

Immunology is a branch of [biology](#) and [medicine](#)^[1] that covers the study of [immune systems](#)^[2] in all [organisms](#).

Immunology charts, measures, and contextualizes the [physiological](#) functioning of the immune system in states of both health and diseases; malfunctions of the immune system in immunological disorders (such as [autoimmune diseases](#), [hypersensitivities](#),^[3] [immune deficiency](#),^[4] and [transplant rejection](#)^[5]); and the physical, chemical, and physiological characteristics of the components of the immune system *in vitro*,^[6] *in situ*, and *in vivo*.^[7] Immunology has applications in numerous disciplines of medicine, particularly in the fields of organ transplantation, oncology, rheumatology, virology, bacteriology, parasitology, psychiatry, and dermatology.

The term was coined by Russian biologist [Ilya Ilyich Mechnikov](#),^[8] who advanced studies on immunology and received the Nobel Prize for his work in 1908 with [Paul Ehrlich](#) "in recognition of their work on immunity". He pinned small thorns into starfish larvae and noticed unusual cells surrounding the thorns. This was the active response of the body trying to maintain its integrity. It was Mechnikov who first observed the phenomenon of [phagocytosis](#),^[9] in which the body defends itself against a foreign body. Ehrlich accustomed mice to the poisons ricin and abrin. After feeding them with small but increasing dosages of ricin he ascertained that they had become "ricin-proof". Ehrlich interpreted this as immunization and observed that it was abruptly initiated after a few days and was still in existence after several months.

Prior to the designation of [immunity](#),^[10] from the etymological root *immunis*, which is [Latin](#) for 'exempt', early physicians characterized organs that would later be proven as essential components of the immune system. The important lymphoid organs of the immune system are the [thymus](#),^[11] [bone marrow](#), and chief lymphatic tissues such as [spleen](#), [tonsils](#), [lymph vessels](#), [lymph nodes](#), [adenoids](#), and [liver](#). However, many components of the immune system are [cellular](#) in nature, and not associated with specific organs, but rather embedded or circulating in various [tissues](#) located throughout the body.

Classical immunology

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Classical immunology ties in with the fields of [epidemiology](#) and [medicine](#). It studies the relationship between the body systems, [pathogens](#), and immunity. The earliest written mention of immunity can be traced back to the [plague of Athens](#) in 430 BCE. [Thucydides](#) noted that people who had recovered from a previous bout of the disease could [nurse](#) the sick without contracting the illness a second time.^[12] Many other ancient societies have references to this phenomenon, but it was not until the 19th and 20th centuries before the concept developed into scientific theory.

The study of the molecular and cellular components that comprise the immune system, including their function and interaction, is the central science of immunology. The immune system has been divided into a more primitive [innate immune system](#) and, in [vertebrates](#), an [acquired or adaptive immune system](#). The latter is further divided into [humoral](#) (or [antibody](#)) and [cell-mediated](#) components.^[citation needed]

The immune system has the capability of self and non-self-recognition.^[13] An antigen is a substance that ignites the immune response. The cells involved in recognizing the antigen are Lymphocytes. Once they recognize, they secrete antibodies. Antibodies are proteins that

neutralize the disease-causing microorganisms. Antibodies do not directly kill pathogens, but instead, identify antigens as targets for destruction by other immune cells such as phagocytes or NK cells.

The (antibody) response is defined as the interaction between antibodies and [antigens](#).^[14] Antibodies are specific [proteins](#) released from a certain class of immune cells known as [B lymphocytes](#), while antigens are defined as anything that elicits the generation of antibodies (**antibody generators**). Immunology rests on an understanding of the properties of these two biological entities and the cellular response to both.

It is now getting clear that the immune responses contribute to the development of many common disorders not traditionally viewed as immunologic,^[15] including metabolic, cardiovascular, cancer, and neurodegenerative conditions like Alzheimer's disease. Besides, there are direct implications of the immune system in the infectious diseases (tuberculosis, malaria, hepatitis, pneumonia, dysentery, and helminth infestations) as well. Hence, research in the field of immunology is of prime importance for the advancements in the fields of modern medicine, biomedical research, and biotechnology.

Immunological research continues to become more specialized, pursuing non-classical models of immunity and functions of cells, organs and systems not previously associated with the immune system (Yemeserach 2010).

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Main article: [Immunodiagnostics](#)

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Clinical immunologists also study ways to prevent the immune system's attempts to destroy [allografts](#) ([transplant rejection](#)).^[17]

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When health conditions worsen to emergency status, portions of immune system organs, including the thymus, spleen, bone marrow, lymph nodes, and other lymphatic tissues, can be [surgically](#) excised for examination while patients are still alive.

Theoretical immunology

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Immunology is strongly experimental in everyday practice but is also characterized by an ongoing theoretical attitude. Many theories have been suggested in immunology from the end of the nineteenth century up to the present time. The end of the 19th century and the beginning of the 20th century saw a battle between "cellular" and "humoral" theories of immunity. According to the cellular theory of immunity, represented in particular by [Elie Metchnikoff](#), it was cells – more precisely, phagocytes – that were responsible for immune responses. In contrast, the humoral theory of immunity, held by [Robert Koch](#)^[19] and [Emil von Behring](#),^[20] among others, stated that the active immune agents were soluble components (molecules) found in the organism's "humors" rather than its cells.^{[21][22][23]}

In the mid-1950s, [Macfarlane Burnet](#), inspired by a suggestion made by [Niels Jerne](#),^[24] formulated the [clonal selection theory](#) (CST) of immunity.^[25] On the basis of CST, Burnet developed a theory of how an immune response is triggered according to the self/nonself distinction: "self" constituents (constituents of the body) do not trigger destructive immune

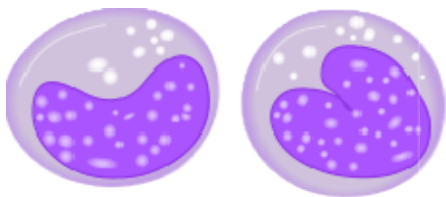
responses, while "nonself" entities (e.g., pathogens, an allograft) trigger a destructive immune response.^[26] The theory was later modified to reflect new discoveries regarding [histocompatibility](#) or the complex "two-signal" activation of T cells.^[27] The self/nonself theory of immunity and the self/nonself vocabulary have been criticized,^{[23][28][29]} but remain very influential.^{[30][31]}

More recently, several theoretical frameworks have been suggested in immunology, including "[autopoietic](#)" views,^[32] "cognitive immune" views,^[33] the "[danger model](#)" (or "danger theory"),^[28] and the "discontinuity" theory.^{[34][35]} The danger model, suggested by [Polly Matzinger](#) and colleagues, has been very influential, arousing many comments and discussions.^{[36][37][38][39]}

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Similarly, the response of T-cells to vaccination differs in children compared to adults, and vaccines that induce Th1 responses in adults do not readily elicit these same responses in neonates.^[41] Between six and nine months after birth, a child's immune system begins to respond more strongly to [glycoproteins](#), but there is usually no marked improvement in their response to [polysaccharides](#) until they are at least one year old. This can be the reason for distinct time frames found in [vaccination schedules](#).^{[43][44]}

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Main articles: [Ecoimmunology](#) and [Behavioral immune system](#)

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More recent ecoimmunological research has focused on host pathogen defences traditionally considered "non-immunological", such as [pathogen avoidance](#), self-medication, [symbiont-mediated](#) defenses, and fecundity trade-offs.^[52] Behavioural immunity, a phrase coined by [Mark Schaller](#), specifically refers to psychological pathogen avoidance drivers, such as [disgust](#) aroused by stimuli encountered around pathogen-infected individuals, such as the smell of [vomit](#).^[53] More broadly, "behavioural" ecological immunity has been demonstrated in multiple species. For example, the [Monarch butterfly](#) often lays its eggs on certain toxic [milkweed](#) species when infected with parasites. These toxins reduce parasite growth in the offspring of the infected Monarch. However, when uninfected Monarch butterflies are forced to feed only on these toxic plants, they suffer a fitness cost as reduced lifespan relative to other uninfected Monarch butterflies.^[54] This indicates that laying eggs on toxic plants is a costly behaviour in Monarchs which has probably evolved to reduce the severity of parasite infection.^[52]

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The preserved immune tissues of extinct species, such as the thylacine (*Thylacine cynocephalus*), can also provide insights into their biology.^[56]

Cancer immunology

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The study of the interaction of the immune system with cancer cells can lead to diagnostic tests and therapies with which to find and fight cancer. The immunology concerned with physiological reaction characteristic of the immune state. Inflammation is an immune response that can be seen in many types of cancers.^[57]

Reproductive immunology

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Main article: [Reproductive immunology](#)

This area of the immunology is devoted to the study of immunological aspects of the reproductive process including [fetus](#) acceptance. The term has also been used by fertility clinics to address fertility problems, recurrent miscarriages, premature deliveries and dangerous complications such as [pre-eclampsia](#).

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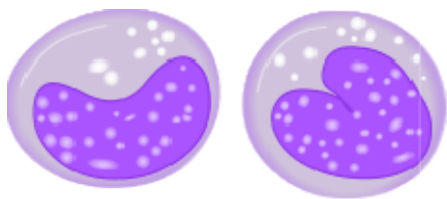
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[\[edit\]](#)

Main article: [Cancer immunology](#)

The study of the interaction of the immune system with cancer cells can lead to diagnostic tests and therapies with which to find and fight cancer. The immunology concerned with physiological reaction characteristic of the immune state. Inflammation is an immune response that can be seen in many types of cancers.^[57]

Reproductive immunology

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Main article: [Reproductive immunology](#)

This area of the immunology is devoted to the study of immunological aspects of the reproductive process including [fetus](#) acceptance. The term has also been used by fertility clinics to address fertility problems, recurrent miscarriages, premature deliveries and dangerous complications such as [pre-eclampsia](#).