

# JUNQUEIRA'S Basic Histology

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50<sup>th</sup> ANNIVERSARY  
EDITION!

**I INTERNATIONAL EDITION**

**ANTHONY L. MESCHER**

**SIXTEENTH EDITION**

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SIXTEENTH EDITION

Junqueira's  
**Basic Histology**  
TEXT AND ATLAS

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**Junqueira's Basic Histology, Sixteenth Edition**

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# Contents

PREFACE VII | ACKNOWLEDGMENTS IX

## 1 Histology & Its Methods of Study 1

Preparation of Tissues for Study 1  
Light Microscopy 4  
Electron Microscopy 8  
Autoradiography 9  
Cell & Tissue Culture 10  
Enzyme Histochemistry 10  
Visualizing Specific Molecules 10  
Interpretation of Structures in Tissue Sections 14  
Summary of Key Points 15  
Assess Your Knowledge 16

## 2 The Cytoplasm 17

Cell Differentiation 17  
The Plasma Membrane 17  
Cytoplasmic Organelles 27  
The Cytoskeleton 42  
Inclusions 48  
Summary of Key Points 51  
Assess Your Knowledge 52

## 3 The Nucleus 53

Components of the Nucleus 53  
The Cell Cycle 58  
Mitosis 61  
Stem Cells & Tissue Renewal 65  
Meiosis 65  
Apoptosis 67  
Summary of Key Points 69  
Assess Your Knowledge 70

## 4 Epithelial Tissue 71

Characteristic Features of Epithelial Cells 72  
Specializations of the Apical Cell Surface 77  
Types of Epithelia 80  
Transport Across Epithelia 88  
Renewal of Epithelial Cells 88  
Summary of Key Points 90  
Assess Your Knowledge 93

## 5 Connective Tissue 96

Cells of Connective Tissue 96  
Fibers 103  
Ground Substance 111  
Types of Connective Tissue 114  
Summary of Key Points 119  
Assess Your Knowledge 120

## 6 Adipose Tissue 122

White Adipose Tissue 122  
Brown Adipose Tissue 126  
Summary of Key Points 127  
Assess Your Knowledge 128

## 7 Cartilage 129

Hyaline Cartilage 129  
Elastic Cartilage 133  
Fibrocartilage 134  
Cartilage Formation, Growth, & Repair 134  
Summary of Key Points 136  
Assess Your Knowledge 136

## 8 Bone 138

Bone Cells 138  
Bone Matrix 143  
Periosteum & Endosteum 143  
Types of Bone 143  
Osteogenesis 148  
Bone Remodeling & Repair 152  
Metabolic Role of Bone 153  
Joints 155  
Summary of Key Points 158  
Assess Your Knowledge 159

## 9 Nerve Tissue & the Nervous System 161

Development of Nerve Tissue 161  
Neurons 163  
Glial Cells & Neuronal Activity 168  
Central Nervous System 175  
Peripheral Nervous System 182

Neural Plasticity & Regeneration 187  
Summary of Key Points 190  
Assess Your Knowledge 191

## 10 Muscle Tissue 193

Skeletal Muscle 193  
Cardiac Muscle 206  
Smooth Muscle 208  
Regeneration of Muscle Tissue 213  
Summary of Key Points 213  
Assess Your Knowledge 214

## 11 The Circulatory System 215

Heart 215  
Tissues of the Vascular Wall 219  
Vasculature 220  
Lymphatic Vascular System 232  
Summary of Key Points 235  
Assess Your Knowledge 235

## 12 Blood 237

Composition of Plasma 237  
Blood Cells 239  
Summary of Key Points 252  
Assess Your Knowledge 253

## 13 Hemopoiesis 254

Stem Cells, Growth Factors, & Differentiation 254  
Bone Marrow 255  
Maturation of Erythrocytes 258  
Maturation of Granulocytes 260  
Maturation of Agranulocytes 263  
Origin of Platelets 263  
Summary of Key Points 265  
Assess Your Knowledge 265

## 14 The Immune System & Lymphoid Organs 267

Innate & Adaptive Immunity 267  
Cytokines 269  
Antigens & Antibodies 269  
Antigen Presentation 271  
Cells of Adaptive Immunity 273  
Thymus 276  
Mucosa-Associated Lymphoid Tissue 281  
Lymph Nodes 282  
Spleen 286  
Summary of Key Points 293  
Assess Your Knowledge 294

## 15 Digestive Tract 295

General Structure of the Digestive Tract 295  
Oral Cavity 298  
Esophagus 305  
Stomach 307  
Small Intestine 314  
Large Intestine 318  
Summary of Key Points 326  
Assess Your Knowledge 327

## 16 Organs Associated with the Digestive Tract 329

Salivary Glands 329  
Pancreas 332  
Liver 335  
Biliary Tract & Gallbladder 345  
Summary of Key Points 346  
Assess Your Knowledge 348

## 17 The Respiratory System 349

Nasal Cavities 349  
Pharynx 351  
Larynx 352  
Trachea 354  
Bronchial Tree & Lung 354  
Lung Vasculature & Nerves 367  
Pleural Membranes 368  
Respiratory Movements 369  
Summary of Key Points 369  
Assess Your Knowledge 370

## 18 Skin 371

Epidermis 372  
Dermis 380  
Subcutaneous Tissue 381  
Sensory Receptors 382  
Hair 383  
Nails 384  
Skin Glands 385  
Skin Repair 388  
Summary of Key Points 391  
Assess Your Knowledge 392

## 19 The Urinary System 393

Kidneys 393  
Blood Circulation 394  
Renal Function: Filtration, Secretion, & Reabsorption 395  
Ureters, Bladder, & Urethra 406

- Summary of Key Points 410  
Assess Your Knowledge 411
- 20 Endocrine Glands 413**  
Pituitary Gland (Hypophysis) 413  
Adrenal Glands 423  
Pancreatic Islets 427  
Diffuse Neuroendocrine System 429  
Thyroid Gland 430  
Parathyroid Glands 432  
Pineal Gland 435  
Summary of Key Points 437  
Assess Your Knowledge 437
- 21 The Male Reproductive System 439**  
Testes 439  
Intratesticular Ducts 449  
Excretory Genital Ducts 449  
Accessory Glands 451  
Penis 456  
Summary of Key Points 457  
Assess Your Knowledge 459
- 22 The Female Reproductive System 460**  
Ovaries 460  
Uterine Tubes 470  
Major Events of Fertilization 471  
Uterus 471  
Embryonic Implantation, Decidua, & The Placenta 478  
Cervix 482  
Vagina 483  
External Genitalia 483  
Mammary Glands 483  
Summary of Key Points 488  
Assess Your Knowledge 489
- 23 The Eye & Ear: Special Sense Organs 490**  
Eyes: The Photoreceptor System 490  
Ears: The Vestibuloauditory System 509  
Summary of Key Points 522  
Assess Your Knowledge 522
- APPENDIX 525**  
**FIGURE CREDITS 527**  
**INDEX 529**

# Preface

Publication of the 16th English edition of *Basic Histology* marks the 50th anniversary of the book's creation by L. C. Junqueira, M.D. and colleagues. That edition, the first histology textbook published in soft cover, was compact, concise, highly readable, yet authoritative and quickly set the standard by which subsequent textbooks in the area of histology and cell biology would be judged. After Dr. Junqueira's death I accepted the McGraw Hill editors' challenge to maintain this high standard with the English edition and strove to improve all aspects of the book's utility for the modern student in the health professions while maintaining its compact size and ease of use. Based on its position as a perennial best-seller among Histology textbooks on Amazon and its selection as a Core Title in the Health Sciences by Doody's Book Review Service, *Junqueira's Basic Histology* clearly continues as the preeminent source of **concise yet thorough** information on human tissue structure and function. For five decades this educational resource has met the needs of learners for a well-organized and summarizing presentation of **cell biology and histology** that integrates the material with that of **biochemistry, immunology, endocrinology, and physiology** and provides an excellent foundation for subsequent studies in **pathology**. The text is prepared specifically for students of medicine and other health-related professions, as well as for advanced undergraduate courses in human tissue biology. Because of its value and appeal to students and instructors alike, *Junqueira's Basic Histology: Text and Atlas* has been translated into **more than a dozen languages** and is used in medical schools throughout the world.

Unlike any other histology texts and atlases, each chapter of this edition again includes a set of multiple-choice **Self-Test Questions**, which allow readers to assess their comprehension and knowledge of important points in the subject. A few questions in each set utilize clinical vignettes for framing the medical relevance and applications of basic science concepts, as recommended by the United States National Board of Medical Examiners, in addition to the questions assessing learners' understanding of basic concepts. Each chapter also includes a **Summary of Key Points** to guide students for review of the most clearly important information. **Summary Tables** in each chapter organize and condense important information, facilitating efficient learning. Modern page design and graphics further simplify study of this material.

Each chapter has been revised and shortened where feasible, while coverage of specific topics has been expanded and

updated as needed. Inserted throughout each chapter are more numerous, short paragraphs indicating how the information presented can be applied clinically and emphasizing the foundational relevance of the material learned.

The art and other figures are presented in each chapter, with the goal to simplify learning and integration with related material. Used throughout the text the McGraw Hill biomedical illustrations are arguably the most useful, thorough, and attractive of any similar medical textbook. Every human tissue and cell is shown with electron and light micrographs which comprise a complete atlas of cell, tissue, and organ structures fully compatible with the students' own collection of glass or digital light microscope slides.

The digital version of *Junqueira's Basic Histology: Text and Atlas* includes significant changes with this edition. The digital version is available at no charge to health science students whose medical library offers McGraw Hill's **AccessMedicine** among its electronic resources, which includes the library resources of more than 95% of medical schools in North America. Each chapter of this new SIXTEENTH edition now incorporates a detailed **Lab Guide** for that material, including (1) **the learning objectives for that laboratory session**, (2) **a list of important structures to identify and terms to use and understand**, (3) **detailed microscopic directions for studying each tissue and locating those structures**, and (4) **self-assessment questions** with each session. These laboratory exercises link the photographic material in the Junqueira textbook and correlate with slides in any virtual or glass slide collection, making this digital Lab Guide a unique instrument among the learning resources of any other histology text and atlas. **No other major textbook of tissue biology includes such detailed guidance for learners through the microscopic or laboratory portion of the typical medical school coverage of histology.** As of this writing in mid-2020, the previous FIFTEENTH edition of Junqueira on AccessMedicine continues to include these features of the digital Lab Guide, along with links to an excellent collection of scannable and focusable virtual light microscope slides.

Students who cannot link to AccessMedicine will lack this digital Lab Guide but may still utilize the collection of over 150 virtual light microscope slides of human tissues and organs at: <http://medsci.indiana.edu/junqueira/virtual/junqueira.htm>. This set of virtual slides is presently available without restrictions for use with any instructor's guide for human histology lab exercises.

As with other recent editions of *Junqueira*, both print and digital versions of this edition facilitate learning by their overall **organization**:

- An opening chapter reviews the **histological techniques** which allow understanding of cell and tissue structure.
- Two chapters then summarize the structural and functional organization of **human cell biology**, presenting the cytoplasm and nucleus separately.
- The next seven chapters cover the **four basic tissues** that make up our organs: epithelia, connective tissue (and its major sub-types), nervous tissue, and muscle.
- Remaining chapters explain the organization and functional significance of these tissues in **each of the body's organ systems**, closing with up-to-date consideration of cells in the unique organs of special sense, the eye and ear.

For additional review of what's been learned or to assist rapid assimilation of the material in *Junqueira's Basic Histology*, McGraw Hill has published a set of 200 full-color **Basic Histology Flash Cards**, which I've also authored. Each card includes images of key structures to identify, a summary of important facts about those structures, and a clinical comment. This valuable learning aid is available as a set of actual cards from Amazon.com, or as an app for smartphones or tablets from the online App Store.

With its proven strengths, excellent up-to-date pedagogical features, and links with the new digital Lab Guide, I am confident that *Junqueira's Basic Histology* will continue as one of the most valuable and most widely read educational resources in histology. As always, users are invited to provide me with feedback about any aspect of the book's content or features.

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# Acknowledgments

I wish to thank the students at Indiana University School of Medicine and the undergraduates at Indiana University Bloomington with whom I studied histology and cell biology for over 38 years and from whom I have learned much about presenting basic concepts most effectively. Their input has greatly helped in the task of maintaining and updating the presentations in this classic textbook. The help of Sue Childress and Dr. Mark Braun was invaluable in slide preparation and creation of the virtual microscope for human histology respectively.

As with the last edition, the present text includes multiple-choice questions at the end of each chapter, aimed to test the learner's retention and understanding of important points in that body of material. Many of these questions were used in my courses, but others are taken or modified from a few of the many excellent review books published by McGraw Hill/Lange for students preparing to take the United States Medical Licensing Examination. These include *Histology and Cell Biology: Examination and Board Review*, by Douglas Paulsen; *USMLE Road Map: Histology*, by Harold Sheedlo; and

*Anatomy, Histology, & Cell Biology: PreTest Self-Assessment & Review*, by Robert Klein and George Enders. The use here of questions from these valuable resources is gratefully acknowledged. Students are referred to those review books for hundreds of additional self-assessment questions.

I am also grateful to colleagues and reviewers throughout the world who provided specialized expertise or original photographs, as also acknowledged further in these figures' captions. I thank those professors and students in the United States and countries throughout the world who provided useful suggestions that have improved the new edition of *Junqueira's Basic Histology*. Finally, I am pleased to acknowledge the help and collegiality provided by the staff of McGraw Hill, especially editor Michael Weitz, whose work made possible publication of this 16th edition of *Junqueira's Basic Histology: Text and Atlas*.

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# Histology & Its Methods of Study

<b>PREPARATION OF TISSUES FOR STUDY</b>	<b>1</b>	<b>AUTORADIOGRAPHY</b>	<b>9</b>
Fixation	1	<b>CELL &amp; TISSUE CULTURE</b>	<b>10</b>
Embedding & Sectioning	3	<b>ENZYME HISTOCHEMISTRY</b>	<b>10</b>
Staining	3	<b>VISUALIZING SPECIFIC MOLECULES</b>	<b>10</b>
<b>LIGHT MICROSCOPY</b>	<b>4</b>	Immunohistochemistry	11
Bright-Field Microscopy	4	Hybridization Techniques	12
Fluorescence Microscopy	5	<b>INTERPRETATION OF STRUCTURES IN TISSUE SECTIONS</b>	<b>14</b>
Phase-Contrast Microscopy	5	<b>SUMMARY OF KEY POINTS</b>	<b>15</b>
Confocal Microscopy	5	<b>ASSESS YOUR KNOWLEDGE</b>	<b>16</b>
Polarizing Microscopy	7		
<b>ELECTRON MICROSCOPY</b>	<b>8</b>		
Transmission Electron Microscopy	8		
Scanning Electron Microscopy	9		

**H**istology is the study of the tissues of the body and how these tissues are arranged to constitute organs. This subject involves all aspects of tissue biology, with the focus on how cells' structure and arrangement optimize functions specific to each organ.

Tissues have two interacting components: cells and extracellular matrix (ECM). The ECM consists of many kinds of macromolecules, most of which form complex structures, such as collagen fibrils. The ECM supports the cells and contains the fluid transporting nutrients to the cells, and carrying away their wastes and secretory products. Cells produce the ECM locally and are in turn strongly influenced by matrix molecules. Many matrix components bind to specific cell surface receptors that span the cell membranes and connect to structural components inside the cells, forming a continuum in which cells and the ECM function together in a well-coordinated manner.

During development, cells and their associated matrix become functionally specialized and give rise to fundamental types of tissues with characteristic structural features. Organs are formed by an orderly combination of these tissues, and their precise arrangement allows the functioning of each organ and of the organism as a whole.

The small size of cells and matrix components makes histology dependent on the use of microscopes and molecular methods of study. Advances in biochemistry, molecular biology, physiology, immunology, and pathology are essential for

a better knowledge of tissue biology. Familiarity with the tools and methods of any branch of science is essential for a proper understanding of the subject. This chapter reviews common methods used to study cells and tissues, focusing on microscopic approaches.

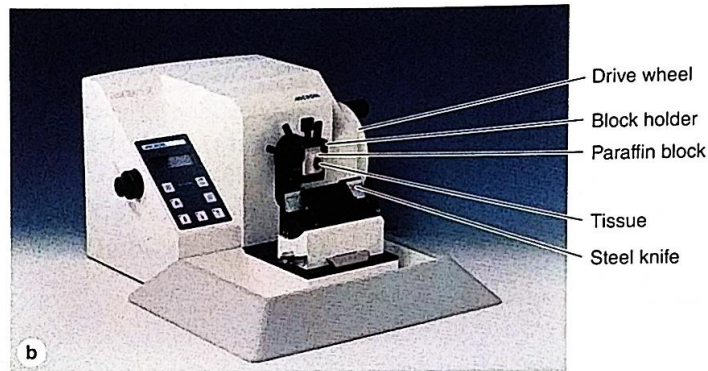
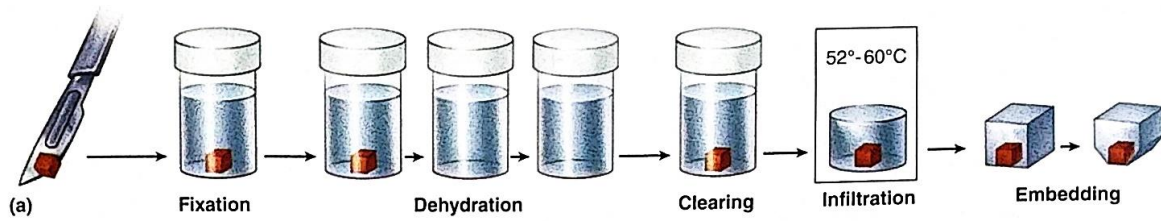
## ► PREPARATION OF TISSUES FOR STUDY

The most common procedure used in histologic research is the preparation of tissue slices or "sections" that can be examined visually with transmitted light. Because most tissues and organs are too thick for light to pass through, thin translucent sections are cut from them and placed on glass slides for microscopic examination of the internal structures.

The ideal microscopic preparation is preserved so that the tissue on the slide has the same structural features it had in the body. However, this is often not feasible because the preparation process can remove cellular lipid, with slight distortions of cell structure. The basic steps used in tissue preparation for light microscopy are shown in Figure 1-1.

### Fixation

To preserve tissue structure and prevent degradation by enzymes released from the cells or microorganisms, pieces of

**FIGURE 1–1** Sectioning fixed and embedded tissue.

Most tissues studied histologically are prepared as shown, with this sequence of steps (a):

- **Fixation:** Small pieces of tissue are placed in solutions of chemicals that cross-link proteins and inactivate degradative enzymes, which preserve cell and tissue structure.
- **Dehydration:** The tissue is transferred through a series of increasingly concentrated alcohol solutions, ending in 100%, which removes all water.
- **Clearing:** Alcohol is removed in organic solvents in which both alcohol and paraffin are miscible.
- **Infiltration:** The tissue is then placed in melted paraffin until it becomes completely infiltrated with this substance.
- **Embedding:** The paraffin-infiltrated tissue is placed in a small mold with melted paraffin and allowed to harden.
- **Trimming:** The resulting paraffin block is trimmed to expose the tissue for sectioning (slicing) on a microtome.

Similar steps are used in preparing tissue for transmission electron microscopy (TEM), except special fixatives and dehydrating solutions are used with smaller tissue samples and embedding involves epoxy resins which become harder than paraffin to allow very thin sectioning.

(b) A **microtome** is used for sectioning paraffin-embedded tissues for light microscopy. The trimmed tissue specimen is mounted in the paraffin block holder, and each turn of the drive wheel by the histologist advances the holder a controlled distance, generally from 1 to 10  $\mu\text{m}$ . After each forward move, the tissue block passes over the steel knife edge and a section is cut at a thickness equal to the distance the block advanced. The paraffin sections are placed on glass slides and allowed to adhere, deparaffinized, and stained for light microscope study. For TEM, sections less than 1  $\mu\text{m}$  thick are prepared from resin-embedded cells using an ultramicrotome with a glass or diamond knife.

organs are placed as soon as possible after removal from the body in solutions of stabilizing or cross-linking compounds called **fixatives**. Because a fixative must fully diffuse through the tissues to preserve all cells, tissues are usually cut into small fragments before fixation to facilitate penetration. To improve cell preservation in large organs, fixatives are often introduced via blood vessels, with vascular perfusion allowing fixation rapidly throughout the tissues.

One widely used fixative for light microscopy is formalin, a buffered isotonic solution of 37% formaldehyde. Both this compound and glutaraldehyde, a fixative used for electron

microscopy, react with the amine groups ( $\text{NH}_2$ ) of proteins, preventing their degradation by common proteases. Glutaraldehyde also cross-links adjacent proteins, reinforcing cell and ECM structures.

Electron microscopy provides much greater magnification and resolution of very small cellular structures, and fixation must be done very carefully to preserve additional “ultrastructural” detail. Typically in such studies, glutaraldehyde-treated tissue is then immersed in buffered osmium tetroxide, which preserves (and stains) cellular lipids as well as proteins.