



# Hematology



## WHAT IS HEMATOLOGY?

The study (morphology, physiology, and pathology) of blood and blood-forming organs and the diseases thereof

- Uses:
  - As part of a routine medical exam to assess overall health
  - Diagnosis (e.g., an infection, anemia, leukemia)
  - Monitoring of a condition and its treatment

## HEMATOPOIESIS/HEMOPOIESIS

The formation of blood cells and platelets. In a fetus, formation starts in the yolk sac, moves to the liver and spleen, and then moves to the bone marrow. In an infant, formation occurs in bone marrow, which is present in almost all bones. In an adult, formation of blood cells (red and most white) and platelets occurs in the marrow of the proximal ends of the femur, pelvis, sacrum, vertebrae, ribs, sternum, and skull.

- **Hemopoietic growth factors:** Erythropoietin (EPO), FLT3 ligand (FLT3-L), granulocyte colony-stimulating factor (G-CSF), granulocyte-macrophage-CSF (GM-CSF), interleukin-1 (IL-1), IL-3, IL-5, IL-6, macrophage-CSF (M-CSF), stem cell factor (SCF), thrombopoietin (TPO), tumor necrosis factor (TNF), vascular endothelial growth factor (VEGF). Effects are mediated by binding receptors on cell surfaces.
- **Hemopoietic stem cell:** Pluripotent, rare (frequency is 1 per 20 million nucleated cells in bone marrow) CD34<sup>+</sup>CD38<sup>-</sup>Lin<sup>-</sup> phenotype. Gives rise to more than 10<sup>6</sup> mature cells after 20 cell divisions and can self-renew by asymmetric cell division.
- **Hemopoietic progenitor cell:** Multipotent.
- **Erythropoiesis:** Formation of red blood cells (RBCs); regulated by EPO, which is secreted by the kidneys in response to hypoxia (oxygen tension, the partial pressure of oxygen).
  - Stem cell → progenitor cell → colony-forming unit (CFU) granulocyte, erythroid, monocyte, and megakaryocyte (GEMM) (CFU<sub>GEMM</sub>) → burst-forming unit (BFU) erythroid (BFU-E) (CFU<sub>E</sub>) → proerythroblast → series of normoblasts in marrow that decrease in size, increase in hemoglobin (Hb) content, lose RNA; protein synthesis apparatus, and increase chromatin condensation → reticulocyte (nucleus extruded; nuclear DNA lost), which contains some ribosomal RNA (rRNA) and synthesizes Hb → mature erythrocyte (RBC) (red), which is a non-nucleated, bi-concave disc (i.e., cell-like).
  - Assays by Hb level, reticulocyte count, and bone marrow exam.
  - **Total erythropoiesis** assessed by the cellularity of marrow and myeloid/erythroid ratio.
  - **Effective erythropoiesis** assessed by reticulocyte count.
  - **Ineffective erythropoiesis:** 50–15% of erythroblasts die in bone marrow; increases in some chronic anemias; associated with increased unconjugated bilirubin (derived from the breakdown of Hb) and lactate dehydrogenase LDH (derived from breakdown of cells) in serum.
- **Extramedullary hematopoiesis (EH):** Formation and development of blood cells outside bone marrow in response to the failure of erythropoiesis in bone marrow.
- **Granulopoiesis:** Formation of granulocytes.
  - Stem cell → CFU → CFU granulocyte progenitor (CFU<sub>G</sub>) → basophil
  - Stem cell → CFU → CFU granulocyte monocyte neutrophil (CFU<sub>GMN</sub>) → CFU eosinophil progenitor (CFU<sub>E</sub>) → eosinophil (acidophil)
  - Mast cell (mastocyte or basophil)
  - Stem cell → CFU → CFU → CFU granulocyte monocyte progenitor (CFU<sub>GMP</sub>) → CFU-G → neutrophil
- **Lymphopoiesis:** Formation of lymphocytes and natural killer (NK) cells.
  - Stem cell → common lymphoid progenitor → B-lymphocyte (B cell)
  - Stem cell → common lymphoid progenitor → thymus → T lymphocyte (T cell)
  - Stem cell → common lymphoid progenitor → natural killer cell (NK cell)
- **Myelopoiesis:** Formation of blood marrow and all blood cells in marrow.
  - Monocyte formation
  - Stem cell → CFU → CFU → CFU → CFU-M → monocyte
- **Thrombopoiesis:** Formation of thrombocytes, or platelets, in about 10 days; regulated by TPO (95% from the liver; 50% constitutively produced and 50% produced in response to platelet destruction). As the platelet ages, it loses cell-surface sialic acid, exposing galactose residues that attach to the Achewell-Morell receptor in the liver, signaling for TPO production.
  - Stem cell → CFU → CFU megakaryocyte progenitor (CFU<sub>MK</sub>) → platelet (fragment of cytoplasm of megakaryocyte)
  - TPO binds to the c-MPL receptor on megakaryocytes and platelets, so plasma TPO is low in patients with excess platelets and high in patients with thrombocytopenia.

## ORGANS OF THE LYMPHATIC SYSTEM

- **Bone marrow:** Modified connective tissue in bone cavities that is soft, fatty, and vascular.
  - **Red marrow:** Where blood cells are formed.
  - **Yellow marrow:** Mostly fat.
- **Lymph nodes:** Small, widespread organs of the lymphatic system, connected by lymphatic vessels. They filter lymph, form lymphocytes, become inflamed/enlarged with infection, disease, and injury, and are used to stage cancer.
- **Thymus gland:** Lymphoid organ behind the sternum where T cells are produced and mature; mature T cells migrate to lymph nodes throughout the body. This gland decreases in size with the onset of puberty and is replaced with fat.
  - **Thymosin:** Hormone produced by the thymus gland; stimulates T cell development.
- **Tonsils:** Pair of masses of lymphoid tissue located at the root of the tongue in the throat; M cells on the surface take up antigens (Ag) produced by pathogens and stimulate B cells and T cells; they also produce T cells.
- **Spleen:** Largest organ of the lymphatic system, located in the upper left quadrant of the abdomen. It filters blood, including old and damaged red blood cells, and produces lymphocytes.

## BLOOD

Delivers oxygen, nutrients, and hormones to tissues; delivers carbon dioxide to lungs and other waste products to kidneys for removal; blood that leaves the heart returns in 20–30 seconds; there are 5–6 quarts of blood in the human body.

### COMPONENTS

#### Red Blood Cells (RBCs)

- Also called **erythrocytes**, they are non-nucleated, bi-concave discs when mature. They contain Hb, have a 120-day lifespan, and are 6–8 µm diameter (avg).
- **Hemoglobin (Hb):** 4 polypeptide (globin) chains: 96–98% Hb-A (α<sub>2</sub>β<sub>2</sub>), 1.5–1.2% Hb-A<sub>2</sub> (α<sub>2</sub>β<sub>2</sub>), and 0.5–0.8% Hb-F (α<sub>2</sub>γ<sub>2</sub>), wherein each polypeptide chain (α, β, γ, and δ) contains an iron atom bound to protoporphyrin to form a heme; it transports oxygen from lungs to body tissues and carbon dioxide from body tissues to lungs.

#### White Blood Cells (WBCs)

Also called **leukocytes**, they defend the body against infection. There is ~1 WBC for every 500–700 RBCs.

#### GRANULOCYTES

- Also called **myelocytes**, they are immune cells containing granules that release enzymes.
- **Basophil:** Cell's granules release enzymes during an allergic reaction, asthma, and infection. It can be stained by basic dye, is phagocytic, and has a lifespan of a few hours to a few days.
- **Eosinophil (acidophil):** Cell's granules release enzymes during an allergic reaction, asthma, and an infection with parasites. It can be stained by acidic dye, is phagocytic, and has a lifespan of 8 to 12 days.
- **Neutrophil (polymorph):** Most numerous WBC; characterized by a dense, multi-lobed nucleus (2–5 lobes) and a pale cytoplasm with an irregular outline and fine azurophilic granules, which are predominantly secondary (specific) granules (see **myelocyte** below). Has a 6–50 hour lifespan.
  - These precursors, located in bone marrow, rarely occur in normal peripheral blood other than the band, stab, and juvenile forms.
- **Myeloblast:** Also called **myelomonoblast**, it is the earliest recognizable precursor; characterized by a large nucleus with fine chromatin and 2–5 nucleoli, and a cytoplasm with no granules. It varies in size, is capable of cell division, and it gives rise to promyelocytes. Bone marrow comprises less than 5% myeloblasts and it is difficult to distinguish from monoblasts, promonocytes, and monocytes (see **monocyte** below).
- **Promyelocyte:** Slightly larger than myeloblasts, can distinguish commitment to basophilic, eosinophilic, and neutrophilic lineages using electron microscopy (EM). Cytoplasm contains primary granules (of lysosomal origin) containing myeloperoxidase (MPO) and other acid hydrolases. It is capable of cell division, and gives rise to myelocytes.
- **Myelocyte:** Can distinguish morphological commitment to basophilic, eosinophilic, and neutrophilic lineages. The nuclear chromatin is more condensed, nucleoli are not visible, and the cytoplasm contains secondary (specific) granules of lysosomal origin containing lactoferrin, lysozyme, and other enzymes. It is capable of cell division and gives rise to metamyelocyte.
- **Metamyelocyte:** Non-dividing cell. The nucleus is indented or band-shaped and the cytoplasm contains primary and secondary granules.
- **Band, stab, or juvenile:** Forms of neutrophil between metamyelocyte and mature neutrophil. They are distinguishable from mature neutrophil by the absence of clear, fine filaments between nuclear lobes.
- **Functions:**
  - **Chemotaxis:** Cell is mobilized and migrates to a foreign material (e.g., bacterium, fungus, debris) or a site of inflammation by chemotactic substances released by damaged tissue, cytokines, and by the interaction of leukocyte adhesion molecules with ligands on damaged tissue.
  - **Phagocytosis:** Ingestion of bacteria, fungi, foreign debris, and dead or damaged host cells.
  - **Cling and digestion:**
    - **Oxygen-dependent:** Superoxide, hydrogen peroxide, and other activated oxygen species are generated from oxygen and reduced nicotinamide adenine dinucleotide phosphate (NADPH). Bacteria are killed when hydrogen peroxide reacts with halide and myeloperoxidase; process may also involve activated oxygen species.
    - **Oxygen-independent:** Proteins, such as cathelicin G, lysozyme (with hydrogen peroxide), or elastase (with hydrogen peroxide) kill bacteria; may also act with a decrease in pH inside a phagocytic vacuole containing lysosomal enzymes. Lactoferrin binds iron, thereby depriving bacteria of iron and generating free radicals (bactericlastic).

# Paramedic Hematology Study Guide

**Victor Trainor**



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**Emergency and Trauma Care for Nurses and Paramedics** Kate

Curtis, Clair Ramsden, 2011-08-15 Emergency and Trauma Care is written for Australian emergency care providers including paramedics emergency nurses pre hospital care providers nurse practitioners general practice nurses and allied health practitioners including occupational therapists and physiotherapists who are caring for trauma patients This book follows the patient journey from pre hospital to definitive care Using a body systems approach each chapter provides comprehensive coverage of all aspects of adult and paediatric emergencies Implications for clinical practice is supported by chapters of professional practice clinical skills research evidence based practice and legal ethical and cultural issues Clinical assessment physiology management and rationale for intervention of common and not so common emergency presentations are provided with each chapter providing clear and relevant examples for both Paramedics and Nurses Emergency and Trauma Care brings together a team of highly respected clinical practitioners and academics to deliver the most up to date text dealing with the practical procedures and evidence experienced by emergency and trauma care providers every day Chapter 2 Pre hospital care overview in Australia and NZ Chapter 10 Scene assessment management and rescue Chapter 11 Pre Hospital Clinical Reasoning Triage and Communication Pre hospital and emergency nursing considerations included in all relevant chapters Chapter 5 Cultural Considerations in Emergency Care addresses cultural diversity beliefs and values and focuses on Aboriginal and Torres Strait Islander health and Maori health Chapter 19 Resuscitation includes advanced life support airway management and incorporates the 2010 Australian Resuscitation Council guidelines Chapter 37 People with disabilities provides assessment examination and communication strategies for working with clients with intellectual and physical disabilities Section 5 focuses on examination and communication strategies for working with unique population groups including the elderly disabled obstetric and paediatric patients Section 6 details major trauma assessment and management blast injury and trauma to specific body regions Essentials outline the main points addressed in each chapter Practice tips assist with communication skills procedures and assessment Case studies supported by questions throughout Summaries and Key points review questions web links and references provide for consolidation and further research Evolve resources include Power point slides 30 additional Case studies image bank web links Three paramedic specific chapters including scene assessment and management      **Paramedic Care** Bryan E. Bledsoe, Robert S. Porter, Richard A.

Cherry, 2009 Completely updated in a new edition and written by the best selling author team of Bryan E Bledsoe D O F A C E P EMT P Robert S Porter M A NREMT P and Richard A Cherry M S NREMT P this student friendly easy to understand series covers the DOT National Standard Curriculum The third of 5 titles in the Brady Paramedic Care Principles and Practice series Volume 3 Medical Emergencies covers pulmonology cardiology neurology endocrinology allergies and anaphylaxis gastroenterology urology and nephrology toxicology and substance abuse hematology environmental emergencies infectious diseases psychiatric and behavioral emergencies gynecology and obstetrics      **Current Catalog** National Library of Medicine (U.S.), 1992 First multi year cumulation covers six years 1965 70      **Veterinary Technician's Daily Reference**

**Guide** Candyce M. Jack, Patricia M. Watson, 2014-05-20 Veterinary Technician's Daily Reference Guide Canine and Feline Third Edition provides a quick reference to all aspects of a technician's daily responsibilities in clinical practice. Retaining the tabular format for easy access, the Third Edition adds more in-depth skill descriptions, allowing the technician to reach an even higher level of care. Coverage ranges from anatomy and preventative care to diagnostic and patient care skills, pain management, anesthesia, and pharmacology. Now fully revised and updated, the book is designed to build on a veterinary technician's current knowledge, acting as a quick refresher in the daily clinic setting. A companion website offers forms and worksheets, training materials, review questions, vocabulary flashcards, links to online resources, and the figures from the book in PowerPoint. The Third Edition is an invaluable practical resource for increasing confidence and improving technical skills for veterinary technicians.

**Magill's Medical Guide** Anne Chang, 2008. Covers diseases, disorders, treatments, procedures, specialties, anatomy, biology, and issues in an A-Z format with sidebars addressing recent developments in medicine and concise information boxes for all diseases and disorders.

**Interactive Video Primer: Medical Education** Scott Alan Stewart, 1990-05-01. Provides an overview on the use of interactive videodisc systems in medical education. Includes information about videodisc systems, computer graphic overlay boards, and videodisc players, as well as videodisc programs developed by universities and colleges, commercial firms, professional associations, public organizations, and testing and certification organizations. Videodisc research, surveys, periodicals, conferences, film festivals, and other resources also are listed.

American Book Publishing Record, 2006.

**Guidance Manual for Complying with the Hazardous Waste Source Reduction & Management Review Act of 1989** California Environmental Protection Agency. Dept. of Toxic Substances Control. External Affairs. Office of Pollution Prevention and Technology Development, 1999.

*Lovejoy's Career and Vocational School Guide* Clarence Earle Lovejoy, 1982. A directory of schools and opportunities for training in more than 250 careers, skills, and trades.

NHSQIC Annual Bibliography National Health Standards and Quality Information Clearinghouse (U.S.), 1980.

*Emergency Medical Services*, 1996.

**Who's Who in Medicine and Healthcare** Marquis Who's Who, Inc., 1998. Recognizing today's leaders in the teaching, practice, planning, financing, and delivery of healthcare. Across the country, healthcare professionals are facing new demands for accessible, high-quality care at a reasonable cost. Who's Who in Medicine and Healthcare™ recognizes those whose achievements place them at the forefront of an evolving healthcare system. The current edition provides vital biographical background on approximately 22,700 successful medical professionals, administrators, educators, researchers, clinicians, and industry leaders from across the diverse fields of medicine and healthcare: Association administration, Dentistry, Medical education, Geriatrics, Gynecology, Healthcare products, Hospital administration, Internal medicine, Mental health, Nursing, Optometry, Pediatrics, Pharmaceuticals, Public health, Research, Social work, Speech pathology, Substance abuse, Surgery.

1996 Healthcare CAI Directory Scott Alan Stewart, 1996-05-01. Contains descriptions for 864 computer-assisted instruction and reference programs for Medicine, Nursing, Allied Health, Dentistry, and

other health professions Those dealing with Patient Education and Health Promotion can be found in a separate volume

**The Publishers' Trade List Annual**, 1981      **Nelson Textbook of Pediatrics E-Book** Robert Kliegman, Joseph W. St. Geme III, 2019-04-01 Welcome to the 21st Edition of Nelson Textbook of Pediatrics the reference of choice among pediatricians pediatric residents and others involved in the care of young patients This fully revised edition continues to provide the breadth and depth of knowledge you expect from Nelson while also keeping you up to date with new advances in the science and art of pediatric practice Authoritative and reader friendly it delivers the information you need in a concise easy to use format for everyday reference and study From rapidly changing diagnostic and treatment protocols to new technologies to the wide range of biologic psychologic and social problems faced by children today this comprehensive reference keeps you on the cutting edge of the very best in pediatric care Includes more than 70 new chapters including Postural Orthostatic Tachycardia Syndrome POTS Rare and Undiagnosed Diseases Approach to Mitochondrial Disorders Electronic Nicotine Delivery Systems Zika update on Ebola Epigenetics Autoimmune Encephalitis Global Health Racism Media Violence Strategies for Health Behavior Change Positive Parenting and many more Features hundreds of new figures and tables throughout for visual clarity and quick reference Offers new and expanded information on CRISPR gene editing LGBT health care gun violence vaccinations immune treatment with CAR T cells new technology in imaging and genomics new protocols in cancer genetics immunology and pulmonary medicine and much more Provides fresh perspectives from four new associate editors Nathan J Blum of The Children's Hospital of Philadelphia Karen Wilson of Mt Sinai School of Medicine in New York Samir S Shah of Cincinnati Children's Hospital Medical Center and Robert C Tasker of Boston Children's Hospital Remains your indispensable source for definitive evidence based answers on every aspect of pediatric care

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