



HERMANN

QP34  
F6  
1890  
c.1





1080074632

480



Plate I.

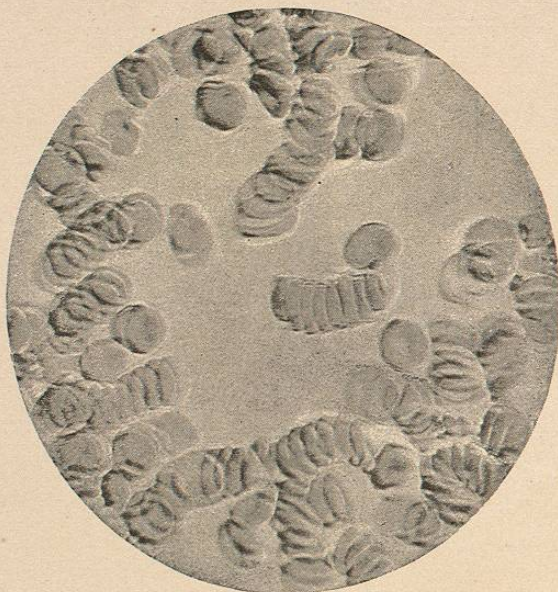


FIG. 1.

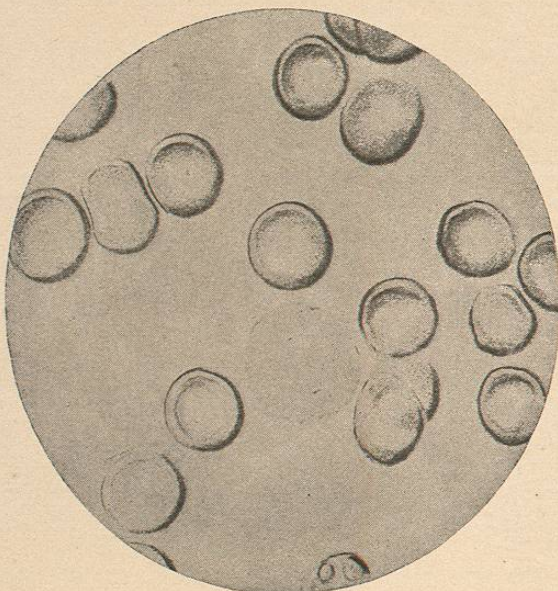


FIG. 2.

FIG. 1.—Human blood-corpuscles, fresh; magnified 840 diameters,  $\frac{1}{8}$  inch homogeneous oil-immersion-objective by Zeiss, original negative amplified twice (Stratford).  
FIG. 2.—Blood of Guinea-pig, spread and dried on glass cover; magnified 1,450 diameters,  $\frac{1}{8}$  inch homogeneous oil-immersion-objective by Zeiss, and Tolles's amplifier (Sternberg).

# A TEXT-BOOK OF HUMAN PHYSIOLOGY

BY

AUSTIN FLINT, M. D., LL. D.

PROFESSOR OF PHYSIOLOGY AND PHYSIOLOGICAL ANATOMY IN THE BELLEVUE HOSPITAL MEDICAL COLLEGE  
NEW YORK; VISITING PHYSICIAN TO BELLEVUE HOSPITAL; FELLOW OF THE NEW YORK STATE  
MEDICAL ASSOCIATION; CORRESPONDENT OF THE ACADEMY OF NATURAL SCIENCES  
OF PHILADELPHIA; MEMBER OF THE AMERICAN PHILOSOPHICAL SOCIETY, ETC.

WITH THREE HUNDRED AND SIXTEEN FIGURES IN THE TEXT, AND THREE PLATES

FOURTH EDITION, ENTIRELY REWRITTEN

NEW YORK  
D. APPLETON AND COMPANY  
1890



QP34

F6

1890



COPYRIGHT, 1875, 1879, 1881, 1888,  
D. APPLETON AND COMPANY.

## PREFACE.

THE present edition of this treatise has been rewritten; and while the general arrangement of subjects is retained, but little remains of the original text. Although the third edition, published in 1880, is still much used as a text-book, for several years I have not been able to follow it closely in public teaching; and its defects have become so important that it has seemed to me impossible to remedy them without making a new book.

I have thought it advisable to curtail still more the historical references contained in former editions. At the present day it is not possible to give even a brief account of the literature of physiology within the limits of a single volume of convenient size. I have avoided, also, as far as practicable, discussions of unsettled and disputed questions, as unprofitable and confusing.

I have adopted the new, chemical nomenclature, which is now almost universally accepted, but have not attempted to give a full account of the chemistry of the body. Physiological chemistry has now become a science by itself; and while it has contributed very largely to exact, physiological knowledge, its full consideration is properly confined to special treatises.

Recent advances in the knowledge of minute anatomy, due largely to improved instruments and methods, have had an important share in the progress of physiology. These have been considered incidentally, and they now form an essential part of all complete works on anatomy.

One who has long been a student and teacher of physiology can hardly fail to have an idea, more or less definite, of what a text-book should be, however imperfectly he may carry out this idea in his own work. I shall be more than satisfied if I have been able to give concise and connected statements of well-established facts, in such a form that they can easily be acquired by students and in language that can not be misunderstood. Peculiar views and theories, whether of the author or of others, have no proper place in a text-book, which should represent facts generally recognized and accepted, and not the ideas of any one individual.



It does not seem to me that the value of a text-book is materially enhanced by elaborate descriptions of apparatus and methods, except as they involve principles susceptible of general, physiological application; nor does it seem profitable to follow out the details of intricate, mathematical calculations involved in certain studies, such as physiological optics and acoustics, the results of which are universally accepted. It is sufficient to teach by text-books the science of physiology. The art of investigation and the methods employed in physiological research are to be learned in the laboratory and from special treatises and monographs.

To those who, by early education and common usage, have long been accustomed to English weights and measures, the metric system frequently fails to convey a definite idea, without a mental reduction to the familiar standard; but the metric system is now very generally used in scientific works. In the text, the English weights and measures and the Fahrenheit scale of the thermometer have been retained, and their equivalents in the metric system are given in parentheses. In microscopic measurements the micromillimetre ( $\frac{1}{1000}$  of a millimetre, or  $\frac{1}{25000}$  of an inch), indicated by the Greek letter  $\mu$ , is frequently employed.

The form and typography of the book have been changed, it is hoped for the better. One new plate and sixty-one new figures have been introduced. Two plates and sixty-three figures have been discarded. The old illustrations which remain have been carefully examined and all remediable defects have been corrected. For most of the illustrations that have been retained, new electrotypes have been taken from the originals, and thirty cuts have been re-engraved. A few engravings, however, taken from classical authorities, though defective from an artistic point of view, have been retained in their original form. It is due to the publishers to make these statements, and to say that they have spared nothing in the mechanical execution of the work.

AUSTIN FLINT.

NEW YORK, August, 1888.

I HAVE taken advantage of the opportunity afforded by the printing of a second impression of this edition, to introduce a new description of the anatomy of the human ovum, with a lithographic plate, in accordance with the very recent studies of the normal, human ovum, by Nagel (1888). These observations appeared after the fourth edition had been completed. I have also introduced three new figures in the text, and have revised the descriptions of fecundation of the ovum and segmentation of the vitellus.

A. F.

March, 1889.

## CONTENTS.

### CHAPTER I.

#### THE BLOOD.

	PAGE
Quantity of blood—General characters of the blood—Blood-corpuscles—Development of the blood-corpuscles—Leucocytes—Development of leucocytes—Blood-plaques—Composition of the red corpuscles—Globuline—Hæmaglobine—Composition of the blood-plasma—Inorganic Constituents—Organic saline constituents—Organic non-nitrogenized constituents—Excrementitious constituents—Organic nitrogenized constituents—Plasmine, fibrin, metalbumen, serine—Peptones—Coloring matter—Coagulation of the blood—Conditions which modify coagulation—Coagulation of the blood in the organism—Cause of the coagulation of the blood . . . . .	1

### CHAPTER II.

#### CIRCULATION OF THE BLOOD—ACTION OF THE HEART.

Discovery of the circulation—Physiological anatomy of the heart—Valves of the heart—Movements of the heart—Impulse of the heart—Succession of the movements of the heart—Force of the heart—Action of the valves—Sounds of the heart—Causes of the sounds of the heart—Frequency of the heart's action—Influence of age and sex—Influence of digestion—Influence of posture and muscular exertion—Influence of exercise etc.—Influence of temperature—Influence of respiration on the action of the heart—Cause of the rhythmical contractions of the heart—Accelerator nerves—Direct inhibition of the heart—Reflex inhibition of the heart—Summary of certain causes of arrest of the action of the heart . . . . .	29
---	----

### CHAPTER III.

#### CIRCULATION OF THE BLOOD IN THE VESSELS.

Physiological anatomy of the arteries—Course of blood in the arteries—Locomotion of the arteries and production of the pulse—Pressure of blood in the arteries—Pressure in different parts of the arterial system—Depressor nerve—Influence of respiration on the arterial pressure—Rapidly of the current of blood in the arteries—Rapidly in different parts of the arterial system—Circulation of the blood in the capillaries—Physiological anatomy of the capillaries—Pressure of blood in the capillaries—Relations of the capillary circulation to respiration—Causes of the capillary circulation—Influence of temperature on the capillary circulation—Influence of direct irritation on the capillary circulation—Circulation of the blood in the veins—Physiological anatomy of the veins—Course of the blood in the veins—Pressure of blood in the veins—Rapidly of the venous circulation—Causes of the venous circulation—Air in the veins—Uses of the valves—Conditions which impede the venous circulation—Regurgitant venous pulse—Circulation in the cranial cavity—Circulation in erectile tissues—Derivative circulation—Pulmonary circulation—Circulation in the walls of the heart—Passage of the blood-corpuscles through the walls of the vessels (diapedesis)—Rapidly of the circulation—Phenomena in the circulatory system after death . . . . .	60
---	----

### CHAPTER IV.

#### RESPIRATION—RESPIRATORY MOVEMENTS.

General considerations—Physiological anatomy of the respiratory organs—Movements of respiration—Inspiration—Muscles of inspiration—Expiration—Muscles of expiration—Types of respiration—	
---	--



Frequency of the respiratory movements—Relations of inspiration and expiration to each other—Respiratory sounds—Capacity of the lungs and the quantity of air changed in the respiratory acts—Residual air—Reserve air—Tidal, or breathing air—Complemental air—Extreme breathing capacity—Relations in volume of the expired to the inspired air—Diffusion of air in the lungs . . . 108

## CHAPTER V.

*CHANGES WHICH THE AIR AND THE BLOOD UNDERGO IN RESPIRATION.*

Composition of the air—Consumption of oxygen—Exhalation of carbon dioxide—Relations between the quantity of oxygen consumed and the quantity of carbon dioxide exhaled—Sources of carbon dioxide in the expired air—Exhalation of watery vapor—Exhalation of ammonia—Exhalation of organic matter—Exhalation of nitrogen—Changes of the blood in respiration (hæmatosis)—Difference in color between arterial and venous blood—Comparison of the gases in venous and arterial blood—Analysis of the blood for gases—Nitrogen of the blood—Condition of the gases in the blood—Relations of respiration to nutrition etc.—The respiratory sense—Sense of suffocation—Respiratory efforts before birth—Cutaneous respiration—Breathing in a confined space—Asphyxia . . . 135

## CHAPTER VI.

*ALIMENTATION.*

General considerations—Hunger—Seat of the sense of hunger—Thirst—Seat of the sense of thirst—Duration of life in inanition—Classification of alimentary substances—Nitrogenized alimentary substances—Non-nitrogenized alimentary substances—Inorganic alimentary substances—Alcohol—Coffee—Tea—Chocolate—Condiments and flavoring articles—Quantity and variety of food necessary to nutrition—Necessity of a varied diet . . . 164

## CHAPTER VII.

*DIGESTION—MASTICATION, INSALIVATION AND DEGLUTITION.*

Prehension of food—Mastication—Physiological anatomy of the teeth—Anatomy of the maxillary bones—Temporo-maxillary articulation—Muscles of mastication—Action of the tongue, lips and cheeks in mastication—Parotid saliva—Submaxillary saliva—Sublingual saliva—Fluids from the smaller glands of the mouth, tongue and fauces—Mixed saliva—Quantity of saliva—General properties and composition of the saliva—Action of the saliva on starch—Uses of the saliva—Physiological anatomy of the parts concerned in deglutition—Mechanism of deglutition—First period of deglutition—Second period of deglutition—Protection of the posterior nares during the second period of deglutition—Protection of the opening of the larynx and uses of the epiglottis in deglutition—Third period of deglutition—Deglutition of air . . . 188

## CHAPTER VIII.

*GASTRIC DIGESTION.*

Physiological anatomy of the stomach—Glands of the stomach—Closed follicles—Gastric juice—Gastric fistula in the human subject in the case of St. Martin—Secretion of the gastric juice—Properties and composition of gastric juice—Action of the gastric juice in digestion—Peptones—Action of the gastric juice upon fats, sugars and amylaceous substances—Duration of gastric digestion—Conditions which influence gastric digestion—Movements of the stomach . . . 211

## CHAPTER IX.

*INTESTINAL DIGESTION.*

Physiological anatomy of the small intestine—Glands of Brunner—Intestinal tubules, or follicles of Lieberkühn—Intestinal villi—Solitary glands, or follicles, and patches of Peyer—Intestinal juice—Action of the intestinal juice in digestion—Pancreatic juice—Action of the pancreatic juice upon starches and sugars—Action upon nitrogenized substances—Action upon fats—Action of the bile in digestion—Biliary fistula—Variations in the flow of bile—Movements of the small intestine—Peristaltic and antiperistaltic movements—Uses of the gases in the small intestine—Physiological anatomy of the large intestine—Processes of fermentation in the intestinal canal—Contents of the large intestine—Composition of the fæces—Excretine and excretolic acid—Stercorine—Indol, skatol, phenol etc.—Movements of the large intestine—Defæcation—Gases found in the alimentary canal . . . 233

## CHAPTER X.

*ABSORPTION—LYMPH AND CHYLE.*

Absorption by blood-vessels—Absorption by lacteal and lymphatic vessels—Physiological anatomy of the lacteal and lymphatic vessels—Lymphatic glands—Absorption by the lacteals—Absorption by the skin—Absorption by the respiratory surface—Absorption from closed cavities, reservoirs of glands, etc.—Absorption of fats and insoluble substances—Variations and modifications of absorption—Mechanism of the passage of liquids through membranes—Lymph and chyle—Properties and composition of lymph—Origin and uses of the lymph—Composition of the chyle—Microscopical characters of the chyle—Movements of the lymph and chyle . . . 272

## CHAPTER XI.

*SECRETION.*

Classification of the secretions—Mechanism of the production of the true secretions—Mechanism of the production of the excretions—Influence of the composition and pressure of the blood on secretion—Influence of the nervous system on secretion—Anatomical classification of glandular organs—Classification of the secreted fluids—Synovial membranes and synovia—Mucous membranes and mucus—Physiological anatomy of the sebaceous, ceruminous and Meibomian glands—Ordinary sebaceous matter—Smegma of the prepuce and of the labia minora—Vernix caseosa—Cerumen—Meibomian secretion—Mammary secretion—Physiological anatomy of the mammary glands—Mechanism of the secretion of milk—Conditions which modify the lacteal secretion—Quantity of milk—Properties and composition of milk—Microscopical characters of milk—Composition of milk—Variations in the composition of milk—Colostrum—Lacteal secretion in the newly-born—Secretory nerve-centres . . . 306

## CHAPTER XII.

*EXCRETION BY THE SKIN AND KIDNEYS.*

Differences between the secretions proper and the excretions—Physiological anatomy of the skin—Physiological anatomy of the nails—Physiological anatomy of the hairs—Sudden blanching of the hair—Perspiration—Sudoriparous glands—Mechanism of the secretion of sweat—Properties and composition of the sweat—Peculiarities of the sweat in certain parts—Physiological anatomy of the kidneys—Mechanism of the production and discharge of urine—Influence of blood-pressure, the nervous system etc., upon the secretion of urine—Physiological anatomy of the urinary passages—Mechanism of the discharge of urine—Properties and composition of the urine—Influence of ingesta upon the composition of the urine and upon the elimination of nitrogen—Influence of muscular exercise upon the elimination of nitrogen—Water regarded as a product of excretion—Variations in the composition of the urine . . . 341

## CHAPTER XIII.

*USES OF THE LIVER—DUCTLESS GLANDS.*

Physiological anatomy of the liver—Distribution of the portal vein, the hepatic artery and the hepatic duct—Structure of a lobule of the liver—Arrangement of the bile-ducts in the lobules—Anatomy of the excretory biliary passages—Nerves and lymphatics of the liver—Mechanism of the secretion and discharge of bile—Quantity of bile—Uses of the bile—Properties and composition of the bile—Biliary salts—Cholesterine—Tests for bile—Excretory action of the liver—Formation of glycogen in the liver—Change of glycogen into sugar—Conditions which influence the quantity of sugar in the blood—Summary of the glycogenic action of the liver—Probable office of the ductless glands—Physiological anatomy of the spleen—Suprarenal capsules—Addison's disease—Thyroid gland—Myxœdema—Thymus—Pituitary body and pineal gland . . . 392

## CHAPTER XIV.

*NUTRITION—ANIMAL HEAT AND FORCE.*

Nature of the forces involved in nutrition—Life, as represented in development and nutrition—Substances which pass through the organism—Metabolism—Substances consumed in the organism—Conditions which influence nutrition—Animal heat and force—Estimated quantity of heat produced by the body—Limits of variation in the normal temperature in man—Variations with external temperature—Variations in different parts of the body—Variations at different periods of life etc.—