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SECTION 16

IMMUNE DISORDERS

CHAPTER 183

Biology of the Immune System

The immune system is designed to defend the body against foreign or dangerous substances that invade it. Such substances include microorganisms (commonly called germs, such as bacteria, viruses, and fungi), parasites (such as worms), cancer cells, and even transplanted organs and tissues.▲ Substances that stimulate an immune response in the body are called antigens. Antigens may be contained within or on bacteria, viruses, other microorganisms, or cancer cells. Antigens may also exist on their own—for example, as pollen or food molecules. A normal immune response consists of recognizing a foreign antigen, mobilizing forces to defend against it, and attacking it.

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Disorders of the immune system occur

- when the body generates an immune response against itself (an autoimmune disorder)▲
- when the body cannot generate appropriate immune responses against invading microorganisms (an immunodeficiency disorder)■
- when a normal immune response to foreign antigens damages normal tissues (an allergic reaction).★

The first line of defense against invaders is mechanical or physical barriers: the skin; the cornea of the eye; and the membranes lining the respiratory, digestive, urinary, and reproductive tracts. As long as these barriers remain unbroken, many invaders cannot penetrate them. If a barrier is broken—for example, if extensive burns damage much of the skin—the risk of infection is increased. In addition, the barriers are defended by secretions containing enzymes that can destroy bacteria. Examples are tears in the eyes and secretions in the digestive tract and vagina.

The next line of defense involves white blood cells that travel through the bloodstream and into tissues, searching for and attacking microorganisms and other invaders. This defense has two parts. The first part, called nonspecific (innate) immunity, involves several types of white blood cells that usually act on their own to destroy invaders. The second part, called specific (adaptive) immunity, involves white blood cells that work together to destroy invaders. Some of these cells do not directly destroy invaders but enable other white blood cells to recognize and destroy invaders.

Nonspecific immunity and specific immunity interact, influencing each other directly or through substances that attract or activate other cells of the immune system—part of the mobilization step in defense. These substances include cytokines (which are the messengers of the immune system), antibodies, and complement proteins (which form the complement system). These substances are not contained in cells but are dissolved in a body fluid, such as plasma, the liquid part of blood.

To be able to destroy invaders, the immune system must first recognize them. That is, the immune system must be able to distinguish what is nonself (foreign) from what is self. The immune system can make this distinction because all cells have identification molecules on their surface. Microorganisms are recognized because they have unique, foreign identification molecules on their surface. In people, identification molecules are called human leukocyte antigens (HLA), or the major histocompatibility complex (MHC). HLA molecules are called antigens because they can provoke an immune response in another person (normally, they do not provoke an immune response in the person who has them). Each person has unique human leukocyte antigens. A cell with molecules on its surface that are not identical to those on the body's own cells is identified as being foreign. The immune system then attacks that cell. Such a cell may be a microorganism, a cell from transplanted tissue, or one of the body's cells that has been infected by an invading microorganism.

Some white blood cells—B lymphocytes—recognize invaders directly. But others—T lymphocytes—need help from other cells of the immune system—called antigen-presenting cells. These cells ingest an invader and break it into fragments. Antigen fragments from the invader are then "presented" in a way that T lymphocytes can recognize.

The immune system includes several organs in addition to cells dispersed throughout the body. These organs are classified as primary or secondary lymphoid organs. The primary lymphoid organs—the thymus gland and bone marrow—are the sites where white blood cells are produced. In the thymus gland, T lymphocytes—a type of white blood cell—are produced and trained to recognize foreign antigens and ignore the body's own antigens. (T lymphocytes are critical for specific immunity.) The bone marrow produces several types of white blood cells, including neutrophils, monocytes, and B lymphocytes. When needed to defend the body, the white blood cells are mobilized, mainly from the bone marrow. They then move into the bloodstream and travel to wherever they are needed.

The secondary lymphoid organs include the spleen, lymph nodes, tonsils, liver, appendix, and Peyer's patches in the small intestine. These organs trap microorganisms and other foreign substances and provide a place for mature cells of the immune system to collect, interact with each other and with the foreign

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How T Lymphocytes Recognize Antigens

T lymphocytes are part of the immune surveillance system. They travel through the bloodstream and lymphatic system, looking for foreign substances (antigens) in the body. However, a T lymphocyte cannot recognize an antigen unless it has been processed and "presented" to the T lymphocyte by another white blood cell, called an antigen-presenting cell. Antigen-presenting cells consist of dendritic cells (which are the most effective), macrophages, and B lymphocytes.

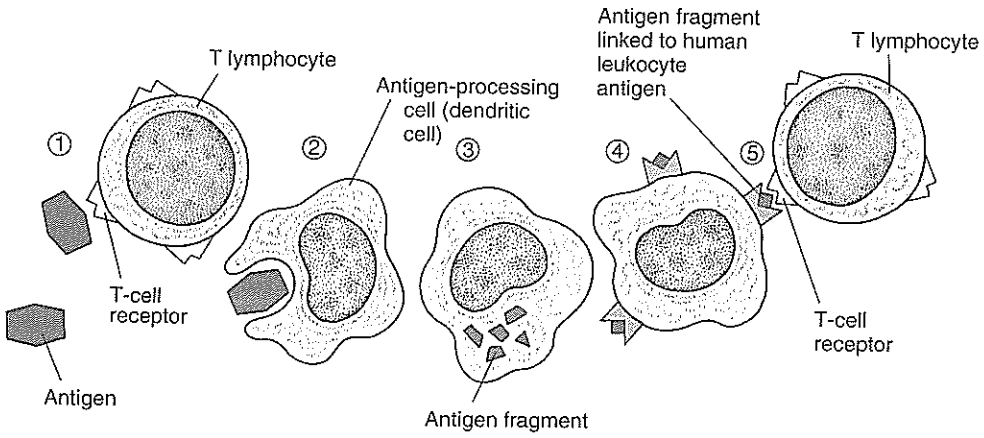
1. By itself, a T lymphocyte cannot recognize an antigen circulating in the body.

2. A cell that can process antigens, such as a dendritic cell, ingests the antigen.

3. Enzymes in the antigen-processing cell break the antigen into fragments.

4. Some antigen fragments are picked up by human leukocyte antigen (HLA) molecules as they are assembled inside the antigen-processing cell. Then the molecules with the antigen fragments are transported to the cell's surface.

5. A special molecule called a T-cell receptor, which is located on the surface of a T lymphocyte, can recognize the antigen fragment when it is attached to and presented by an HLA molecule. The T-cell receptor then attaches to the part of the HLA molecule presenting the antigen fragment, fitting in it as a key fits in a lock.



substances, and generate a specific immune response.

The lymph nodes are strategically placed in the body and are connected by an extensive network of lymphatic vessels, which act as the immune system's circulatory system. The lymphatic system transports microorganisms, other foreign substances, cancer cells, and dead or damaged cells from the tissues to the lymph nodes and then to the bloodstream. Lymph nodes are one of the first places that cancer cells can spread. Thus, doctors often evaluate lymph nodes to determine whether a cancer has spread. Cancer cells in a lymph node can cause the node to swell. Lymph nodes can also swell after an infection, because immune responses to infections are generated in lymph nodes.

Nonspecific Immunity

Nonspecific (innate) immunity is present at birth. Nonspecific immunity is so named because its components treat all foreign substances in much the same way.

The white blood cells involved in nonspecific immunity are monocytes (which develop into macrophages), neutrophils, eosinophils, basophils, and natural killer cells. Each type has a slightly different function. The complement system and cytokines also participate in nonspecific immunity.

Macrophages

Macrophages develop from a type of white blood cell called monocytes after monocytes move from the bloodstream to the tissues.

Understanding the Immune System

Antibody (immunoglobulin): A protein that is produced by B lymphocytes and that interacts with a specific antigen.

Antigen: Any substance that can stimulate an immune response.

Basophil: A white blood cell that releases histamine (a substance involved in allergic reactions) and that produces substances to attract neutrophils and eosinophils to a trouble spot.

Cell: The smallest unit of a living organism, composed of a nucleus and cytoplasm surrounded by a membrane.

Chemotaxis: The process of attracting cells by means of a chemical substance.

Complement system: A group of proteins with various immune functions, such as killing bacteria and other foreign cells, making foreign cells easier for macrophages to identify and ingest, attracting macrophages and neutrophils to a trouble spot, and enhancing the effectiveness of antibodies.

Cytokines: The immune system's messengers, which help regulate an immune response.

Dendritic cell: A white blood cell that usually resides in tissues and that helps T lymphocytes recognize foreign antigens.

Eosinophil: A white blood cell that can ingest bacteria and other foreign cells, that may help immobilize and kill parasites, that participates in allergic reactions, and that helps destroy cancer cells.

Helper T cell: A white blood cell that helps B lymphocytes recognize and produce antibodies against foreign antigens.

Histocompatibility: Literally, compatibility of tissue; determined by human leukocyte antigens (the major histocompatibility complex) and used to determine whether a transplanted tissue or organ will be accepted by the recipient.

Human leukocyte antigens (HLA): A group of molecules that are located on the surface of cells and that are unique in each organism, enabling the body to distinguish self from nonself; also called the major histocompatibility complex.

Immune response: The reaction of the immune system to an antigen.

Immunoglobulin: A synonym for antibody.

Interleukin: A type of cytokine secreted by some white blood cells to affect other white blood cells.

Killer (cytotoxic) T cell: A lymphocyte that attaches to foreign or abnormal cells and kills them.

Leukocyte: A white blood cell, such as a monocyte, a neutrophil, an eosinophil, a basophil, or a lymphocyte.

Lymphocyte: The white blood cell responsible for specific immunity, including producing antibodies (by B lymphocytes) and distinguishing self from nonself (by T lymphocytes).

Macrophage: A large cell that is derived from a white blood cell called a monocyte, that ingests bacteria and other foreign cells, and that helps white blood cells identify microorganisms and other foreign substances.

Major histocompatibility complex (MHC): A synonym for human leukocyte antigens.

Mast cell: A cell in tissues that releases histamine and other substances involved in allergic reactions.

Molecule: A group of atoms chemically combined to form a unique chemical substance.

Natural killer cell: A type of lymphocyte that, unlike other lymphocytes, is formed ready to kill certain microorganisms and cancer cells.

Neutrophil: A white blood cell that ingests and kills bacteria and other foreign cells.

Phagocyte: A cell that ingests and kills invading microorganisms, other cells, and cell fragments.

Phagocytosis: The process of a cell ingesting an invading microorganism, another cell, or a cell fragment.

Receptor: A molecule on a cell's surface or inside the cell that allows only molecules that fit precisely to it—as a key fits in its lock—to attach to it.

Suppressor T cell: A white blood cell that helps end an immune response.

When infection occurs, monocytes leave the bloodstream and move into the tissues. There, over a period of about 8 hours, monocytes enlarge greatly and produce granules within themselves. The granules are filled with enzymes and other substances that help digest bacteria and other foreign cells. Monocytes that have enlarged and contain granules are macrophages. Macrophages stay in the tissues. They ingest bacteria, foreign cells, and dam-