Why do we need a defence system?

This lesson looks at the defence system in humans. In particular, it covers the general and specific mechanisms the body uses to overcome attack from disease-causing agents. We also learn how we can use vaccines to strengthen our immune system against particular diseases.

Our bodies are a rich resource of materials that other *organisms* could use to grow and reproduce. We are constantly under attack from a wide variety of organisms that try to 'feed on' us.

Our greatest enemies are the *pathogenic bacteria, viruses, fungi* and *protista.* For example, malaria, our most lethal enemy, is caused by a *unicellular* protist and infects half a billion new people each year killing almost 3 million.

We also have to protect ourselves from our own rogue cells - *cancerous* cells.

How do we protect ourselves?

Our bodies have two major defence strategies – general and specific.

The *general defence system* is made up of components that deal with all pathogens in the same manner. The main general defence strategies are: *barrier defence, phagocytosis, fever* and *inflammation, interferon* and the *complement system.*

In contrast, the *specific defence system* can distinguish between different pathogens. It attacks each pathogen with a unique *antibody* produced in enormous quantities by a particular clone of *B-cells.*

How do we stop pathogens from entering the body?

Our *skin* is our major defence barrier against pathogens trying to enter our bodies. Skin protects us with its impenetrable outer layer of dead cells, the *bactericides* and *fungicides* in *sweat* and *sebum,* protective *enzymes* and *mutualistic* bacteria and yeast living on the surface. If the skin tears, *blood clotting* will quickly seal the break to help keep pathogens out.

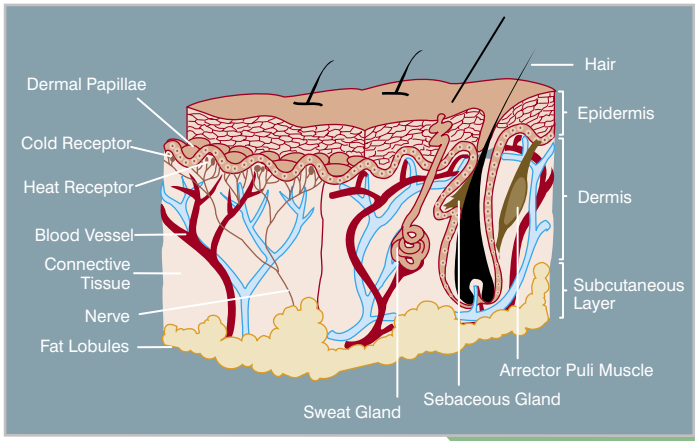

Fig.1 Skin Diagram

As well as wrapping ourselves in skin, we protect our bodies by producing *mucus,* a slimy material secreted by *mucous membranes.* Mucus entraps *micro-organisms,* and so helps protect the *reproductive, digestive, respiratory* and *urinary* systems. An enzyme in mucus called *lysozyme* kills bacteria – you find lysozyme in tears and saliva too. In the stomach the *hydrochloric acid* in gastric juice also kills bacteria.

Other general defences include the *cilia* that move the mucus in our breathing system up to the *pharynx* where it is swallowed, mutualistic bacteria in our *large intestine* and the acidic environment of the *vagina.*

What is phagocytosis?

Phagocytosis is the ingestion of cells, cell debris or large particles into a *'food vacuole'* by a big engulfing cell called a *phagocyte.* There are many types of phagocytes and the *macrophages* are the major kind. They develop from *white blood cells,* known as *monocytes,* which have passed out of the bloodstream and into the tissues.

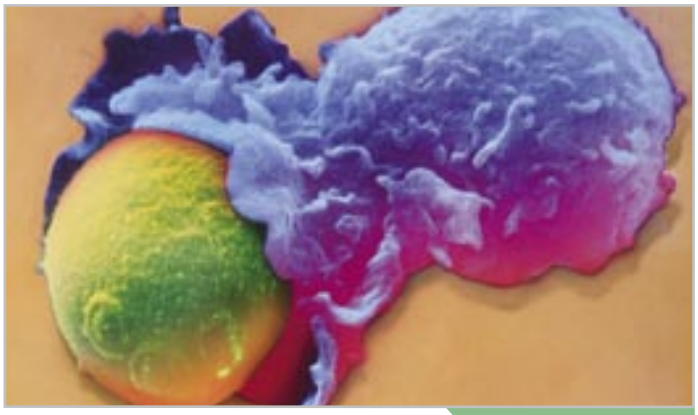

Fig.2 Phagocytosis

What is the specific defence system?

The specific defence system can distinguish between pathogens. It produces a unique defence protein against a particular pathogen, which leads to its destruction.

The specific defence system is also called the *immune system.* It has four major attributes – specificity, memory, non-self recognition and diversity.

It is specific in that the defensive action is only against one particular pathogen.

The immune system has memory in that once it has developed a defence against a particular pathogen, any future infections by that pathogen are dealt with so much sooner and strongly that no disease symptoms appear.

The immune system has non-self recognition in that it is able to distinguish between our own chemicals and 'foreign' chemicals. The *non-self chemicals* that stimulate the specific defence system to produce distinct antibodies are called *antigens.*

Finally, the immune system has diversity in that it is able to recognise and mount a unique attack on a huge variety of millions of non-self chemicals.

How does the specific defence system operate?

At this moment billions of *lymphocytes* are scattered throughout your entire body and their job is to detect non-self chemicals. When the immune system encounters an antigen, it stimulates a huge production of *clone* lymphocytes that produce and *secrete* the specific *antibody* that will bind to the antigen.

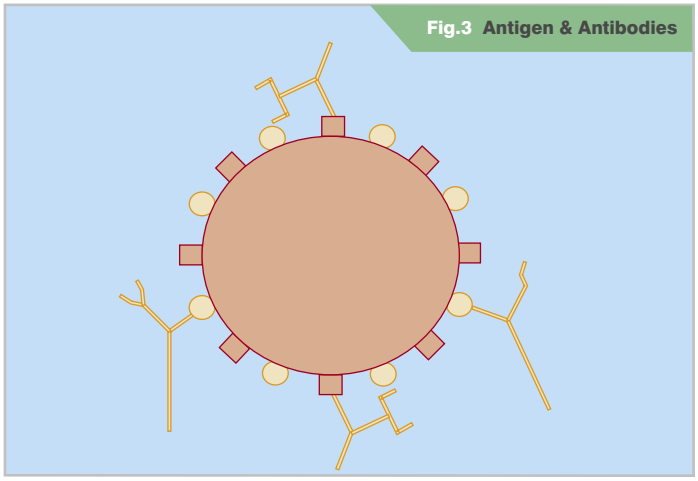

Fig.3 Antigen & Antibodies

The antigen-antibody complex may act as a chemical signal to phagocytes and killer T-cells to destroy the pathogen. Or the antibodies may instead glue and immobilise all the antigen-bearing structures. In many cases, *viruses* are defeated because the antibodies block the surface structures or 'landing gear' they use to attach to their specific host cell so they now cannot penetrate to replicate.

Does the specific defence system only operate against pathogens?

No. It also protects us against free chemical agents such as *toxins* or poisons – they are recognised as non-self chemicals.

When cells turn cancerous or are invaded by viruses, bacteria or protista, they often display new non-self chemicals on the outer cell membrane. As a result they can be detected and destroyed by the specific defence system.

How does vaccination protect against disease?

The success of *vaccination* depends on the memory aspect of the specific defence system. A *vaccine* is a harmless material that carries the antigen of a particular pathogen. Introducing the vaccine into the body does not cause disease but it stimulates a specific defence response to the antigen and memory cells form. The memory cells generated by the vaccination will immediately deal successfully with any future infection by that particular pathogen.

Wyeth

Wyeth - The search for new drugs

Wyeth is a global leader in pharmaceuticals, consumer health care products, and animal health care products.

Wyeth improves the lives of millions of people around the world with its outstanding products and other innovative medicines are on the way. With research and development (R&D) programmes focused on small molecules, vaccines, and biotechnology, Wyeth is exploring more than 60 new therapies for medical conditions such as diabetes, breast cancer, multiple sclerosis, HIV, Alzheimer's disease, and schizophrenia.

Wyeth, with headquarters in Philadelphia in the USA, has major manufacturing operations in Ireland and Wyeth currently employs approximately 3,000 people here. The main facilities are:

- **Wyeth Nutritionals Ireland**, *Askeaton, County Limerick* – established in 1974 and involved in the manufacture of Nutritional Products.
- **Wyeth Medica Ireland,** *Newbridge, County Kildare* – established in 1992 on a 120-acre site. It is involved in the manufacturre of Solid Dose Pharmaceutical Products.
- **Fort Dodge Laboratories Ireland**, *Sligo* – established in 1990 and involved the manufacture of Animal Healthcare Products.
- **Wyeth BioPharma Campus,** *Grange Castle, Dublin* – launched in 2001 and opened in 2005. This is one of the most modern high tech pharmaceutical plants in the world. It is situated on a 90-acre site and employs about 1,100 people producing vaccines, antibiotic and anti-arthritis drugs.

At Wyeth, scientists seek to discover new drug targets, or sites for drugs to work. Many potential drug targets are enzymes because they are so important for reactions within the cell. Scientists figure out how an enzyme works in the normal cell and also in a disease. This information helps them find or design a drug that can control the enzyme's activity in a therapeutic way.

You can find out more about science at Wyeth and the people who work there, at **www.wyeth.ie** and **www.sciencetechnologyaction.com**

Syllabus Reference

Leaving Certificate Biology:
3.5.1. Structures for Reponse
H.3.5.7. Human Immune System (Extended Study)

Learning Objectives

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

- List some micro-organisms that can attack us
- Differentiate between our general and specific defence systems
- Identify ways that we stop pathogens from entering the body
- List the four major attributes of the immune system
- Outline how the body responds to an antigen-antibody complex
- Explain how vaccination can protect us against attack

General Learning Points

- Our body is a rich reservoir of materials needed by other organisms for their growth, survival and reproduction.
- We have evolved a variety of strategies, general and specific, to protect ourselves against pathogens.
- The specific immune system depends on being able to distinguish between self and non-self chemicals.
- Many pathogens have evolved strategies to overcome our defence tactics.
- It is unusual to suffer from the same disease more than once.
- The invention of the microscope made it possible to discover the cause of many diseases.
- Scientific study of disease has greatly reduced the impact of many pathogens.
- There is much more to discover about immunity.

Investigative Activities

Be a disease detective. See if you can find out more about these different illnesses.

- Research the Spanish flu of 1918.
- What to the abbreviations HIV and AIDS stand for?

  Why do people infected with HIV often develop cancer and suffer from diseases they once had before they became infected with HIV?

  Why has it not been possible to develop a vaccine against the HIV virus, the causative agent of AIDS? Clue: think about the cells in the body that the virus strikes.

  How many people worldwide and in Ireland are today infected with the HIV virus? How many people die worldwide and in Ireland each year from complications arising from HIV infection?
- Allergies, rheumatoid arthritis and multiple sclerosis are known as autoimmune diseases. Investigate how the specific immune system may attack the body's own tissues.

True or False

Indicate whether the following are true (T) or false (F) by drawing a circle around T or F.

(a) A pathogen is a disease-causing organism.	**T**	**F**
(b) A virus in not a living organism.	**T**	**F**
(c) A fungus is a eukaryotic organism.	**T**	**F**
(d) Phagocytosis is carried out by red blood cells.	**T**	**F**
(e) B cells produce antibodies.	**T**	**F**
(f) Sebum is secreted by mucous membranes.	**T**	**F**
(g) Lysozyme is a bactericide found in mucus, tears and saliva.	**T**	**F**
(h) Macrophages develop from monocytes.	**T**	**F**
(i) Antibodies stimulate the production of specific antigens.	**T**	**F**
(j) Lymphocytes are a class of white blood cells.	**T**	**F**
(k) Our specific immune system cannot protect us against cancer.	**T**	**F**
(l) The protista are all unicellular organisms.	**T**	**F**

Check your answers to these questions on www.sciencetechnologyaction.com

Examination Questions

2004: Higher Level State Examinations Commission: Sample Paper

(i) What is meant by the term immunity? Distinguish between active and passive immunity.

(ii) Describe two ways in which the skin helps to defend the body against pathogenic micro-organisms.

(iii) Lymphocytes play a vital role in the body's immune system. To which group of blood cells do lymphocytes belong? Name two types of lymphocytes and state a role of each.

(iv) What is the purpose of vaccination? (30)

Describe briefly the part played by the skin in the general defence system of the body.

It is possible to provide immunity against certain pathogens by the introduction of a vaccine. What is a vaccine and how does its use result in immunity?

How can the specific immune system detect some types of cancers and cells that have been invaded by viruses or other intracellular pathogens?

For further examples of past paper exam questions check out www.sciencetechnologyaction.com

Biographical Notes

Edward Jenner

It has been more than 200 years since Edward Jenner first made the experimental vaccination – the inoculation with cow-pox viruses to build immunity against the deadly scourge of smallpox. His research was based on careful case studies and clinical observations. His discovery came more than 100 years before scientists could explain viruses.

Louis Pasteur

came up with the 'germ theory of disease'. His discovery that most infectious diseases are caused by germs is one of the most important discoveries in medical history. Pasteur also developed the process where harmful microbes in food are destroyed without harming the food itself. This process is called pasteurisation.

Alexander Fleming

discovered penicillin in 1928. While working on the influenza virus, he observed that a mould that had accidentally developed on staphylococcus culture plate and that the mould had a bacteria free ring around it. After further investigations he called the active substance penicillin.

Discover more about these and other great scientists at www.sciencetechnologyaction.com

Did You Know?

- Ancient civilisations believed that illness and disease were caused by the anger of the gods, evil spirits, foul air or someone's 'evil eye'.
- Even in more recent times, scientists weren't aware of microbes like we are today. Until the 17th century, tiny insects were the smallest known living organisms, but with the invention of the microscope that all changed. Bacteria were first observed with a microscope in 1773.
- In 1776, English country doctor Edward Jenner used the cowpox virus to inoculate against the related smallpox virus. He called his protective method 'vaccination'. The last reported case of smallpox occurred in 1977.
- In the 19th century, French microbiologist Louis Pasteur discovered that living organisms, pathogens, can cause disease.
- In 1882, a German doctor called Robert Koch discovered the bacterium that caused tuberculosis, a disease that killed one in seven people at that time.
- In the 20th century, scientists also made important discoveries that help protect us against disease.
- For example, in the 1920s, the Scottish doctor Alexander Fleming discovered lysozyme and, most famously, the antibiotic penicillin.

Revise the Terms

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

Organism; pathogenic; bacteria; viruses; fungi; protista; unicellular; cancerous; general defence system; barrier defence; phagocytosis, fever inflammation; interferon; complement system; specific defence system; antibody; B-cells; bactericides; fungicides; sweat; sebum; enzymes; mutualistic; blood clotting; mucus; mucous membranes; micro-organisms; reproductive; digestive; respiratory system and urinary system; lysozyme; tears; saliva; hydrochloric acid; pharynx; cilia; large intestine; vagina; ingestion; food vacuole; phagocyte; macrophages; white blood cells; monocytes; immune system; non-self chemicals; antigens; lymphocytes; antibody; T-cells; clone secrete; viruses; toxins; vaccination; vaccine.

Check the glossary of terms for this lesson at www.sciencetechnologyaction.com