PRINCIPLES
OF
HEMATOLOGY

HADEN

PRINCIPLES OF HEMATOLOGY

WITH

106 ILLUSTRATIVE CASES, AND 167 ILLUSTRATIONS
INCLUDING 173 ORIGINAL PHOTOMICROGRAPHS
AND 95 ORIGINAL CHARTS AND DRAWINGS

BY

RUSSELL L. HADEN, M.A., M.D.

CHIEF OF THE MEDICAL DIVISION OF THE CLEVELAND CLINIC, CLEVELAND, OHIO;
FORMERLY PROFESSOR OF EXPERIMENTAL MEDICINE IN THE UNIVERSITY
OF KANSAS SCHOOL OF MEDICINE, KANSAS CITY, KANSAS

THIRD EDITION, THROUGHLY REVISED

THE HONVAN BOOK COMPANY
614 PEKING ROAD (WESTERN)
SHANGHAI CHINA

CONTENTS

PRINCIPLES
OF
HEMATOLOGY

HADEN

PRINCIPLES OF HEMATOLOGY

WITH

106 ILLUSTRATIVE CASES, AND 167 ILLUSTRATIONS
INCLUDING 173 ORIGINAL PHOTOMICROGRAPHS
AND 95 ORIGINAL CHARTS AND DRAWINGS

BY

RUSSELL L. HADEN, M.A., M.D.

CHIEF OF THE MEDICAL DIVISION OF THE CLEVELAND CLINIC, CLEVELAND, OHIO;
FORMERLY PROFESSOR OF EXPERIMENTAL MEDICINE IN THE UNIVERSITY
OF KANSAS SCHOOL OF MEDICINE, KANSAS CITY, KANSAS

THIRD EDITION, THROUGHLY REVISED

THE HONVAN BOOK COMPANY
614 PEKING ROAD (WESTERN)
SHANGHAI CHINA

PREFACE TO THE THIRD EDITION

THIS small volume on hematology was written to simplify the studies of disorders of the blood for the student and physician. The reception it has received seems to justify its appearance. The concept of blood disorders as disturbances in the normal physiology of the constituents of the blood rather than as true diseases has been retained in this third edition.

A complete resetting of the book has afforded an opportunity for some changes which seem indicated and justified. Certain corrections have been made to keep abreast of developments in this field. A few additional illustrative cases have been added. The most important addition is the description of the technique of bone marrow puncture and the study of bone marrow films. This procedure has proven of great value in the study of blood disorders. It remains, however, a procedure requiring special skill and experience for both making good preparation and for interpretation. More complicated methods such as the study of the Rh factor have again been intentionally omitted to keep this volume a simple discussion of the fundamental principles of hematology.

R. L. H.

CONTENTS

Principles of Hematology

CHAPTER I

THE BLOOD

THE blood is a tissue made up of cells in suspension and of plasma containing substances in solution. The miles of arteries, veins, and capillaries are highways on which red cells shuttle back and forth, transporting oxygen from lungs to tissues, and white cells and platelets travel from site of formation to seat of action. The red cells act as oxygen carriers while moving in the blood stream; the white cells function almost entirely after they have come to rest in the tissues; the platelets disintegrate in the blood stream or after localization and set free thromboplastic substances necessary for clot formation. The vessels serve also as pipelines through which water and substances in solution reach the tissue cells and waste products are carried away.

A normal man weighing 150 pounds has approximately 5 liters of blood constituting about one-thirteenth of his body weight. The fluid part of the circulating blood is a little more than one-half of the total volume. The total blood volume is normally very constant. This is remarkable since almost all the water taken into the body must go through the blood stream and the excess be disposed of through the kidneys, lungs, and skin. A diminution of the plasma volume alone causes a high viscosity of the blood by concentrating the red cells and slowing the circulatory rate. The heart cannot function efficiently if the total blood volume falls below a critical level so death usually follows the sudden loss of one-third the total blood volume. The red cell mass, however, may be greatly decreased without producing serious symptoms if the normal total blood volume is maintained.

Nearly one-half of the blood volume is made up of formed elements, the greater part of which are red cells. While normally the total mass of red cells in a man is 2 to 2½ liters, this may be greatly increased or decreased. In polycythemia the red cell mass may be as high as 8 liters and in aplastic anemia as low as 300 to 400 cc. (Fig. 1). The variation in total blood volume when

calculated in relation to body weight is relatively small except in polycythemia vera. As the red cell mass decreases the plasma volume usually increases; as the red cell mass increases, there is little change in the plasma volume. The total volume of the blood, the total mass of the red cells, and the total volume of the plasma have to be considered in many hematologic problems.

The blood must be visualized as an ever-changing mass. Fluid is constantly flowing in and out, carrying with it substances in solution. White cells and platelets traveling in the blood stream are always leaving to be used somewhere; red cells are always wearing out and being removed. Since the number of cells per unit volume of blood normally varies little, each red cell, white cell, and platelet lost from the blood stream must be replaced by a new one. Red cells remain on an average of twenty-five to thirty days, and white cells and platelets one to four days, so an enormous number of new cells must be delivered into the blood stream to maintain the normal level. About one trillion new red cells, ten billion new granulocytes, ten billion new lymphocytes, and five hundred billion new platelets are required daily.

All disorders of the blood and variations in structure or function of the hematopoietic system are quite simple. Only three types of cells, the erythrocyte, the leukocyte, and the thrombocyte (platelet) are involved. A blood dyscrasia can affect only one or more of the cells or the clotting ferments. A cell can only be increased or decreased in number or show qualitative changes.

The disorders of the blood may be classified as those:

I. Affecting the erythrocyte:
   1. Anemia.
   2. Polycythemia.
   3. Qualitative changes (abnormalities in size, shape, hemoglobin content, and maturation of red cell).

II. Affecting the leukocytes:
   1. Leukocytosis.
   2. Leukopenia.
   3. Qualitative changes (abnormalities in maturity, in granules, and in ferment content).

III. Affecting the thrombocyte (platelet):
   1. Thrombocytosis.
   2. Thrombopenia.
   3. Qualitative changes (such as increased resistance to dissolution in hemophilia).

Each of the three types of blood cells is discussed separately in succeeding chapters. The mechanism by which changes in each cell come about is then considered.

Every blood cell has three phases in its life cycle, viz.: formation, circulation, and destruction. It is just as important to study the formation and destruction of blood cells in hematologic problems as it is to examine the cells in the circulation. In the exact sense of the word there are no diseases of the blood. All such disorders

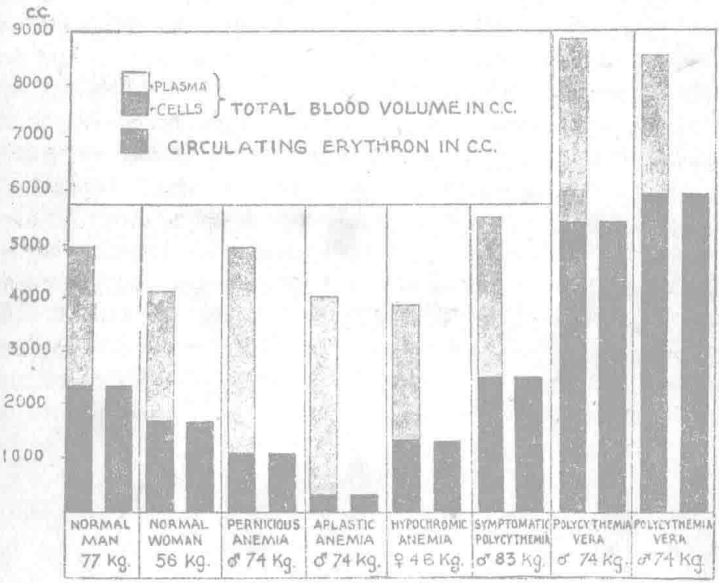

FIG. 1.—Total mass of circulating red cells. These figures were obtained from total blood volume and hematocrit readings. The mass is designated the circulating erythron. Note the enormous variation in the red cell mass from over 6000 cc. in a patient with polycythemia vera to 367 cc. in one with aplastic anemia.

are manifestations of disturbances in the formation, circulation, or destruction of cells, a combination of these factors, or some abnormality in the physiology of the clotting elements. To say that a patient has an anemia, a polycythemia, a leukocytosis, a leukopenia, a leukemia, a thrombopenia, or hemophilia does not designate some specific disease as typhoid fever or measles, but denotes only some abnormality or break in the normal mechanism of red cell, white cell, platelet, or clotting physiology.

An anemia should not be thought of as a reduction in red cells

and hemoglobin in a unit volume of blood, but rather as a loss of the normal balance between red cell and hemoglobin formation and destruction. So many variations are possible that the clinical and laboratory picture is seldom the same in any two patients. The fundamental problem in every disorder of the blood is to obtain all possible information concerning the level of essential elements and the rate of formation and loss. Such a study requires information concerning the activity of all parts of the hematopoietic system. The patient's symptoms so far as the blood is concerned are only a reflection of this activity or a failure of elements of the blood to fulfil their proper functions.

In the following chapters the disorders of the blood are discussed as abnormalities in the blood-forming organs, in the circulating elements, and in the mechanism of blood destruction rather than as true diseases of the blood. A single examination of the blood is only one view of a passing cavalcade which is constantly receiving reinforcements and constantly losing members. To understand the cavalcade, the sources and adequacy of supply as well as the losses of the passing procession must be known. This means that a clinician, to have an intelligent conception of any hematologic problem, must always visualize the formation and disposal of blood cells as well as the number and type in the circulation.

CHAPTER II

THE HEMATOPOIETIC SYSTEM AND BLOOD FORMATION

The hematopoietic system (Fig. 2) includes the:

1. *Bone-marrow* which forms (1) neutrophilic, basophilic, and eosinophilic leukocytes, (2) red cells, and (3) platelets, and synthesizes (4) hemoglobin.

2. *Spleen* which (1) forms monocytes and lymphocytes, (2) acts as a reservoir for red cells, (3) destroys red cells which are abnormal or have lived the normal life-span, and (4) disintegrates hemoglobin.

3. *Lymph glands* which form lymphocytes.

4. *Stomach* which (1) forms the erythrocyte-maturing factor (EMF) and (2) secretes hydrochloric acid which influences the absorption of iron and possibly other nutritional factors.

5. *Liver* which (1) stores the erythrocyte-maturing factor (EMF) and possibly influences its utilization, (2) forms fibrinogen, prothrombin and other clotting elements, and (3) excretes bilirubin (end-product of hemoglobin metabolism).

6. *Reticulo-endothelial cells* which (1) form monocytes in the marrow, (2) dispose of red cells and platelets in the spleen, (3) convert hemoglobin into iron and bilirubin in the spleen, (4) store iron in the marrow, and (5) synthesize hemoglobin in the marrow. The reticulo-endothelial cells are widely distributed but the most important sites are the bone-marrow and spleen. They have in common the property of phagocytosis.

7. *Circulating blood* which carries in suspension or solution all the elements supplied by the hematopoietic system.

Bone-marrow.—The bones have the dual function of forming a mechanical support and acting as a container for the tissues from which most of the blood cells are formed. The spaces within the bones consist of the medullary cavity of the shaft of long bones and the irregular cavities between the bony trabeculæ composing the spongy bone in the extremities of long bones and in short bones. These spaces are filled with marrow to form an irregularly branching mass. The marrow tissue of all bones has a volume of about 1400 cc. and constitutes an organ as definite as the liver or brain.