11.3D: Pathogen Recognition

Upon pathogen entry to the body, the innate immune system uses several mechanisms to destroy the pathogen and any cells it has infected.

Learning Objectives

• Describe the role of PAMPs and PRRs, interferons, and other cytokines in innate immunity

Key Points

• Pathogens are recognized by a variety of immune cells, such as macrophages and dendritic cells, via pathogen-associated molecular patterns (PAMPs) on the pathogen surface, which interact with complementary pattern-recognition receptors (PRRs) on the immune cells’ surfaces.

• Upon binding of PRRs with PAMPs (pathogen recognition), immune cells release cytokines to tell other cells to start fighting back.

• One class of cytokines, interferons, warn nearby uninfected cells of impending infection, cause cells to start cleaving RNA and reduce protein synthesis, and signal nearby infected cells to undergo apoptosis.

• Another class of cytokines, called interleukins, mediate interactions between white blood cells (leukocytes) and help bridge the innate and adaptive immune responses.

• Inflammation (hot, red, swollen, painful tissue associated with infection) is encouraged by cytokines that are produced immediately upon pathogen recognition; the increase in blood flow associated with inflammation allows more leukocytes (a type of innate immune cell) to reach the infected area.
Key Terms

- **macrophage**: a white blood cell that phagocytizes necrotic cell debris and foreign material, including viruses, bacteria, and tattoo ink; part of the innate immune system
- **phagocytosis**: the process where a cell incorporates a particle by extending pseudopodia and drawing the particle into a vacuole of its cytoplasm
- **cytokine**: any of various small regulatory proteins that regulate the cells of the immune system; they are released upon binding of PRRs to PAMPS

Pathogen recognition

When a pathogen enters the body, cells in the blood and lymph detect the specific pathogen-associated molecular patterns (PAMPs) on the pathogen’s surface. PAMPs are carbohydrate, polypeptide, and nucleic acid “signatures” that are expressed by viruses, bacteria, and parasites, but which differ from molecules on host cells. These PAMPs allow the immune system to recognize “self” from “other” so as not to destroy the host.

The immune system has specific cells with receptors that recognize these PAMPs. A macrophage is a large, phagocytic cell that engulfs foreign particles and pathogens. Macrophages recognize PAMPs via complementary pattern recognition receptors (PRRs). PRRs are molecules on macrophages and dendritic cells which are in contact with the external environment and can thus recognize PAMPs when present. A monocyte, a type of leukocyte (white blood cell) that circulates in the blood and lymph, differentiates into macrophages after it moves into infected tissue. Dendritic cells bind molecular signatures of pathogens, promoting pathogen engulfment and destruction.

Figure: **Blood cells related to the innate immune response**: Cells of the blood include (1) monocytes, (2)
lymphocytes, (3) neutrophils, (4) red blood cells, and (5) platelets. Leukocytes (1, 2, 3) are white blood cells that play an important role in the body’s immune system.

<table>
<thead>
<tr>
<th>Cell type</th>
<th>Characteristics</th>
<th>Location</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mast cell</td>
<td>Elicit blood vessel dilation and mediates inflammation through release of histamines and heparin. Reacts to macrophages and neutrophils involved in wound healing and also be responsible for allergic reactions.</td>
<td>Connective tissues, mucous membranes</td>
<td><img src="https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/11%3A_Immunology/11.02%3A_The%E2%80%A6" alt="Mast cell Image" /></td>
</tr>
<tr>
<td>Macrophage</td>
<td>Phagocytic cell that consumes foreign pathogens and cancer cells. Stimulates response of other immune cells.</td>
<td>Migrates from blood vessels into tissues.</td>
<td><img src="https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/11%3A_Immunology/11.02%3A_The%E2%80%A6" alt="Macrophage Image" /></td>
</tr>
<tr>
<td>Natural killer cell</td>
<td>Kills tumor cells and virus-infected cells.</td>
<td>Circulates in blood and migrates into tissues.</td>
<td><img src="https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/11%3A_Immunology/11.02%3A_The%E2%80%A6" alt="Natural Killer Cell Image" /></td>
</tr>
<tr>
<td>Dendritic cell</td>
<td>Present antigens on surface, thereby triggering adaptive immunity.</td>
<td>Present in epithelial tissues of the digestive tract. Migrates to lymph nodes upon activation.</td>
<td><img src="https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/11%3A_Immunology/11.02%3A_The%E2%80%A6" alt="Dendritic Cell Image" /></td>
</tr>
<tr>
<td>Monocyte</td>
<td>Differentiates into macrophages and dendritic cells in response to inflammation.</td>
<td>Stored in spleen, moves through blood vessels to infected tissues.</td>
<td><img src="https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/11%3A_Immunology/11.02%3A_The%E2%80%A6" alt="Monocyte Image" /></td>
</tr>
<tr>
<td>Neutrophil</td>
<td>First responders at the site of infection or injury. Pre-eminent phagocytic cell represents 60 percent of all leukocytes. Releases toxins that kill or inhibit bacteria and fungi and recruit other immune cells to the site of infection.</td>
<td>Migrates from blood vessels into tissues.</td>
<td><img src="https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/11%3A_Immunology/11.02%3A_The%E2%80%A6" alt="Neutrophil Image" /></td>
</tr>
<tr>
<td>Eosinophil</td>
<td>Responsible for defense against parasites. Releases histamines that cause inflammation and may be responsible for allergic reactions.</td>
<td>Circulates in blood and migrates to tissues.</td>
<td><img src="https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/11%3A_Immunology/11.02%3A_The%E2%80%A6" alt="Eosinophil Image" /></td>
</tr>
<tr>
<td>Basophil</td>
<td>Releases toxins that kill bacteria and parasites but also causes tissue damage.</td>
<td>Circulates in blood and migrates to tissues.</td>
<td><img src="https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/11%3A_Immunology/11.02%3A_The%E2%80%A6" alt="Basophil Image" /></td>
</tr>
</tbody>
</table>

Figure: **Cells involved in the innate immune system**: The immune system has specific cells whose job is to recognize pathogen-associated molecular patterns. The characteristics and location of cells involved in the innate immune system are described in this chart.

Once a pathogen is detected, the immune system must also track whether it is replicating intracellularly (inside the cell, as with most viruses and some bacteria) or extracellularly (outside of the cell, as with other bacteria, but not viruses). The innate immune system must respond accordingly by identifying the extracellular pathogen and/or by identifying host cells that have already been infected.

### Cytokine release affect

The binding of PRRs with PAMPs triggers the release of cytokines, which signal that a pathogen is present and needs to be destroyed along with any infected cells. A cytokine is a chemical messenger that regulates cell differentiation (form and function), proliferation (production), and gene expression to affect immune responses. At least 40 types of cytokines exist in humans that differ in terms of the cell type that produces them, the cell type that responds to them, and the changes they produce.

One subclass of cytokines is the interleukin (IL), which mediates interactions between leukocytes (white blood cells). Interleukins are involved in bridging the innate and adaptive immune responses. In addition to being released from cells...
after PAMP recognition, cytokines are released by the infected cells which bind to nearby uninfected cells, inducing those cells to release cytokines, resulting in a cytokine burst.

A second class of cytokines is interferons, which are released by infected cells as a warning to nearby uninfected cells. A function an interferons is to inhibit viral replication, making them particularly effective against viruses. They also have other important functions, such as tumor surveillance. Interferons work by signaling neighboring uninfected cells to destroy RNA (often a very important biomolecule for viruses) and reduce protein synthesis; signaling neighboring infected cells to undergo apoptosis (programmed cell death); and activating immune cells.

Figure: Interferon release: Interferons are cytokines that are released by a cell infected with a virus. The response of neighboring cells to interferons helps stem the infection.

Cytokines also send feedback to cells of the nervous system to bring about the overall symptoms of feeling sick, which include lethargy, muscle pain, and nausea. These effects may have evolved because the symptoms encourage the individual to rest, preventing them from spreading the infection to others. Cytokines also increase the core body temperature, causing a fever, which causes the liver to withhold iron from the blood. Without iron, certain pathogens (such as some bacteria) are unable to replicate; this is called nutritional immunity.

Phagocytosis and inflammation

The first cytokines to be produced are pro-inflammatory; that is, they encourage inflammation, or the localized redness, swelling (edema), heat, loss of function, and pain that result from the movement of leukocytes and fluid through increasingly-permeable capillaries to a site of infection. The population of leukocytes that arrives at an infection site depends on the nature of the infecting pathogen. Both macrophages and dendritic cells engulf pathogens and cellular debris through phagocytosis. A neutrophil is also a phagocytic leukocyte that engulfs and digests pathogens. Neutrophils, the most-abundant leukocytes of the immune system, have a nucleus with two to five lobes and contain organelles (lysosomes) that digest engulfed pathogens. An eosinophil is a leukocyte that works with other eosinophils to surround a parasite. It is involved in the allergic response and in protection against helminthes (parasitic worms).

Neutrophils and eosinophils are particularly important leukocytes that engulf large pathogens, such as bacteria and
fungi. A mast cell is a leukocyte that produces inflammatory molecules, such as histamine, in response to large pathogens. A basophil is a leukocyte that, like a neutrophil, releases chemicals to stimulate the inflammatory response. Basophils are also involved in allergy and hypersensitivity responses and induce specific types of inflammatory responses. Eosinophils and basophils produce additional inflammatory mediators to recruit more leukocytes. A hypersensitive immune response to harmless antigens, such as in pollen, often involves the release of histamine by basophils and mast cells; this is why many anti-allergy medications are anti-histamines.

Figure: Innate immune response to cuts: In response to a cut, mast cells secrete histamines that cause nearby capillaries to dilate. Neutrophils and monocytes leave the capillaries. Monocytes mature into macrophages. Neutrophils, dendritic cells, and macrophages release chemicals to stimulate the inflammatory response. Neutrophils and macrophages also consume invading bacteria by phagocytosis.

LICENSES AND ATTRIBUTIONS

CC LICENSED CONTENT, SHARED PREVIOUSLY

- Curation and Revision. Provided by: Boundless.com. License: CC BY-SA: Attribution-ShareAlike

CC LICENSED CONTENT, SPECIFIC ATTRIBUTION

- OpenStax College, Biology. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...ol11448/latest. License: CC BY: Attribution
- OpenStax College, Innate Immune Response. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...e_42_01_05.jpg. License: CC BY: Attribution
- OpenStax College, Biology. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...ol11448/latest. License: CC BY: Attribution

https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/11%3A_Immunology/11.02%3A_The…
Updated: Wed, 14 Oct 2020 06:39:09 GMT
Powered by

• OpenStax College, Biology. December 4, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...ol11448/latest. License: CC BY: Attribution


• OpenStax College, Innate Immune Response. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...e_42_01_05.jpg. License: CC BY: Attribution


• OpenStax College, Biology. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...ol11448/latest. License: CC BY: Attribution


• OpenStax College, Innate Immune Response. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...e_42_01_05.jpg. License: CC BY: Attribution


• OpenStax College, Innate Immune Response. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...e_42_01_06.jpg. License: CC BY: Attribution

• OpenStax College, Biology. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...ol11448/latest. License: CC BY: Attribution


• OpenStax College, Innate Immune Response. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...e_42_01_05.jpg. License: CC BY: Attribution


• OpenStax College, Innate Immune Response. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...e_42_01_06.jpg. License: CC BY: Attribution

• OpenStax College, Innate Immune Response. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...e_42_01_04.jpg. License: CC BY: Attribution

• OpenStax College, Innate Immune Response. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...e_42_01_03.jpg. License: CC BY: Attribution

• OpenStax College, Innate Immune Response. October 17, 2013. Provided by: OpenStax CNX. Located at: http://cnx.org/content/m44820/latest...e_42_01_01.jpg. License: CC BY: Attribution