

Basic Concepts in Immunology and Components of the Immune System

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Received: 08-04-2026

Accepted: 22-04-2026

Published online: 28-04-2026

DOI: <https://doi.org/10.33687/ricosbiol.04.04.120>

Based on the handout: Abouelhag, H. (2010). Basic immunology, MLT 360: Hand out 2010/2011 [Unpublished course handout].

Supplementary references: Abbas et al., 2022; Murphy, Weaver, & Berg, 2022; Punt et al., 2023; Delves et al., 2023; Huang et al., 2023; Shafiqat et al., 2023; Wang et al., 2024; Nature Portfolio, 2024; Science Immunology, 2025.

Abstract

This chapter introduces the fundamental concepts of immunology, focusing on the relationship between infection and the host immune system. It defines key terms such as infection, pathogenicity, and normal microbiota, and classifies infections by localisation, incidence, etiology, and systematic site. The chapter then distinguishes between the two major branches of the immune system: nonspecific (innate) immunity and specific (adaptive) immunity. The cellular components—including lymphocytes (B cells, T cells, natural killer cells), mononuclear phagocytes, granulocytes, mast cells, and dendritic cells—are described in terms of their origin, maturation, and function. The primary lymphoid organs (bone marrow and thymus) and secondary lymphoid tissues (spleen, lymph nodes, and mucosa-associated lymphoid tissue) are explained as sites of lymphocyte development and antigen encounter. Finally, the physical and mechanical barriers that constitute the first line of defence—skin, mucous membranes, and associated secretions—are reviewed, with special attention to the role of M cells in mucosal immunity. Together, these elements provide the foundation for understanding how the body recognises and defends against microbial invaders while maintaining self-tolerance.

Keywords:

Infection, pathogenicity, normal microbiota, innate immunity, adaptive immunity, B lymphocytes, T lymphocytes, natural killer cells, macrophages, neutrophils, dendritic cells, thymus, bone marrow, spleen, lymph nodes, mucosal-associated lymphoid tissue (MALT), M cells, skin barrier, lysozyme, lactoferrin, first line of defence.

Learning Objectives

After studying this chapter, you should be able to:

1. Define infection, pathogenicity, and the normal microbiota.
2. Distinguish between nonspecific (innate) and specific (adaptive) immunity.
3. List the major cells of the immune system and describe their primary functions.
4. Identify the primary and secondary lymphoid organs and explain their roles.
5. Explain how physical and mechanical barriers contribute to first-line defense, including the role of M cells.

1. Infection and Disease

1.1 Definitions

- **Infection** – an interaction between a host and a microorganism that involves tissue damage (Abouelhag, 2010, p. 4).
- **Pathogenicity** – the ability of a microorganism to produce pathologic changes or disease.
- **Normal microbiota (normal flora)** – the mixture of microorganisms regularly found on skin and mucous membranes; they help prevent colonisation by pathogens (Wang et al., 2024).

1.2 Classification of Infection (Detailed Explanation)

Infections can be classified according to several criteria, each providing clinically useful information about the behaviour, spread, and impact of the infectious agent (Abouelhag, 2010, p. 4). The table below summarises the classification, followed by a detailed explanation of each category.

Basis	Types
Localisation	Local, general (systemic), latent
Incidence	Sporadic, enzootic, epizootic
Etiology	Primary, secondary, mixed
Systematic (site)	Respiratory, urinary tract, etc.

A. Classification by Localisation (Site of Infection within the Body)

This refers to the anatomical distribution of the infection.

- **Local infection** – The microorganism remains confined to a single, well-defined area of the body. Examples include a boil (furuncle) on the skin or a localised abscess. The host’s inflammatory response typically walls off the infection, preventing systemic spread (Murphy et al., 2022).
- **General (systemic) infection** – The microorganism spreads throughout the body via the bloodstream or lymphatic system. Bacteraemia (bacteria in blood) or septicaemia (systemic illness with fever, tachycardia, and petechial haemorrhages) are examples (Abouelhag, 2010, p. 5). Systemic infections often produce generalised signs such as fever, malaise, and lymphadenopathy.
- **Latent infection** – The microorganism remains dormant within the host for a prolonged period without producing detectable signs of disease. However, the immune system may still produce antibodies that can be detected by serological tests (Abouelhag, 2010, p. 4). Examples include herpesviruses (e.g., varicella-zoster virus) and *Mycobacterium tuberculosis*. Reactivation can occur when host immunity is compromised (Punt et al., 2023).

B. Classification by Incidence (Frequency and Pattern in a Population)

This classification describes how often and in what pattern an infection occurs within a host population.

- **Sporadic infection** – Isolated cases occur irregularly and unpredictably, with no clear pattern. For example, a single case of tetanus in a community is considered sporadic (Abouelhag, 2010, p. 4).
- **Enzootic infection** – A disease that recurs regularly (endemic) in a particular animal host population within a defined geographic area. For example, Lyme disease is enzootic in certain rodent and tick populations. The term is analogous to “endemic” in human epidemiology (Abbas et al., 2022).
- **Epizootic infection** – A disease suddenly affects a large number of animals in a population over a short period, then rapidly declines. This is analogous to an “epidemic” in humans. Examples include avian influenza outbreaks in poultry (Abouelhag, 2010, p. 4; Delves et al., 2023).

C. Classification by Etiology (Cause or Sequence of Infection)

This classification is based on the cause or the order in which different microorganisms contribute to disease.

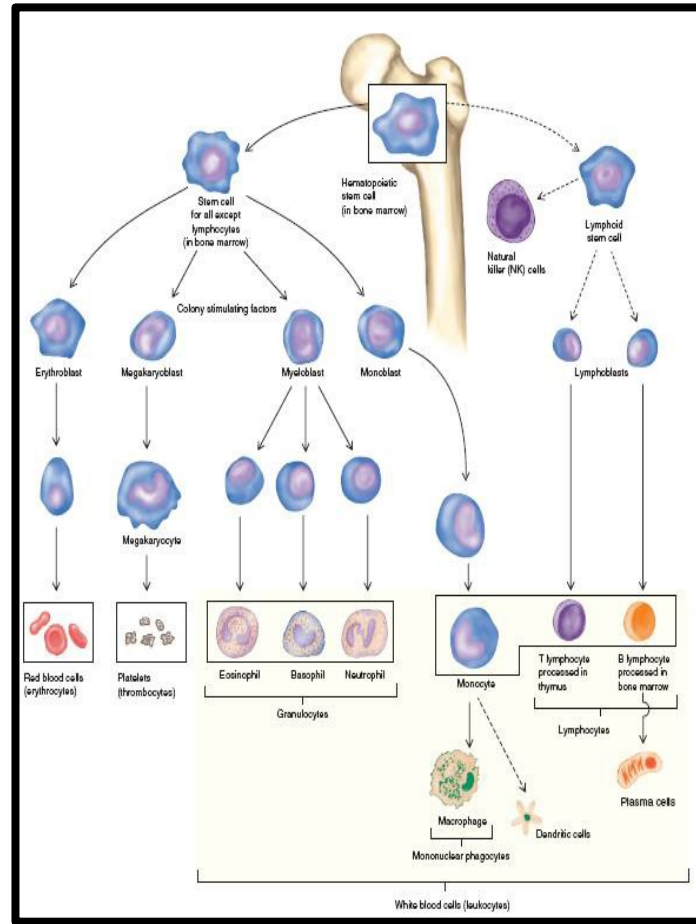
- **Primary infection** – Caused by a single species of microorganism that initiates the disease process. For example, infection with *Mycobacterium tuberculosis* causing primary tuberculosis (Abouelhag, 2010, p. 4).
- **Secondary infection** – Occurs when a primary infection weakens the host’s defences, allowing a different microorganism to cause an additional infection. For example, viral influenza (primary) may be followed by bacterial pneumonia caused by *Streptococcus pneumoniae* or *Staphylococcus aureus* (Abouelhag, 2010, p. 4).
- **Mixed infection** – Caused by more than one microorganism simultaneously, making diagnosis and treatment more difficult. For example, certain types of pneumonia may involve both bacteria and viruses, or a wound infection may contain multiple bacterial species (Abouelhag, 2010, p. 4; Wang et al., 2024).

D. Classification by Systematic Site (Anatomical System Affected)

This classification is based on the organ system involved. It is the most common clinical classification and guides both diagnosis and treatment.

3. Cells of the Immune System

All leukocytes originate from **pluripotent haematopoietic stem cells** in fetal liver and bone marrow.



3.1 Lymphoid Cells (Major cells of specific immunity)

Cell Type	Maturation Site	Main Function
B cells	Bone marrow	Produce antibodies (plasma cells); present antigens
T cells	Thymus	Helper T cells (CD4+), cytotoxic T cells (CD8+), regulatory T cells
Natural Killer (NK) cells	Bone marrow	Kill virus-infected cells and tumour cells

(Abbas et al., 2022)

3.2 Mononuclear Phagocytes

- **Monocytes** – circulate in blood, then migrate into tissues and mature into macrophages.

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