IAVI VACCINE LITERACY LIBRARY

2022

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Translating **science** into **global** health impact

About IAVI

IAVI is a non-profit scientific research organization dedicated to addressing urgent, unmet global health challenges including HIV, tuberculosis, and emerging infectious diseases. Its mission is to translate scientific discoveries into affordable, globally accessible public health solutions.

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And many other generous individuals and partners around the world

As of April 2022

Abbreviations

AE	Adverse event
AIDS	Acquired immunodeficiency syndrome
APC	Antigen-presenting cell
BCG	Bacillus of Calmette and Guerin
CAB	Community advisory board
CBO	Community-based organisation
CD	Cluster of differentiation
CDC	Centers for Disease Control and Prevention
CEPI	Coalition for Epidemic Preparedness Innovations
COVID-19	Coronavirus Disease 2019
CRF	Circulating recombinant forms
CTL	Cytotoxic T lymphocyte
DNA	Deoxyribonucleic acid
DOT	Directly observed therapy
EMA	European Medicines Agency
ERC	Ethics Review Committee
FDA	U.S. Food and Drug Administration
GCLP	Good Clinical Laboratory Practice
GCP	Good Clinical Practice
HIV	Human immunodeficiency virus
ICH	International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use
IEC	Independent Ethics Committee
IGRA	Interferon-gamma release assays
IRB	Institutional Review Board
LASV	Lassa virus
LMIC	Low- to middle-income countries
LTBI	Latent tuberculosis infecton
MDR-TB	Multidrug-resistant tuberculosis
M.tb	Mycobacterium tuberculosis
NAT	Nucleic acid test
NGO	Non-governmental organisation
NK	Natural killer cells
NP	Nucleoprotein
NRA	National Regulatory Authority
POD	Prevention of disease
POI	Prevention of infection
POR	Prevention of reinfection
RNA	Ribonucleic acid
SAE	Serious adverse event
SAHPRA	South African Health Products Regulatory Authority
TB	Tuberculosis
TPP	Target product profile
TST	Tuberculin skin test
UNAIDS	Joint United Nations Programme on HIV/AIDS
VISP	Vaccine-induced seropositivity
VL	Viral load
VMMC	Voluntary medical male circumcision
WHO	World Health Organization
XDR-TB	Extensively drug-resistant TB

Introduction

The **IAVI Vaccine Literacy Library** contains basic information about HIV, TB, and Lassa virus vaccines, explained in simple language and in a user-friendly format. The text is divided into eight modules covering a range of topics, from basic science and clinical trials to social and ethical issues related to vaccine development and testing, as well as future access to and use of vaccines. The resource also includes a list of abbreviations used and a glossary with definitions of key terms.

Audience

The **IAVI Vaccine Literacy Library** is targeted to a broad range of stakeholders involved in HIV, TB, and Lassa virus vaccine-related work. While all the modules can be adapted for use at the local community level, they are generally written for individuals who provide education and information related to HIV, TB and Lassa virus.

Use of the IAVI Vaccine Literacy Library

The **IAVI Vaccine Literacy Library** is meant for use by individuals and organisations that are providing education and information related to HIV, TB and Lassa virus vaccine research and development.

Groups that may use this material include, but are not limited to:

- Clinical vaccine trial site staff.
- Non-Governmental Organisation (NGO) staff, to incorporate vaccine messages into their existing work.
- Medical professionals or institutions, to provide vaccine information to patients or to incorporate into advocacy efforts.
- Health Centres, to provide clients with vaccine information.
- Academic or religious leaders, to provide information and/or informed advice.
- Community Advisory Boards.

The **IAVI Vaccine Literacy Library** is designed for multiple uses to serve a variety of needs. For certain audiences, it may be used as reference information, such as background reading for training workshops. It can also be used as a reference document to develop educational materials or tools, or to incorporate vaccine information into existing tools, such as:

- Fact sheets on specific vaccine topics.
- Brochures to be given to potential vaccine trial participants.
- Informational videos to be shown in community settings.
- Street plays to be performed in community settings.
- Radio programmes.

The **IAVI Vaccine Literacy Library** can also be used directly for recruitment of trial participants or may be used to engage communities or national-level stakeholders to build understanding of and support for clinical trials and an eventual vaccine.

Using and Navigating the Core Content

The **IAVI Vaccine Literacy Library** is divided into eight modules covering a range of topics, from basic science and clinical trials to social and ethical issues related to vaccine development and testing, as well as future access and use.

Each module can be read and used as a standalone document.

Certain issues or concepts are covered in more than one module. These "cross-cutting issues" are cross referenced to other modules in capitalised text. All scientific and technical terms are defined in a comprehensive glossary that provides definitions for technical and scientific terms and expressions.

Acknowledgement of IAVI and Materials Review

As described, the **IAVI Vaccine Literacy Library** is designed primarily as a reference on HIV, TB, and Lassa virus vaccines that can be used to develop or adapt materials or messages.

If IAVI has not been involved in production of materials or tools based on the **IAVI Vaccine Literacy Library**, no review by IAVI is required. IAVI does request that appropriate acknowledgement of the **IAVI Vaccine Literacy Library** be given, but the IAVI logo should not be used.

IAVI requests that it be notified of any tools or materials produced, in order that they be added to the **IAVI Vaccine Resource Library**, which is a public resource serving the entire HIV, TB, and Lassa virus-vaccine field. Proper credit will be given for all resources included in the **IAVI Vaccine Literacy Library**.

Disclaimer

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How to Cite the IAVI Vaccine Literacy Library

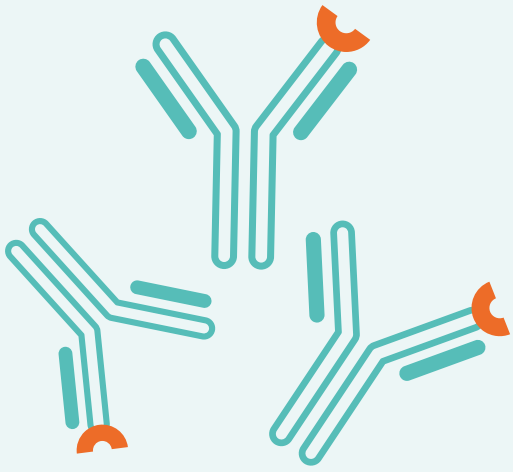
IAVI Vaccine Literacy Library, IAVI, New York, USA, 2022.

MODULE 3:
THE IMMUNE SYSTEM

MODULE 3

THE IMMUNE SYSTEM

CONTENTS 40



» Summary Points

- The immune system is the set of organs, tissues, and cells that defend the body against infections and diseases.
- It is very sophisticated and is designed to recognise common pathogens that enter the body, such as viruses, bacteria, or parasites.
- The immune system develops defence responses to invading organisms and usually will 'remember' and respond more rapidly during future encounters.
- Some pathogens such as HIV can disrupt or evade immune responses.

1. Introduction

The immune system is a complex system of organs, tissues, cells, and processes that has evolved to protect us from diseases. The immune system enables the body to recognise anything that is different from itself (i.e., 'foreign') and that is potentially harmful. The immune system creates defences against these invaders, which are called pathogens. Our immune system is divided into two broad categories: 'innate immunity' and 'acquired immunity.'

Innate immune defences are the first to respond to any pathogen. These defences are not specific to one pathogen. This arm of the immune system cannot usually be 'taught' to respond better by a vaccine. Innate immunity is often not enough to get rid of pathogens as the first line of defence and a second line of defence kicks in.

Acquired immunity is the second line of defence of the body. These defences are activated only after our immune system has 'seen' and 'recognised' a pathogen. Acquired immunity is typically directed towards a single, specific pathogen. The acquired immune responses are those involved in the function of a vaccine.

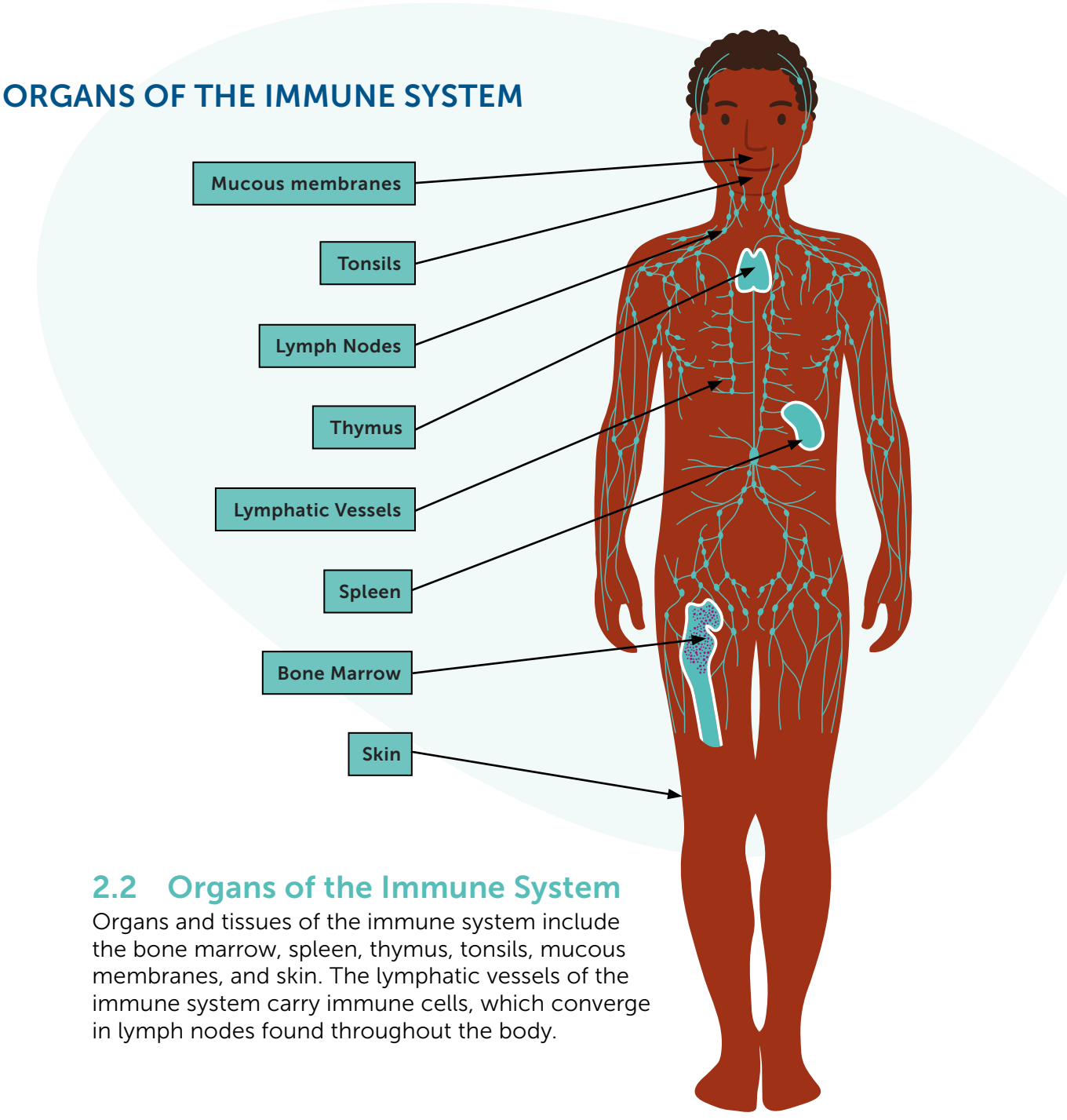
This module describes acquired immunity. There are two branches or 'arms' of the acquired immune system (see **BOX** and **DIAGRAM**):

- **Cell-mediated or cellular immune response** – the immune response coordinated by 'T cells' which targets cells that have been infected with a pathogen.
- **Antibody-mediated or humoral immune response** – includes antibodies and 'B-cell' responses.

2. The Immune System: Key Concepts

2.1 The Immune Response

The immune response is a collection of activities from the immune system to defend the body against bacteria, viruses, or other substances that the body recognises as foreign and harmful. When a pathogen enters the body, the immune system's first responders (macrophages and dendritic cells) detect and ingest the invader, package some of its components or pieces (called antigens) and present these on their outer surfaces, so that other immune cells (lymphocytes) can 'see' the pathogen and respond appropriately to it.

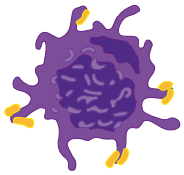


2.2 Organs of the Immune System

Organs and tissues of the immune system include the bone marrow, spleen, thymus, tonsils, mucous membranes, and skin. The lymphatic vessels of the immune system carry immune cells, which converge in lymph nodes found throughout the body.

2.3 Cells of the Immune Systems

The immune system comprises many cells located in different organs. Each plays a role in recognising pathogens and mounting a response.



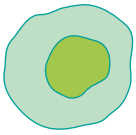
Macrophages/Dendritic cells/Phagocytes

These cells look out for pathogens. When they encounter a pathogen, they ingest and process it and 'alert' other immune cells of its presence.

Antigen-presenting cells (APCs)

APCs engulf and process the antigens to present them on their own outer surface in a way that can be 'seen' by other immune cells called lymphocytes. This process activates the lymphocytes to function. Immune cells that act as APCs include:

- B cells
- Macrophages
- Dendritic cells

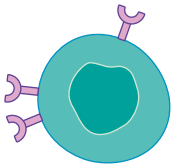


Lymphocytes

Lymphocytes are white blood cells. When the APCs present antigens to the lymphocytes they respond against the pathogen associated with the antigens. The two most important types of lymphocytes are T cells and B cells.

B-Cell receptors and T-Cell receptors

B-cell receptors and T-cell receptors are key proteins responsible for specific antigen recognition in acquired immunity. They are found at the surface of the T and B cells of the immune system, and they can recognise antigens or part of the antigens presented by the APCs. There is a vast diversity of B- and T-cell receptors allowing the human immune system to recognise a very large number of pathogens.



T cells

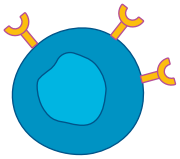
T cells can recognise a pathogen or a virus-infected cell presented by the antigen presenting cells (APCs). They release substances that cause inflammation (cytokines), and they can kill abnormal or virus-infected cells. There are two types of T cells: CD4+ lymphocytes and CD8+ lymphocytes.

- CD4+ cells

  The main function of these T cells is to recognise antigens presented by the APCs and to help coordinate the specific immune response against that antigen. Therefore, they are also called 'helper T cells.'

- CD8+ cells

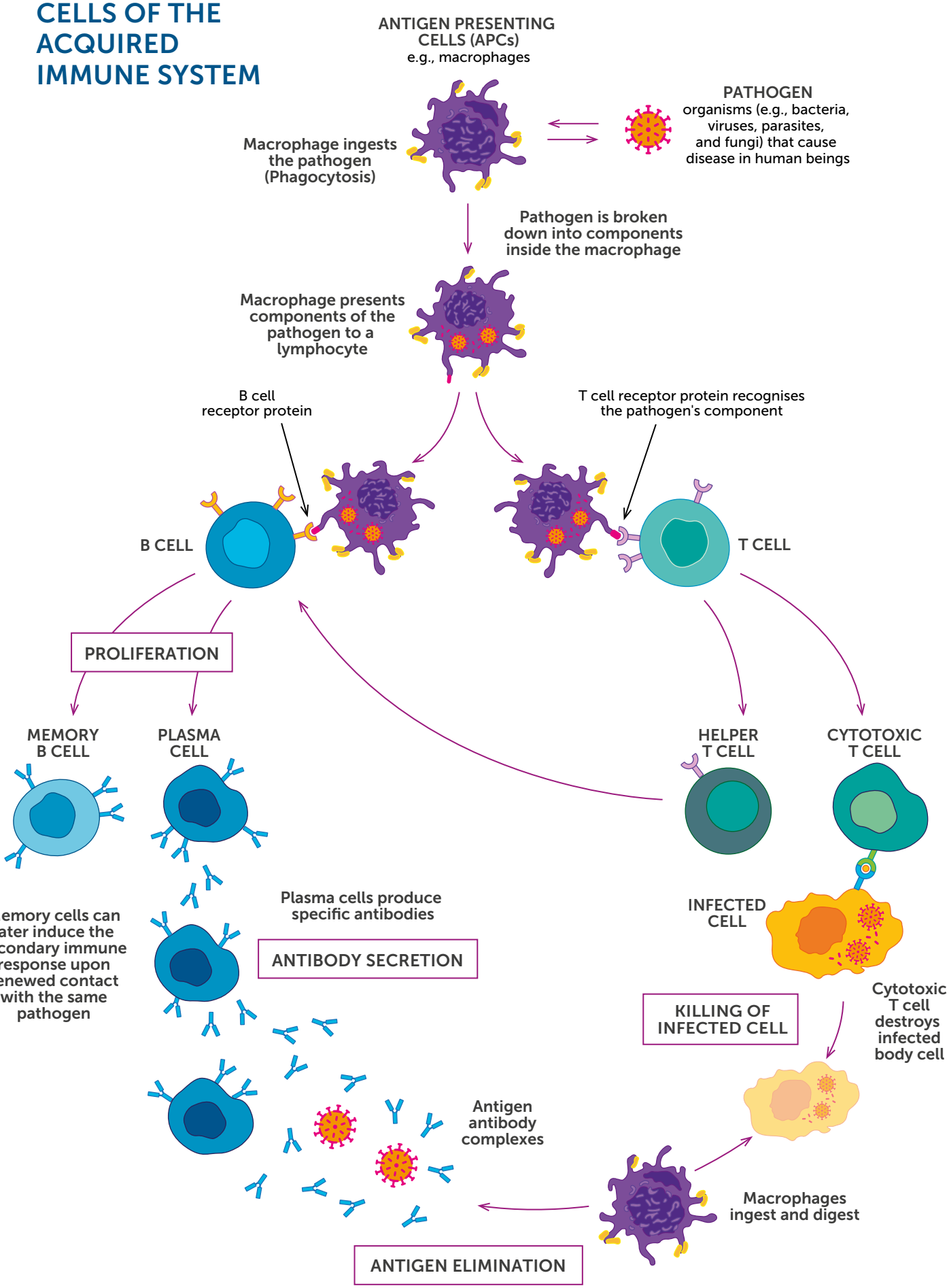
  These T cells kill cells or slow down activity of cells that have been infected with the pathogen. They are also called cytotoxic T lymphocytes (CTLs) or 'killer T cells.' They do this through 'cytotoxic' activity, a process that kills the infected cells.

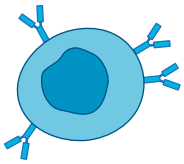


B Cells

B cells can recognise and target pathogens that have entered the body. B cells can evolve into plasma B cells that produce antibodies specifically designed to recognise and attach to circulating pathogens and antigens.

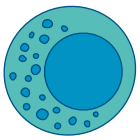
CELLS OF THE ACQUIRED IMMUNE SYSTEM





Memory B cells and memory T cells

Helper T cells, killer T cells and plasma B cells form responses to many infections, such as HIV, tuberculosis, or malaria. Once the individual has recovered from the infection, a small population of memory T cells and memory B cells remains. These cells can quickly restart a response if the pathogen ever returns. Memory cells 'remember' the pathogen and are prepared to start an appropriate response more quickly and more vigorously the next time the body encounters the same pathogen.



Natural killer (NK) cells

Natural killer (NK) cells are a type of lymphocyte that contain enzymes that can kill other cells, especially tumour cells and cells infected by viruses.

2.4 The Humoral Immune Response

The humoral response is the arm of the immune system mediated by B cells through the production of antibodies.

Antibody

Also called immunoglobulins, antibodies are proteins produced by plasma B cells in response to an antigen. They can be found in bodily fluids such as plasma, serum, tears, saliva, and cervical fluids. An antibody is specifically designed to attach to part of the pathogen, called an antigen.

When antibodies lock or bind to antigens on the surface of the pathogen, they coat the pathogen, making it inactive and marking it so that other immune cells can kill it. Antibodies can also prevent viruses from getting into cells, which is where they must be to reproduce. There are different types of antibodies.

Binding antibody

Binding antibodies are usually produced in large quantities following a bacterial or viral infection. They can recognise and bind to parts of a foreign body but cannot directly prevent infections or destroy the pathogen. They require the involvement of other immune mechanisms to destroy the foreign agent. A common way of diagnosing infections is to test for the presence of these antibodies in biological fluids. Binding antibodies are also called non-neutralising antibodies.

Neutralising antibody

Neutralising antibodies react with an infectious agent, usually a virus, and destroy or inhibit its ability to enter a cell (infectiveness) and virulence (ability to multiply).

Broadly neutralising antibody (bnAbs)

Viruses can evade the immune response and in particular the humoral response through a variety of mechanisms. Viral DNA can mutate quickly allowing viruses to escape recognition by both humoral and cellular immune responses. However, as a virus evolves, the immune response also evolves in tandem and can adapt by developing bnAbs. These antibodies are more efficient because they can recognise a wide range of viruses even if they are different from the virus that initially infected the individual. This evolution of both the virus and the immune system is a complex and lengthy process which is not necessarily inevitable and requires other cells of the immune responses.

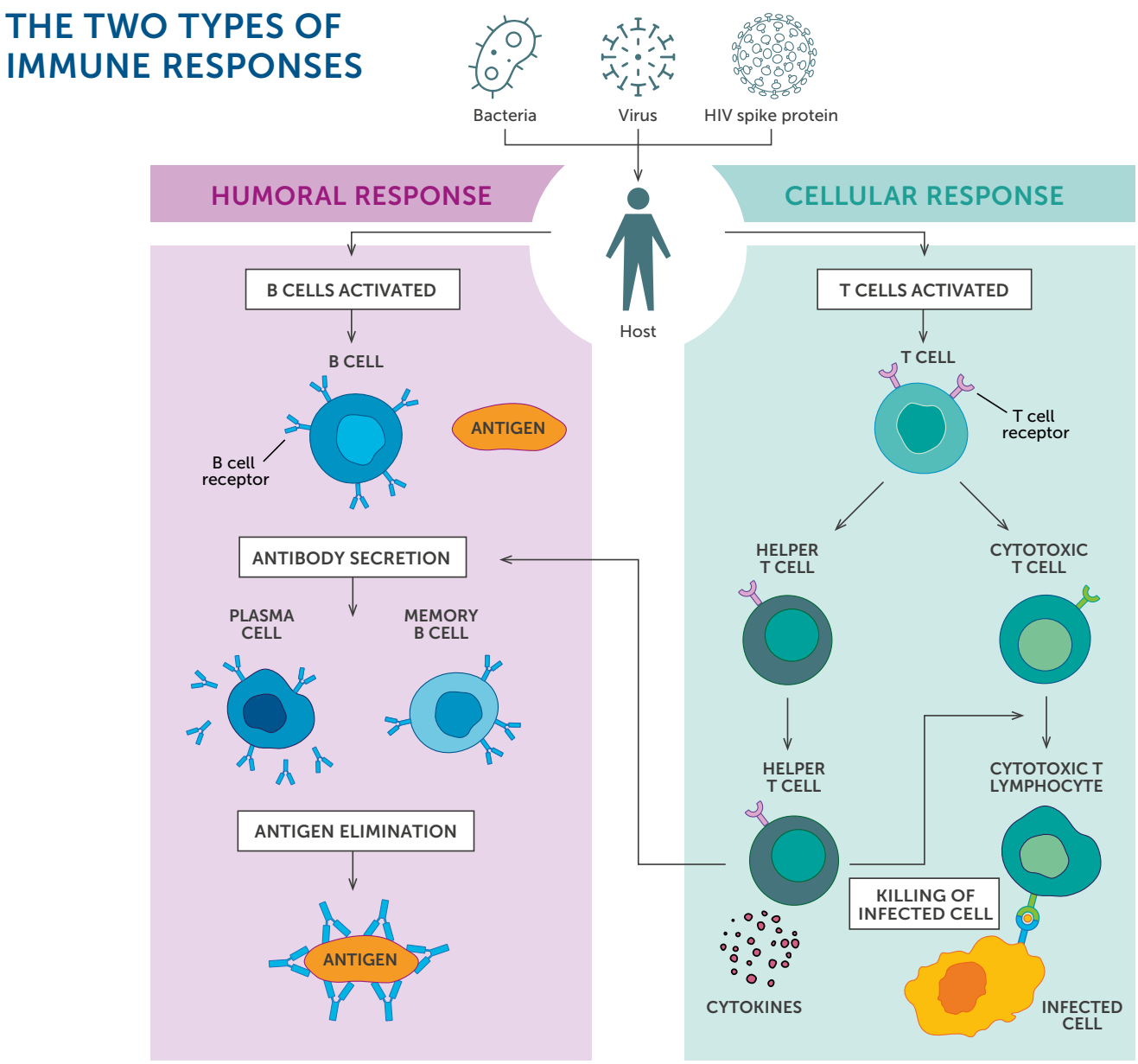
2.5 The Cellular Immune Response

The cellular response is the arm of the immune response mediated by cells from the immune system and the production of cytokines. Cytokines are proteins that act as messengers between cells to regulate and coordinate the immune responses.

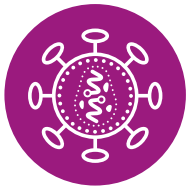
Cellular immunity is most effective in destroying virus-infected cells, and bacteria within cells. Cellular immunity works by activating antigen-specific cytotoxic T lymphocytes (CTLs), macrophages and natural killer cells that can destroy cells displaying foreign antigens on their surface.

Cells involved in the cellular immune response produce a variety of cytokines that influence the function of other cells involved in acquired immune responses and innate immune responses.

The cellular immune response is also responsible for the development of CD4+ and CD8+ memory cells. These memory cells can persist for the remainder of a person's life and lead to a rapid response if the body is exposed again to the same pathogen.



3. HIV and the Immune System



At first, the immune system mounts a defence that can help people living with HIV to remain healthy for some years after acquiring HIV. Eventually HIV overcomes these defences, allowing infections and diseases to take hold, and ultimately causing death.

HIV preferentially infects the cells of the immune system, killing them and therefore making it difficult for the body to fight against the virus and other pathogens. When someone has had HIV for some time, their immune system weakens, and they may get ill from pathogens that would not normally cause disease in a person not infected with HIV. These are called opportunistic infections. Pneumocystis pneumonia (a fungal disease) and thrush are examples of common opportunistic infections. Other infectious diseases may be more serious in people living with HIV, such as tuberculosis or genital herpes.

HIV has many ways of avoiding the immune system. Starting with transmission, HIV interacts with various immune cells such as dendritic cells, macrophages, APCs, and lymphocytes. HIV uses these cells to make more copies of itself, killing them in the process.

HIV also kills the CD4+ cells that help plasma B cells to make antibodies and direct CD8+ T-cell responses, both of which are important to fight HIV. The lower the number of CD4+ cells, the more difficult it is for the body to fight pathogens. Another weapon that HIV can use is its viral diversity, which is a major challenge for the immune system. HIV can change some of its parts to avoid detection. This process is sometimes referred to as 'immune evasion.'

The virus can also hide its surface envelope glycoprotein by coating it with sugar molecules and therefore making it difficult for the cells of the immune system to see and to mount a response against the virus. In this way the virus can escape antibodies and cellular responses. Although the body can adapt and develop bnAbs, these are rare and ultimately fail to prevent the disease from progressing because other parts of the immune system are too weak.

Finally, another way for the virus to escape from the body's immune response is where HIV viral DNA hides in the genome in a dormant state without multiplying, in a 'reservoir' of infected cells.

4. TB and the Immune System

The interaction between the immune system and *M.tb*, the pathogen responsible for tuberculosis (TB), are complex and lead to either clearance of the bacteria, latent TB infection, or TB disease (see **MODULE 2**).

- Macrophages and CD4+ T lymphocytes play a central role in the immune responses to M.tb that can use multiple strategies to escape the immune system.
- M.tb can prevent the activation of pathogen destruction systems within macrophages where it can hide, reproduce slowly, and modify the cell to its advantage.
- M.tb can affect the function of dendritic cells by altering the production of various cytokines involved in the immune responses and the suppression of T lymphocyte activity.
- M.tb can also interfere with the interactions between the different cells of the immune system and hamper their ability to work together and kill or constrain the organism.

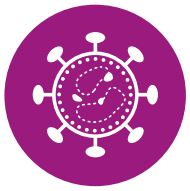
Following infection of the cells of the lung by M.tb, a complex, localised and well-coordinated immune response keeps the pathogen under control, preventing transmission in 90% of infected individuals and resulting in latent TB infection (LTBI). The granuloma is made of many cells involved in the immune responses and aims at keeping the pathogen contained and under control. M.tb trapped in a dormant state within a granuloma is a characteristic of latent M.tb infection (LTBI).

Macrophages, CD4+ T lymphocytes and the formation of the granuloma are believed to be central to the immune defence against M.tb. The development of the granuloma is the ancestral mechanism of defence against M.tb and a defining feature of TB disease.

LTBI progresses into active TB disease when the balance between host immune responses and M.tb counter-response in the granuloma is broken. M.tb can escape the granuloma leading to the individual developing TB disease and becoming capable of transmitting the infection. This shift can be triggered by M.tb virulence factors, molecules that help the bacteria to colonise the host at the cellular level.

M.tb represents a classic example of an organism that has evolved with the human species over thousands of years, developing a remarkable ability to take advantage of what otherwise would be an appropriate immune response against it and using this immune response to successfully propagate itself, leading to its spread and the infection of more than 25% of humanity with M.tb across most areas of the globe.

5. Lassa Fever and the Immune System



The immune response to natural Lassa virus infection has yet to be fully explained by scientists. Knowledge and understanding are hampered by several factors including the need to handle the virus in a special high safety laboratory. Outbreaks are typically sporadic, with the annual peak of cases usually observed during the dry season (December–April), and often in remote locations, where laboratory infrastructure is limited. However, it appears that Lassa virus infection results in immunosuppression enabling the Lassa virus to evade and undermine effective immune responses.

The Lassa virus specifically targets antigen-presenting cells (APCs), dendritic cells, and macrophages. Infected cells can produce large quantities of viruses without being killed and the virus prevents them performing their function of presenting antigens to other cells of the immune system.

Temporary reduction in the number of CD4+ and CD8+ T cells, NK cells and B cells have been observed in the early stage of the disease. The Lassa virus can also reduce and alter the production of cytokines involved in the immune responses.

The Lassa nucleoprotein (NP) can hold back the ability of both arms of the immune system to respond to the infection. Despite being strong, the antibody response to the virus does not seem to impact the progression of the disease and neutralising antibodies are produced in small amounts.

Cellular immune responses may play a crucial role in the progression and outcome of the disease as these responses are strongest in those that recover well, albeit with limited data. Unfortunately, the Lassa virus seems to be able to interfere with T-cell activation as well as destroying the lymphoid organs in which these cells reside.

FIND OUT MORE...

- Essential Medical Immunology: *http://www.roitt.com*
- ClinicalInfoHIV.gov: *https://clinicalinfo.hiv.gov/en/glossary*
- British Society for Immunology: *https://www.immunology.org/public-information*
- de Martino M, Lodi L, Galli L and Chiappini E, Immune Response to Mycobacterium tuberculosis: A Narrative Review. Front. Pediatr. 7:350 (2019)
- Prescott JB, Marzi A, Safronetz D, Robertson SJ, Feldmann H, Best SM. Immunobiology of Ebola and Lassa virus infections. Nat Rev Immunol. 17(3):195-207 (2017)

Glossary

A

Acquired immunity: immunity that develops during a person's lifetime.

Adjuvant: a substance added to its formulation to enhance or modify the immune response to the components of the vaccine.

Adverse event: an unexpected medical problem experienced by an individual in a clinical trial. The term is used whether the effect can be attributed to the vaccine under study or something else happening during the study.

Adverse reaction (also known as adverse event or side effect): in a clinical trial, an unwanted effect detected in participants and attributed to the study vaccine.

AIDS (acquired immunodeficiency syndrome): the most advanced stage of HIV infection, characterised by a deterioration of the immune system and a susceptibility to a range of opportunistic infections and cancers.

Antibody: a protein found in the blood or bodily fluids that binds, neutralises, and helps destroy pathogens (e.g., bacteria, viruses) or toxins. Antibodies are also known as immunoglobulins. Each antibody binds specifically to the antigen that stimulated its production.

Antibody-mediated immunity: immunity that results from the activity of antibodies. Also called humoral immunity.

Antigen: any substance that stimulates the immune system to trigger an immune response.

Antigen-presenting cell (APC): B cell, macrophage, dendritic cell or other cells that ingest and process pathogens such as bacteria and viruses. An APC displays fragments of the pathogen on its surface to attract and activate the cells of the immune system that respond specifically to that antigen (see also dendritic cell; macrophage).

Antiretrovirals: drugs that reduce the ability of HIV or other types of viruses to multiply in the body.

Apoptosis: cellular suicide. A possible mechanism used by HIV to destroy cells of the immune system. HIV may cause apoptosis in both HIV-infected and HIV-uninfected immune system cells. Also known as programmed cell death.

Arm: a group of participants in a clinical trial, all of whom receive the same treatment, intervention, or placebo.

Attenuated: weakened. Attenuated viruses are often used as vaccines because they can no longer produce disease but still stimulate a strong immune response, similar to that caused by the natural virus.

B

B lymphocyte (B cell): one of the two major classes of lymphocytes, B lymphocytes are white blood cells of the immune system that are derived from the bone marrow and spleen. B cells develop into plasma cells, which produce antibodies.

Baseline: the time point in a study just before initiation of an intervention (for example vaccination). Measurements taken at later time points may be compared with those taken at baseline to determine if the intervention makes a difference.

B

Binding antibody: an antibody that attaches to part of a pathogen. Binding antibodies may or may not lead to the killing of the pathogen.

Blinded study: a clinical trial in which participants are unaware as to whether they are in the experimental or control arm of the study. See also double-blind study.

Booster: a vaccine dose given after the first dose to increase the immune response to the vaccine antigen(s). A booster may be given shortly after the first dose or much later. The vaccine given as the booster dose may or may not be the same as the primary vaccine. See also prime-boost.

Breakthrough infection: an infection that occurs during a vaccine trial conducted to prevent that infection. Such an infection is caused by exposure to the infectious agent and may occur before or after the vaccine has taken effect or all doses have been given.

C

CD: abbreviation for 'cluster of differentiation,' referring to molecules at the surface of cells that are used to identify immune cells, for example, CD4+ T cells.

CD4+ T lymphocyte: cell of the immune system that carries a molecule on its surface known as 'cluster of differentiation 4' (CD4). These cells are the primary targets of HIV. Also known as helper T cells, CD4+ T cells help orchestrate the immune response, including antibody responses as well as CTL responses (see also T cell).

CD8+ T lymphocyte: cell of the immune system that carries a molecule on its surface known as 'cluster of differentiation 8' (CD8) (see also cytotoxic T lymphocyte (CTL); T cell).

Cell-mediated immunity (cellular immune response): the immune response coordinated by T cells. This branch of the immune system targets cells infected with microorganisms such as viruses, fungi, and certain bacteria.

Challenge: in vaccine research and development, the deliberate exposure of an immunised animal to the infectious agent. Challenge experiments are never done in human HIV vaccine research.

Circulating recombinant forms (CRFs): HIV made of different subtypes of the virus that have recombined.

Clade: a group of related viruses classified according to their degree of genetic similarity. Also called a subtype or strain.

Cohort: groups of individuals who share one or more characteristics in a research study and who are followed over time. For example, a vaccine trial might include two cohorts, a group at low risk for HIV and a group at higher risk for HIV.

Complement proteins: blood proteins that play an important role in the immune response. Generally, complement proteins amplify the effects of antibodies and inflammation.

Control arm: in vaccine clinical trials, the group of participants that is not given the experimental intervention. The control arm can be given an intervention that is considered effective (the standard of prevention), a placebo, or no intervention. The control group is compared with one or more groups of participants given experimental vaccines to measure any effects of the vaccines tested as well as to measure differences in safety.

C

Core: the section of a virus that contains the genetic information and other proteins needed for a virus to replicate.

Correlates of immunity (correlates of protection): the immune responses a vaccine or natural immunity need to trigger to protect an individual from a certain infection.

Cytokine: a hormone-like protein produced by white blood cells that acts as a messenger between cells. Cytokines can stimulate or inhibit the growth and activity of various immune cells. Cytokines are essential for a coordinated immune response and can also be used as immunologic adjuvants. HIV replication is regulated by a delicate balance among cytokines.

Cytotoxic T lymphocyte (CTL): a type of immune system cell that can destroy cancer cells and cells infected with viruses, fungi, or certain bacteria. Also known as killer T cells.

D

Deletion (genetic): elimination of a gene or portion of a gene. Genetic deletion can occur naturally or in the laboratory.

Dendritic cell: antigen-presenting cell with thread-like tentacles (called dendrites) used to surround antigen, which they present to T cells.

DNA (deoxyribonucleic acid): the double-stranded, helical molecular chain found within the nucleus of each cell. DNA carries the genetic information that encodes proteins and enables cells to reproduce and perform their functions.

Dose-ranging study: a clinical trial in which two or more doses (starting at a lower dose and proceeding to higher doses) of a vaccine are tested against each other to determine which dose works best and has acceptable side effects.

Dose-response relationship: the relationship between the dose of a vaccine and an immune or physiologic response. In vaccine research, a dose-response effect means that as the dose of the vaccine increases, so does the level of the immune response.

Double-blind study: a type of clinical trial in which neither the participants nor the research team know which intervention a specific participant is receiving. This helps prevent bias or expectations from influencing the results of the study.

Data and Safety Monitoring Board (DSMB): a committee of independent clinical research experts who review data while a clinical trial is in progress. The DSMB ensures that participants are not exposed to undue (unacceptable) risk and looks for any differences in effectiveness between the experimental and control groups. The DSMB may review the data in such a way that they know which group received the vaccine and which group did not. This group may also recommend that a trial be modified or stopped if there are safety concerns or if the trial objectives have been achieved or will not be achieved. See futility.

E

Effectiveness: the measurement of how well a vaccine works to reduce infection or disease in the overall population when used in the 'real world.'

Efficacy: the measurement of how well a vaccine works at producing a desired clinical effect in optimal conditions, that is, in clinical trials.

ELISA (enzyme-linked immunoabsorbent assay): a laboratory test to detect the presence of antibodies in the blood or other body fluid.

E

Endpoint: an outcome or event used to objectively measure the effect of a drug or other intervention being studied in a clinical trial. Common endpoints include infection, severe toxicity, relief of symptoms, and improvements in quality of life.

Envelope: outer surface of a virus, also called the coat. Not all viruses have an envelope.

Enzyme: a protein produced by cells to trigger a specific chemical reaction. Enzymes are generally named by adding the ending '-ase' to the name of the substance on which the enzyme acts (for example, the HIV reverse transcriptase converts HIV RNA into viral DNA)

Epidemic: a widespread outbreak of a disease in a large number of individuals over a particular period of time either in a given area or among a specific group of people.

Epidemiology: the study of the characteristics, frequency, and distribution of diseases in human populations.

Epitope: a specific part of an antigen that stimulates specific immune responses.

Experimental arm: in a clinical trial, the group of participants given the intervention being studied. Outcomes in the experimental arm are compared with those in the control arm to determine any differences, for example, in safety and effectiveness.

F

Functional antibody: an antibody that binds to an antigen and has an effect that can be demonstrated in laboratory tests. For example, neutralising antibodies are functional antibodies that inactivate HIV or prevent it from infecting other cells.

Futility: the inability of a clinical trial to achieve its objectives. A clinical trial can be stopped when an interim analysis of the results by the DSMB suggests that it is unlikely to achieve its objective and stopping it can save resources and time that could be used on more promising research.

G

Genetic engineering: the laboratory technique of recombining genes to produce proteins used for drugs and vaccines.

Genome: the complete genetic material of an organism, including all its genes. The genomes of viruses can exist as DNA or RNA.

Glycoprotein (gp): A protein that is coated with carbohydrates (sugars).

H

Healthy participant: someone with no known significant health conditions who participates in research to test a new drug, device, or intervention. Also known as 'Clinical Research Participant.'

Helper T cell: T-cell lymphocyte bearing the CD4 marker. Helper T cells regulate the functions of other cells of the immune response.

Herd immunity: protection from an infectious disease happening when a significant percentage of a population is immune to the infection either through vaccination or immunity developed through previous infection.

Host: a plant or animal harbouring another organism.

Humoral immunity: see antibody-mediated immunity.

Hypothesis: a proposed explanation made based on limited evidence as a starting point for further investigation.

I

Immune complex: an antigen bound to its specific antibody.

Immune deficiency: a breakdown or inability of certain parts of the immune system to function, thus making a person susceptible to diseases that they would not ordinarily develop.

Immunisation: the process of inducing immunity by administering a vaccine.

Immunity: protection provided by the immune system to a specific disease. Immunity may be innate or acquired, partial or complete, specific or nonspecific, long-lasting, or temporary.

Immunocompetent: capable of developing an immune response; possessing a normal immune system.

Immunogen: a substance capable of provoking an immune response. Also called an antigen.

Immunogenicity: the ability of an antigen or vaccine to stimulate immune responses.

Immunoglobulin: a general term for antibody immunotherapy: a treatment that stimulates or modifies the body's immune response.

in vitro: an artificial environment outside a living organism (e.g., in a laboratory) used for the conduct of experimental research.

in vivo: research performed with a living organism, e.g., human or animal studies.

Incidence: the number of individuals who develop a specific disease or experience a specific health-related event during a particular period of time (such as a month or year).

Inclusion/exclusion criteria: factors used to determine whether a person is eligible (inclusion criteria) or not eligible (exclusion criteria) to participate in a clinical trial. Eligibility criteria may include disease type and stage, other medical conditions, previous treatment history, age, and gender.

Informed consent: a process between a person and a researcher to ensure that the person understands all relevant facts associated with their participation in a clinical trial. Participants into a clinical trial are required to sign an informed consent form before joining a clinical trial to show that they understand the risks and benefits of participating in the research. Informed consent includes the right to leave a clinical trial at any point during the study.

Innate immunity: immunity that is present at birth and lasts a person's entire life. Innate immunity is the first response of the body's immune system to a harmful foreign substance or pathogen.

Institutional Review Board (IRB): a committee of medical professionals, statisticians, community advocates, and others that reviews clinical trial protocols before they can be initiated. IRBs ensure that the trial is scientifically sound, ethical, and that the rights and safety of participants are adequately protected.

K

Key populations: groups of people such as sex workers, people who use drugs, prisoners, transgender people, and men who have sex with men that are at higher risk of HIV or TB, in part due to discrimination and social exclusion.

L

Latent TB infection (LTBI): a state of persistent immune response to stimulation by *Mycobacterium tuberculosis* antigens without evidence of active TB.

Live-vector vaccine: a vaccine in which a live pathogen is weakened (attenuated) through chemical or physical processes to produce an immune response without causing the severe effects of the disease.

Lymphadenopathy: enlargement of the lymph nodes in response to regional infection or inflammation.

Lymphocyte: a type of white blood cell primarily responsible for immune responses. Present in the blood, lymph, and lymphoid tissues. See also B cell and T cell.

Lymphoid tissue: the part of the body that plays an important role in the immune response and helps protect it from infection and pathogens. Lymphoid tissue is present throughout the body and includes the lymph nodes, spleen, tonsils, adenoids, and other organs.

Lymphomas: types of cancer that begin in the lymphatic system.

M

Macrophage: a large cell of the immune system that can ingest pathogens. Macrophages stimulate other immune cells by presenting them with small pieces of the pathogen. Macrophages also can harbour large quantities of HIV without being killed, acting as reservoirs of the virus.

Memory cell: a subset of T cells and B cells that help the body defend itself against disease by remembering prior exposure to specific pathogens. They can proliferate (recognise the antigen and divide) more readily when the immune system re-encounters the same pathogen.

Monoclonal antibody: a custom-made, identical antibody that recognises only one epitope.

Monocyte: a type of immune cell that is made in the bone marrow and travels through the blood to tissues in the body where it becomes a macrophage or a dendritic cell.

Monovalent vaccine: a vaccine that contains only one antigen.

Mucosal immunity: immune response pertaining to mucous membranes. Mucosal immunity relies on immune cells and antibodies present in the linings of the reproductive tract, gastrointestinal tract, and other moist surfaces of the body exposed to the outside world.

N

Natural killer cell (NK cell): a type of immune cell that can kill tumour cells or cells infected with a virus or bacteria. An NK cell is a type of white blood cell. NK cells are 'natural' killers because they do not need to recognise a specific antigen to attack and kill their target.

Neutralising antibody: an antibody that prevents a virus from infecting a cell in the body, usually by blocking receptors on the cell or the virus itself.

Nosocomial: an infection acquired or occurring in a hospital.

Nucleic acid: an important class of macromolecules found in all cells and viruses. Nucleic acids play an important role in how genetic information is stored and used.

Nucleic acid test (NAT): a laboratory test to detect the genetic material of a microorganism. The viral load (HIV RNA) test is a type of nucleic acid test.

O

Off-label use: the legal use of a prescription drug to treat a disease or condition for which the drug has not already been approved by the regulatory authority.

Open-label trial: a type of clinical study in which both the researchers and the participants are aware of the drug or treatment being given.

Opportunistic infection: an illness caused by an organism that usually does not cause disease in a person with a healthy immune system.

P

Pandemic: An epidemic occurring over a very wide area (several countries or continents) and usually affecting a large proportion of the population.

Parenteral: administered into the bloodstream or by injection.

Pathogen: organisms (e.g., bacteria, viruses, parasites, and fungi) that cause disease in human beings.

Pathogenesis: the origin and development of a disease. More specifically, the way a microbe (bacteria, virus, etc.) causes a disease.

Peptide: a short compound formed by linking two or more amino acids. Peptides that contain many amino acids are called polypeptides or proteins.

Phase I clinical trial: The first step in testing a new vaccine in humans. A Phase I clinical trial tests the safety, side effects, best dose, and timing of a new vaccine.

Phase II clinical trial: These trials measure safety and immunogenicity in a larger group (50–3000) of participants. Here the goal is also to find the best dose and regimen. Phase II trials may last up to two years or longer.

Phase III vaccine trial: A large study that tests the safety and how well a new vaccine works compared with a standard treatment.

Placebo: An inactive substance or other intervention that looks the same as, and is given the same way as, the vaccine being tested.

Plasma: The clear, yellowish, fluid part of the blood that carries the blood cells.

Preclinical: research often using animals to find out if a drug, procedure, or treatment is likely to be useful. Preclinical studies take place before any testing in humans is done.

Prevalence: the total number of individuals in a population who have a disease or health condition at a specific point in time, usually expressed as a percentage of the population.

Prime-boost: in HIV vaccine research, administration of one type of vaccine, such as a live-vector vaccine, followed by or together with a second type of vaccine, such as a recombinant subunit vaccine. The intent of this combination regimen is to induce different types of immune responses and enhance the overall immune response, a result that may not occur if only one type of vaccine were to be given for all doses.

Priming: the first dose of a vaccine given to induce a particular immune response, followed by or together with a second dose of vaccine. The intent of priming is to induce certain immune responses that will be enhanced by the booster dose(s).

Prophylaxis: the prevention of disease.

Protocol: the detailed plan for a clinical trial that states the trial's rationale, purpose, vaccine dosage, routes of administration, length of study, eligibility criteria and other aspects of trial design.

R

Randomised trial: a study in which participants are assigned by chance to one of two or more intervention arms or regimens. Randomisation minimises the differences among groups by equally distributing people with particular characteristics among all the trial arms.

Reactogenicity: physical reactions that occur soon after vaccination and are a physical manifestation of the inflammatory response to vaccination.

Reagent: any chemical used in a laboratory test or experiment.

Receptor: a molecule on the surface of a cell that can recognise and bind to other molecules such as antigens, antibodies.

Recombinant DNA technology: the technique by which genetic material from one organism is inserted into a cell to mass produce proteins.

Regulatory gene: genes that regulate the replication of pathogens.

Reservoir: HIV-infected cells that are not actively producing HIV.

Retrovirus: viruses that carry their genetic material in the form of RNA rather than DNA and have the enzyme reverse transcriptase that can transcribe it into DNA. In turn, this DNA will be used to create viral RNA in the infected cells.

Reverse transcriptase: the enzyme found in retroviruses that enables them to direct a cell to make DNA from their viral RNA.

RNA (ribonucleic acid): one of two types of nucleic acid made by cells. RNA contains information that has been copied from DNA (the other type of nucleic acid). Many forms of RNA have functions related to making proteins.

S

Seroconversion: the production of antibodies against a particular antigen in the blood of a person who did not have the antibodies before. When people develop antibodies, they 'seroconvert' from antibody-negative to antibody-positive (see also VISP).

Serostatus: the state of either having or not having detectable antibodies against a specific antigen, as measured by a blood test (serologic test).

Serum: the clear, yellowish liquid part of blood that remains after clotting. Serum is used for various laboratory tests.

Simian-Human Immunodeficiency Virus (SHIV): a genetically engineered hybrid virus with a human virus envelope and a simian virus core.

Side effect: see adverse reaction.

Simian Immunodeficiency Virus (SIV): a diverse group of viruses that naturally infect a wide range of African monkeys. This infection generally does not result in immunodeficiency in African monkeys, but Asian or Indian rhesus macaques will develop simian AIDS (SAIDS).

Statistical significance: a mathematical measure of difference between groups in a clinical study. The difference is said to be statistically significant if it is greater than what might be expected to happen by chance alone.

Sterilising immunity: an immune response that completely prevents the establishment of an infection.

Strain: a specific version of virus of bacteria. Many diseases, including HIV and Lassa fever virus have multiple strains.

S

Stratification: separation of a study cohort into subgroups or strata according to specific characteristics.

Subtype: a subgroup of genetically related HIV-1 viruses. Also called a clade.

Subunit vaccine: a vaccine that contains only part of the virus or other pathogen which have been specially selected for their ability to stimulate immune cells.

Surrogate marker: substitute measure of a clinical or biological endpoint. For example, CD4 count is a surrogate marker of disease progression.

T

T cell: a type of white blood cell critical to the immune response. Among these are CD4 T cells and CD8 T cells.

Therapeutic HIV vaccine: a vaccine designed to boost the immune response against HIV in a person living with the virus to slow the progression of HIV infection or delay the onset of AIDS.

V

Vaccine: a substance administered to trigger an immune response against a particular disease to prevent an infection.

Vector: a bacteria or virus that does not cause disease in humans and is used in genetically engineered vaccines to transport genes coding for antigens into the body to induce an immune response.

Viral Load (VL): the amount of HIV in a sample of blood. Viral load is reported as the number of HIV RNA copies per millilitre of blood.

Viremia: the presence of virus in the bloodstream.

Virion: a mature infectious virus particle that exists outside of a cell.

Virus: a microorganism that infects cells and may cause disease. To reproduce, a virus must infect a cell and direct its cellular machinery to produce new viruses.

Vaccine-Induced HIV Seropositivity (VISP): antibody induced by vaccination and that can confound the interpretation of HIV diagnostics tests. VISP may have implications in the everyday life of clinical trial participants (for example access to insurance, employment, or immigration).

W

Western blot: a laboratory test to detect antibodies to specific components of a virus such as HIV in the blood.

Window period: the period of time from exposure to HIV to when the body produces enough HIV antibodies to be detected by standard HIV tests.

RESOURCES

- NIH glossary of HIV/AIDS-related terms: *https://clinicalinfo.hiv.gov/en/glossary*
- CDC Vaccines and immunisation glossary: *https://www.cdc.gov/vaccines/terms/glossary.html*

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