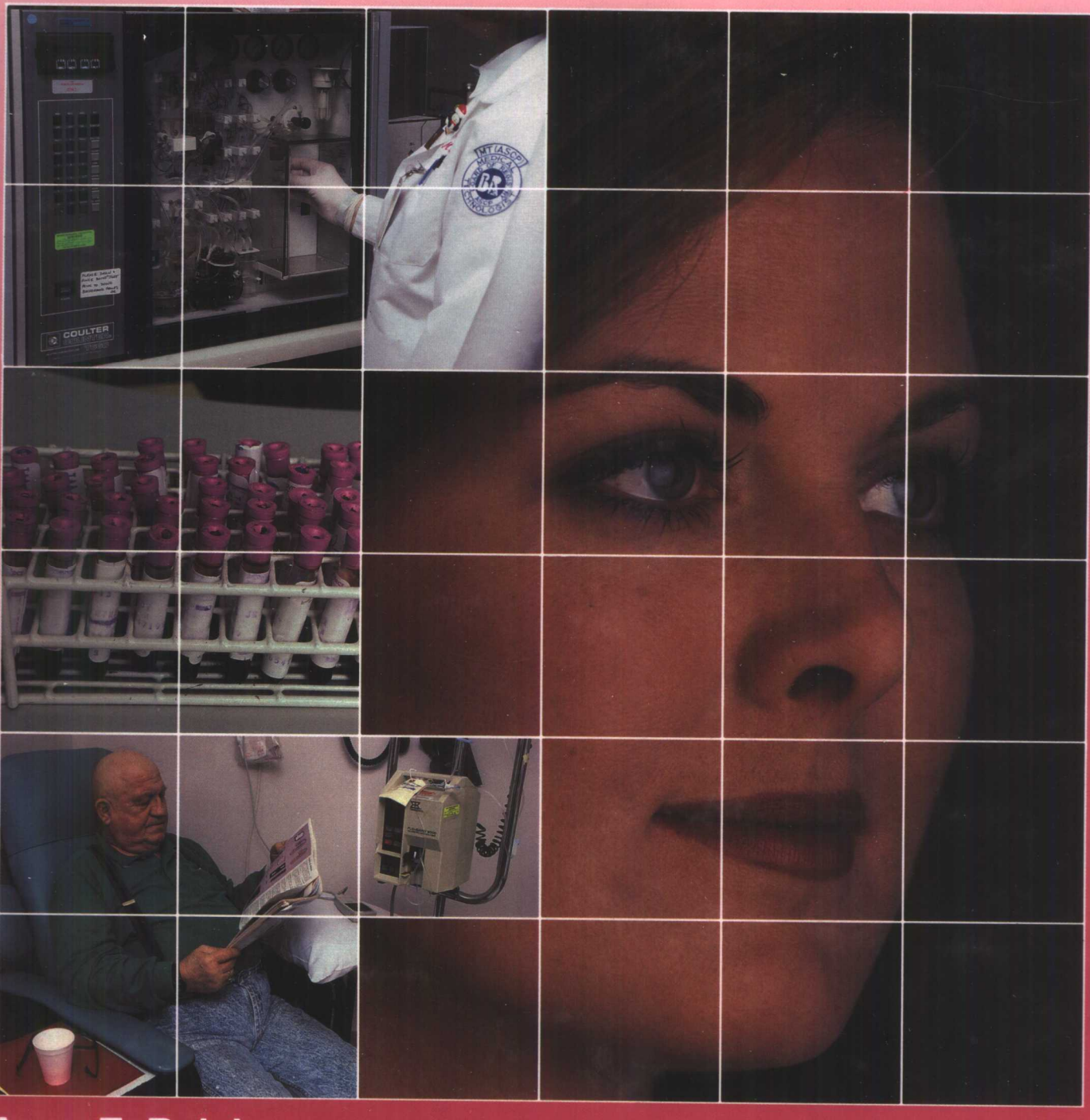
BLOOD DISORDERS

Mosby's Clinical Nursing Series



Anne E. Belcher

BLOOD DISORDERS

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Preface

Blood Disorders is the eleventh volume in *Mosby's Clinical Nursing Series*, a new kind of resource for practicing nurses.

The *Series* is the result of the most elaborate market research ever undertaken by Mosby. We first surveyed hundreds of working nurses to determine what kinds of resources practicing nurses want to meet their advanced information needs. We then approached clinical specialists, proven authors and experts, and asked them to develop a format that would meet the needs of nurses in practice. This format was presented to nine focus groups composed of working nurses and refined between each group. In the later stages we published a 32-page, full-color sample so that detailed changes could be made to improve physical layout and appearance, section by section and page by page. The result is a new genre of professional books for nursing professionals.

Blood Disorders begins with a clear and concise discussion of the anatomy and physiology of the blood and blood-forming organs. The first chapter includes a variety of illustrations that depict sometimes difficult-to-visualize aspects of normal and abnormal cellular generation and function.

Chapter 2 is a pictorial guide to the nurse's assessment of the body systems affected by blood disorders. Clear, full-color photographs show proper position and technique in sharp detail, augmented by concise instructions, rationales, and tips.

Chapter 3 presents the latest in diagnostic tests, using full-color photographs of equipment, techniques, monitors, and output. A consistent format for each procedure provides information about the purpose of the test, indications and contraindications, and nursing care associated with each test, including patient teaching. Inside the front cover of the book are tables of normal laboratory values.

Chapters 4 through 9 present the nursing care of patients experiencing specific blood disorders and the major surgical and therapeutic interventions. Chapter 4 focuses on erythrocytic disorders; Chapter 5 on leukocytic disorders; Chapter 6 on thrombocytic disorders; Chapter 7 on myelodysplastic syndromes; Chapter 8 on multiple myeloma; and Chapter 9 on lymphomas. Information on pathophysiology answers questions nurses often have. Definitive diagnostic tests and the physician's treatment plan are briefly reviewed to promote collaborative care among members of the health team.

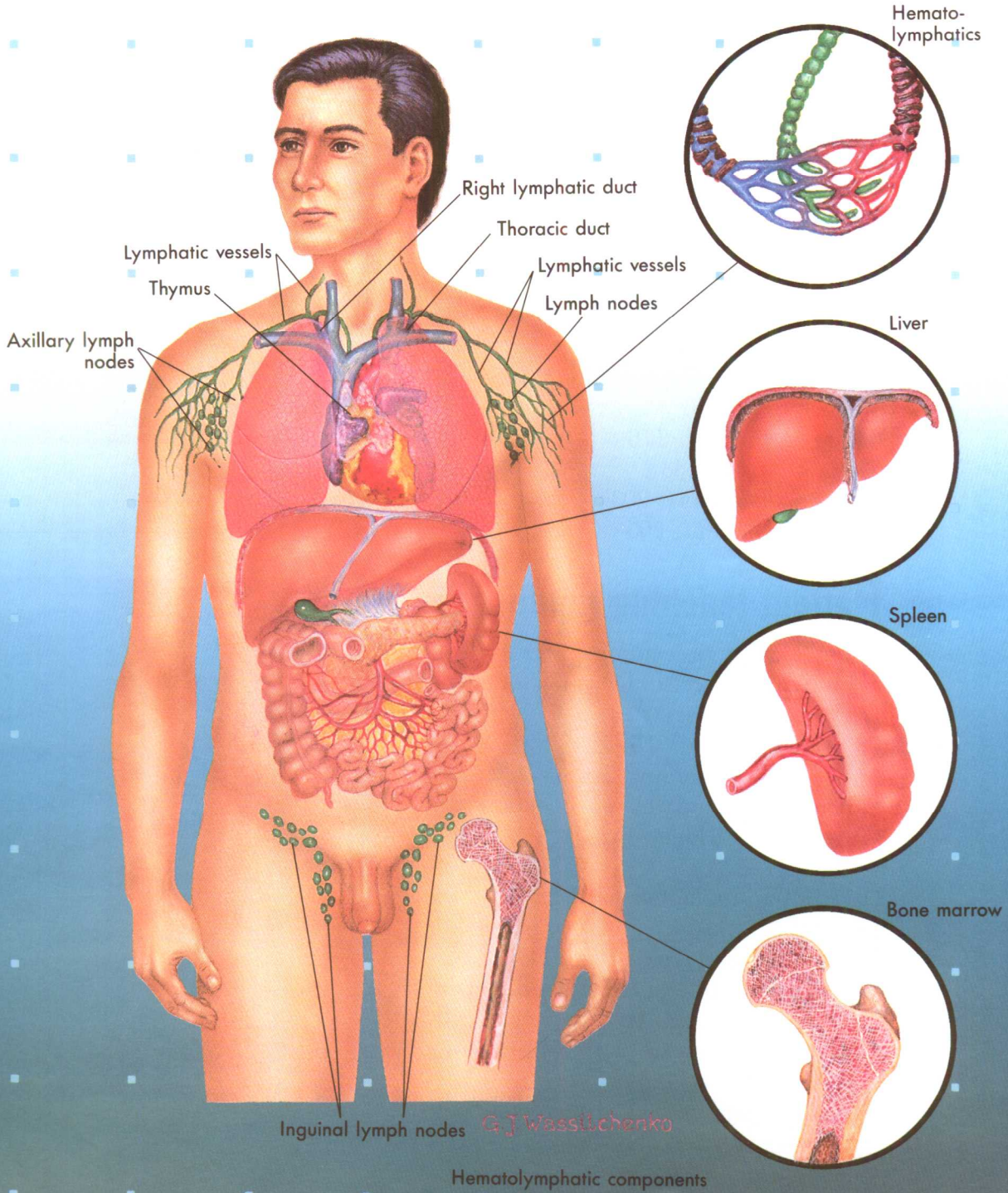
The heart of the book is the nursing care, presented according to the nursing process. These pages are bordered in blue to make them easy to find and use on the unit. The nursing care is structured to integrate the five steps of the nursing process, centered around appropriate nursing diagnoses accepted by the North American Nursing Diagnosis Association (NANDA). The material can be used to develop individualized care plans quickly and accurately, and it meets the standards of nursing care required by the Joint Commission on the Accreditation of Healthcare Organizations (JCAHO). By facilitating the development of individualized and authoritative care plans, this book can actually save you time to spend on direct patient care.

Chapter 10 describes therapies, including surgery, radiation, chemotherapy, and bone marrow transplantation. Supportive therapies such as blood and blood-component therapy, nutritional support, and pain management are also described.

In response to requests from scores of nurses participating in our research, a distinctive feature of this book is its use in patient teaching. Background information on diseases and medical interventions enables nurses to answer with authority questions patients often ask. The illustrations in the book, particularly those in the color atlas (Chapter 1) and the chapter on diagnostic procedures (Chapter 3), are specifically designed to support patient teaching. Chapter 11 consists of 15 patient teaching guides written to be copied, distributed to patients and their families, and used for self-care after discharge. In addition, patient teaching sections in each care plan provide nurses with checklists of concepts to teach, promoting this increasingly vital aspect of care.

The book concludes with a concise guide to drugs used for the treatment of blood disorders, and, inside the back cover, a resource section directs you to organizations and other resources for nurses and patients.

We hope this book contributes to the advancement of professional nursing by serving as a first step toward a body of professional literature for nurses to call their own.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Right lymphatic duct
Thoracic duct
Lymphatic vessels
Thymus
Lymphatic vessels
Lymph nodes
Axillary lymph
nodes
Liver
Spleen
Bone marrow
Inguinal lymph nodes
G.J. Wassilchenko
Hematolymphatic components

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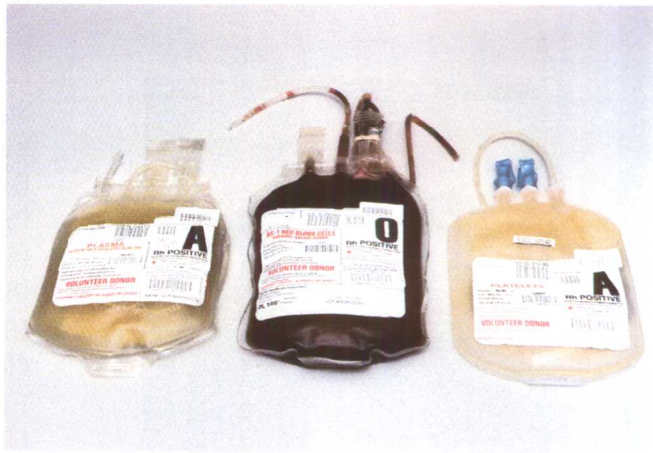

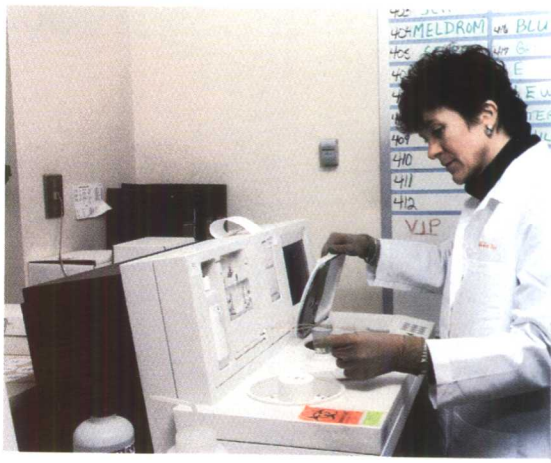

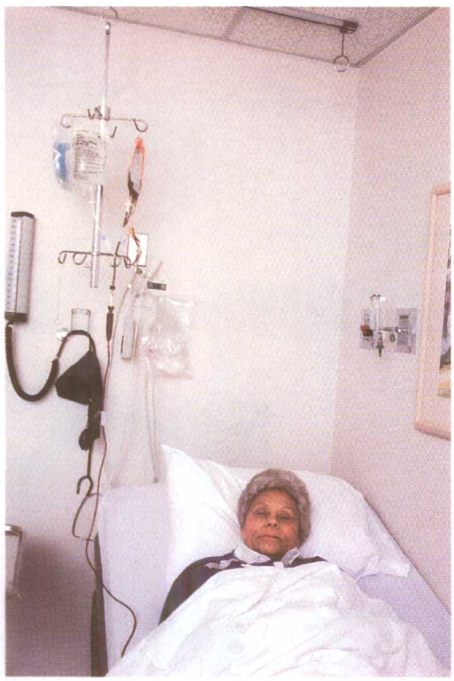

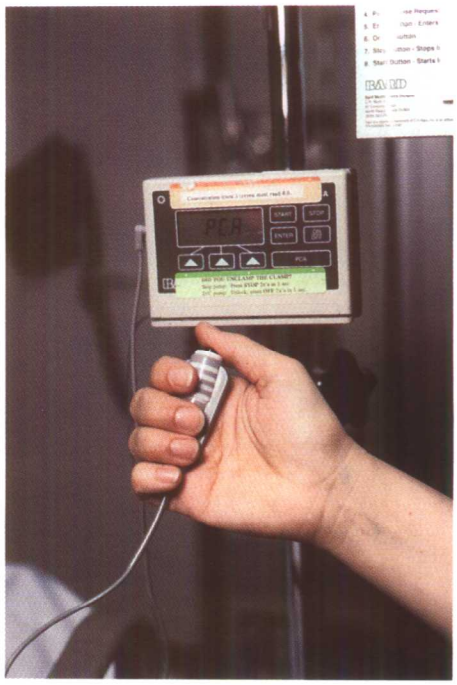

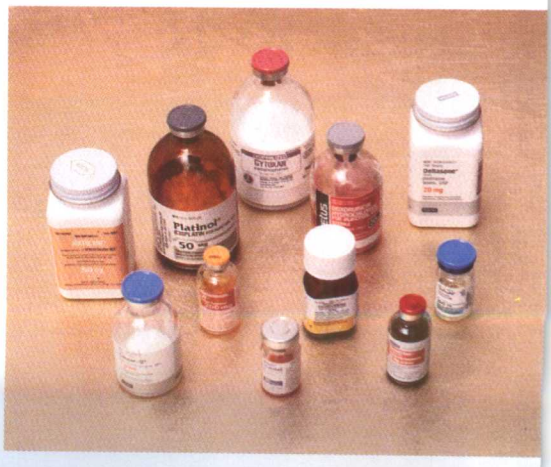

CHAPTER 1

Color Atlas of the Blood and Blood-Forming Organs

HEMATOLYMPHATIC SYSTEM

The hematolymphatic system is composed of blood and blood-forming organs, the bone marrow, spleen, liver, and lymphatics.

BLOOD AND ITS COMPONENTS

Blood, which circulates continuously through the heart and vascular system, performs numerous vital functions (see box).

The major characteristics of blood include color (arterial blood is bright red; venous blood is dark red); viscosity (blood is three to four times thicker than water); reaction (the pH is 7.35 to 7.4); and volume (adults have approximately 70 to 75 ml/kg of body weight, or 5 to 6 L).

Blood is a suspension of particulate matter in an aqueous solution of colloid and electrolytes that serves as a medium of exchange between body cells and the exterior. It also has protective properties that benefit the body and the blood itself. The liquid portion of blood, **plasma,** is a suspension of colloid, electrolytes, proteins, and numerous other substances (Table 1-1). The concentration of these substances varies on the basis of diet, metabolic demand, hormones, and vitamins. **Serum** is plasma that has had fibrinogen (a clotting factor) or some other unwanted or unneeded substance removed from the sample in the laboratory.

Plasma is about 90% water and 10% dissolved substances (solutes). The dominant substances in weight are the plasma proteins, which are classified as albumins; globulins (immunoglobulins and gamma-globulins); and clotting factors, primarily fibrinogen.

The plasma proteins are synthesized in the liver, except for the **immunoglobulins,** which are synthesized by lymphocytes in the lymph nodes and other lym-

FUNCTIONS OF BLOOD

- Transport of oxygen and absorbed nutrients to cells
- Transport of waste products to kidneys, skin, and lungs
- Transport of hormones from endocrine glands to other tissues
- Protection of the body from life-threatening microorganisms
- Regulation of body temperature by heat transfer

Table 1-1

ORGANIC AND INORGANIC COMPONENTS OF ARTERIAL PLASMA

Constituent	Amount/concentration	Major functions
Water	93% of plasma weight	Medium for carrying all other constituents
Electrolytes	Total <1% of plasma weight	Maintain water in extracellular compartment; act as buffers; function in membrane excitability
Sodium (Na^+)	142 mEq/L (142 mM)	
Potassium (K^+)	4 mEq/L (4 mM)	
Calcium (CA^{++})	5 mEq/L (2.5 mM)	
Magnesium (Mg^{++})	3 mEq/L (1.5 mM)	
Chloride (CL^-)	103 mEq/L (103 mM)	
Bicarbonate (HCO_3^-)	27 mEq/L (27 mM)	
Phosphate (mostly HPO_4^{2-})	2 mEq/L (1 mM)	
Sulfate (SO_4^{2-})	1 mEq/L (0.5 mM)	
Proteins	7.3 g/dl (2.5 mM)	Provide colloid osmotic pressure of plasma; act as buffers; bind other plasma constituents (e.g., lipids, hormones, vitamins, metals); clotting factors; enzymes; enzyme precursors; antibodies (immune globulins); hormones
Albumins	4.5 g/dl	
Globulins	2.5 g/dl	
Fibrinogen	0.3 g/dl	
Gases		
Carbon dioxide (CO_2) content	22-20 mmol/L plasma	By-product of oxygenation, most carbon dioxide content is from bicarbonate and acts as a buffer
Oxygen (O_2)	Pao_2 80 torr or greater (arterial); Pvo_2 30-40 torr (venous)	Oxygenation
Nitrogen (N_2)	0.9 ml/dl	By-product of protein catabolism
Nutrients		Provide nutrition and substances for tissue repair
Glucose and other carbohydrates	100 mg/dl (5.6 mM)	
Total amino acids	40 mg/dl (2 mM)	
Total lipids	500 mg/dl (7.5 mM)	
Cholesterol	150-250 mg/dl (4-7 mM)	
Individual vitamins	0.0001-2.5 mg/dl	
Individual trace elements	0.001-0.3 mg/dl	
Waste products		
Urea (BUN)	7-18 mg/dl (5.7 mM)	End product of protein catabolism
Creatinine (from creatinine)	1 mg/dl (0.09 mM)	End product from energy metabolism
Uric acid (from nucleic acids)	5 mg/dl (0.3 mM)	End product of protein metabolism
Bilirubin (from heme)	0.2-1.2 mg/dl (0.003-0.018 mM)	End product of red blood cell destruction
Individual hormones	0.000001-0.05 mg/dl	Functions specific to target tissue

(From Vander, Sherman, and Luciano.)[61a]

phoid tissues. **Albumin** is essential for regulating the passage of water and solutes through the capillaries. Because these molecules are large and do not diffuse freely through the vascular endothelium, they provide the critical colloid osmotic pressure that regulates the passage of water and solutes through the microcirculation. Albumin also serves as a carrier molecule for normal blood components and exogenous agents such as drugs. The immunoglobulins (antibodies) are synthesized by plasma cells in the lymphoid organs. The antibodies are IgA, IgG, IgM, IgD, and IgE, and they are critical for defense against infectious microorganisms.

The **clotting factors** (Table 1-2) stop bleeding from damaged blood vessels. **Fibrinogen,** the most plentiful of the clotting factors, is the precursor of the fibrin clot. **Hemostasis,** which means arrest of bleeding, involves a complex sequence of events, including vasoconstriction, formation of a platelet plug, activation of the coagulation cascade, and formation of a blood clot (Figures 1-1 and 1-2 and box on p. 3).

Other plasma proteins include complement proteins involved in the immune response, a variety of enzymes and their inhibitors, and specific carriers of such elements as iron and copper.

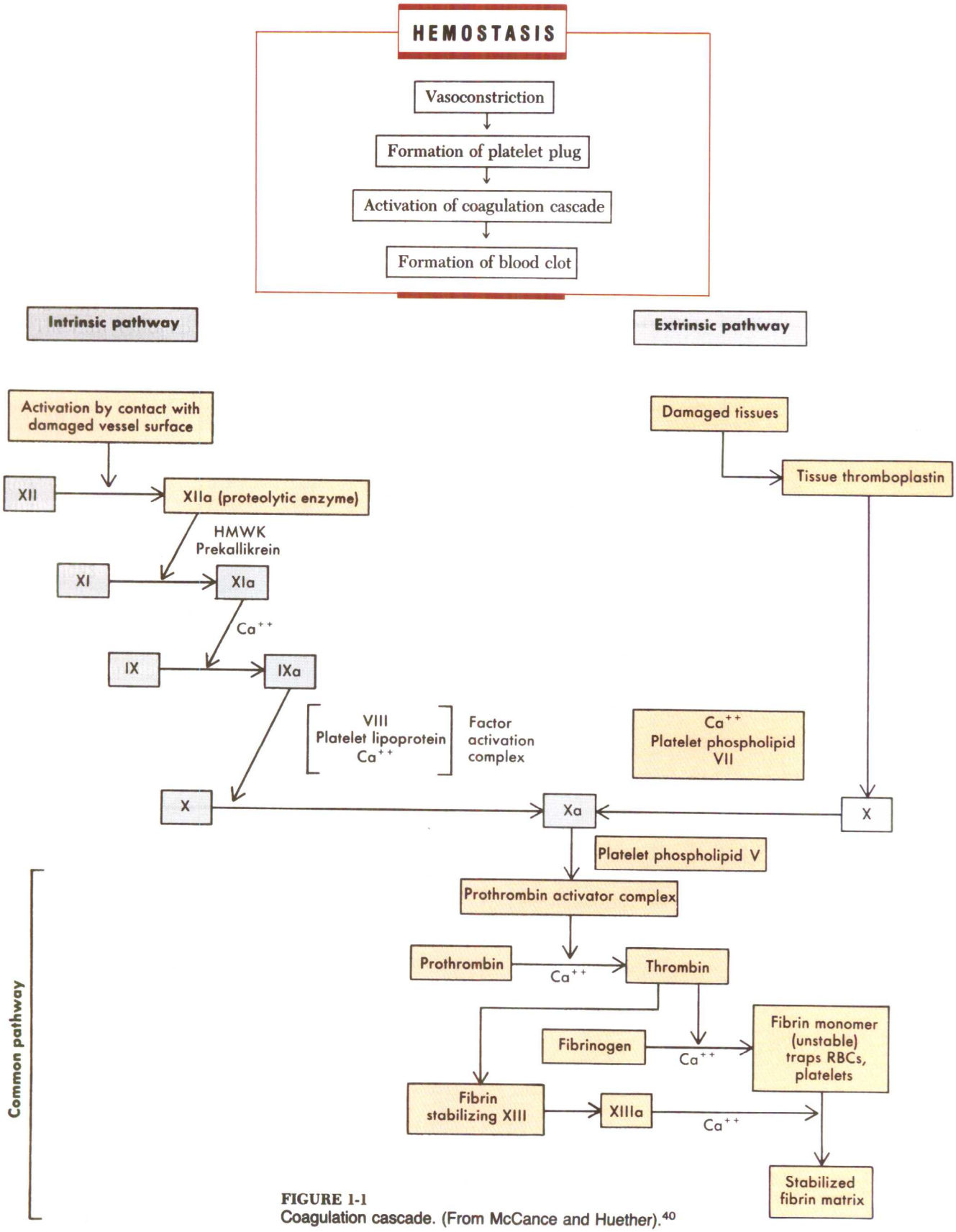

FIGURE 1-1
Coagulation cascade. (From McCance and Huether).[40]

Table 1-2

CLOTTING FACTORS

International nomenclature	Synonym	Substance	Source	Enzymatic function	Pathway of activation
I	Fibrinogen	Plasma protein	Liver	Precursor of fibrin	Final common pathway
II	Prothrombin	Plasma protein	Liver	Precursor of thrombin	Final common pathway
III	Tissue thromboplastin Tissue factor Thrombokinase	Lipoprotein and phospholipid	Released from damaged tissues	Activates prothrombin	Extrinsic pathway
IV	Calcium ion	Ion in plasma	Diet and bones	Activates prothrombin and fibrin formation	All
V	Labile factor Proaccelerin accelerator globulin (AcG) Thrombogen	Plasma protein	Liver	Accelerates conversion of prothrombin to thrombin	Final common pathway
VI	Obsolete; same as V				
VII	Serum prothrombin conversion factor Proconvertin Stable factor	Plasma protein	Liver	Accelerates conversion of prothrombin to thrombin; part of enzyme complex	Extrinsic pathway
VIII	Antihemophilic globulin (AGH) Antihemophilic factor (AHF) Thromboplastinogen Platelet cofactor 1	Plasma protein (three subunits)	Large molecular weight Subunit by endothelium	Associated with platelet factor 3 and Christmas factor (IX), activates prothrombin (II)	Intrinsic pathway
IX	Plasma thromboplastin component (PTC) Christmas factor Antihemophilic factor B Autoprothrombin II (protein C) Platelet cofactor 2	Plasma protein	Liver	Associated with platelet factors 3 and 6; activates prothrombin	Intrinsic pathway
X	Stuart-Prower factor Stuart factor Autoprothrombin III	Plasma protein	Liver and plasma	Activated by Hageman factor	Extrinsic and intrinsic pathway
XI	Plasma thromboplastin antecedent (PTA) Antihemophilic factor C	Plasma protein	Possibly liver	Activated by Hageman factor; accelerates thrombin formation; substrate for activator enzymatic complex	Intrinsic pathway
XII	Hageman factor Contact factor Glass factor Antihemophilic factor D	Plasma protein	Liver and (plasma?)	Involved in first step of activation of intrinsic pathway; activates XI	Intrinsic pathway

Table 1-2

CLOTTING FACTORS—cont'd

International nomenclature	Synonym	Substance	Source	Enzymatic function	Pathway of activation
XIII	Fibrin-stabilizing factor (FSF) Fibrinase Fibrinoligase Laki-Lorand factor (LLF) Plasma transglutaminase	Plasma protein	Present in plasma and platelets Liver	Produces stronger fibrin clot; stabilizes clot formation	Common
High-molecular-weight kininogen	HMWK Fitzgerald factor Williams factor Fluajeac factor Reid factor Washington factor	Alpha-globulin	Tissues	Activates contraction of clot	Intrinsic kinin cascade
Prekallikrein	Fletcher factor	Gamma-globulin	Tissues	Activates contraction of clot	Intrinsic kinin cascade

The factors are numbered in the order of their discovery. Numerals do not denote their sequence of activation in the coagulation cascade. (From McCance and Huether.)[40]

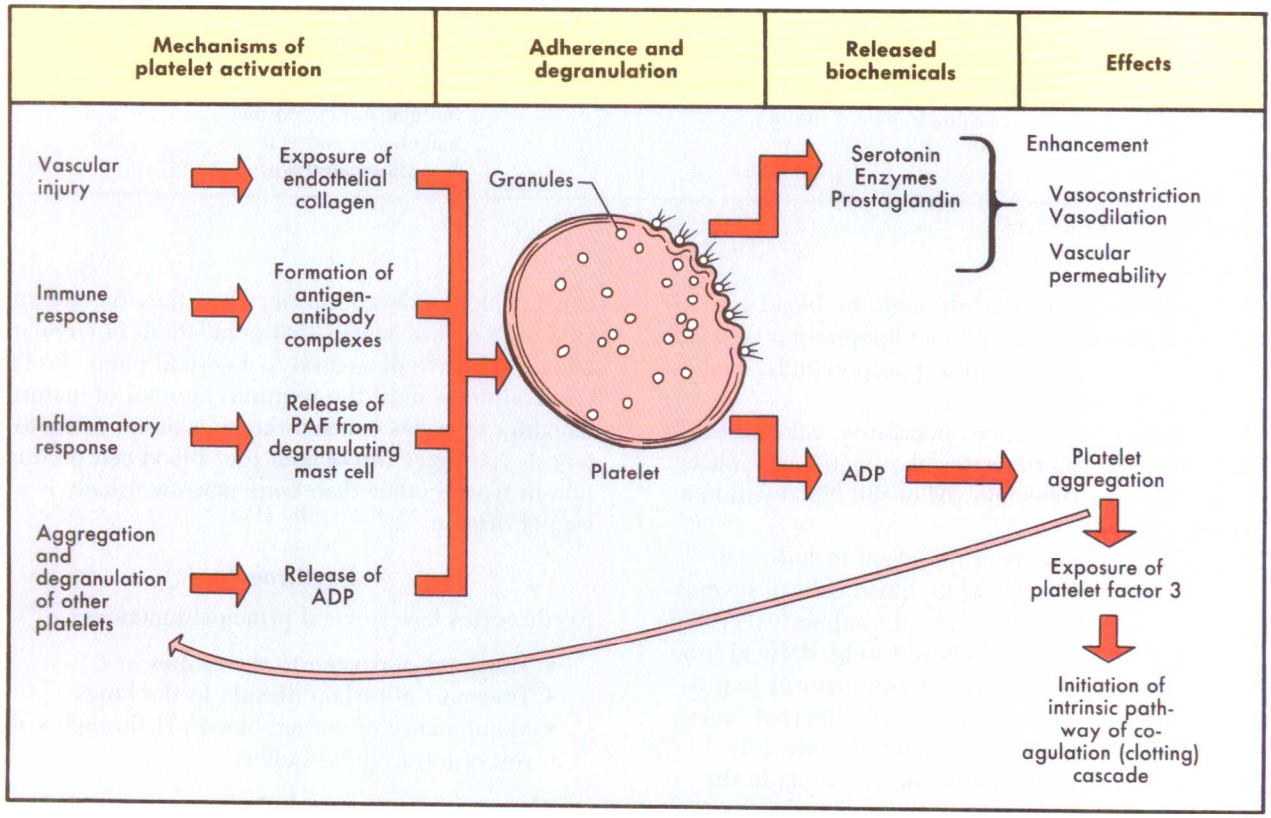

FIGURE 1-2
Platelet degranulation. PAF, Platelet-activating factor. (From McCance and Huether).[40]

Table 1-3

CELLULAR COMPONENTS OF THE BLOOD

Cell	Structural characteristics	Normal amounts in circulating blood	Function	Life span
Erythrocyte (red blood cell)	Nonnucleated cytoplasmic disk containing hemoglobin	4.2-6.2 million/mm^3	Gas transport to and from tissue cells and lungs	80-120 days
Leukocyte (white blood cell)	Nucleated cell	5,000-10,000/mm^3	Bodily defense mechanisms	See below
Lymphocyte	Mononuclear immunocyte	25%-33% of leukocyte count (leukocyte differential)	Humoral and cell-mediated immunity	Days or years, depending on type
Monocyte and macrophage	Large mononuclear phagocyte	3%-7% of leukocyte differential	Phagocytosis; mononuclear phagocyte system	Months or years
Eosinophil	Segmented polymorphonuclear granulocyte	1%-4% of leukocyte differential	Phagocytosis; antibody-mediated defense against parasites, allergic reactions; associated with Hodgkin disease, recovery phase of infection	Unknown
Neutrophil	Segmented polymorphonuclear granulocyte	57%-67% of leukocyte differential	Phagocytosis, particularly during early phase of inflammation	4 days
Basophil	Segmented polymorphonuclear granulocyte	0-0.75% of leukocyte differential	Unknown, but associated with allergic reactions and mechanical irritation	Unknown
Thrombocyte (platelet)	Irregularly shaped cytoplasmic fragment (not a cell)	140,000-340,000/mm^3	Hemostasis following vascular injury; normal coagulation and clot formation/retraction	8 to 11 days

(From McCance and Huether.)[40]

Lipoproteins are carried through the blood as complexes with **plasma proteins.** The lipoproteins include the plasma lipids, triglycerides, phospholipids, cholesterol, and fatty acids.

The **electrolytes** (sodium, potassium, calcium, magnesium, chloride, bicarbonate, phosphate, and sulfate) maintain the osmolarity and pH of the blood within a physiologic range.

The cellular elements of the blood include red blood cells (erythrocytes), white blood cells of several types (leukocytes), and platelets (thrombocytes) (Table 1-3). All of these cells are believed to be derived from a single stem cell, which divides and matures to produce three distinct types of cells with different functions, properties, and characteristics (Figure 1-3). Blood cell production (**hematopoiesis**) occurs in the bone marrow; it is a two-stage process involving mitotic division (**proliferation**) and maturation (**differentiation**). Each type of blood cell has parent cells (**stem cells**), which undergo mitosis when they receive specific biochemical signals that populations of circulating blood cells have decreased to a certain point. Proliferation continues until the required number of mature daughter cells has entered the circulation. Hematopoiesis continues throughout life. Blood cell production in tissues other than bone marrow usually is a sign of disease.

Erythrocytes

Erythrocytes have several principal functions:

- Transport of oxygen to the tissues
- Transport of carbon dioxide to the lungs
- Maintenance of normal blood pH through a series of intracellular buffers

There are approximately 5 million erythrocytes per cubic millimeter of blood; normal hemoglobin is 15 g/dl of blood. Erythrocytes are produced in the red

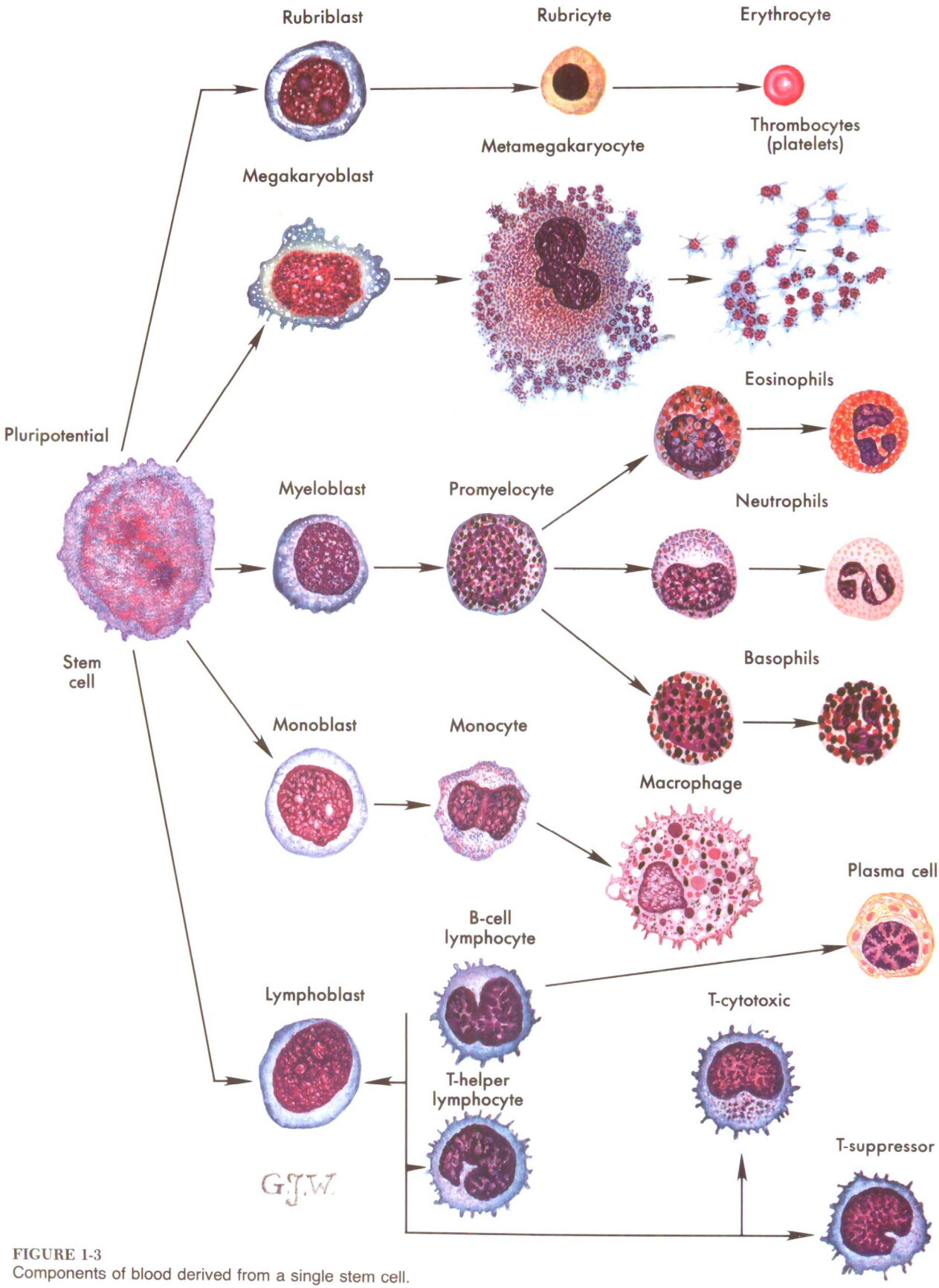

FIGURE 1-3
Components of blood derived from a single stem cell.

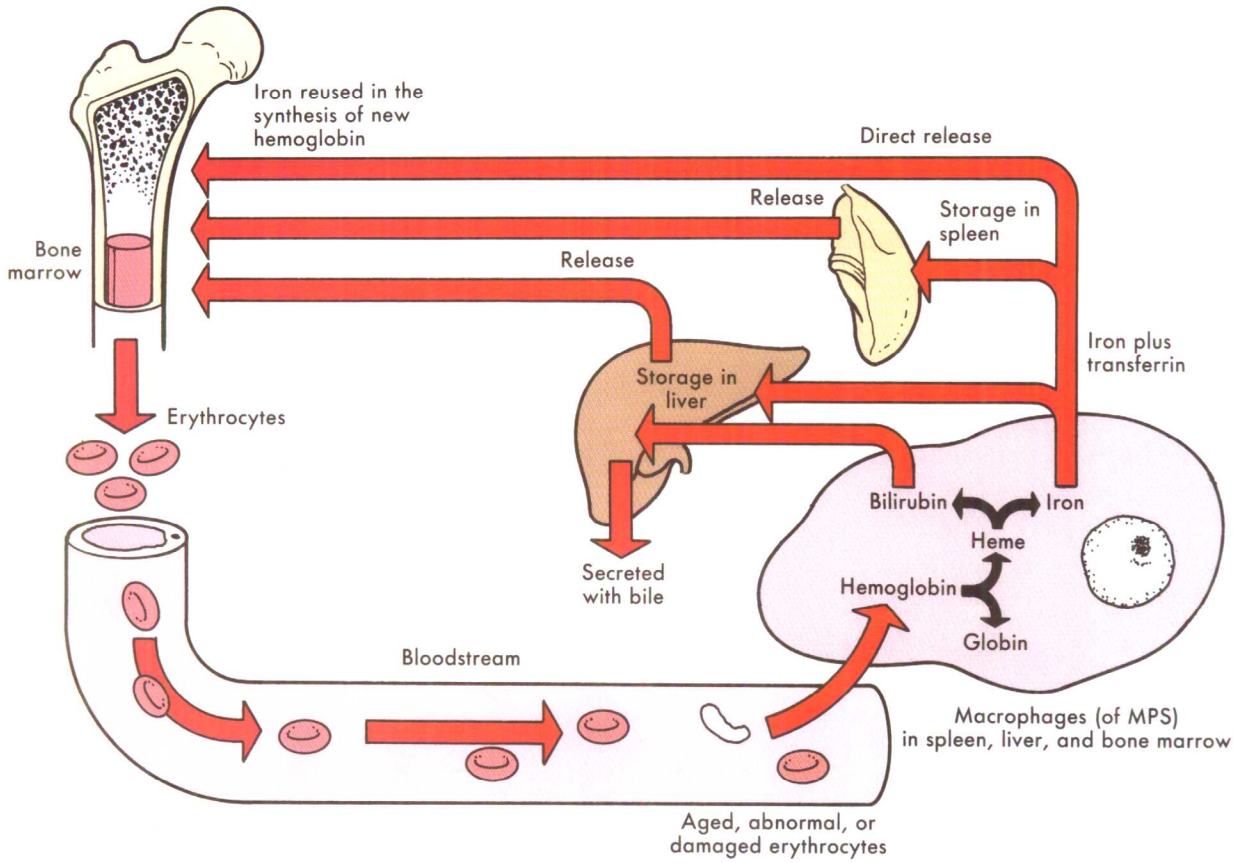

FIGURE 1-4
Iron cycle. Iron (Fe) released from gastrointestinal epithelial cells circulates in the bloodstream associated with its plasma carrier, transferrin. It is delivered to erythroblasts in the bone marrow, where most of it is incorporated into hemoglobin. Mature erythrocytes circulate for approximately 120 days, after which they become senescent and are removed by the mononuclear phagocyte system (MPS). Macrophages of the MPS (mostly in the spleen) break down ingested erythrocytes and return iron to the bloodstream directly or after storing it as ferritin or hemosiderin. (From McCance and Huether.)[40]

bone marrow and found in the ribs, sternum, skull, vertebrae, and bones of the hands, feet, and pelvis. Numerous nutrients are needed for normal cell formation, including iron, vitamin B_{12}, folic acid, and pyridoxine. The young reticulocytes released from the bone marrow circulate for 4 days while maturing into adult erythrocytes. The average life span of an erythrocyte is 115 to 130 days; dead cells are eliminated by phagocytosis in the mononuclear phagocyte system, particularly in the spleen and liver.

The size and shape of the erythrocyte are ideal for its function as a gas carrier. It is a small disk with the unique characteristics of biconcavity and reversible deformability. The flattened, biconcave shape provides a surface area to volume ratio that is optimal for the diffusion of gases into and out of the cell. Reversible deformity enables the cell to alter its shape to squeeze through the microcirculation and then return to normal.

Hemoglobin, the iron-containing substance of the red blood cell, is composed of a simple protein called globin and a red compound called heme, which contains iron and porphyrin. Each erythrocyte contains 200 million to 300 million molecules of hemoglobin, which combine chemically with oxygen to form oxyhemoglobin. Hemoglobin also combines with carbon dioxide. These two capacities enable the blood to carry oxygen to the tissues and carbon dioxide to the alveoli and thus to the atmosphere.

Total iron in the body ranges from 2 to 6 g, two thirds of which is contained in hemoglobin (Figure 1-4 illustrates the iron cycle). The rest is stored in the bone marrow, spleen, and liver. Iron is obtained from such rich dietary sources as liver; oysters; lean meat;