Lines of Barriers Against Pathogens

Based on Advanced Immunology Foundations

ZHAO WENYING

June 17, 2026

1 Introduction to Host Defense Strategies

The human body adopts three primary strategies to handle the threats posed by infectious microbes: **avoidance**, **resistance**, and **tolerance**. Avoidance mechanisms prevent exposure to microbes entirely, resistance aims to reduce or eliminate established pathogens via immune mediators, and tolerance enhances tissue capacity to withstand damage without directly attacking the microbe.

Levels of Defense Against Pathogens

Protection against pathogens relies on multiple sequential layers of defense. If the initial physical and chemical barriers are breached, cellular mechanisms of the innate and adaptive immune systems are progressively activated.

1. Anatomic and Physical Barriers (Avoidance Strategy)
   (a) Epithelial Surfaces
   - **Skin** – Forms a continuous, structural outer barrier protecting internal tissues.
   - **Mucosal Surfaces** – Lines respiratory, gastrointestinal, and urogenital tracts to entrap and sweep away potential invaders.

   The skin and mucosal surfaces act as the absolute first line of defense to prevent microbial entry.

2. Chemical and Enzymatic Systems (Immediate Resistance)
   - **Antimicrobial Proteins** – Functions as natural antibiotics produced directly at mucosal surfaces to destroy microbial membranes or inhibit growth.
   - **Complement System** – A network of around 30 different plasma proteins acting together in serum and interstitial tissues. It can target and lyse foreign organisms even without specific antibodies.

3. Cellular and Adaptive Defenses (Induced Responses)
   (a) **Innate Lymphoid and Myeloid Cells**
   - Coordinate rapid, cell-mediated defenses immediately near breached epithelia.

(b) **Adaptive Immune System**

- Slower-acting but highly specific defenses brought to bear if pathogens overcome all preceding innate barriers.

[a]

[a]Concepts adapted from classic immunological defense frameworks detailing epithelial barrier functions and immediate serum effector mechanisms.

The Triad of Host Immunity Strategies

Understanding how a host survives microbial threats requires distinguishing between how the body manages exposure, clearance, and tissue damage.

1. Structural Framework

- **Avoidance** – Anatomic barriers and behavioral modifications.
- **Resistance** – Effector mechanisms/mediators designed to eliminate microbes.
- **Tolerance** – Capacity enhancement to resist pathogen-induced damage.
- **Immunological Tolerance** – Distinct from tissue tolerance; prevents self-reactive immune responses.
- **Effector Mechanisms** – Molecular and cellular actions suited to resist distinct pathogen categories.

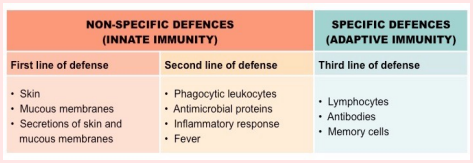


Image Placeholder: Interaction between Avoidance, Resistance, and Tolerance.

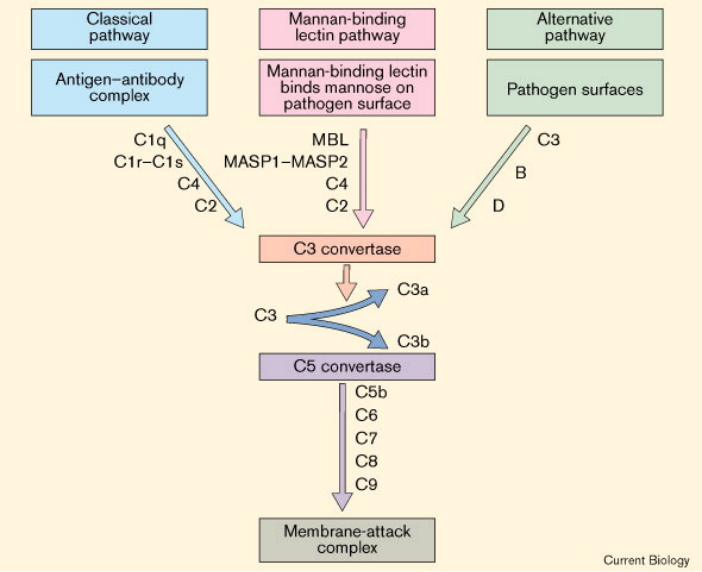
When structural physical barriers fail, chemical components such as the complement cascade provide an immediate bridge between innate resistance and adaptive responses.

Table 1: Comparison between Immune Barrier Strategies

	Anatomic/Chemical Barriers	Induced Cellular Responses
Speed of Action	Immediate, constitutive barrier	Delayed (hours for innate, days for adaptive)
Primary Components	Skin, mucosa, antimicrobial proteins, complement	Myeloid cells, lymphoid cells, antibodies
Mechanism of Action	Physical exclusion and chemical lysis/inhibition	Phagocytosis, cytotoxicity, and targeted memory responses
Primary Strategy	Avoidance and immediate localized resistance	Systemic resistance and clearance

More about Complement System

Discovered natively alongside antibodies, the complement system consists of roughly 30 distinct soluble plasma proteins. It operates as one of the most vital effector cascades within extracellular fluids, functioning natively in both innate and adaptive immunity to clear pathogens via direct lysis, opsonisation, or inflammation recruitment.



For a deeper dive into fluid-phase immunity, refer to classic texts on serum effector mechanisms.