EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES

http://www.ejbps.com

ISSN 2349-8870
Volume: 8
Issue: 12
504-508
Year: 2021

IMMUNOBIOLOGY: PRINCIPLES AND HERD IMMUNITY

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Article Received on 21/10/2021 **Article Revised on 11/11/2021** **Article Accepted on 01/12/2021**

ABSTRACT

The immune system has evolved to protect the host from a universe of pathogenic microbes that are themselves constantly evolving. The immune system also helps the host eliminate toxic or allergenic substances that enter through mucosal surfaces. Central to the immune system's ability to mobilize a response to an invading pathogen, toxin or allergen is its ability to distinguish self from non-self. The host uses both innate and adaptive mechanisms to detect and eliminate pathogenic microbes. Both of these mechanisms include self, non-self discrimination. This overview identifies key mechanisms used by the immune system to respond to invading microbes and other exogenous threats and identifies settings in which disturbed immune function exacerbates tissue injury.

KEYWORDS: Toxic, Immunity, Antibodies, Pathogens, Reproduction number (R0).

1. INTRODUCTION

We all live in a world where we are affected by both pathogenic and non pathogenic microorganisms. Microorganisms are of a range of varieties consisting of bacteria, viruses, protozoans and fungi. Immunity is the resistance exhibited by host against any foreign antigen. This resistance plays a major role in the prevention of many diseases from microorganisms. The immunity of individual is a powerful force which affects the health of host as well as pathogen evolution.[1] Immune responses are of two major types the acquired and innate immunity. Acquired immunity is the one which we acquire in our entire life span whereas innate is the immunity we represent from birth. Immune system includes all parts of the body that help in recognition of foreign materials. Acquired immunity is mediated through two means that are either cell mediated or mediated through antibodies. The cell mediated immunity is bought up by T-lymphocytes. This immunity is need in chronic infections where organisms survive in phagocytes: viral infection; fungal infections; against the tumors.

It is not surprising, therefore, that the immune system uses a complex array of protective mechanisms to control and usually eliminate these organisms and toxins. Immune system is an organization of cells and molecules with specialized roles in defending against infections.[2] A general feature of the immune system is that these mechanisms rely on detecting structural features of the pathogen or toxin that mark it as distinct from host cells. Such host-pathogen or host-toxin discrimination is essential to permit the host to eliminate the threat without damaging its own tissues. Immune system is eliminating pathological microbes and toxic or allergenic proteins; it must avoid responses that produce excessive damage of self-tissues or that might eliminate beneficial, commensal microbes. Our environment contains a huge range of pathogenic microbes and toxic substances that challenge the host by a very broad selection of pathogenic mechanisms. The mechanisms permitting recognition of microbial, toxic, or allergenic structures can be broken down into two general categories:

i) Hard-wired responses that are encoded by genes in the host's germ line.
ii) Responses that are encoded by gene elements that somatically rearrange to assemble antigen binding molecules with exquisite specificity for individual unique foreign structures.

2. IMMUNOBIOLOGY

The science of immunity and its mediator is known as immunobiology. It is a major branch of science as it helps in knowing deeply how our body responses to various foreign materials and microorganisms. The immune system employs many potent effect or mechanisms that have the ability to destroy a broad range of microbial cells and to clear a broad range of both toxic and allergenic substances. It is critical, therefore, that the immune response is able to avoid unleashing these destructive mechanisms against the mammalian host's own tissues. The ability of the immune response to avoid damaging self-tissues is referred to as self-tolerance. Because failure of self-tolerance underlies the broad class of autoimmune diseases, this process has been extensively studied. It is now clear that mechanisms to avoid reaction against self-antigens are expressed in many parts of both the innate and the adaptive immune response.

3. PRINCIPLE OF ACQUIRED AND INNATE IMMUNITY

Innate immunity is the first line of defense against infectious intruders and also plays an important role in development of sterile infection.[3] It is majorly regulated by the gene we acquire. These include physical barriers, such as epithelial cell layers that express tight cell-cell contacts (tight junctions, cadherin-mediated cell interactions, and others), the secreted mucus layer that overlays the epithelium in the respiratory, gastrointestinal and genitourinary tracts, and the epithelial cilia that sweep away this mucus layer permitting it to be constantly refreshed after it has been contaminated with inhaled or ingested particles. Inflammation and fever are also major factors of innate immunity as they prevent spreading of infection further by acting as barriers and activating immune responses of the body.

3.1 Cellular components of immunity

Different leucocytes are part of this cellular component of immunity which includes T-lymphocytes; B-lymphocytes; neutrophils. The T-lymphocytes are of 4 types comprising of natural killer T lymphocytes, cytotoxic T lymphocytes, memory T lymphocytes and helper T lymphocytes.[4] Mature, circulating leukocytes differentiate from hematopoietic stem cells. Cells of the granulocyte lineage that play prominent immune functions include neutrophils, monocytes, macrophages, eosinophils, basophils, and mast cells figure1.

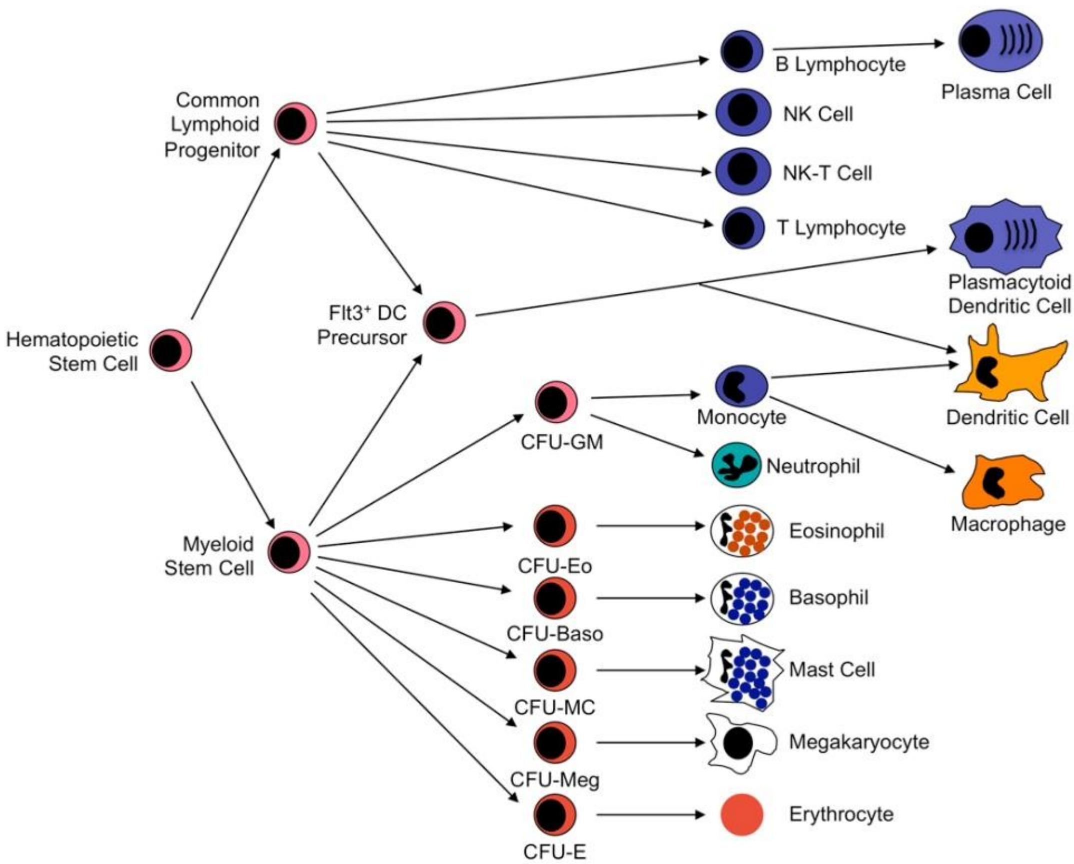

Figure 1: Cell Division.

In some mammals, platelets also release immunologically significant mediators that expand their repertoire beyond their role in hemostasis. Neutrophils accumulate in large quantities at sites of bacterial infection and tissue injury and possess prominent phagocytic capabilities that permit them to destroy foreign material.

A major challenge faced by the immune system is to identify host cells that have been infected by microbes that then use the cell to multiply within the host. Simply recognizing and neutralizing the microbe in its extracellular form does not effectively contain this type of infection. The infected cell that serves as a factory for production of progeny microbes must be identified and destroyed. In fact, if the immune system were equally able to recognize extracellular microbes and microbially infected cells, a microbe that managed to generate large amounts of extracellular organisms or antigen might overwhelm the recognition capacity of the immune system, allowing the infected cells to avoid immune recognition. A major role of the T cell arm of the immune response is to identify and destroy infected cells.

Humoral immunity or antibody mediated immunity is through B-lymphocytes. They are defined by their production of Ig. The antibody consists of 2 light and 2 heavy chains composed in a Y shaped structure binded together by hydrogen bonds. An antibody is a globulin which is seen in serum of an animalafter teir interaction with a foreign substance known as antigen.[5] Antibodies are of five types: IgG; IgE; IgA; IgM; IgD. The major phagocytic cells are neutrophils, macrophages, and monocytes. These cells engulf pathogenic microbes and localize them in intracellular vacuoles were they are exposed to toxic effector molecules such as nitric oxide, superoxide, and degradative enzymes in an effort to destroy the organism. Phagocytic cells use a variety of Fc receptors and complement receptors to enhance uptake of particles that have been marked by the adaptive and innate immune systems for destruction.

4. HERD IMMUNITY

"Herd immunity" has something of the rhythm of nature about it the happily grazing herd, living through the cycles of birth and death, and acquiring immunity along the way. But the term "herd immunity" is typically used in the context of immunity produced through vaccination, and not by letting an infection rip through a population a mode of thinking more appropriate to our genocidal imagination. Herd effect applies to transmission or other health interventions which reduce the probability of transmission confined to transmission infected human to human directly or via vector.[6]

For many infectious agents, the number of individuals in a population (herd) who are (relatively) immune to infection with an infectious agent depends on the proportion who have previously been infected with the infectious agent and the proportion of the remainder who have been immunised with an efficacious vaccine against the agent. A measure of the level of population immunity, or herd-immunity, is the proportion who are thus immune from further infection. For many infections, the level of herd immunity in a population may have an effect on the amount of transmission of the infection within the population and, in particular, may affect the risk of an uninfected becoming infected. For such infections, increasing the level of herd immunity will decrease the risk of an uninfected person becoming infected.[9-10] For some infections this so-called herd effect, or herd protection, may be very important for disease control through vaccination. If the herd effect reduces the risk of infection among the uninfected sufficiently, then the infection may no longer be sustainable within the population and the infection may be eliminated. This concept is important in disease elimination or eradication programmes. It means, for example, that elimination of the infectious agent in a population can be achieved without necessarily vaccinating the entire population.

Infection in naive populations and the basic reproduction number (R0) Imagine a situation in which a person acquires an infection and then migrates to a population in which the infectious agent has never previously circulated, and thus all in the population are susceptible to infection. While the person is infectious and is capable of transmitting the infectious agent to others, he or she will have contact with a number of other persons that is sufficiently "close" to infect them. The number of persons thus infected will depend upon multiple factors, including the nature of the infectious agent and the contact patterns of the infectious person. However, it is possible to conceive of the average number of new transmissions of an infectious agent that will typically occur directly from an infectious person when he or she is newly introduced into the totally susceptible population. This average number is known as the basic reproductive number and is commonly designated symbolically as "R0" the average number of other persons that an infectious person will infect with an agent in a completely susceptible population. R0 will vary between different infectious agents depending on the infectiousness of the agent, which is influenced by factors such as: how long it survives in the environment; the dose necessary for infection; the duration of infectiousness in the host, and whether or not infectiousness precedes infection symptoms. R0 may also vary from population to population depending on factors such as population density, which may affect the number of effective contacts a person has while he/she is infectious. It may also vary with season for some infections, as the ambient conditions may affect the survival of the agent in the environment and the extent to which people have close contact with each other may be different in warmer and colder periods. Infection in populations in which some are immune: indirect protection and the effective reproduction number (R). The indirect protection that may be provided to unvaccinated persons if the level of herd immunity is increased by vaccination is illustrated schematically in figure 2. We consider an "idealised" population in which during the period of infectiousness an infectious person has contact with 4 other persons and with 2 of the 4 the contact is "close" enough for the infection to be transmitted. Herd immunity is the adaptive type of immune response which is considered as a boon in every other disease.

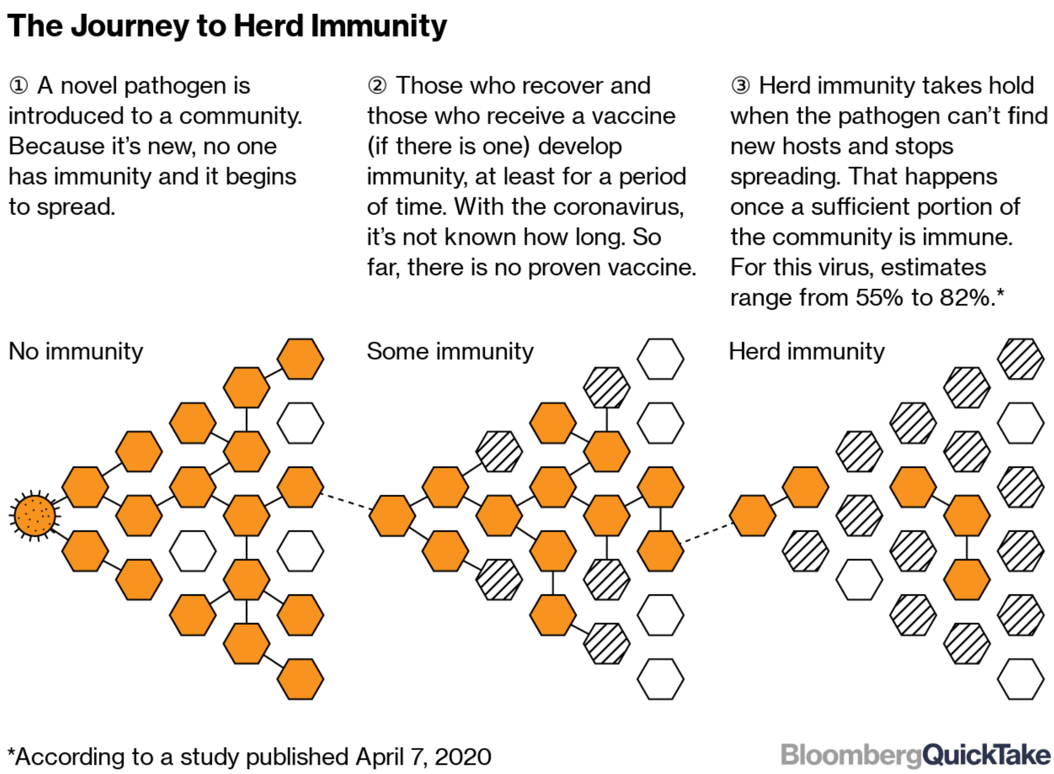

Figure 2: Journey to Herd Immunity.

Measles, mumps, polio, and chickenpox are examples of infectious diseases that were once very common but are now rare in the U.S. because vaccines helped to establish herd immunity. We sometimes see outbreaks of vaccine-preventable diseases in communities with lower vaccine coverage because they don't have herd protection. Herd immunity has to do with the protection of populations from infections which are brought about by the presence of immune individuals.[7] There are two ways to achieve herd immunity: A large proportion of the population either gets infected or gets a protective vaccine. Based on early estimates of this virus's infectiousness, we will likely need at least 70% of the population to be immune to have herd protection. The emergence of (SARS-COV-2) and its associated disease, has demonstrated devastating impact of a novel infectious pathogen on a susceptible population.[8] This herd immunity is majorly needed in COVID-19. Herd immunity can also be reached when a sufficient number of people in the population have recovered from a disease and have developed antibodies against future infection. For example, those who survived the 1918 flu (influenza) pandemic were later immune to infection with the H1N1 flu, a subtype of influenza A. During the 2009-10 flu seasons, H1N1 caused the respiratory infection in humans that was commonly referred to as swine flu. Herd immunity is a statistical concept. It only means that, because a crucial proportion of the herd is immune, the pathogen cannot find sufficient hosts to produce an epidemic. But the biological immunity earned by the once-infected members of the herd the maids and drivers through the production of antibodies, this does not osmotically transfer to the bosses.

CONCLUSION

Immunity means being protected from something and being unaffected or not bothered by it. Let's say you have immunity to heat - this means heat can't bother you whatsoever - walking up to hot molten lava (about 2,000 degrees F) would be no different than walking up to a river. The immune system is spread throughout the body and involves many types of cells, organs, proteins, and tissues. Crucially, it can distinguish our tissue from foreign tissue — self from non-self. Dead and faulty cells are also recognized and cleared away by the immune system. If the immune system encounters a pathogen, for instance, a bacterium, virus, or parasite, it mounts a so-called immune response.

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