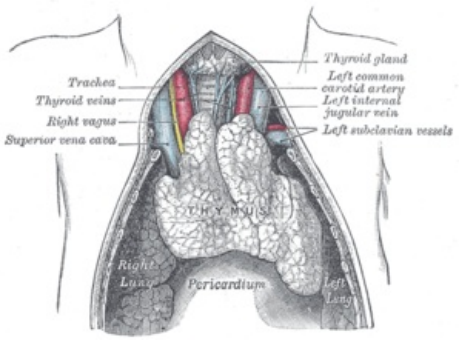
# Primary immune organs

Among the primary human lymphatic organs are the thymus and the **bone marrow** (medulla ossium). Differentiation and selection of immune cells takes place in them.

## Thymus

🔎 *For more information see Thymus.*

### Anatomy



Topography of the thymus

The thymus is pink, in adults a yellow organ due to the accumulation of fat. In childhood, it is stored in the *mediastinum superior and mediastinum anterior*, in adulthood practically only behind the manubrium sterni (mediastinum superius). Topographically, it is located **behind the sternum and in front of the veins entering the heart**. It is formed by two craniocaudally extended lobes, **lobus dexter** et **lobus sinister**. **It is larger in childhood** (12–15 g in a newborn, 40 g in the 3rd year of life) and after puberty **undergoes involution** by transformation into corpus thymicum adipose tissue (13 g in the 50th year of life).

The arterial supply comes from the branches of the a. thyroidea inferior et a. thoracica interna, the venous blood drains mainly into the v. thoracica interna et v. thyroidea inferor. The thymus has sympathetic innervation from the nn. cardiaci and parasympathetic from nn. laryngei recurrentes (nn. vagi). Sensitive innervation is ensured by fibers separating from the nn. phrenici.

### Embryology

The base of the thymus arises in pairs in the 5th week of development from the medial parts of the **3rd pair of pharyngeal pouches**. (Gll. parathyroideae inferiores arise from the lateral ones.)

### Involution

Until the third year of life, the thymus enlarges, after which there is a gradual involution, it is most massive in puberty. The morphological basis of involution is a relative increase in the extent of the pulp at the expense of the cortex, a decrease in lymphocytes in the cortex, an increase in the number of **Hassal's bodies** and a decrease in reticular tissue with a simultaneous increase in fatty tissue.

### Histology

On the surface, the thymus has a developed **fibrous sheath**, from which **fibrous septa** divide the thymus tissue into **false lobes**. Each lobule consists of a peripherally located lighter cortex - **cortex thymi** and a more centrally located darker medulla - **medulla thymi**.

The septum is pierced by arteries that copy the course of the septa. Arterioles diverge at the border of cortex and medulla; in the cortex we find only capillaries. Veins follow the course of arteries. The thymus **does not have afferent lymphatic vessels**, efferent ones are found in small quantities.

The stroma consists of cells of the r**eticular epithelium;** it is made up of stellate-shaped epithelial reticular cells with long, thin projections that connect through the macula densa. Of the immunocytes, mature T lymphocytes and macrophages are most often found here, but also maturing T lymphocytes.

#### Bark

On histological sections, we see it as a darker layer, we find a large number of lymphocytes and fewer reticular epithelial cells in it than in the marrow. The reticular epithelial cells here have long processes surrounding groups of developing T lymphocytes, capillaries and individual pseudolobules.

Lymphocytes originating in the bone marrow move precisely to the cortex of the thymus, where they divide, differentiate, select and gradually move to the marrow area. Thus, the maturation of lymphocytes itself takes place in the cortex. A large number of dead lymphocytes are phagocytosed by the macrophages present.

Capillaries in the cortex are of the somatic type and together with the cells of the reticular epithelium form a limiting barrier between the blood and the microenvironment of the thymus. This barrier separates the large number of antigens circulating in the blood and allows only some to pass through.

#### Marrow

It is a lighter layer, there are more reticular epithelial cells and fewer lymphocytes. The barrier between blood and thymus is not developed here. Here we find specific formations - **Hassall's bodies,** which are made up of many layers of flattened concentrically arranged keratinized cells. The number and size of Hassall's corpuscles increase throughout life. Lymphocytes found in the marrow make up only 5% of all lymphocytes in the thymus. However, all lymphocytes in the marrow are already immunocompetent! Immunocompetent lymphocytes enter the bloodstream through the postcapillary venules, which are at the border of the cortex and medulla. Subsequently, they populate thymodependent areas in secondary lymphatic organs.

### Peptide production

The production of peptides was demonstrated in reticular epithelial cells, which contribute to the maturation of T lymphocytes. These peptides include: thymosin D, thymic humoral factor, thymopoietin.

### Function

After their formation in the bone marrow, pre-T-lymphocytes move to the thymus via the bloodstream, where they mature into so-called naïve T-lymphocytes. The difference between lymphocytes before and after their "residence" in the thymus is mainly in the formed surface costimulatory molecules. This change occurs under the influence of the peptides described above, which are formed in the thymus. In addition, so-called **negative** and **positive** selection occurs. T-lymphocytes have antigen receptors on their surface, which we call TCR (T-cell receptor). Based on their affinity to MHC molecules, selection occurs. With negative selection, T-lymphocytes with a very high affinity to MHC glycoproteins are killed, and with positive selection, those with a certain degree of affinity for MHC gp are selected. T-lymphocytes that cannot bind MHC at all are also killed. Due to the existence of a barrier between the blood and the environment of the thymus, the existence of the so-called PAE (peripheral antigen expressing cells) is necessary. These are cells capable of presenting antigens found in the body outside the thymus to maturing T-lymphocytes. In this way, the correct selection is achieved, which also takes peripheral antigens into account.

The result of these processes are **naive T-lymphocytes**, which means that they have not yet encountered the antigen. These lymphocytes leave the thymus and populate **thymus-dependent regions** in secondary lymphatic organs.

## Bone marrow

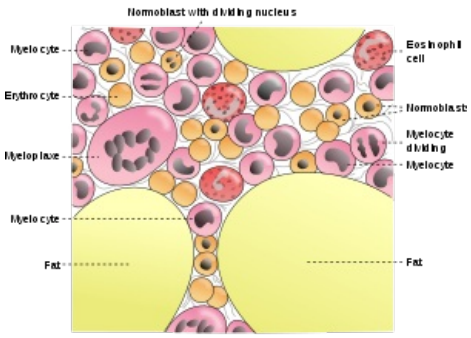
### Anatomy, histology and function

The **medulla ossium** (bone marrow) fills the **cavitas medullaris** (medullary cavity) in the bodies of long bones and the area between the cancellous trabecular bone. We distinguish red – active bone marrow (medulla ossium rubra); yellow - inactive, penetrated by fatty tissue (medulla ossium flava), which can turn gray (medulla ossium grisea) due to loss of fat. Gray bone marrow is typical of old individuals. In the event of an increased need for hematopoiesis, a re-transformation of the yellow bone marrow into red is not excluded.

From the 5th lunar month, the red bone marrow is the **primary organ of hematopoiesis**, and it also fulfills this function in adulthood. In it, we find pluripotent cells, which, through their differentiation, provide the basis for cells of the myeloid and lymphoid lineages. It therefore participates in the development of all blood corpuscular elements. overview|Bone marrow cells

The stroma of the bone marrow is made up of **reticular tissue**, which defines the islets of **hematopoietic tissue**. Here we find numerous **sinusoidal capillaries**. It should be noted that the development of blood elements takes place essentially extravascularly.

In childhood, red bone marrow is found in the cavities of all long bones, vertebral bodies, ribs, alla ossis ilii, finger joints, and sternum. During puberty, functional bone marrow tissue is replaced by fatty tissue, but due to the life span of blood cells, their permanent production is inevitable. Therefore, even in adulthood, functional bone marrow is preserved in the following areas: the epiphyses of long bones, in the pelvis, ribs, sternum, vertebral bodies and in the diploe of the cranial bones.



Bone narrow cells

The immunological function of the bone marrow (red) is intertwined with its function in hematopoiesis. From the myeloid line, **granulocytes** arise, and from the lymphoid, immature **B-lymphocytes and pre-T-lymphocytes**. While pre-T-lymphocytes travel to the thymus for their final development, B-lymphocyte development takes place fully in the bone marrow. A **negative selection** of B-lymphocytes takes place here, during which those lymphocytes that recognize MHC gp with too high an affinity are eliminated or inactivated.

## Links

### Related articles

- Thymus
- Bone marrow
- Hematopoiesis
- HLA system

## Source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