Organisms must constantly protect themselves from harm caused by invaders such as bacterial and viral pathogens. The immune system delivers this protection via numerous pathways, but this can broadly be broken down into two arms, innate immunity and adaptive immunity.

Immunity definition

Immunity is defined as an organism's ability to protect itself from anything it does not recognize as self, such as a pathogen or toxin.

How does the immune system tell self from non-self?

In humans, all nucleated cells express distinctive surface molecules called **major histocompatibility complex class I (MHC class I)** that identify them as being self. Anything that does not possess these "self-tags" may be recognized by the immune system as foreign and targeted. Anything that triggers the immune system is called an **antigen**.

What is innate immunity?

Innate immunity, also known as genetic or natural immunity, is immunity that an organism is born with. This type of immunity is written in one's genes, offering lifelong protection. It is considered the more evolutionarily primitive immune system and consequently, as well as being found in vertebrates, is also found in various shapes and forms in plants, fungi and insects. The innate immune response is fast-acting and non-specific, meaning it does not respond differently based on the specific invader that it detects.

In humans, the innate immune system encompasses physical and chemical barriers, that provide a first line of defense, and chemical (humoral) and cellular aspects as the second line of defense.

- **Physical and chemical barriers** protect the body from invasion and include things like the skin and eyelashes, while substances at these barriers, such as tears, mucous, blood clotting factors and stomach acid help to stop and destroy them.
- **Chemical defenses** consist of proteins able to interact directly or indirectly with invaders, activating cascades of reactions to cause inflammation and recruit further immune mediators that help to defend the body. Examples include the complement system, interferons and interleukin-1.
- **Cellular defenses** identify things that are non-self, take steps to neutralize or destroy them and activate the adaptive immune system. Examples include phagocytes, natural killer cells and mast cells.

The path taken will depend upon whether the threat is **intracellular**, such as a virus, or **extracellular**, such as a bacterium. Invaders may be recognized by the innate immune system if the host MHC-class I molecules that indicate it as self are absent, as is the case with natural killer cell surveillance. Alternatively, molecules may be recognized that are common to many pathogens but are absent in the host. These are called **pathogen-associated molecular**

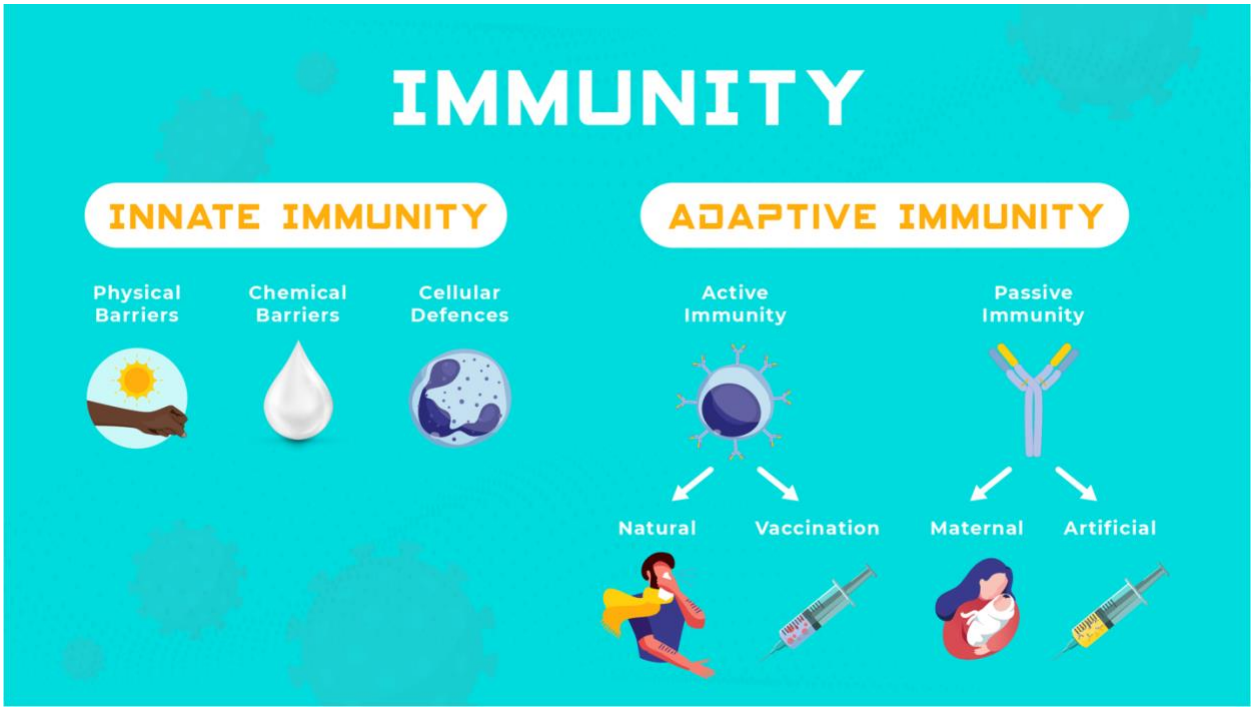
patterns or **PAMPs**, and their recognition promotes their destruction through phagocytosis or cytotoxic killing.

For intracellular threats, **pattern recognition receptors (PRRs)** detect non-self-components, such as viral RNA, DNA, or intermediate products. This leads to the production of pro-inflammatory cytokines, induces apoptosis of infected cells or flags them to be targeted by other innate immune cells for destruction.

Phagocytic cells, such as dendritic cells, are able to chop up the foreign material they engulf and present it on their surfaces which is an important step in activating the adaptive immune response. This has earned them the name, antigen-presenting **cells (APCs)**.

Collectively, the main roles of the innate immune system are to:

1. Prevent the entry of foreign material using physical and chemical barriers.
2. Prevent further spread of infection through humoral mediators such as the complement cascade.
3. Remove non-self via phagocytosis (e.g., macrophages or neutrophils) or cytotoxic means.
4. Activate the adaptive immune system through signaling cytokines and antigen presentation.



What is adaptive immunity?

Organisms are not born with adaptive immunity and it is not "hard-wired" in their genes like innate immunity. It is acquired during their lifetime as a result of exposure to specific antigens, be that through natural means such as infection or by vaccination. Consequently, it is also known as acquired immunity. An adaptive immune response is much slower than an innate response, taking days or even weeks to develop on first encounter (the primary immune response), but is specific to the antigen(s) present and can retain a long-term "memory" to enable a faster response if it is encountered again in the future. Adaptive immunity does it necessarily last throughout an organism's entire lifespan, especially if it is not regularly re-exposed, although it can.

If the innate immune system alone is insufficient to control a foreign threat, the adaptive immune system is activated via signaling molecules and/or the presentation of antigens by antigen-presenting cells. Professional antigen-presenting cells, such as dendritic cells, have **major histocompatibility complex class II (MHC class II)** molecules on their surface that are involved in the presentation of foreign peptides, helping to ensure appropriate immune activation. The adaptive response consists of the **cell-mediated immune response**, which is executed by T cells, and the **humoral immune response**, which is controlled by activated B cells and antibodies. Clonal expansion of T and B cells that specifically recognize epitopes of the antigens present occurs.

T-cells have diverse functions and may cause direct killing of infected cells or help to stimulate B cells towards antibody production. Once stimulated, naïve B cells differentiate into memory cells and plasma cells. Plasma cells produce and secrete large quantities of antigen-specific antibodies for the remainder of their lifecycle to help neutralize and destroy their target. Memory cells can survive for decades, reactivating in response to the presence of their target antigen to produce antibodies. Consequently, the response to repeated exposures may be faster and more robust.

The above description of adaptive immunity describes active immunity, which is the result of first-hand exposure, infection, or vaccination. Passive immunity.is also a type of adaptive immunity but instead of creating its own antibodies, the organism receives external antibodies that help to protect them. This may be because of transfer from mother to baby through the placenta via breast milk, or by injection to defend against a specific disease.