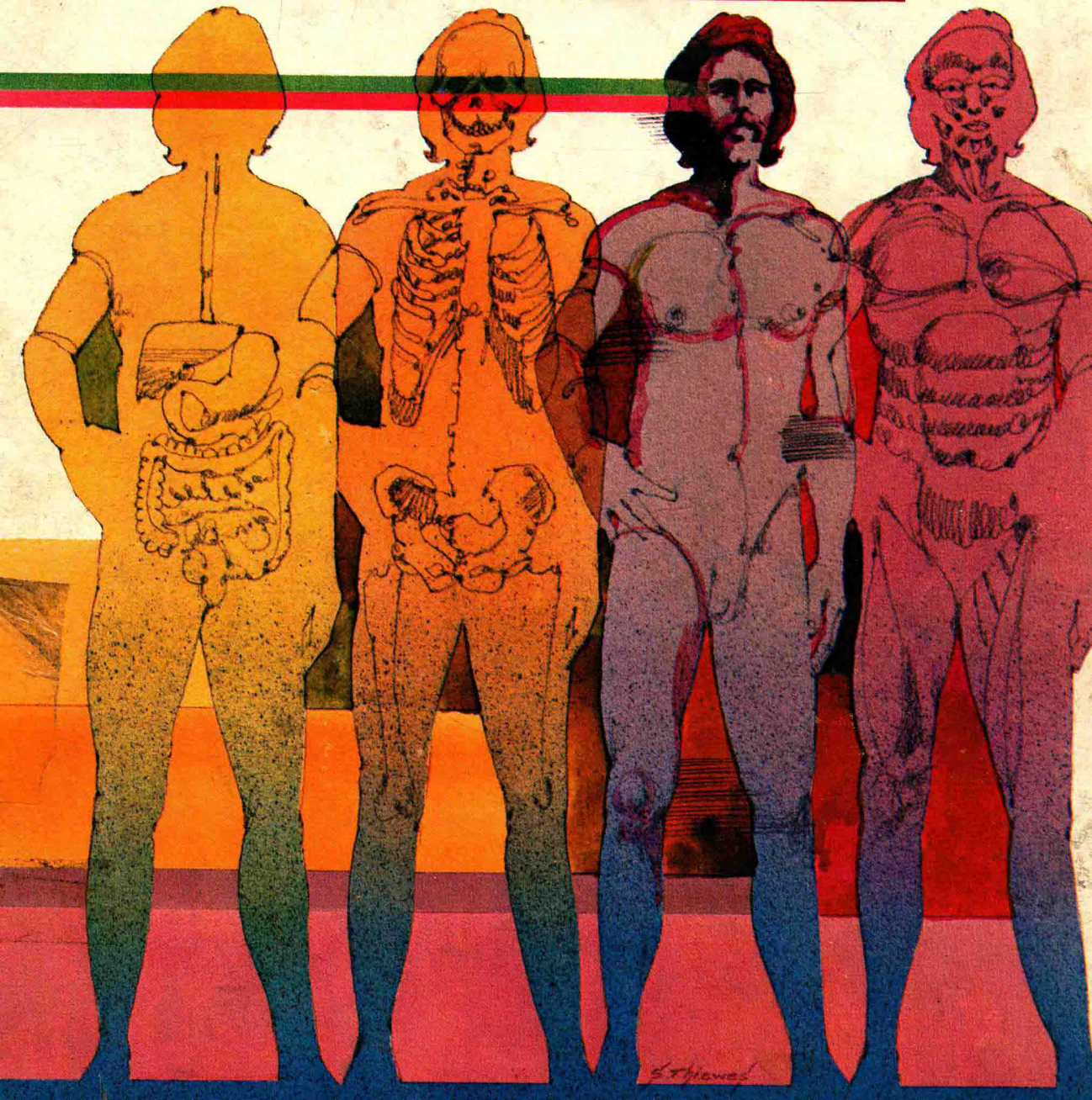
ANATOMY AND PHYSIOLOGY

John Raynor



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Preface

This text is designed to present the basic concepts of human anatomy and physiology for students planning a career in one of the health professions. Training programs in all of the health professions are based on the fact that a knowledge of the normal structures and functions of the human body is required to understand medical problems and how they can be treated. In this text I have tried to include and emphasize material that the student will apply to later professional courses.

Our present understanding of human anatomy and physiology is much broader than can be presented in an introductory text of this type. In being selective I have tried to emphasize the basic physiological processes and the reasons these processes take place. It is hoped that this information will provide a framework into which later knowledge can be placed.

Each chapter of the text includes behavioral objectives. These objectives are meant to serve two purposes. They are meant to delineate information the student should retain upon completion of each chapter and also to serve as a way for the student to test himself or herself on the subject matter.

The excellent illustrations were supplied by Robert Frank and by Eric G. Hieber Associates. Every attempt has been made to make the illustrations clear and readable. In addition to the anatomical illustrations, there are a large number of schematic illustrations which are meant to clarify physiological processes. Flowcharts are also used to sum up sequences of events involved in physiological processes. All of these illustrations are integrated with the written material in the text.

I would like to thank Dr. Ronald Slavin for his many helpful suggestions as to the type of material relevant to an introductory anatomy and physiology course. Finally, I would like to thank Joe Ingram, Holly Detgen, T. R. Funderburk, and Howard S. Leiderman of Harper & Row for all of the time and effort they have put into making this book a reality.

J.R.

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Human **anatomy** is the study of the structure of the human body, and human **physiology** is the study of how the human body functions. Because the structure of the body is interrelated with the way in which it functions it is reasonable to study anatomy and physiology as one subject.

Although the study of anatomy and physiology requires learning a large amount of detailed information, most of the information is relatively straightforward and should not be tremendously difficult to understand. In general the human body functions in a reasonable and logical way and most of the detailed information can be fit into an overall pattern. We are going to begin our description of human anatomy and physiology by looking at certain general principles that hopefully will serve as a framework for learning the details of anatomy and physiology.

GENERAL PRINCIPLES

1. From an anatomical and physiological point of view survival is the object of living.

The structure and function of the human body are directed toward one end: survival. This includes survival of each individual part of the body, such as the liver or kidney, the survival of the body as a whole, and the survival of human beings as a form of life via reproduction. In looking at any particular aspect of structure or function you should always try to see in what way it aids in survival. For example, when it is hot out we sweat. Is there any point in sweating? Does it aid in survival? The evaporation of water from any object uses up heat and cools the object. When it is hot out we sweat; the evaporation of the sweat from our skin cools our body. If the body became too hot it would no longer function properly.

2. Cells are the basic functional unit of the body.

The human body is made up of trillions of tiny structures called **cells.** Cells are the basic working unit of the body. In each of these cells an enormous number of activities take place. Some of these activities serve to keep the cell itself alive while other activities contribute to the survival of the entire body. Therefore if one were to look at a particular cell in the pancreas, many of the activities taking place in that cell would be directed toward keeping itself alive. However, the cells of the pancreas also manufacture chemicals that are secreted into the digestive tract where they aid in the breakdown of food. Through the production of these digestive chemicals the cells of the pancreas contribute to the survival of the entire body.

In Chapter 3 we will discuss in detail those aspects of cell structure and function that are common to all cells. However, throughout the book you should keep in mind the fact that any activity that takes place in the body is really the result of activities that take place in the cells. Thus the pumping of blood by the heart is due to the action of heart cells, and the formation of urine by the kidney is a result of activities that take place in kidney cells.

3. The environment surrounding cells must be kept stable for cells to survive.

Cells are exceedingly delicate and can only function in a very stable environment. The immediate environment of all the cells of the body is the surrounding fluid, known as the **extracellular fluid.** The temperature, pressure, acidity, salt content, etc., of this fluid determine the conditions under which the cells function. It is from the extracellular fluid that the cells must obtain their nutrients and into which the cells must deposit their wastes. This extracellular fluid is referred to as the **internal environment,** the environment within the body. This is to distinguish it from the **external environment,** the environment outside the body. Whereas the condition of the external environment can vary over a reasonably large range, the conditions of the internal environment must be kept quite stable. For example, a change in external temperature from 98.6°F to 60°F would not affect the activities of most cells. On the other hand, a lowering of the internal temperature from its normal value of 98.6°F to 60°F would greatly slow down all cellular activity.

The idea that the internal environment must be kept constant was first developed by the nineteenth-century French physiologist Claude Bernard, and was later elaborated upon by the American physiologist W. B. Cannon. Cannon introduced the word **homeostasis** to mean a stable internal environment.

4. Most specialized body functions are directed toward maintaining homeostasis.

Survival depends on maintaining a stable internal environment, homeostasis. We have already stated that within each cell two types of activities take place. Some activities serve to keep the cell itself alive. Other activities are specialized activities of that particular type of cell. All of the specialized activities of cells act either directly or indirectly to maintain homeostasis. For example, one of the specialized functions of liver cells is to help maintain a stable amount of sugar in the extracellular fluid. If the level of sugar in the extracellular fluid begins to fall, the liver cells produce additional sugar which can be added to the extracellular fluid. If the amount of sugar in the extracellular fluid begins to get too high the liver cells remove sugar from the fluid. By adding sugar when there is not enough in the extracellular fluid and by removing sugar when there is too much, the liver helps to maintain a stable level of sugar in the internal environment.

5. Body functions must be controlled to meet the needs of different situations.

Although the internal environment must be kept very stable, the external world in which we live is continuously changing. The temperature, the amount and type of food available, and the need for physical activity are but a few of the factors that can change from day to day and from place to place. In order to maintain a stable internal environment we must be able to adjust to a changing external environment. For example, our internal temperature stays close to 98.6°F whether the external temperature is 105°F or 45°F. We accomplish this, in part, by sweating when it is hot and by shivering when it is cold. In order to have the appropriate response to a particular situation, body function must be controlled. Thus something must stimulate the sweat glands to secrete large amounts of sweat when it is hot and small amounts of sweat when it is cold. Likewise something must stimulate the rhythmic muscle tremors of shivering when it is cold but not when it is hot. To a very large extent the various body functions are controlled by the nerves and hormones. Thus nerves and hormones act to stimulate the sweat glands to secrete sweat when it is hot and to stimulate the muscle cells to tremor when it is cold.

LEVELS OF ORGANIZATION

In order to carry out their specialized activities the cells of the body are grouped together into larger structures. A **tissue** consists of a group of similar cells along with the material between the cells, which are organized to carry out a particular function. There are

four major types of tissues: epithelial, connective, nervous, and muscular, each of which will be discussed in Chapter 4.

Different types of tissues are combined into larger functional units known as **organs.** An organ is defined as a group of tissues working together to perform a particular function. The heart, for instance, is an organ made up of epithelial tissue which protects it, muscle tissue which is responsible for the actual contractions, nervous tissue which controls it, and connective tissue which holds the other tissues together.

Finally a number of different organs may act together to perform a particular function. Such a collection of organs is known as an **organ system.** The lungs and the tubes that connect the lungs with the outside air form the respiratory system, which is responsible for the exchange of oxygen and carbon dioxide between the internal and external environments.

In summary there are four basic levels of organization within the body: the individual cells, groups of similar cells organized into tissues, groups of tissues organized into organs, and groups of organs organized into organ systems.

THE ORGAN SYSTEMS

Survival depends on maintaining homeostasis, a stable internal environment in which the cells can live and carry out their functions. At this point we are going to describe briefly each of the major organ systems and at least some of the ways in which they contribute to homeostasis. There are really two reasons for doing this: one is to give you an idea of the basic physiological needs of the body and the other is to give you an idea of at least some of the functions of the major internal organs. An overall idea of what goes on in the body should make it easier to learn the detailed information about the various organ systems given in Chapters 5 through 18.

Survival depends on obtaining from the outside world the raw materials that the cells require to carry out their functions. These raw materials include: molecules that can provide the energy necessary to do the work of the cells; molecules that can become part of the structure of the body; vitamins, which aid the cells in carrying out certain chemical reactions; minerals; and water. With the exception of oxygen, all of the substances taken into the body from the external world enter through the **digestive system.** The digestive system must then break down the food (digest it) into particles small enough to enter the bloodstream. Those substances in the food that for one reason or another cannot be absorbed into the blood are eliminated from the body as feces.

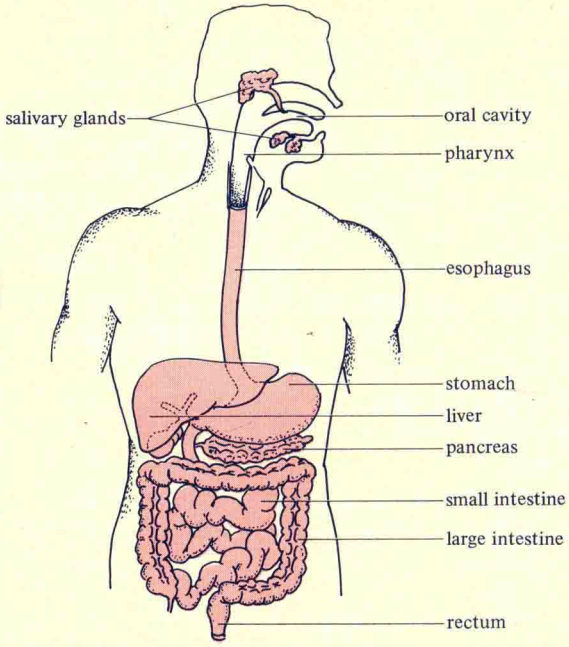

Figure 1-1 The digestive system.

Basically the digestive system consists of a tube that runs from the mouth to the anus, as illustrated in Figure 1-1. This tube, the **digestive tract,** consists of the **oral cavity** where food enters the body; the **pharynx** (throat) located at the back of the oral cavity; the **esophagus** which is a long tube connecting the pharynx with the stomach; the **stomach** which stores food and partially digests it; the **small intestine** in which most of the food is digested and absorbed into the blood; and the **large intestine** and **rectum** in which the unabsorbed food is stored until its elimination from the body. In addition to the digestive tract, the digestive system contains certain structures which secrete chemicals that aid in digestion: the salivary glands in the mouth and the liver and pancreas in the abdomen.

The only substance needed from the outside world which does not enter the body through the digestive system is oxygen, a gas used in the process by which the energy in food is released for use by the cells. The exchange of gases between the external environment and the internal environment is carried out by the **respiratory system.** The respiratory system brings oxygen into the body and eliminates carbon dioxide, a potentially poisonous gas produced by the combination of oxygen and food.

The major structures of the respiratory system are shown in Figure 1-2. Gases enter or leave the body through either the nasal cavity or the oral cavity. These two cavities are joined at the pharynx, which has one opening into the esophagus through which

food passes on its way to the stomach and one opening into the **larynx** through which air passes on its way to the lungs. The larynx, which contains the two vocal cords used in speaking, guards against the entry of food into the lungs. An opening from the larynx leads into a tube, the **trachea,** which branches into two **bronchi,** one to each lung. Within the lungs the bronchi branch into smaller and smaller tubes which finally end in tiny sacs called alveoli. At the alveoli oxygen enters the blood to be carried to the cells, and carbon dioxide, which has been removed from the cells, enters the respiratory tract to be eliminated from the body. Thus the respiratory tract consists of a set of tubes through which oxygen passes as it moves from the mouth or nose, where it enters the body, to the alveoli, where it enters the blood; carbon dioxide passes through these same tubes as it moves from the alveoli, where it leaves the blood, to the mouth or nose, where it leaves the body. Some of these tubes—the small branching bronchi—as well as the tiny air sacs where gases enter or leave the blood—the alveoli—are located within the lungs.

Food from the digestive tract and oxygen from the respiratory tract must be transported to cells throughout the body. The **circulatory system** functions to transport material from one part of the body to another much as a subway system transports people from one part of a city to another. The circulatory system is composed of the **blood,** which is the transporting fluid that moves throughout the body, the **blood vessels,** which are tubes through which the blood flows, and the **heart,** which pumps the blood through the blood vessels.

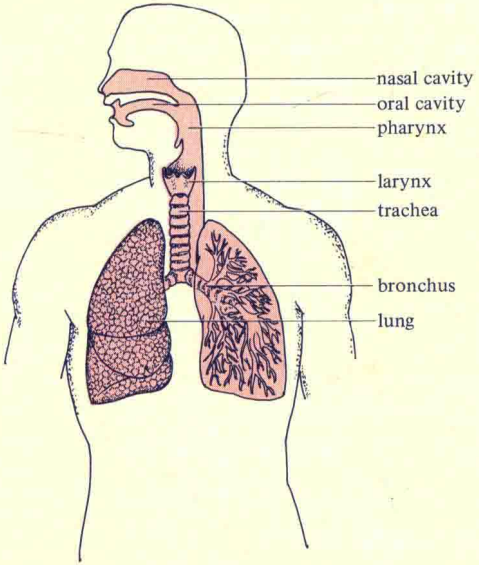

Figure 1-2 The respiratory system.

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