UNESCO HARARE CLUSTER OFFICE
in collaboration with the National Universities Commission, Nigeria
Virtual Institute for Higher Education in Africa

HIV/AIDS EDUCATION

...a training programme for teachers involved in the delivery of basic and higher education in Africa

---

...without a vaccine, a major pathway to HIV/AIDS prevention is through education

---

Coordinators
Juma Shabani
Peter Okebukola

Lesson 1

Lesson Objectives

After completing this lesson, you will be able to:

- give the full meanings of HIV and AIDS;
- explain what a virus is;
- name two types of HIV; and
- state how HIV is contracted.

Basic Content

HIV is the shortened form for **H**uman **I**mmunodeficiency **V**irus. It is a virus, such as the virus that causes the flu or cold. A virus is a minute particle that lives as a parasite in plants, animals, and bacteria. It consists of an inside (core) made of a substance known as **nucleic acid** and an outside (sheath) made of **protein**. Viruses can only replicate within living cells and are not considered to be independent living organisms.

In order to make more viruses (and to do all of the other nasty things that viruses do), a virus has to infect a cell. HIV mostly infects the white blood cells of the body's immune system. These cells are known as T-cells or CD4 cells. Once inside the T-cell or CD4 cell, HIV starts producing millions of little viruses, which eventually kill the cell and

then go out to infect other cells. All of the drugs marketed to treat HIV work by interfering with this process

If one is infected with HIV, the body will try to fight the infection. It will make "antibodies", special molecules that are supposed to fight HIV. When you get a blood test for HIV, the test looks for these antibodies. If a person has them in the blood, it means that the person has HIV infection. People who have the HIV antibodies are called "HIV-Positive".

Infection with HIV does not necessarily mean that a person has AIDS. Some people who have HIV infection may not develop any of the clinical illnesses that define the full-blown disease of AIDS for ten years or more. Physicians prefer to use the term *AIDS* for cases where a person has reached the final, life-threatening stage of HIV infection.

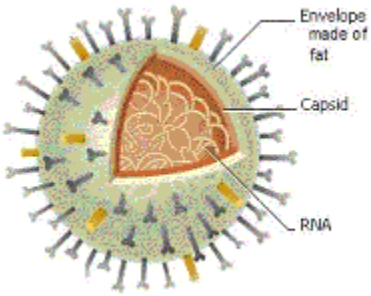
What about AIDS? AIDS is a shortened form for **A**cquired **I**mmune **D**eficiency **S**yndrome. It is a condition caused by HIV. This virus, as stated earlier, attacks the immune system, the body's "security force" that fights off infections. When the immune system breaks down, this protection is lost and can lead to the development of many serious, often deadly infections and cancers. These are called "opportunistic infections (OIs)" because they take advantage of the body's weakened defenses. You have heard it said that someone "died of AIDS." This is not entirely accurate, since it is the opportunistic infections that cause death. AIDS is the condition that lets the OIs take hold.

There are some specific criteria for determining when a person living with HIV progresses to AIDS. One thing they look at is T-cell counts: if a person falls below 200 T4 cells, then they have officially progressed to AIDS. Another thing they look for are OIs: if an HIV+ individual is diagnosed with an opportunistic infection the list of over two dozen possible HIV-related OIs, then they are diagnosed with AIDS.

What is a Virus?

A virus is an infectious agent that is found in virtually all life forms, including humans, animals, plants, fungi, and bacteria. Viruses consist of two major parts- an outer protective coat called a **capsid** which is

made of protein; and an inside which consists of genetic material. The genetic material is either of two substances with rather long names. These names have been abbreviated as **DNA** and **RNA**. DNA stands for **d**eoxyribo**n**ucleic **a**cid while RNA stands for **r**ibo**n**ucleic **a**cid. It is also worth noting that the capsid may or may not have an outer envelope made of fat.



Viruses are between 20 and 100 times smaller than bacteria and hence are too small to be seen by the light microscope. Viruses vary in size from the largest poxviruses of about 450 nanometre in length to the smallest polioviruses of about 30 nanometres. (Note: 1 nanometre is a billionth of a metre) Viruses are not considered free-living, since they cannot reproduce outside of a living cell; they have evolved to transmit their genetic information from one cell to another for the purpose of replication.

Viruses often damage or kill the cells that they infect, causing disease in infected organisms. A few viruses stimulate cells to grow uncontrollably and produce cancers.

Types of HIV

There are two types of this virus: HIV-1, which is the primary cause of AIDS worldwide, and HIV-2, found mostly in West Africa. On its surface, HIV carries a protein structure that recognizes and binds only with a specific structure found on the outer surface of certain cells. HIV attacks any cell that has this binding structure. However, white blood cells of the immune system known as T cells, which orchestrate a wide variety of disease-fighting mechanisms, are especially vulnerable to HIV attack. Particularly vulnerable are certain T cells known as CD4 cells. When HIV infects a CD4 cell, it commandeers the genetic tools within the cell to manufacture new HIV virus. The newly formed HIV virus then leaves the cell, destroying the CD4 cell in the process. No

existing medical treatment can completely eradicate HIV from the body once it has integrated into human cells.

The loss of CD4 cells endangers health because these immune cells help other types of immune cells respond to invading organisms. The average healthy person has over 1,000 CD4 cells per microlitre of blood. In a person infected with HIV, the virus steadily destroys CD4 cells over a period of years, diminishing the cells' protective ability and weakening the immune system. When the density of CD4 cells drops to 200 cells per microlitre of blood, the infected person becomes vulnerable to any of about 26 opportunistic infections and rare cancers, which take advantage of the weakened immune defences to cause disease.

HOW DO YOU GET AIDS?

You don't actually "get" AIDS. You might get infected with HIV, and later you might develop AIDS.

You can get infected with HIV from anyone who is infected, even if they don't look sick, and even if they haven't tested HIV-positive yet. The blood, vaginal fluid, semen, and breast milk of people infected with HIV has enough of the virus in it to infect other people. Most people get HIV by:

- Having sex with an infected person.
- Sharing a needle with someone who's infected.
- Being born when the mother is infected, or drinking the breast milk of an infected woman.
- Using unsterilised instruments in some traditional practices such as circumcision, tattooing, manicure, pedicure, and using unsterilised clippers in barbing saloons.

Getting a transfusion of infected blood used to be a way people got AIDS, but now the blood supply is screened very carefully and the risk is extremely low.

There are no documented cases of HIV being transmitted by tears or saliva, but it is possible to be infected with HIV through oral sex or in rare cases through deep kissing, especially if you have open sores in your mouth or bleeding gums.

IS THERE A CURE FOR AIDS?

Currently, there is no cure for AIDS. There are drugs that can slow down the HIV virus, and slow down the damage to your immune system. But there is no way to get all the HIV out of your body.
There are other drugs that you can take to prevent or to treat opportunistic infections (OIs). In most cases, these drugs work very well. The newer, stronger anti-HIV drugs have also helped reduce the rates of most OIs. A few OIs, however, are still very difficult to treat.

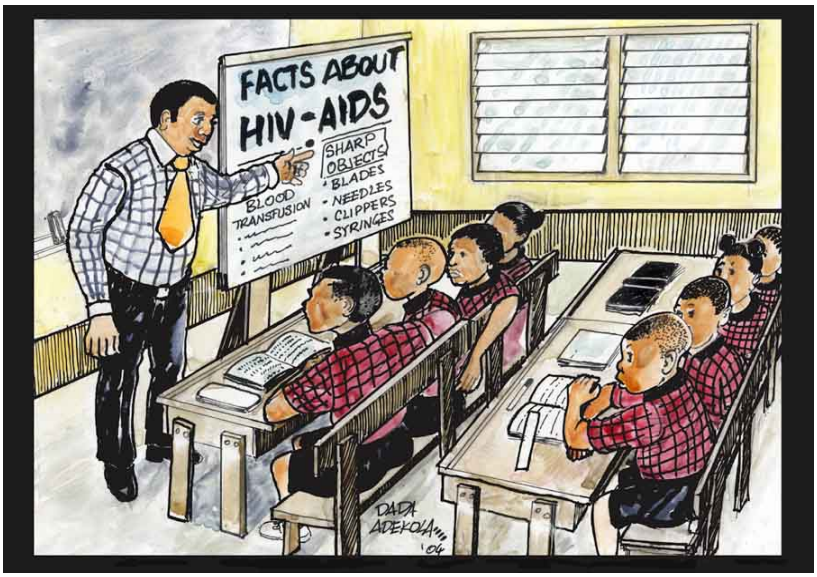
Resources: Three charts: (A) showing the expansion of HIV as Human Immunodeficiency Virus; and AIDS as Acquired Immune Deficiency Syndrome; (B) showing two diagrams- one of the virus – HIV, the other of an AIDS patient; and (C) listing ways of contracting the disease with relevant illustrative sketches.

Procedure: Using chart A, lead pupils to give the full meanings of HIV and AIDS. Remove the chart and call pupils randomly to give the meanings.

Using chart B, explain to the pupils that a virus is an infectious agent that is found in virtually all life forms, including humans, animals, plants, fungi, and bacteria. Viruses are not considered free-living,

since they cannot reproduce outside of a living cell; they have evolved to transmit their genetic information from one cell to another for the purpose of replication. Viruses often damage or kill the cells that they infect, causing disease in infected organisms. A few viruses stimulate cells to grow uncontrollably and produce cancers.

Name the two types of HIV as HIV-1, which is the primary cause of AIDS worldwide, and HIV-2, found mostly in West Africa. Emphasise that the virus attacks the immune system, the body's "security force" that fights off infections. When the immune system breaks down, this protection is lost and can lead to the development of many serious, often deadly infections and cancers. The infections are called "opportunistic infections (OIs)" because they take advantage of the body's weakened defenses. You have heard it said that someone "died of AIDS." This is not entirely accurate, since it is the opportunistic infections that cause death. AIDS is the condition that lets the OIs take hold.



Using chart C, explain to the pupils how HIV can be contracted. Most people get HIV by:

- Having sex with an infected person.
- Sharing a needle with someone who's infected.
- Being born when the mother is infected, or drinking the breast milk of an infected woman.
- Using unsterilised instruments in some traditional practices such as circumcision, tattooing, manicure, pedicure, and using unsterilised clippers in barbing saloons.

Let pupils know that there are no documented cases of HIV being transmitted by tears or saliva, but it is possible to be infected with HIV through oral sex or in rare cases through deep kissing, especially if you have open sores in your mouth or bleeding gums.

Conclude with the discussion on the cure for AIDS that currently, there is no cure for AIDS. There are drugs that can slow down the HIV virus, and slow down the damage to the immune system. But there is no way to get all the HIV out of the body.

Assist pupils to develop a simple concept map of the lesson. An example is given below.

In this lesson, we learned that

- HIV is the shortened form for **H**uman **I**mmunodeficiency **V**irus.
- A virus is an infectious agent that is found in virtually all life forms consisting of two major parts- an outer protective coat called a **capsid** which is made of protein; and an inside which consists of genetic material- **DNA** or **RNA**.
- HIV mostly infects T-cells, also known as CD4+ cells, or T-helper cells. These cells are white blood cells that turn the immune system on to fight disease. Once inside the cell, HIV starts producing millions of little viruses, which eventually kill the cell and then go out to infect other cells.
- There are two types of this virus: HIV-1, which is the primary cause of AIDS worldwide, and HIV-2, found mostly in West Africa.
- AIDS is a shortened form for **A**cquired **I**mmune **D**eficiency **S**yndrome). It is a condition caused by HIV.
- Most people get the HIV virus by having sex with an infected person; sharing a needle or sharp instruments with someone who's infected; and being born when the mother is infected, or drinking the breast milk of an infected woman.

We also learned how to teach the lesson to our pupils using three charts and a concept map.

Lesson 2

Lesson Objectives

After completing this lesson, you will be able to:

- give a brief narrative of the history of HIV/AIDS;
- describe the global picture of the prevalence of the disease; and
- share your knowledge on the topic with your pupils, friends and relations.

Basic Content

AIDS was first identified in 1981 among homosexual men and intravenous drug users in the United States in New York and California. Shortly after its detection in the United States, evidence of AIDS epidemics grew among heterosexual men, women, and children in sub-Saharan Africa. AIDS quickly developed into a worldwide epidemic, affecting virtually every nation. By 2003 over 40 million adults and 4 million children worldwide were living with HIV infection or AIDS. The World Health Organization (WHO), a specialised agency of the United Nations (UN), estimates that from 1981 to the end of 2002 about 20 million people died as a result of AIDS. About 4.5 million of those who died were children under the age of 15. In the short time since the first cases of the AIDS epidemic were reported in 1981, scientists have identified the viral cause of the illness, the basic modes of transmission, accurate tests for the presence of infection, and effective drugs that slow or halt the progression of the disease. During that same period, governments and grassroots organisations

around the world were spurred into action to meet the growing need for AIDS education, counselling, patients' rights, and clinical research. Despite these advances, critics observe that many governments were slow to respond to the crisis.

History of the Virus

There is a raging controversy about the origin of HIV. Using computer technology to study the structure of HIV, some scientists have claimed that HIV originated around 1930 in rural areas of Central Africa, where the virus may have been present for many years in isolated communities. According to this theory which is contested by African scientists, the virus probably did not spread because members of these rural communities had limited contact with people from other areas. But in the 1960s and 1970s, political upheaval, wars, drought, and famine forced many people from these rural areas to migrate to cities to find jobs. During this time, the incidence of sexually transmitted infections, including HIV infection, accelerated and quickly spread throughout Africa. As world travel became more prevalent, HIV infection developed into a worldwide epidemic. Studies of stored blood from the United States suggest that HIV infection was well established there by 1978. Many scientists from Africa have argued that HIV originated from North America.

Beginning in June 1981 reports were published on clusters of gay men (homosexuals) in New York and California who had been diagnosed with pneumocystic pneumonia or Kaposi's sarcoma. These two rare illnesses had previously been observed only in people whose immune systems had been damaged by drugs or disease. These reports triggered concern that a disease of the immune systems was spreading quickly in the homosexual community. Initially called gay-related immunodeficiency disease (GRID), the new illness soon was identified in population groups outside the gay community, including users of intravenous drugs, recipients of blood transfusions, and heterosexual partners of infected people. In 1982 the name for the new illness was changed to acquired immunodeficiency syndrome, or AIDS.

While the disease was making headlines for the speed with which it was spreading around the world, the cause of AIDS remained

unidentified. Fear of AIDS and ignorance of its causes resulted in some outlandish theories. Some thought the disease was God's punishment for behaviours that they considered immoral. These early theories created a social stigma surrounding the disease that still lingers.

Scientists quickly identified the primary modes of transmission—sexual contact with an infected person, contact with infected blood products, and mother-to-child transmission. From these modes of transmission it was clear that the new illness was spread in a specific manner that matched the profile of a viral infection. In 1983 French cancer specialist Luc Montagnier and his colleagues isolated what appeared to be a new human retrovirus from AIDS patients. They named it lymphadenopathy virus (LAV). Eight months later Gallo and his colleagues isolated the same virus in AIDS patients, naming the virus HTLV-III. Eventually, scientists agreed to call the infectious agent human immunodeficiency virus (HIV). In 1985 a new AIDS-causing virus was discovered in West Africa. Named HIV-2, the new virus is closely related to the first HIV, but it appears to be less harmful to cells of the immune systems and reproduces more slowly than HIV-1.

Research leading to the development of the ELISA test was conducted simultaneously by teams led by Gallo in the United States and Montagnier in France. In 1985 the ELISA test to identify HIV in blood became available, followed by the development of the Western Blot test. These tests were first employed to screen blood for the presence of HIV before the blood was used in medical procedures. The tests were later used to identify HIV-infected people, many of whom did not know they were infected. These diagnostic tests also helped scientists study the course of HIV infection in populations.

In 1970, American molecular biologist David Baltimore and American virologist Howard Temin independently discovered the enzyme called reverse transcriptase, which could be used to identify retroviruses. Over the next ten years, many retroviruses were identified in animals. But not until 1980, shortly before the first AIDS cases were recognized in the United States, did American virologist Robert Gallo identify the first human retroviruses, HTLV-I and HTLV-II (HTLV stands for human T cell lymphotropic virus).

Other studies demonstrated that these human retroviruses were more closely related to a retrovirus found in African chimpanzees than to each other. This discovery suggests that the human retroviruses may have evolved from retroviruses that originally infected chimpanzees. The chimpanzee retrovirus likely infected people and underwent

mutations to form the human retrovirus. In 1999 some scientists found that HIV spread from chimpanzees to humans on at least three separate occasions in Central Africa, probably beginning in the 1940s or 1950s.

Diagnosing Illness as AIDS

Physicians diagnose AIDS if a person has an illness known to be caused by immune deficiency, as long as there is no known cause for this immune deficiency (people who undergo radiation therapy or who take certain drugs may impair their immune systems). As more information became known about the course of HIV infection and the nature of the virus itself, this definition of AIDS was revised repeatedly to expand the list of illnesses considered diagnostic indicators of the disease. Early definitions were based on the opportunistic infections commonly found in HIV-infected men. As a result, many women who did not have symptoms covered in the official AIDS definition were denied disability benefits and AIDS-related drug therapies.

The current definition of AIDS was created in 1993 and includes 26 opportunistic infections and cancers, known as diagnostic indicators, that affect both men and women. The definition also emphasizes the importance of the level of CD4 cells in the blood. Today doctors make the diagnosis of AIDS in anyone with a CD4 count below 200 cells per microlitre of blood, regardless of the associated illnesses they may have.

Prevalence of HIV/AIDS: The Global Picture

The global HIV/AIDS epidemic killed more than 3 million people in 2003, and an estimated 5 million acquired the human immunodeficiency virus (HIV)—bringing to 40 million the number of people living with the virus around the world.

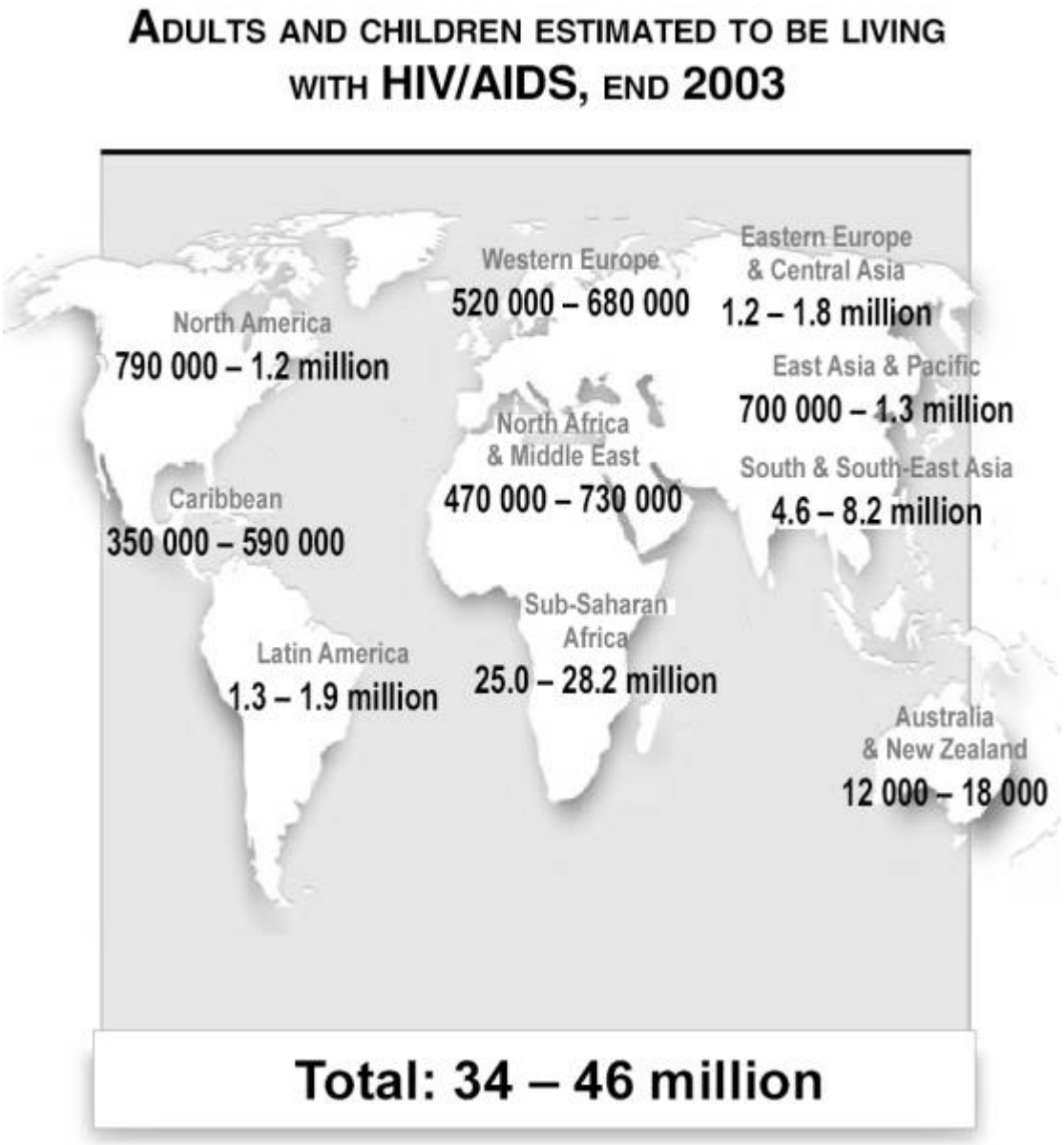
REGIONAL HIV/AIDS STATISTICS AND FEATURES, END OF 2003

Region	Adults and children living with HIV/AIDS	Adults and children newly infected with HIV	Adult prevalence (%)*	Adult & child deaths due to AIDS
Sub-Saharan Africa	25.0 – 28.2 million	3.0 – 3.4 million	7.5 – 8.5	2.2 – 2.4 million
North Africa & Middle East	470 000 – 730 000	43 000 – 67 000	0.2 – 0.4	35 000 – 50 000
South & South-East Asia	4.6 – 8.2 million	610 000 – 1.1 million	0.4 – 0.8	330 000 – 590 000
East Asia & Pacific	700 000 – 1.3 million	150 000 – 270 000	0.1 – 0.1	32 000 – 58 000
Latin America	1.3 – 1.9 million	120 000 – 180 000	0.5 – 0.7	49 000 – 70 000
Caribbean	350 000 – 590 000	45 000 – 80 000	1.9 – 3.1	30 000 – 50 000
Eastern Europe & Central Asia	1.2 – 1.8 million	180 000 – 280 000	0.5 – 0.9	23 000 – 37 000
Western Europe	520 000 – 680 000	30 000 – 40 000	0.3 – 0.3	2 600 – 3 400
North America	790 000 – 1.2 million	36 000 – 54 000	0.5 – 0.7	12 000 – 18 000
Australia & New Zealand	12 000 – 18 000	700 – 1 000	0.1 – 0.1	<100
TOTAL	**40 million (34 – 46 million)**	**5 million (4.2 – 5.8 million)**	**1.1% (0.9 – 1.3%)**	**3 million (2.5 – 3.5 million)**

* The proportion of adults (15 to 49 years of age) living with HIV/AIDS in 2003, using 2003 population numbers.

The ranges around the estimates in this table define the boundaries within which the actual numbers lie, based on the best available information. These ranges are more precise than those of previous years, and work is under way to increase even further the precision of the estimates that will be published mid-2004.

Source: UNAIDS, 2003



How Do I Teach Students?

Resources: Guest teacher and map of the world showing regional HIV/AIDS statistics.

Procedure: Invite a teacher in your school or from another school to lead discussions on the history of HIV/AIDS. Share the contents of this lesson with the guest teacher to enable him/her prepare for the lesson. Invite 3-4 students who will serve as group leaders for a briefing on the topic. After the presentation by the guest teacher, the class will break into groups (3 to 4) for follow-up round-table group

discussions. The group leaders will summarise the main points made by each group. With the aid of the map of the world, lead pupils to discuss the distribution of HIV/AIDS afflicted persons by region. Call on a random selection of pupils to describe, using the map of the world displayed in front of the class, sub-regional and national distribution of adults and children estimated to be living with HIV and AIDS in Africa.

In this lesson, we learned that:

- AIDS was first identified in 1981 among homosexual men and intravenous drug users in the United States in New York and California.
- AIDS quickly developed into a worldwide epidemic, affecting virtually every nation. By 2003 over 40 million adults and 4 million children worldwide were living with HIV infection or AIDS.
- Some scientists have claimed that HIV originated around 1930 in rural areas of Central Africa, where the virus may have been present for many years in isolated communities.
- Studies of stored blood from the United States suggest that HIV infection was well established there by 1978. Many scientists from Africa have argued that HIV originated from North America.
- In 1985 a new AIDS-causing virus was discovered in West Africa. Named HIV-2, the new virus is closely related to the first HIV, but it appears to be less harmful to cells of the immune systems and reproduces more slowly than HIV-1.
- In 1999 some scientists found that HIV spread from chimpanzees to humans on at least three separate occasions in Central Africa, probably beginning in the 1940s or 1950s.
- The global HIV/AIDS epidemic killed more than 3 million people in 2003, and an estimated 5 million acquired the human immunodeficiency virus (HIV)—bringing to 40 million the number of people living with the virus around the world.

Lesson 3

Lesson Objectives

After completing this lesson, you will be able to:

- describe the basic structure of the immune system of the human body;
- outline the activities of the immune system
- define immune deficiency; and
- identify the role of HIV in human immune deficiency;

Basic Content

Every minute of every day wars rage within our bodies. The combatants are too tiny to see. Some, like the infamous virus that causes AIDS, or acquired immune deficiency syndrome, are so small that 200 million would fit on the tip of a needle. Yet they employ tactics that can kill much larger cells they swarm upon.

Usually we never even notice the battles in the incessant wars within us. We have evolved legions of defenders, specialised cells that silently rout the unseen enemy. Sometimes these warriors mistake harmless invaders, such as pollen, for deadly foes, and they mount an allergic reaction. Sometimes our defenders are caught unprepared, and we

develop a cold, the flu, or worse. Occasionally some of our own cells begin the mutinous proliferation of cancer and manage to evade the surveillance of our body's defence forces. But for every successful penetration of our defences, thousands of attempts are repelled. We sleep securely, trusting the invisible vigilantes of our immune system.

The **immune system** of the human body is made up of group of cells, molecules, and organs that act together to defend the body against foreign invaders that may cause disease. The health of the body is dependent on the immune system's ability to recognise and then repel or destroy these invaders.

In humans the immune system consists of about a trillion (10^{12}) cells called lymphocytes and about 100 million trillion (10^{20}) molecules called antibodies that are produced and secreted by the lymphocytes. The special capability of the immune system is pattern recognition and its assignment is to patrol the body and guard its identity.

White blood cells are the mainstay of the immune system. Some white blood cells, known as *macrophages,* play a function in innate immunity by surrounding, ingesting, and destroying invading bacteria and other foreign organisms. *Lymphocytes* are specialised white blood cells whose function is to identify and destroy invading antigens. All lymphocytes begin as "stem cells" in the *bone marrow,* the soft tissue that fills most bone cavities, but they mature in two different places. Some lymphocytes mature in the bone marrow and are called B lymphocytes. *B lymphocytes,* or *B cells,* make *antibodies,* which circulate through the blood and other body fluids, binding to antigens and helping to destroy them. Other lymphocytes, called *T lymphocytes,* or *T cells,* mature in the thymus, a small glandular organ located behind the breastbone. Mature lymphocytes constantly travel through the blood to the lymphoid organs and then back to the blood again. This recirculation ensures that the body is continuously monitored for invading substances.

Immune Deficiency

Deficiencies in immune function may be either inherited or acquired. ***Inherited immune deficiencies*** usually reflect the failure of a gene important to the generation or function of immune system components. DiGeorge syndrome is an inherited immune disorder in

which a person has no thymus and, therefore, cannot produce mature T lymphocytes. People with this disorder can mount only limited humoral immune responses, and their cell-mediated immune responses are severely limited. The most extreme example of a hereditary immune deficiency is severe combined immunodeficiency (SCID). Individuals with this disease completely lack both T and B lymphocytes and thus have no adaptive immune responses. People with SCID must live in a completely sterile environment, or else they will quickly die from infections.

Acquired immune deficiencies can be caused by infections and also other agents. For example, radiation therapy and some kinds of drugs used in treating disease reduce lymphocyte production, resulting in damaged immune function. People undergoing such therapies must be carefully monitored for lowered immune function and susceptibility to infections. Environmental and lifestyle factors, such as poor nutrition or stress, can also affect the immune system's general status.

An infectious agent resulting in fatal immune deficiency is the human immunodeficiency virus (HIV). This virus causes acquired immunodeficiency syndrome (AIDS) by infecting and eventually destroying helper T cells. Because helper T cells regulate all immune responses, their loss results in an inability to make adaptive immune responses. This complete lack of immune function makes individuals with AIDS highly susceptible to all infectious agents.

Activity of the Immune System

Of the one hundred trillion cells that make up a human body, one in every hundred is there to defend us. They are the white blood cells that are born in the bone marrow. When they emerge, they form three distinct regiments of warriors—the ***phagocytes*** and two kinds of lymphocytes, the ***T cells*** and ***B cells***. Each has its own strategies of defence. The first defenders to arrive would be the phagocytes—the scavengers of the system. Phagocytes constantly scour the territories of our bodies, alert to anything that seems out of place. What they find, they engulf and consume.

Phagocytes are not choosy. They will eat anything suspicious that they find in the bloodstream, tissues, or lymphatic system. In the lungs, for instance, they consume particles of dust and other pollutants that

enter with each breath. They can cleanse lungs that have been blackened with the contaminants of cigarette smoke, provided the smoking stops. Too much cigarette smoking, over too long a time, destroys phagocytes faster than they can be replenished. Environmental pollutants like silica and asbestos also overwhelm them.

We can watch phagocytes at work when our skin is injured. The skin is our first defence line—until a cut allows bacteria and other micro-organisms to invade. Immediately cells near the wound release substances that stimulate nearby blood vessels to dilate, causing swelling and reddening around the cut. Phagocytes flow in through the distended blood vessels, devouring the invaders. In time the body weaves threads of fibrin across the wound to restore the skin's barrier.

There is a special kind of phagocyte called a macrophage. As the macrophage engulfs a stray virus, it plucks a special piece, an antigen, from the invader. It displays that small piece on its own cell surface like a captured banner of war. That flag plays a critical role in the immune system's response: It alerts a highly specialised class of lymphocytes, the T cells. All our lives a small contingent of those lymphocytes has circulated through our bodies, waiting for this particular virus. They recognise it, as the virus identified its victim among the cells, by shape. The antigens on the surface of the virus fit exactly into these T cells' receptors.

How did that particular group of T cells know the shape of the antigen? Their training takes place in the thymus, a mysterious pale grey gland that sits behind the breastbone, above the heart. (The “T” in T cell stands for thymus-derived.) This unsung little gland swells in size from birth to puberty and then begins to shrink. Somehow, as the T cells mature in the thymus, one learns to recognise the antigens of, say, the hepatitis virus, another to identify a strain of flu antigens, a third to detect rhinovirus 14, and so on.

Most T cells die in the thymus, We do not know why. A guess is that the thymus is selecting only the best T cells, those with the sharpest powers of recognition. And what a staggering task the thymus confronts. Nature can create antigens in hundreds of millions of different shapes. The thymus must turn out a group of T cells that recognises each one. Remarkably, we have T cells trained to recognise even artificial antigens created in the lab—antigens the body has never encountered in its millions of years of evolution.

The thymus pumps out T cells by the tens of millions. Even though only a few of them may recognize any one antigen, the collective scouting force is vast enough to identify the almost infinite variety of antigens nature produces.

So diligent are our T cells that even desirable cells transplanted from one person to another are quickly recognised as foreign and destroyed. The process, called rejection, can defeat a lifesaving heart or kidney transplant unless surgeons use drugs to keep the immune system at bay.

The T cells that first detect antigens, known as ***helper T's***, carry no weapons. Rather they send urgent chemical signals to a small squadron of allies in the body—the ***killer T cells***. The message: Multiply fast!

Like all T cells, killer T's are trained to recognise one specific enemy. When alerted by the helper T's, the squadron reproduces into an army. The killer T's are lethal. They can trigger a chemical process that punctures the cell membranes of bacteria or destroys infected cells before viruses inside have time to multiply.

Besides summoning the killer T's, helper T cells call more phagocytes into the battle. They also rush toward the spleen and the lymph nodes. There they will alert the last major regiment of the immune system, the B cells.

B cells migrate after their birth in the bone marrow, with many of them concentrating in our lymph nodes. These small bean-shaped capsules are scattered along the intricate branching of the lymph system. We are aware of them only during certain infections, when they become swollen and sometimes painful to the touch. Our lymph nodes are small munitions factories, staffed by the B cells. Their product: the chemical weapons called antibodies.

By sticking to the surface of unwelcome cells, antibody molecules slow them down, making them easier targets—as well as more attractive ones—for phagocytes. Antibodies can also kill. Locking on to the enemy's antigens, which they precisely mirror in shape, the antibodies collect substances in the bloodstream called complement. When this complement comes together in the right sequence, it detonates like a bomb, blasting through the invader's cell membrane. At the peak of operation, each B cell can churn out thousands of antibodies a second. As the immune defences gather, the tide of battle turns. Normally

within a week or so the invader is in retreat. Then the third member of the T-cell family takes over—the ***suppressor T***, the peacemaker.

Suppressor T's release substances that turn off B cells. They order killer cells to stop the fight. Suppressor T's even command helper T's to cease and desist. The battle is won. In the aftermath phagocytes range over the area, cleaning up the litter of dead cells and spent substances. Tissue damage is repaired. The threat is over—but not forgotten. Most of the T and B cells recruited for battle die off within days of an infection.

There is one simple reason why the AIDS virus is so deadly. It kills the one lymphocyte most critical to the immune response: the helper T cell. Like Greeks hidden inside the Trojan horse, the AIDS virus enters the body concealed inside a helper T cell from an infected host. Almost always it arrives as a passenger in blood or semen. In the invaded victim, helper T's immediately detect the foreign T cell. But as the two T's meet, the virus slips through the cell membrane into the defending cell. Before the defending T cell can mobilise the troops, the virus disables it.

Some researchers believe the AIDS virus also may change the surface of helper T cells in such a way that they fuse together. That strategy makes it even easier for the virus to pass from cell to cell undetected.

Once inside an inactive T cell, the virus may lie dormant for months, even years. Then, perhaps when another, unrelated infection triggers the invaded T cells to divide, the AIDS virus also begins to multiply. One by one, its clones emerge to infect nearby T cells. Slowly but inexorably the body loses the very sentinels that should be alerting the rest of the immune system. Phagocytes and killer cells receive no call to arms. B cells are not alerted to produce antibodies. The enemy can run free!

By the late 1960s, it had become clear that stem cells give rise to two broad lineages of lymphocytes (as well as the other blood cells). One consists of the *B* cells, which originate in the bone marrow and produce antibodies that bind to foreign proteins and mark them for attack by other cells. They act against extra-cellular pathogens such as bacteria. The other, the *T* cells, arises in the thymus. *T* cells handle such intracellular pathogens as viruses in addition to such intracellular parasites as tuberculosis. *T* cells also secrete molecules known as lymphokines, which direct the activity of *B* cells, other *T* cells and other parts of the immune system.

Once formed, cells of both types migrate to the spleen, lymph nodes and intestinal lymphoid tissues. There they can encounter antigen, the molecular signature of microbial or viral invaders, and be called into action. Lymphocytes continuously circulate through the body's vascular and lymphatic systems, stopping periodically in the lymphoid organs as they patrol for foreign antigens.

Use the drama method to teach this lesson. Pupils should be assigned roles as invading germs and white blood cells. Let pupils act their roles based on a script developed from the basic content of this lesson.

In this lesson, we learned that

- The **immune system** of the human body is made up of group of cells, molecules, and organs that act together to defend the body against foreign invaders that may cause disease.
- The system consists of about a trillion (10^{12}) cells called lymphocytes and about 100 million trillion (10^{20}) molecules called antibodies that are produced and secreted by the lymphocytes.
- White blood cells also called lymphocytes are the mainstay of the immune system.
- Some lymphocytes mature in the bone marrow and are called B lymphocytes. Other lymphocytes, called *T lymphocytes,* or *T cells,* mature in the thymus, a small glandular organ located behind the breastbone.
- Deficiencies in immune function may be either inherited or acquired. ***Inherited immune deficiencies*** usually reflect the failure of a gene important to the generation or function of immune system components. ***Acquired immune deficiencies*** can be caused by infections and also other agents.
- An infectious agent resulting in fatal immune deficiency is the human immunodeficiency virus (HIV). This virus causes acquired immunodeficiency syndrome (AIDS) by infecting and eventually destroying helper T cells. Because helper T cells regulate all immune responses, their loss results in an inability to make adaptive immune responses. This complete lack of immune function makes individuals with AIDS highly susceptible to all infectious agents.
- Once inside an inactive T cell, the virus may lie dormant for months, even years. Then, perhaps when another, unrelated infection triggers the invaded T cells to divide, the AIDS virus

also begins to multiply. One by one, its clones emerge to infect nearby T cells. Slowly but inexorably the body loses the very sentinels that should be alerting the rest of the immune system. Phagocytes and killer cells receive no call to arms. B cells are not alerted to produce antibodies. The enemy can run free!