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BIRIKTIRUVCHI TO‘QIMALAR TIZIMIDA QON VA LIMFANING GISTOLOGIK TUZILISHI VA GEMOPOEZ MEXANIZMLARI TAHLILI

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ANNOTATSIYA

Biriktiruvchi to‘qimaning maxsus turlari hisoblangan qon va limfaning gistologik tuzilishi hamda ularning organizm gomeostazini saqlashdagi roli tahlil qilinadi. Tadqiqot davomida gemopoez (qon hosil bo‘lish) jarayonining bosqichlari, suyak ko‘migidagi hujayralar differensiatsiyasi va immun himoya tizimidagi o‘zgarishlar o‘rganilgan. Maqolaning maqsadi qon hujayralarining hayotiy sikli va patologik jarayonlarda gemopoetik to‘qimaning regeneratsiyasini ilmiy asoslashdan iborat. Olib borilgan tahlillar qon va limfa tizimining o‘zaro bog‘liqligini zamonaviy gistologik nuqtayi nazardan yoritib beradi.

Kalit so‘zlar: Biriktiruvchi to‘qima, qon, limfa, gemopoez, suyak ko‘migi, ekstrasellyulyar matriks, fibroblastlar, eritrotsitlar, leykotsitlar, trombotsitlar, immun tizim.

ГИСТОЛОГИЧЕСКАЯ СТРУКТУРА КРОВИ И ЛИМФЫ И АНАЛИЗ МЕХАНИЗМОВ ГЕМОПОЭЗА В СИСТЕМЕ СОЕДИНИТЕЛЬНЫХ ТКАНЕЙ

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АННОТАЦИЯ

В данной статье анализируется гистологическая структура крови и лимфы, являющихся особыми типами соединительной ткани, и их роль в поддержании гомеостаза организма. В ходе исследования изучались стадии процесса гемопоэза (кроветворения), клеточной дифференцировки в костном мозге и изменения в системе иммунной защиты. Цель статьи – научно обосновать жизненный цикл клеток крови и регенерацию гемопоэтической ткани при патологических процессах. Полученные анализы проливают свет на взаимосвязь кровеносной и лимфатической систем с современной гистологической точки зрения.

Ключевые слова: Соединительная ткань, кровь, лимфа, гемопоэз, костный мозг, внеклеточный матрикс, фибробласты, эритроциты, лейкоциты, тромбоциты, иммунная система.

HISTOLOGICAL STRUCTURE OF BLOOD AND LYMPH AND ANALYSIS OF HEMATOPOIESIS MECHANISMS IN THE CONNECTIVE TISSUE SYSTEM

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ABSTRACT

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This article analyzes the histological structure of blood and lymph, which are special types of connective tissue, and their role in maintaining homeostasis of the body. During the study, the stages of the process of hemopoiesis (blood formation), cell differentiation in the bone marrow, and changes in the immune defense system were studied. The purpose of the article is to scientifically substantiate the life cycle of blood cells and the regeneration of hemopoietic tissue in pathological processes. The analyzes obtained shed light on the interrelationship of the blood and lymphatic systems from a modern histological point of view.

Keywords: Connective tissue, blood, lymph, hematopoiesis, bone marrow, extracellular matrix, fibroblasts, erythrocytes, leukocytes, thrombocytes, immune system.

INTRODUCTION

In modern medicine and histology, the complex study of systems that maintain the stability of the body's internal environment (homeostasis) is a key scientific direction. Blood and lymph, which belong to the connective tissue system, are morphologically and functionally unique, playing a decisive role in transport, trophic, immunological defense, and humoral regulation processes [5]. The histological structure of blood and lymph, along with their interrelationship, is crucial for maintaining metabolic balance and immune reactivity in the body [6, 7].

From a histological perspective, blood and lymph are liquid connective tissues composed of cellular elements and liquid intercellular substance; their structural and functional differences manifest differently in physiological states and pathological processes [2]. While erythrocytes, leukocytes, and platelets predominate in blood, lymphocytes are the primary cellular elements in the lymphatic system, highlighting its priority in immunological function [3,8].

In recent years, the rise in hematological diseases, immunodeficiency states, and chronic inflammatory processes has necessitated a deeper study of hemopoiesis mechanisms. Hemopoiesis is a complex, multi-stage process of mature blood cell formation from multipotent stem cells, strictly regulated by genetic and humoral factors [5,9]. The theoretical foundations of this process were first described in the unitarian theory proposed by A.A. Maximov, which is now being enriched by modern molecular and cellular research [4].

According to current scientific views, the activity of hemopoietic stem cells in the bone marrow is inextricably linked to their surrounding microenvironment—the stroma, reticular cells, and signaling molecules (erythropoietin, interleukins, colony-stimulating factors) [6,10]. This microenvironment governs cell proliferation, differentiation, and migration, ensuring the normal functioning of the blood system. At the same time, the process of lymph formation and its dynamic relationship with tissue fluid, as well as the compensatory capabilities of hemopoietic tissue in pathological conditions, remain among the issues that have not yet been fully explored [7].

In this regard, a complex analysis of the histological structure of blood and lymph and the mechanisms of hemopoiesis within the connective tissue system is of great importance not only for theoretical but also for practical medicine.

Research Objective: To scientifically substantiate the morphofunctional characteristics of blood and lymph as connective tissues, analyze the stages of hemopoiesis based on modern histological approaches, and reveal the interrelationship between these systems.

Object of Research: Formed elements of blood (erythrocytes, leukocytes, platelets), lymph composition, and hemopoietic organs (bone marrow, thymus, spleen).

Research Tasks:

- To conduct a comparative analysis of the cellular and intercellular components of blood and lymph;
- To study cell morphology during the stages of hemopoiesis;

- To evaluate the immunological significance of lymphogenesis.

The results of this study will contribute to a deeper understanding of blood, lymph, and hemopoiesis processes within the connective tissue system, creating a scientific basis for the early diagnosis and prognosis of hematological and immunological diseases in practice.

MATERIALS AND METHODS:

This study was conducted based on theoretical-methodological, comparative-histological, and analytical approaches. To highlight the histological structure of blood and lymph and the morphofunctional characteristics of hemopoiesis within the connective tissue system, scientific data from fundamental morphology and modern hematology were utilized [5].

Data Sources: The information base of the study consisted of the following reliable sources:

- Fundamental textbooks: *Junqueira's Basic Histology: Text and Atlas* (15th–16th editions), *Gartner & Hiatt's Color Textbook of Histology*, and national histology manuals [5,6];
- International scientific databases: Hematological and cytological studies published over the last 10 years on the PubMed, Scopus, and Web of Science platforms [7–10]. Scientific reliability, peer-review status, and modernity were the main criteria for source selection.

Research Methods: A set of the following scientific methods was applied:

1. **Systemic Analysis Method:** Blood and lymph were analyzed as a single functional system consisting of cellular elements (erythrocytes, leukocytes, platelets, lymphocytes) and intercellular substance (plasma, lymph plasma) as special types of connective tissue [2,6].
2. **Morphological Description Method:** The hemopoiesis process was studied according to the 6-stage differentiation of blood cells based on A.A. Maximov's unitarian theory. Morphological features—size, nuclear-cytoplasmic ratio, chromatin structure, and granulation degree—were systematized at each stage [4,5].
3. **Comparative-Histological Method:** Quantitative and qualitative indicators of formed elements in peripheral blood and lymph, as well as microenvironment characteristics in hemopoietic organs (bone marrow, thymus, spleen), were compared. This approach allowed for the identification of functional differences and similarities between the blood and lymph systems [3,7].
4. **Deduction and Interpretation Method:** Deviations in hematological parameters (leukocytosis, anemia, lymphocytosis) were analyzed in connection with morphofunctional changes in hemopoietic tissue. The results were interpreted based on modern scientific data [8,9].

Ethical Principles: All information used during the research was selected in accordance with international bioethical standards and evidence-based medicine principles. Academic integrity and citation rules were strictly observed in the use of scientific sources.

RESULTS

As a result of the systemic analysis, the morphofunctional indicators of blood and lymph (special types of connective tissue) and the stages of hemopoiesis were established as follows:

1. **Comparative Morphology of Blood and Lymph.** Research results show that blood and lymph have a liquid intercellular substance (plasma), and their primary differences lie in the composition of formed elements and protein concentration. While erythrocytes predominate in the blood system, lymphocytes are the main cellular element in the lymph.

Table 1. Comparative morphofunctional indicators of blood and lymph.

Indicators	Blood (Sanguis)	Lymph (Lympha)

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Intercellular substance	Plasma (55-60%)	Lymph plasma
Primary cells	Erythrocytes, Leukocytes, Platelets	Lymphocytes (up to 90%), Monocytes
Protein content	60-80 g/l	20-30 g/l
Primary function	Gas exchange, transport, trophics	Tissue drainage, immune control
Coagulation property	High (due to fibrinogen)	Slow (low fibrinogen)

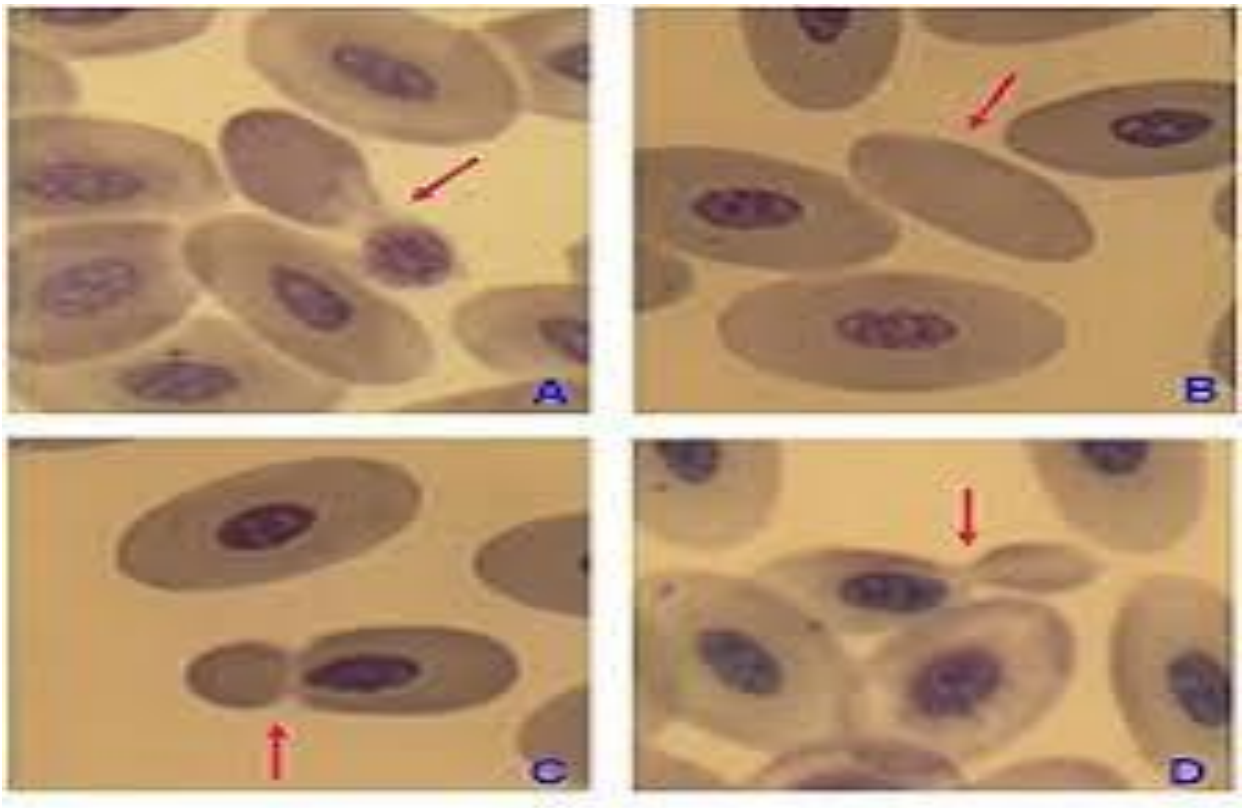

Figure 1. Stages of the Hemopoiesis (Blood Formation) Process.

The hemopoiesis process begins with multipotent stem cells in the bone marrow and progresses through six main morphological classes. Results indicate that during cellular differentiation, cell size decreases and nuclei become more condensed (in erythropoiesis, the nucleus disappears entirely).

Table 2. Step-by-step differentiation of hemopoiesis (Based on the Unitarian Theory)

Class Order	Class Name	Description
Class I	**Multipotent stem cell**	The common ancestor of all blood cells (HSC)
Class II	**Determined progenitor**	Partially restricted (committed to myelopoiesis or lymphopoiesis)
Class III	**Unipotent progenitor**	Directed toward only one cell type (e.g., erythrocyte)
Class IV	**Blast cells**	Morphologically identifiable young cells

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Class V	**Maturing cells**	Differentiating cells preparing for function
Class VI	**Mature cells**	Functional elements entering the peripheral blood

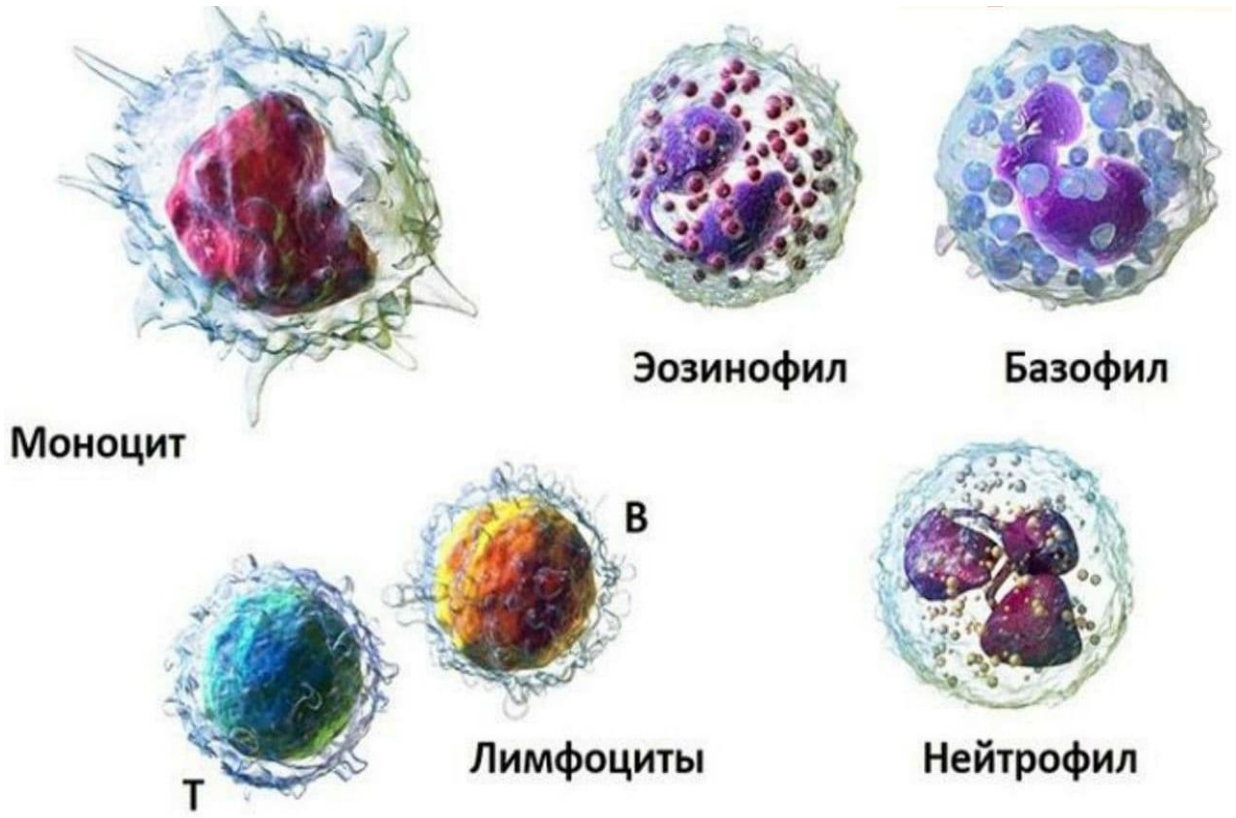

Figure 2. Normal formed elements of blood.

Research findings indicate that the hemopoiesis process proceeds normally only in the presence of reticular tissue (the framework of the bone marrow). Reticular cells serve as a "home" (niche) for hemopoietic islets and produce growth factors that stimulate cell proliferation.

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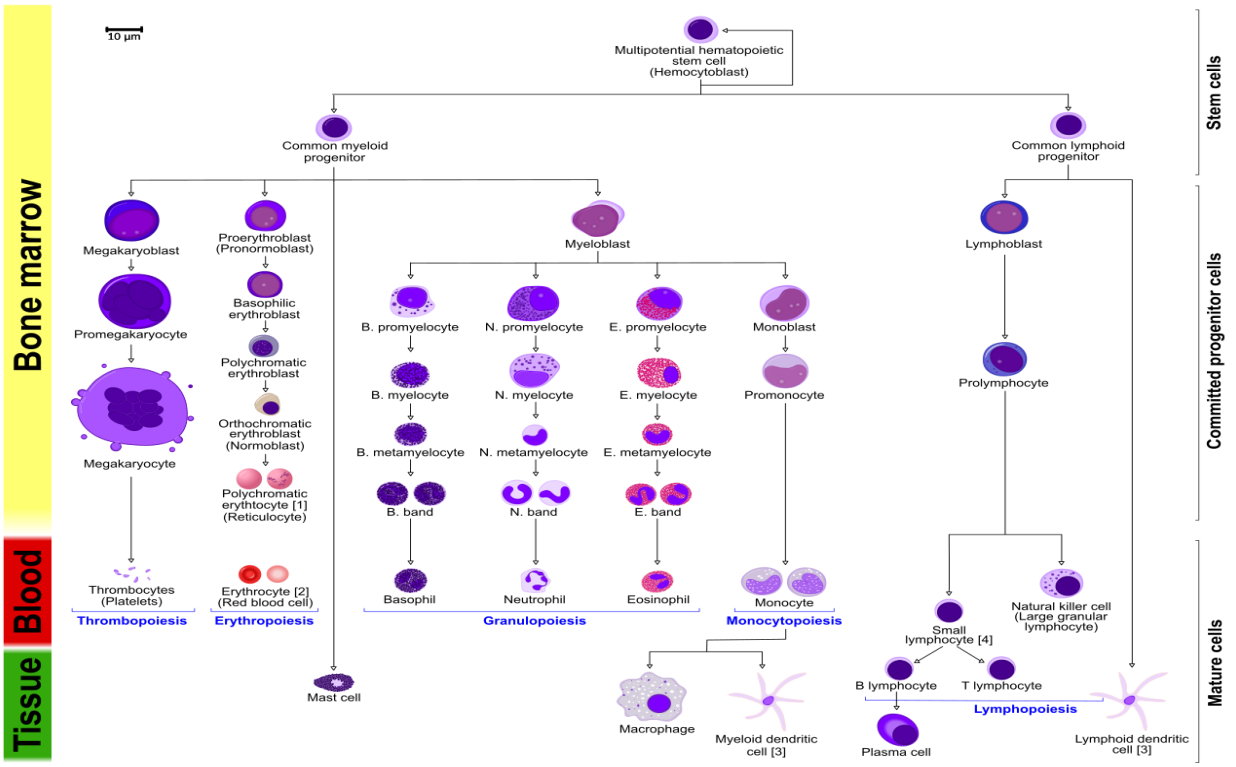

Figure 3. Stages of Hemocytopoiesis.

DISCUSSION

The research results indicate that classifying blood and lymph as special types of connective tissue is justified not only by their common mesenchymal origin but also by their liquid intercellular substance. The comparative data presented in Table 1 confirm that blood and lymph function as a unified "internal environment tissue." While blood delivers oxygen and nutrients to tissues, lymph acts as a "drainage" system removing metabolites, thereby ensuring the dual dynamics of body homeostasis.

The patterns identified during the study of the hemopoiesis process (Table 2) show that cellular differentiation is under strict genetic and humoral control. The morphological similarity of Class I–III cells (lymphocyte-like appearance) emphasizes the necessity of using modern immunocytochemical methods in hematological diagnostics. The increased cytoplasmic basophilia at the blast cell stage (Class IV) indicates the activation of the protein-synthesizing apparatus (ribosomes), which creates the foundation for synthesizing specific proteins (e.g., hemoglobin) required for mature cells.

A crucial aspect of the discussion is that hemopoiesis is not merely cell division, but an interaction between cells and their microenvironment (stroma). Interleukins and cytokines produced by the reticular tissue determine the direction (erythropoiesis or leukopoiesis) in which stem cells develop. If a defect exists in this microenvironment, even healthy stem cells cannot produce sufficient blood elements, which helps in understanding severe pathologies such as hypoplastic anemia.

Furthermore, the high concentration of lymphocytes in lymph proves that the lymphatic system is not only for transport but serves as a primary "immune filter." This demonstrates the inextricable link between the blood and lymph systems regarding both anatomy and protective functions.

CONCLUSION

The conducted research and morphofunctional analysis of the connective tissue system allow for the following conclusions:

1. **Structural Integrity:** As special types of connective tissue, blood and lymph constitute a single dynamic system that ensures the body's internal homeostasis. The ratio of cells to plasma changes according to the body's physiological state, forming the basis of adaptive reactions.

2. **Strict Hierarchy of Hemopoiesis:** Blood formation is a complex mechanism based on the step-by-step differentiation of multipotent stem cells, occurring through six morphofunctional classes. At each stage, the cell undergoes specific morphological changes (nuclear condensation, appearance of specific granulation), ensuring functional maturity in peripheral blood.

3. **Importance of the Microenvironment:** Hemopoietic tissue (bone marrow) and its reticular stroma are the necessary inductive environments for blood cell development. The interaction between stromal cells and cytokines directs hemopoiesis to meet the body's cellular and humoral needs.

4. **Practical Significance:** In-depth study of the histological indicators of blood and lymph serves as a fundamental diagnostic criterion in clinical medicine, particularly for the early diagnosis of anemia, leukodystrophies, and immunodeficiency states.

This study shows that investigating the hemopoiesis process at the molecular level will open new perspectives for regenerative medicine and the treatment of hematological pathologies in the future.

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