

# **Histology**

1st year medical school

Cambridge University  
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2011

# Aim of this presentation

When starting to learn histology, I was looking for simple overviews presenting the key features of each tissue type or tissue found in the body.

Since I could not find that anywhere, I made it myself!

This presentation should be used with a standard histology textbook (or the internet ;-)) showing you slides/pictures of the structures described here.

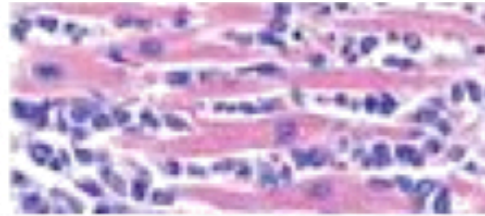
Pictures of particular stains (part I) have been cited.

# Contents

1. staining and fixing techniques
2. histological properties of human tissue types
  - 2.1. connective tissue
  - 2.2. muscle tissue
  - 2.3. nervous tissue
  - 2.4. epithelial tissue
3. histological properties of anatomical structures
4. ways to identify tissues/cells
  - blood cells (connective tissue)
  - ganglia (nervous tissue)
  - components of the urinary system
  - tissue types of the GI tract

# I.

## staining and fixing techniques



### Haematoxylin and eosin (H&E)

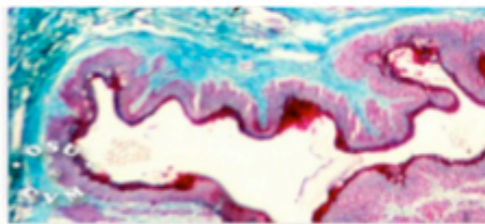
**BLUE NUCLEI**

most common stain

**acidic structures: nuclei, ribosomes, rough ER, DNA, RNA**

**basic structures: proteins**

<http://www.theaidsreader.com/display/article/1145619/1371021>



### Masson's trichrome

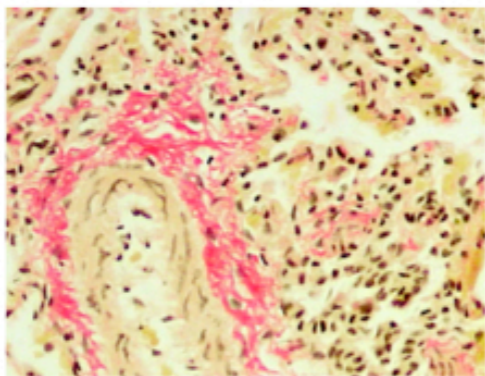
connective tissue technique, collagen stain

**nuclei and basophilic**

**collagen/collagen**

**cytoplasm, muscle, erythrocytes, keratin**

<http://instruction.cvhs.okstate.edu/histology/HistologyReference/hrd1.htm>



### Van Gieson

connective tissue

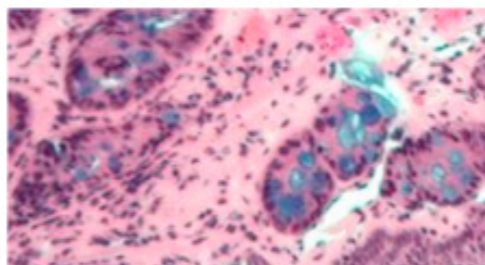
**nuclei**

**erythrocytes and cytoplasm**

**collagen**

combined with **elastin stain** which colours **elastin**

<http://www.bristol.ac.uk/vetpath/cpl/hvg.html>



### Alcian blue

mucin stain, combined with H&E or van Gieson

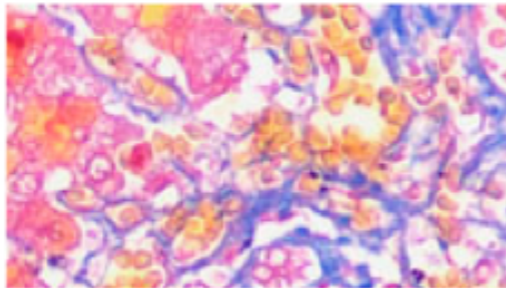
**certain types of mucin**

**certain types of mucin and van Gieson**

[http://en.wikipedia.org/wiki/Alcian\\_blue\\_stain](http://en.wikipedia.org/wiki/Alcian_blue_stain)

# I.

## staining and fixing techniques (2)



### Azan

connective tissue, fine detail, resp. epithelium

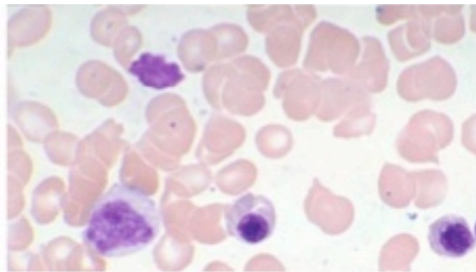
**nuclei**

**collagen, basement membrane, mucin**

**muscle, red blood cells**

**RED NUCLEI**

<http://www.jichi.ac.jp/pathology/index.php>



### Giemsa

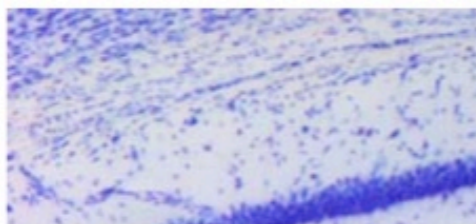
for blood cells and smears of cells, bone marrow

**nuclei**

**background cytoplasm**

**erythrocytes**

<http://pathy.med.nagoya-u.ac.jp/atlas/doc/node6.html>

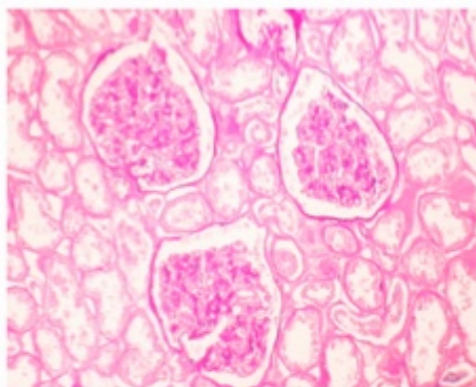


### Nissl methylene blue

stains rER in neurones = Nissl substance

**rough ER**

<http://serc.carleton.edu/genomics/units/27886.html>



### Periodic acid - Schiff reaction (PAS)

histochemical: stains specific cellular compartments

**complex carbohydrates**

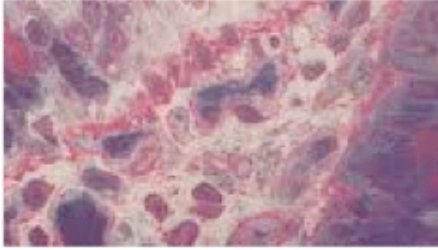
PAS positive: mucin from goblet cells of gastro and respiratory tract  
basement membrane and brush borders of kidney tubules, small and large intestine

**cartilage, collagen, glycogen**

<http://www.polyrnd.com/products/reagent-assembly-kits/microwave-kits.aspx?page=2>

# I.

## staining and fixing techniques (3)



### **Azure blue and basic fuchsin**

for resin embedded material

**cytoplasm**

**elastin**

**collagen**

[http://www.msd.com.mx/msdmexico/account/signin.html?request\\_url=ebooks/TextbookofGastroenterology/sid3249165.html](http://www.msd.com.mx/msdmexico/account/signin.html?request_url=ebooks/TextbookofGastroenterology/sid3249165.html)

**Goldner's's trichrome** (alternative: kossa stain (silver), but no cellular detail)

for acrylic resin section and undecalcified bone

distinguishes mineralised and unmineralised bone

haematoxylin: **nuclei, osteoblasts, osteocytes, osteoclasts, marrow cells**

### **Toluidine blue**

for epoxy resin sections (very thin, high res)

**nuclei and Nissl granules** other

### **Sudan black (LM) and osmium (EM)**

**myelin** = lipid containng

# I. staining and fixing techniques (4)

## **Immersion**

fixative diffuses through small slices of tissue  
squashing and mechanical damage  
capillaries squashed flat

## **Perfusion**

pumped through capillaries  
virtually instantaneous fixation without cell stress  
capillary blood volume preserved, but no more blood cells  
network of white spaces = capillary bed with very few blood cells

## **Heat**

dry, only good for overall structure, but no internal structure, proteins precipitate

## **OBJECTIVE SIZES**

x4	diameter 4.5mm
x10	diameter 1.8mm
x40	diameter 0.45mm
diameter of red blood cell = 7µm	

# 2.

# tissue types: **connective tissue**

Overview of tissue types:

C.Riedinger

tissue type	function	cell types	layers/components	appearance	stains
<p><b>connective</b> (mesoderm)</p>	<ul style="list-style-type: none"> <li>- binds functional cell groupings together</li> <li>- regulation</li> </ul>	<ul style="list-style-type: none"> <li>- <b>fibroblasts</b> (excrete ECM), come from mesoderm</li> <li>- adipocytes</li> <li>- chondroblasts</li> <li>- myofibroblasts</li> <li>- immune cells: macrophages, histiocytes, mast cells, white blood cells</li> </ul>	<ul style="list-style-type: none"> <li>- <b>collagen</b> mostly I, II in cartilage, II in skin, vessels, IV in epithelium of basement membranes</li> <li>- <b>elastic fibres</b> (stain poorly)</li> <li>- <b>ground substance</b> (= gel embedding collagen and elastin)</li> </ul>	<p>types:</p> <ol style="list-style-type: none"> <li><b>Loose</b> (10-20% C)</li> <li><b>Dense</b> (40-50% C, tendons 90%)</li> <li><b>elastic</b> lung, skin, bladder, vessels, change with age</li> <li><b>cartilage</b> 70% ground substance</li> <li><b>bone</b> = cartilage with 70% salts</li> <li><b>fat</b> white or brown</li> <li><b>blood</b></li> </ol>	<ul style="list-style-type: none"> <li>- <b>masson's trichrome</b> (collagen)</li> <li>- <b>van gieson</b> (collagen)</li> <li>- <b>elastin stain</b> (elastin)</li> <li>- <b>eosin</b> (collagen, but not specific)</li> <li>- <b>silver stain</b> (reticulin)</li> </ul>



# 2.

# tissue types: muscle tissue

Overview of tissue types:

C.Riedinger

tissue type	function	cell types	layers/components	appearance	stains
<b>muscular</b> (embryologically a subtype of connective from mesoderm)	- contraction	<b>- unicellular:</b> myoepithelial cells (secretory glands), pericytes (like smooth muscle, surrounds blood vessels, called multiunit smooth muscle as each unit functions individually), myofibroblasts (contractile and collagen, scarring)  <b>- multicellular:</b> <b>smooth</b> (lots of cells function as single unit), <b>cardiac, skeletal</b>	- surrounded by lamina - attached via link proteins <b>- endomysium:</b> supp. tissue around each individual muscle fibre <b>- perimysium:</b> surrounds each muscle cell bundle = fascicle <b>- epimysium:</b> around groups of fasciculi, dense collagenous sheath around whole muscle	- <b>no striations, spindles</b> - <b>1 elongated centrally located nucleus</b> - irregularly branching fasciculi, can have ganglia - <b>shorter</b> , often layered - <b>fasciculi aren't in parallel</b> - no myofibrils - caveolae - gap junctions	- masson's trichrome: (muscle, connective tissue)
				- intermediate - appears striated - <b>1-2 central nuclei</b> - intracellular boundaries hard to see - cells <b>appear continuous</b> (funct. Syncytium) - branched ends - long, <b>cylindrical</b> - <b>rich capillary network</b> - <b>intercalated discs (Z)</b> - gap junctions - no end plates, tendons! - diad (SR + T)	
				- extremely elongated - multinucleate (in transverse section may not be seen) - nucleus at periphery - striated - parallel fasciculi - triad = SR terminal cisterna + T-tubule	

## 2.

# tissue types: muscle tissue (2)

C.Riedinger

### striated:

light: I-band containing Z-line (made of actin fibres)  
dark: A-band containing myosin fibres

H-band: myosin-only region in A-band  
M-line: middle of A-band

### T-tubules:

T-tubules are at level of Z-bands (cardiac, amphibian skeletal)  
T-tubule at junction of A and I bands (skeletal)

Red skeletal muscle: (aerobic, stains more strongly)  
rich in myoglobin, numerous mitochondria, many capillaries  
White skeletal muscle: (anaerobic, stain is more pale)  
less myoglobin, fewer mitochondria, poorer blood supply

### cardiac: **junctions!**

intercalated discs: black line perpendicular to length of fibre, parallel to striations

membrane-to-membrane contact in intercalated discs (only visible at EM resolution):

1. Fascia adherens: intermediate junction, anchors actin at terminal sarcomeres - mechanical connection
2. desmosomes: (macular adherens), attachment of intermediate filaments to cytoskeleton - mechanical
3. Gap junctions: (nexus), exchange/transmission of ions and small molecules from cell to cell - electrical

result: functional syncytium!

purkinje fibres: pacemaker cells, larger than cardiac muscle cells and sometimes binucleated  
contain lots of mitochondria but less myofibrils (irregular), no T-tubules and intercalated discs  
still have desmosomes and gap junctions, lots of glycogen (can stain for it specifically!)

### smooth:

dense bodies/plaques: points of attachment for actin filaments  
caveolae: invaginations of the plasma membrane, help Ca<sup>2+</sup> entry

macula - spot (latin)

# 2.

# tissue types: nervous tissue

Overview of tissue types:

C.Riedinger

tissue type	function	cell types	layers/components	appearance	stains
<p><b>nervous</b> (from ectoderm?)</p>	<p>- electrically conduct signals</p>	<p>- <b>neurons</b> (multipolar, bipolar, pseudounipolar)            - <b>glial cells</b> (schwann cells, oligodendrocyte, astrocytes, satellite cells)            - <b>fibrocytes</b></p>	<p>transverse:            - bundles of axons = fasciculi             - <b>endoneurium</b> = around each nerve fibre along with myelin             - <b>perineurium</b> = dense conn. tiss around bundles of nerve fibres = fascicles             - <b>epineurium</b> = loose conn. tiss around fascicles             Longitudinal:            dendrite, nodes of ranvier            other: ganglia, myelin, axon hillock, terminal</p>	<p>- large <b>cell body</b>             - large, round, prominent but pale staining nucleus, dispersed chromatin             - extensive basophilic cytoplasm             - large and central nucleolus (transcriptional activity)             - in longitudinal section of <b>nerve trunks</b>: zig-zaggy lines with round nuclei (of schwann cells!!!!)             - abundant rER in nucleus and dendrites (= Nissl substance from Nissl staining RNA)             - <b>ganglia</b>: cell bodies and/or synapses</p>	<p>- <b>Nissl methylene blue</b> (rER)             - <b>Sudan black</b> (for LM) and <b>osmium</b> (for EM) (myelin and lipids, connective tissue)</p>

# 2.

# tissue types: **epithelial tissue**

Overview of tissue types:

C.Riedinger

tissue type	function	cell types	layers/components	appearance	stains
<b>epithelial</b> (endoderm, ectoderm)	<ul style="list-style-type: none"> <li>- cover the body and line spaces and tubes within it</li> <li>- protect</li> <li>- absorb</li> <li>- secrete</li> <li>- skin, nephrons, airways, glands, gut...</li> </ul>	<ul style="list-style-type: none"> <li>- very closely packed epithelial cells</li> <li>- subtype reflects function</li> <li>- goblet cells (mucus secreting)</li> <li>- hair cell (sensory)</li> <li>- gustatory (taste cell)</li> </ul> <p>Even though not a cell type: epithelial tissue <b>always contains a basement membrane</b> (lamina densa) consisting of type IV collagen</p>	<p><b>simple:</b> = <b>single layer</b></p> <ul style="list-style-type: none"> <li>- squamous</li> <li>- cuboidal</li> <li>- columnar</li> <li>- pseudostratified</li> </ul>	<ul style="list-style-type: none"> <li>- flat thin cells difficult to distinguish sometimes only nuclei visible</li> <li>- round centrally located nucleus, often polygonal</li> <li>- tall, elongated cells may be ciliated</li> <li>- mostly ciliated cells, nuclei not in line</li> </ul>	
			<p><b>stratified:</b> = <b>multiple layers</b></p> <ul style="list-style-type: none"> <li>- squamous (wear &amp; tear)</li> <li>- cuboidal</li> <li>- columnar</li> <li>- transitional</li> </ul>	<ul style="list-style-type: none"> <li>- <b>NEVER CILIATED!</b></li> <li>- only top layer flat, bottom layer cuboid</li> <li>- intermediate betw. Stratified cuboidal and squamous. But all layers have the same shape!</li> </ul>	

# 3.

# anatomical structures: vessels

organs: vessels

C.Riedinger

blood vessels	layers					other
	1. Tunica intima	internal elastic lamina	2. Tunica media	external elastic lamina	3. Tunica adventitia	
<b>general</b>	<b>1a. Endothelium</b> (1 flat layer, cells difficult to distinguish in LM, often see only nuclei) <b>1b. Basement membrane</b> <b>1c. Connective tissue</b>	fenestrated layer of elastin separating 1. and 2.. In very large elastic vessels hard to see as media has so many layers of elastin.	- <b>smooth muscle</b> - <b>collagen</b> - <b>elastin</b> - quite thick compared to intima	less defined layer of elastin separating 2. and 3.	- <b>supporting tissue: collagen</b> - contains innervation and blood supply (for very large vessels, vasa vasorum) - in continuation with surrounding tissue	
<b>arteries, elastic</b>	+	+	+ very broad, contains concentrically arranged layers of elastin with some smooth muscle between layers, elastin decreases with age	+	+	
<b>arteries, muscular</b>	+	+	+ circumferentially arranged smooth muscle	+	+	
<b>arteriole</b>	+ (thin)	+	+ (almost entirely smooth muscle)	-	+ (merges with surrounding tissue)	<0.3mm diam
<b>vein</b>	+ (thin)	-	+ (thin)	-	+ (most prominent)	overall much thinner wall compared to lumen
<b>lymph</b>	like veins but no erys in lumen, few leucocytes and precipitated lymph protein (artifact of preparation!)					
<b>capillaries</b>	+ (only 1a and 1b)	-	-	-	-	continuous, fenestrated (windows bridged by thin diaphragm) or sinusoidal with proper gaps
<b>venule</b>	+	-	-	-	+	

nuclei of endothelial cells are elongated in direction of vessel, smooth muscle nuclei are elongated circumferentially

# 3.

# anatomical structures: **respiratory system**

organs: respiratory system (lung)

C.Riedinger

compartment	1. mucosa?			2. submucosa	3. cartilage	stain
	1a. epithelium	1b. Lamina propria	1c. Smooth Muscle			
<b>trachea</b>	<ul style="list-style-type: none"> <li>- <b>pseudostratified columnar ciliated</b></li> <li>- many mucus secreting goblet cells</li> <li>- unusually thick basement</li> </ul>	<ul style="list-style-type: none"> <li>- loose connective tissue</li> <li>- many blood vessels</li> </ul>	-	<ul style="list-style-type: none"> <li>- numerous seromucinous glands</li> <li>- serous cells stain strongly</li> <li>- mucous cells stain poorly</li> </ul>	<ul style="list-style-type: none"> <li>- C-shaped hyaline cartilage</li> <li>- with layers of fibroelastic tissue between cart. rings</li> <li>- submucosa merges with its perichondrium</li> </ul>	- H&E
<b>bronchus</b>	<ul style="list-style-type: none"> <li>- <b>pseudostratified columnar ciliated</b> (less tall, smaller)</li> <li>- fewer goblet cells</li> </ul>	<ul style="list-style-type: none"> <li>- more dense</li> <li>- more elastic</li> </ul>	+	<ul style="list-style-type: none"> <li>- fewer seromucous glands</li> </ul>	<ul style="list-style-type: none"> <li>- flatter, interconnected plates of cartilage rather than rings</li> <li>- not C-shaped</li> </ul>	
<b>bronchioles</b>	<ul style="list-style-type: none"> <li>- <b>simple columnar ciliated</b></li> <li>- &lt;1mm diam.</li> <li>- smaller bronchioles cuboidal</li> <li>- less to no goblet cells, but Clara cells! (= resp. bronchiole)</li> </ul>	-very thin - is it there?	<ul style="list-style-type: none"> <li>+</li> <li>prominent feature!</li> </ul>	<ul style="list-style-type: none"> <li>-seems to be there but much less glands and thinner</li> </ul>	<ul style="list-style-type: none"> <li>-</li> <li>thin-walled pulmonary artery branches can lie next to bronchiole</li> </ul>	
<b>alveoli</b>	<ul style="list-style-type: none"> <li>- lined with <b>pneumocyte type I cells</b> (40% covering 90%)</li> <li>- can only see nuclei</li> <li>- 60/10% pneumocyte type II (cuboidal, much CP, secrete surfactant)</li> <li>- endothelial cell on the blood side</li> </ul>	<ul style="list-style-type: none"> <li>- alveolar ducts: smooth muscle cells, collagen and elastic fibres</li> <li>- alveolar septum (wall): alveolar capillaries and sparse network of elastin and collagen with pneumocytes of the walls of the two adjacent alveoli next to it</li> <li>- septum also contains few fibroblasts</li> <li>- elastin and collagen condense around alveolar openings to form supporting network for lung parenchyma (parenchyme = bulk of a substance = lung material)</li> <li>- 8um openings in septum: alveolar pores (of Kohn) for air exchange</li> <li>- also alveolar macrophages (dust cells) with thin flattened, even nucleus</li> </ul>				

# 3.

# anatomical structures: urinary system

organs: urinary system (kidneys)

C.Riedinger

compartment	epithelium	other cells	features (Wheater's p. 318, 320,325)
afferent arteriole	simple squamous endothelium	<b>1. juxtaglomerular cells</b>	- modified smooth muscle cells
renal corpuscle	simple squamous endothelium (fenestrated)	- podocytes - mesangial cells <b>2. extraglomerular mesangial cells</b>	- 1* and 2* foot processes - embrace capillary loops - filtration barrier: 1. Endothelial cells, 2. Basement membrane, 3. podocytes - contractive cells, phagocytotic (can reduce GFR) - surround glomerular capillaries - mesangium = supportive tissue similar to basement membrane, cytoplasm very stained - flat, elongated continuous with glomerular mesang. cells - conical mass, cytoplasmic processes
	<div style="border: 1px solid blue; padding: 5px; width: fit-content; margin: auto;"> <b>JUXTAGLOMERULAR APPARATUS</b>                      formed by compartments of glomerulus, afferent arteriole and distal convoluted tubule                 </div>		
bowman's capsule	simple squamous epithelium	-	- invaginated sphere - visceral and parietal layer (but where is visceral layer? Can't see it on EM)
proximal convoluted tubule (PCT)	simple cuboidal epithelium	-	- <b>brush border</b> (aids reabsorption) - many mitochondria, endocytotic vesicles and lysosomes - <b>FUZZY LUMEN!!!</b>
thin descending and thin ascending loop of henle	simple squamous epithelium	-	
thick ascending loop of henle	simple cuboidal epithelium (low)	-	
distal convoluted tubule (DCT)	simple cuboidal epithelium	<b>3. macula densa</b> (where in contact with glomerulus)	- <b>NO</b> brush border! - smaller cells, stain less intensely - <b>CLEAR LUMEN!!!</b> - nucleus protrudes into lumen - cell volume smaller - specialised epithelial cells - closely packed, taller, thin basement membrane - located on side of DCT that faces corpuscle
collecting tubules (CT)	simple cuboidal epithelium	-	- wider than CDT - less regular in shape
collecting duct (CD)	simple columnar epithelium	- principal cells - a-intercalated cells	- large diameter - pale cytoplasm, few organelles - pale stained - short microvilli - darker cytoplasm, many mitos, vesicles (H+)
ureter, bladder	stratified transitional epithelium	-	- 3-6 layers - thick luminal surface - impermeable to urine/water

# 3.

# anatomical structures: glands

organs: glands

C.Riedinger

type of gland	arrangement	main component	ducts	features	other
<b>Salivary</b>	lobules separated by septa, surrounded by capsule	<b>acini</b> (end pieces) = clusters of mucus secreting cells, serous secreting cells, or a mix of both. Duct system more prominent	intercalated ducts leading to striated ducts, stain <b>red</b> . Simple cuboidal epi, central round nucleus	mucus secreting: bigger, stain pale with nuclei on side. Serous secreting: smaller, stain strongly, pyramidal/cuboidal cells	lots of vessels, nerves, (parasympathetic) ganglions, excretory ducts, connective tissue, lymphatic vessels
<b>Pancreas</b>	lobules separated by loose supporting tissue surrounded by collagenous capsule. Exocrine (80-85%) and <b>endocrine</b> (1-2%) features!	<b>acini</b> (exclusively serous with central nuclei, surrounded by fine network of supporting tissue containing sinusoids)	intercalated ducts (difficult to ID with LM), leading to intralobular and interlobular ducts (big lumen)	<b>arranged circularly with lateral nuclei</b> (apex towards inside, nucleus basal), tiny lumen, sometimes centroacinar cells	abundant blood supply, network of arterioles. in ducts: cells change from squamous or cuboidal epithelium to stratified cuboidal in large ducts
		<i>islets of langerhans</i>	-	<i>smaller, scattered pale staining blobs of varying size, cells contained smaller than acinar cells, evenly distributed cells with evenly distributed nuclei</i>	<i>immunological stain for glucagon (alpha-cells, smaller) or insulin (beta-cells, stain with aldehyde fuchsin) reveals that glucagon is produced in the periphery whereas insulin is produced centrally</i>
<b>Liver</b>	polygonal lobules with thin boundaries of collagenous supporting tissue	hepatocytes and sinusoid arterioles	canaliculi with microvilli that run countercurrent to the sinusoids	<b>polyhedral cells with round nuclei</b> , some binucleated, arranged into branching sheaths of 1 cell thickness, separated by sinusoids which appear as empty spaces	macrophages (Kupffer cells) present in sinusoids to remove debris, sinusoids have gaps between endothelial cells to promote exchange of plasma components with the hepatocytes (see EM).
		portal tracts/triads: entry site of blood from terminal branches of portal vein and hepatic artery, leads to central vein, exit of bile duct (canaliculus).		thin-walled veins, thicker walled arteries, darkly staining bile ducts. Also contains lymphatic tissue/ducts which is often collapsed	



# 3.

# anatomical structures: glands (2)

organs: glands

C.Riedinger

type of gland	arrangement	components	products	features	other
<b>Thyroid</b>	lobulated	<b>follicles</b> , contain thyroid hormones stored in homogenous colloids, lined with single layer of cuboidal <b>follicular cells</b>	tri-iodothyronine, 4-iodothyronine (=thyroxine)	morphology ~ activity: resting thyroid follicular cells flattened, lots of colloid, active thyroid follicular cells large, columnar, basal nucleus, less colloid	hormones bound to thyroglobulin, a glycoprotein, when stored. Thyroid gland is unique in storing lots of hormone when inactive!
		<b>parafollicular cells</b>	calcitonin	scattered, lumps or single cells, near fenestrated capillaries for hormones to enter blood stream	endoneurocrine, derived from neural crest cells?
<b>Parathyroid</b>	poorly defined lobules + septa contained in the capsule of thyroid gland (septae [blue] = extensions of capsule containing neurovascular structures)	<b>chief/principal cells</b> (most common)	PTH	large, round nuclei, resting cells have pale cytoplasm, prominent golgi, rER, secretory granules. When active smaller, more rER, stain more strongly	glandular elements can be intermixed with adipose cells, in age becomes infiltrated by lymphocytes
		<b>oxyphil cells</b> (minor component)	unknown	eosinophilic cytoplasm, numerous mitochondria, larger than principal cells	
<b>Anterior pituitary (adeno)</b>	blob	<b>glandular epithelium</b> , intimate vascular connections with hypothalamus. chromophobe and chromophil cells = <b>~troph</b> cells with lots of granules*	GH, ACTH, LH, FSH, prolactin, thyrotrophin	cords or clumps of cells, sinusoid capillaries, collagen and reticulin network, chromophobes: smallest, few granules, chromophils: acidophil or basophil.	*50% somatotrophs (GH) 20% corticotrophs (ACTH) 20% lactotrophs (prolactin) 5% gonadotrophs (LH, FSH) 5% thyrotrophs (thyrotrophin)
<b>Posterior pituitary (neuro)</b>	connects to hypothalamus via stalk	non-myelinated <b>axons</b> , <b>pituicytes</b> (specialised glial cells)	ADH, oxytocin	axons: lots of granules, accumulate in distended terminations = Herring bodies, granules contain hormone precursors generated in cell body, final hormone generated during transport. Pituicyte EM: few granules	cell bodies of axons in hypothalamus

# 3.

# anatomical structures: GI tract

organs: alimentary system (gut)

C.Riedinger

organ	1. mucosa			2. submucosa	3. muscularis propria	4. adventitia
	1a. epithelium	1b. lamina propria	1c. muscularis mucosae			
oesophagus	stratified squamous			Meissner's nerve plexus	thicker, inner circular and outer longitudinal	
stomach	<b>stratified straight glandular epithelium</b> - mucus secreting cells - parietal/oxynitic cells in body and fundus - peptic cells in body and fundus - G-cells in cardia and pylorus - PITS! - no lymphoid aggregates			Meissner's nerve plexus (thick) (--> secretion)		
duodenum	<b>stratified glandular epithelium</b> villous mucosa ( <b>villi</b> ) and microvilli, endocrine			<b>Brunner's mucus secreting glands (entire submuc.)</b> Meissner's nerve plexus	inner circular and outer longitudinal	
jejunum ileum	<b>simple columnar epithelium</b> villous mucosa ( <b>villi</b> ) and <b>microvilli</b> , (only one thin layer to aid absorption) - crypts of lieberkuhn - enterocytes - parath cells - goblet cells --> mucus - absorptive cells - lymphocytes - enteroendocrine			Meissner's nerve plexus in ileum: peyer's patches (lymphoid tissue)	<b>myenteric plexus of auerbach</b> (--> motility) between layers! Cell bodies of nerves inner circular and outer longitudinal	
large intestine	<b>glandular epithelium</b> with straight crypts, no villi but <b>microvilli</b> - colonic crypts - tubular glands - goblet cells - bacteria			Meissner's nerve plexus	looks like one, inner circular and outer longitudinal	

# 4. identify: **blood cells (connective tissue)**

## **BLOOD**

Wheater's: table page 64

### **1. red blood cells:**

- total absence of organelles
- no nucleus
- flattened disc with elevated circumference
- reticulocytes (= precursors, <1% of circulating erys) have some residual nuclear material
- very young cells some rER and mitochondria

### **2. white blood cells:** (1/1000 blood cells)

5 types, named based on staining properties of granules

granulocytes:

<b>Neutrophils</b>	do not stain in humans	60%
<b>eosinophils</b>	pick up eosin and therefore stain orange	3%
<b>basophils</b>	pick up azures and therefore stain blue, rarest cells	1%

single multilobed nuclei (polymorphonuclear)  
originally believed to be polynuclear

mononuclear leucocytes:  
(agranular)

<b>lymphocytes</b>	clear cytoplasm, rounded nucleus	34%
<b>monocytes</b>	large, indented curved nucleus	4%

non-lobulated nuclei  
agranulocytes

### **3. platelets:**

- small
- non-nucleated
- round or oval, biconvex
- cytoplasm purple stained
- granules = 20% of platelet volume
- many organelles

## 4. identify: **blood cells (connective tissue) (2)**

### **How to distinguish blood cells:**

#### **How many nuclei?**

- \* no nucleus: platelet or erythrocyte

#### **Are there organelles?**

- \* no organelles and larger = **erythrocyte**
- \* granules and tiny = **platelet**

- \* single nucleus:

#### **Shape of nucleus?**

- \* round and smallest cell overall = **lymphocyte**
- \* huge and indentated nucleus = **monocyte**

- \* granulated (= apparent polynucleation)

#### **Shape of nucleus?**

- \* horseshoe = **eosinophil**
- \* blue granules = **basophil**
- \* lobulated granules = **neutrophil**

# 4. identify: **type of ganglia (nervous tissue)**

C.Riedinger

## how to distinguish ganglia

cell bodies are large with smaller supporting cells around it

symp + parasymp:

contain synapses

(stellar ganglion = largest symp ganglion)

sensory:

just contain cell bodies

appearance

sensory ganglion:

many and larger nuclei of satellite (supporting cells), form neat circle around cell body, even larger cell bodies  
pseudounipolar neurons!

sympathetic ganglion:

smaller and more scattered satellites, smaller cell bodies  
more space between cell bodies as axons and dendrites have to pass through!  
same basic structure as sensory ganglia

parasymp. Ganglion:

near target organ! Islands of connective tissue with blood vessels, nerves and ducts  
nerve cell bodies lie within nerve trunk, are surrounded by support cells,  
less satellites, smaller cell bodies  
large cell bodies and axons

## nerves in longitudinal section

zig-zaggy strands with nuclei of schwann cells visible

each myelin producing schwann cell covers ca. 1mm of the nerve fibre

in-between: nodes of ranvier

often stained black with pink connective tissue in-between individual myelinated fibres

# 4.

# identify: GI tract

Wheater's:

page 286, 287, for glands 97

## How to distinguish different parts of the gut:

Are there villi?

\* Yes

Small intestine: Duodenum/Jejunum/Ileum

Are there brunner's glands?

\* Yes

\* No

**Duodenum**

Jejunum/Ileum

Are there peyer's patches?

\* Yes

\* No

Ileum

Jejunum

\* No

Oesophagus/Stomach/Colon

Are there glands?

\* Yes

Stomach/Colon

What do the glands look like?

Straight and beautiful

Thick very thick layer

underneath ducts, less

ordered

Colon

Stomach

\* No

Stratified squamout epithelium?

Oesophagus

# 4.

# identify: urinary system

organs: urinary system (kidneys)

C.Riedinger

## adrenal gland

embedded in dense supporting tissue that extends into gland to support secretory cells

- cortex:**
  - zona glomerulosa 5-10%
    - secretes mineralocorticoids (e.g. aldosterone)
    - whorls of cells and capillaries
  - zona fasciculata 75%
    - narrow cords of large cells
    - sinusoid capillaries
    - rich in sER and lipids
    - "foamy"
  - zona reticulosa
    - secretes glucocorticoids (e.g. cortisol)
    - irregular network of branching cords
    - numerous capillaries of wide diameter
    - smaller cells than other two layers
    - secretes androgenic steroids
- medulla:**
  - chromaffin cells
    - clumps and cords of cells
    - surrounded by fine supporting tissue
    - large nucleus (stains blue)
    - basophilic cytoplasm
    - secretes catecholamines (e.g. (nor)adrenaline)

steroid secreting cells: many mitochondria with unusual tubular cristae  
 sER  
 lipid droplets (if secreting cholesterol, in cortex)  
 membrane-bound granules (if secreting catecholamines in medulla, but those are not steroids)

**The End.**