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Hematology and Oncology: From Conceptual Dichotomy to an Integrated Discipline in the Era of Cancer Pathophysiology

S.A. Mikayelyan[1], H.S. Khachatryan[1,2], G.N. Tamamyan[1], M.G. Melik-Andreasyan[1,2], H.G. Grigoryan[2], A.V. Sargsyan[2]

[1] *Yerevan State Medical University after Mkhitar Heratsi*
0025, Yerevan, Koryun st. 2
[2] *"Yeolyan" Hematology and Oncology Center of the Ministry of Health of the Republic of Armenia*
0014, Yerevan, Nersisyan st. 7

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Introduction

At first glance, hematology and oncology appear to occupy separate intellectual territories, and considering the scope of each field in turn helps highlight the foundations upon which they developed. Hematology encompasses a wide spectrum, spanning the molecular mechanisms of blood cell formation to diseases of the blood, bone marrow, and lymphatic system. Hematologists diagnose and guide therapy for disorders ranging from anemias and hemostatic abnormalities to malignant conditions such as leukemias. Oncology focuses on the study, diagnosis and management of malignant diseases. Oncologists examine how and why cells become malignant. Guided by tumor histology, molecular markers, and staging, they utilize surgical, radiation, and systemic therapies to halt or reverse the course of disease.

This traditional distinction has fostered a perceived dichotomy between the two disciplines. However, advances in the understanding of cancer pathophysiology have progressively blurred the boundaries, particularly in the study and management of hematologic malignancies, which share key biological mechanisms with solid tumors while requiring specialized hematologic expertise. This convergence has led to the emergence of the integrated discipline of hematology-oncology, which now plays a central role in modern cancer care.

Understanding the differences helps patients navigate their care teams, know why they are referred to one specialist versus another, and understand the nature of their condition - whether a blood disorder, cancer, or both. At the same time, hematology and oncology can be combined or pursued separately as clinical and

academic disciplines. Knowing the differences also helps medical students choose between benign hematology, malignant hematology, solid-tumor oncology, or combined heme-oncology practice, each associated with distinct workloads, research opportunities, and clinical focus.

Aim of the review: To examine the historical and professional boundaries between hematology and oncology, and critically assess whether modern integration in training and practice addresses current academic, clinical and workforce challenges.

Methodology

This article is a narrative review with targeted evidence synthesis, based on a clear methodological framework. Relevant literature was identified from multiple sources, including World Health Organization (WHO), National Resident Matching Program (NRMP), International Agency for Research on Cancer (IARC), American Society of Clinical Oncology (ASCO), PubMed, and other professional and policy databases The literature search encompassed publications spanning 2006 to 2025. Inclusion criteria encompassed studies and reports addressing the core domains of hematology, molecular and translational oncology research, relevant historical insights, hematology-oncology workforce patterns, and policy or training frameworks relevant to the integration of the two specialties.

Core and Emerging Areas Within Hematology

Diagnostic hematology remains a core component of the specialty.

It encompasses:

▪ Morphologic interpretation of peripheral blood smears and bone marrow specimens. Hematologists continue to serve as the bridge between classical microscopy and modern molecular data, contextualizing each within the patient's clinical picture.

▪ Flow cytometry, which enables immunophenotypic classification of leukemias and lymphomas, minimal residual disease (MRD) assessment, and quantification of immune subsets. Hematologists participate in gating strategies, and interpretation of high-parameter panels.

▪ Specialized Coagulation and hemostasis diagnostics. Hematologists interpret these in tandem with genetic panels for thrombophilia or bleeding disorders, ensuring clinically meaningful evaluation.

▪ Molecular hematopathology: incorporation of technologies like Fluorescence *in situ* Hybridization (FISH), Polymerase Chain Reaction (PCR), immunohistochemistry, cytogenetics, and Next-Generation Sequencing (NGS) panels. Hematologists are now expected to understand variant classification, clonal architecture, allele burden trends, and the clinical relevance of actionable mutations, which redefines the diagnostic responsibilities [5].

Clinical hematology covers the full spectrum of management, and monitoring of blood-related diseases.

Benign hematology is a subspecialty domain, where hematologists manage red cell disorders (hemolytic and dyserythropoietic anemias, hemoglobinopathies), platelet and hemostatic abnormalities (thrombocytopenia, inherited/acquired platelet function defects), coagulation disorders (hemophilias, Von Willebrand Disease**,** thrombophilia, antiphospholipid syndrome), bone marrow failure syndromes (aplastic anemia, Paroxysmal Nocturnal Hemoglobinuria), and non-neoplastic white blood cell disorders. The examples listed here illustrate merely a fraction of the extensive array.

Transfusion medicine and cellular therapy

Most hematologists maintain active roles in transfusion support, blood product stewardship, and management of transfusion complications. They also possess specialized expertise in immunohematology and blood compatibility.

In addition to traditional stem cell transplantation, the rise of Chimeric Antigen Receptor T-cells (CAR-T cells), gene-edited stem cells, and ex vivo-expanded cellular products has further expanded the hematologists' responsibilities. They now oversee patient selection, toxicity management and long-term monitoring.

Within *malignant hematology***,** clinicians diagnose and manage leukemias, lymphomas, myelodysplastic syndromes (MDS), myeloproliferative neoplasms (MPN), multiple myeloma (MM), and other neoplasms. Cancer biology concepts such as clonal evolution, stem cell dysfunction, somatic mutations, epigenetic alterations were first described in hematologic malignancies. Because blood is uniquely accessible for sampling, hematology remains a prototype for translational precision medicine [5].

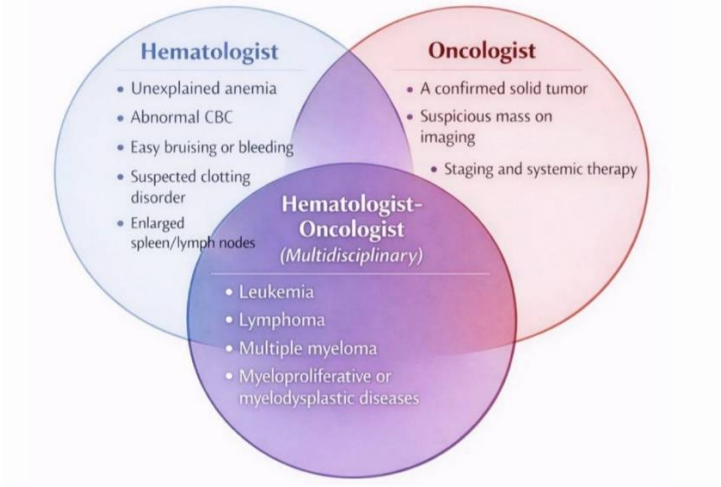

Fig. 1. *Referral pathways in hematology and oncology*

Hematology versus Oncology: Historical Evolution

Post-World War II, hematology evolved from classical blood disorders toward cancer-focused investigations. As some hematologists refocused their work toward cancer, a number of internists became interested in the application of chemical therapies to solid tumors. However, they encountered antagonism, reflecting both professional territoriality and skepticism toward emerging therapeutic modalities. To circumvent these barriers, internists aligned with related fields or joined specialized cancer hospitals such as Memorial Sloan-Kettering or Roswell Park. They also formed a national society **(**American Society of Clinical Oncology **(**ASCO)) and developed standard training requirements-common expressions of the rise of specialization in the 20th century.

When medical oncologists claimed wide-ranging expertise over the treatment of all patients suffering from malignant disease, the leukemias became contested ground. At the annual meeting of the American Society of Hematology (ASH)**,** and in a subsequent letter to the ABIM (American Board of Internal Medicine), hematologists declared- *"The separation of the two boards is itself a denial of the capabilities and dedication of a large number of practicing hematologists to the care of patients with neoplastic disease."*

This led to a structured negotiation: the development of *dual certification and joint training programs*, a compromise that preserved hematologists' involvement while establishing medical oncology as an independent subspecialty.

By the late 1970s, medical oncology had secured institutional legitimacy. Hematology-oncology relations evolved from conflict to structured cooperation, though tensions over training and certification persisted. The ABIM revised its training requirements. Candidates who had focused primarily on hematology required an additional year in oncology, those with an oncology background needed 2 years in hematology, and those from a combined program completed 3 years of training [7].

Table 1

Nobel laureates whose contributions are relevant to hematology and oncology.

Nobel laureate	Year	Key Discovery	Relevance to Hematology/Oncology
William G. Kaelin Jr.	2019	Oxygen sensing (HIF pathway)	Tumor hypoxia, angiogenesis, ASCO Science of Oncology Award recipient
James P. Allison	2018	CTLA-4 immune checkpoint inhibition	Immunotherapy, transformative impact in solid and hematologic malignancies
George H. Hitchings	1988	Rational drug design	Foundational chemotherapy principles
Gertrude B. Elion	1988	Rational drug development	Antimetabolites used in solid and hematologic malignancies
Paul Ehrlich	1908	Immunology and chemotherapy concepts	Foundational ideas underpinning hematology, oncology, and immunotherapy

The Longstanding and Growing Overlap Between Hematology and Oncology

The overlap between the clinical boundaries of these two disciplines is particularly evident in patient management, where hematologic principles often inform the care of patients with solid tumors. For instance, solid-tumor management often overlaps with hematology due to treatment-related cytopenias, thrombosis, anemia, and immunologic effects. Emergencies that arise across both hematologic and solid malignancies reflect shared pathophysiologic mechanisms, including high tumor burden, rapid cell turnover, bone marrow dysfunction, and treatment-related toxicity. Common emergencies include febrile neutropenia, sepsis, tumor lysis syndrome, hypercalcemia of malignancy, disseminated intravascular coagulation, and acute organ compromise such as spinal cord compression or superior vena cava syndrome [1]. Collectively, these shared clinical challenges highlight the longstanding integrated nature.

With advances in novel diagnostic and therapeutic approaches, the two fields further converge. Molecular oncology and NGS-based comprehensive sequencing have reshaped classification systems, particularly in MDS and acute leukemias, and now guide therapy across solid and hematologic cancers. Tumor mutational profiling, minimal residual disease tracking, and liquid biopsy technologies are expanding across both specialties.

Contemporary master protocol frameworks such as basket and umbrella trials, often combine hematologic and solid tumors, particularly when targeting common molecular alterations. Basket trials**,** for example, enroll patients with a shared actionable genomic aberration (such as BRAF V600E, NTRK fusions, IDH1/2 mutations), across diverse cancer types, thereby evaluating a single targeted therapy in a histology-agnostic manner. In a systematic review, 180 basket trials were identified, with 55 % reporting results and a median objective response rate of 14 %.

Umbrella trials complement this approach by stratifying patients with a single disease (for instance acute leukemia or non-small cell lung cancer) into molecularly defined sub-cohorts that receive different targeted agents. Of 73 umbrella trials evaluated, 38 % had published outcomes with a median response rate of 17.8 % [4].

CAR-T, bispecific T-cell engagers (BiTEs)**,** and Natural killer cell (NK-cell) therapies were pioneered in blood cancers and now illustrate how treatment approaches cross specialty boundaries (although their global availability remains uneven, contributing to substantial disparities in care). At the same time, conventional oncology modalities (chemotherapy, radiation) and hematology treatments (stem-cell transplant, supportive transfusion care, anticoagulation) are often used together in combined care pathways.

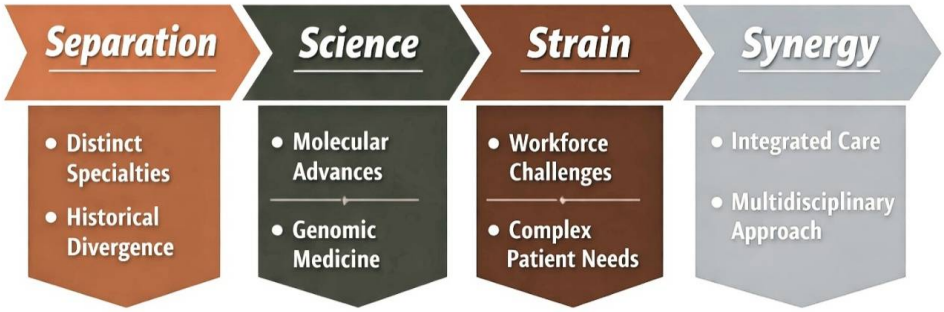

Fig. 2. *Hematology-oncology integration schema*

Workforce shortages amid an increasing number of new cases

Latest global estimates from IARC GLOBOCAN 2022 highlight the growing burden of cancer (20 million new cancer cases and 9.7 million deaths) and the disproportionate impact on underserved populations. These increases are mostly due to population aging and growth, not changes in individual risk alone. Hematologic malignancies accounted for 6.6% of total cancer cases (non-Hodgkin lymphoma exhibits the highest incidence) and 7.2% of total cancer-related deaths (leukemia has the highest mortality rate) [10]. WHO survey (2022) on Universal Health Coverage (UHC) and cancer shows that only 39% of participating countries covered the basics of cancer management as part of their financed core health services for all citizens [11].

A new (2025) report from the American Society of Clinical Oncology finds that the overall density of medical and hematology oncologists relative to the aging population is decreasing. In 2014, there were an estimated 15.9 oncologists per 100,000 people aged 55 and older, that number dropped to 14.9 in 2024. Data identify significant “cancer care deserts,” particularly in rural communities. By 2037, non-metropolitan areas are projected to meet only 29% of their demand for medical and hematology oncologists, contrasting with metropolitan areas which are projected to meet 102% of their demand [6].

Residency Experience and Academic Outlook

Interest in combined hematology-oncology fellowships continues to grow compared with hematology-only or medical-oncology-only programs. NRMP (the National Resident Matching Program) data tables show that the number of hematology-oncology programs has increased from ~149 in 2019 to around 198 by the 2024 appointment year, with 773 certified positions (fill rate was 99%) [9].

Factors influencing career choice included clinical interest in the field (98%), previous research experience in HO, career mentorship, lifestyle considerations, and perceived job market [2].

A central challenge of the model lies in the breadth and complexity of knowledge required to practice competently across both domains. Despite the intention of combined fellowship programs to ensure balanced training in hematology and oncology, clinical exposure varies substantially which may lead to inadequate preparation for the realities of practice and contribute to future career dissatisfaction. At the same time, the expanding scientific and clinical scope of both fields places considerable pressure on already crowded curricula. In this context, benign hematology – often less procedurally oriented and less commercially supported – risks marginalization, raising concerns about workforce preparedness to manage non-malignant blood disorders.

More adaptive curricular structures that permit early or later subspecialty tracking while maintaining a common heme-onc foundation may help align with future workforce needs.

Health-system and policy factors, especially in the context of LMICs, where training capacity, specialist numbers, and clinical resources are often limited – add extra pressure. Reimbursement often favors oncology treatments over hematology care, like transfusions or managing clotting disorders, which can affect practice patterns and threaten the sustainability of comprehensive care.

Recruitment into academic medicine remains a challenge across medical specialties. A 2025 national survey of U.S. hematology/oncology fellowship leaders found that about one-third of trainees pursue community-based careers despite training in academic centers. While most leaders agree that fellowship programs should prepare trainees for community practice, non-clinical career skills remain insufficiently covered [4].

In Armenia, residency training in adult hematology and medical oncology is organized as two separate specialty tracks. In contrast, pediatric hematology and pediatric oncology are integrated into a single residency program. This model provides combined exposure to pediatric hematologic and oncologic diseases within a single center and training pathway based at the Yeolyan Center. Separate tracks provide focused expertise in a single discipline, yet may require more coordination if transitioning between hematology and oncology roles. At the same time, comprehensive exposure to both hematology and oncology disorders in children facilitates a multidisciplinary approach but can stretch trainee focus and depth in either hematology or oncology individually and may also cause quicker mental burnout when covering two subspecialties simultaneously. As with any functioning training model, each track has its advantages and limitations, and in both cases, the scenario that balances specialization, comprehensive care, and trainee sustainability was selected. In fact, in recent years, the field of pediatric oncology has been rapidly advancing, offering, in many settings, survival rates of up to 70%, and these training program has prepared specialists who are considered experts in their fields and are active members of international working groups.

Despite the unavailability of some diagnostic tools, advanced treatment options such as targeted therapies or immunotherapies, and the lack of genetic and

molecular data, the medical community in Armenia remains committed to providing the best possible care. Efforts are underway to address these gaps by advocating for the registration of therapeutic agents and exploring avenues for funding assistance. Since 2019, there has been a steady increase in coverage of services in Armenia, attributed to a rise in the health budget, and the country is making concerted efforts to successfully implement universal health coverage.

There is an increasing emphasis each year on the advancement of scientific research in Armenia**.** This emphasis is reflected in the heightened engagement of professionals in conducting and participating in clinical trials, attending international scientific events, and fostering the promising careers of young specialists. Armenian hematologists-oncologists are also striving to make contributions to global medical and scientific endeavors. In this context, it is worth mentioning the commencement of the blastic plasmacytoid dendritic cell neoplasm (BPDCN) international registry in 2022, initiated by the Immune Oncology Research Institute, which is the only similar initiative globally [8].

Table 2

Major Hematology and Oncology Conferences

Conference	Primary Focus	Approx. Attendance
Major Hematology Conferences		
American Society of Hematology (ASH) Annual Meeting & Exposition	Malignant and non-malignant blood disorders, premier global hematology event with research, clinical updates, and education	30,000+
European Hematology Association (EHA) Congress	Cutting-edge hematology research and clinical updates across Europe and globally	~17,000
British Society for Haematology (BSH) Annual Scientific Meeting	UK-focused advances in hematology	~2,000
Society of Hematologic Oncology (SOHO) Annual Meeting	Hematologic malignancies (leukemias, lymphomas, myeloma)	~3,500
Major Oncology Conferences		
American Society of Clinical Oncology (ASCO) Annual Meeting	Broad oncology, clinical trials and practice-changing data across cancers	40,000+
European Society for Medical Oncology (ESMO) Congress	Advances in oncology research and care	~25,000
IASLC World Conference on Lung Cancer	Thoracic malignancies (lung cancer focus)	~7,000
SABCS (San Antonio Breast Cancer Symposium)	Breast cancer (specialized oncology)	~10,000

Many physician-scientists ultimately choose hematology/oncology because of the rapid pace of scientific advances and the opportunities for biomedical research. In addition to traditional bench (“wet lab”) research, many focus on computational biology and health services (“dry lab”) work. Reviews on ASH educational resources detail how research priorities (bioinformatics, Real-World Data, Artificial Intelligence) reshape clinical expectations.

Conclusion

The clinical and biological overlap between hematology and oncology is evident, as many cancers originate in the blood, bone marrow, and lymphatic system, making cancer care and blood-system medicine naturally connected. The growing convergence of diagnostic and therapeutic strategies, emerging targeted and cellular approaches further reinforces the rationale for integrating the two domains. Such combined models reduce fragmentation of care, and facilitate multidisciplinary management but also demand broad training, a commitment to lifelong learning, and robust infrastructure. Addressing these challenges may require a deliberate shift from uniform integration toward structured differentiation within unity. When sustaining the dual model, aligning incentives across hematology-oncology practice pathways is essential to prevent underutilization of the hematology track.

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Гематология и онкология: от концептуальной дихотомии к интегрированной дисциплине в эпоху патофизиологии рака

С. А. Микаелян, Х. С. Хачатрян, Г. Н. Тамамян, М. Г. Мелик-Андреасян, Х. Г. Григорян, А. В. Саргсян

На первый взгляд, гематология и онкология представляются как отдельные медицинские дисциплины: гематология сосредоточена на патологиях крови, костного мозга и лимфатической системы, в то время как онкология занимается изучением и лечением различных злокачественных новообразований. Эта традиционная дифференциация способствовала восприятию дихотомии между двумя дисциплинами. Однако достижения в понимании патофизиологии рака постепенно размыли эти границы, особенно в изучении и лечении гематологических злокачественных новообразований, которые разделяют ключевые биологические механизмы с солидными опухолями, но при этом требуют специализированной гематологической экспертизы. Эта конвергенция способствовала формированию интегрированной дисциплины – гематологии-онкологии. В данном обзоре рассматриваются как историческое расхождение, так и научный и клинический фундамент, обеспечивающий интеграцию гематологии и онкологии, и как эта интеграция влияет на подготовку специалистов и организацию клинической практики в современных условиях академических, клинических и кадровых вызовов.

Արյունաբանություն և ուռուցքաբանություն. գաղափարական դիխոտոմիայից մինչև ինտեգրված դիսցիպլինա քաղցկեղի պաթոֆիզիոլոգիայի դարաշրջանում

Ս.Ա. Միքայելյան, Հ.Ս. Խաչատրյան, Գ.Ն. Թամամյան, Մ.Գ. Մելիք-Անդրեասյան, Հ.Գ. Գրիգորյան, Ա.Վ. Սարգսյան

Առաջին հայացքից հեմատոլոգիան և օնկոլոգիան հանդես են գալիս որպես առանձին բժշկական ոլորտներ: Արյունաբանությունը կենտրոնացած է արյան, ոսկրածուծի և լիմֆատիկ համակարգի պաթոլոգիաների վրա, իսկ ուռուցքաբանությունը՝ չարորակ հիվանդությունների ուսումնասիրության և բուժման վրա: Այս ավանդական տարանջատումը հանգեցրել է երկու մասնագիտությունների միջև դիխոտոմիկ ընկալման: Այնուամենայնիվ, քաղցկեղի պաթոֆիզիոլոգիայի իմացության ընդլայնումն աստիճանաբար ջնջել է այդ սահմանները հատկապես արյան չարորակ նորագոյացությունների ուսումնասիրության և բուժման հարցում, որոնք թեև կիսում են սոլիդ ուռուցքներին բնորոշ հիմնական կենսաբանական մեխանիզմները, սակայն պահանջում են արյունաբանական նեղ մասնագիտական փորձառություն: Այս կոնվերգենցիան նպաստել է արյունաբանություն-ուռուցքաբանություն ինտեգրված դիսցիպլինայի ձևավորմանը:

Սույն հոդվածում քննարկվում են ինչպես արյունաբանության և ուռուցքաբանության պատմական տարանջատումը, այնպես էլ ինտեգրման գիտական և կլինիկական հիմքը, և թե ինչպես է այն ազդում մասնագետների պատրաստման ու գործունեության կազմակերպման վրա ներկայիս ակադեմիական, կլինիկական և կադրային մարտահրավերների պայմաններում:

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