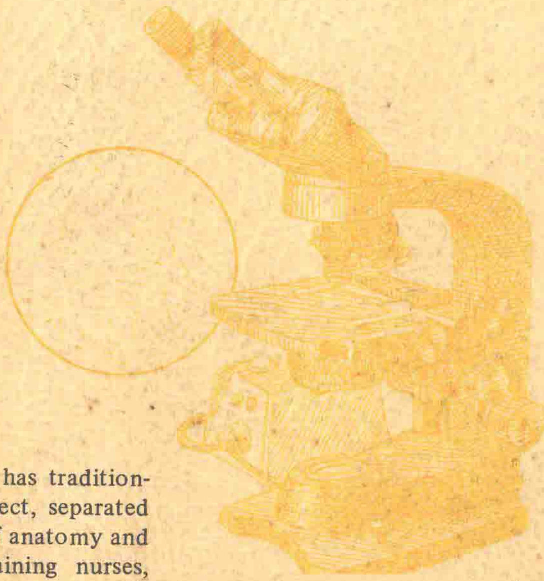
ELEMENTARY MICROSTUDIES OF HUMAN TISSUES

JAMES V. BRADLEY
M.A.T.

Illustrations by

Dennis Giddings



The study of histology has tradition-
·ly been a distant subject, separated
·n the basic courses of anatomy and
·siology used in training nurses,
·lical technologists, teachers, high
·ool students, and laymen. The pur-
·se of this text is to make the microscopic study of tissues available
·· students who have a limited knowl-
·ge of the human body.

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ELEMENTARY MICROSTUDIES OF HUMAN TISSUES

To Ardyth

PREFACE

ELEMENTARY MICROSTUDIES OF HUMAN TISSUES was written to make the study of human tissue available to the student who has only a minimal knowledge of the human body.

The book is intended for use in a variety of courses, including basic anatomy, physiology, or histology courses; in colleges, junior colleges, nursing schools, teacher-training institutions, and high schools. Some of the ways in which the book can be used are these:

1. As textual material for basic courses.
2. As a supplementary text for either teacher-directed or independent student work in the laboratory.
3. As a source book for specific learning units on particular organs or systems of the human body.
4. As a helpful supplementary aid for students taking more advanced histology courses.

ELEMENTARY MICROSTUDIES OF HUMAN TISSUES presents each organ individually, describing its location, basic function, and major structural features. The microstructure of the organ is then described, and the distinguishing features and functions of the most important cells are discussed. With this background, a microscope study of typical sections of the tissue is presented and the most significant features of the cells and structures are pointed out.

Except for a few examples of bone tissue and nerve tissue, H-and-E–stained (hematoxylin-and-eosin–stained) tissues are described. In all cases, the slides described and the drawings correlate well with the typical prepared slides furnished by biological supply houses.

The cells and structures seen in drawings of tissues labeled L.P. can be seen by studying the particular slide under low power, which is taken here as being 100×. Those figures labeled H.P. refer to high-power magnification, taken here as about 400×.

A list of reference texts is offered as an aid to the student, and a complete set of color-photographed slides may be obtained from the author by writing to Lake Forest High School, Lake Forest, Illinois.

ACKNOWLEDGMENTS

THE generosity and kindness of several people have contributed much to this text.

Dr. Rowen D. Frandson of the Department of Anatomy, Colorado State University, encouraged me, read the manuscript, and offered needed advice.

Dr. Ronald K. Plakke of the Department of Biological Sciences, Northern Colorado University, read the entire text. His advice and comments were greatly valued and appreciated.

All figures in this text were drawn by Mr. Dennis Giddings, an electronmicroscopist at Colorado State University. Working with this pleasant man was a rewarding experience.

And, finally, I would like to thank my wife, Ardyth, whose help made this book possible.

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ELEMENTARY MICROSTUDIES OF HUMAN TISSUES

Chapter One

INTRODUCTION: THE MICROSCOPE AND HISTOLOGICAL SLIDE

THE microscope is shown in Figure 1 with its major parts labeled. It is assumed that the instructor will demonstrate its use, and only a few suggestions are offered here.

1. Use only lens paper when cleaning the lenses. For more persistent stains, breathe on the lens and rub clean with lens paper, using a circular motion. If this does not suffice, moisten the lens paper with a small amount of saliva or, in exceptional cases, xylene; and immediately rub clean. Never use alcohol for cleaning lenses.
2. Always find the image under low power first, then switch to high power.
3. Use only the fine adjustment (never the coarse adjustment) under high power.
4. Keep both eyes opened when examining tissue, looking with one eye for a while and then switching to the other eye when working long periods.
5. Develop a pattern for systematically scanning a slide. A thumb placed on either side of the slide will suffice to move

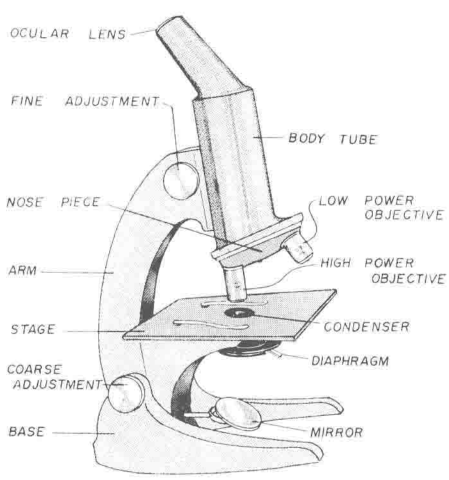

Figure 1. The microscope.

the slide if the microscope is not equipped with a mechanical stage.

6. Do not hesitate to use a dissecting scope to examine the overall structure of a tissue.
7. If an oil-immersion lens is available, learn how to use it and use it often.
8. Remember that each tissue varies in thickness and density, so use the diaphragm or disc often to regulate the amount of light passing through the tissue. Choose the best light for the particular tissue being studied.
9. Make sure the slide being examined is clean and free of fingerprints.
10. Use both hands when carrying a microscope, one hand on the base and one on the arm.

HOW A HISTOLOGIC SLIDE IS PREPARED

The preparation of a typically stained tissue involves a number of elaborate procedures, some of which must be precisely timed. The following steps are offered to give the student just a general knowledge of the procedures. The only way to fully appreciate a slide is to prepare one, after which respect in handling comes easily.

The procedures involve the following major steps: (a) fixation, (b) dehydration, (c) clearing, (d) infiltration with paraffin, (e) sectioning, and (f) staining.

A small piece of tissue, usually about a cubic centimeter in volume, is removed as soon as possible after death. The tissue is trimmed, washed, and placed in a solution of fixative, such as formalin, which coagulates protein, protects against distortion, and prevents postmortem changes such as self digestion and bacterial growth.

After fixation, the tissue is passed through a timed sequence of baths, first of increasing concentrations of alcohol and then of increasing concentrations of a clearing agent such as toluene. The first sequence, a dehydration process, removes water from the tissue and replaces the water with alcohol, while the second sequence removes the alcohol from the tissue and replaces it with a clearing agent.

The tissue is then placed in melted wax or paraffin, which can now infiltrate the tissue. After infiltration, the tissue is placed in paraffin which is allowed to harden into a cube. The tissue is then cut, with the aid of a microtome, into very thin sections. Each section is mounted on a glass slide and passed through a timed sequence of baths containing dyes of various types which stain the tissue.

Because of their chemistry, many dyes are specific in that they stain particular parts of cells. Hematoxylin and eosin, referred to as H and E, are specific in that hematoxylin, a basic dye, stains nuclei blue or purple, and eosin, an acid dye, stains cytoplasm pink. Except for a few examples of bone and nerve tissue, all of the slides described in this text are of H-and-E–stained tissues.

After staining, a thick, clear, fluid medium is applied to the tissue, which remains attached to the glass slide. A cover slip is then placed over the medium, which is allowed to dry. The slide is then ready to be examined.

INTERPRETING SLIDES OF TISSUES

A microscopic examination of a slide of tissue presents only a two-dimensional view of that tissue, and this is a distinct disadvantage to the student. This disadvantage can be illustrated by trying to visualize the three-dimensional structure of a common object by examining sections of that object. Viewing Figure 2, a student might visualize an orange as seen in section C as being composed of parallel walls; or, from looking at section B of the electric cable, he might visualize a cable of insulated wires as being oval in shape.

It is hoped that the drawings of three-dimensional views of the tissues and the discussions of the cellular structure will aid in making the slides more rewarding and meaningful for the student.

Probably the most important advantage the student can have, aside from a thorough understanding of the descriptions preceding the microscope study of a tissue, is patience. The student must learn to concentrate patiently and think about what he is looking at under the microscope. As I have just pointed out, a tissue can appear markedly different, depending on the plane of sectioning. And in addition, no two sections, even in the same plane, are exactly alike. The specific cells mentioned in the text will not leap out of the tissue to announce themselves; they must be sought after and checked and rechecked with the descriptions in the text.

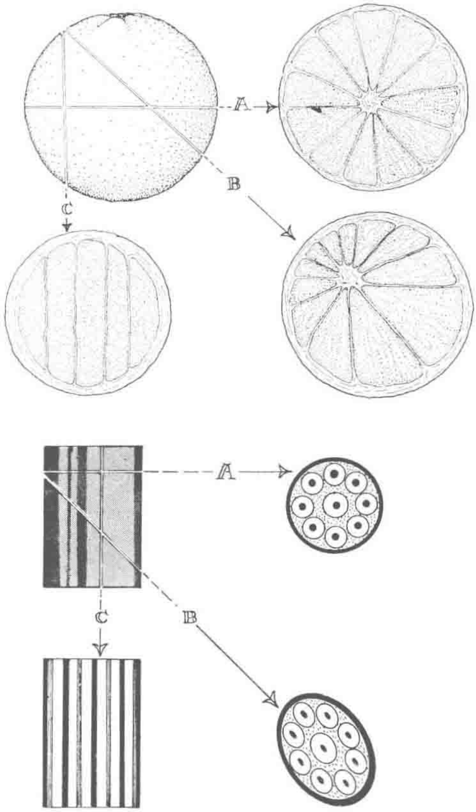

Figure 2. Interpreting different sections of an orange and an electric cable. (Redrawn and slightly modified after Ham, Arthur W.: *Histology*, 6th ed. Philadelphia, Lippincott, 1969.)

With just a little more patience than is demanded in other courses, histology will prove to be a very rewarding experience in understanding the structure and function of the tissues and organs of the body.

Chapter Two

COMMON TISSUES

THE CELL

THE basic living unit of structure and function in the body is the cell. Each cell contains a nucleus which serves as the governing body of the cell and houses the genetic, or hereditary, material. The living substance other than the nucleus is called the cytoplasm; it carries on the work of the cell, responding to chemical instructions from the nucleus and maintaining the cell's functional purpose. For example, it may produce a certain enzyme, as in some cells that line the intestine, or carry an impulse, as in a nerve cell.

Figure 3 is a highly schematic drawing of a typical cell, showing some of the structural units of the nucleus and cytoplasm. Some of these structures can be seen with the light microscope, but the detail seen in the figure is based on studies with the electron microscope at approximately 200,000 magnifications.

The nucleus is a membranous structure (spherical or oval) and contains a nucleolus and fine, granulated threads which form the chromatin network. The nucleolus is composed primarily of a chemical called ribonucleic acid (RNA) which is important in

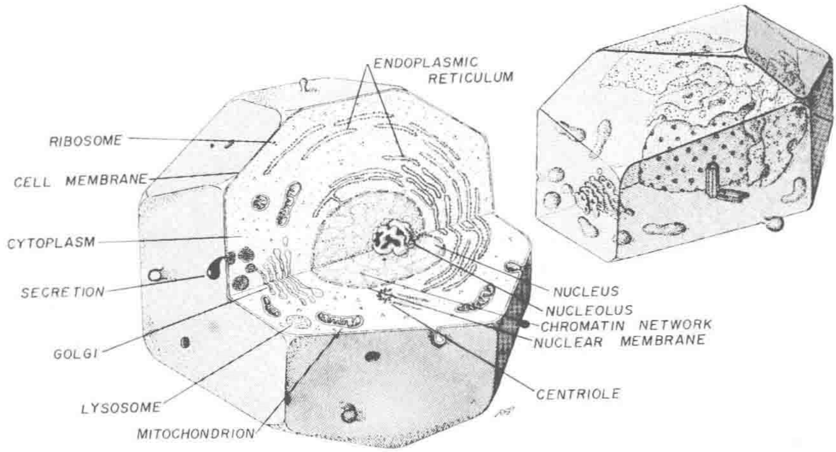

Figure 3. The cell.

protein synthesis, while the chromatin contains deoxyribonucleic acid (DNA) which is the genetic (hereditary) material. The entire nucleus plays an important role in cell division. In the cytoplasm, the endoplasmic reticulum and the ribosomes function in protein synthesis, while the golgi apparatus serves in forming a membranous package around secretory products. The centriole becomes active in cell division. The lysosomes are small sacs that contain enzymes which break down or digest large molecules that are taken into the cell. The mitochondria contain enzymes which drive certain metabolic reactions that result in the production of the high-energy molecules adenosine triphosphate (ATP). The energy-rich ATP supplies the energy for the many cytoplasmic chemical reactions essential to life. The cell membrane, like the membrane of the nucleus, consists of an inner and an outer protein layer with a lipid, or fatty, middle layer. The cell membrane serves in regulating what goes in and out of the cell.

All of these structures are part of the living protoplasm. Nonliving substances, such as oil droplets, pigment, and crystalline granules, may also be present and are called cell inclusions.

In cells stained with hematoxylin and eosin, the nucleus will appear as a dark blue, oval, or spherical-shaped structure. A large nucleus may show one or more small dark bodies (the nucleoli) and a stringy configuration of dark-staining granules (the chromatin network). A single cell may show more than one nucleus. The cytoplasm usually shows granules, some of which are organelles, while others are nonliving structures such as secretory products. The cell membrane, marking the external limits of the cell, is extremely thin and is often difficult to distinguish in H-and-E–stained slides.

TISSUES AND ORGANS

The different types of cells of the body are not mixed together; instead, similar cells are grouped together to form tissues. A tissue is a group of similar cells that perform a common function. The various types of tissues, most of which will appear often in the microscope study of particular organs, are discussed below.

An organ consists of a group of tissues that work together in performing common functions. The overall arrangement of the tissues determines the unique structure of any particular organ. For example, the skin is primarily composed of tissues arranged in sheets or layers (Fig. 7). Liver tissue consists of cords or wall-like structures one or two cells in thickness (Fig. 109).

Different glandular tissues, such as those seen in the pancreas, salivary glands, and breasts, have the same basic structural plan, usually a single layer of cells lining a central lumen or cavity; but differences are apparent (Figs. 82, 161). These differences may include the type of cells that line the cavity, the general shape of the lumen or cavity, associated cells or structures, and many other features.

It is the basic pattern of tissues that the student should concentrate on, rather than color or some other superficial or variable factor. In this way, the student can gain a better understanding of the structure and function of particular organs and, in addition, be able to recognize unknown tissues or unmarked slides when tested.

TYPES OF TISSUES

For convenience in studying them, tissues may be classified into the following six groups: (a) epithelial, (b) connective, (c) supportive, (d) muscle, (e) nerve, and (f) blood and lymph. Supportive tissue (bone and cartilage) and blood and lymph are classified as connective tissue by some authorities, but because of their unique functions they are treated separately in this text. (See Figs. 4, 5, 6, 7.)

Epithelial Tissue

Epithelial tissue, or epithelium, is composed of cells that lie in close proximity to one another, separated only by a thin, nonliving secretion of intercellular substance that serves to hold the cells firmly in place. Epithelium has one surface exposed to either air or fluid, while the deeper surface is separated from the underlying connective tissue and capillaries by a very thin, nonliving basement membrane secreted primarily by the epithelium. The basement membrane, composed of a clear, semisolid or jelly-like substance, serves to fasten the epithelium to the underlying connective tissue. It is usually not visible in H-and-E–stained slides.

Epithelium has a variety of functions depending on its type and location. These functions include protection, secretion, absorption, lubrication of surfaces, and other more specialized functions. The more specific terms *endothelium* and *mesothelium* identify