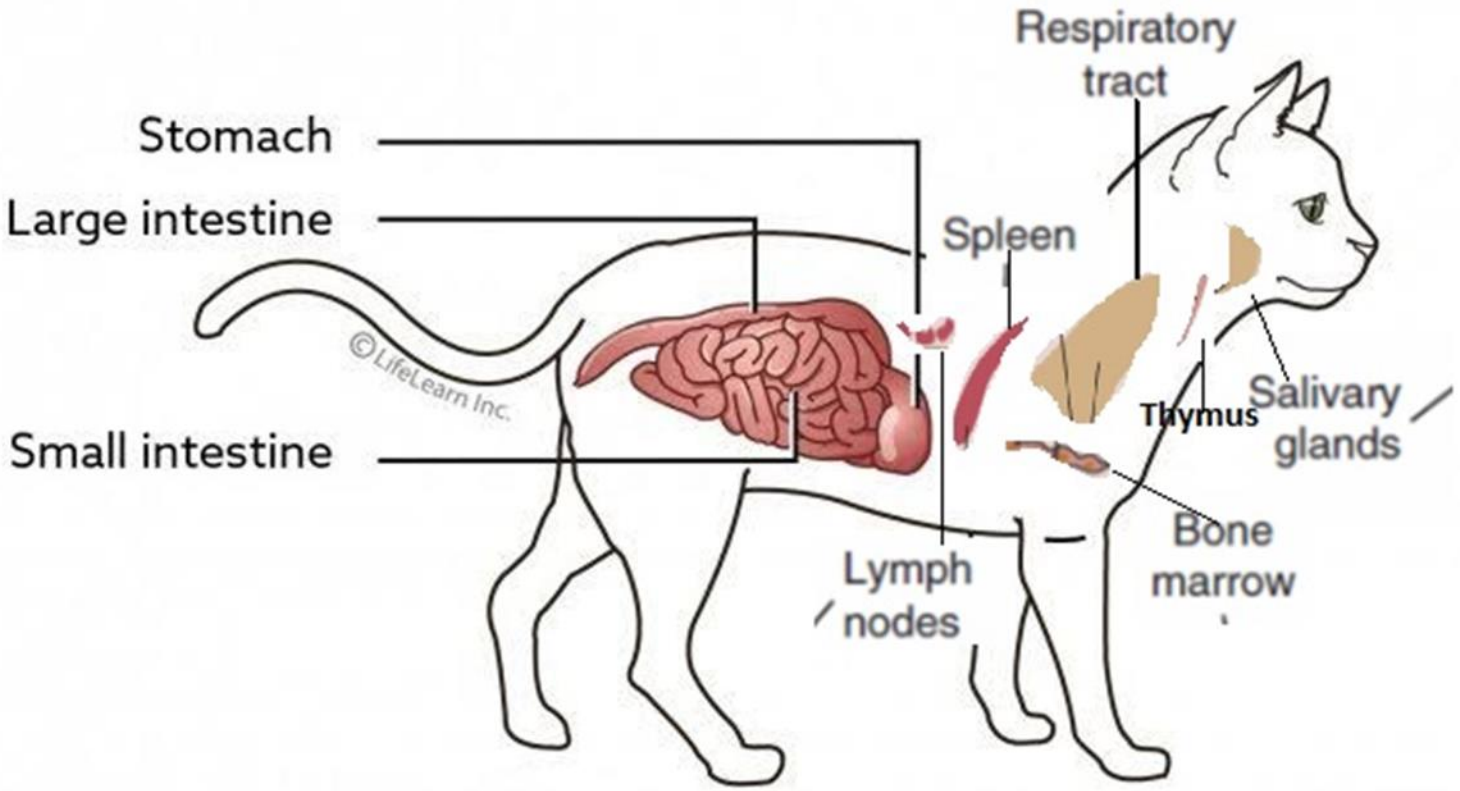
Organs of the Immun System



Key Points

- Adaptive immunity is mediated by cells called lymphocytes that are found mainly within lymphoid organs.
- Lymphocytes arise from **stem cells in the bone marrow**.
- Lymphocytes mature within **primary lymphoid organs.**
- T cells mature within the **thymus**. B cells mature within **gastrointestinal lymphoid tissues, the bone marrow**, or the **bursa of Fabricius,** depending on species.
- If newly developed lymphocytes have receptors for self-antigens that could potentially cause tissue damage, they are killed before they can leave primary lymphoid organs.
- Mature lymphocytes leave the primary lymphoid organs to reside in **secondary lymphoid organs**, where their role is to encounter and respond to foreign antigens.
- The major secondary lymphoid organs include lymph nodes, spleen, bone marrow, and some Peyer's patches within the intestine.

Key Points

- The lymphoid organs provide an environment for efficient interaction among lymphocytes, antigen-presenting cells, and foreign antigens as well as sites where lymphocytes can respond optimally to processed antigens.
- Immune responses must be carefully regulated**. Lymphocytes must be selected so that their receptors will only bind foreign antigens, and the response of each lymphocyte must be regulated so that it is sufficient but not excessive for the body's requirements.**
- The lymphoid organs may therefore be classified on the basis of their roles in generating lymphocytes, in regulating the production of lymphocytes, and in providing an environment for trapping foreign antigens, processing them, and maximizing the opportunity for processed antigens to encounter and interact with lymphocytes.

Sources of Lymphocytes

- Lymphoid stem cells are first found in the **fetal omentum**, **liver**, and **yolk sac**. In older fetuses and in adults, these stem cells are mainly found in the bone marrow.
- **The bone marrow** has multiple functions in adult mammals. It is a **hematopoietic organ** containing the precursors of all blood cells, including lymphocytes.
- In some mammals, such as primates, it also acts as a **primary lymphoid organ** (a site where newly produced lymphocytes can mature).
- Like the spleen, liver, and lymph nodes, the bone marrow is also a **secondary lymphoid organ**. It contains many dendritic cells and macrophages and thus removes foreign material from the blood. It contains large numbers of antibody-producing cells and is therefore a major source of antibodies.

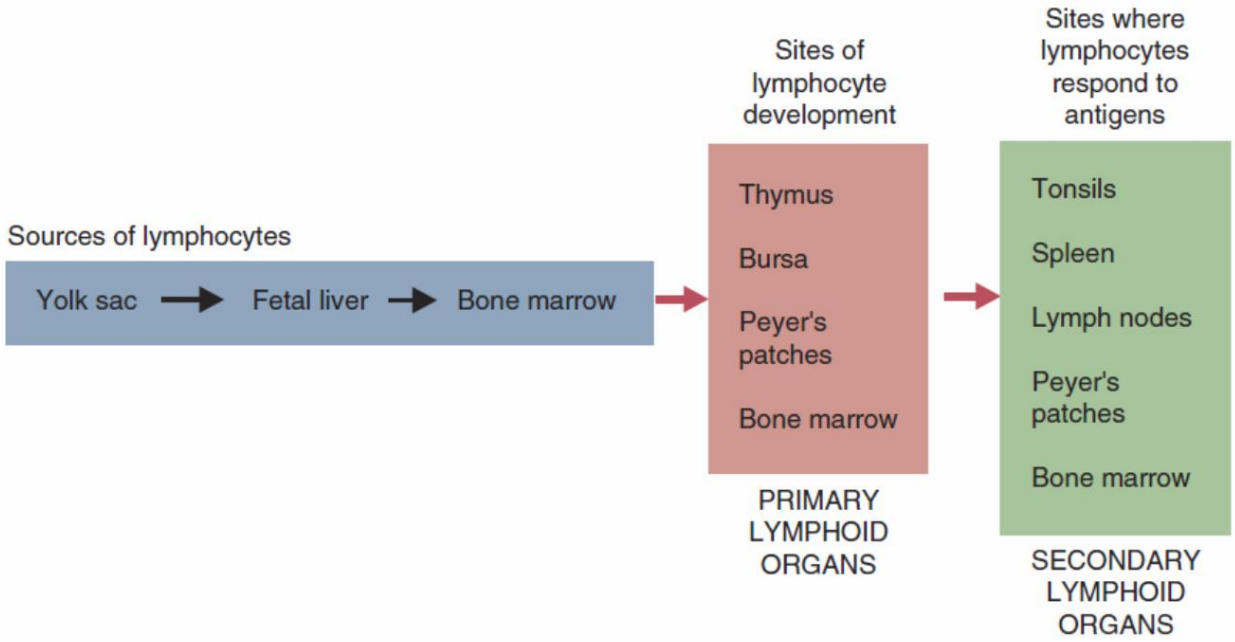


FIGURE 12-2 The lymphoid organs can conveniently be divided into three groups based on their role in the development and functioning of lymphocyte populations.

Primary Lymphoid Organs

- The organs that regulate the development of lymphocytes are called **primary lymphoid organs**.
- All T cells mature in the **thymus.** B cells, in contrast, mature within different organs depending on species. These include the **bursa of Fabricius** in birds, **the bone marrow** in primates and rodents, and **the intestinal lymphoid tissues** in rabbits, ruminants, and pigs.
- The primary lymphoid organs are not sites where lymphocytes encounter foreign antigens, and they **do not enlarge** in response to antigenic stimulation.

Bone Marrow

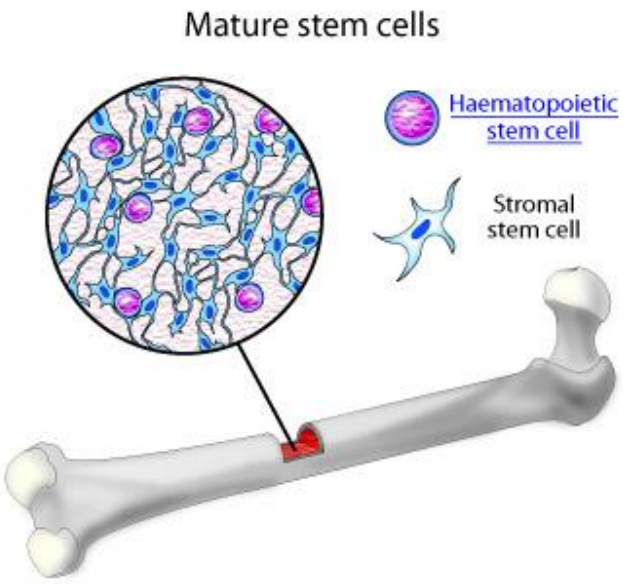
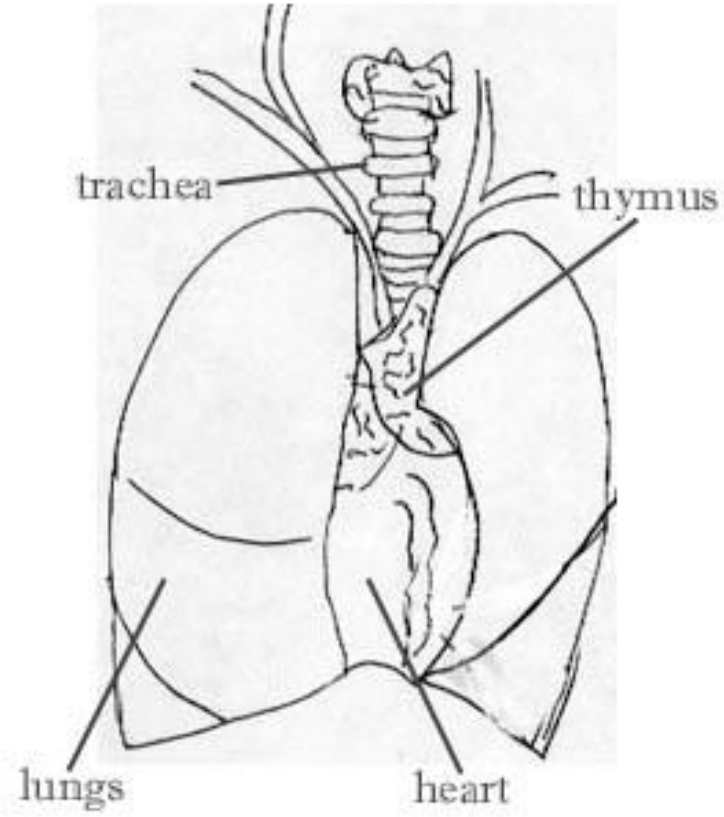


Illustration by Cell Imaging Core of the Center for Reproductive Sciences.

- It is the organ from which all blood cells originate in mammals.
- Late Fetal period and adults: bone marrow is a source of lymphocytes
- Early fetal period: liver, omentum is a source of lymphocytes
- Maturation of B-lymphocytes in mammals (except ruminants and pigs)
- The Bone Marrow serves as a primary lymphoid organ and also a secondary lymphoid organ

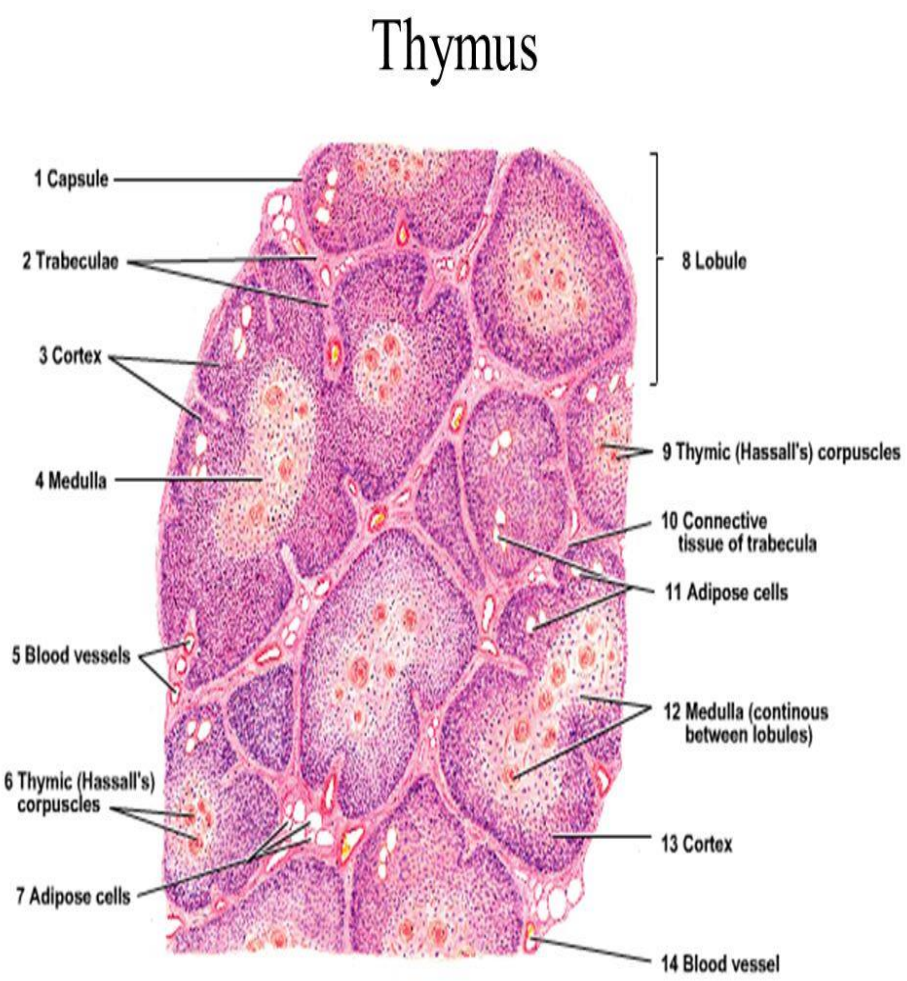
Thymus



- The thymus consist of lobules

Located in anterior mediastinal cavity

Thymus

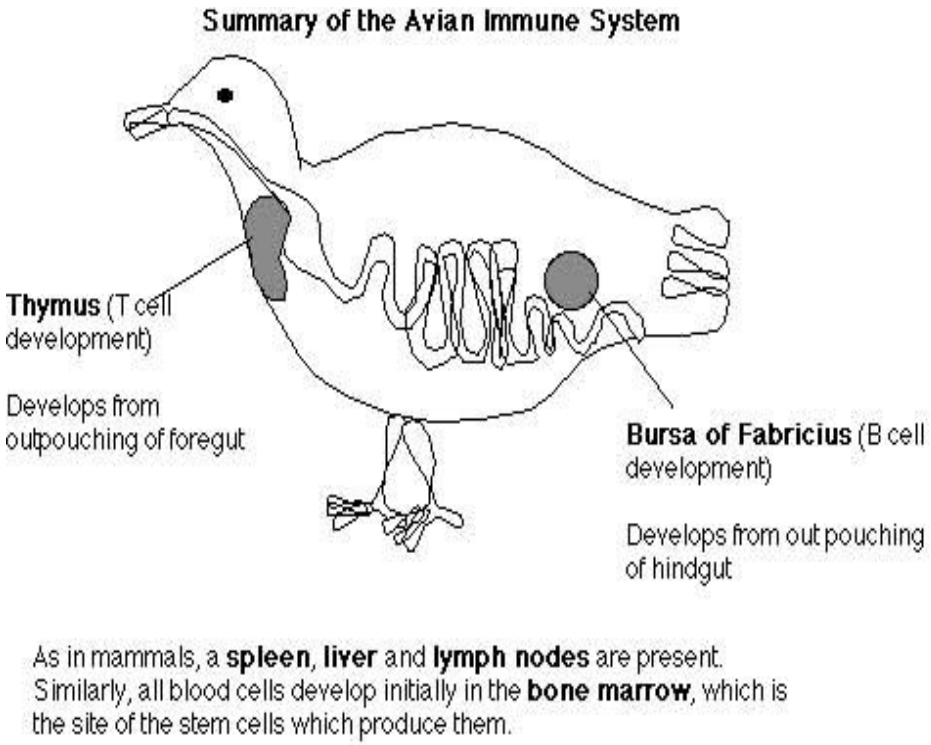


- The thymus is located in the thoracic cavity in front of and below the heart.
- The size of the thymus varies, its relative size being greatest in the newborn animal and its absolute size being greatest before puberty. It may be very small and difficult to find in adult animals.

Thymus

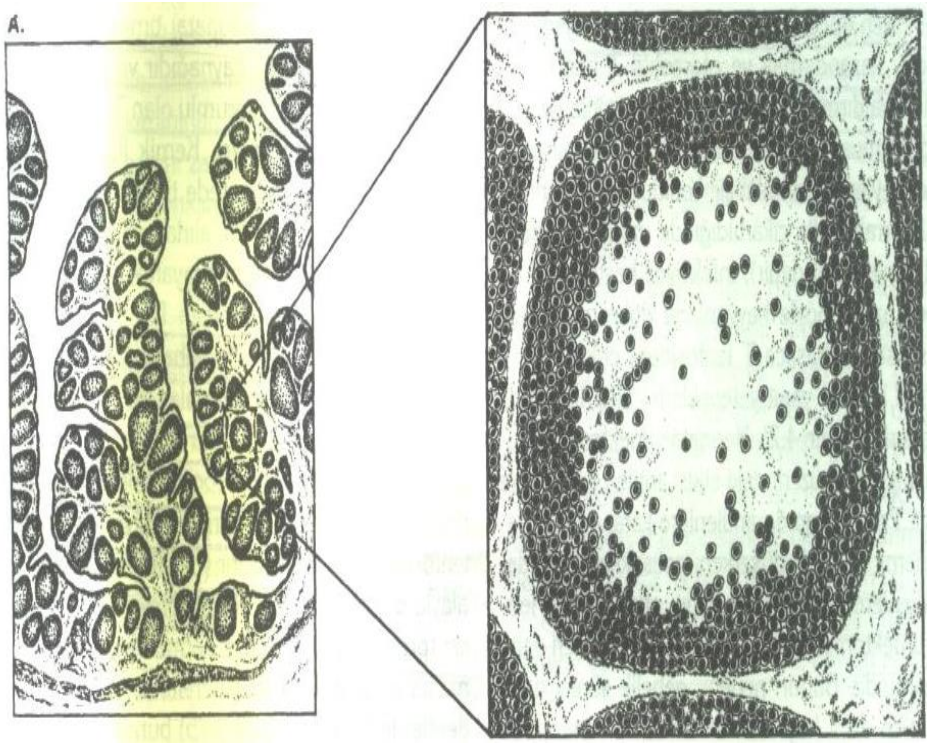
- Independent development of antigenic stimulation
- Neonatal thymectomy- Loss of function
- Tasks:
- -Maturation of precursor T cells
- - Killing of autoreactive T cells
- -Thymic hormone synthesis
- Mature T lymphocytes are stored in secondary lymphoid organs

Bursa Fabricius



- The bursa of Fabricius is found only in birds.
- It is a round sac located just above the cloaca.
- Like the thymus, the bursa reaches its greatest size in the chick about 1 to 2 weeks after hatching and then shrinks as the bird ages. It is very difficult to identify in older birds.

Bursa Fabricius



- Lobar-follicular structure surrounded by connective tissue
- Cortex and medulla
- Cortex: lymphocytes, plasma cells, macrophages
- Medulla: lymphoblasts and lymphocytes
- Neonatal bursectomy-humoral immune loss
- Tasks:
- -Maturation of precursor B cells
- - killing of autoreactive B cells
- -hormone (bursin) synthesis

Peyer's Patches

Ruminants:

-Iliocecal peyer patches-primary lymphoid organ

-Jejunal peyer patches-secondary lymphoid organ

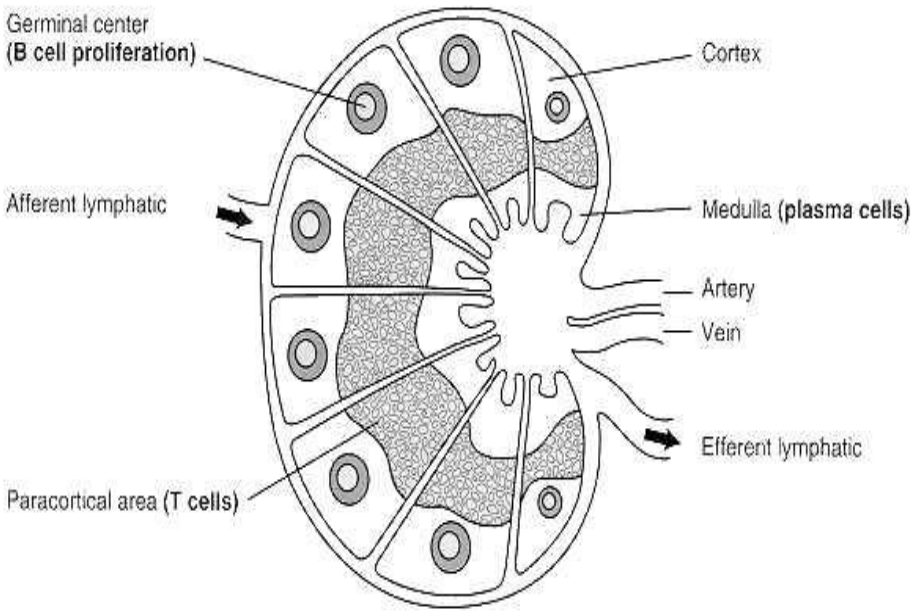
Ileocecal Peyer's Patch

- Maximum size in fetal period.
- They disappear by 15 months of age
- It is the maturation site of B lymphocytes in ruminants and pigs.
- Destruction of autoreactive B lymphocytes
- Surgical removal leads to B lymphocyte loss

Secondary Lymphoid Organs

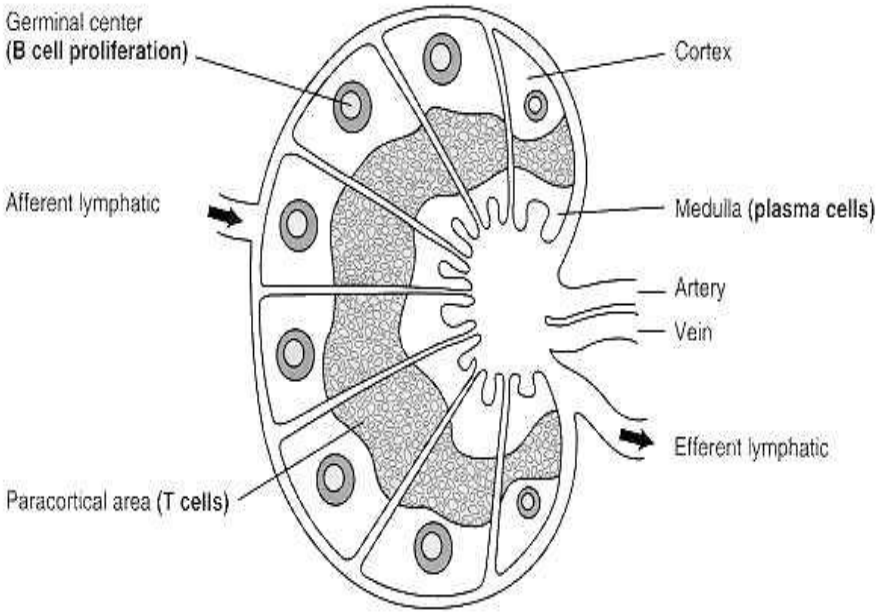
- **In contrast to the primary lymphoid organs, the secondary lymphoid organs arise late in fetal life and persist in adults**.
- **Unlike primary lymphoid organs, they enlarge in response to antigenic stimulation.**
- **Surgical removal of one of them does not significantly reduce immune capability.**
- Secondary lymphoid organs include the spleen, the lymph nodes, the tonsils, and other lymphoid tissues in the intestinal, respiratory, and urogenital tracts.
- These organs contain dendritic cells that trap and process antigens and lymphocytes that mediate the immune responses.

Lymph Nodes



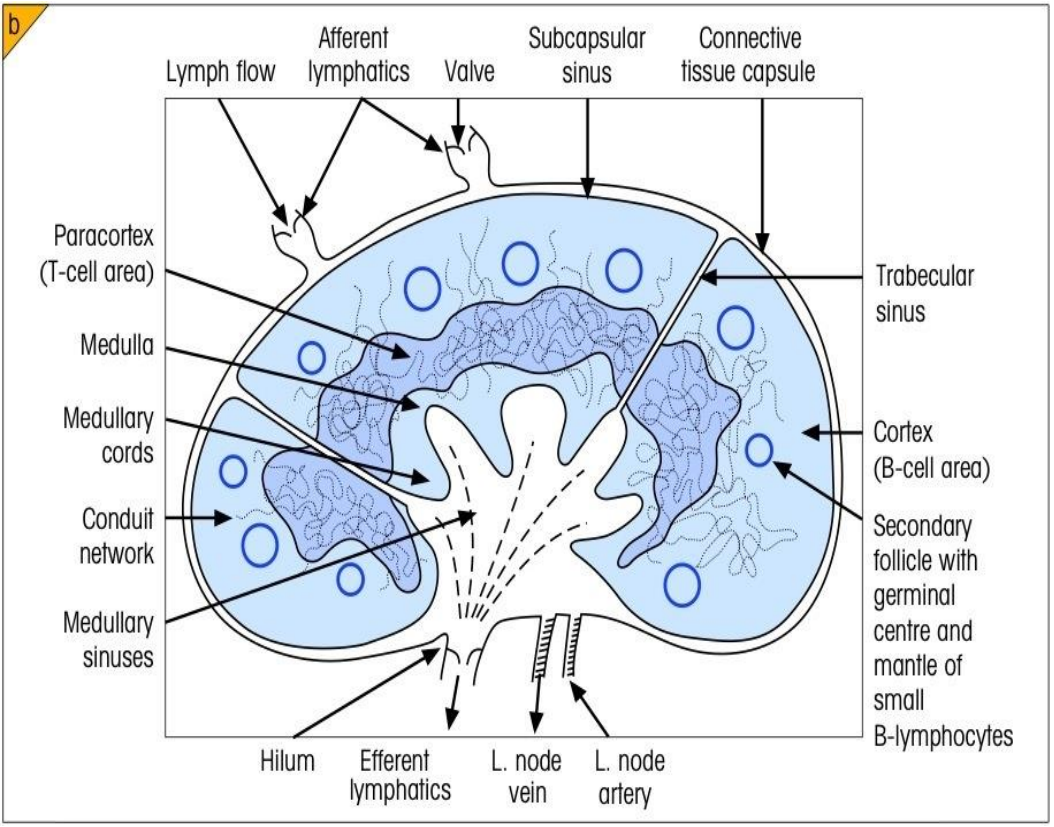
- Lymph nodes are round or bean-shaped filter strategically placed
- The lymph node thus acts as a filter for lymph fluid
- It catches antigens carried by lymphatic way/lymphatic circulation
- Cortex: B cells-germinal centers
- Paracortex:T cells
- Medulla: B cells, makrofaj, plasma cells

Lymph Nodes



- Antigen encounters immune system for the first time → captured by macrophages in medulla
- If the antigen has already been exposed to the immune system, it is captured by dendritic cells in the cortex.
- Not in poultry.
- They take names according to their location; mandibular, maxillary, tracheobronchial, sternal, hepatic, splenic, gastric, jejunal, popliteal etc

Spleen



- Captures antigens from blood circulation
- Red-White pulp
- Immune system cells are found in white pulp Primary follicle → Germinal center

Organs of the Immun System

	Primary Lymphoid Organs	Secondary Lymphoid Organs
Origin	Ectoendodermal junction or endoderm	Mesoderm
Time of development	Early in embryonic life	Late in fetal life
Persistence	Involutes after puberty	Persists in adults
Effect of removal	Loss of lymphocytes	No or minor effects
Response to antigen	Unresponsive	Fully reactive
Tasks	Change and maturation of lymphocytes	Creating an immune response
Examples	Thymus, bursa, some Peyer patches	Spleen, lymph nodes

Other Secondary Lymphoid Organs

- Secondary lymphoid organs include not only the spleen and lymph nodes but also the bone marrow, tonsils, and lymphoid tissues scattered throughout the body, most notably in the digestive, respiratory, and urogenital tracts.
- If antigen is given intravenously, much will be trapped not only in the liver and spleen but also in the bone marrow.
- During a primary immune response, antibodies are mainly produced in the spleen and lymph nodes. Toward the end of that response, memory cells leave the spleen and colonize the bone marrow. When a second dose of an antigen is given, the bone marrow produces very large quantities of antibody and is the major source of antibodies in adult rodents.