Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

The MMR Vaccine

Infection and Disease

The human body is constantly under attack by disease-causing *organisms* called *pathogens*. Many of these pathogens are tiny *microbes*, such as *bacteria* and *viruses* that try to enter our bodies and live within. The invasion of the body by pathogens is called *infection*.

How the body prevents infection

The human body has several ways of defending itself. The first line of defence is the presence of physical and chemical barriers that prevent pathogens getting into the body tissues. This is also known as the *general defence system*; it includes the skin, *mucus* in the breathing passages, blood clotting at a wound and acid in the stomach – all of which inhibit the entry of harmful microbes.

Once the tissues have been invaded by a pathogen, a second, more specific defence system known as the *immune response* takes over. The immune system involves a number of different types of white blood cells, such as the *phagocytes* and *lymphocytes* as well as specialised organs of the body including the *spleen*, *thymus* and the *lymph glands*. The phagocytes, also known as *macrophages,* are large white blood cells that engulf and destroy harmful bacteria and viruses.

The lymphocytes provide a more specialised protection. Because the membranes of all cells are covered with special 'marker' chemicals called *antigens*, it is important for the body to be able to distinguish between its own cells and 'foreign' cells. When a *pathogen* enters the body, the immune system responds by making a specific *antibody* to the 'foreign' antigen. Antibodies generally work by causing the pathogens to clump together and this enables the phagocytes to engulf and destroy them.

The type of antibody made depends on the type of antigen invading. For example an invading cold virus antigen will stimulate the production of a cold virus antibody that will only destroy the cold virus.

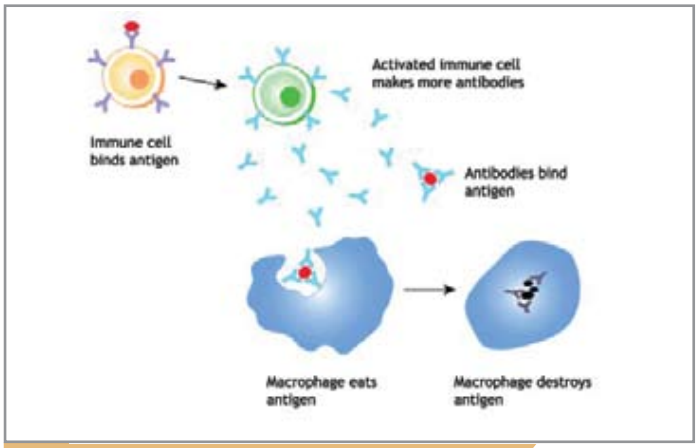

Fig. 1 Antigen-antibody action

The first time a particular pathogen invades the body, it takes quite a while for the immune system to respond and make the correct antibodies. As a result the pathogen has time to multiply and you suffer from the illness. But once you have made a particular antibody, *memory cells* in the immune system retain the ability to recognise the pathogen and produce antibodies should you be infected with that pathogen again. So if you are infected with the same pathogen a second time, the memory cells cause a large number of specific antibodies to be produced very quickly and these disable the pathogen and you do not suffer from the disease. This explains why you never suffer from the same cold virus more than once. Having suffered from a particular cold *virus* you have developed *immunity* to that particular cold virus.

What is a Vaccine?

A *vaccine* is a preparation that contains either a live, weakened form of the pathogen or a dead form of the pathogen (or pieces of it). Although it is now harmless, the pathogen is still an antigen. Once injected into the body the vaccine stimulates the production of antibodies and *memory cells*, without causing the person to suffer from the disease. The purpose of a vaccine is to bring about immunisation to a particular pathogen.

Live vaccines are usually more effective in stimulating antibody production, than *dead vaccines*. Many of the vaccines produced over the last 100 years have had a major impact in controlling the occurrence of particular diseases; these include the polio vaccine (polio), the meningococcal C vaccine (meningococcal C disease) and the *MMR vaccine* (measles, mumps and rubella (German measles).

Vaccination Programmes

Once it became known how effective vaccination could be, the health authorities in different countries set up vaccination programmes to try and eliminate many diseases. In 1967 the World Health Organisation (WHO) launched a worldwide immunisation programme to protect people against *smallpox*. This was so successful that by 1977 smallpox was eradicated.

Ideally 100% of the population should be vaccinated against a particular disease. A level over 95% of the population will prevent outbreaks, but non-vaccinated individuals would still be at some risk. In 2000 only 69% of children in Ireland were vaccinated with MMR to protect them against measles and as a result of the low vaccination rate there were over 1600 cases of measles. Outbreaks of measles have occurred because significant numbers of people have not been vaccinated. In Ireland the HSE (Health Service Executive) National Immunisation Office is the body responsible for promoting and facilitating vaccination programmes.

Measles, Mumps and Rubella – What are they?

Measles, mumps and rubella are highly *infectious*, viral diseases. A person becomes infected when these viruses are passed from somebody who has the disease to a person who has no protection from it.

Fig. 2 Measles rash

Measles

Measles virus causes fever, distinct red spots followed by a rash and red painful eyes. In addition there are often complications from measles, such as ear infections, bronchitis or

pneumonia, and it can still kill. Measles occurs most commonly in children aged 1-4 years who have not been vaccinated.

Mumps

Mumps is a viral disease which causes fever and painful swollen glands typically under the jaw. Until the MMR vaccine was introduced mumps was the single largest cause of *viral meningitis* in children.

Until the 1950s it was a common childhood disease worldwide, and in countries in which the vaccine is not widely available it is still common.

Children generally recover fully from the disease but teenagers and adults can have more lasting effects. In young men it causes painful testicular swelling in about 30% of cases, but rarely causes sterility.

There is no specific treatment for mumps apart from controlling the symptoms with anti-inflammatory medication or painkillers.

Rubella

Rubella virus causes German measles, a quite mild infection in itself but it can cause serious damage (deafness, blindness and heart defects) to unborn babies if their mother catches German measles when pregnant.

The MMR Vaccine

Fig. 3 MMR vaccine

The MMR vaccine was introduced to Ireland in 1988. MMR contains weakened forms of the natural viruses. It protects against measles, mumps and rubella. It is given to children at 12 months and again at age 4-5 years (in Junior Infants in Primary School). The second dose increases protection significantly. The World Health Organisation European Region has put in place a strategic plan to eliminate measles and rubella by 2010. The strategy includes ensuring that all children will have the opportunity to receive two doses of MMR vaccine.

Vaccine Effectiveness and Safety

The production and action of a vaccine is governed by the very strictest standards of health and safety. The long term effects and efficacy of vaccines are subject to continuous rigorous study. But despite this from time to time concerns are raised about the possible side effects of vaccines.

In 1998 a study of autistic children raised the possibility of a connection between MMR vaccine and *autism*. This study only involved 12 children. Since then several larger studies of up to half a million children have found no relationship between MMR vaccine and autism.

The World Health Organisation describes MMR as a 'highly effective vaccine which has an outstanding safety record'.

When children contract actual diseases, they become ill. Their bodies are in a race to produce antibodies to destroy the pathogens before they multiply and cause damage to the body. It is much better for children to be vaccinated and have the memory cells already in their bloodstream, ready to kill the pathogens.

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The National Immunisation Office is a coordinating Unit within the Directorate of Population Health of the Health Service Executive (HSE).

Childhood immunisations are recommended for all children to protect against a wide number of serious diseases e.g. measles, mumps, polio, tetanus and since July 2008 pneumococcal and hepatitis B diseases. Adult immunisations are recommended for certain at risk groups e.g. flu vaccine for those over 65 or hepatitis B vaccine for health care workers.

The HSE National Immunisation Office is responsible for the planning and implementation of immunisation programmes and ensures that

- Up to date accurate information re immunisation is available for parents and health professionals
- Sufficient vaccine stocks are available for the national immunisation programmes
- Vaccines are distributed to all sites under validated temperature controlled conditions

The Health Protection Surveillance Centre ensures that accurate statistics are collected on vaccine uptakes and disease outbreaks.

Find out more about the National Immunisation Office or the Health Protection Surveillance Centre and the work of the Health Service Executive at **www.sta.ie**, **www.immunisation.ie** or **www.hpsc.ie**

Speaking at the launch of the New Immunisation Guidelines for Ireland on July 24th 2008, Professor Brian Keogh, Chairperson of the National Immunisation Advisory Committee, stressed the importance of immunisation as a public health measure. Prof Keogh said:

"Immunisation protects individuals and communities from specific infectious diseases which can sometimes cause serious illness, even death. I particularly welcome the improvement for MMR vaccine uptake, from 70% to 85% and I hope it will soon reach our target of 95%".

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Syllabus References

Leaving Certificate Biology

Unit 3.3.2.2 Organisational Complexity of the Human – the lymphatic system (p. 32).

Composition of blood; white blood cells.

H.3.2.3 Blood cells- classification of white blood cells (p. 32).

Unit 3.3.5.1 Structures for Response – the immune system.

3.5.3 Responses in the human - the defence system in humans (p. 39).

3.5.4 Viruses (p. 39)

H.3.5.7 Human Immune System – the role of the lymphocytes (p. 40).

Junior Certificate Science

1C8 Microbiology and biotechnology. Examples of bacteria, fungi and viruses. Biotechnology in medicine (p. 14).

Learning Outcomes

On completing this lesson, the student will be able to:

- Explain what is meant by infection
- Describe the human immune system
- Understand the antigen-antibody reaction
- Explain what a vaccine is and how vaccination can result in immunisation
- Describe the effectiveness of a vaccination programme
- Appreciate what measles, mumps and rubella are
- Describe the effectiveness and safety of the MMR vaccine.

General Learning Points

- The body needs to be able to protect itself from disease causing bacteria and viruses.
- The immune system is responsible for ensuring we have resistance to disease.
- Antigens are special chemicals (proteins and glycoproteins) that are found on the surface of every cell.
- The body responds to foreign antigens by producing antibodies that disable the invading antigen.
- The body makes a specific antibody for each type of foreign antigen.
- A healthy immune system is able to distinguish between the body's own antigens (self) and foreign, potentially harmful, antigens (non-self).
- Vaccination is a method of activating a person's immune response before they can become infected with a pathogen.
- It is not possible to provide long term protection against all diseases, e.g. influenza. The influenza virus changes regularly, altering the antigens on its surface so a new influenza vaccine has to be developed each year
- MMR protects against three serious illnesses; measles, mumps and rubella. If children go unprotected, they are at risk from these diseases.
- MMR has an excellent safety record worldwide and is considered highly effective.

Student Activities

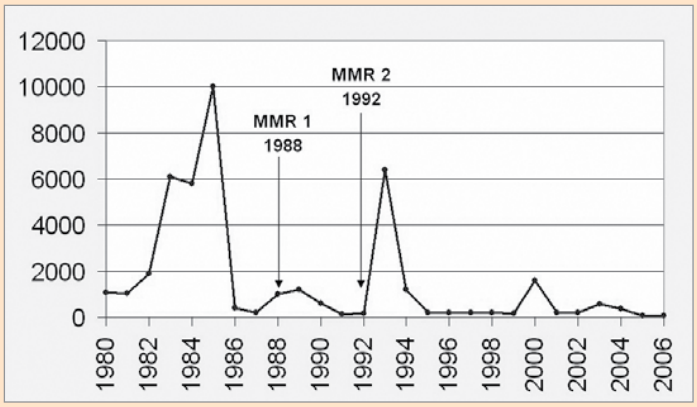
1. Students should work in groups to discuss and decide whether or not a child should be given the MMR vaccination. Use the internet to research the hazards of the diseases and the vaccine. Make a list of the pros and cons involved in making the decision to vaccinate.
2. Consult leaflets from your local GP, health centre or the website www.immunisation.ie, and then copy and complete the table below:

Vaccination Programmes for children in Ireland		
Name of Vaccine	Disease(s) it protects from	Age(s) at which vaccine should be given

How many vaccinations should children have before the age of twelve?

Against how many diseases do these vaccinations give protection?

3. Design a leaflet for parents who are trying to decide whether to have their child vaccinated with the MMR vaccine. The leaflet, which can be made using an A4 page folded in three, should have a clear simple message and be colourful.
4. The graph below represents the cases of measles reported in Ireland between 1980 and 2006 (source HPSC).



a) In which year was the highest number of cases of measles recorded (notifications)? Approximately how many cases were reported that year?

b) What was the number of cases recorded in 1985, the year the measles vaccine was introduced? What was the effect of the introduction of the vaccine on the number of cases reported?

c) Despite the introduction of the vaccine, in 1993 there were 4,328 cases of measles reported. Suggest why this high incidence of the disease might have occurred.

d) In which year since 1995 has there also been a sharp increase in the disease? Suggest a reason for this increase.

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True or False

a) Since rubella affects unborn babies of pregnant women, only girls need be vaccinated against rubella. T F
b) Vaccination gives you the disease. T F
c) Antibodies are produced in response to antigens. T F
d) Lymphocytes and phagocytes are types of red blood cell. T F
e) The MMR vaccine works by stimulating the immune system to produce antigens against these diseases. T F
f) If 80% of the population are vaccinated, measles, mumps and rubella will be eradicated. T F
g) Measles is not fatal. T F
h) Measles, mumps and rubella have become less common since the vaccine was introduced. T F
i) Epidemics are most likely when vaccination levels are not sufficiently high. T F

Check your answers to these questions on www.sta.ie

Examination Questions

Leaving Certificate Biology, 2008 Higher Level

15 (b) (v) Outline briefly how a virus replicates (reproduces).

Leaving Certificate Biology, 2007 Higher Level

14 (b)
(i) Comment on the difficulty of defining viruses as living organisms.
(ii) What are the two main biochemical components of a virus particle?
(iii) Name two diseases caused by viruses.
(iv) Give an example of a beneficial example of a virus.
(v) What is an antibiotic?
(vi) Antibiotics should not be prescribed for a person suffering from a viral infection. Suggest a reason for this.

14 (c)
(i) What is meant by the term immunity?
(ii) Outline briefly the role of B lymphocytes in the human immune system.
(iii) Distinguish between active and passive immunity.
(iv) "Vaccination gives rise to active immunity". Explain this statement.
(v) In certain situations a person is given a specific antibody rather than being vaccinated.
1. Is this an example of active or passive immunity?
2. Under what circumstances might an antibody, rather than a vaccination, be given?
3. Comment on the duration of immunity that follows the administration of an antibody.

Leaving Certificate Biology, 2005 Higher Level

15 (a) (iv) "Immunity that results from vaccination is effectively the same as the immunity that develops following an infection". Do you agree with this statement? Explain your answer.

Leaving Certificate Biology Higher Level (Exam Commission Sample Paper)

15 (b) (i) Describe two ways in which the skin helps to defend the body against pathogenic micro-organisms.
(ii) Lymphocytes play a vital role in the body's immune system. To which group of blood cells do lymphocytes belong? Name two types of lymphocyte and state a role for each.
(iii) What is the purpose of vaccination?

For further examples of past questions check www.sta.ie

Did You Know?

- The process of vaccination comes from 'vacca', the Latin word for cow. The term was named by Edward Jenner.
- Mumps gets its name from "to mumble", because of the swelling it causes to the neck glands.
- Mumps was the leading cause of viral meningitis in children before the MMR vaccine was introduced. Now it is virtually eliminated.
- Every year more than a million children die from measles worldwide.
- Babies can be born deaf and blind, if their mother catches rubella (German measles) while pregnant.
- It is now thought that each human can make more than 10 million different types of antibody.
- Since 2005 Ireland has been involved in the World Health Organisation's European Immunisation Week (EIW), which aims to highlight the benefits of immunisation for all member nations. The slogan of EIW is 'Prevent, Protect, Immunise'.
- Severe allergic reaction to the MMR vaccine is extremely rare (about 1 in 100,000).

Biographical Notes

Louis Pasteur (1822-1895)

Louis Pasteur was a great French scientist. He is regarded as one of the three main founders of microbiology along with Ferdinand Cohn and Robert Koch. Pasteur's work on diseases included experiments on chicken cholera. During his work, a culture of the responsible bacteria had spoiled and failed to induce the disease in some chickens he was trying to infect. Upon reusing these healthy chickens, Pasteur found that he could not infect them, even with fresh bacteria. They had become immune from exposure to the weakened bacteria. Pasteur gave these artificially weakened diseases the generic name of 'vaccines' to honour Edward Jenner, who had discovered that cowpox vaccinations gave cross immunity to smallpox.

Pasteur produced the first vaccine for rabies by growing the virus in rabbits and weakening it by drying the nerve tissue. This was then used to treat 9-year-old Joseph Meister who had been bitten by a rabid dog. This was a dangerous experiment, as the vaccine had only been tested in eleven dogs and Pasteur was not a licensed physician and could have been prosecuted. Fortunately the treatment was a success and the boy avoided the fatal disease. This experiment was the beginning of the development of many other vaccines. Pasteur was awarded the Leeuwenhoek Medal, microbiology's highest honour and was made a Grand Croix of the Legion of Honour. He is buried beneath the Institut Pasteur – a rare honour in France.

Revise the Terms

Can you recall the meaning of the following terms? Revising the terminology is a powerful aid for recall and retention.

antibody, antigen, autism, bacteria, efficacy, general defence system, immunisation, immunity, infection, infectious, lymphocyte, macrophage, memory cell, pathogen, phagocyte, smallpox, vaccine, viral meningitis, virus, organism, mucus, microbe, spleen, thymus, lymph, memory cell, live vaccine.

Check the Glossary of Terms for this lesson at www.sta.ie