introduction into the body of antigens from pathogens	Vaccination against measles significantly reduces the number of cases.
Vaccine	A preparation including antigens from pathogens used to induce artificial immunity	Vaccines can be made from inactivated pathogens or from parts of pathogens.

Tutorial 1 – Baseline assessment

What is the Purpose of Tutorial 1?

- To complete the self evaluation form prior to the course
- To complete a baseline assessment to compare with the assessment at the end of the course

Tutorial 2 – Pathogens and immunity

What is the Purpose of Tutorial 2?

By the end of this tutorial you should be able to:

A) understand what a virus is and what a bacterium is and how they differ
B) understand what **antigens** and **antibodies** are, and how they interact to give immunity
C) apply this understanding to named diseases

A) Viruses and bacteria

Bacteria are living organisms composed of a single cell. They consist of cytoplasm surrounded by a cell membrane and a cell wall. Circular DNA, not associated with proteins, is contained in the cytoplasm. They reproduce by binary fission, when one bacterium divides into two bacteria. All they need to live is a source of food (some but not all bacteria also need oxygen). Some bacteria are pathogenic – disease causing – but many are not. The human body contains many normal – non pathogenic – bacteria. In fact there are more bacterial cells in the human body than human cells. Bacterial diseases can be treated by medicines called antibiotics which disrupt bacterial cells but not human cells. Antibiotics can work, for example, by disrupting the cell walls of bacteria.

Viruses, on the contrary, are not free living organisms. They can only reproduce when they infect living cells. A virus that infects animal cells – such as human cells – consists of a small piece of DNA or RNA surrounded by a protein coat. Viruses can be **pathogenic**.

Diseases caused by viruses can not be treated by antibiotics. Viral diseases are much harder to treat than bacterial diseases because the viruses are contained within cells. However, there are some antiviral drugs which are used to treat HIV (human immunodeficiency virus) infections.

Worked example:
Q Compare and contrast viruses and bacteria.
A Bacteria are free living and can grow and reproduce on their own with a source of food, whereas viruses can only reproduce in a living cell. Viruses are much smaller than bacteria.

Practice A

1. Name the two parts of a virus that infects human cells. Explain what each one is for.

2. Explain why bacteria will grow on a medium containing only nutrients but viruses will not.

3. What must viruses have in order to be able to multiply? Explain your answer.

4. The common cold is caused by a virus. Explain why it is difficult to treat diseases caused by viruses.

Assessment A

Which of the following statements is correct?

A) Viruses can multiply if given a source of food.
B) Viruses can not be pathogens.
C) Bacteria multiply inside cells.
D) Diseases caused by bacteria can be treated with an antibiotic.

B) Antigens and antibodies

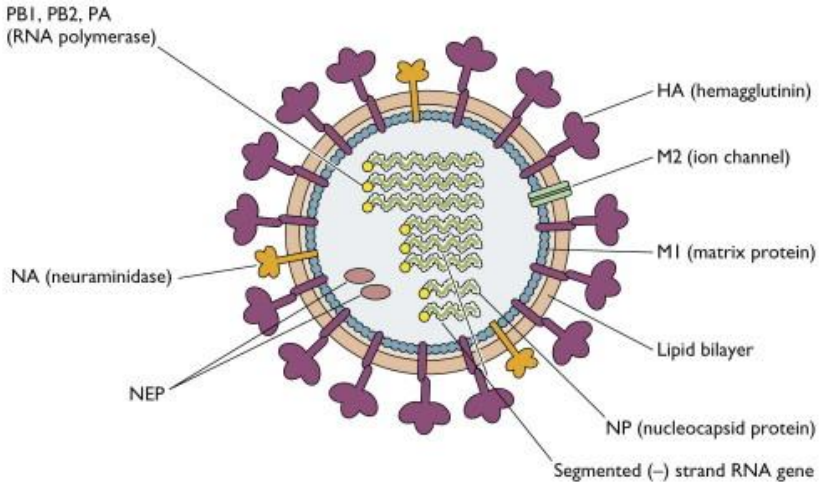
An antigen is a molecule (usually a protein) on the surface of a foreign microorganism that is recognised by the immune system. Antigens must be on the outside of a pathogen to be recognised by the immune system. The immune system does not normally recognise antigens on the body's own cells. Each antigen has a different shape.

Antibodies are protein molecules produced by white blood cells which are complementary in shape to antigens, so that they fit on to them, and can neutralise the pathogen bearing the antigen. For each antigen on a pathogen, the body makes an antibody which is specific for it, which means that each type of antibody has a different shape which fits a different antigen. Although they can both help control diseases, antibodies are completely different from antibiotics: antibodies are produced by the body's own cells and can act against viruses, for example, as well as against bacteria, while antibiotics are medicines administered from outside the body, and are only effective against bacteria.

Worked example:
Q Explain what is meant by the specificity of antibodies.
A Each type of antibody has a shape that only fits on to one type of antigen so it can only act against pathogens that have that particular antigen.

Practice B

1. This diagram shows an influenza virus. Suggest which parts of the virus can act as antigens. Explain your answer.



2. Explain why antibodies against the measles virus don't protect against the influenza virus.

3. Explain the difference between an antibody and an antibiotic.

4. Explain how the shape of an antibody is related to the antigen that it is against.

Assessment B

An antibody works by:

A) Binding with a molecule on the surface of the pathogen
B) Binding with a molecule inside the pathogen
C) Disrupting the cell wall of a pathogen
D) Combining with an antibiotic

C) Immunity to diseases

A pathogen is a microorganism that causes disease, such as HIV, whereas the disease, such as AIDS, is defined in terms of the symptoms caused by the pathogen – in the case of HIV a reduced number of white blood cells and susceptibility to other infections. Examples of pathogenic viruses are the measles virus, influenza virus, and human immunodeficiency virus (HIV). HIV causes acquired immunodeficiency syndrome (AIDS) by infecting the cells of the immune system. Examples of pathogenic bacteria are: *Salmonella*, which causes food poisoning by disrupting the water balance in the intestine; *Neisseria*, which causes gonorrhoea, a sexually transmitted disease; and *Mycobacterium*, which causes tuberculosis.

Worked example:
Q Explain, with an example, how one disease can interact with other.
A HIV causes AIDS resulting in a reduced number of white blood cells, which means that the immune response to other pathogens, such as *Mycobacterium* causing tuberculosis, is much more limited, making the second disease more severe.
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Practice C

1. Influenza is caused by a virus. Explain why a doctor will not prescribe antibiotics to treat it.

2. Tuberculosis is caused by a bacterium. How could it be treated?

3. HIV (human deficiency virus) causes AIDS (acquired immunodeficiency syndrome) by infecting white blood cells. Explain why someone with AIDS is more likely to get a fungal disease than someone who doesn't have AIDS.

Assessment C

Which of the following statements correctly explains why the common cold isn't treated with antibiotics?

A) It is too costly to prescribe antibiotics for everyone with a cold.
B) Colds are caused by viruses and antibiotics have no effect on viruses.
C) Antibiotics against the virus that caused colds are already produced by the immune system.
D) The bacteria that cause colds are usually resistant to antibiotics.

Tutorial 3 – Principles of immunity

What is the Purpose of Tutorial 3?

A) To understand the principle of **vaccination**
B) To understand the different types of **immunity**
C) To understand the different types of vaccine and how they work

A) Vaccination

Vaccination is the artificial introduction into the body of antigens to stimulate the production of specific antibodies against them. White blood cells called memory cells are then ready to divide quickly to produce many more cells producing those specific antibodies if the body encounters the same antigen again through a natural infection. Vaccination works against pathogens causing infectious diseases.

Worked example:
Q Describe the role of antibodies in vaccination.
A Specific antibodies are produced against the antigen that is introduced into the body in vaccination and they can defend the body against pathogens with the same antigen

Practice A

1. Explain how vaccination can prevent you catching a disease.

2. Explain why vaccination against measles will not prevent you from catching a cold.

3. Explain why it is not possible to vaccinate against heart disease.

Assessment A

Vaccination works by:

A) Injection of small quantities of antibodies
B) Injection of small quantities of antibiotics
C) Introducing small quantities of dead or inactive pathogens into the body
D) Introduction of large quantities of antibodies

B) Types of immunity

Active immunity is when you make your own antibodies, either in response to an infection – natural active immunity, or in response to vaccination – artificial active immunity. Passive immunity is when you receive antibodies ready made, either from your mother – natural passive immunity, or through injection of antibodies – artificial passive immunity. It is not possible to control diseases once symptoms have started by injection of antibodies, but this artificial passive immunity can be used, for example, to protect against

prevent the disease tetanus, which is caused by a bacterium, or to neutralise snake venom, or to protect against rabies virus.
If a large proportion of the population is vaccinated – 95% or more – then the pathogen can not easily spread and it is possible to stop infections by it. This is called herd immunity.

Worked example:
Q Suggest why an individual child may not be vaccinated against a given disease, but may still be protected against the disease.
A It could be that a sufficient proportion of the population is vaccinated against the disease to stop it spreading, so the individual is not infected. This is herd immunity.

Practice B

1. Antibodies against snake venom are injected at the site of a snake bite. What type of immunity is this?

2. What is the meaning of the term 'active immunity?' Give an example.

3. What is the difference between artificial passive immunity and natural artificial immunity? Give examples.

4. Explain in as much details as you can why it is not necessary to vaccinate 100% of a population to stop an infectious disease spreading in the population.

Assessment B

Which of the following statements is **incorrect**?

A) Active immunity means making your own antibodies
B) Injection of antibodies can cure a viral disease after symptoms appear
C) Artificial active immunity can protect against infection by a pathogen
D) Natural active immunity can protect against infection by a pathogen

C) Types of vaccine

The aim of administering a **vaccine** is to produce antibodies against the antigens on a pathogen without the pathogen causing disease. It often consists of a killed pathogen, but it can also be a weakened pathogen, which is still alive but can not cause disease, or just parts of a pathogen which include the antigen. Another type of vaccine is made by genetic engineering, inserting the **gene** that codes for an antigen in a pathogen into the DNA of a different microorganism. Live weakened pathogens can spread between individuals, but the other types of vaccine can not. The disadvantage of this type of vaccine is that it could revert to a pathogenic form of the microorganism.

Worked example:
Q Explain why live pathogenic viruses are not used in vaccines.
A. Although live pathogenic viruses would provide immunity to the pathogen, they would also cause the disease.

Practice C

1. Vaccines can be weakened live pathogens, parts of a pathogen, or another microorganism with part of the pathogen genetically engineered into it. Which one of these could spread from one individual to another? Explain your answer.

2. What would be the advantage of a vaccine that could spread from one individual to another?

3. What is the advantage of a genetically engineered vaccine compared to one made from a weakened pathogen?

Assessment C

Which sentence **correctly** describes why the different types of vaccine work?

A) They all present an antigen from the pathogen to the immune system.
B) All types of vaccine involve injection of the pathogen.
C) They all contain antibodies.
D) None of the vaccines are harmful.

Tutorial 4 – Interpreting graphs

What is the Purpose of Tutorial 4?

A) To be able to produce graphs from tables
B) To be able to calculate percentage change from graphs
C) To be able to manipulate data from graphs to get results in a different format

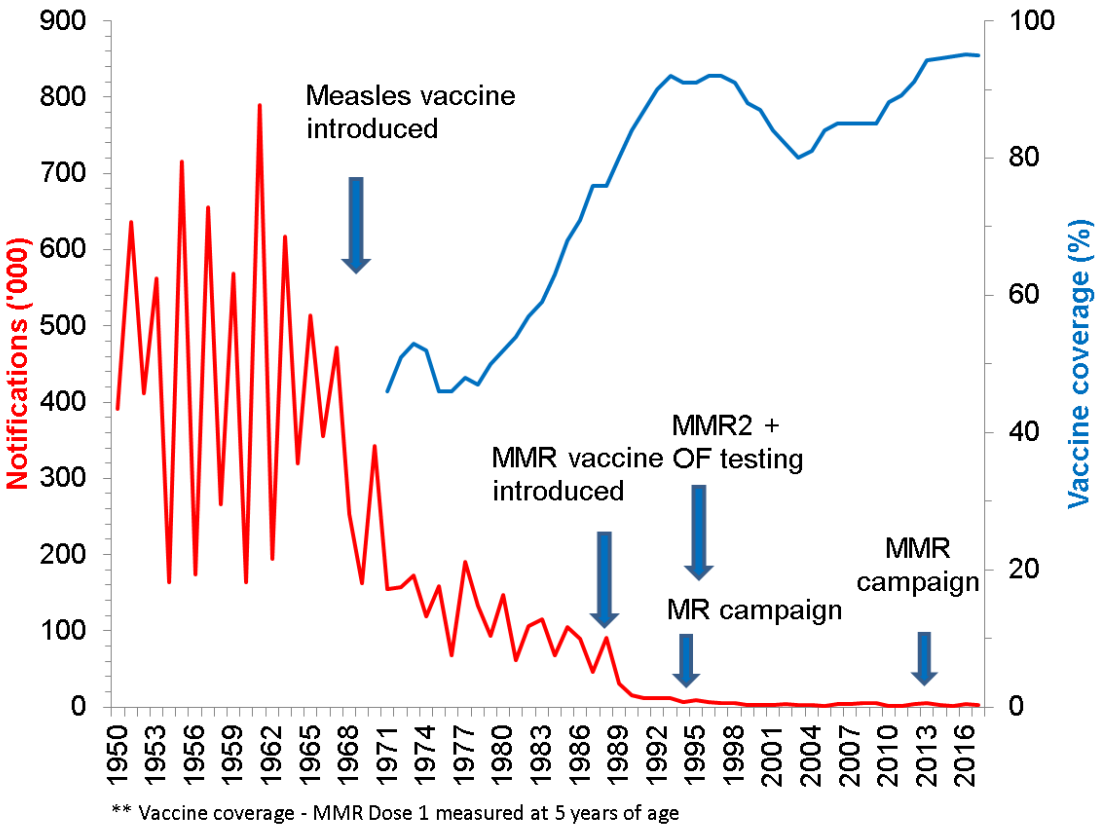

Fig 1. UK coverage of measles vaccination and measles notifications from 1950 to 2016

The graph shown in Fig 1 is an example of the sort graph you need to be able to interpret. The red line shows the number of cases of measles notified in a given year in thousands. That means, for example, that in 1950 the number of cases notified was 500 X 1,000 = 500,000. The number of cases notified is not the same as the number of cases that there actually were in that year, because not all cases were reported. The blue line shows the vaccine coverage – this means the percentage of the population that was vaccinated. Note that as the vaccine coverage goes up, the number of cases notified reduces, suggesting – but not proving – that the vaccination is preventing the disease.

Often cases are presented per 100,000 population. This means that if, for example there were 8 cases per 100,000 population, in a population of 2 million there were 160 cases – 2 million divided by 100,000 multiplied by 8.

You may also be required to draw graphs from data, such as plotting the number of cases of a disease against time. In this case you have to first choose suitable scales for the x axis, on which you plot time, and the y axis, on which you plot the number of cases. The axes must be labelled and the graph must be given a title. Then the points are plotted – in pencil – and in this case a straight line is drawn with a ruler between each point, as shown by the red line in Fig 1.

To calculate percentage change, you first calculate the *difference* by the subtracting the original value from the new value, and then you calculate the percentage change by dividing the difference by the *original* value and multiplying it by 100. For example the *difference* in cases notified between 1950 and 1962 is 800-400 = 400. Then the percentage change is this difference, 400, divided by the *original* number 400, multiplied by 100:

400/400 X 100 = 1 X 100 = 100%.

Practice

The following table gives the number of cases and number of deaths from avian influenza (bird flu) in Indonesia between 2005 and 2018.

Year	Number of cases	Number of deaths
2005	20	13
2006	55	45
2007	42	37
2008	24	20
2009	21	19
2010	9	7
2011	12	10
2012	9	9
2013	3	3
2014	2	2
2015	2	2
2016	0	0
2017	1	1
2018	0	0

1. Plot the number of cases and the number of deaths against the year on the graph paper on the next page.

2. In which year was greatest number of cases?

3. Calculate the percentage of cases that resulted in death in a) 2008 and b) 2015.

4. The population of Indonesia is 264 million. What percentage of the population got bird flu in 2006?

5. How many cases were there per 100,000 population in 2006?

Assessment

If the number of cases of influenza per 100,000 population in England during the 2018-19 flu season was 17.4 and the population was 55.62 million, how many cases were there altogether?

A) 9,678
B) 1,740,000
C) 5,747
D) 319,655

Tutorial 5 – Preventing disease in populations

What is the Purpose of Tutorial 5?

A) To understand the principle of herd immunity and how diseases can be eliminated by vaccination
B) To understand how the balance the risks and benefits of vaccination
C) To understand how antigenic variation affects vaccination

A) Herd Immunity

To protect a population from the spread of a pathogen, the aim is to ensure that each infected individual infects less than one new individual. If this is case, it means that the number of cases will decline and the disease will die out. If the majority of individuals that an infected individual encounters are vaccinated, they will not be infected, and this can indeed reduce the number of new cases infected from the infected individual less than one. So the population has been protected from infection by the vaccination of the majority, but not all, the individuals in it. This is known as herd immunity. It is generally considered that vaccination of 95% of the population will provide herd immunity.

Practice A

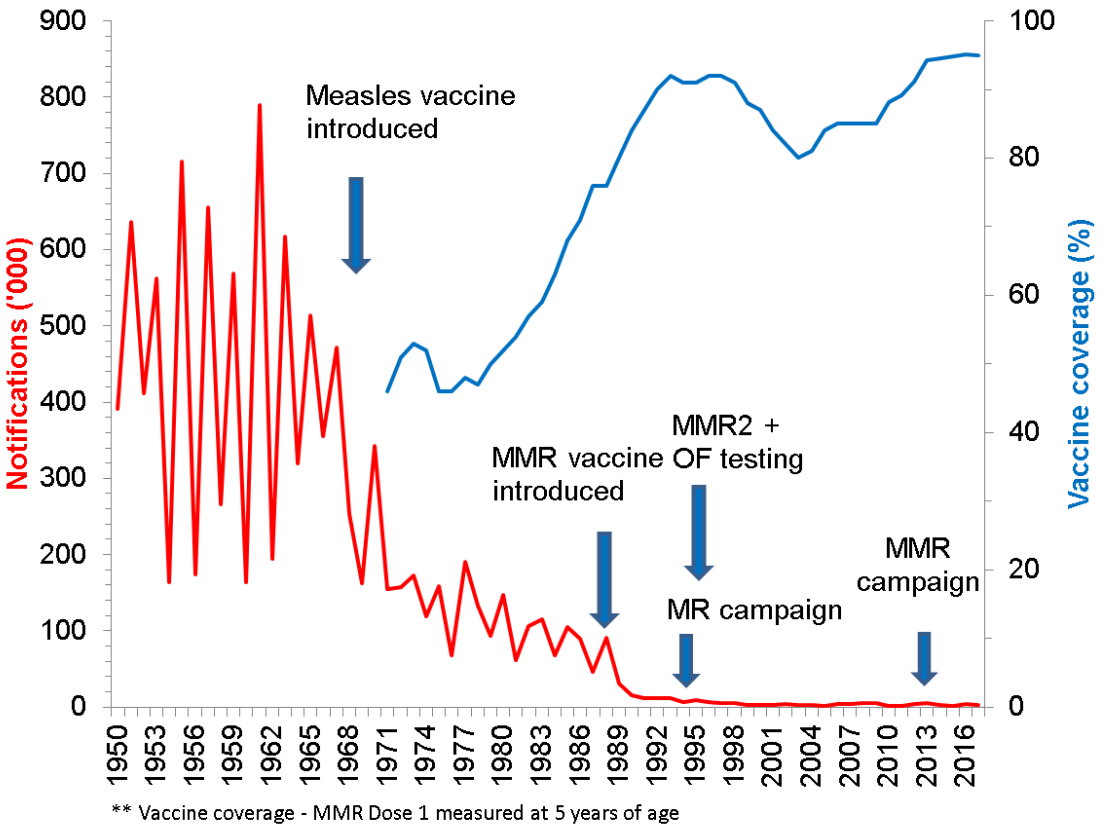

Fig 1. UK coverage of measles vaccination and measles notifications from 1950 to 2016

1. Explain the relationship between vaccine coverage with time and the number of measles cases notified shown in the graph in Fig. 1.

2. With reference to Fig. 1, suggest in which year herd immunity was achieved? Explain your answer.

3. In England and Wales, 91.6% of children of the appropriate age received the MMR (measles, mumps and rubella) vaccine in the period 2016-17 and 91.2% received it in the period 2017-18. In 2017 there were 284 cases of measles in England and Wales and 2018 there were 991 cases. Discuss these data in relation to the concept of herd immunity.

Assessment A

Herd immunity is:

A) The vaccination of a group of cows
B) Veterinary vaccination
C) A popular movement against vaccination
D) The protection of a whole population by vaccination of a large part of it

B) Risks and benefits of vaccination

Vaccination can protect against serious diseases, but it is not entirely without risk. In order to evaluate the benefit of vaccinations it is necessary to know both the severity of risks and the probably of the risk. For example, if 1 in 100,000 of the population receiving a given vaccine suffer from nausea, but 23 out of 100,000 not receiving the vaccine die from the disease, then there is a clear benefit to having the vaccine. The principle of herd immunity can mean that there is conflict between the interest of the individual and that of the population in general: if everyone else's children are vaccinated, your children are not at risk of the disease and don't need to undergo the risk of vaccination. The risks of vaccinated have been exaggerated by the "anti-vaxxers," leading to an increase in cases of disease.

Practice B

1. Evaluate the use of a vaccine that reduces mortality from a disease from 78 to 14 per 100,000 population, but produces a rash in 1 in 1,000 people receiving it.

2. Write a reasoned argument against the viewpoint that vaccination is always harmful.

3. Suggest why some people are opposed to vaccination.

Evaluation B

Which of the following statements is **correct**?

A) Vaccination is always of benefit.
B) Vaccination is always harmful.
C) The risks and benefits of vaccination need to be evaluated before deciding if a vaccine is beneficial.
D) It is not possible to determine whether a vaccine is beneficial.

C) Antigenic variation and vaccination

If the antigen on the pathogen does not change, then a vaccination campaign against the disease is relatively straight forward. The antigen on the surface of the smallpox virus does not change and smallpox was eradicated by vaccinating people in every country in the world. However, if the antigen changes, then the antibodies against specific antigens of a pathogen introduced by vaccination will no longer protect against that pathogen. For example, this is the case for influenza virus, which has 16 main types of an antigen called haemagglutinin, and 9 types of another antigen called neuraminidase, meaning that there are 144 main antigenic types. The antigenic type of the virus is constantly changing, and the vaccine against one type will not give immunity against another. It takes six months to prepare and grow vaccines to a sufficient quantity to vaccinate a large population, and it is not always possible to predict what antigenic types are going to arise, so that in practice it is difficult to vaccinate against the disease.

Practice C

1. Flu vaccine has been given to most of a population, but there are still frequent cases of the disease. Suggest why.

2. Explain why vaccines against some pathogens continue to be effective over a long time period.

3. Explain why it is not possible to change a vaccine each time the antigen on a pathogen changes.

Assessment C

When a vaccine fails to protect against an infectious disease the reason could be:

A) The antigens on the pathogen have changed so existing antibodies no longer protect against it.
B) The antibodies in the body have changed, so they no longer protect against the pathogen.
C) The antibodies and antigens have not changed but they can longer interact
D) Both the antibodies and the antigens have changed.

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Tutorial 6 – Final Assessment

What is the Purpose of Tutorial 3?

To assess what you have learnt during the course.

Tutorial 7 - Feedback

What is the Purpose of Tutorial 7?

A) To receive feedback on final assessments.
B) To share examples of best practice with the other pupils in your group.
C) To write targets for improvement in school lessons.
D) To reflect on the programme including what was enjoyed and what was challenging.

Final assessment feedback

What I did well...	What I could have improved on...
•	•
•	•
•	•

My target for future work is...

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
• • •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Notes

Notes

Notes

Vaccination

Key Stage 4 Programme

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