



Atlas of Human Histology

**A Guide to Microscopic Structure
of Cells, Tissues and Organs**

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CONTENTS

Cells and Tissues

1.	Introduction and Cell	1
2.	Epithelium	15
3.	Connective tissue	29
4.	Muscle tissue	43
5.	Cartilage and Bone	61
6.	Nerve tissue	85
7.	Peripheral blood	107
8.	Hematopoiesis	113

Organology

9.	Cardiovascular System	127
10.	Lymphoid system	157
11.	Skin	181
12.	Exocrine glands	193
13.	Endocrine glands	205
14.	Gastrointestinal Tract	223
15.	Liver and Gall Bladder	247
16.	Urinary System	261
17.	Respiratory System	289
18.	Female Reproductive System	305
19.	Male Reproductive System	329
20.	Organs of Special Sense	343
	Index	359

This atlas is a series of photographs ranging from low to high magnifications of the individual tissue specimens. The low magnification images should be used for orientation, while the higher magnification images show details of cells, tissues, and organs. Although every effort has been made to faithfully reproduce the colors of the tissues, a full appreciation of histological structure is best achieved by examining the original specimens with a microscope. This atlas is a preview of what should be observed.

The photomicrographs found in this atlas come from the collection of microscope slide used by medical, dental and undergraduate students of histology at the University of Minnesota. Most of these slides were prepared by Anna-Mary Carpenter M.D., Ph.D. during her tenure as Professor in the Department of Anatomy (University of Minnesota Medical School).

Each tissue specimen, in its entirety, has been digitized with a high resolution 40x or 60x lens to generate virtual microscope slides. The Virtual Microscope Collection includes additional slides which complement and extend the core slide collection.

The drawings that appear in the atlas are the product of Jean E. Magney, who is accomplished both as an histologist and an artist. Her talented interpretation of biological structure and its artistic rendering greatly facilitate the learning and comprehension of histology. These drawings first appeared in "Color Atlas of Histology" Stanley L. Erlandsen and Jean E. Magney, Mosby 1992.

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INTRODUCTION

What is histology?

Histology is the study of cells, tissues and organs as seen through the microscope. Although this atlas is a guide to biological structure that can be observed through the light microscope, histology also includes cellular detail down to the molecular level that can be observed using an electron microscope. The importance of histology is that it is the structural basis for cell, tissue and organ biology and function (physiology) and disease (pathology).

What is the plan for the study of cells, tissues and organs?

Histology is organized into four basic types of tissues.

1. Epithelium
2. Connective tissue including
 - a. Cartilage and bone
 - b. Blood and blood formation
3. Muscle
4. Nervous tissue

Chapters 2-8 are concerned with the features of the four basic tissues. The remaining chapters focus on features of organs. Organs are typically made up of more than one type of tissue and cells with varying degrees of differentiation.

Light Microscope and Tissue Preparation: Limits and Challenges.

The bright field light microscope is a two lens compound optical instrument. The two lenses are the objective and the oculars. The oculars have a 10 fold magnification and the objectives range from 10x, 20x, 40x to 100x. Thus the total magnification typically ranges from 100 fold to 1000 fold. In practice this means that while using the 10x objective you have a wide field of view, but with low resolution. While using the 100x objective you have high resolution, but with a very small field of view. To use a metaphor what this means is that when using the low power objective you can see the forest but not the trees and while using the high power objective you can see the leaves on the trees but not the forest. Therefore when

examining a specimen it is essential to start with the low power objective to gain perspective and then work up to the highest power magnification as needed to observe the necessary detail.

Examination of tissues requires that they be prepared for viewing with a microscope. This is a multi-step process that includes fixation (preserves the tissue), embedment (stabilizes the tissue for sectioning), sectioning (cuts the specimen into thin slices of about 5 μm) then placing the sections on a glass slide so they can be stained for viewing.

A note about resolution and detection. Resolution refers to the ability to discriminate between two adjacent objects. For the light microscope with optimal lenses and sample preparation this approaches 0.2 μm , which is the theoretical limit for light microscopes. [The eye can resolve about 250-500 μm and the electron microscope can resolve about 1 nm] Detection refers to the ability to detect something and this can be much smaller than the limit of resolution. For fluorescence molecules this can be as little as a few molecules!

Structure	Diameter	Light Microscope
Human ovum	120 μm	
Most cells	10-30 μm	
Red blood cell (RBC)	7 μm	
Mitochondria	0.4-1.0 μm	
Cilia	0.3 μm	
Microvilli	100 nm	Electron Microscope
Microtubules	24 nm	
Myosin filaments	15 nm	
Intermediate filaments	10 nm	
Plasma membrane (thickness)	9 nm	
Microfilaments (actin)	5 nm	

There are several challenges in learning histology. The first being that the view observed through a microscope gives you a perspective that you are unlikely to have experienced previously. It is a complex data set – one with a broad range of

shapes and sizes, with varying shades of red and blue. This complex image offers very few clues that are intuitive. Also, the tissue specimen is a two dimensional slice of a complex three dimensional structure. So, once the two dimensional image has been ascertained you still have the challenge of imagining its three dimensional elaboration. The ideal situation is to have the student and teacher viewing the same specimen simultaneously such as in a dual view microscope. Since this is not always possible, this atlas was written as if a teacher was always at your side to help guide you from low power to the highest power necessary to observe the essential features of the tissue specimens. Thus you will notice that images of all of the slides range from a macroscopic view of the microscope slide itself and then progress through higher magnifications as needed.

How to Study Microscope Slides

1. Know what structures are important to learn. This atlas shows and identifies the structures and how to find them.
2. The next task in learning is to see if you can identify the structures when examining a slide. Always start at the lowest power (this is important for context and orientation). Increase the magnification as needed so that additional features of the specimen can be observed.
3. Take notes on the features that are observed in the slide. This is best done by drawing pictures and writing a description of the specimen. As in any science laboratory, it is essential that observations be recorded. Not only is this good practice but in research and medicine it is also a legal requirement.
4. Each chapter has a section "Observe and note". This lists the features that are essential to learning histology and are noteworthy.

How to Take Histology Laboratory Notes

- A. Draw a picture of the object of interest.

A blue and red pencil is sufficient for nearly all drawings

- B. Write notes about its appearance, characteristics and features.

Nearly every cell can be described by taking note of:

1. Size
2. Shape
3. Nuclear size and shape and nuclear/cytoplasmic ratio
4. General Staining properties (H&E)
 - a. Basophilia and eosinophilia
 - b. Hetero- and euchromatin
5. Special staining properties
 - a. Verhoeff, Azan, silver, etc.
6. Cellular specializations
 - a. Microvilli, cilia, secretion granules, myofilaments etc.
 - b. Unusual amounts of mitochondria, RNA, etc
7. Cellular constituents such as secretion granule contents (hormones, enzymes)
8. Polarity
9. Extracellular material
 - a. Extent
 - b. Appearance

10. Location
 - a. Example
 - i. Adjacent to similar cells
 - ii. Borders a lumen
 - iii. Surrounded by extensive extracellular matrix
 - iv. Etc.
11. Organization (cells, tissues and organs)
 - a. Arrangement of cells of similar and different types
 - b. Arrangement of cells with respect to extracellular material
12. Compare and contrast with similar/different cells.
13. Heterogeneity among homologous cells:
 - a. Cell development and differentiation
 - b. Cell Cycle
 - c. Active and resting cycles
 - d. Exposure to a concentration gradient of nutrients
 - i. Example
 1. Skin cells
 2. Liver hepatocytes

C. Include questions in the notes.

Carefully formulated questions can often reveal the answer.

D. Drawing (and taking notes) is a way of thinking, seeing and understanding.

Chapter 1 Introduction and Cell

The first chapter is an exercise in examining histological tissue specimens through the microscope. A variety of cells, tissues and organs are provided as samples. Also, several different histological stains are used.

Note About Stains

Biological material is inherently of low contrast and provides little to see in the standard brightfield microscope unless treated with a histological stain.

5. Verhoeff: stains elastic protein black
6. Feulgen: stains DNA
7. Sudan: stains lipids
8. PAS (periodic acid Schiff): stains glycogen
9. Aldehyde fuchsin: stains insulin, mast cell granules and elastic fibers purple

Hematoxylin and Eosin (H&E)

1. This is the most commonly used stain for histology and histo-pathology.
 - a. Hematoxylin: Cationic, positively charged, blue dye complex.
 - i. Reacts with negatively charged groups:
 1. COO^- - in proteins
 2. SO_4^- - in proteoglycans (GAGs)
 3. PO_4^- - in nucleic acids
 - ii. Reacts with basophilic structures: basophilia
 - b. Eosin: Anionic, negatively charged red dye
 - i. Reacts with positively charged groups:
 1. NH_3^+ - in proteins
 2. mitochondria
 - ii. Reacts with acidophilic structures: acidophilia, eosinophilia

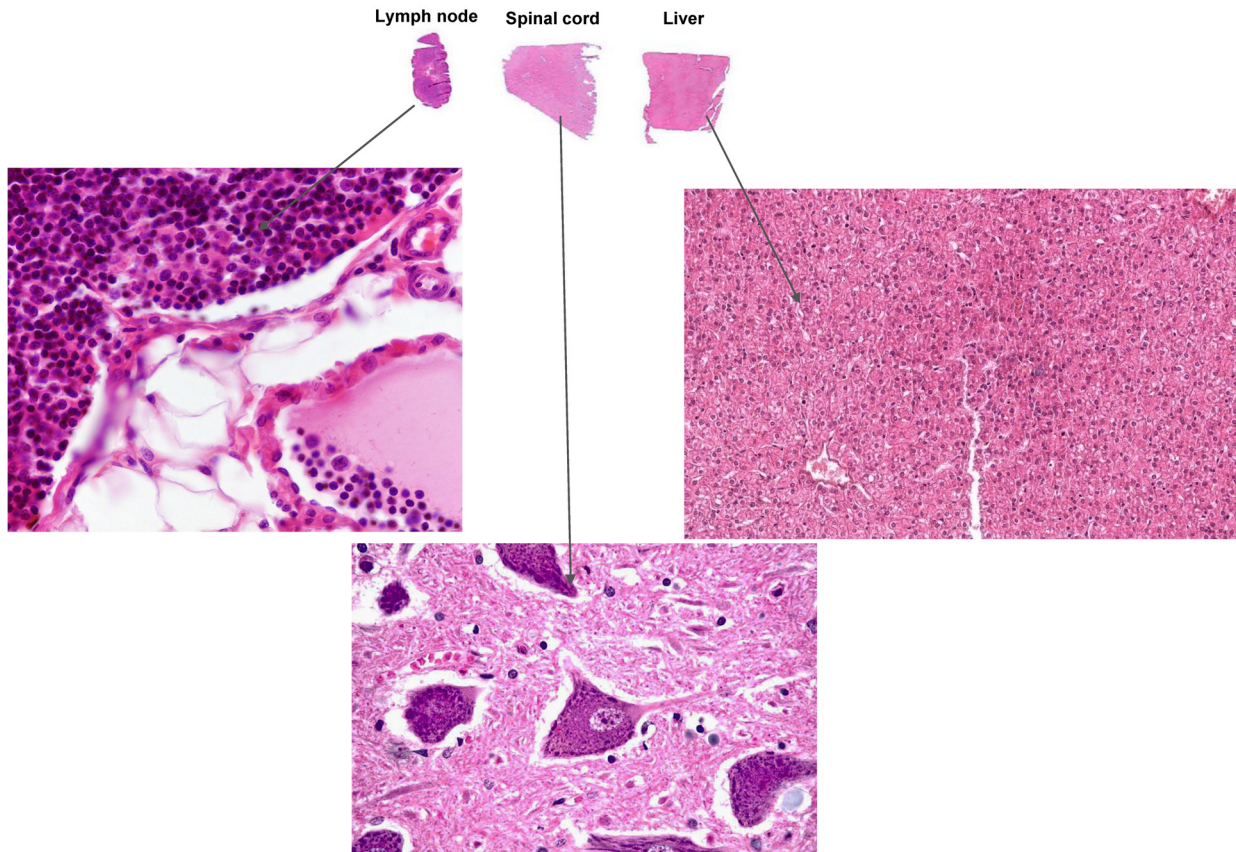
Observe and Note

1. Staining characteristics of various cells and tissues.
2. Cell size using red blood cells ($7\ \mu\text{m}$) as an internal metric.
3. Cell size, shape, nuclear size and shape and nuclear/cytoplasmic ratios.
4. Eosinophilia and basophilia.
5. Euchromatin and heterochromatin.
6. Cellular versus extracellular material such as collagen.
7. Characteristics of different histological stains.

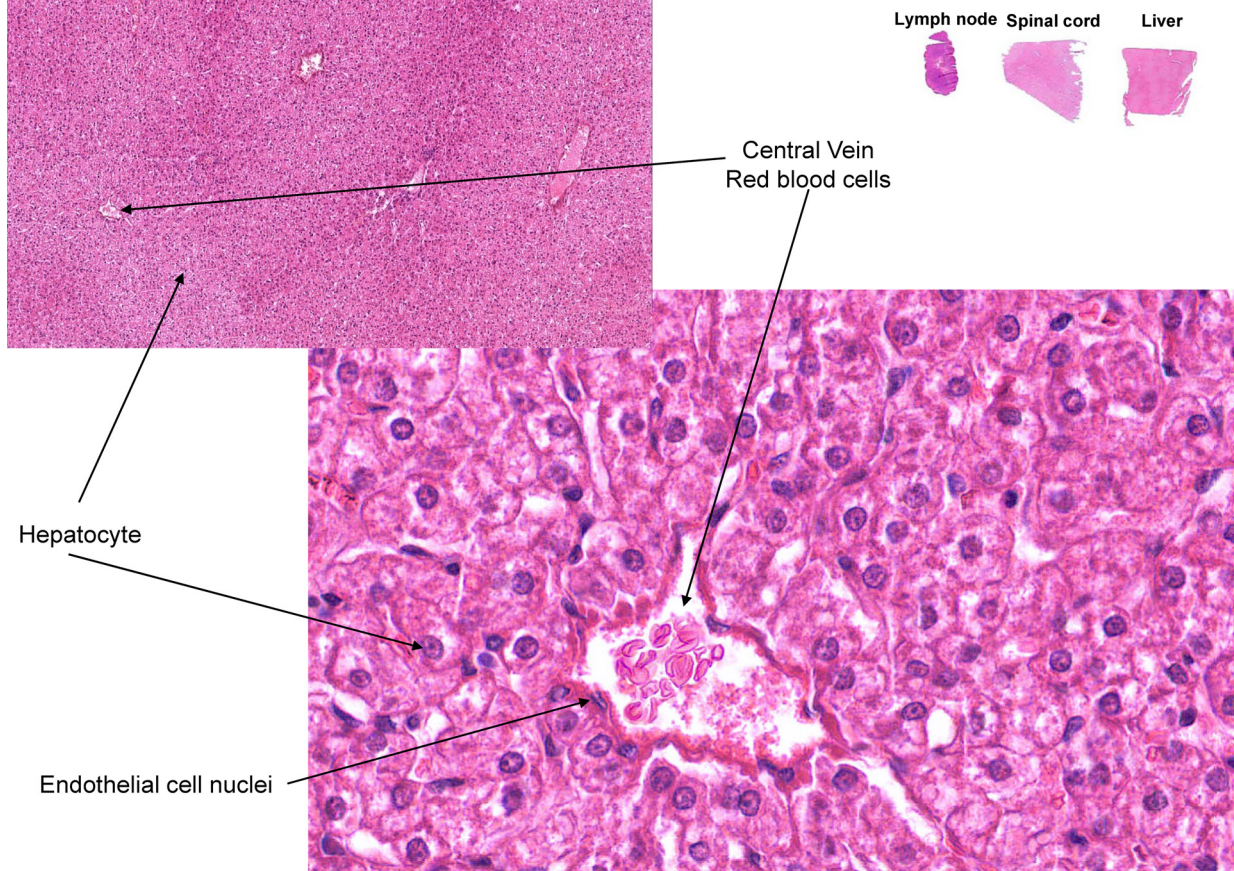
Other Stains

1. Azan: stains collagen blue
2. Silver: stains reticular fibers (collagen type III) black
3. Golgi stain: stains Golgi apparatus
4. Toluidine blue: stains RNA blue and stains mast cells purple

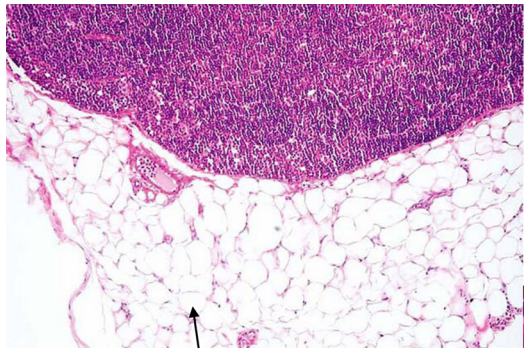
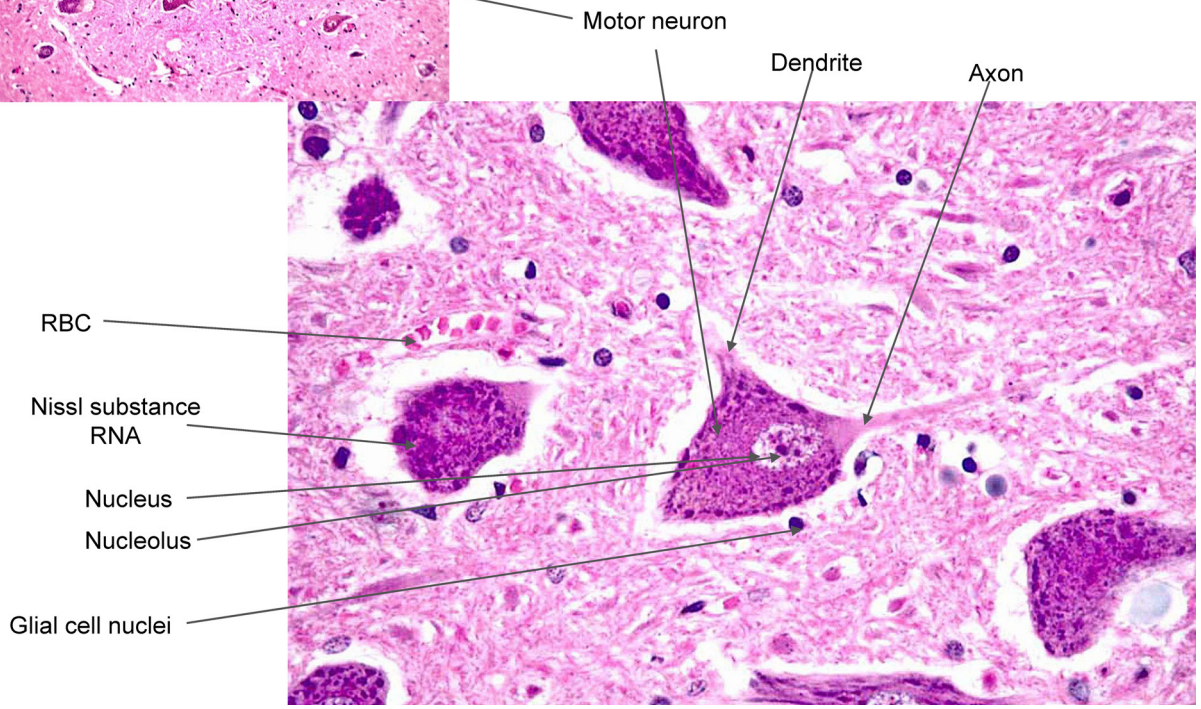
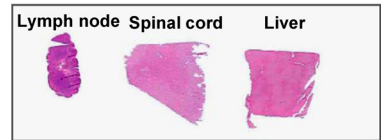
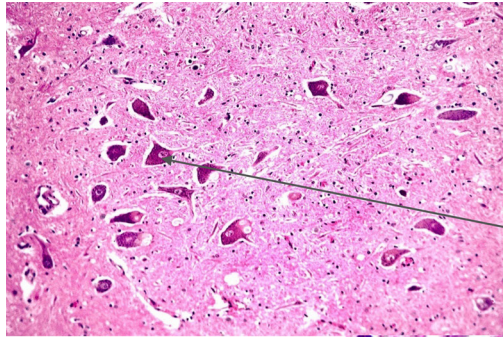
Slide # 1 Nuclear morphology & cell size (H&E)



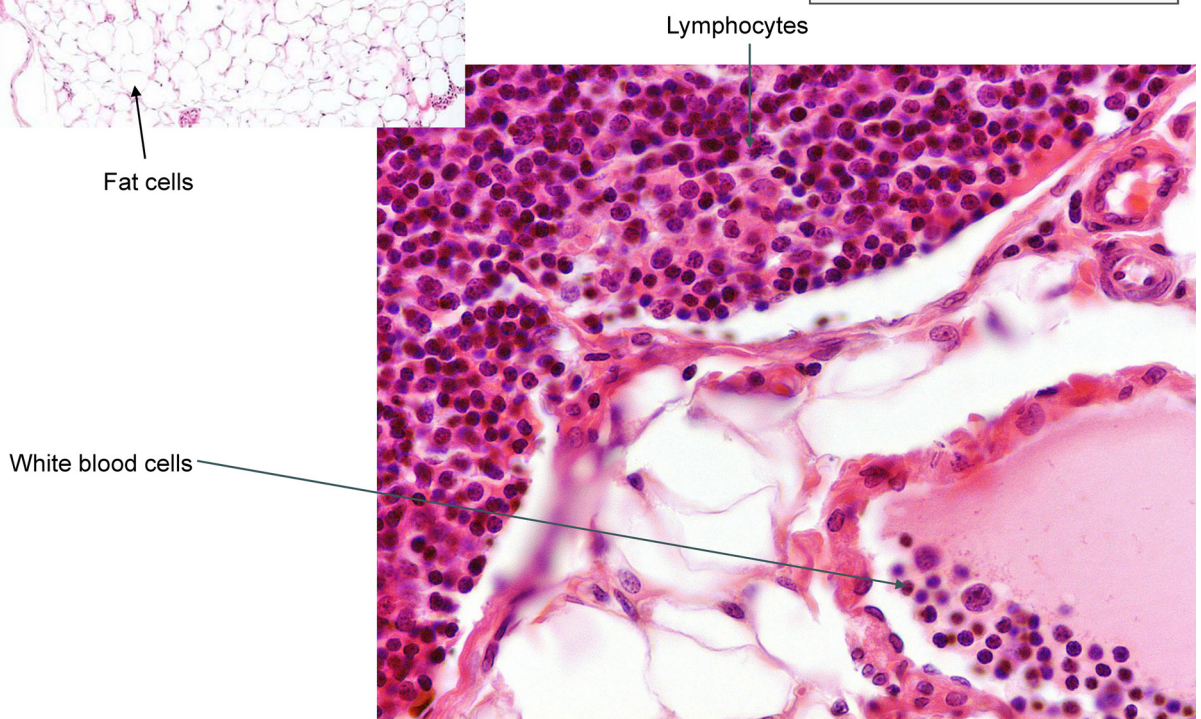
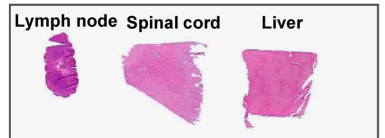
Slide # 1 Liver (H&E)

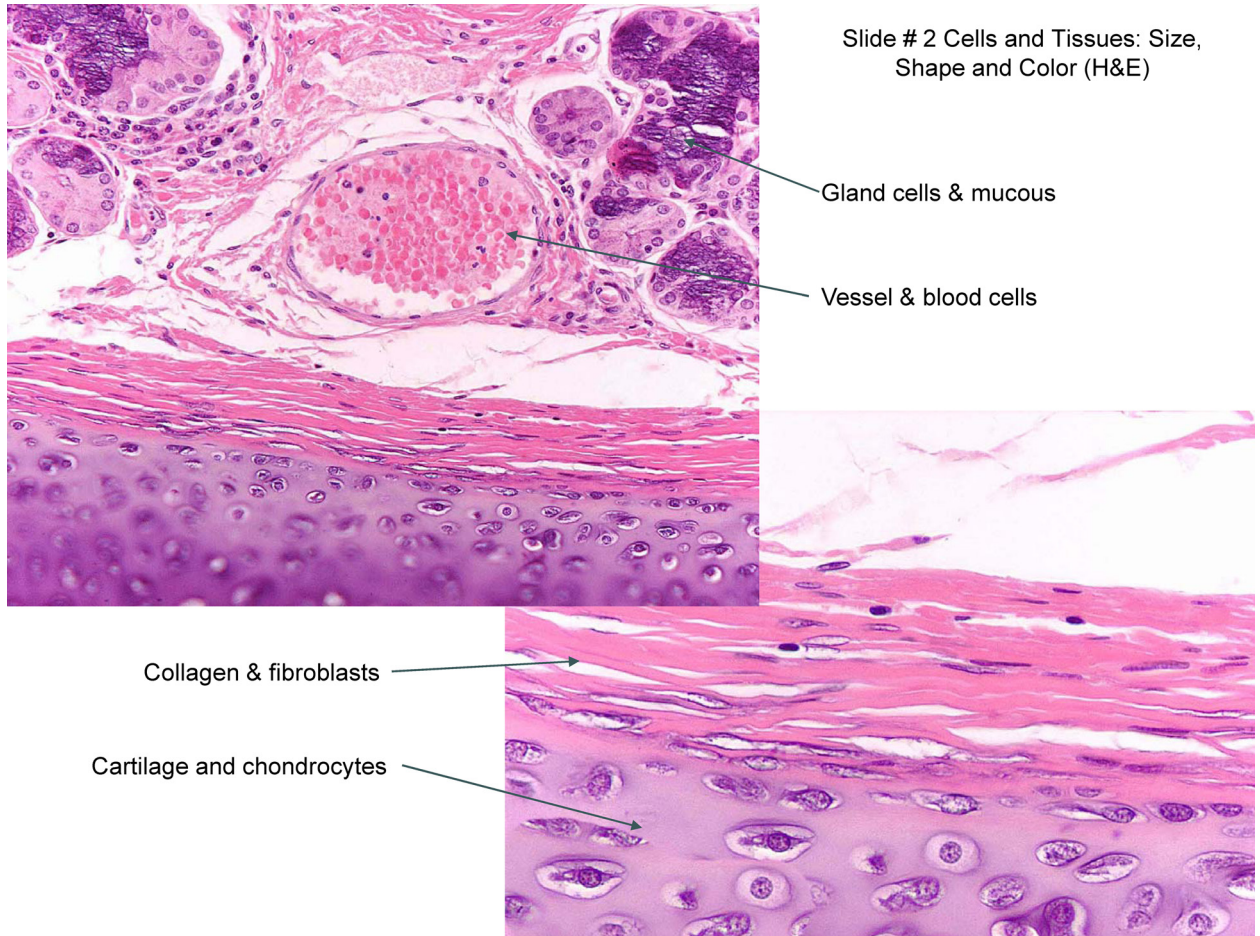
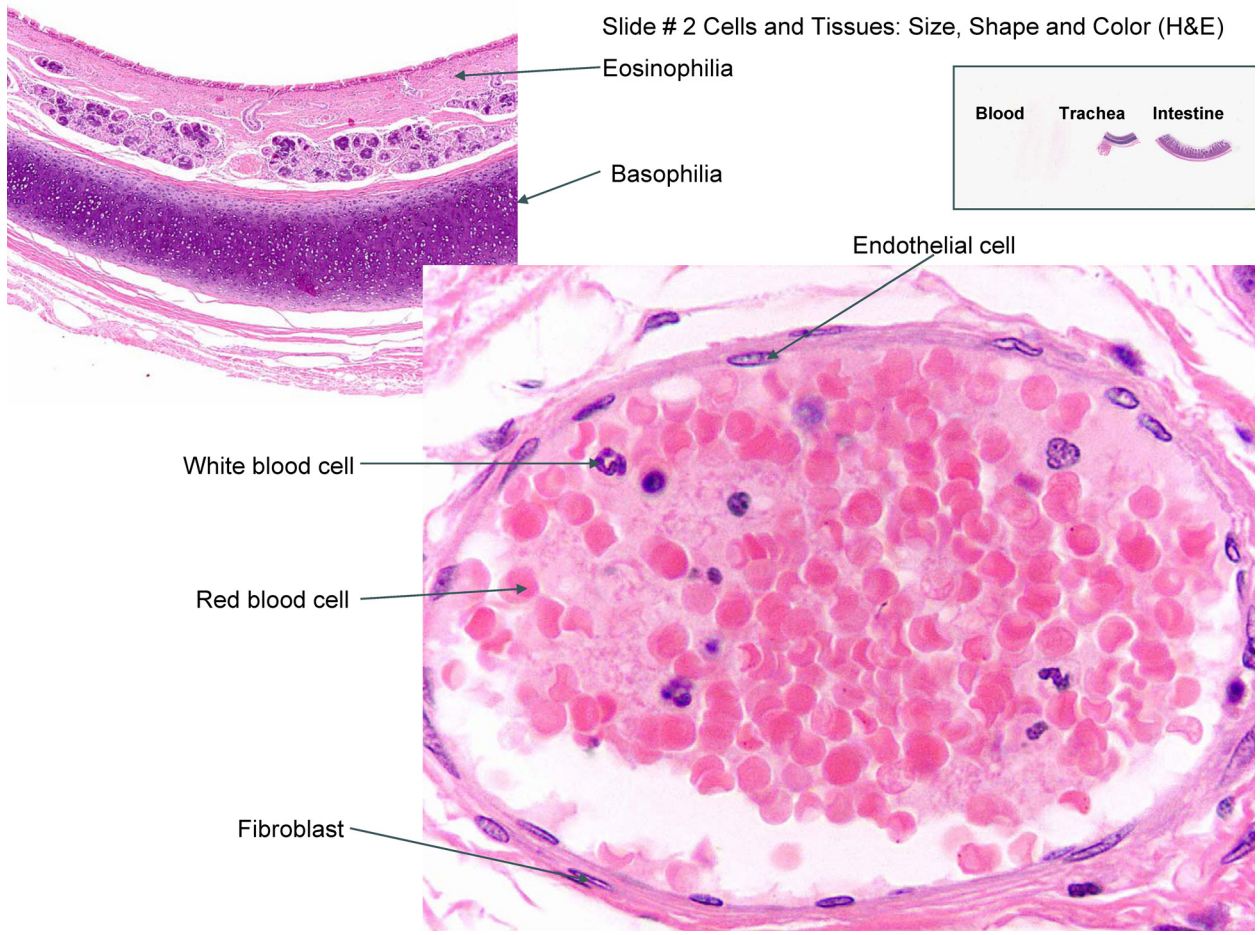


Slide # 1 Spinal Cord (H&E)

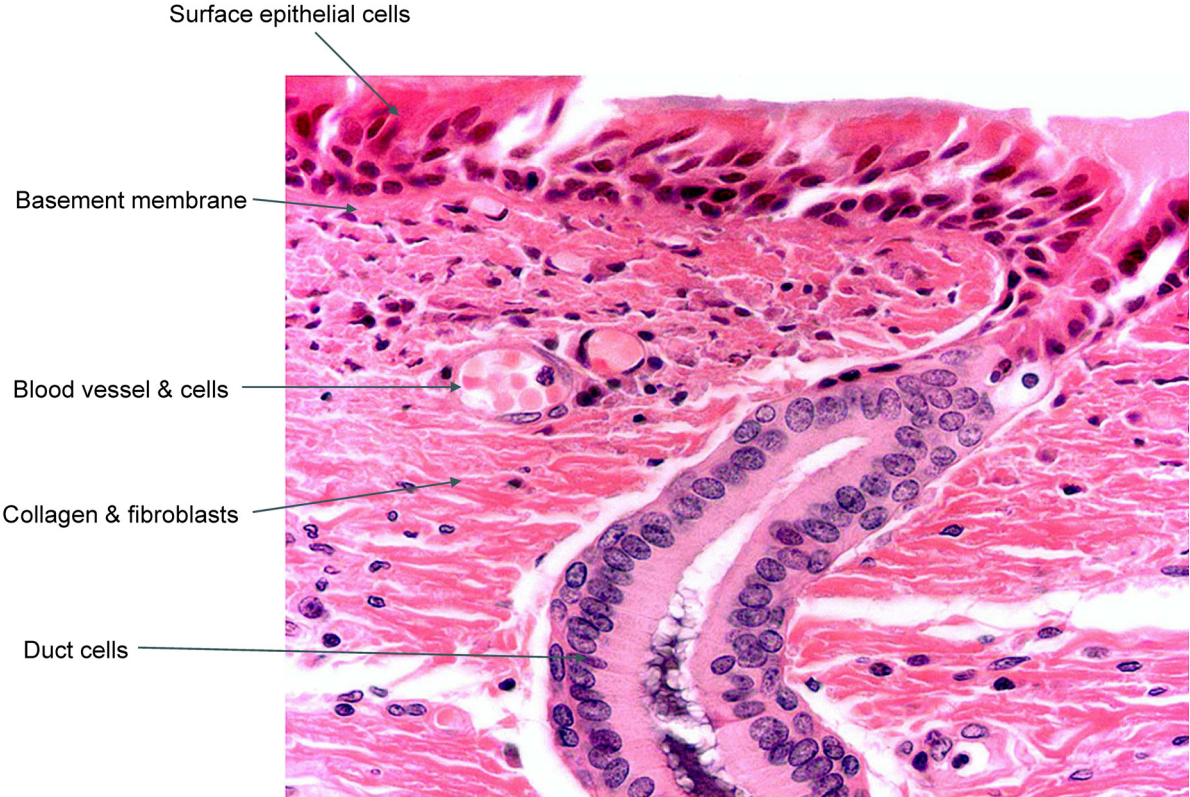


Slide # 1 Lymph Node (H&E)





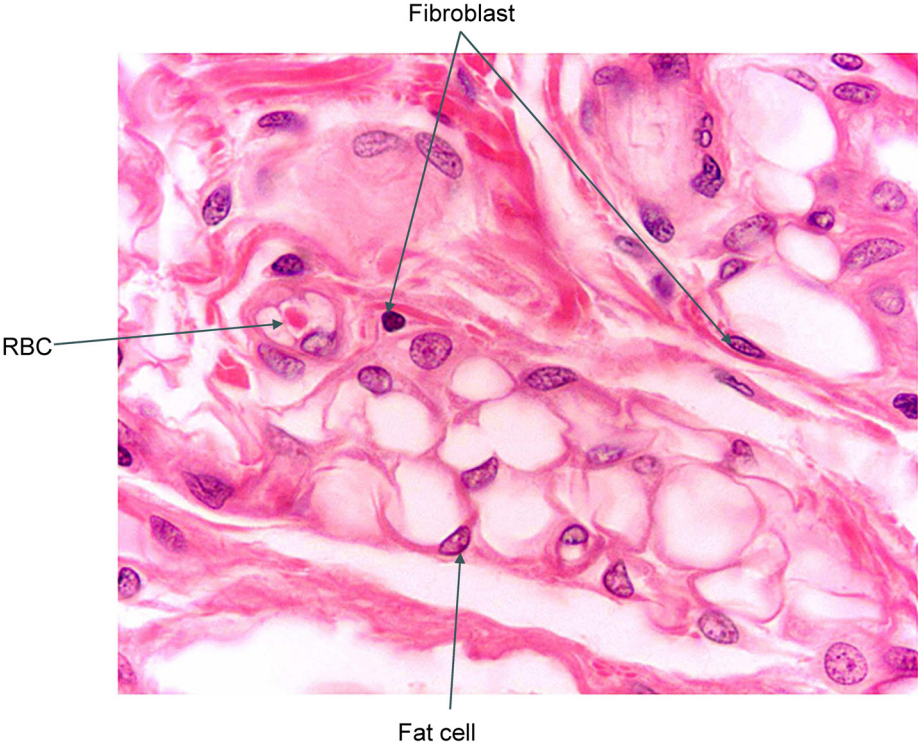
Slide # 2 Cells and Tissues: Size, Shape and Color (H&E)



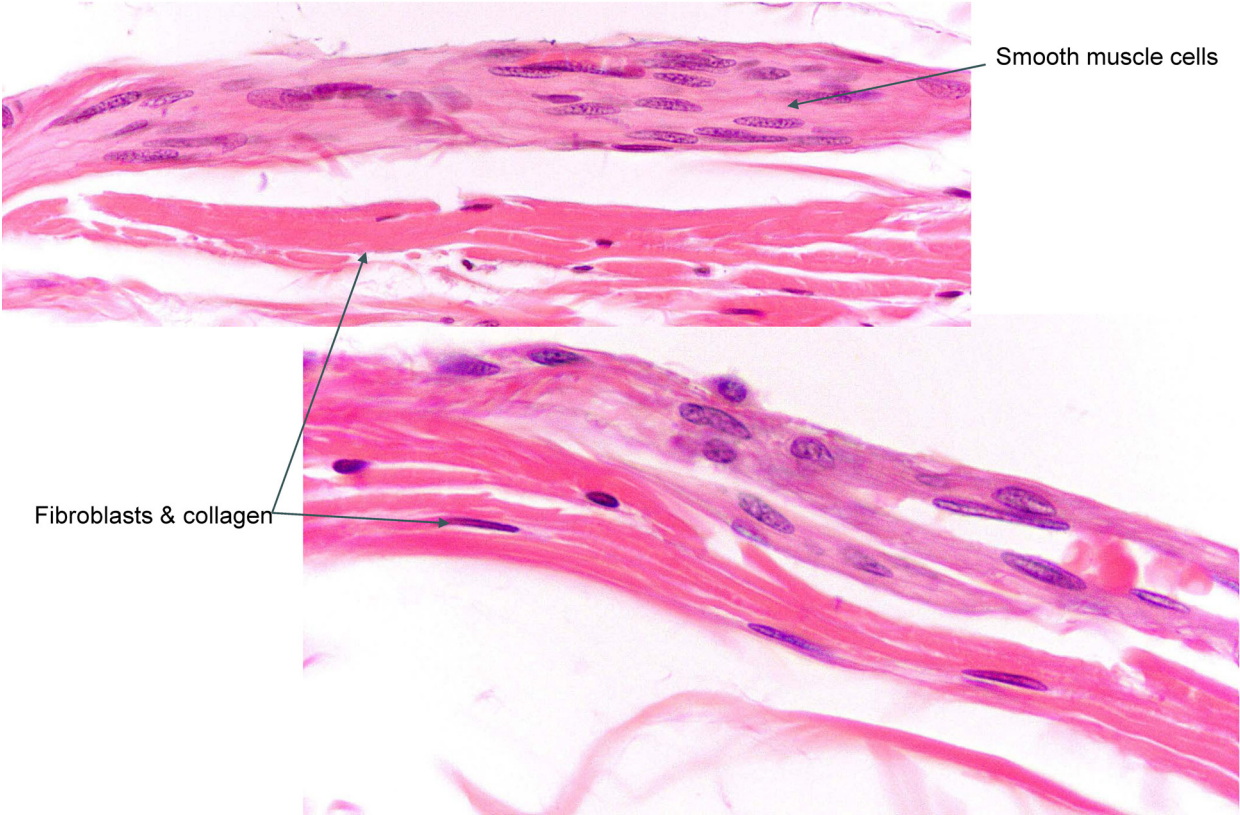
Slide # 2 Cells and Tissues: Size, Shape and Color (H&E)



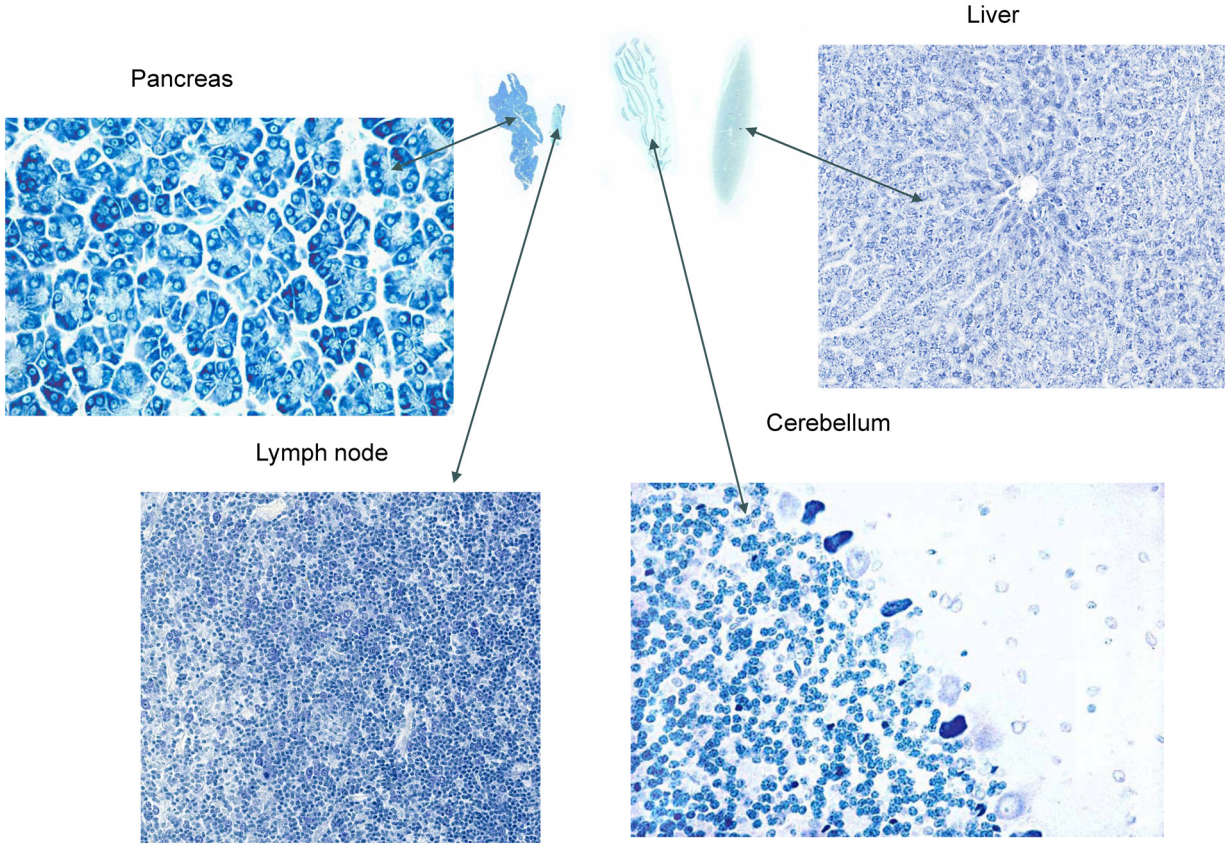
Slide # 2 Cells and Tissues: Size, Shape and Color (H&E)



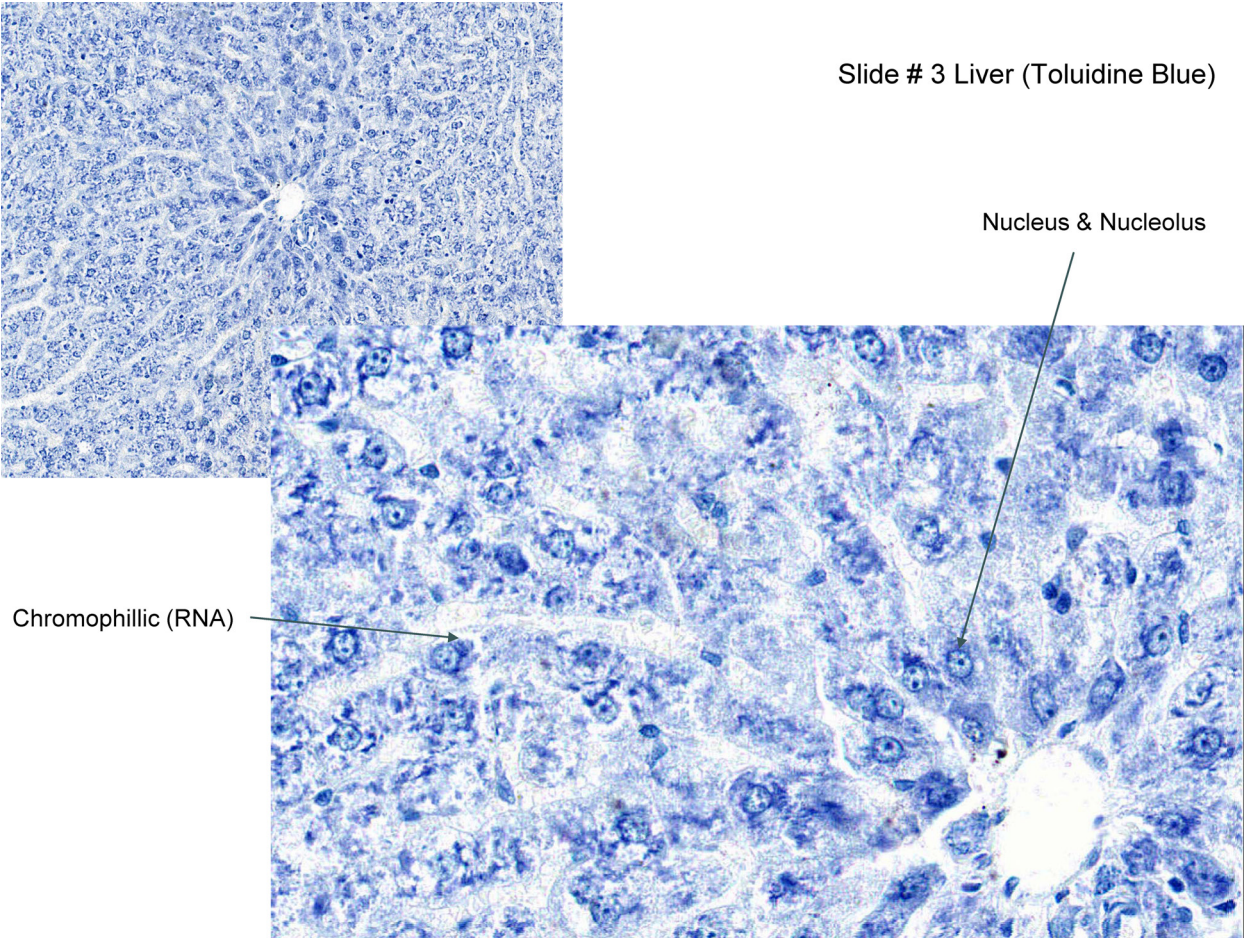
Slide # 2 Cells and Tissues: Size, Shape and Color (H&E)

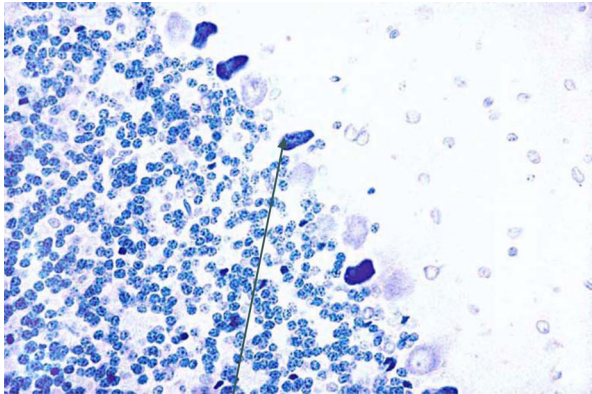


Slide # 3 (Toluidine Blue)



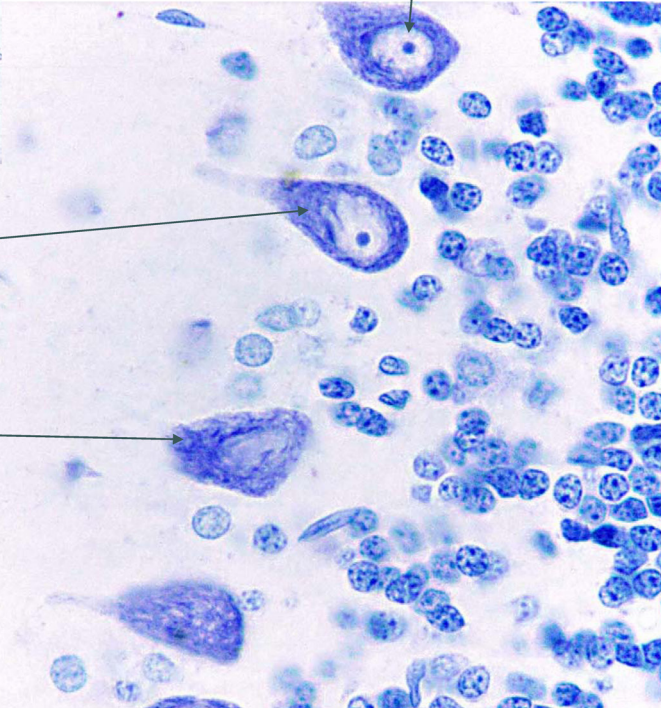
Slide # 3 Liver (Toluidine Blue)





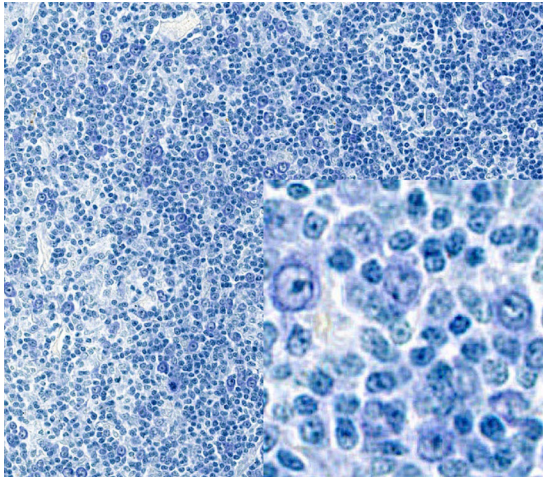
Slide # 3 Cerebellum (Toluidine Blue)

Nucleus & Nucleolus



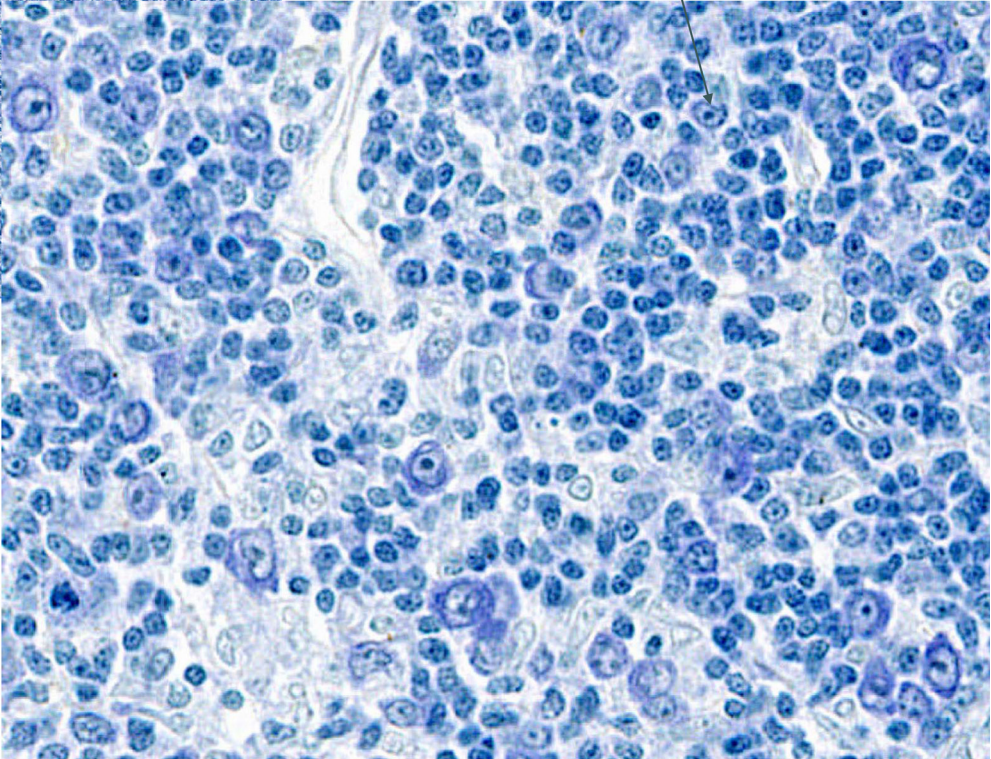
Purkinje Cells

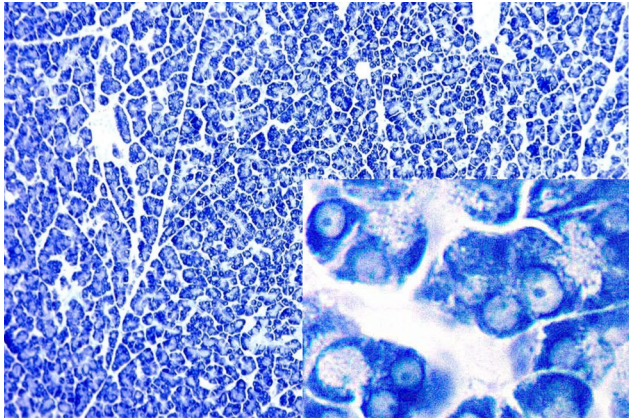
Chromophilic (RNA)



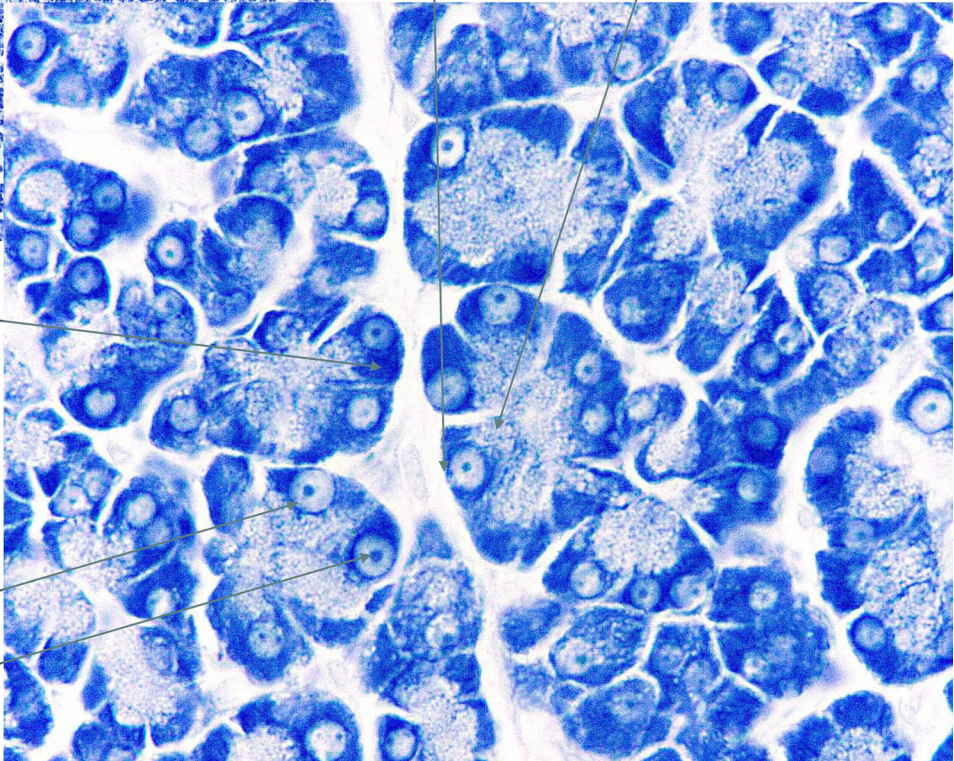
Slide # 3 Lymph Node (Toluidine Blue)

Nucleus & Nucleolus





Slide # 3 Pancreas (Toluidine Blue)



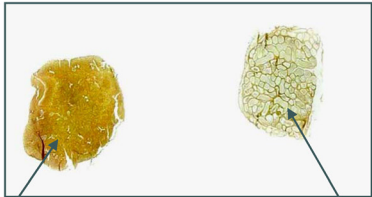
Basal Apical

RNA

Nucleus

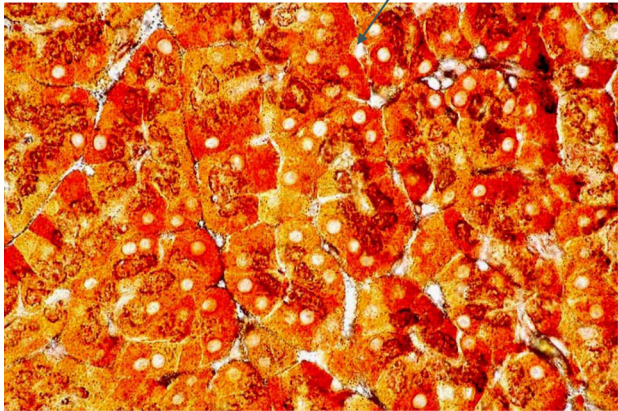
Nucleolus

Slide # 9 (Golgi Stain)

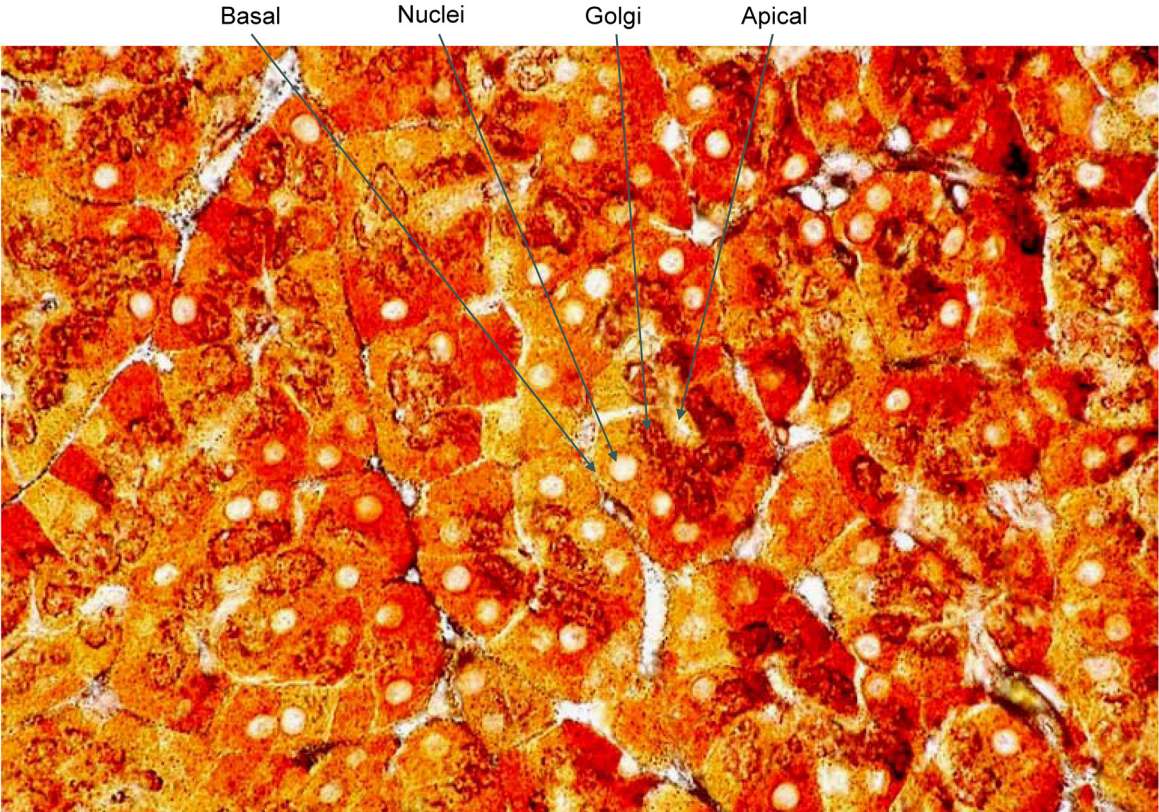


Pancreas

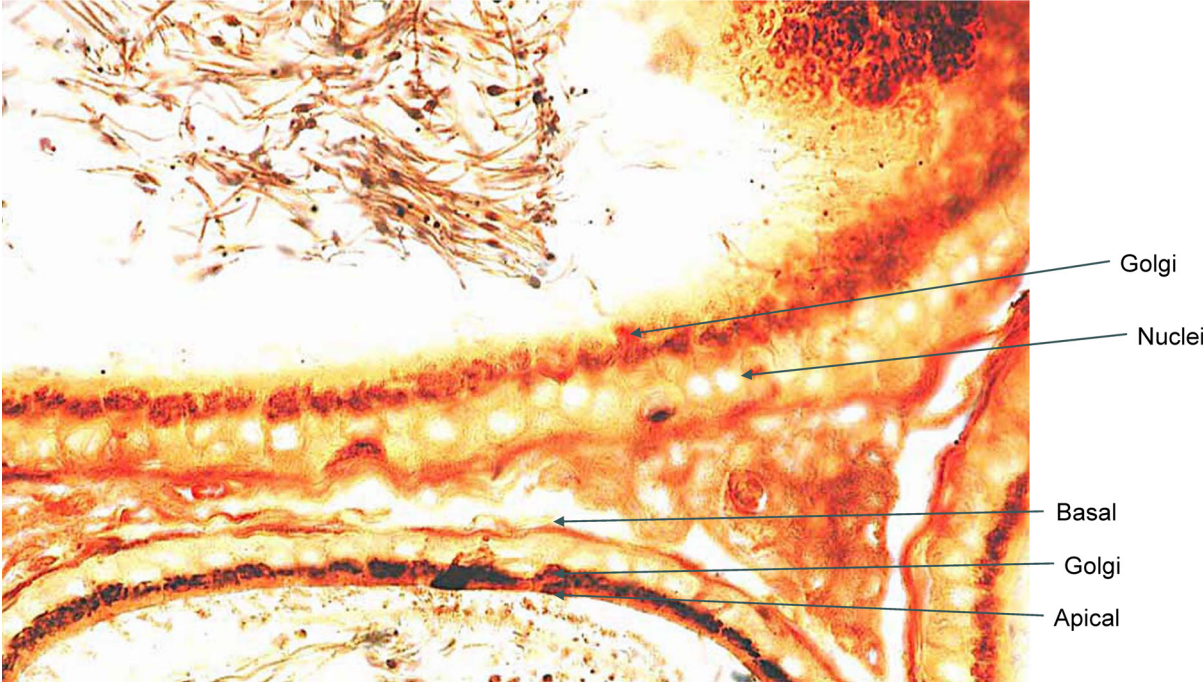
Epididymis

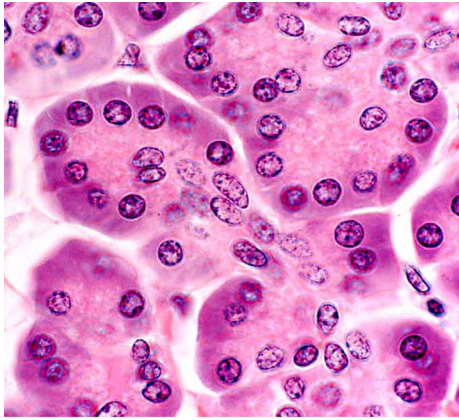


Slide # 9 Pancreas (Golgi Stain)

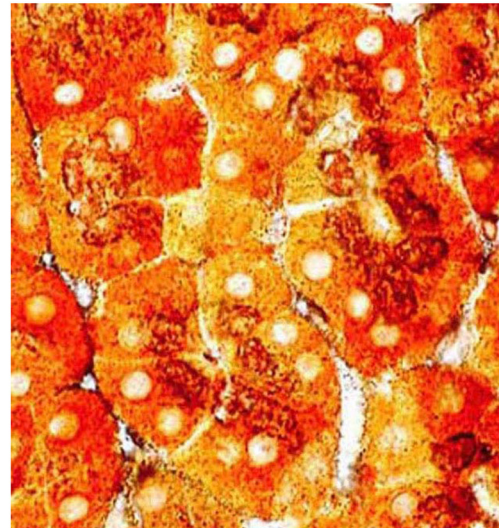
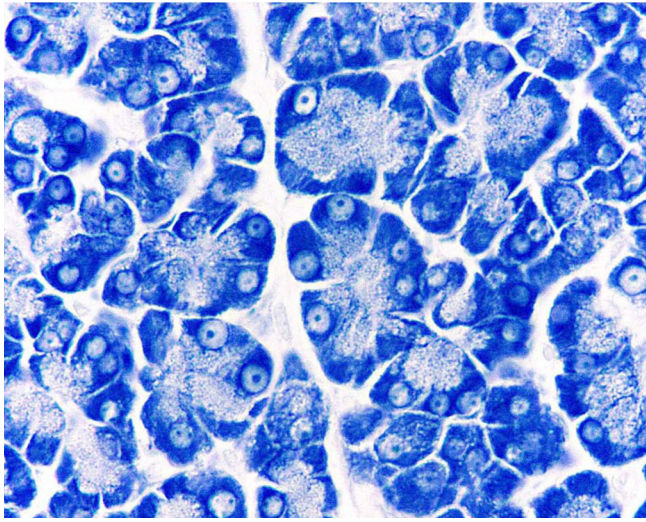


Slide # 9 Epididymis (Golgi Stain)

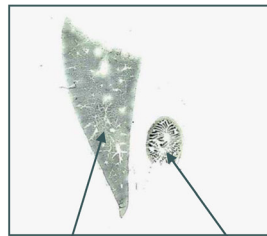




Same cells (Pancreas) with 3 stains
(H&E, Toluidine blue, Golgi)

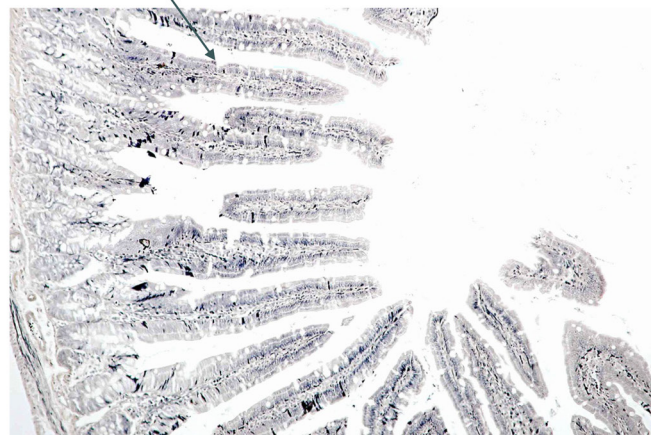
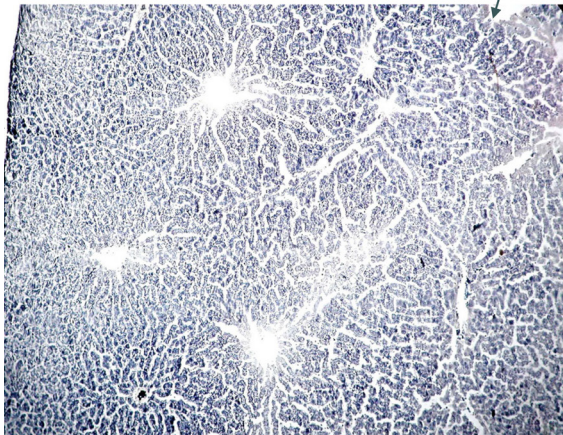


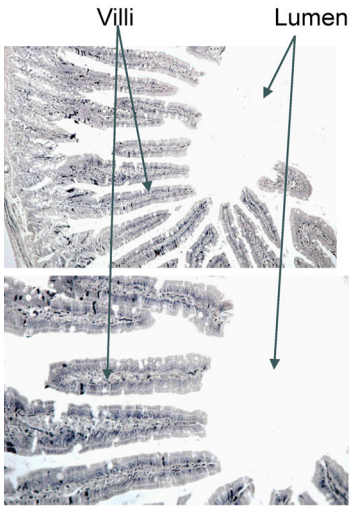
Slide # 10 Mitochondria (Iron
Hematoxylin)



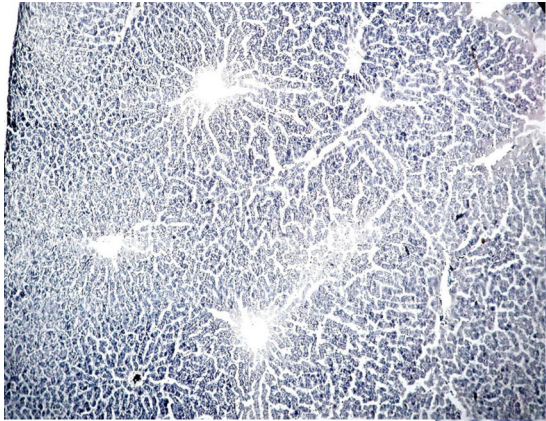
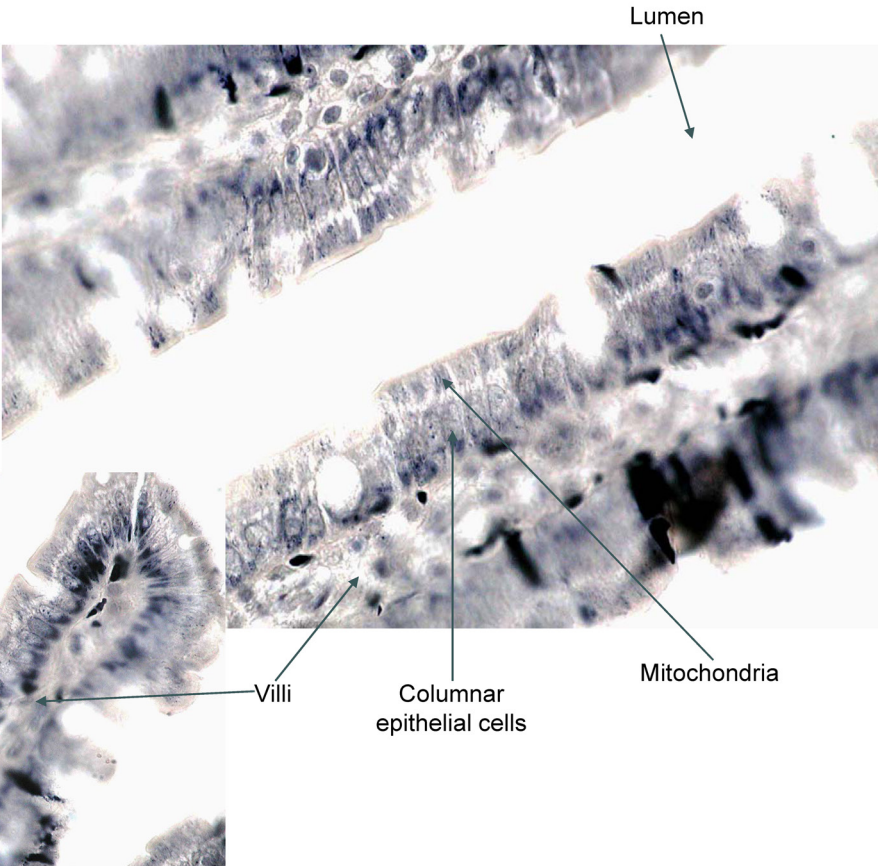
Liver

Intestine

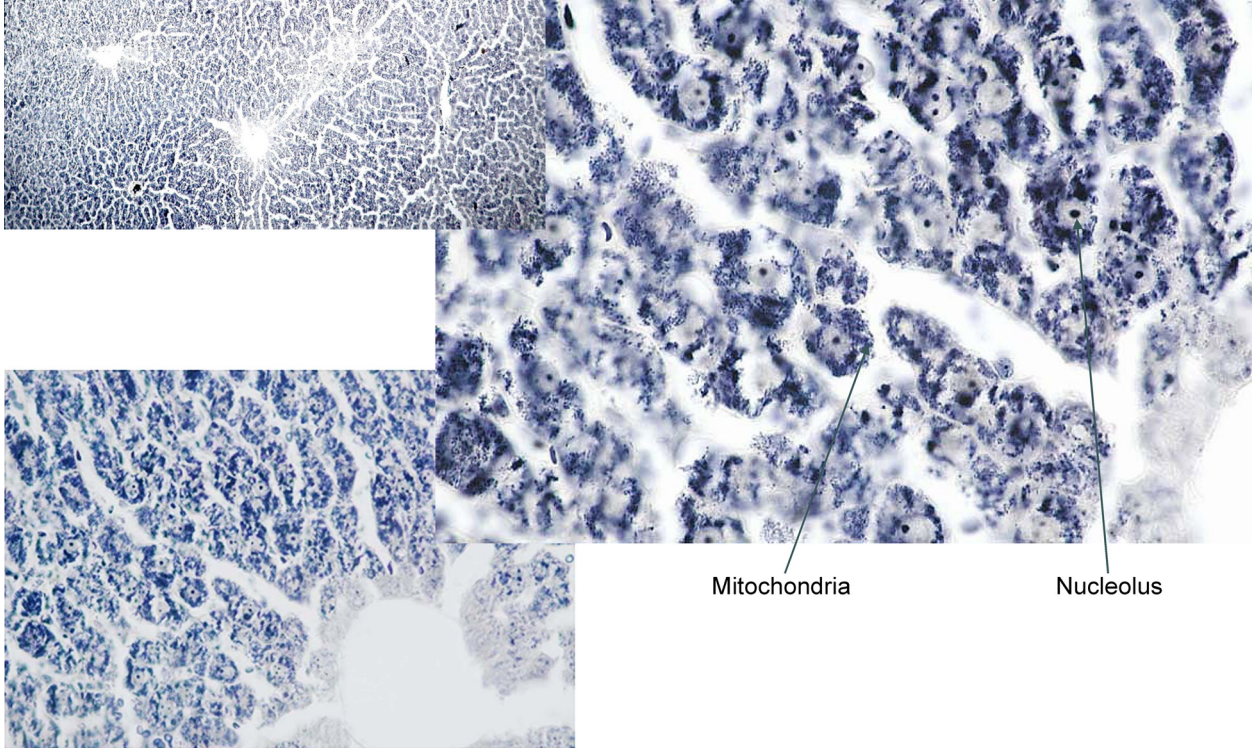




Slide # 10 Duodenum - Mitochondria (Iron Hematoxylin)



Slide # 10 Liver - Mitochondria(Iron Hematoxylin)

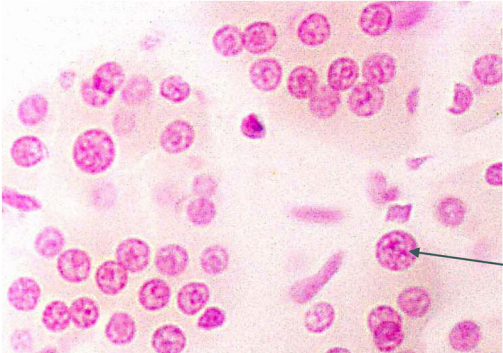
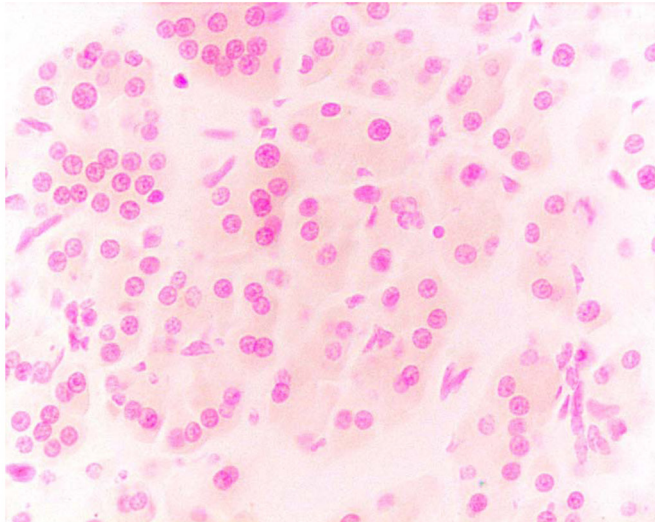


Slide # 12 Feulgen Stain for DNA

DNAase control



DNA (+)



Nucleus - DNA

INDEX

A

A-band, 43-44, 48
 absorptive cells, 224-225, 227-228
 acidophils, 205, 207, 209, 211
 acinar pancreas, 195
 acini, 194, 196-197, 207
 actin, 15, 43, iii
 adenohypophysis, 205
 adipocytes, 29-30, 35, 194, 207
 adrenal cortex, 128, 206-207, 216-218
 adrenal gland, 128, 206-207, 215-219
 adrenal medulla, 206, 216, 219
 adventitia, 127-130, 133-136, 142, 144-145, 223, 227, 233, 247, 265, 306, 331
 afferent lymphatic, 158-159, 163-164
 agranulocytes, 107
 aldehyde fuchsin, 1, 198, 207, 221-222
 alpha-cells, 206, 221
 alveolar cells, 290, 292, 302-303, 307
 alveolar duct, 290, 292, 301
 alveolar macrophage, 290, 292
 alveolar pore, 290
 alveolar sac, 290, 292
 alveolus, 16, 193, 289-290, 292, 301, 309, 344
 ameloblasts, 84
 ampulla, 305, 307, 322-323, 329, 331, 338, 346
 anterior chamber, 343-345
 anterior pituitary gland, 207, 209-211
 antigen presenting cells, 157, 181, 224
 aorta, 127, 130, 143-145
 aortic valve, 127, 151-152
 appendix, 223, 225, 228, 243
 appositional growth, 61-62
 arcuate arteries, 262, 308, 318
 arcuate artery, 262, 264, 270, 278, 306, 308, 318
 area cribrosa, 261
 areolar tissue, 29-30, 35-36
 arrector pili, 182-183, 186
 arrector pili muscle, 182, 186
 arteriole, 127-130, 138, 158-160, 174-177, 179, 247-248, 253, 261-264
 artery, 127-129, 133-134, 136-144, 150, 158, 248, 261, 264, 270, 278, 306, 341
 articular cartilage, 77, 79-80
 atrioventricular node, 127
 atrioventricular septum, 127
 atrium, 43, 127, 130, 147-148
 Auerbach's plexus, 86-87, 96-98, 223, 225, 228, 232, 245
 autonomic nervous system, 85-86, 206
 axon, 85-86, 90, 100-101, 182
 axon hillock, 85-86, 90
 azan, 1, 30, 33, 35,
 azure granules, 107, 113-114

B

band forms, 114, 119
 basement membrane, 6, 15-16, 18, 20, 23, 25, 127-129, 159, 181-182, 193, 205, 261, 263, 289, 295, 299, 307, 329-330, 343
 basilar membrane, 346
 basophilia, 1, 5, 157, iv
 basophilic erythroblast, 113-114
 basophilic metamyelocytes, 122
 basophilic myelocyte, 114
 basophilic myelocytes, 122
 basophilic normoblasts, 116-117
 basophils, 107-108, 111-112, 114, 205, 207, 209, 211
 beta-cells, 206-207, 221
 bile canaliculi, 247-248, 254-255
 bile ducts, 247
 bile ductule, 247-248, 253
 bladder, 16, 247, 258-259, 261-262, 265, 285-287,
 blood, 1, 4-5, 15-16, 29, 43, 61-63, 107-109, 112-114, 127-128,
 B-lymphocytes, 157-159
 bone, 29, 61-63, 69-70, 72-82,
 bony labyrinth, 346
 Bowman's capsule, 16, 261, 263-264, 268, 276
 Bowman's membrane, 343-344
 Bowman's serous glands, 289
 Bowman's space, 261, 264
 brachiocephalic vein, 142-143
 bronchi, 16, 289-292, 303
 bronchiole, 289-292, 300
 Bruch's membrane, 343-345
 brush border, 15, 227, 261

C

calcified cartilage, 81
 calyx, 281-282
 canal of Schlemm, 343-344, 350
 canaliculi (bone), 62-63, 74
 cancellous bone, 63, 69-70, 77
 capillaries, 15, 128, 130, 132, 159, 181, 194, 205-207, 248, 261, 263-264, 307, 330-331, 343
 capsule cells, 85-86, 91, 95, 159-160, 276
 cardiac muscle, 43-44, 49, 51-53, 55-56, 58-59, 127
 cardiac skeleton, 43-44, 55, 61, 127, 130, 151-152, 155
 cardioesophageal junction, 226
 cardiovascular system, 127,
 carotid artery, 141-142
 cartilage, 5, 29, 43, 61-68, 77, 79-81, 127, 289-291, 296, 298, 303,
 cartilage histogenesis, 64
 cell nest, 61-62, 66
 cells of Boettcher, 346
 cells of Claudius, 346

cells of Hensen, 346
 central arteries, 158
 central arteriole, 158-160, 174, 176-177, 179
 central canal, 86, 89
 central lymphoid organs, 157
 central nervous system, 85
 central vein, 247-248, 251-254
 centroacinar cells, 193-194, 196-197
 cerebellum, 9
 cervical glands, 306, 308, 324
 cervix, 306, 308, 324
 chief cell, 224
 chief cells, 205, 207, 215, 224, 227, 235, 237
 cochlear nerve, 346
 chondroblast, 61-62, 64-66, 292
 chondrocyte, 5, 61-66
 chondrogenic layer, 61-62
 chorion, 307
 choroid, 343-345, 348, 351
 chromaffin cells, 206-207, 219
 chromophils, 205-206
 chromophobes, 205-207, 209, 211
 cilia, 15-16, 20, 25, 295, iv
 ciliary body, 343-344, 348, 350
 ciliary glands, 344-345, 354-355
 ciliated cells, 323
 clear cells, 181, 205, 207, 215
 club cells, 289, 291, 300
 cochlea, 346, 356
 cochlear duct, 346, 356-357
 collagen, 1, 5-7, 29-30, 33, 43, 61-62, 86,
 collecting ducts, 261, 263-265, 282
 collecting tubules, 261, 264, 269-271, 273, 279
 collecting veins, 128, 178
 compact bone, 62-63, 69-70
 conjunctiva, 344-345, 353-355
 connective tissue, 15, 29-30, 33, 35-38, 43,
 convoluted tubules, 261, 263-264, 267-268, 274,
 278-279
 cornea, 343-344, 348
 corneal-scleral junction, 343
 corona radiata, 305, 313
 coronary artery, 150
 corpora amylacea, 330-331
 corpora cavernosae, 330-331
 corpus albicans, 305, 307
 corpus cavernosum, 340-341
 corpus hemorrhagicum, 305, 307, 315
 corpus luteum, 305, 307, 316
 corpus spongiosum, 330-331, 340
 cortex (adrenal gland), 128, 206-207, 216-218
 cortex (kidney), 157, 261-264, 267-268, 270-272,
 278
 cortex (lymph node), 157-159, 163-164, 166
 cortex (ovary), 307
 corticotropes, 205
 crista ampullaris, 346-347, 358
 crypt cells, 224
 crypts of Lieberkuhn, 225, 244

INDEX

cumulus oophorus, 305, 307, 313
 cuticle, 182
 cystic duct, 224

D

decidua basalis, 307
 decidua capsularis, 307
 decidua parietalis, 307
 dendrite, 85-86, 90
 dendritic cells, 157-159
 dense irregular connective tissue, 29, 36, 38,
 127-128, 223, 247, 305-306, 308, 329, 343
 dense regular connective tissue, 29, 36-37, 61,
 330
 dental papilla, 83
 dental pulp, 84
 dentin, 84
 dermal papillae, 86, 181-182, 188
 dermis, 29, 38, 86, 181-182, 184, 189-190, 309
 Descemet's layer, 343
 desmosomes, 15, 157, 181
 diastole, 127
 diffuse lymphocytic infiltrations, 158
 distal convoluted tubule, 261, 263-264, 268, 274,
 279
 distributing arteries, 128
 DNA, 1, 14
 dorsal horn, 85-86, 89
 dorsal root ganglion, 85-86, 88, 91-93
 dorsal roots, 85
 duct cells, 6, 183, 193, 197, 307
 ducts of Bellini, 261, 264
 ductus deferens, 329-331
 dust cells, 157, 301-302

E

ear, 61, 346, 356-358
 efferent ductules, 329
 efferent lymph vessels, 158
 ejaculatory duct, 330
 elastic artery, 127-130, 134, 141, 143-144
 elastic cartilage, 61-62, 67-68, 289-291, 296
 elastic fibers, 1, 29-30, 61, 86, 127-129, 181,
 290-291, 306
 elastic lamina, 127-130, 133-134, 145
 elastic tissue, 29-30, 62, 127-129, 306, 343
 elastin, 33-34
 endocardium, 127, 130, 148-149
 endochondral bone growth, 63
 endocrine glands, 15, 128, 205, i
 endometrium, 306, 308, 317, 320
 endomysium, 43-44, 47, 50-51
 endoneurium, 85-87, 93, 100
 endosteum, 62-63
 endothelial cell, 5, 15, 127-130, 158-160, 247-248,
 263-264, 290, 331
 enteroendocrine cells, 224-225, 227

eosin, 1, 30
 eosinophilia, 1, 5, 193, 224, 261, 263, iv
 eosinophilic metamyelocytes, 122
 eosinophilic myelocytes, 122
 eosinophils, 29-30, 41, 107-108, 111-112, 114, 122, 228
 epicardium, 127, 130, 148-149
 epidermis, 15, 181-182, 184, 189-190
 epididymis, 329, 331, 336
 epiglottic cartilage, 289
 epiglottis, 61, 67-68, 289, 291, 294-296
 epimysium, 43-44
 epineurium, 86-87, 99
 epiphyseal plate, 63, 77, 79
 epithelial reticular cells, 157, 160, 169-171
 epithelium, 15-16, 18-20, 22-27, 83,
 erythropoiesis, 113
 esophagus, 16, 26, 96-97, 223, 226, 230-232
 euchromatin, 1, 6, iv
 exocrine glands, 15, 193, 224, 290, i
 exocrine pancreas, 193, 196
 external elastic lamina, 128-130, 133-134
 external root sheath, 182, 188
 extracellular matrix, 29, 343, v
 extraglomerular mesangium, 263, 272
 extralobular ducts, 193-194, 197, 199
 eye, 343-344, 348-353, iii
 eyelid, 344-345, 354-355
 eyelids, 344

F

Fallopian tube, 305, 322-323
 false vocal cords, 289
 fascicle, 43, 48, 86
 fat cells, 4, 7, 29-30, 38, 158, 206, 247
 female reproductive system, 305, i
 fetal liver, 247-248, 258
 fetal lung, 292, 304
 Feulgen, 1, 14
 Feulgen stain, 14
 fibria, 322
 fibroblast, 5-7, 29-32, 43, 61, 85-87, 129, 182, 247, 263, 290, 305, 329-330, 343
 fibrocartilage, 55, 61, 68
 fibroelastic lamina propria, 289
 fibrogenic layer, 61-62
 fimbriae, 305
 follicles, 182, 184, 186-188, 205, 207, 213, 305, 307, 311-314, 344-345
 follicular cells, 205-207, 214, 305, 307
 follicular phase, 305

G

gall bladder, 247, 258-259, i
 gastric glands, 223-224, 227, 234, 238
 gastric pits, 223-224, 227, 234
 gastrointestinal tract, 86, 223, i

INDEX

germinal center, 158, 160, 165
 germinal epithelium, 305, 329-330
 gland cells, 5, 183, 193, 202-204, 207, 214-215, 344
 glands of Littre, 331, 341
 glans penis, 330
 glassy membrane, 182, 188
 glia, 85
 glomerulus, 261, 263-264
 glucagon, 206
 glycogen, 1, 43, 127, 247-248, 255-256, 306
 goblet cell, 15-16, 20, 24-25, 224-225, 227-228, 241, 244, 289-291, 295, 344
 Golgi apparatus, 1, 11, 205
 Golgi stain, 1, 10-11
 gonadotropes, 205
 Graafian follicle, 305, 312-313
 granulocytes, 107
 granulomere, 107
 granulopoiesis, 113
 granulosa, 305, 307, 312-313, 316
 granulosa cells, 305, 307, 316
 granulosa luteal cells, 307, 316
 grey matter, 85
 ground substance, 29, 61-62

H

hair bulb, 182, 188
 hair follicles, 182, 184, 186-188
 Hassel's corpuscles, 157-158, 160
 Haversian, 62-63, 70-74
 Haversian canal, 63, 70-74
 Haversian lamellae, 62-63, 70-71, 74
 H-band, 43-44, 48
 heart, 43, 127-130, 154
 heart conduction system, 127
 helicine artery, 341
 helicotrema, 346, 356
 hematopoiesis, 113, 247, 258, i
 hematoxylin, 1, 12-13, 61
 Henle's loop, 261, 263, 269, 271, 273, 279, 281
 hepatic arteriole, 247-248, 253
 hepatic ducts, 247
 hepatic sinusoids, 247, 254-255
 hepatic stellate cells, 247
 hepatocytes, 247-248, 252, v
 Herring bodies, 205, 207, 210, 212
 heterochromatin, 1, 6, 43
 high endothelial venules, 158-159, 166
 high resistance channels, 128
 horny cells, 181
 hyaline cartilage, 61-62, 65-66, 289-291, 303
 hyalomere, 107
 hypodermis, 86, 181-182, 184, 189

I

I-band, 43-44, 48

ileum, 223-225, 227, 241
 immature bone, 63
 infundibulum, 305, 307, 322-323
 inlet vessels, 247
 inner circumferential lamellae, 62, 73
 inner enamel epithelium, 83
 inner root sheath, 182
 insulin, 1, 206-207
 interalveolar septum, 290
 intercalated disks, 43-44, 52-53
 intercalated ducts, 193-194, 200
 interlobar vessels, 261, 264
 interlobular arteries, 262
 interlobular ducts, 193-194, 196-197
 internal elastic lamina, 128-129, 133-134
 Interstitial cells of Leydig, 329, 331, 333
 interstitial growth, 61-62
 interstitial lamellae, 62-63, 70, 74
 interterritorial matrix, 61-62
 intervetebral disk, 68
 intestinal crypts, 224-225, 228
 intestinal glands, 224-225, 228
 intralobular duct, 193, 197
 intralobular ducts, 193-194, 196, 200, 309
 intramembranous bone formation, 75-76, 82
 intramembranous bone growth, 63
 iris, 343-344, 348-349
 islets of Langerhans, 193-195, 198, 206-207, 220-222
 isthmus, 224, 305-306

J

jejunum, 223-225, 227, 239-240
 junctional complex, 15, 43, 193
 juxtamedullary cortex, 164
 juxtamedullary renal corpuscles, 262, 264

K

keratin, 15-16, 26-27, 181
 keratinocytes, 181
 keratinosome, 181
 keratohyalin granules, 181
 kidney, 15-16, 107, 113, 157, 205, 261-264, 267-282
 Kupffer cells, 157, 247-248, 257

L

lacrimal gland, 344, 353
 lacteals, 225, 227
 lactiferous duct, 306, 326
 lactiferous sinus, 307
 lactotrope, 205-206
 lacunae, 61-63, 70-74, 307
 lamellae, 62-63, 70-71, 73-74
 lamina propria, 29, 158, 223-228, 231, 247, 262, 265, 289, 291-292, 306, 308-309, 329, 331, 344

INDEX

Langerhans cells, 157, 181, 207
 Large intestine, 223, 225
 larynx, 25, 289, 291, 297
 lens, 343-345, 348-349, iii
 Leydig cells, 329, 331, 333
 limbus, 343-344, 346, 348
 lipofuscin pigment, 43-44, 52, 86, 206, 218
 Littre, 330-331, 341
 liver, 8, 15, 128, 157, 224-225, 247-248, 250-258, i, v
 liver hematopoiesis, 247, 258
 liver lobules, 247-248, 250-251, 253
 lobules, 157, 193-194, 247-248, 250-251, 253, 307, 309, 330
 loose connective tissue, 29, 127, 129, 158, 307, 329, 331, 343
 lung, 15-16, 127, 157, 290-292, 299-304
 luteal phase, 305
 lymph node, 4, 9, 40-41, 158-159, 162-167
 lymph node cortex, 163, 166
 lymph node medulla, 163
 lymph nodes, 29, 157-158
 lymph nodules, 158-159, 228, 289, 291
 lymphatic vessel, 139, 158-159, 162, 223, 247-248
 lymphocyte nuclei, 4
 lymphocytes, 107-108, 110, 112, 124, 157-160, 223-225, 228, 306-307
 lymphoid system, 157, i

M

M cells, 224-225
 macrophage, 29-32, 41-42, 157-160, 162-163, 224, 247-248, 263, 290, 292, 301, 305-306, 329, 331
 macrophages, 157, 159, 224, 247-248
 macula, 261, 263-264, 275, 279-280, 344, 346
 macula densa, 261, 263-264, 275, 279-280
 major calyces, 262
 male reproductive system, 329, i
 mammary gland, 305-306, 309, 325-327
 mammatropes, 205
 marginal zone, 159-160, 177
 mast cells, 1, 29-30, 39-40, 329, 331
 mature (Graafian) follicle, 305
 mediastinum testis, 329, 335
 medium and large veins, 128
 medulla, 157-160, 163-164, 182, 206-207, 216, 219, 261-264, 267, 270-271, 278, 305
 medulla (adrenal gland), 206-207, 216, 219
 medulla (kidney), 157, 261-264, 267, 270-271, 278
 medulla (lymph node), 157-159, 163-164, 305
 medulla (ovary), 305
 medullary cords, 158-159
 medullary ray, 261, 263-264, 270, 272-273, 278, 282
 medullary region, 157, 261

megakaryocytes, 114, 123
 Meibomian glands, 344-345, 354-355
 Meissner's corpuscles, 86, 182
 Meissner's plexus, 86-87, 97-98, 223
 melanin, 181, 189
 melanocytes, 181, 183, 188
 membranous labyrinth, 346
 menstrual phase, 306
 Merkle cells, 181
 mesangial cells, 157, 263-264, 276
 mesangium, 263, 272, 276-277
 mesenchymal cells, 30-32, 63
 mesentery nerves, 102-103
 metamyelocytes, 119-120, 122
 microvilli, 15-16, 20, 24, 224, 227, 241, 289, 307, 329, iv
 minor calyces, 262
 mitochondria, 1, 12-13, 63, 193, 205, 224, iv
 modiolus, 346, 356
 monocytes, 63, 107-108, 110, 112, 125, 157
 mucoid connective tissue, 29
 mucosa, 158, 223-228, 230-231, 233, 235, 238, 243, 247, 262, 289, 305-308, 330
 mucous, 5, 15-16, 193-194, 202-204, 223-224, 226-227, 236, 289, 303, 306, 331, 344
 mucous cells, 5, 15, 193-194, 202-204, 223-224, 227, 236
 mucous glands, 193, 223-224, 227, 303, 306, 331
 mucous neck cells, 224, 227, 236
 multilaminar primary follicles, 307, 311, 314
 muscle, 7, 15, 33, 37, 43-44, 47-53, 55-59, 86,
 muscle fascicle, 43, 48
 muscle insertion, 44, 50-51
 muscular artery, 129, 133-134, 136-140
 muscularis externa, 223, 225-228, 230-233, 235, 243
 muscularis mucosa, 223-228, 230-231, 233, 235, 238, 243, 247, 305-306
 myelin, 85-87, 100-101
 myeloblast, 113-114, 119-120
 myelocytes, 119-120, 122
 myenteric plexus, 223, 226, 228, 232
 myocardium, 127, 130, 149
 myoepithelial cells, 193, 307, 343-344
 myofibrils, 43-44, 50, 127
 myometrium, 306-308, 317, 320
 myoneural junctions, 43
 myosin, 43, iii
 myo-tendinous insertion, 43-44

N

nasal cavity, 289, 291
 nasopharynx, 289
 nephron, 261, 263
 nerve, 43, 85-87, 99-101, 128, 182,
 nerve fascicles, 87, 99
 neurohypophysis, 205
 neuron, 85-86, 289

INDEX

neutrophil, 113-114
 neutrophilic band, 113-114, 120-121
 neutrophilic band cells, 121
 neutrophilic metamyelocyte, 113-114, 120
 neutrophilic myelocyte, 113-114, 120
 neutrophils, 29, 107-108, 112-114, 159
 Nissl bodies, 86, 95
 Nissl substance, 4, 85-86, 90
 node of Ranvier, 86-87, 100-101
 nodule, 158-159, 164, 172, 174, 177, 179, 228
 non-striated muscle, 43
 nucleolus, 4, 9-10, 85, 329
 nucleus, 4, 9-10, 29, 43-44, 85-86,

O

odontoblasts, 84
 olfactory region, 289
 oocytes, 305, 307
 optic disk, 344-345, 352
 optic nerve, 343-345, 352
 ora serrata, 343, 345
 oral epithelium, 83
 organ of Corti, 346, 357
 orthochromatic erythroblast, 113-114
 orthochromatic normoblasts, 116-117
 osseous spiral lamina, 346
 ossified cartilage, 80
 osteoblasts, 61-63, 76, 78, 81-82
 osteoclasts, 63, 78-79, 81
 osteocyte, 62-63, 70-74, 76, 82
 osteocyte lacunae, 63, 70-74
 osteoid, 62-63, 76, 82
 osteon, 62-63
 otoliths, 346
 outer circumferential lamellae, 62-63, 73
 outer enamel epithelium, 83
 ovarian cycle, 305-306
 ovary, 16, 305, 307, 311-316
 oviducts, 305-306
 ovulation, 305
 oxyphils, 205-207, 215

P

Pacinian corpuscle, 86-87, 104-105, 182, 192
 palate, 291, 293-294
 palatine tonsil, 172
 palpebra, 344, 353-354
 pancreas, 10, 16, 39, 128, 193-198, 206, 220-222, 224-225
 pancreatic ducts, 16, 224
 Paneth cells, 224-225, 227-228, 242
 papillary layer, 181
 paracortex, 158-159
 parafollicular cell, 205, 207, 214
 parasympathetic ganglion, 86-87, 96-98, 232
 parasympathetic nerves, 86, 223
 parathyroid gland, 205-207, 214-215

paratrabecular sinuses, 158
 parietal cells, 224, 227, 235, 237
 parotid gland, 193-194, 199-201
 pars distalis, 205
 pars intermedia, 205
 pars tuberalis, 205
 PAS, 1, 43, 54-55, 127, 193, 247-248, 255-256
 pasasympathetic ganglion, 97
 pectinate muscle, 147
 penicillar arteries, 159
 penis, 329-331, 340-341
 periarteriolar lymphocytic sheath, 158, 174, 179
 peribiliary capillary, 253
 perichondrium, 61-62, 64-66
 pericyte, 128
 perimysium, 43-44
 perineurium, 86-87, 99
 periodic acid Schiff, 1, 247
 periosteum, 37, 51, 62-63, 79, 82
 peripheral lymphoid tissues, 158
 peripheral nerve, 85, 87, 99-101
 peripheral nervous system, 85
 Peyer's patches, 158, 225, 228, 242
 pituicytes, 205, 207
 pituitary gland, 205, 207-212
 placenta, 305, 307, 309, 328
 plasma cells, 29-30, 40, 114, 124, 157-159, 223-224, 228, 307
 platelets, 107-108, 114
 plicae circulares, 224, 228
 pneumocytes, 290, 292, 302
 podocytes, 261, 263-264, 276-277
 polychromatic normoblasts, 116
 polychromatic erythroblast, 113-114
 portal canal, 247-248, 252-253
 portal venule, 247-248, 253
 post capillary venules, 128-129
 posterior chamber, 343, 345
 posterior pituitary gland, 205, 210, 212
 PP-cells, 206
 predermin, 84
 primary nodule, 158-159, 164
 primary nodules, 158-159
 primary oocytes, 305, 307
 primordial follicles, 305, 307, 311
 proerythroblast, 113-114
 proliferative phase, 306
 promyelocyte, 113, 119-120
 promyelocytes, 119-120
 pronormoblasts, 116
 prostate, 330-331, 339-340
 proximal convoluted tubule, 261, 263-264, 267-268, 274, 278-279
 pseudostratified columnar epithelium, 15-16, 20, 25, 289, 295, 297, 299, 303, 329-331, 344
 pseudounipolar, 85
 PTA stain, 49, 53, 56
 pulp arteriole, 159, 174-177
 pupil, 343-344, 348

R

radial arteries, 306, 308, 318
 Rathke's cysts, 205, 207-208
 RBC, 4, 7, 113, iii
 reaction center, 174
 red blood cells, 1, 5, 107-108, 158-159, 264
 red pulp, 158-160, 173, 175-177
 regenerative cells, 224
 Reissner's vestibular membrane, 346
 renal arteries, 262
 renal columns, 261-262
 renal corpuscle, 261-264, 267-268, 274-277, 279
 respiratory bronchioles, 289-291, 300
 respiratory epithelium, 16, 289, 291, 299
 respiratory system, 15, 289, i
 resting zone, 63, 78, 80
 rete testis, 329, 331, 335
 reticular fibers, 1, 29-30, 34, 43, 86, 128-130, 132, 158-159, 167, 181, 247, 290, 329
 reticular layer, 181-182
 reticular tissue, 29-30, 329
 reticulocyte, 113, 116
 retina, 343-345, 348, 351-352
 retina layers, 345, 352
 RNA, 1, 4, 8-10, 85, iv
 root sheath, 182, 188
 rugae, 223, 227, 235, 247

S

saccule, 346-347
 satellite cells, 85
 scala media, 346
 scala tympani, 346, 356-357
 scala vestibuli, 346, 356-357
 scalp, 182, 184-188
 Schwann cell, 85-87, 100-101
 sclera, 343-344, 348, 351
 sebaceous gland, 182-183, 185-186, 344-345
 secondary follicles, 305, 307, 312-313
 secondary nodule, 158-159, 164
 secretion granules, 193, 205, 224, iv
 secretory phase, 306
 semicircular canals, 346-347, 356
 seminal vesicle, 329-331, 338-339
 seminiferous germinal epithelium, 329
 seminiferous tubules, 329-330, 332, 334
 sero-mucous glands, 289, 291
 serosa, 223, 225, 247, 305-306
 serous cells, 193-194, 202-204, 289-290, 344
 serous demilune, 203
 serous glands, 193, 289
 serous secretory cells, 193
 Sertoli cells, 329-330, 333-335
 sheathed arteriole, 159-160, 175
 sheathed capillary, 177

silver stain, 128, 158, 167
 simple columnar epithelium, 19, 24, 223-224, 226-227, 241, 247, 289, 306-308, 330, 346
 simple cuboidal epithelium, 18-19, 23, 182, 193, 197, 205, 247, 261, 263, 289, 305, 307, 311
 simple squamous epithelium, 16, 18, 23, 261, 263, 289, 343
 sino-atrial node, 43, 127
 sinuses, 158-159, 306, 331
 sinusoids, 128, 159-160, 175, 177-179, 206-207, 217, 247-248, 254-255
 skeletal muscle, 43-44, 47-51, 53, 58-59, 223, 289, 291, 306
 skin, 15-16, 26-27, 29, 86, 103-105, 157, 181-182, 189-192,
 small collecting veins, 128
 small intestine, 223-225
 smooth muscle, 7, 43-44, 49, 56-59, 127-129, 182, 223, 225, 247, 262-263, 289-292, 306-307, 309, 329-331, 343-344
 soma, 85
 somatostatin, 206
 somatotropes, 205
 space of Disse, 247-248
 specific granules, 107, 113-114
 spermatids, 329-330, 334
 spermatocytes, 329-330, 334
 spermatogonia, 329-330, 333-334
 spermiogenesis, 334
 spinal cord, 4, 85-86, 88-91
 spiral ganglion, 346, 356-357
 spleen, 128, 157-158, 160, 173-178
 splenic artery, 158
 splenic cords, 159-160
 splenic sinusoids, 159, 175
 spongy bone, 62, 69
 stellate reticulum, 83
 stereocillia, 329, 331, 346
 stomach, 16, 193, 223-225, 227, 233-238
 straight tubules, 261, 264
 stratified cuboidal, 16, 193, 307, 309
 stratified squamous epithelium, 25-27, 159, 181-182, 223, 226, 289, 291, 295, 297, 306, 308, 343-344
 stratified squamous keratinized epithelium, 181-182, 344
 stratum basale, 181-182, 189-190
 stratum basalis, 306, 308, 317, 321
 stratum corneum, 181, 189-190
 stratum functionalis, 306, 308, 317, 321
 stratum germinativum, 181, 190
 stratum granulosum, 181, 189-190
 stratum intermedium, 84
 stratum lucidum, 181
 stratum spinosum, 181, 189-190
 striate border, 224
 striate ducts, 193, 200
 striated muscle, 43, 226
 subcapsular sinus, 158-159, 165

INDEX

sublingual gland, 193-194, 203-204
 submandibular gland, 193-194, 201-203
 submucosa, 223-228, 230, 233, 247
 submucosal glands, 223-227, 238, 240, 330
 surface mucous cells, 223-224, 227
 sweat glands, 182, 184-185, 187, 190, 193, 345
 sympathetic ganglion, 86, 88, 91, 95
 syncytiotrophoblasts, 307, 328
 systole, 127

T

taenia coli, 225, 228, 243
 tarsal glands, 345, 354-355
 tarsal plate, 344-345, 355
 tectorial membrane, 346, 357
 tendon, 37, 50-51
 teritorial matrix, 66
 terminal bar, 15-16, 20, 227
 terminal bronchioles, 289-291, 300
 terminal pulp capillaries, 159
 terminal web, 15-16, 20, 227-228, 241
 territorial matrix, 61-63
 testis, 128, 329-335
 theca externa, 305, 307, 313
 theca interna, 305, 307, 313
 theca luteal cells, 305, 316
 thick skin, 27, 86, 103-105, 181-182, 190-192
 thin skin, 26, 86, 181-182, 189, 289
 thymus, 157, 160, 168-171
 thyroid follicles, 207, 213
 thyroid gland, 205-207, 213-214
 thyrotropes, 205
 T-lymphocytes, 157-159
 toluidine blue, 1, 8-10
 tonofilaments, 181
 tonsil crypt, 172
 tonsils, 158, 289
 tooth development (bell stage), 83-84
 trabeculae, 62, 157-160, 330-331
 trabecular sinus, 159, 165
 trabecular veins, 159-160, 178
 trabecular vessels, 158-159, 176, 178
 trachea, 25, 65-66, 289-291, 298-299
 tracheal cartilage, 289, 298
 trachealis muscle, 289, 291, 298
 transitional epithelium, 15-16, 22-23, 262, 265, 283-287
 tricuspid valve, 150
 tubuli recti, 329, 331, 335
 tunica adventitia, 127-130, 133-136, 142, 144-145
 tunica albuginea, 305, 329-331, 340
 tunica intima, 127-130, 133, 135, 144-145
 tunica media, 127-130, 133, 135, 142, 144-145
 type I pneumocytes, 290, 292, 302
 type II pneumocytes, 290, 292, 302

U

umbrella cells, 16, 22-23, 262, 265, 285-287
 unilaminar primary follicles, 307, 311, 314
 ureter, 16, 261-262, 265, 283-284
 urethra, 261, 329-331, 340-341
 urinary bladder, 16, 265, 285-287
 urinary pelvis, 261
 urinary pole, 261, 263-264, 268, 275-277, 280
 urinary system, 261, i
 uriniferous tubule, 261
 uterine glands, 306, 308, 317-318
 uterine tube, 305, 322-323
 uterus, 16, 43, 305-308, 317-321
 uterus (late secretory), 308, 319
 uterus (menopausal), 321
 uterus (menstrual), 308, 320-321
 uterus (proliferative), 308, 317-318
 uterus (secretory), 308, 319
 utricle, 346-347

V

vagina, 16, 305-306, 308, 325
 valves of Kerckring, 224
 vas deferens, 329, 331, 336-338
 vas deferens (ampulla), 331, 338
 vasa recta, 262, 264, 270-271, 278
 vasa vasorum, 128, 129, 130, 142-143, 145
 vascular pole, 261, 263-264, 275-276, 280
 vein, 128, 135-137, 140-143, 146, 159, 247-248, 251-254
 vein valve, 146
 vena cava, 130, 145-146
 ventral horn, 85-86, 89
 ventral motor neurons, 89-90
 ventral roots, 85
 ventricle, 127, 130, 149, 289, 291
 ventricular fold, 289
 venule, 130, 138-139, 253
 Verhoeff, 1, 30, 35, 67-68, 128, 291, iv
 vestibular apparatus, 356, 358
 vestibular membrane, 346, 356-357
 vestibule, 289, 306, 346
 villi, 224-225, 227-228, 307, 309
 vitreous body, 343
 vitreous chamber, 343
 vocal cords, 289
 vocal fold, 289, 291
 vocal ligament, 291, 297
 vocalis muscle, 289, 291, 297
 Volkman canal, 73
 Volkmann's canals, 62

W

Wasserhelle cells, 205, 207, 215
 white blood cells, 4-5, 107-108, 128
 white pulp, 158, 160, 173-174, 176

Z

Z-line, 43-44, 48
 zona fasciculata, 206, 216, 218
 zona glomerulosa, 206, 216-217
 zona pellucida, 305, 307, 313
 zona reticularis, 206, 216, 218-219
 zone of calcification, 78, 80-81
 zone of hypertrophy, 63, 78, 80
 zone of ossification, 63, 78, 80-81
 zone of proliferation, 63, 78, 80

Slides

Slide 1 Lymph Node, 4
 Slide 1 Nuclear Morphology & Cell Size, 3
 Slide 1 Spinal Cord, 4, 90
 Slide 3 Toluidine Blue, 8-10
 Slide 2 Cells and Tissue: Size, Shape, Color, 5-7
 Slide 9 Golgi Stain, 10-11
 Slide 10 Iron Hematoxylin Stain, 12-13
 Slide 12 Feulgen Stain, 14
 Slide 16 Gut: Smooth muscle, 57-58
 Slide 16 Simple Epithelia, 18-20
 Slide 17 Stratified Epithelia, 21
 Slide 18 Transitional Epithelium, 287
 Slide 20 Pig Snout, 31-32, 64, 75-76, 83-84
 Slide 20 Pig Snout Embryo, 64, 75-76, 83-84
 Slide 21 Connective tissue H&E, 35
 Slide 22 Connective tissue Verhoeff, 35
 Slide 23 Connective tissue Azan, 35
 Slide 23 Tendon: Muscle insertion (Azan), 51
 Slide 24 Connective Tissue H&E, 33
 Slide 24 Mesentery, 38, 41, 102, 132-139, 162-163
 Slide 24 mesentery Lymph Node, 41, 162-163
 Slide 24 Mesentery nerves, 102
 Slide 24 Vessel: Smooth muscle, 57
 Slide 25 Connective Tissue Verhof, 33
 Slide 25 Mesentery (Verhof), 33, 134-135, 137-139
 Slide 26 Connective Tissue Azan, 33
 Slide 26 Mesentery (Azan), 42, 102-103, 134, 136-137
 Slide 26 Mesentery nerves (azan), 102-103
 Slide 29 Endochondral Bone Formation, 77-79
 Slide 29 Muscle Attachment, 37
 Slide 29 Tendon: Muscle insertion, 51
 Slide 30 Tendon: Muscle insertion, 50
 Slide 31 Liver (Trypan Blue), 256-257
 Slide 33 Blood Smear, 109, 112
 Slide 34 Bone Marrow Smear, 115
 Slide 36 Epiglottis (H&E), 67-68
 Slide 38 Epiglottis, 294-296
 Slide 39 Epiglottis (Verhof), 67-68, 296
 Slide 40 Intervetebral Disk: Fibrocartilage, 68
 Slide 43 Epiphysis - Cancellous and compact Bone, 69
 Slide 43 Skill - Cancellous and compact bone, 69-70

Slide 44 Ground bone, 73-74
 Slide 45 Decalcified bone, 72
 Slide 46 Endochondral Bone Formation, 79-82
 Slide 46 Intramembranous bone formation, 82
 Slide 47 Spinal Cord, 88-89, 91
 Slide 50 Dorsal Root Ganglion, 91-92
 Slide 51 Dorsal Root Ganglion (Azan), 93
 Slide 52 Peripheral Nerve, 99-101
 Slide 53 Smooth Muscle, 56
 Slide 54 Cardiac Muscle, 51-53
 Slide 55 Skeletal Muscle, 47-49
 Slide 56 Skeletal, Cardiac and Smooth Muscle (PTA stain), 49, 53
 Slide 57 Skeletal Muscle Teased, 50
 Slide 58 Cardiac Skeleton, 55, 155
 Slide 58 Cardiac Skeleton (PAS), 53, 55, 155
 Slide 58 Purkinje Fibers, 54, 153-154
 Slide 58 Purkinje fibers (PAS), 54
 Slide 59 Sympathetic Ganglion, 95
 Slide 61 Popliteal Artery and Vein, 140-141
 Slide 62 Popliteal Artery and Vein, 140-141
 Slide 63 Brachiocephalic Vein, 142-143
 Slide 63 Carotid Artery, 141-142
 Slide 65 Aorta, 143-145
 Slide 65 Vena Cava, 146
 Slide 66 Aorta (Verhof), 144-145
 Slide 66 Vena Cava (Verhof), 145-146
 Slide 67 Vein Valve, 146
 Slide 69 Pectinate Part of Right Atrium, 147
 Slide 69 Smooth part of Left Atrium, 148
 Slide 70 Left Ventricle, 149
 Slide 70 Right Ventricle, 149
 Slide 71 Coronary Artery, 150
 Slide 71 Tricuspid Valve and Coronary Artery, 150
 Slide 72 Coronary Artery (Verhof), 150
 Slide 73 Aortic Valve, 151-152
 Slide 74 Cardiac Skeleton, 152
 Slide 74 Purkinje Fibers, 56, 152-153
 Slide 76 Lymph Node, 164-166
 Slide 78 Reticular fibers, 34
 Slide 79 Thymus, 168-171
 Slide 81 Palatine Tonsil, 172
 Slide 84 Spleen, 176-178
 Slide 85 Spleen, 173-175
 Slide 86 Scalp, 184-187
 Slide 87 Scalp, 188
 Slide 88 Hair Follicle, 186
 Slide 88 thin skin, 189
 Slide 90 Thin Skin, 26, 189
 Slide 91 Thick Skin, 27, 103-105, 190-192
 Slide 94 Parotid Gland, 199-201
 Slide 95 Submandibular Gland, 201-203
 Slide 96 Sublingual Gland, 203-204
 Slide 109 Esophagus, 26, 96-97, 230-232
 Slide 110 Trachea, 298
 Slide 119 Simple columnar epithelium, 23-24
 Slide 120 Simple columnar epithelium, 24
 Slide 123 Colon, 97-98, 243-245
 Slide 125 Liver (6 mos. Fetus), 257-258

INDEX

Slide 126 Liver, 250-252
 Slide 127 Liver (Azan), 253-255
 Slide 128 Liver (PAS), 255-256
 Slide 130 Gall Bladder, 258-259
 Slide 131 Pancreas, 195-197, 220
 Slide 132 Pancreas (Azan), 198
 Slide 133 Pancreas (Aldehyde Fuchsin), 198, 221-222
 Slide 134 Nasal Conchae and Palate, 293
 Slide 134 Palate, 293-294
 Slide 135 Larynx, 25, 297
 Slide 136 Trachea, 25, 65-66, 298-299
 Slide 136 Trachea, Hyaline Cartilage, 65-66
 Slide 137 Lung (fetal), 304
 Slide 139 Lung, 303
 Slide 140 Fetal Kidney, 267-269
 Slide 141 Kidney, 270-277
 Slide 141 Simple epithelium, 23
 Slide 142 Kidney, 278-281
 Slide 142 Kidney (Azan), 278-281
 Slide 143 Kidney, 281-282
 Slide 146 Ureter, 283-284
 Slide 147 Bladder, 285
 Slide 149 Pituitary Gland, 208-210
 Slide 150 Pituitary Gland (Azan), 210-212
 Slide 151 Thyroid Gland, 213-214
 Slide 154 Parathyroid Gland, 214-215
 Slide 155 Adrenal Cortex, 218
 Slide 155 Adrenal Gland, 215-219
 Slide 155 Adrenal Medulla, 216, 219
 Slide 160 Ovary, 311-312
 Slide 165 Uterus (proliferative), 317-318
 Slide 166 Uterus (late secretory), 319
 Slide 167 Uterus (menstrual), 320-321
 Slide 170 Uterus (menopausal), 321
 Slide 171 Fallopian Tube, 322-323
 Slide 172 Cervix, 324
 Slide 173 Vagina, 325
 Slide 174 Mammary Gland, 325-327
 Slide 175 Placenta, 328
 Slide 178 Testis (adult), 333-335
 Slide 178 Testis (neonate), 332-333
 Slide 181 Vas Deferens, 336-337
 Slide 182 Seminal Vesicle, 338-339
 Slide 183 Prostate, 339-340
 Slide 184 Penis, 340-341
 Slide 185 Epididymis, 336
 Slide 207 Cervix, 324
 Slide 211 Pancreas, 221
 Slide 214 Urinary Bladder, 287
 Slide 218 Mammary Gland, 327
 Slide 224 Uterine Tube, 323
 Slide 226 Eye, 352
 Slide 227A Eye, 348-350
 Slide 227B Eye, 353
 Slide 229 Eye, 351-352
 Slide 230 Ear, 356-358
 Slide 231 Eyelid, 354-355
 Slide 245 Heart Purkinje Fibers, 154

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Robert L. Sorenson, PhD

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