

# Vaccines: Separating fact from fiction

## Pellagra: a true story

In the early 20<sup>th</sup> century in the southern USA up to 5000 people a year were affected by a debilitating disease called pellagra and up to 40% of them died as a result. At the time it was unclear what caused the disease but it was assumed to be **contagious** because members of the same family were often afflicted. However, pellagra was uncommon among children younger than 2 years of age, older adolescents and active men.



*Pellagra victim*

A study (published in 1913) by Dr R.M. Grimm found that the disease was associated with poverty and poor sanitation. The following year Joseph Goldberger, a respected **epidemiologist**, was appointed to investigate the disease. Within a few months he was convinced that it was not contagious. He noted that pellagra was common among inmates of '**mental institutions**' but not among the nurses and staff. To prove his case Goldberger chose three state institutions in which pellagra had been endemic for years. Beginning in September 1914 he had the diets changed to include fresh animal foods and **legumes**.



*Joseph Goldberger*

The following spring, there was only one recurrence among the 245 patients, there was no new case and 244 were cured. But Goldberger's conclusions were not accepted. So, he conducted further large scale studies that demonstrated that pellagra was a dietary disease and was completely preventable.

Still the southern authorities and the people felt that his conclusions insulted their way of life. As a result nothing was done to improve the living conditions of the poor and Goldberger was relieved of his duties.

In the 1920s he continued his research to find out exactly what caused pellagra. He discovered that a small amount of **yeast** in the diet was just as effective as fresh milk, meat and vegetables in preventing pellagra. In 1927, on his advice, the Red Cross distributed dried yeast to Mississippi flood victims and successfully prevented a pellagra epidemic. Sadly Joseph Goldberger died of cancer in January 1929.

Eventually in 1937 it was shown that absence of **niacin** in the diet was the cause of **pellagra**. Niacin is present in yeast and in foods such as meat, fruit and potatoes. Nowadays it is routinely added to flour.

## Why do people reject evidence?

- As the story of Goldberger illustrates, when people have their minds made up they reject real evidence in favour of a belief, even when that belief is shown to be without foundation.
- People can sometimes be biased against a person for reasons that have nothing to do with their ability. Some people opposed Goldberger because he was Jewish, despite his proven expertise.
- Statistical evidence is frequently rejected by people who confuse **coincidence** with **causation**, i.e. when two things occur around the same time, they think that one is the cause of the other.

## Facts about HPV (human papillomavirus)

HPV is not just a single **virus**; it is a group of more than 200 viruses. Most people (80%) will get a HPV infection during their lifetime, usually during sexual activity. Most of these infections do not need treatment. Almost all cervical cancer is caused by HPV infection. HPV types (16 and 18) cause over 70% of **cervical cancers**. HPV virus infection is now known to lead to more than 90% of anal cancers, almost 70% of vaginal and vulvar cancers, over 70% of oropharyngeal cancers (tonsil and base of tongue) and more than 60% of penile cancers in the US. Ten other types also cause cervical cancers (types 31, 33, 35, 39, 45, 51, 52, 56, 58, 59). Ireland has one of the highest rates of cervical cancer in Western Europe. Each year in Ireland:

- over 90 women die from cervical cancer
- over 280 (many young) women need treatment (surgery, chemotherapy and/or radiotherapy) for **invasive** cervical cancer
- over 6,500 women need hospital treatment for a **precancerous** form of cervical cancer.

HPV also causes other cancers such as over 90% of anal cancer and over 70% of head and neck cancers.

## Treatment for cervical cancer

Treatment of cervical cancer often involves a radical hysterectomy and oophorectomy (removal of uterus, ovaries and part of the vagina) to prevent the spread of cancer. If the cancer has spread beyond the cervix to the vagina, rectum or bladder more extensive surgery will be required. The cancer can block the ureters (tubes that carry urine from the kidneys to the bladder).

Radiotherapy is often used before and/or after surgery. High energy X-rays are directed at the cancerous tissue in order to kill the cancer cells. The short treatment sessions are typically carried out each weekday for up to eight weeks.

The other commonly used treatment is chemotherapy in which specialised drugs are used to kill cancer cells. All these treatments have significant side effects.

However, by far the best treatment for cervical cancer is to prevent it occurring in the first place. Prevention by vaccination has been offered free to all Irish school girls since 2010.

## Facts about HPV vaccines

Two HPV vaccines (HPV2 and HPV4) were first licensed in 2006 to prevent precancerous changes of the cervix, vulva and vagina and cervical cancers. These diseases are caused by HPV types 16 and 18.

HPV9 was licensed in 2015 and is now available in Ireland. This vaccine protects against 7 types of HPV: HPV types 16, 18, 31, 33, 45, 52, and 58, that are responsible for 90% of cervical cancers. In Ireland the HPV4 vaccine called Gardasil is offered to all 12 year old girls to reduce their risk of cervical cancer in 1st year of second level school.

The HPV vaccine protects girls from developing cervical cancer when they are adults. It is available free of charge from the HSE. HPV vaccines are also effective in preventing infection in men. At present routine vaccination for boys is not recommended as part of the school programme in Ireland.



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## The body's reaction to infection

The two parts of the body's immune system are called **innate immunity** and **adaptive immunity**. Innate immunity is the body's first line of defence. It is fast acting but does not retain a 'memory' of the infection.

The adaptive immune system acts more slowly to the first occurrence of a particular infection. However, it forms **memory T cells** that produce **antibodies** to fight any recurrence of the infection. (Such antibodies can be transmitted from a mother to her unborn child.) If you get a small cut or a scratch a red patch may form on the skin. This is a sign that the immune system is working properly; blood flow to the area is increased causing redness and maybe swelling. **Leucocytes** can then seek out and destroy any infection.

## How do vaccines work?

The HPV vaccine contains purified inactive proteins from some types of HPV virus. The vaccine does not contain the virus. It cannot cause infection but it triggers the body's immune system to form antibodies and memory T cells that can quickly respond to a future infection. In the case of the HPV vaccine two doses are administered over a period of about six months to ensure immunity. Girls aged 15 years and older require 3 doses of the vaccine given over 6 months.

The vaccine used in the **HSE** vaccination program is Gardasil®. It is over 99% effective in preventing pre-cancers associated with HPV types 16 and 18 in young women and 99% effective in preventing genital warts associated with HPV types 6 and 11. In countries such as Australia with high vaccine uptake rates (over 80%) the number of cases of pre cancer have reduced by 75%

## Side effects expected following vaccination

When people are vaccinated about 10% of them may have redness and swelling at the injection site. About 1% experience nausea, pain in the vaccinated arm and mild fever; these symptoms are typically treated with paracetamol or ibuprofen. Less than 1 in 1000 will have an itchy rash or hives. Some people are inclined to faint after any injection but this effect is temporary and easily treated.

The risk of side effects is far outweighed by the long-term benefit – the ability of the body to fight the infection. This not only protects the individual but also their closest contacts. The higher the uptake of the vaccine, the lower the incidence of HPV infection in the community. Those who are not vaccinated run the risk of becoming infected themselves and increase the risk of infecting others.

Although there have been well publicised reports of serious long-term illnesses following vaccination in no case has it been shown to be a consequence of the vaccine. Whether they are vaccinated or not, some young people suffer depression, excessive fatigue, gastrointestinal problems and other chronic health issues. Incidence of these conditions is no more common among those who have been vaccinated. However, when they arise following vaccination people are inclined to assume that the vaccination was the cause.

Over 230,000 girls in Ireland and 100 million people worldwide in countries like the United States, Canada, Australia and New Zealand have safely received the HPV vaccine. Not one of these people has been medically proven to have had a long term side effect from getting the vaccine.



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Health Service Executive

The **National Immunisation Office (NIO)** is a coordinating unit within the Health and Wellbeing Division of the **Health Service Executive (HSE)**.

The National Immunisation Office is entirely government funded and receives no funding from any external commercial source. The NIO is responsible for the coordination of immunisation programmes, for managing vaccine procurement and distribution, and for developing training and communication materials for health professionals and the general public including the national immunisation website [www.immunisation.ie](http://www.immunisation.ie)

All information on the website, developed originally from the Immunisation Guidelines for Ireland, is evidence based and reviewed by a panel of immunisation experts to ensure it is scientifically accurate. The site content is monitored and regularly updated by a team of public health doctors who are members of the National Immunisation Advisory Committee (NIAC) of the Royal College of Physicians in Ireland. This committee makes recommendations on vaccination policy in line with international best practice and based on how common the diseases are in Ireland.

NIAC guidance is regularly updated and the latest updates are available to download from:

<http://www.hse.ie/eng/health/immunisation/hcpinfo/guidelines/>

Information leaflets for parents can be downloaded from [www.immunisation.ie](http://www.immunisation.ie) or can be ordered from [www.healthinfo.ie](http://www.healthinfo.ie) or from local health offices.

For further information see:

[www.immunisation.ie](http://www.immunisation.ie)

[www.hpsc.ie](http://www.hpsc.ie)

<https://www.rcpi.ie/policy-and-advocacy/national-immunisation-advisory-committee/>

You can find out more about the work of the **NIO** at: [www.hse.ie/eng/health/immunisation/whoweare/](http://www.hse.ie/eng/health/immunisation/whoweare/)

Find this and other lessons on [www.sta.ie](http://www.sta.ie)

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## Syllabus References

The main syllabus references for the lesson are:

### Leaving Certificate Biology

- The scientific method (p.7)
- Viruses: identify the problem of definition. Variety of shapes. Basic structure. Viral reproduction. (p.39)
- Specific defence system (immune system): antigen antibody response. Definition of “induced immunity”. (Contemporary issues ...): Vaccination and immunisation. (p.39)

### Leaving Certificate Physics

- to develop the ability to observe, to think logically and to communicate effectively
- to develop an understanding of the scientific method (p.2)

*Science and Technology in Action* is also widely used by **Transition Year** classes.

## Learning Outcomes

On completion of this lesson, students should be able to:

- outline how a vaccine activates the adaptive immune system so that it is ready to fight the real infection later
- describe how beliefs can sometimes prevent people from accepting real evidence
- distinguish between coincidence and causation
- name the types of HPV that cause most cervical cancers
- outline the various treatments for cervical cancer
- see that the benefits of the HPV vaccine far outweigh short-term discomfort (if any).

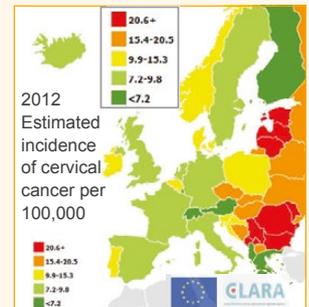
## General Learning Points

These are additional relevant points which are used to extend knowledge and facilitate discussion.

- Sometimes people’s beliefs prevent them from accepting experimental evidence.
- Doctors who believed that pellagra was an infection could not accept that it was caused by an inadequate diet.
- There are over 200 types of HPV. Two of these cause 70% of cervical cancers.
- Every year in Ireland over 280 women need surgery, chemotherapy or radiotherapy for invasive cervical cancer and over 90 women die of cervical cancer.
- Most cervical cancer is preventable by vaccination. The vaccine has no known long term side effects.

## Student Activities

1. If you toss a coin to ‘predict’ whether tomorrow will be dry you have a 50% chance of being right. Does that mean that this method of forecasting is fairly reliable?
2. Scenario: Jo has a headache and walks to the chemist to get an analgesic. Ten minutes after taking it she feels fine. Which of the following made the difference: the fresh air, the walk, the analgesic, time, or the belief that she would get better (i.e. the placebo effect)? How can you be sure?
3. Produce a poster or computer presentation on Louis Pasteur showing how he developed attenuated strains of bacteria for use as vaccines. How did he demonstrate the effectiveness of vaccines?
4. Investigate possible reasons why the incidence of cervical cancer is higher in Ireland than in many other European countries. Summarise your findings in a poster.
5. Prepare a computer presentation on the treatment of cervical cancer: surgery, radiotherapy and chemotherapy.
6. What is cervical cancer screening and how effective is it in reducing the number of deaths due to cervical cancer? Summarise your finding in a poster.



## True/False Questions

- |  |     |
|--|-----|
| a) The story of Joseph Goldberger shows that people accept facts when proof is provided.                 | T F |
| b) When events occur around the same time then one is the cause of the other.                            | T F |
| c) There are more than 200 types of HPV virus.   | T F |
| d) Two types of HPV cause 70% of cervical cancers.   | T F |
| e) More than ten types of HPV cause genital cancers.   | T F |
| f) In Ireland over 250 women need treatment for invasive cervical cancer every year.                     | T F |
| g) Every year about 600 women in Ireland need hospital treatment for precancerous changes to the cervix. | T F |
| h) The adaptive immune system is activated by vaccines.  | T F |
| i) Cervical cancer is preventable by vaccination.  | T F |
| j) Every year in Ireland about 90 women die from cervical cancer.  | T F |

Check your answers to these questions on [www.sta.ie](http://www.sta.ie).

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## Examination Questions

### Leaving Certificate Biology (OL) 2014, Q. 14 b

- What term is used to describe organisms that cause disease?
- The general defence system tries to prevent disease-causing organisms entering the body. List two parts of the general defence system in the body.
- Distinguish between active immunity and passive immunity by defining each. Which of these produces the longest-lasting immunity?
- Name any two diseases caused by viruses.
- Some people receive vaccinations to protect them from disease. What is meant by the term vaccination?

### Leaving Certificate Biology (HL) 2015, Q. 9 a

- What is the purpose of a hypothesis in the scientific method?
- Explain what is meant by double-blind testing in scientific experimentation.

### Leaving Certificate Biology (HL) 2008, Q. 3

- Answer the following, which relate to the scientific method, by completing the blank spaces.

As a result of her observations a scientist may formulate a ..... She will then progress her investigation by devising a series of ..... and then carefully analysing the resulting .....

- Why is a control especially important in biological investigations?
- If a scientist wished to determine the effect of a certain herbicide on weed growth she would include a control in the investigation. Suggest a suitable control in this case.
- The use of replicates is an important aspect of scientific research. What, in this context, are replicates?

### Leaving Certificate Biology (HL) 2001, Q. 11 a

- What is a virus? State two differences between a virus and a bacterium.
- Unlike bacteria, viruses cannot be grown on agar in the laboratory. Why is this?
- State two ways in which a person may contract a viral disease.
- Explain the biological basis of vaccination.
- What is an antibiotic?

### Leaving Certificate Biology (OL) 2007, Q. 14 c (part)

- What is meant by the term immunity?
- Outline briefly the role of B lymphocytes in the human immune system.
- Distinguish between active and passive immunity. "Vaccination gives rise to active immunity". Explain.

## Did You Know?

### Staying alive

- In the EU the main causes of death are circulatory disease, heart disease, various cancers and respiratory disease. Some of the contributory factors are well known: smoking, obesity and lack of exercise. Unfortunately there is no vaccine against many of the killer diseases, even when the cause is known and there is no sure way of preventing most types of cancer.
- However, vaccines are available for two forms of cancer making them almost completely avoidable. One of these is cervical cancer. (The other is liver cancer caused by the hepatitis B virus.)
- The discovery of vaccination in 1796 was a major breakthrough in medical science. Today, the use of approved vaccines has made 25 diseases completely preventable and saved countless millions of lives. Do the math!

## Biographical Note

### Vaccine development

**Edward Jenner** is usually credited as the originator of vaccination when, in 1796, he vaccinated a boy with cow pox and so protected him from smallpox. At the time smallpox killed about 400,000 people in Europe every year. (Interestingly, that same terrible disease is the only one that has been eliminated from the world by large-scale vaccination of all vulnerable communities. The last two cases occurred in 1978.)

In the late 1870s **Louis Pasteur** developed ways of attenuating bacteria so that they could no longer cause disease but would still confer immunity. Even at that time the germ theory of disease was not widely accepted – he was a chemist after all! In 1879 Pasteur began studying the anthrax epidemic which was killing sheep. By 1881 he had developed a vaccine with which he immunised 70 farm animals. Two weeks later they were inoculated with anthrax and all of them survived. However all the controls died within a few days.

## Revise The Terms

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

adaptive immunity, antibodies, causation, cervical cancers, coincidence, contagious, epidemiologist, HSE, innate immunity, invasive, legumes, leucocytes, memory T cells, mental institutions, niacin, Pellagra, precancerous, virus, yeast.

**Check the Glossary of terms for this lesson on [www.sta.ie](http://www.sta.ie)**