Learning Unit 2:

HIV and the immune system

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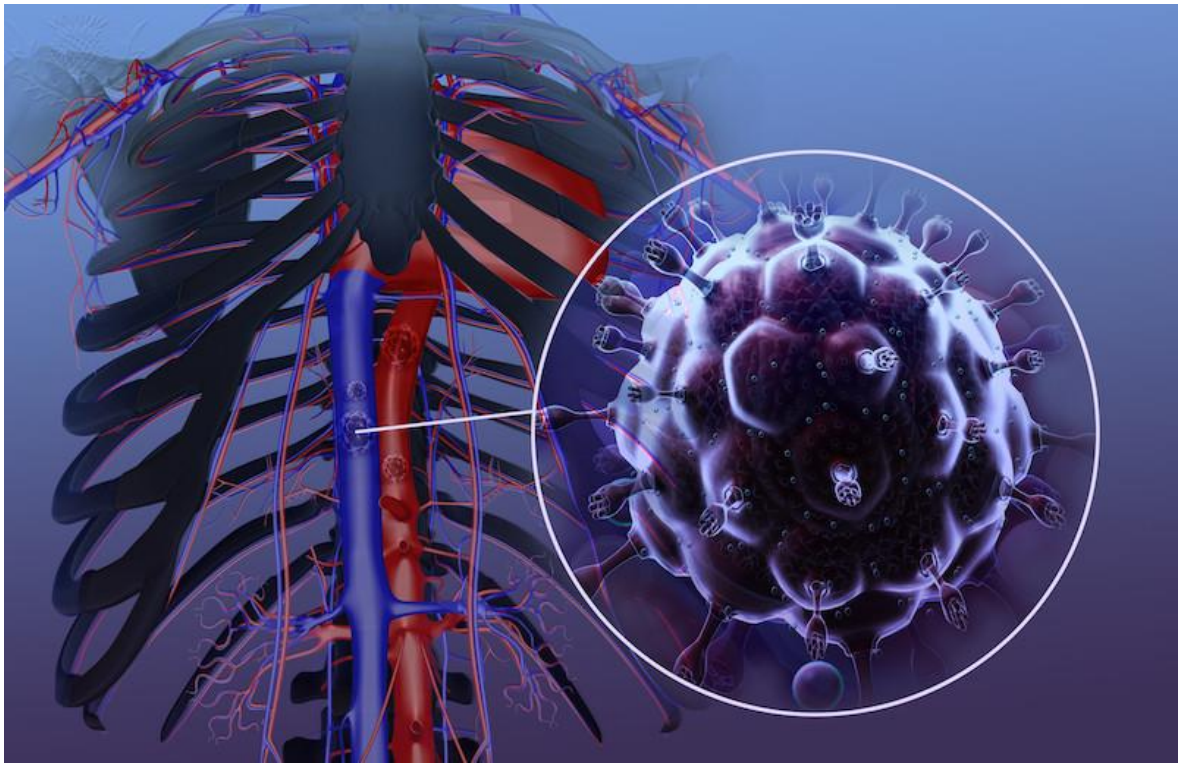

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Learning Unit 2 – HIV and the immune system

Introduction

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All living things have a natural defence system which protects them from attacks by pathogens (i.e. disease causing agents) such as viruses. This defence system is called the immune system.

Key Questions

Use the following questions as pointers to ensure that you retain your focus on the important issues in this learning unit:

- What are the different lines of defence used by the immune system?
- How does the immune system fail in the case of HIV?
- How do viruses work in general?
- What are the unique features of HIV?
- How does HIV enter the body and how does it replicate?
- What is meant by “the variability of HIV” and how many subtypes of HIV are there?
- What are the different responses of the body to HIV infection?

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Key Concepts

While working your way through this learning unit, look out for the following key terms. Make sure that, after you have completed this learning unit, you know what they refer to and how they are used (or look up their definitions in the glossary):

Active and passive immunity	Non-specific and specific defences
Cells and proteins	HIV subtypes (A, B and C)
Antibody	DNA
RNA	Reverse transcriptase
T-cells	B-cells
CD4 cell	Phagocytes
Macrophages	Vaccine
Seroconversion	

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The immune system

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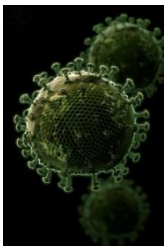
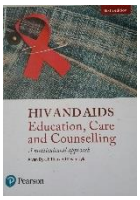


The body's immune system uses various lines of defence to protect the body against pathogens by killing the pathogens (in various ways) and, if possible, by retaining a memory of such pathogens so that they can be killed during future infections by the same pathogen before they can make a person sick (i.e. to make the person immune against a specific pathogen). In the prescribed book, the working of the immune system is described in terms of various lines of defence, involving different immune cells, which can broadly be divided into non-specific and specific defences.

Study	Prescribed book: pp. 26-37	
	**Section 2.1: The Immune system.** Pay special attention to: • The different lines of defence and their associated cells. The third line of defence is especially important because it involves the specific defences of the immune system and its processes of: 1. recognition and warning; 2. mobilisation and battle; 3. demobilisation; and 4. active and passive immunity. Use Figure 2.4 in your prescribed book to help you understand this specific defence system. **Click on the video icon** (http://goo.gl/j5fYex) in the right hand column to watch the YouTube video on the immune system. • The lock-and-key system of attachment. • Reasons why the defence system of the body's immune system fail in the case of HIV infection. • **Click on the video icon** (http://goo.gl/49yeVV) in the right hand column to watch the YouTube video on the T-helper Cells.	 

We should hasten to add that not all immune deficiencies are caused by HIV. Other well-known causes of immune system malfunctioning are inherited immune system disorders, or when the immune system has been damaged by radiation. Inherited immune system disorders are diseases in which part of the body's immune system is missing or does not work properly. People with an immune system disorder are therefore less able to fight infections. Various immune deficiencies may affect the immune system in different ways, causing different kinds of opportunistic infections. These inherited immune disorders are rare, with only about 50,000 people in the United States having some type of inherited immune system disorder, ranging from mild to severe.

In contrast to inherited immune disorders, secondary immune deficiencies may be caused by something outside the body, such as a virus or by chemotherapy. Aids is such a secondary immune deficiency, because it is not inherited, but acquired. That is why it is called Acquired Immune Deficiency Syndrome.

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The Human Immunodeficiency Virus (HIV)

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Viruses are important pathogens and cause many different diseases. (Other pathogens such as bacteria, fungi and micro-organisms are responsible for many other diseases.) Viruses are one-cell organisms and differ from all other living organisms in the sense that they cannot replicate (increase) without first infecting a host cell from another organism (e.g. in a human body) and then, by using the host cell's resources and genetic material, creating new copies of themselves.

Although we often talk about the "HI virus" (as if it were a single organism), the number of viruses in the body of an infected person (who is not on ARVs) may exceed 500 000 per one millilitre of blood. This implies that millions of viruses may live in the body, cells and blood of an (untreated) HIV-infected person.

Although the controversy as to whether Aids was really caused by a virus has now greatly fizzled out in both South Africa and the rest of the world, it is still important to clarify a few matters. After initial doubts about the exact cause of Aids in the very early stages of the epidemic (doubts which have, for far too long, been kept alive by some people pretending to be serious scientists) we now not only know for certain that Aids is caused by HIV, but we also know more about this virus than about any other virus that exists.

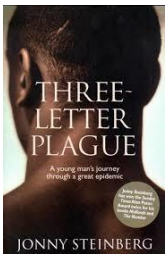
Unfortunately many people still persist in naming various other supposed causes of Aids, which may spread some more confusion. It is therefore important to clearly distinguish between the primary cause of Aids (i.e. HIV) and some contributing factors which may be driving the pandemic. Factors such as poverty, bad nutrition and disempowerment of women are indeed very important driving forces (contributing factors) behind the Aids pandemic, but they could never be termed the causes of Aids as mistakenly proposed by some.

Study	**Prescribed book: pp. 37-47**	
	**Section 2.2: The HI virus.** Pay special attention to: • The general structure of viruses. Use Figure 2.6 to help you understand the various components. **Click on the icon** (http://goo.gl/IsCPQq) in the right hand column to watch the YouTube video on HIV and infection. Also use Activity 2.1 below to help you remember the various components of a virus. • How HIV enters the body and infects a cell. Use Figure 2.7 to visualise the process. It is also a good idea to watch the YouTube video (http://goo.gl/8u1494) in the right hand column, which explains the various processes of how a virus infects a cell and how it replicates (i.e. attachment, fusion, injection, reverse transcription, integration of genetic material, replication of genetic material and production of new copies of the virus). It is important to understand these basics so that you can later understand how ARVs interfere with these processes (see Learning Unit 6). • Some common questions about HIV and its functions.	 

	• The variability of HIV. If you understand why HIV changes so quickly (is highly variable) you will also understand why the immune system fails in the case of HIV and why it is so difficult to make a vaccine for HIV. • Different responses to HIV infection. It is important to realise that people differ from each other and that, following HIV infection, their responses to the infection may also greatly vary. Make sure that you understand the reasons for this.	

ACTIVITY 2.1 – DRAW A DIAGRAM OF A VIRUS

If you really want to understand what a virus looks like it may be a good idea to go to your journal and draw a detailed picture of one. Use the diagram of HIV (Figure 2.6) of your prescribed book to help you and click on the following link: Activity 2.1 to go the instructions for this activity.



A "MUST READ" BOOK.

One of the most insightful fiction books written in the past few years – about the effects of HIV in a rural community in South Africa – was written by Jonny Steinberg and is called *Three letter plague*. To read more about the book click on the following link: Three letter plague (or go to the Appendix if you are using the printed version of this document).

You are now finished with this learning unit. Click on Assessment to do some self-assessment questions.

Assessment

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Study reflection

After completing your journey through Learning Unit 2 (HIV and the immune system), you should have acquired the following knowledge and understanding and be able to:

- label the different components of HIV.
- explain how HIV attacks the body's immune system.
- imagine how viruses work and replicate.

Self-Assessment 2

Now is the time to pause briefly and to assess whether you have acquired the necessary knowledge and skills. Click on the link Self-Assessment 2 to do a few questions on this learning unit. Please note these self-assessment questions do not contribute to your year mark or your admission to the exams. The feedback to the questions will be given to you immediately after you have completed each question.

You are now finished with the assessment. Now go to Learning Unit 3.

Appendices

- Activities
- Self-Assessments
- Glossary

ACTIVITY 2.1 – DRAW A VIRUS

Draw a rough circle – to represent the loose outer membrane around the virus. Label it: Lipid membrane (loose viral envelope). Lipid refers to the fact that the membrane consists primarily of fat.

1. Draw another smaller circle inside the first one and label it: Capsule (shell). This is the main membrane around the virus which protects the inside of the virus like a skin.
2. Next, draw a series of small mushroom-shaped protrusions around the two membranes. Make sure that they go through the first circle (envelope) and are fixed to the inner circle (capsule). Each little mushroom has a small stem and a head that looks like a little suction cup. Label these mushrooms: "Glycoproteins" (gp for short). There are two gp's: gp120 and gp41. Both the gp120 and gp41 are "envelope proteins" (env for short). These gp's play an important role in allowing the virus to attach to another cell and penetrate it during infection. When a virus meets a potential host cell, the suction cups attach to the surface of the cell, but only if the suction cups fit the outside of the cell (like a key and lock system). Gp120 does the "sucking" or adherence and is part of the suction cup proper. Gp41 does the penetration. It is part of the stem of the little suction cups.
3. Complete your picture by also filling in the details about the core of the virus. Draw a third cone-shaped block inside the first two circles (like the pit or stone inside an apricot or peach). Label it: Core. It is inside this core that all the genetic material is stored. It is from the genetic material in the core that the virus receives all its instructions on how to manufacture more copies of itself.
4. Inside the core, draw three or four single snake-like strands – in the prescribed book there are only two. Label them: Viral RNA. These are elements of the genetic material of the virus. The genetic material of most living organisms consists of double-stranded DNA. However, in some exceptional cases the genetic material consists of single-stranded RNA – as is the case with retro-viruses such as HIV. RNA doesn't work as well as DNA when dishing out instructions about copying the virus. It therefore makes a lot of mistakes during the process of copying the virus. It is because of these mistakes that retroviruses (like HIV) mutate or change so quickly.
5. Now for the enzymes. Enzymes can be regarded as biological chemicals which make specific biological or chemical processes in the body possible. Inside the body, enzymes help with digestion and many other biological processes such as cell division or replication. Without enzymes life would not be possible. There are three important enzymes which play a role in the replication of the HI virus: reverse transcriptase, protease and integrase (note that all enzyme names end with "-ase"). Draw a series of dots, crosses and small squares inside the core of your virus – close to the snake-like RNS strands – and give them the names of the three enzymes mentioned above.
6. Draw the last elements of the virus by including the two gag proteins (p's), p 24 and p 17.

[BACK]

A "MUST READ"

Three-letter plague is a story by Jonny Steinberg about a young man's journey through a great epidemic. The following are a few comments about the book:

> *"When people die en masse within walking distance of treatment, my inclination is to believe that there must be a mistake somewhere, a miscalibration between institutions and people. This book is a quest to discover whether I am right." – Jonny Steinberg.*

Jonny Steinberg's groundbreaking work or reportage about pride and shame, sex and death, and the Aids pandemic in Africa is a masterpiece of social observation.

At the end of a steep gravel road in one of the remotest corners of Lusikisiki in the old Transkei lies the village of Ithanga. Home to a few hundred villagers, the majority of them unemployed, it is inconceivably poor. In the broader world, most would consider it entirely inconsequential.

It is here that author Jonny Steinberg explores the lives of a community caught up in a battle to survive the ravages of HIV and Aids. He befriends Sizwe Magadla, a young local man who refuses to be tested for HIV despite the existence of a well-run testing and anti-retroviral programme nearby. It is this apparent illogic that becomes the key to understanding the dynamics that run like a thread through this complex and traditional rural community.

In this eye-opening, compassionate, searing and beautifully written book, Steinberg seeks to understand the Aids crisis in South Africa. As he grapples to get closer to answers that remain maddeningly just out of reach, he realises he must look within to unravel some of the enigmas surrounding the epidemic that has corrupted souls as much as bodies.

> *"In this vivid account of a journey to the frontline in the battle against Aids, Jonny Steinberg portrays with acute perception the impact of the epidemic on village life in a small rural community in South Africa." – Martin Meredith.*
>
> (This extract was published by Jonathan Ball.)

If you are interested, try to get the book and start reading it to supplement your more formal study of HIV and Aids. We trust that the book will enrich your life greatly, but please note that the reading of *Three-letter plague* is not compulsory and that no examination questions will be asked on the content of the book.

BACK

SELF-ASSESSMENT 2

Question 1

What is the first line of defence for the body's immune system?

1. Antibiotics
2. The skin
3. White blood cells
4. Plasma B-Cells

Question 2

CD4 T+ cells are part of the:

1. Specific defences of the body
2. Acquired immune system
3. Non-specific defences of the body
4. Innate immune system

Question 3

The ..... of a pathogen can be regarded as the unique “insignia” which is used by the body's immune system to recognise the specific pathogen. The missing word is:

1. Antibody
2. Colour
3. Antigen
4. Smell

Question 4

Which kind of immunity can one get by having immunoglobulin injections?

1. Protective passive immunity
2. Active immunity
3. Passive immunity
4. **Non-specific immunity**

Question 5

Name the four stages of immune system function when the body is attacked by a pathogen.

Question 6

Name the seven steps in the replication of HIV.

Question 7

HIV is called a ..... because it does not have DNA but RNA as genetic code in its nucleus. The missing word is:

[FEEDBACK]

FEEDBACK 2

Feedback Question 1

The correct answer is alternative 2. The skin is the first line of defence for the body.

Feedback Question 2

The correct answer is alternative 1. CD4 T+ cells are lymphocytes which form part of the specific defences of the body and the acquired immune system. See Section 2.1.1 in your prescribed book.

Feedback Question 3

The correct answer is alternative 3. The "antigen" of a pathogen is the unique insignia by which it is recognised. Do not confuse the words antigen and antibody – although antigens stimulate the development of antibodies, they have different functions.

Feedback Question 4

The correct answer is alternative 1. Protective passive immunity provides short-term protection through the injection of immunoglobulin (a preparation rich in antibodies) into a person's bloodstream. (Passive immunity is acquired by a baby from his or her mother).

Feedback Question 5

1. Recognition and warning
2. Mobilisation and battle
3. Demobilisation
4. Active and passive immunity

Feedback Question 6

1. Attachment
2. Fusion
3. Injection
4. Reverse transcription
5. Integration of genetic material
6. Replication of genetic material
7. Production of new viruses

Feedback Question 7

"Retrovirus". The usual transcription of genetic material is from DNA to RNA to DNA. HIV is called "retro" because it transcribes in the reverse order.

[BACK]

Glossary

CD4 Cells

CD4 T helper lymphocytes (a type of white blood cell). These cells play an important role in keeping the immune system healthy. HIV attaches itself to the CD4 receptors on the outer layer of the CD4 cells. They are also called T4 helper cells.

BACK

Macrophages

Types of phagocytes that generally attack cells infected with viruses. Macrophages are antigen presenting cells – they present antigens to the lymphocytes and thus mobilise the lymphocytes (or the specific defence system) to attack the invaders.

BACK

Phagocytes

Phagocytes are often referred to as the “scavengers” of the immune system. They are white blood cells that engulf and destroy (“eat”) foreign or infected cells. There are two kinds of phagocytes, namely macrophages and neutrophils.

BACK

Retrovirus

A type of virus (of which HIV is one) that replicates by changing its genetic RNA into DNA by using the host's cells.

BACK

Seroconversion

The point at which a person's HIV status converts or changes from being HIV negative to HIV positive. This coincides with the time when an HIV test will show that a person is HIV positive. Seroconversion usually occurs 4 to 8 weeks after an individual has been infected with HIV.

BACK

Vaccine

A substance given to stimulate the immune system to protect the person from infection by a specific microorganism. Vaccines are made from live attenuated pathogens, from killed whole organisms or from purified proteins. The search for an HIV vaccine is based on genetic engineering and protein-based technology.

BACK

Active and passive immunity

Active immunity usually follows after infection by a pathogen but it can also be generated by immunisation. Passive immunity is short-term immunity that a new-born baby gets from its mother.

BACK

Antibody

Special protein complexes produced by the immune system that attack and neutralise specific disease-causing organisms. The antibodies which the body creates in response to HIV are unfortunately powerless to protect the body against the long-term destructive effects of HIV.

BACK

Non-specific and specific defences

Non-specific defences consist of the skin (to keep pathogens out) and an inflammatory reaction (when the skin is broken). These defences are non-specific in the sense that they will attack any pathogen or pollutant to try to protect the body. Macrophages and natural killer cells are examples of non-specific defences. Specific defences “specialise” and they attack specific pathogens that they are made for. For example, CD4 cells have a specific specialisation and that is to stimulate the rest of the immune system to produce more cells to fight off the infection.

BACK

Reverse Transcriptase

Reverse transcriptase is a viral enzyme which helps (with the other viral enzymes protease and integrase) in the copying of the virus inside the host cell, and is injected with the viral genetic material into the host cell during infection.

BACK