Lymphoid System
Lec.14
part 1

Histology

Second year

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The lymphoid system

collects excess interstitial fluid into lymphatic capillaries, transports absorbed lipids from the small intestine, and responds immunologically to invading foreign substances.

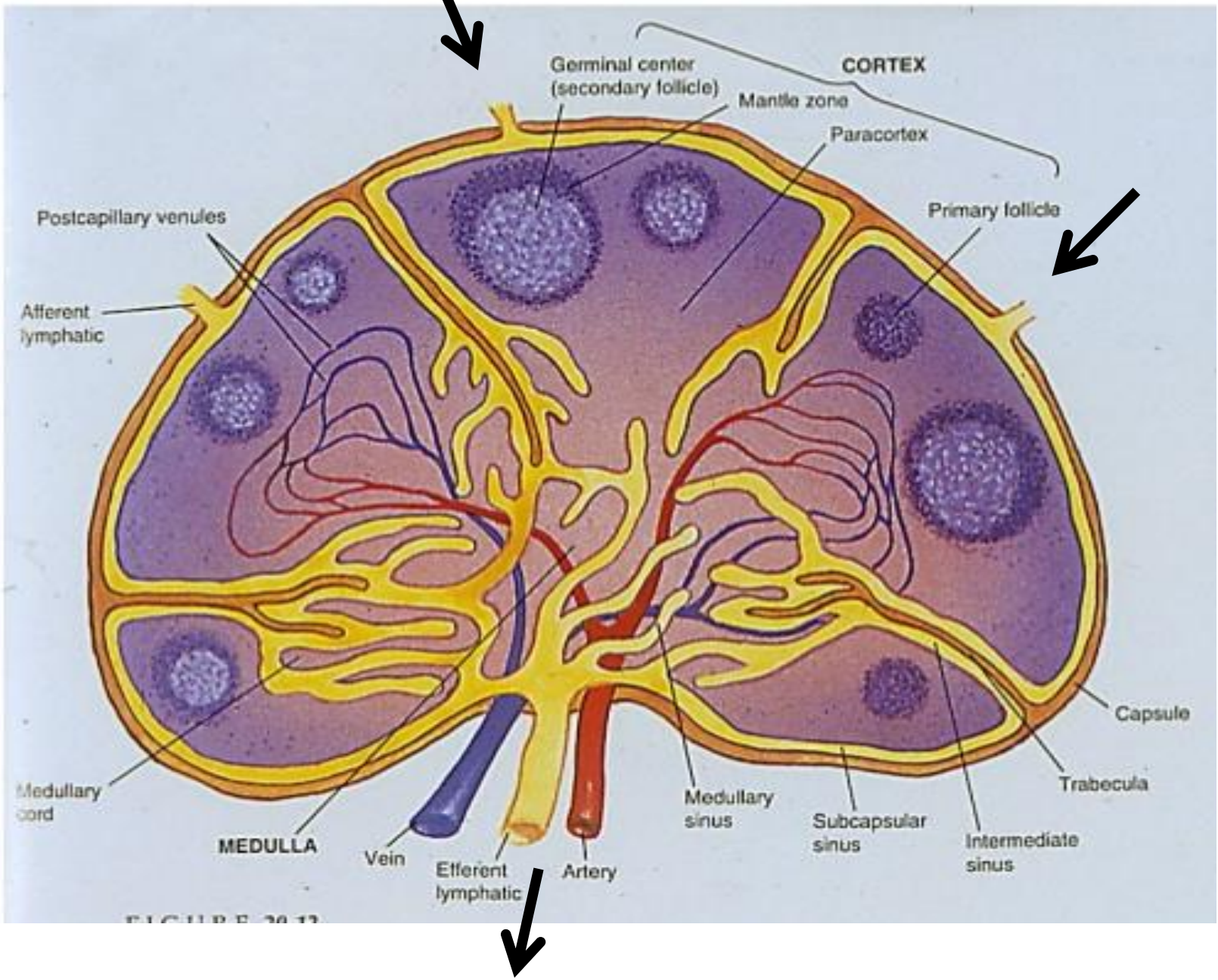
The main function of the lymphoid organs is to protect the organism against invading pathogens or antigens (bacteria, parasites, and viruses). The immune response occurs when the organism detects the pathogens, which can enter the organism at any point. For this reason, lymphatic cells, tissues, and organs have wide distribution in the body.

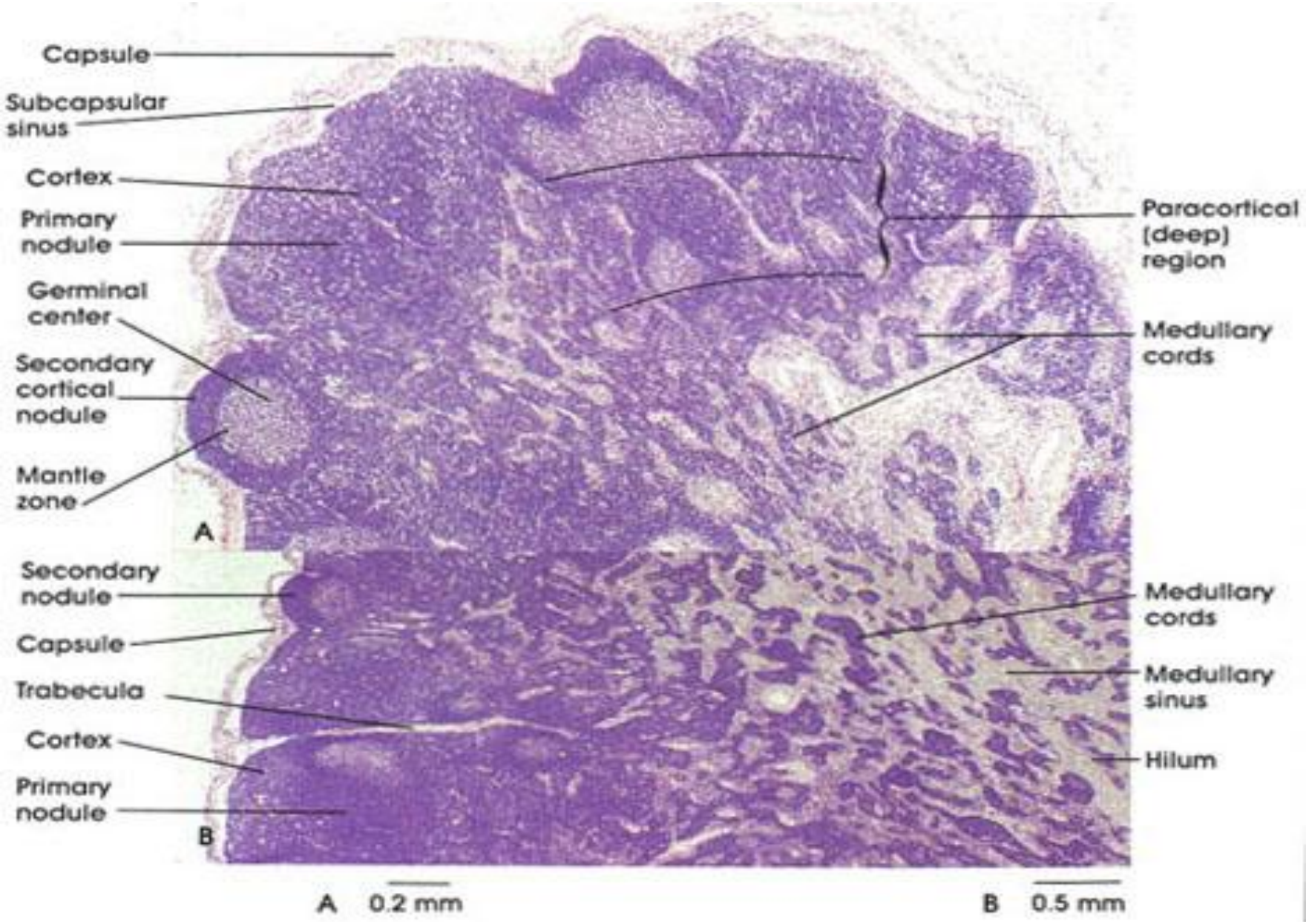
The lymphoid system includes all cells, tissues, and organs in the body that contain aggregates of immune cells called lymphocytes. Cells of the immune system, especially lymphocytes, are distributed throughout the body either as single cells, as isolated accumulations of cells, as distinct non encapsulated lymphatic nodules in the loose connective tissue of **digestive**, **respiratory**, and **reproductive systems**, or as encapsulated individual **lymphoid organs**. The major lymphoid organs are the **lymph nodes, tonsils, thymus, and spleen**. Because bone marrow produces lymphocytes, it is considered a lymphoid organ and part of the lymphoid system.

Lymphoid Organs: Lymph Nodes, Spleen, and Thymus

Lymph Nodes

A connective tissue capsule surrounds the lymph node and sends its trabeculae into its interior. Each lymph node contains an outer cortex and an inner medulla. A network of reticular fibers and spherical, non encapsulated aggregations of lymphocytes called lymphoid nodules characterize the cortex. Some lymphoid nodules exhibit lighter-staining central areas called **germinal centers**. The medulla consists of medullary cords and medullary sinuses. **Medullary cords** are networks of reticular fibers filled with **plasma cells, macrophages**, and **lymphocytes** separated by capillary-like channels called medullary sinuses. Lymph enters the lymph node via afferent lymphatic vessels that penetrate the capsule on the convex surface. Lymph flows through the medullary sinuses and exits the lymph node on the opposite side via the efferent lymphatic vessels .

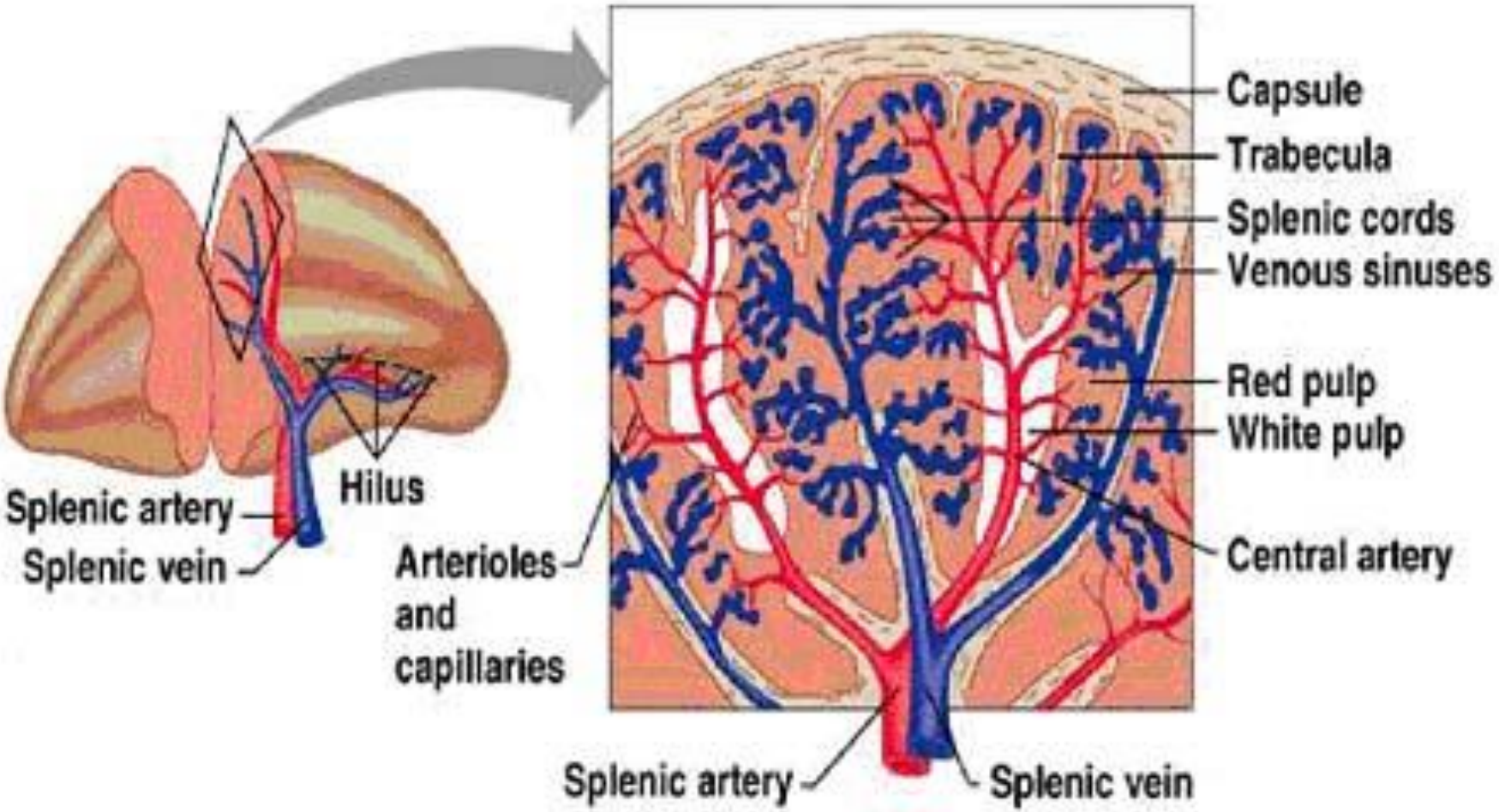

Germinal center
(secondary follicle)
CORTEX
Mantle zone
Paracortex
Postcapillary venules
Primary follicle
Afferent
lymphatic
Capsule
Trabecula
Medullary
cord
MEDULLA
Vein
Efferent
lymphatic
Artery
Medullary
sinus
Subcapsular
sinus
Intermediate
sinus

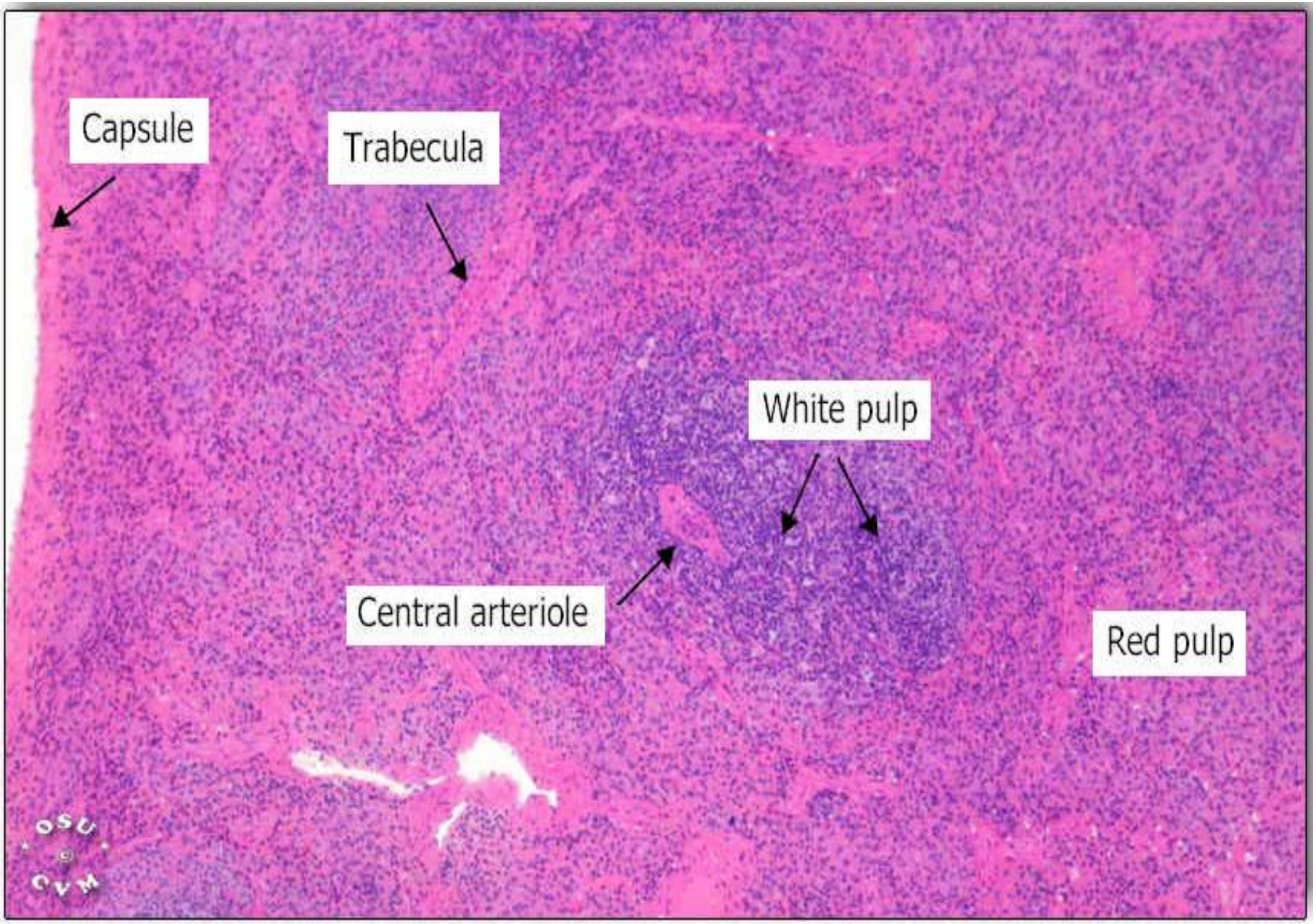

Capsule
Subcapsular sinus
Cortex
Primary nodule
Germinal center
Secondary cortical nodule
Mantle zone
A
Paracortical (deep) region
Medullary cords
Secondary nodule
Capsule
Trabecula
Cortex
Primary nodule
B
Medullary cords
Medullary sinus
Hilum
A 0.2 mm
B 0.5 mm

The spleen

is a large lymphoid organ with a rich blood supply. A connective tissue capsule surrounds the spleen and divides its interior into incomplete compartments called the splenic pulp.

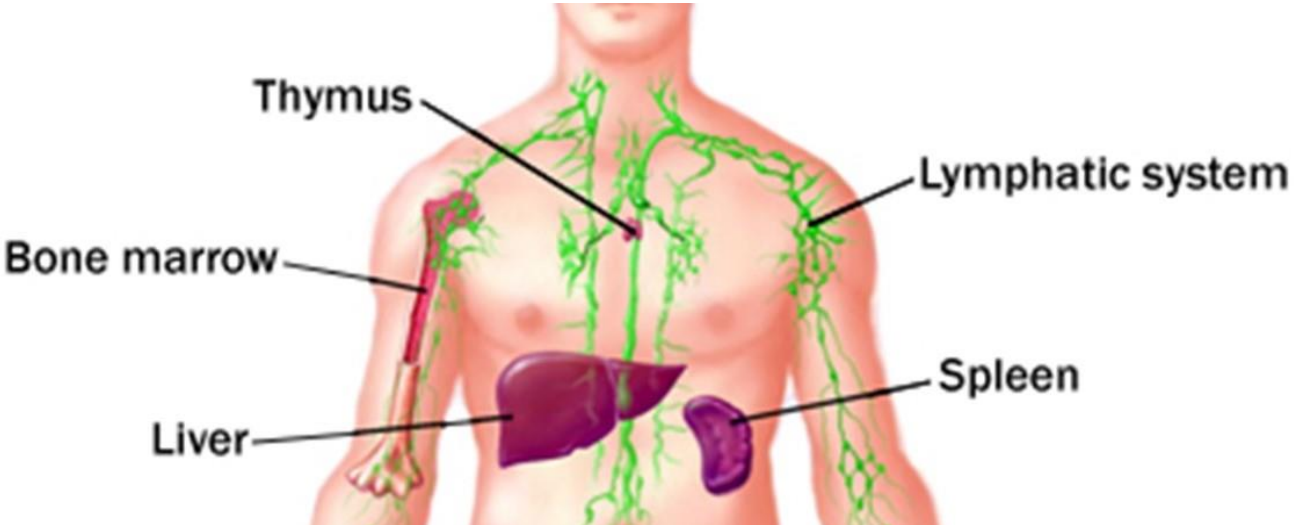
White pulp consists of dark-staining lymphoid aggregations or lymphatic nodules that surround a blood vessel called the **central artery**. White pulp is located within the blood-rich red pulp. **Red pulp**, in turn, consists of splenic cords and splenic (blood) sinusoids. Splenic cords contain networks of reticular fibers in which are found **macrophages, lymphocytes, plasma cells, and different blood cells**. Splenic sinuses are interconnected blood channels that drain splenic blood into larger sinuses that eventually leave the spleen via the splenic vein.


Capsule
Trabecula
Splenic cords
Venous sinuses
Red pulp
White pulp
Central artery
Hilus
Splenic artery
Splenic vein
Arterioles
and
capillaries
Splenic artery
Splenic vein

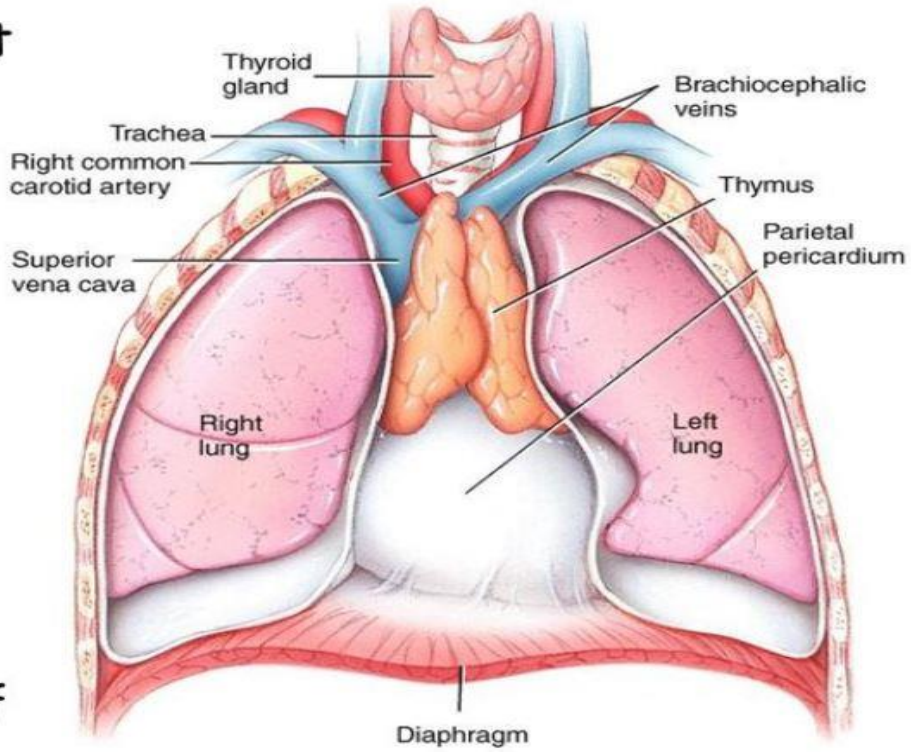

Capsule
Trabecula
White pulp
Central arteriole
Red pulp
OSU
CVM

The thymus gland

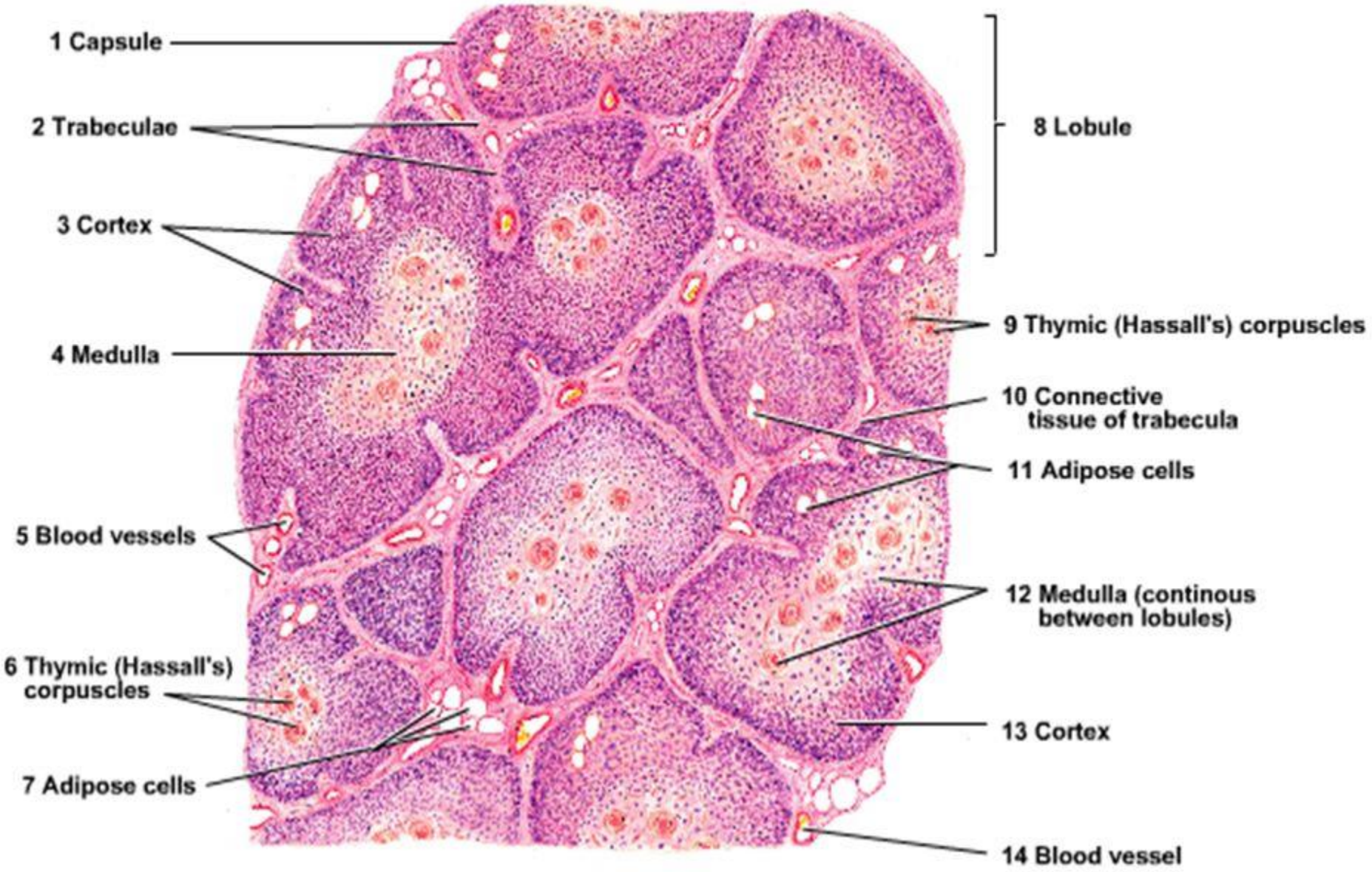
is a soft, lobulated lympho-epithelial organ located in the upper anterior mediastinum and lower part of the neck. The gland is most active during childhood, after which it undergoes slow involution; in adults, it is filled with adipose tissue. The thymus gland is surrounded by a connective tissue capsule, under which is a dark-staining cortex with an extensive network of interconnecting spaces. These spaces become colonized by immature lymphocytes that migrate here from hemopoietic tissues in the developing individual to undergo maturation and differentiation. The epithelial cells of the thymus gland provide structural support for the increased lymphocyte population. In the lighter-staining medulla, the epithelial cells form a coarser framework that contains fewer lymphocytes and whorls of epithelial cells that combine to form thymic (Hassall's) corpuscles.



- Thymus Gland
  - Between sternum, heart
  - 2 lobes
  - Atrophies w/ age
- Structure/Function
  - Outer cortex
    - pre-T cells migrate to thymus
      - proliferation
      - Maturation
    - dendritic cells
    - macrophages
  - Inner medulla – more of the same



Thymus


1 Capsule
2 Trabeculae
3 Cortex
4 Medulla
5 Blood vessels
6 Thymic (Hassall's) corpuscles
7 Adipose cells
8 Lobule
9 Thymic (Hassall's) corpuscles
10 Connective tissue of trabecula
11 Adipose cells
12 Medulla (continous between lobules)
13 Cortex
14 Blood vessel

Lymphoid Cells: T Lymphocytes and B Lymphocytes

All components of the lymphoid system are an essential part of the immune system. Lymphocytes are the cells that carry out immune responses. Different types of lymphocytes are present in various organs of the body. Morphologically, all types of lymphocytes appear very similar, but functionally, they are very different. When lymphocytes are properly stimulated, B lymphocytes or B cells and T lymphocytes or T cells are produced. These two subclasses of lymphocytes are distinguished on the basis of where they differentiate and mature into immunocompetent cells, and on the types of surface receptors present on their cell membranes. These two functionally distinct types of lymphocytes are found in blood, lymph, lymphoid tissues, and lymphoid organs. Like all blood cells, both types of lymphocytes originate from precursor **hemopoietic stem cells** in the bone marrow and then enter the bloodstream.

T cells arise from lymphocytes that are carried from the bone marrow to the thymus gland. Here, they mature, differentiate, and acquire surface receptors and immuno-competence before migrating to peripheral lymphoid tissues and organs. The thymus gland produces mature T cells early in life. After their stay in the thymus gland, T cells are distributed throughout the body in blood and populate **lymph nodes, the spleen, and lymphoid aggregates or nodules** in connective tissue. In these regions, the T cells carry out immune responses when stimulated. On encountering an antigen, T cells destroy the antigen either by cytotoxic action or by activating B cells. There are four main types of differentiated T cells: **helper T cells, cytotoxic T cells, memory T cells, and suppressor T cells.**

When encountering an antigen, **helper T cells** assist other lymphocytes by secreting immune chemicals called **cytokines**, also called **interleukins**. **Cytokines** are protein hormones that stimulate proliferation, secretion, differentiation, and maturation of B cells into plasma cells, which then produce immune proteins called antibodies, also called immunoglobulins.

Cytotoxic T cells specifically recognize antigenically different cells such as virus-infected cells, foreign cells, or malignant cells and destroy them. These lymphocytes become activated when they combine with antigens that react with their receptors. **Memory T cells** are the long-living progeny of T cells. They respond rapidly to the same antigens in the body and stimulate immediate production of cytotoxic T cells. Memory T cells are the counterparts of memory B cells.

Suppressor T cells may decrease or inhibit the functions of helper T cells and cytotoxic T cells, and thus modulate the immune response.

Basic Types of Immune Responses

The presence of foreign cells or antigens in the body stimulates a highly complex series of reactions.

These result in either production of antibodies, which bind to the antigens, or stimulation of cells that destroy foreign cells. B cells and T cells respond to antigens by different means. Two types of closely related immune responses take place in the body, both of which are triggered by antigens.

In the **cell-mediated immune response**, T cells are stimulated by the presence of antigens on the surface of antigen-presenting cells. The T cells proliferate and secrete cytokines. These chemical signals stimulate other T cells, B cells, and cytotoxic T cells. On activation and binding to target cells, cytoxic T cells produce protein molecules called perforin, which perforate or puncture the target cell membranes, causing cell death. Cytotoxic T cells also destroy foreign cells by attaching to them and inducing apoptosis or programmed cell death. The activated lymphocytes then destroy foreign microorganisms, parasites, tumor cells, or virus-infected cells. T cells may also attack indirectly by activating B cells or macrophages of the immune system. T cells provide specific immune protection without secreting antibodies.

In the **humoral immune response**, exposure of B cells to an antigen induces proliferation and transformation of some of the B cells into plasma cells. These, in turn, secrete specific antibodies into blood and lymph that bind to, inactivate, and destroy the specific foreign substance or antigens. The activation and proliferation of B cells against most antigens require the cooperation of helper T cells that respond to the same antigen and the production of certain cytokines.

The presence of the B cells, plasma cells, and antibodies in the blood and lymph are the basis of the humoral immune response.