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Lecture title: Cells and Organs of the Immune System

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Summary:

1- Learning what the components of the Immune system are
2- The importance and function of immune cells and organs

Immune cell include :

1- Phagocytes

Phagocytes, including neutrophils and macrophages, are cells whose primary function is to ingest and destroy microbes and remove damaged tissues. They communicate with other cells in ways that promote or regulate immune responses.

2- Neutrophils

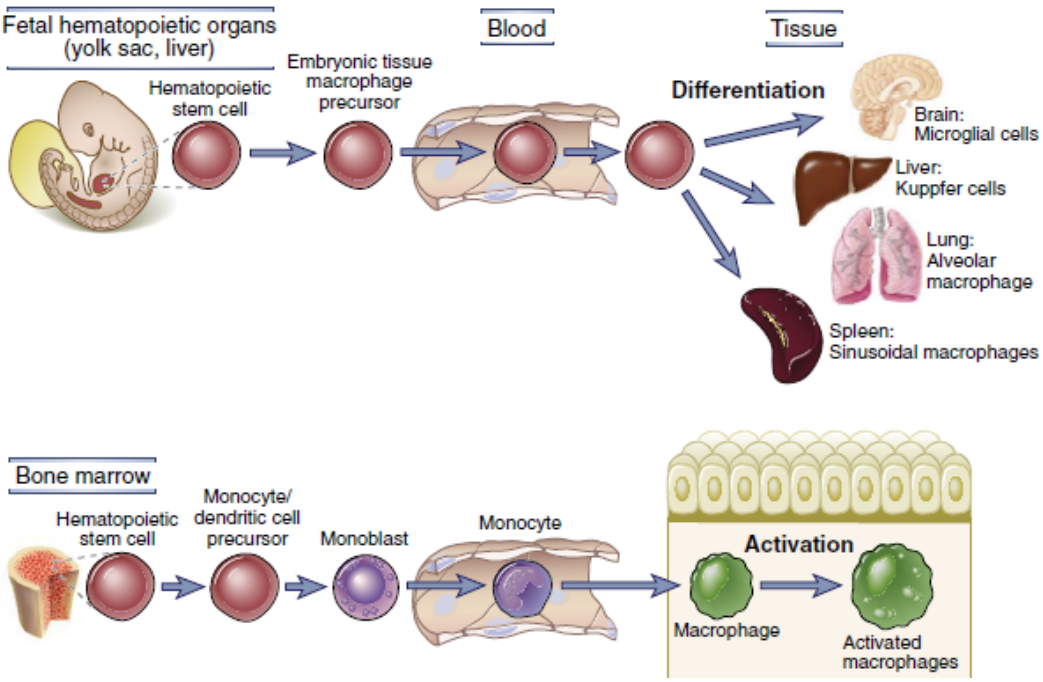
also called polymorphonuclear leukocytes, are the most abundant population of circulating white blood cells and mediate the earliest phases of inflammatory reactions, by rapidly recruiting to sites of infection and tissue injury, where they perform phagocytic and microbial killing functions

3- Mononuclear Phagocytes

The mononuclear phagocyte system includes circulating cells called monocytes and tissue-resident cells called macrophages. Macrophages, which are widely distributed in organs and connective tissue, play central roles in innate and adaptive immunity.

Many tissues are populated with long-lived resident macrophages, which assume specialized phenotypes depending on the organ (Kupffer cells in the liver, sinusoidal macrophages in the spleen, alveolar macrophages in the lung, and microglial cells in the brain).

A major



function of macrophages in host defence :

1- ingest and kill microbes.

2- macrophages also ingest dead host cells and induce inflammatory responses.

3- macrophages serve as APCs

4- Mast cells

are bone marrow-derived cells present in the skin and mucosal epithelia, Mast cells function as sentinels in tissues, where they recognise microbial products and respond by producing cytokines and other mediators that induce inflammation. These cells provide defence against helminths and other microbes but are also responsible for symptoms of allergic diseases

5- Basophils

Basophils are blood granulocytes with many structural and functional similarities to mast cells. Like mast cells, basophils express IgE receptors, bind IgE, and can be triggered by antigen binding to the IgE. Because basophil numbers are low in tissues, their importance in host defence and allergic reactions is uncertain.

6- Eosinophils

Eosinophils are blood granulocytes that express cytoplasmic granules containing enzymes that are harmful to the cell walls of parasites but can also damage host tissues.

7- Antigen-Presenting Cells

Antigen-presenting cells (APCs) are cells that capture microbial and other antigens, display them to lymphocytes, and provide signals that stimulate the proliferation and differentiation of the lymphocytes. By convention, APC usually refers to a cell that displays antigens to T lymphocytes. The major type of APC that is involved in initiating T cell responses is the dendritic cell. Macrophages and B cells present antigens to T lymphocytes in cell-mediated and humoral immune responses, respectively.

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8- Dendritic Cells

the most important APCs for activating naive T cells, and they play major roles in innate responses to infections and in linking innate and adaptive immune responses. They have long membranous projections and phagocytic capabilities and are widely distributed in lymphoid tissues, mucosal epithelium, and organ parenchyma.

9- B- lymphocytes

The cells that produce antibodies were so called because in birds they were found to mature in an organ called the **bursa of Fabricius**. In mammals, the early stages of B cell maturation occur in the **bone marrow.**

10- T- lymphocytes

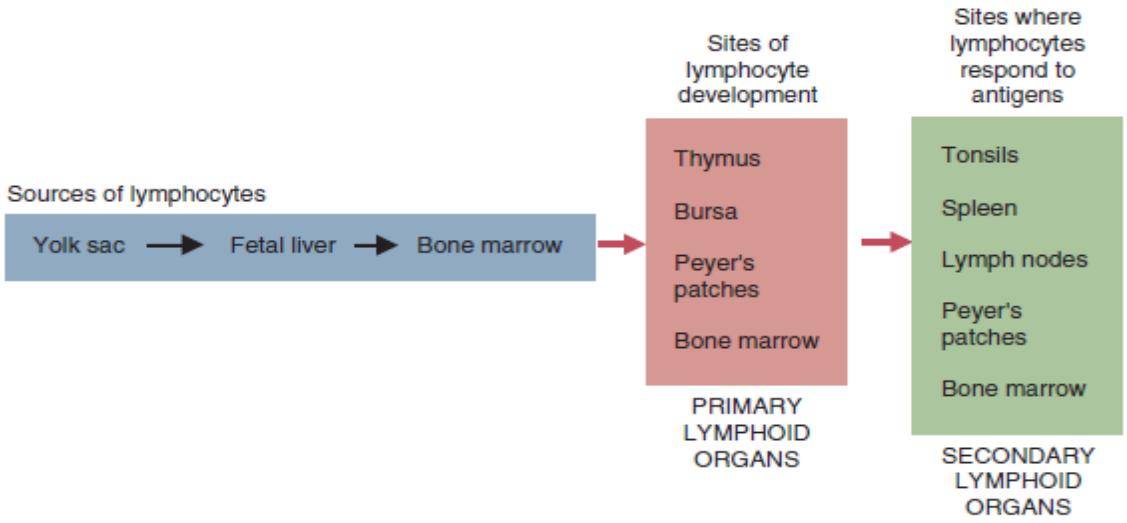
the mediators of cell-mediated immunity, which they mature in the **thymus**; T lymphocytes refer to **thymus derived lymphocytes**

Lymphoid Organs:-

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.

Sources of Lymphocytes

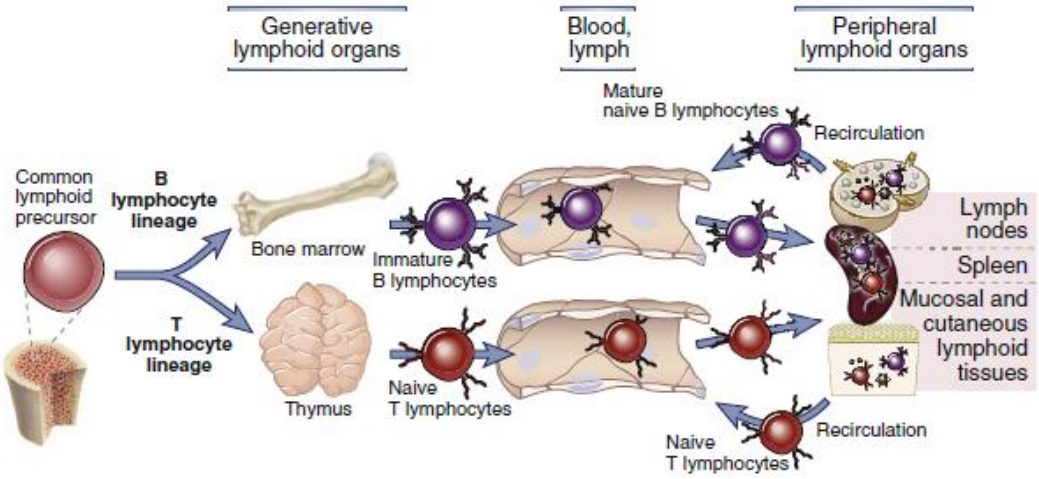
1- Lymphoid stem cells are first found in the fetal omentum, liver, and yolk sac.
2- In older fetuses and adults, these stem cells are mainly found in the bone marrow.
3- Bone marrow is a hematopoietic organ containing the precursors of all blood cells, including lymphocytes, and also acts as a primary lymphoid organ (a site where newly produced lymphocytes can mature).
4-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.
5- It contains large numbers of antibody-producing cells and is therefore a major Source of antibodies.



The lymphoid organs include :

Primary Lymphoid organ:-

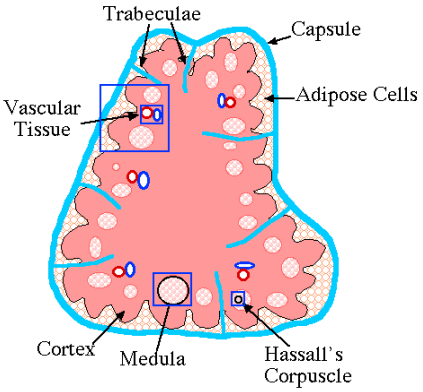
The organs that regulate the development of lymphocytes are called primary lymphoid organs. Lymphocytes fall into two major populations called T cells and B cells, based on the primary organ in which they mature. Thus, all T cells mature in the thymus. B cells, in contrast, mature within different organs depending on the 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 all develop early in fetal life. As animals develop, newly produced, immature lymphocytes migrate from the bone marrow to the primary lymphoid organs, where they mature The primary lymphoid organs are not sites where lymphocytes encounter foreign antigens, and they do not enlarge in response to antigenic stimulation.



Differentiation of lymphocyte from secondary lymphoid organ

Primary lymphoid organs include:-

1- Thymus :-



Lymphocytes in the thymus are mainly responsible for mounting cell-mediated immune responses. They are called thymus-derived lymphocytes or T cells. T-cell precursors originate in the bone marrow but then enter the thymus. Once within the thymus, the cells (called thymocytes) divide rapidly. The new cells produced, whereas remain in the thymus for 4 to 5 days before leaving the thymus as mature T cells, circulate in the bloodstream, and colonize the secondary lymphoid organs. T cells in the thymus learned to:

1- Self-recognizing of (self-antigens).
2- Recognizing foreign antigens

2- bursa of Fabricius in bird and its equivalent in mammal.

is found only in birds. The bursa is a primary lymphoid organ that functions as a maturation and differentiation site for the cells of the antibody-forming system. Lymphocytes originating in the bursa are therefore called B cells. The bursa acts like the thymus in so far as immature cells

produced in the bone marrow migrate to the bursa. These cells then proliferate rapidly, once their maturation is completed, B cells migrate to secondary lymphoid organs.

3- **bone marrow**:-

is the primary lymphoid organ for B cells in mammals. There is no exclusive B cell development site in the bone marrow, although it is suggested that precursor B cells develop at the outer edge of the marrow and migrate to the centre as they mature and multiply.

Secondary lymphoid organ

The secondary lymphoid organs arise late in fetal life and persist in adults. they enlarge in response to antigenic stimulation; The overall anatomical structure of these organs is therefore designed to facilitate antigen trapping and to provide the optimal environment for the initiation of immune responses.

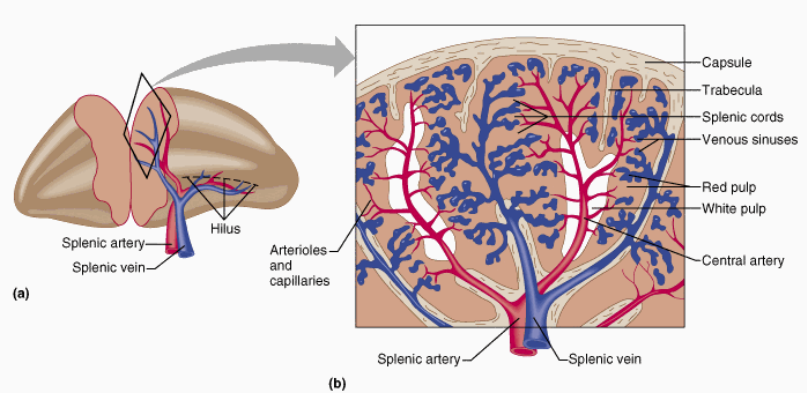
Secondary lymphoid organs are connected to both the blood and lymphoid systems, thus allowing them to continuously sample and concentrate circulating antigens.

Secondary lymphoid organs include

1- **Spleen:**

spleen can be considered a specialized lymph node for blood-born removes antigenic particles such as blood-borne microorganisms, cellular debris, and aged blood cells. This filtering function, together with highly organized lymphoid tissue, makes the spleen an important component of the immune system.

the spleen consists of two forms of tissue. One is used predominantly for blood filtering called the red pulp. It contains large numbers of antigen-presenting cells, lymphocytes, and plasma cells. The other is rich in both B and T cells where immune responses occur and is called the white pulp. The white pulp is separated from the red pulp by a region called the marginal zone. This zone contains numerous macrophages and dendritic cells and a large population of B cells. The spleen is not supplied with lymphatic fluid, although it does possess efferent lymphatic antigens



2- **Payer's patches:**

Peyer's patches are lymphoid organs located in the walls of the small intestine. The ileal PPs of some species function like the avian bursa. as sites of rapid B cell proliferation, release into the circulation

3- Tonsils : similar to lymph node

4- Lymph nodules. Lymph nodes are round or bean-shaped filters. placed on lymphatic vessels in such a way that they can sample antigens carried in the lymph, The lymph node thus acts as a filter for lymph fluid.

The interior of lymph nodes is divided into three discrete regions: a peripheral cortex, a central medulla, and a defined region in between, called the paracortex

B cells predominate in the cortex, where they are arranged in aggregates called follicles. In lymph nodes that have been stimulated by antigens, some of these follicles form specialized structures called germinal centres.
Lymph nodes are rich in antigen-trapping follicular dendritic cells, T cells and dendritic cells predominate in the paracortex.

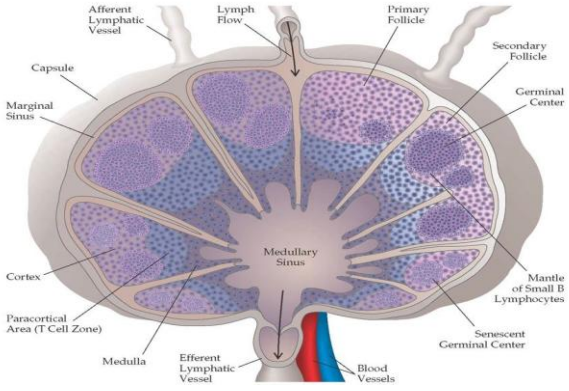
If we have a foreign body entering the lymph node we get a phagocytosis. Then if Ag stimulates humeral immunity, we will get a mitotic activity in the cortex and we can- find the production of Ab in the germinal center, so the Ab and Ig are found in the germinal center.

But if we have Ag stimulate cell-mediated immunity, we will get hypertrophy of the paracortex and trabeculae which is represented by enlargement of the paracortical zone and trabeculae, this indicator for cell-mediated immune response.

The cause of hypertrophy is due to the mitotic activity of T-cells that transform into lymphoblast (T-cell transformation).

In lymph node we have three types of cells that participate in the immune response:-

1- Humoral immunity cells.
2- Cell-mediated immunity cells.
3- Phagocytosis cells



The principal function of secondary lymphoid

1- facilitate the interactions between antigen-presenting cells and antigen-sensitive T and B cells.
2- antibodies are mainly produced in the spleen and lymph nodes.
3- memory cells leave the spleen and colonize the bone marrow.

Differences between primary and secondary lymphoid organs:-

Different	Primary	Secondary
Lymphopoiesis	Ag independent	Ag dependent
Development	Prenatal life	Postnatal life
Participation in immune response	Do not participate directly	Participate directly
atrophy	+	-
Differentiation of lymphocyte	+	- (Already differentiate)