8. IMMUNE SYSTEM

- The immune system is a network of cells, tissues and organs that work together to **defend** the body against attacks by "**foreign" invaders.**
- These are primarily microbes (germs)—tiny, infection-causing organisms such as bacteria, viruses, parasites, and fungi.
- Because the human body provides an ideal environment for many microbes, they try to break in.
- It is the immune system's job to keep them out or, failing that, to seek out and destroy them.
- The secret to its success is an elaborate and dynamic communications network.
- Millions and millions of cells, organized into sets and subsets, gather like clouds of bees swarming around a hive and pass information back and forth.

- Once immune cells receive the alarm, they undergo tactical changes and begin to produce powerful chemicals.
- These substances allow the cells to regulate their own growth and behavior, enlist their fellows, and direct new recruits to trouble spots.

Cytokines

- Components of the immune system communicate with one another by exchanging chemical messengers called cytokines.
- These proteins are secreted by cells and act on other cells to coordinate an appropriate immune response.
- Cytokines include a diverse assortment of interleukins, interferons, and growth factors

The lymphatic system has three main functions:

1. **Fluid balance**.

In addition to water, lymph contains solutes derived from two sources:

(a) substances in plasma, such as ions, nutrients,
gases, and some proteins, which pass from blood capillaries
into the interstitial fluid,

(b) substances derived from cells,
such as hormones, enzymes, and waste products.

2. Lipid absorption.

- The lymphatic system absorbs lipids and other substances from the digestive tract through lymphatic vessels called **lacteals** located in the lining of the small intestine.
- Lipids enter the lacteals and pass through the lymphatic vessels to the venous circulation. The lymph passing through these lymphatic vessels, called **chyle** appears white because of its lipid content.

3. Defense.

- Microorganisms and other foreign substances are filtered from lymph by lymph nodes and from blood by the spleen.
- In addition, lymphocytes and other cells are capable of destroying microorganisms and other foreign substances.

Three major mechanisms are responsible for moving lymph through lymphatic vessels:

1. ***Contraction of lymphatic vessels***. pump lymph. They divide lymphatic vessels into a series of chambers, which function as "primitive hearts."

- smooth muscle cells in the walls of lymphatic vessels are pacemaker cells.
- They spontaneously depolarize, resulting in periodic contraction of the lymphatic vessels.

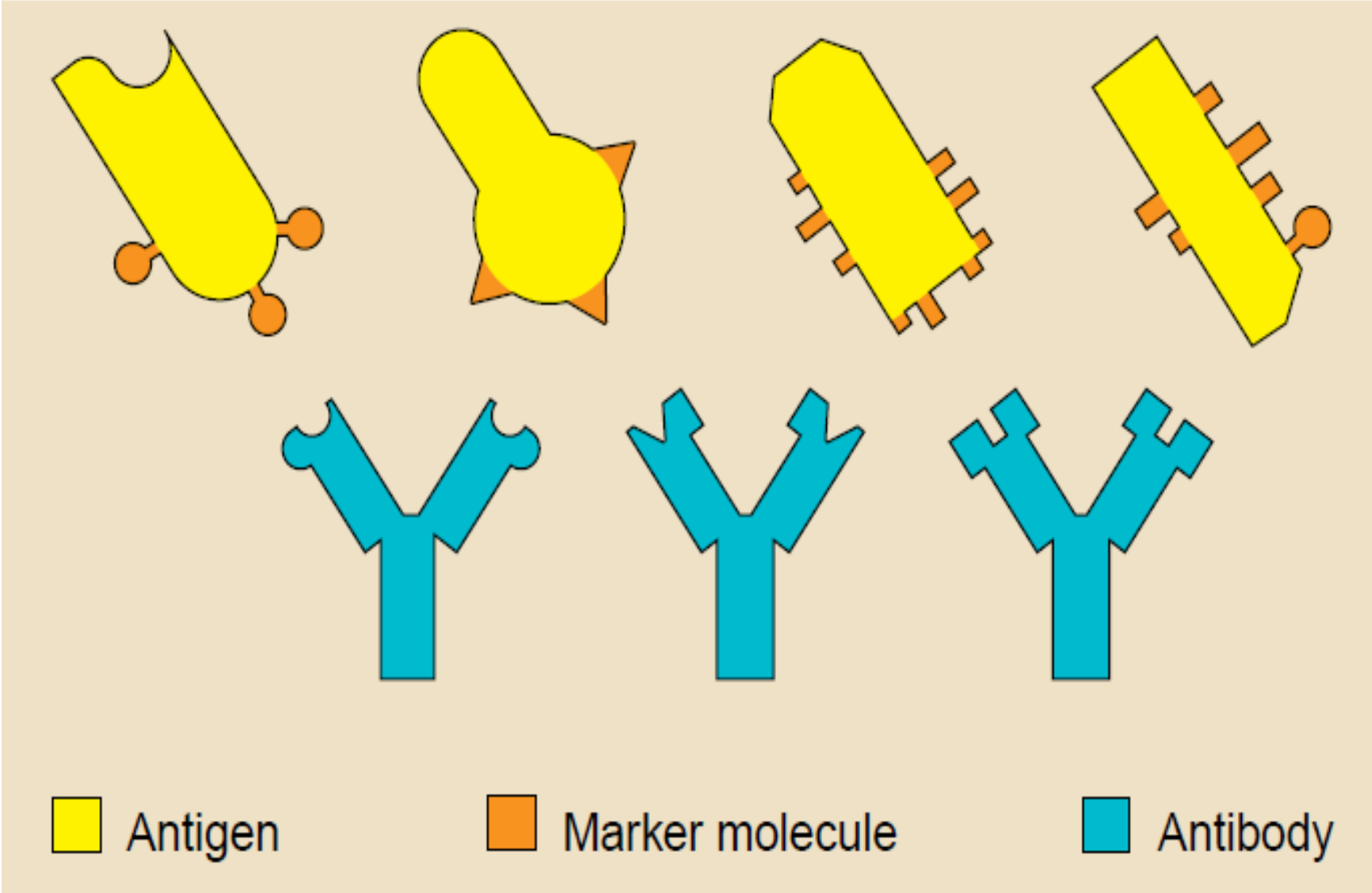
2. ***Contraction of skeletal muscles***. When surrounding muscle cells contract, lymphatic vessels are compressed, causing lymph to move.

3. ***Thoracic pressure changes***. During inspiration, pressure in the thoracic cavity decreases, lymphatic vessels expand, and lymph flows into them.

- During expiration, pressure in the thoracic cavity increases, and lymphatic vessels are compressed, causing lymph to move.

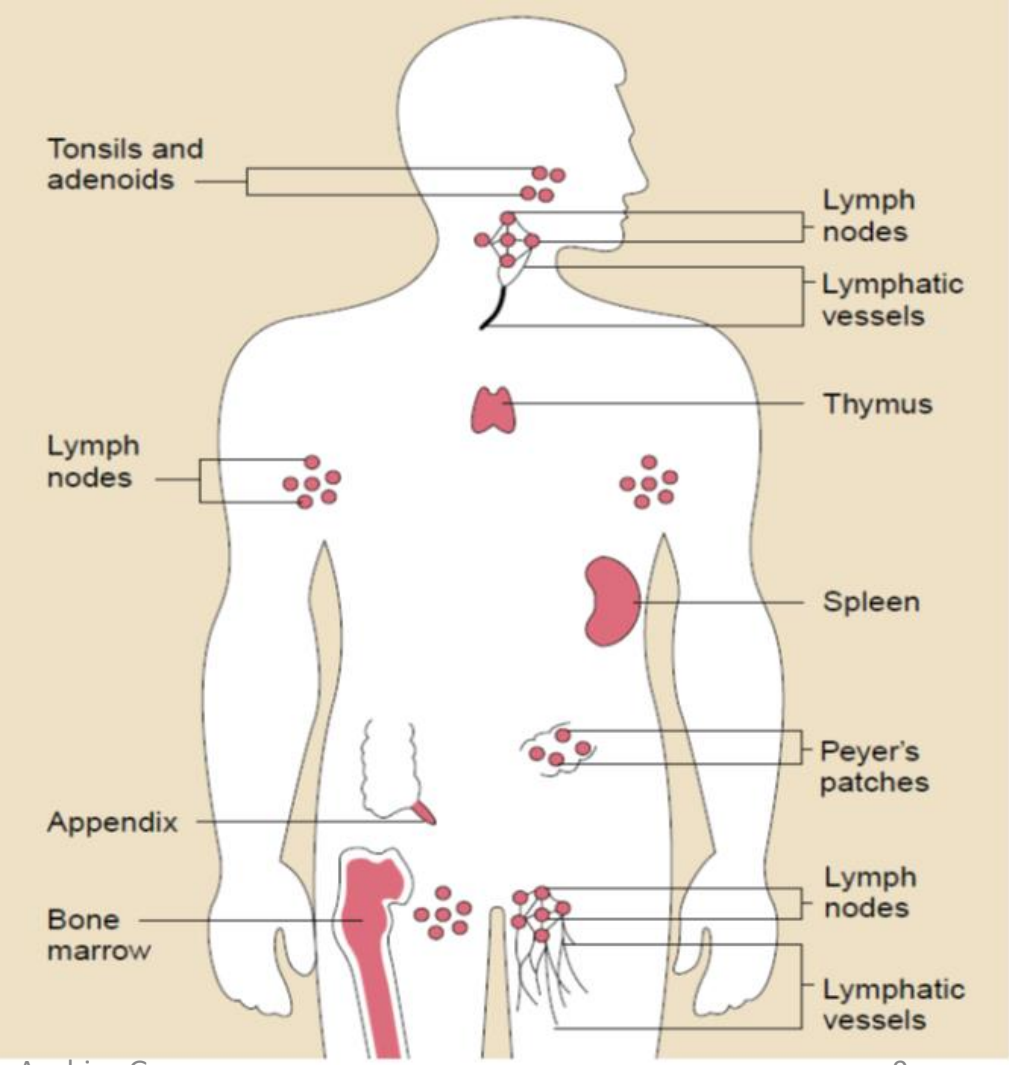
Self and Nonself

- The key to a healthy immune system is its remarkable ability to distinguish between the body's own cells self and foreign cells nonself.
- The body's immune defenses normally coexist peacefully with cells that carry distinctive "self" marker molecules.
- But when immune defenders encounter cells or organisms carrying markers that say "foreign," they quickly launch an attack.
- Anything that can trigger this immune response is called an **antigen**.
- An antigen can be a microbe such as a virus, or even a part of a microbe.
- Tissues or cells from another person (except an identical twin) also carry nonself markers and act as antigens.


Antigen
Marker molecule
Antibody

The Structure of the Immune System

- The organs of the immune system are positioned throughout the body.
- They are called **lymphoid organs** because they are home to lymphocytes
- Small white blood cells that are the key players in the immune system.
- Bone marrow is the ultimate blood cells, including white blood cells destined to become immune cells.



The organs of the immune system are positioned throughout the body.

- The **thymus** is an organ that lies behind the breast bone.
- T lymphocytes or just “T cells,” mature in the thymus.
- The **spleen** is a flattened organ at the upper left of the abdomen.
- Like the lymph nodes, the spleen contains specialized compartments where immune cells gather and work,
- serves as a meeting ground where immune defenses confront antigens

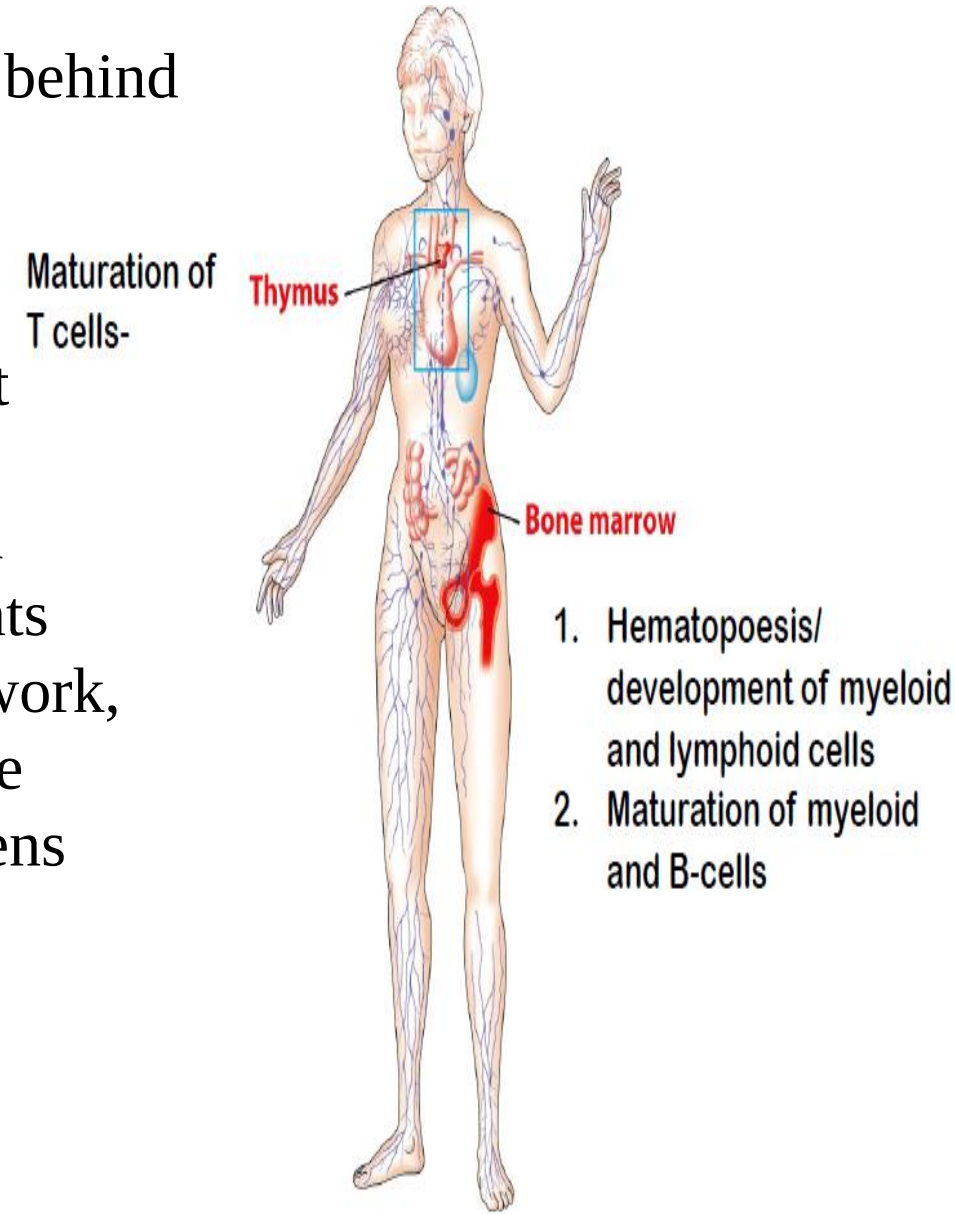
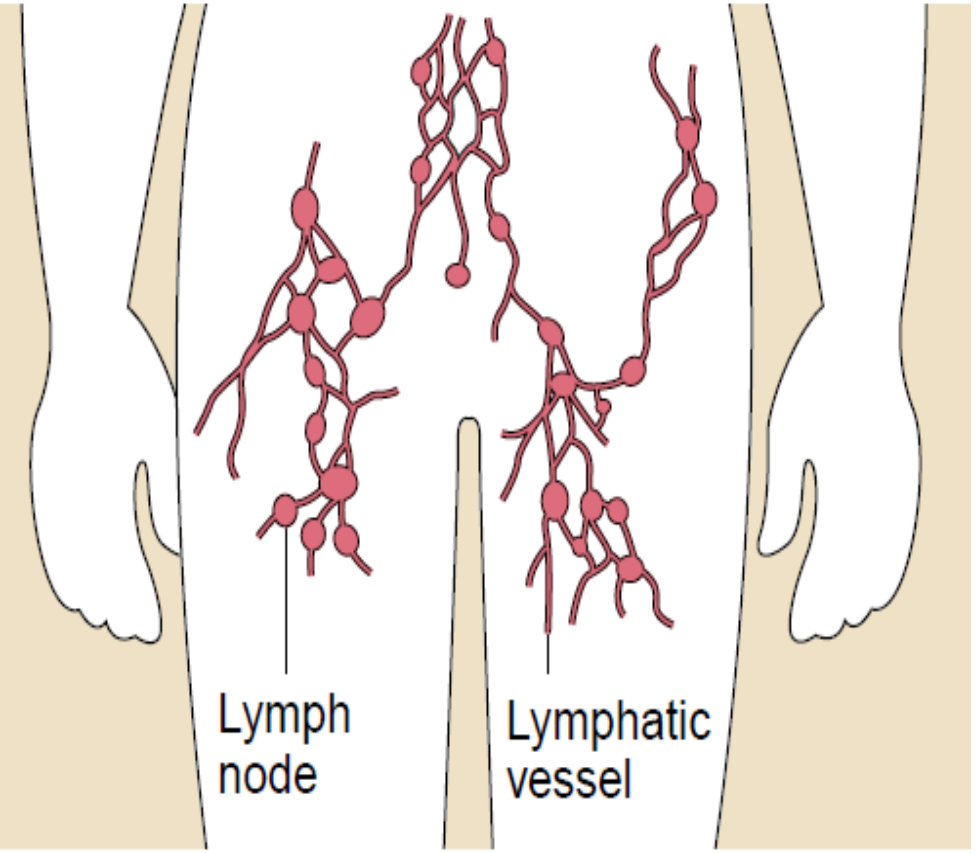


Figure 2-6a
Kuby Immunology, Seventh Edition

- Lymphocytes can travel throughout the body using the blood vessels
- The cells can **also travel** through a system of lymphatic vessels that closely parallels the body's veins and arteries.
- Cells and fluids are exchanged between blood and lymphatic vessels
- enabling the lymphatic system to monitor the body for invading microbes.
- The lymphatic vessels carry **lymph**, a clear fluid that bathes the body's tissues.



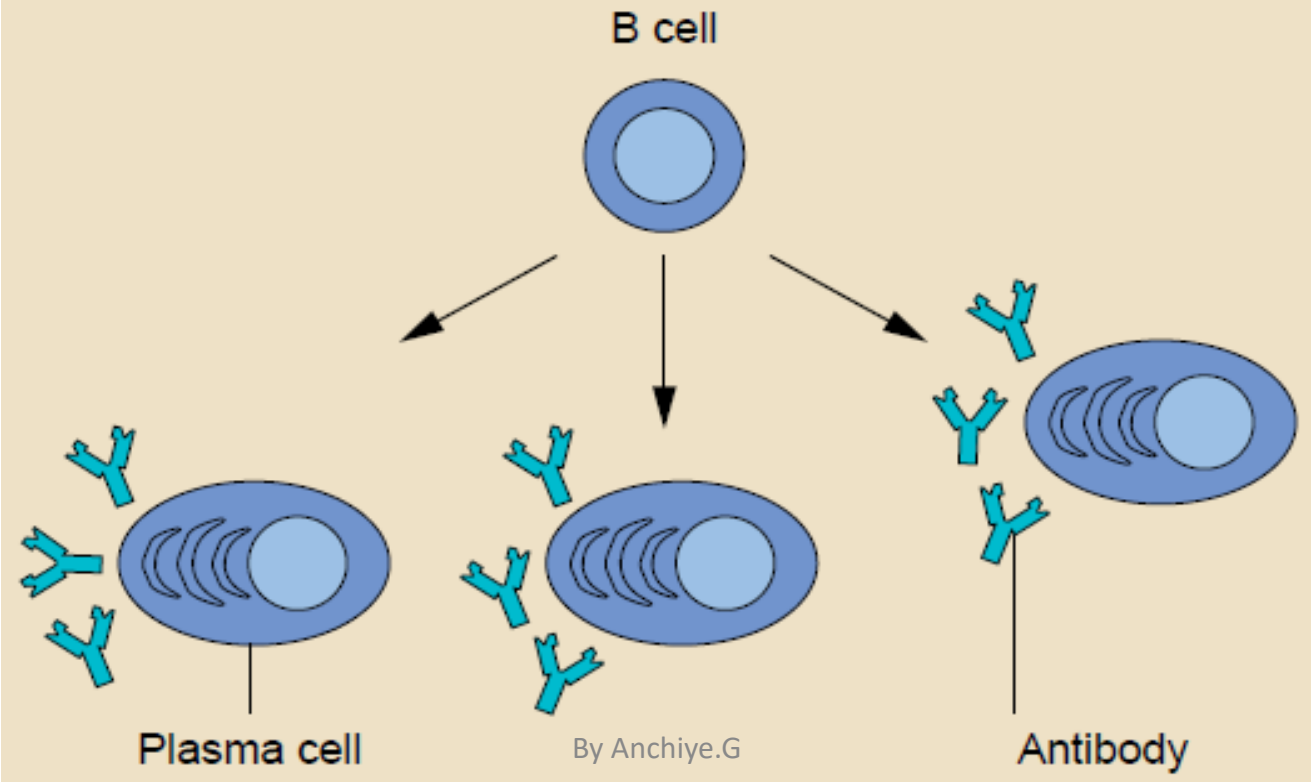
Immune cells and foreign particles enter the lymph nodes via incoming lymphatic vessels or the lymph nodes' tiny blood vessels.

- All immune cells begin as immature stem cells in the bone marrow.
- They respond to different cytokines and other signals to grow into specific immune cell types, such as T cells, B cells or phagocytes.
- Because stem cells have not yet committed to a particular future, they are an interesting possibility for treating some immune system disorders.

B cells and T cells are the main types of lymphocytes.

- **B cells** work chiefly by secreting substances called **antibodies** into the body's fluids.
- Antibodies ambush antigens circulating the bloodstream
- Each B cell is programmed to make one specific antibody

- When a B cell encounters its triggering antigen, it gives rise to many large cells known as **plasma cells**.
- Every plasma cell is essentially a **factory** for producing an antibody.
- Each of the plasma cells descended from a given B cell manufactures millions of identical antibody molecules and pours them into the bloodstream



- Any antigen matches an antibody much as a key matches a lock
- **Antibodies** belong to a family of large molecules known as immunoglobulins.
- Different types play different roles in the immune defense strategy.

• **Immunoglobulin G or IgG**, works efficiently to coat microbes, speeding their uptake by other cells in the immune system.

• **IgM** is very effective at killing bacteria.

• **IgA** concentrates in body fluids tears, saliva, the secretions of the respiratory tract and the digestive tract guarding the entrances to the body.

• **IgE**, whose natural job probably is to protect against parasitic infections, is the villain responsible for the symptoms of allergy.

• **IgD** remains attached to B cells and plays a key role in initiating early B-cell response

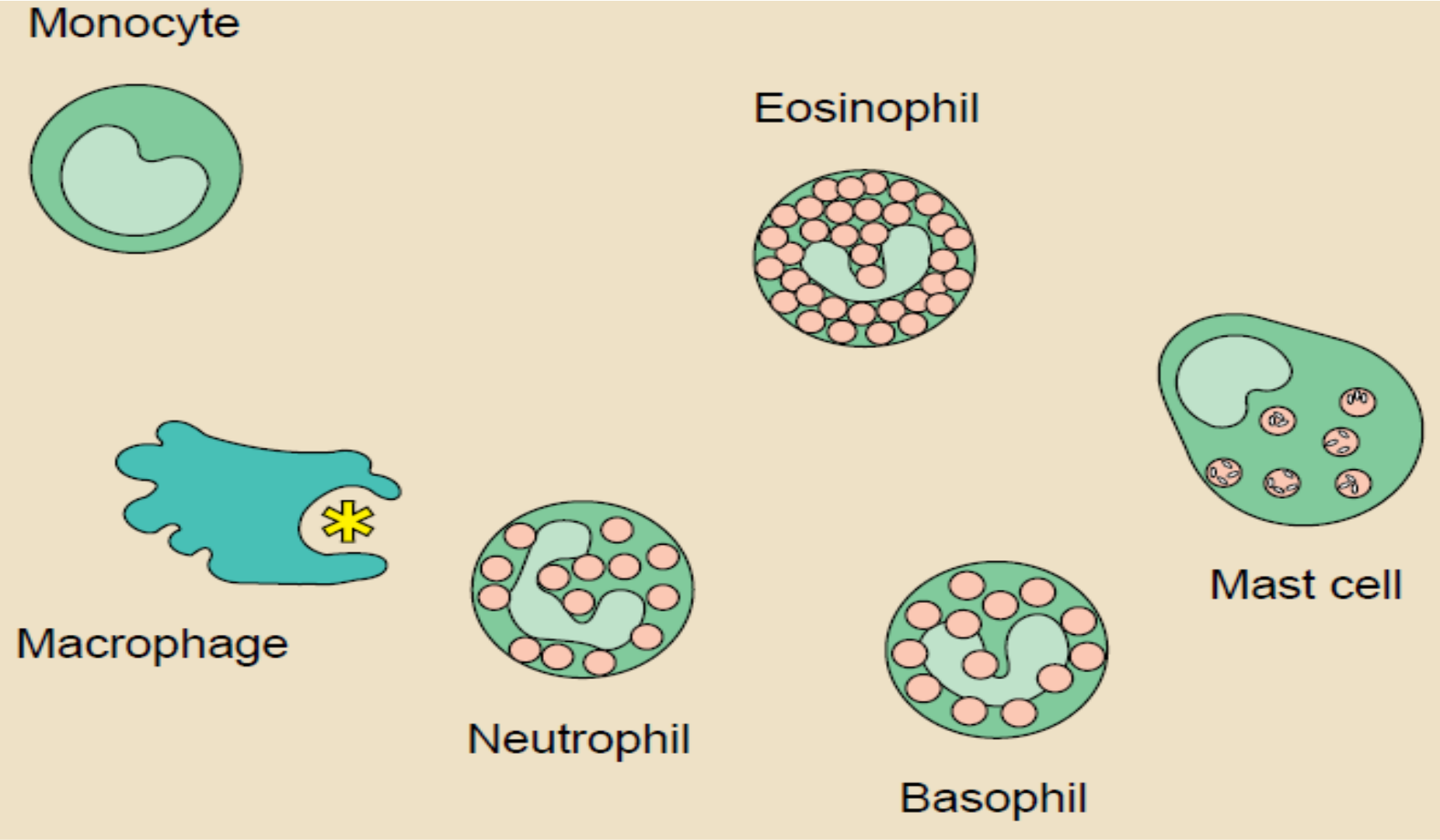
- **T cells** do not recognize free-floating antigens.
- Their surfaces contain specialized antibody-like receptors that see fragments of antigens on the surfaces of infected or cancerous cells.
- T cells contribute to immune defenses in two major ways: some direct and regulate immune responses; others directly attack infected or cancerous cells.
- **Helper T cells** or Th cells, coordinate immune responses by communicating with other cells. Some stimulate nearby B cells to produce antibody, others call in microbe-gobbling cells called phagocytes, still others activate other T cells.

- **Killer T cells** also called cytotoxic T lymphocytes or CTLs perform a different function.
- These cells directly attack other cells carrying certain foreign or abnormal molecules on their surfaces.
- **Natural killer (NK)** cells are another kind of lethal white cell or lymphocyte.
- Like killer T cells, NK cells are armed with granules filled with potent chemicals.
- But while killer T cells look for antigen fragments bound to self-MHC molecules, NK cells recognize cells lacking self-MHC molecules.
- Thus NK cells have the potential to attack many types of foreign cells.
- **MHC (**major histocompatibility complex) **molecules** are required for T-cell responses against foreign invaders
- MHC molecules are proteins recognized by T cells

- Phagocytosis is the endocytosis and destruction of particles by cells called **phagocytes**. The particles can be microorganisms or their parts, foreign substances, or dead cells from the body.
- The most important phagocytic cells are neutrophils and macrophages
- **Neutrophils** are small, phagocytic cells produced in large numbers in red bone marrow and released into the blood, where they circulate for a few hours.
- Approximately 126 billion neutrophils per day leave the blood and pass through the wall of the digestive tract, where they provide phagocytic protection.
- The neutrophils are then eliminated as part of the feces. Neutrophils are usually the first cells to enter infected tissues in large numbers.
- They release chemical signals, such as cytokines and chemotactic factors, that increase the inflammatory response by recruiting and activating other immune cells.
- Neutrophils often die after a single phagocytic event

- **Macrophages** are large phagocytic cells. They are derived from monocytes that leave the blood, enter tissues, enlarge about fivefold, and increase their number of lysosomes and mitochondria.
- Macrophages have longer life spans than neutrophils. In addition, they can ingest more and larger phagocytic particles than neutrophils.
- Macrophages usually accumulate in tissues after neutrophils do, and they are responsible for most of the phagocytic activity in the late stages of an infection, including cleaning up dead neutrophils and other cellular debris.
- In addition to their phagocytic role, macrophages produce a variety of chemicals, such as interferons, prostaglandins, and complement, that enhance the immune response

- **Eosinophils** are produced in red bone marrow, enter the blood, and within a few minutes enter tissues.
  - Eosinophil numbers increase in response to parasitic infections.
  - Eosinophils secrete enzymes that effectively kill some parasites.
  - Also, eosinophil numbers greatly increase in the case of an allergic reaction with much inflammation.
- **Basophils**, which are derived from red bone marrow, are motile white blood cells that can leave the blood and enter infected tissues.
- **Mast cells**, which are also derived from red bone marrow, are nonmotile cells in connective tissue, especially near capillaries.
  - Like macrophages, mast cells are located at points where microorganisms may enter the body, such as the skin, lungs, digestive tract, and urogenital tract.
- **Monocyte** are mononuclear and bean-shaped nucleus
  - Circulate in blood~ 8 hrs and Enter tissues and become fully mature macrophages or dendritic cells



Phagocytes, granulocytes, and mast cells, all with different methods of attack, demonstrate the immune system's versatility.