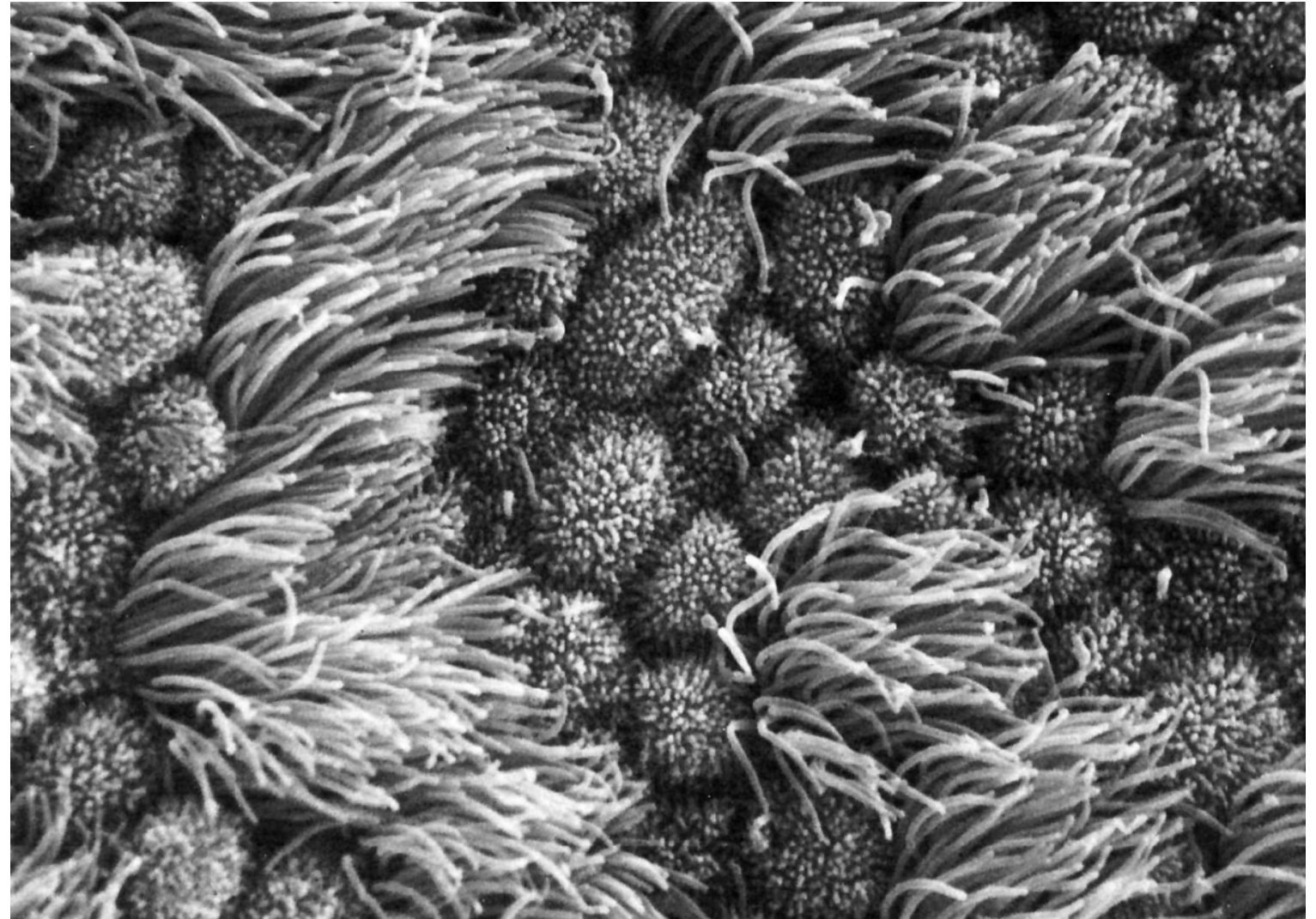


Lab 4 - Epithelia and Glands

IUSM - 2016

- I. **Introduction**
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 - A. Epithelia
 1. Simple
 - a. Simple squamous
 - b. Simple cuboidal
 - c. Simple columnar
 - d. Pseudostratified columnar
 2. Stratified
 - a. Stratified squamous
 - b. Stratified cuboidal
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 - d. Transitional
 - B. Exocrine Glands
 1. Simple (unbranched duct)
 - a. Tubular
 - b. Branched tubular
 - c. Coiled tubular
 - d. Branched acinar
 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. Summary

Epithelia and Glands



SEM of ciliated columnar epithelium of the uterine tube

Lab 4 – Epithelia and Glands

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I. Introduction

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A. Epithelia

1. Simple

- Simple squamous
- Simple cuboidal
- Simple columnar
- Pseudostratified columnar

2. Stratified

- Stratified squamous
- Stratified cuboidal
- Stratified columnar
- Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

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- Branched tubular
- Coiled tubular
- Branched acinar

2. Compound (branched ducts)

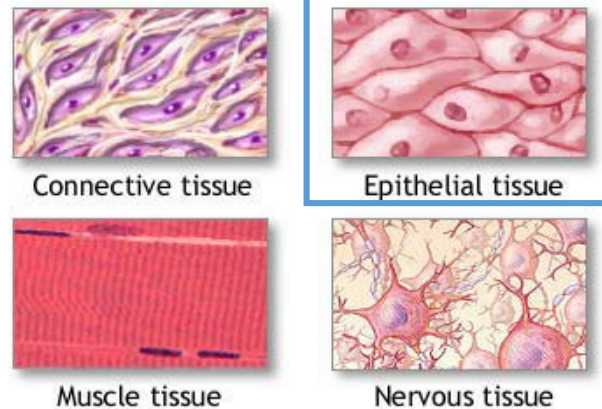
- Tubular
- Acinar
- Tubulo-acinar

V. Summary

Epithelium

- Greek: *epi* – “upon”, *thele* – “teat, nipple”
- Avascular tissue that covers body surfaces, lines body cavities, and forms glands (endocrine and exocrine).
- Composed of sheets of closely aggregated cells, of one or more layers thick, sitting upon a basement membrane.
- Creates a barrier between “external” environment and underlying connective tissue.
- Polarized with a free surface (**apical surface**), generally facing the external environment or lumen, and a bound surface (**basal surface**), facing the basement membrane.
- Epithelial tissues are categorized by the number of cell-layers and the shape of their cells.
- Exocrine glands are categorized by the arrangement of their duct portion (branched or not) and the shape of their secretory portions.

Four types of tissue



ADAM.

Lab 4 – Epithelia and Glands

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Learning Objectives

1. Understand how epithelia are classified into simple, stratified, and pseudostratified types and the usual functional significance of each type.
2. Recognize the (extracellular) basement membrane of epithelia, apical specializations such as the terminal web, and ultrastructural features of the various types of intercellular junctions.
3. Understand that epithelium forms barriers and compartments by covering and lining the body's outer and inner surfaces.
4. Understand that epithelium is specialized for protection (or as a barrier), transport, absorption, and secretion.
5. Understand that glands are composed mostly of epithelial cell aggregates clustered together to perform specific secretory and/or excretory functions and that there are two main types of glands: exocrine and endocrine.

Lab 4 – Epithelia and Glands

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Learning Objectives (cont.)

6. Distinguish the basic differences between the **parenchyma** and **stroma** of a gland.
7. Understand that exocrine glands can be classified according to four features: the secretory portion's shape (alveolar/acinar vs. tubular), the duct system (simple vs. compound), the nature of the secretion (serous vs. mucous), and the mode of cell secretion (merocrine, apocrine, holocrine).
8. Continue to appreciate how structure relates to function.

Lab 4 – Epithelia and Glands

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Keywords

Acinar
Apocrine
Branched tubular
Brush border
Cilia
Coiled tubular
Compound gland
Epithelia
Glands
Glycocalyx
Goblet cells
Holocrine
Intercellular junctions
Keratin
Keratinized
Merocrine
Microvilli

Mucous
Myoepithelial cell
Non-keratinized
PCCE
Pseudostratified columnar
Serous
Simple columnar
Simple cuboidal
Simple epithelia
Simple gland
Simple squamous
Stratified cuboidal
Stratified epithelia
Striated border
Terminal web
Transitional
Tubular

Lab 4 – Epithelia and Glands

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Classifying Epithelium

1. The initial classification of epithelial tissue is based upon the number of cell layers between the basement membrane and the apical surface:
 - a. **Simple epithelia** are only one cell layer thick; despite how it may appear, all the cells of simple epithelia are *directly attached to the basement membrane*.
 - b. **Stratified epithelia** are more than one cell layer thick so that not all the cells are directly attached to the basement membrane; the apical layers of cells are attached to the cells below them, not the basement membrane.
2. Next, epithelia are classified by the shape of the cells composing the tissue:
 - a. The shapes may be classified as **squamous, cuboidal, or columnar**.
 - b. Since it is often difficult to see the actual shape of individual cells, generally the *shape of the nucleus* is used to determine the shape of the cell.
 - c. For stratified epithelia, the shape of the cells may appear different between the basal layer of the cells and the more apical layers of cells; therefore, the *most apical cell shape is used to classify the tissue*.
3. Finally, specific epithelia are distinguished by the presence of apical modifications such as **microvilli, cilia, and stereocilia**.

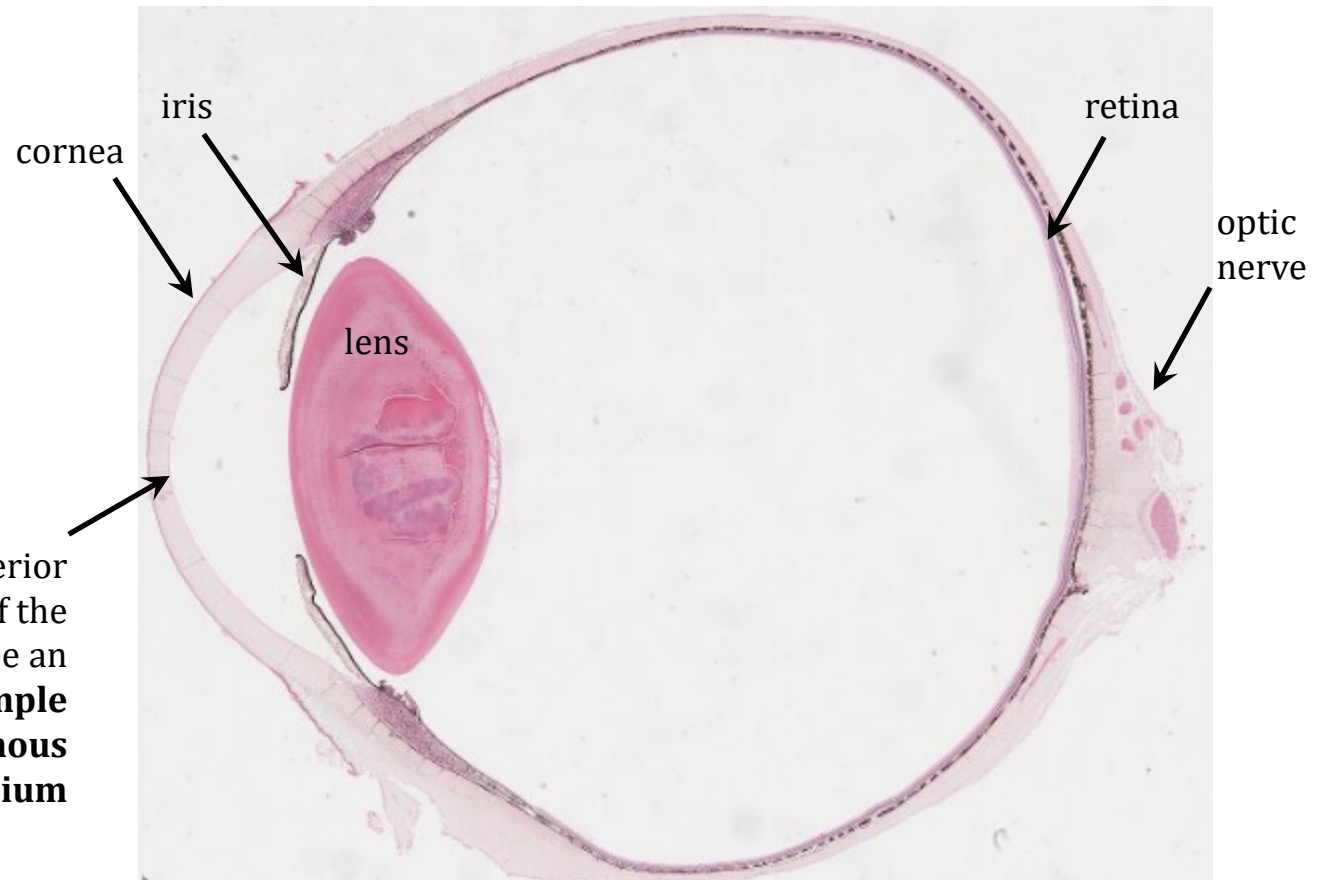
Lab 4 - Epithelia and Glands

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Slide 78: Eye, H&E

Slide Overview



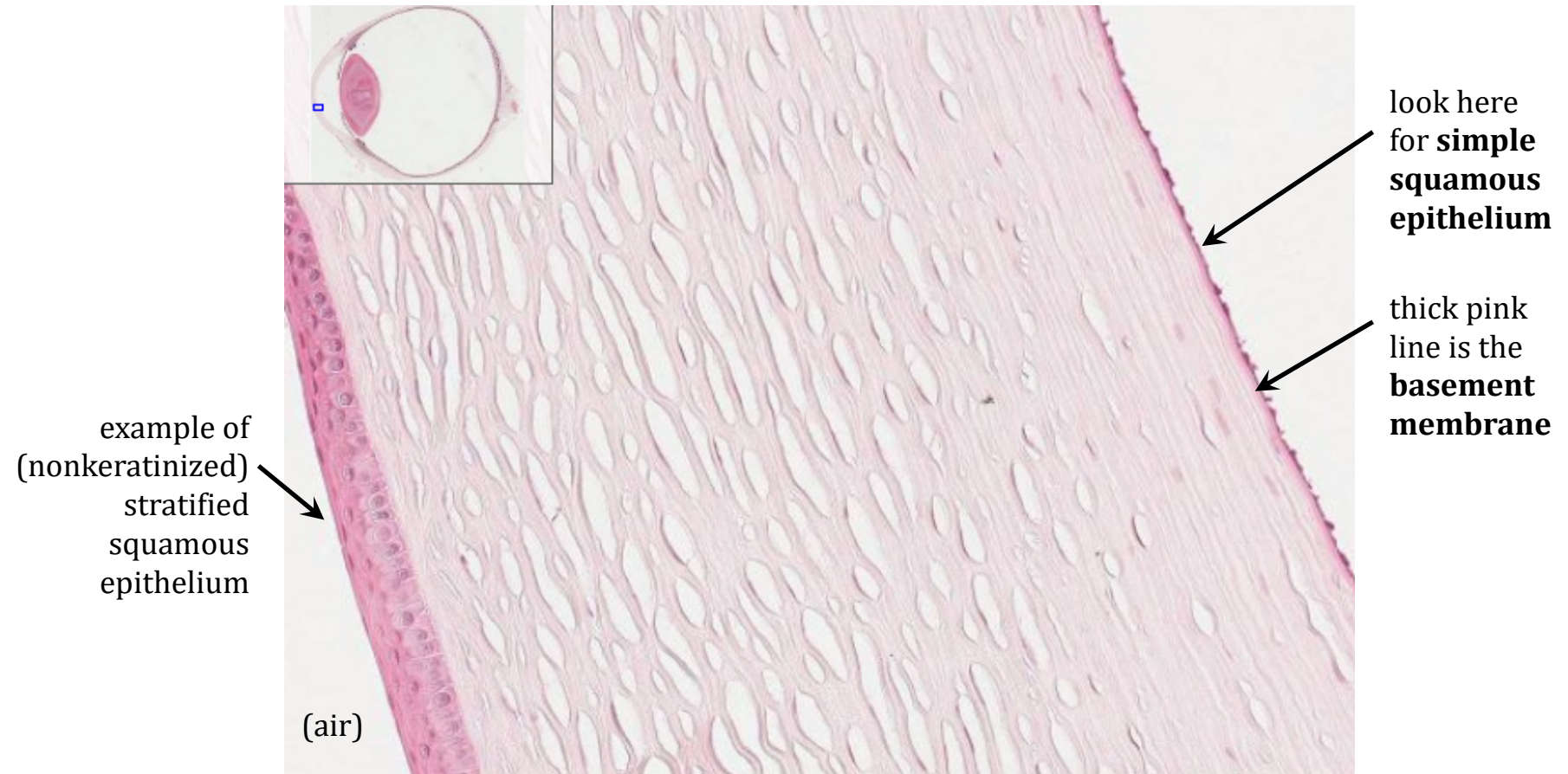
look at the interior surface of the cornea to see an example of **simple squamous epithelium**

Lab 4 - Epithelia and Glands

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- V. Summary

Slide 78: Eye, H&E



simple squamous epithelium consists of a single layer of flattened (squamous) cells; specialized types include *endothelium* (lines the interior of vessels and heart chambers) and *mesothelium* (lines the exterior of certain organs and body cavities)

Lab 4 - Epithelia and Glands

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B. Exocrine Glands

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2. Compound (branched ducts)

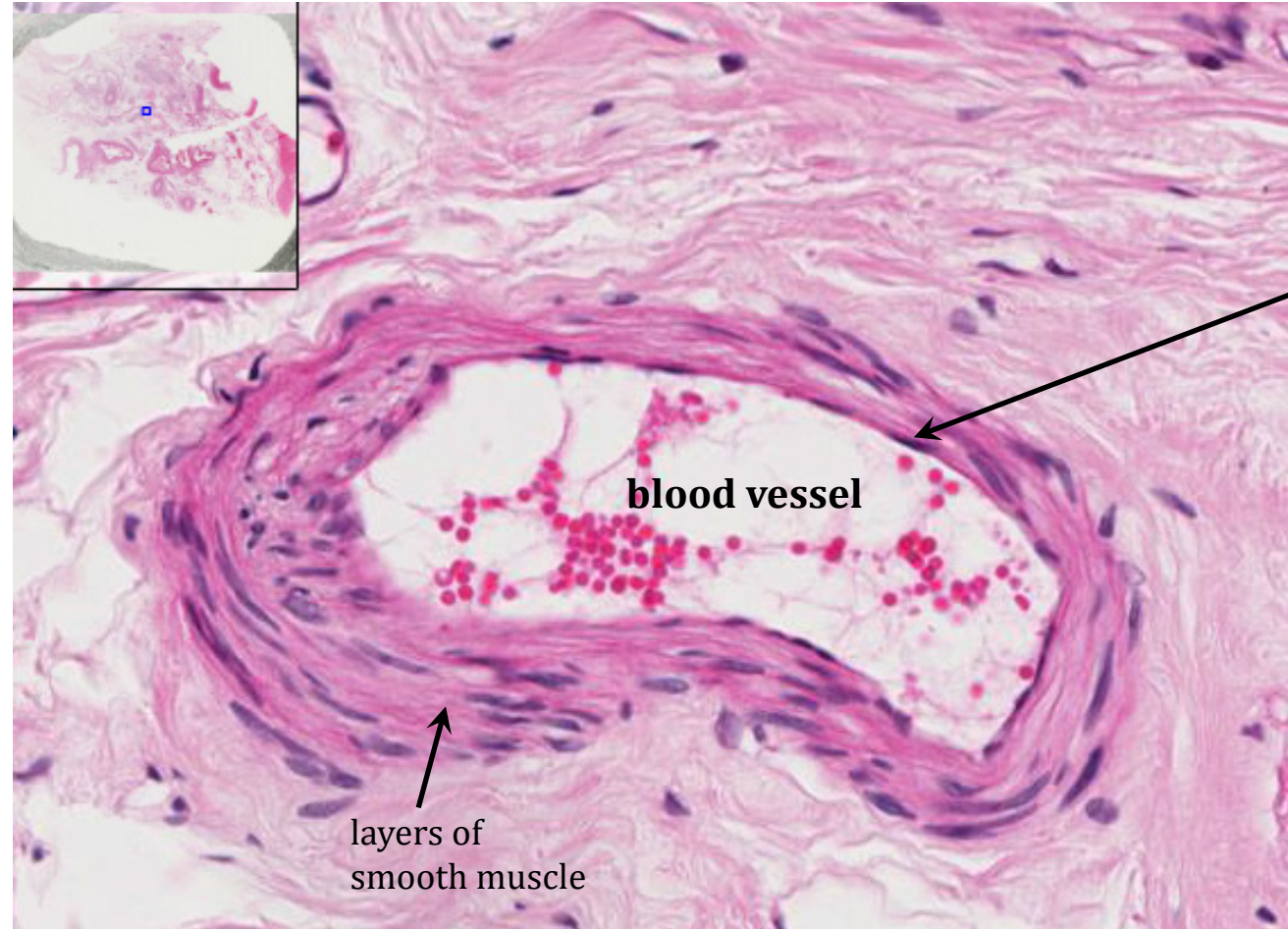
a. Tubular

b. Acinar

c. Tubulo-acinar

V. Summary

Slide 45: Autonomic Ganglia, H&E



**simple
squamous
epithelium
(endothelium)**

blood vessel

layers of
smooth muscle

Lab 4 – Epithelia and Glands

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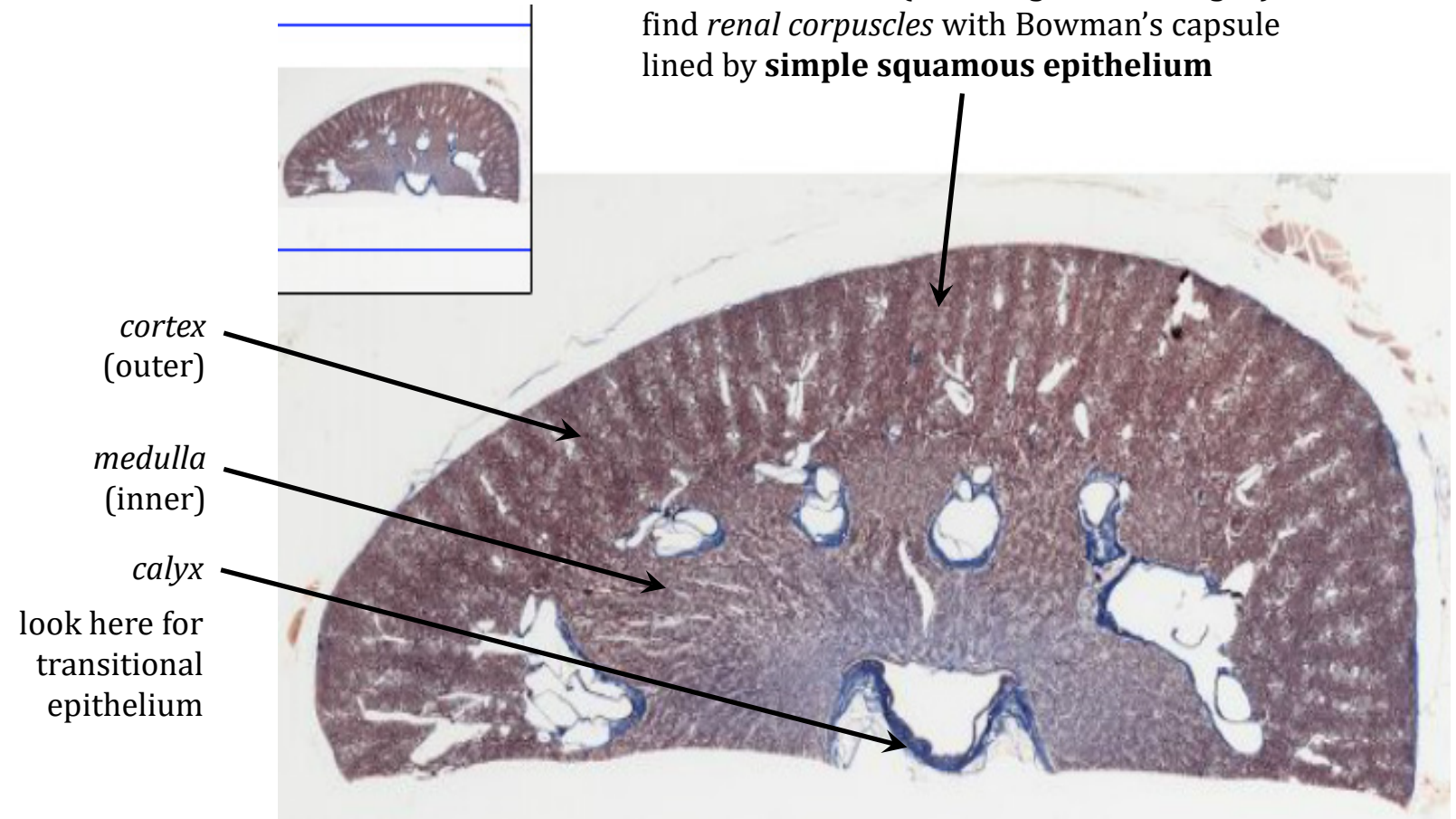
c. Tubulo-acinar

V. Summary

Slide 14: Kidney, Masson Trichrome

Slide Overview

look in the cortex (outer region of an organ) to find *renal corpuscles* with Bowman's capsule lined by **simple squamous epithelium**

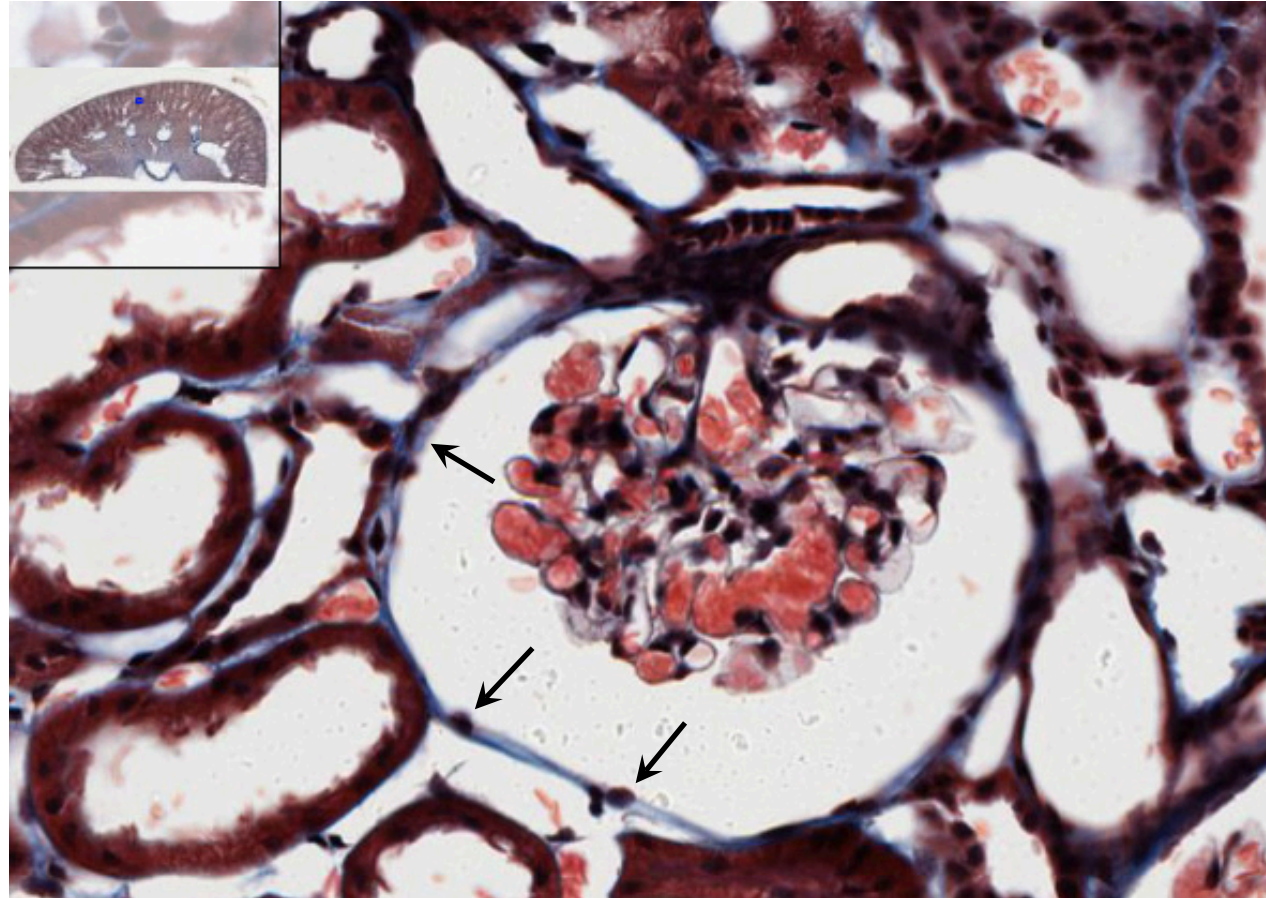


Lab 4 – Epithelia and Glands

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Slide 14: Kidney, Masson Trichrome



using a trichrome stain, blue shows collagen of the **basement membrane** of the **simple squamous epithelium** tissue that forms the outer layer of *Bowman's capsule*

the **basement** membrane is composed of two layers: the *basal lamina* (with type IV collagen) and the *reticular lamina* (with type III collagen)

*the center of the slide shows a glomerulus (capillary network) of a nephron, which compose the **parenchyma** (functional tissue) of the kidney (~ 1 million nephrons / kidney)*

Lab 4 – Epithelia and Glands

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B. Exocrine Glands

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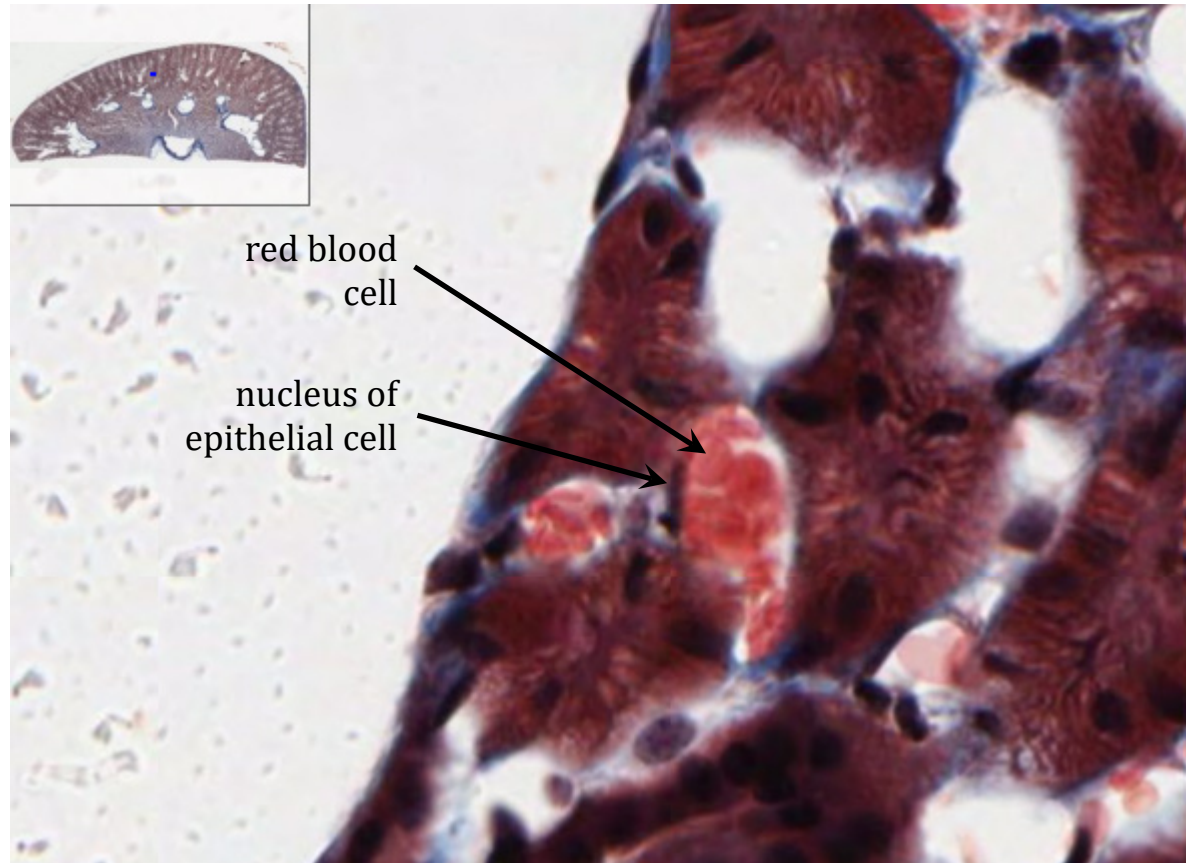
a. Tubular

b. Acinar

c. Tubulo-acinar

V. Summary

Slide 14: Kidney, Masson Trichrome



simple squamous epithelium (endothelium) lines blood vessels

blood vessels, especially venous, can often be distinguished by looking for red blood cells within the lumen

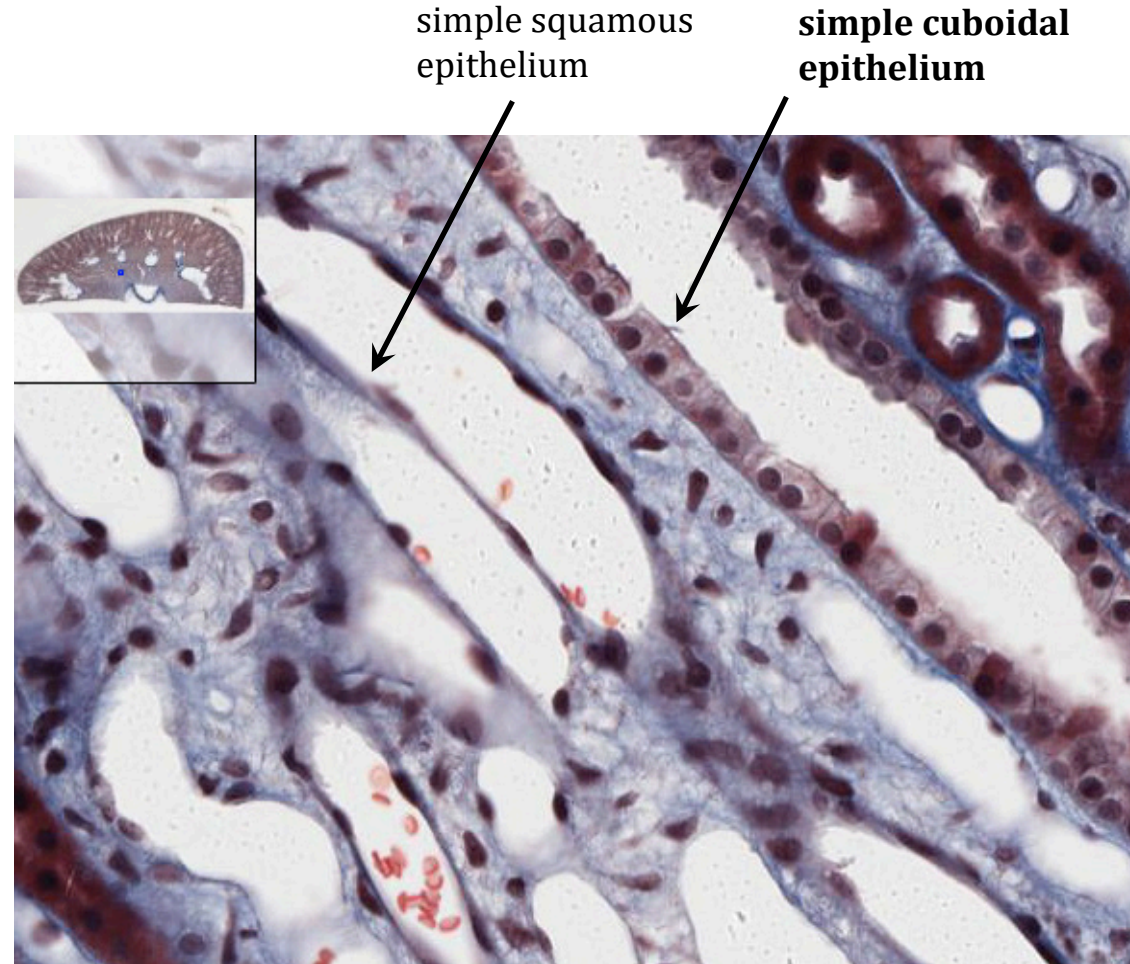
notice that the shape of the nucleus of the squamous epithelial cell is “squashed” (flat and elongated) as is the overall shape of the cell

Lab 4 – Epithelia and Glands

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- V. Summary

Slide 14: Kidney, Masson Trichrome



simple cuboidal epithelium lines small ducts as seen here

the nuclei of the cuboidal epithelial cells are round and generally located in the center of the cell

this is still a **simple epithelium** because all of the cells are directly attached to the basement membrane (thin blue line)

distinguishing the type of epithelium (and apical modifications) will be important later on when discussing the kidney in order to distinguish the different tubules (e.g., collecting duct vs. proximal convoluted tubule)

Lab 4 – Epithelia and Glands

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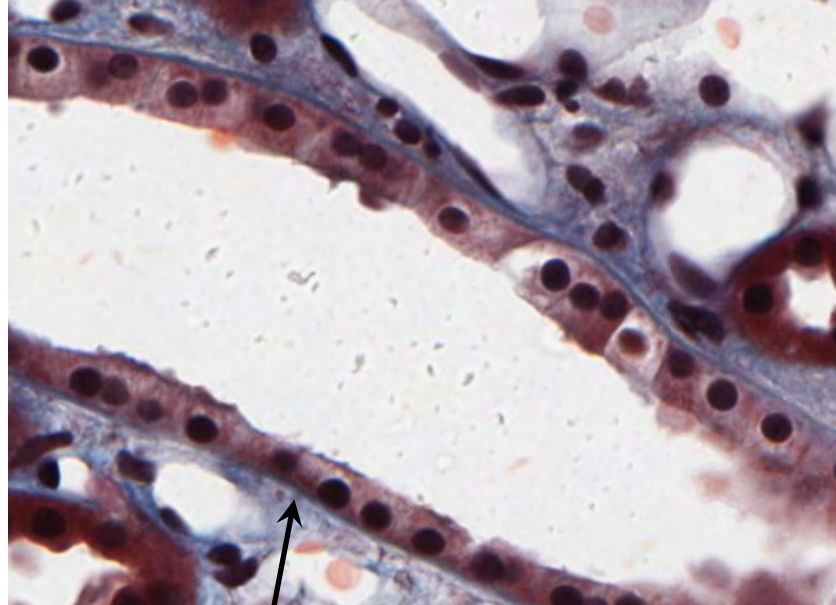
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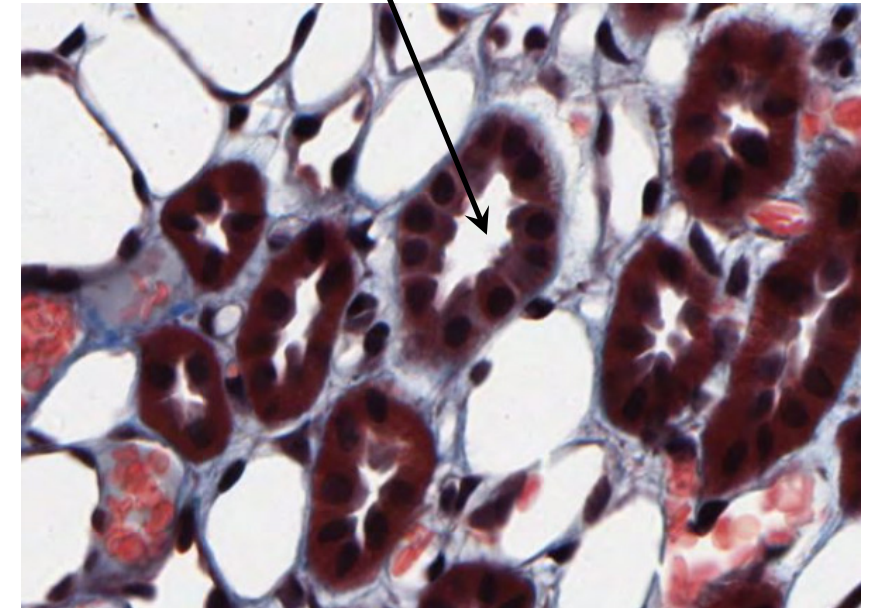
V. Summary

Slide 14: Kidney, Masson Trichrome



**simple cuboidal
epithelium**
(duct in longitudinal section)

**simple cuboidal
epithelium**
(duct in cross section)



Lab 4 - Epithelia and Glands

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B. Exocrine Glands

1. Simple (unbranched duct)

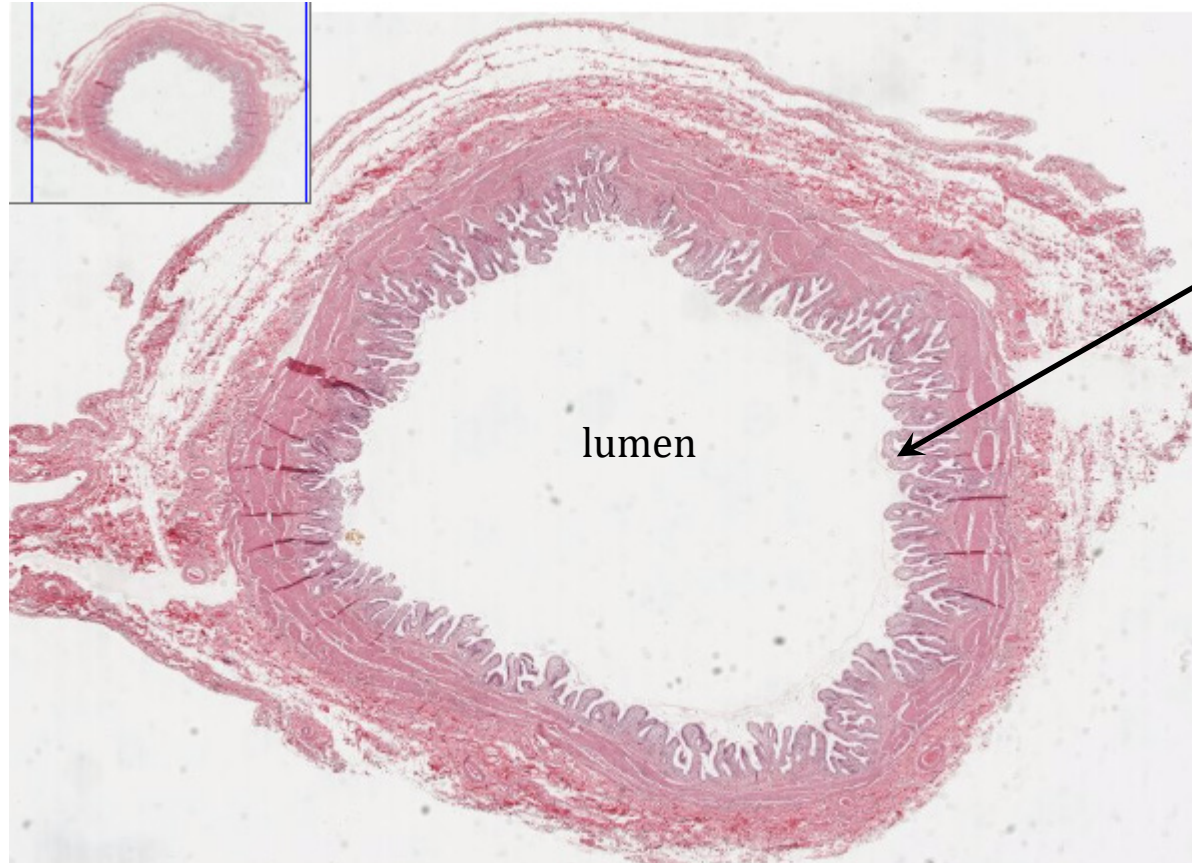
- a. Tubular
- b. Branched tubular
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- d. Branched acinar

2. Compound (branched ducts)

- a. Tubular
- b. Acinar
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V. Summary

Slide 105: Gallbladder, H&E



look at the tissue surrounding the lumen to find **simple columnar epithelium**

Lab 4 - Epithelia and Glands

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V. Summary

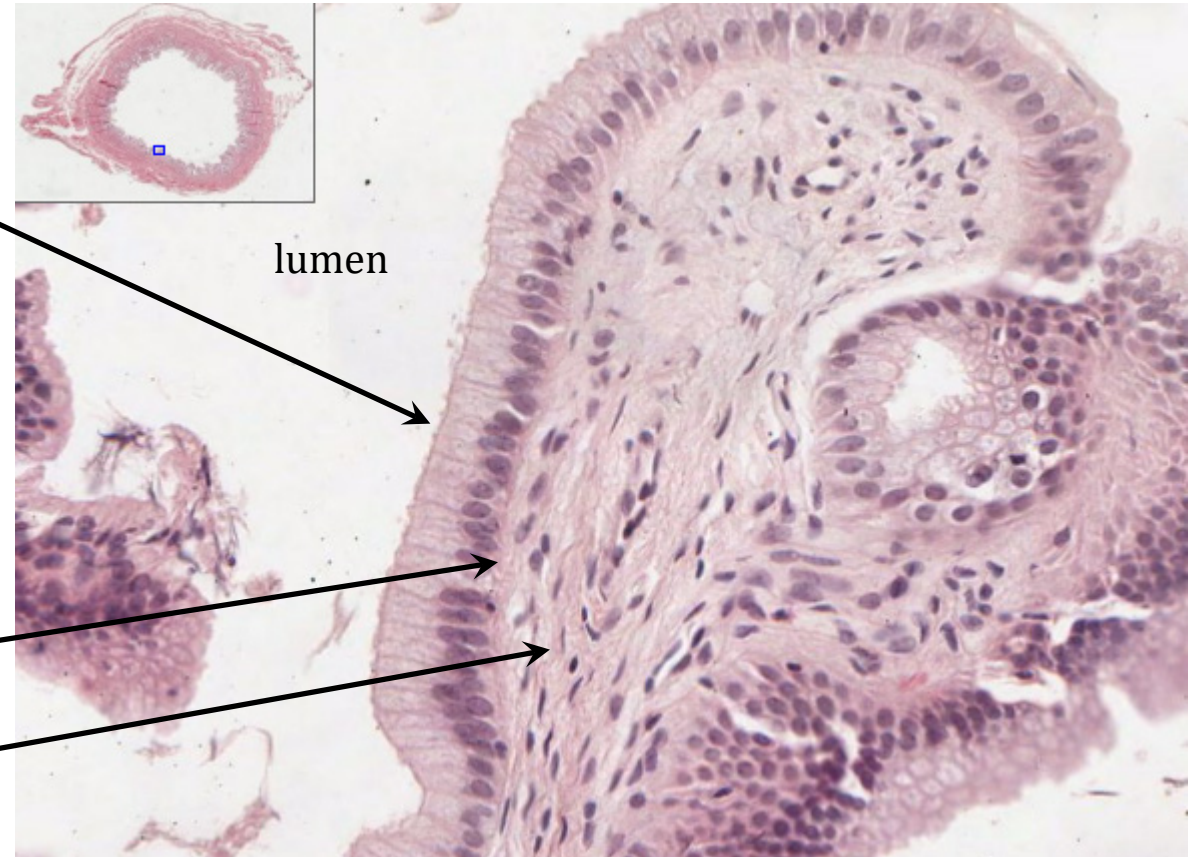
Slide 105: Gallbladder, H&E

the gallbladder
has very tall
**simple
columnar
epithelium**

notice the
column-shaped
nuclei located
toward the basal
aspect of the cells

*basement
membrane*

*underlying
connective tissue*



a mucosa (or mucous membrane), as seen here, is a layer of an organ composed of an epithelium and the underlying loose connective tissue

Lab 4 – Epithelia and Glands

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2. Compound (branched ducts)

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V. Summary

Slide 4: Duodenum, BF PAS



simple columnar epithelium

a **goblet cell** is a specialized type of epithelial gland cell; *why does it stain purple with PAS stain?*

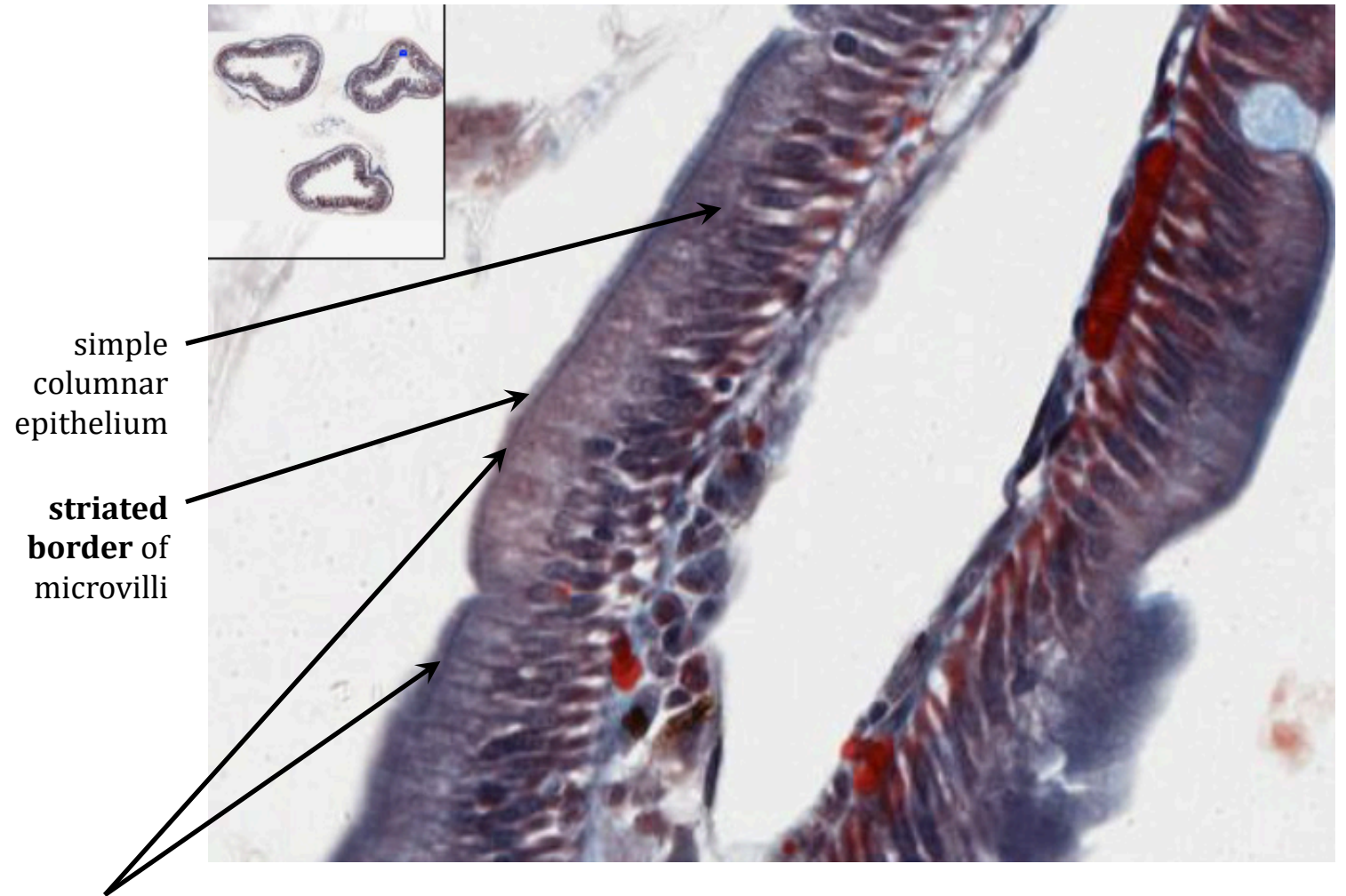
the purple/pink border is **glycocalyx** (glycolipids/glycoproteins) coating the **microvilli** on the apical surface of the epithelium, giving a **brush** or **striated border** appearance; notice that in light microscopy individual microvilli cannot be seen – they are only seen as a collective border – while individual cilia or stereocilia can be seen (none are seen here but will be seen later)

Lab 4 – Epithelia and Glands

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 - c. Tubulo-acinar
- V. Summary

Slide 21: Ileum, Masson Trichrome



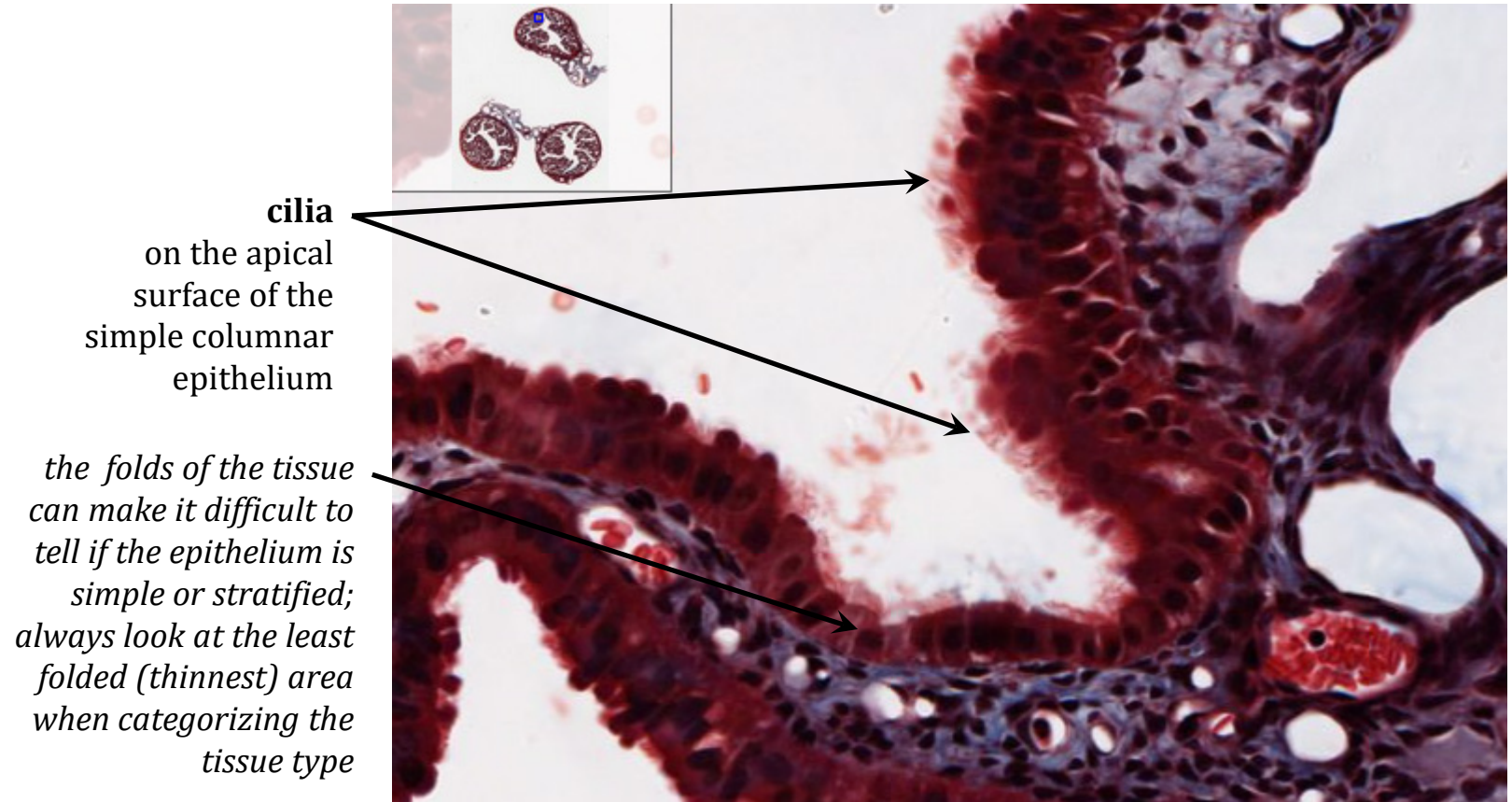
the **terminal web** (seen as a thin dark line) is composed of actin filaments running perpendicular and below the microvilli; it serves to connect and anchor the actin filaments of the cytoskeleton with those extending into the microvilli

Lab 4 – Epithelia and Glands

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- V. Summary

Slide 19: Oviduct, Masson Trichrome



cilia vs. microvilli: cilia are larger, cytoplasmic processes containing microtubules, while microvilli are short, cytoplasmic projections containing actin filaments; while it may be possible to distinguish individual cilia in light microscopy, this is not possible with microvilli

Lab 4 – Epithelia and Glands

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B. Exocrine Glands

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V. Summary

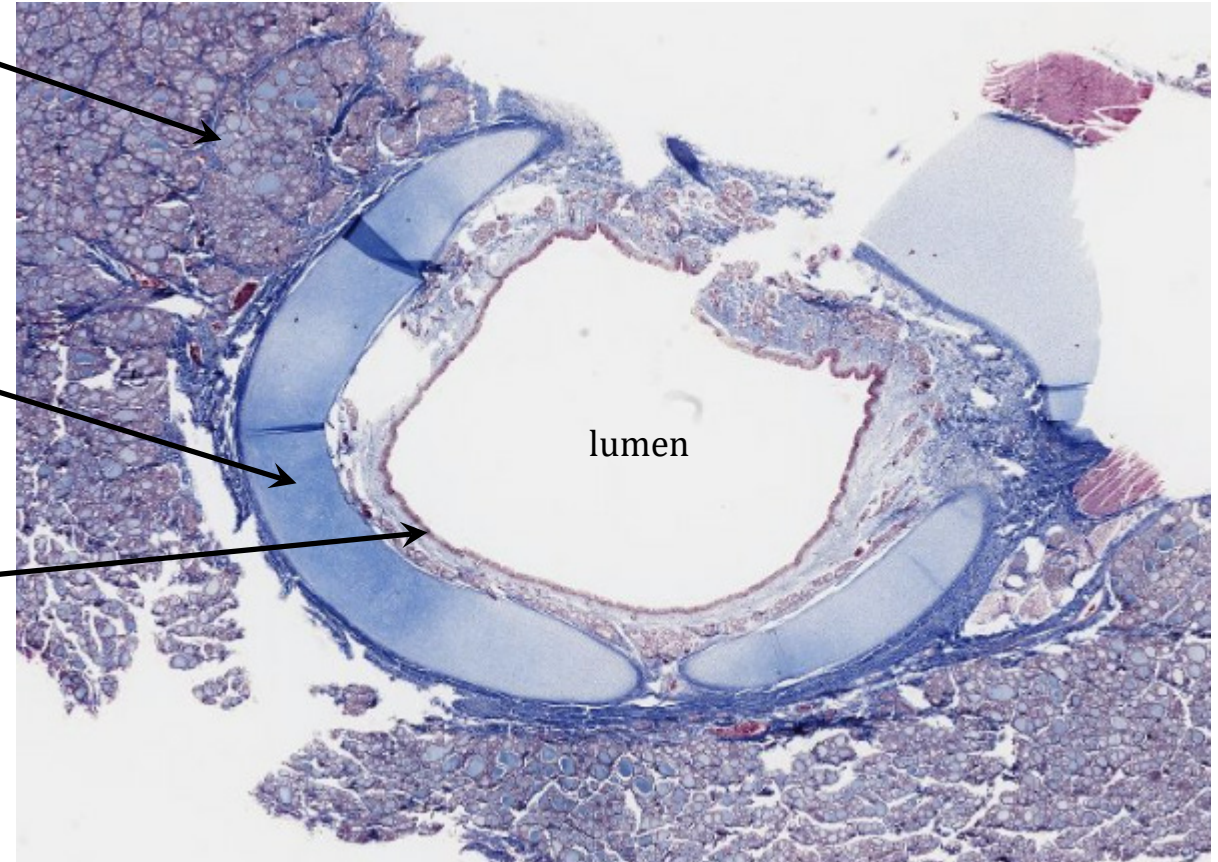
Slide 2: Trachea and Thyroid, Trichrome

Slide Overview

the *thyroid gland* is found adjacent to the trachea; it is easily identified by the presence of numerous colloid-filled *follicles* (at arrow tip)

tracheal rings of *hyaline cartilage*

lumen of the trachea is lined by **pseudostratified ciliated columnar epithelium (PCCE)**, sometimes referred to simply as **respiratory epithelium**



Lab 4 - Epithelia and Glands

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2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

V. Summary

Slide 140: Trachea, H&E



look at the tissue surrounding the lumen to find **pseudostratified ciliated columnar epithelium (PCCE)**

*how does this slide look different from the slide of the gallbladder (slide 105) seen earlier?
what differences can be used to distinguish the slide of the gallbladder vs. the trachea?*

Lab 4 – Epithelia and Glands

IUSM – 2016

I. Introduction

II. Learning Objectives

III. Keywords

IV. Slides

A. Epithelia

1. Simple

a. Simple squamous

b. Simple cuboidal

c. Simple columnar

d. **Pseudostratified columnar**

2. Stratified

a. Stratified squamous

b. Stratified cuboidal

c. Stratified columnar

d. Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

a. Tubular

b. Branched tubular

c. Coiled tubular

d. Branched acinar

2. Compound (branched ducts)

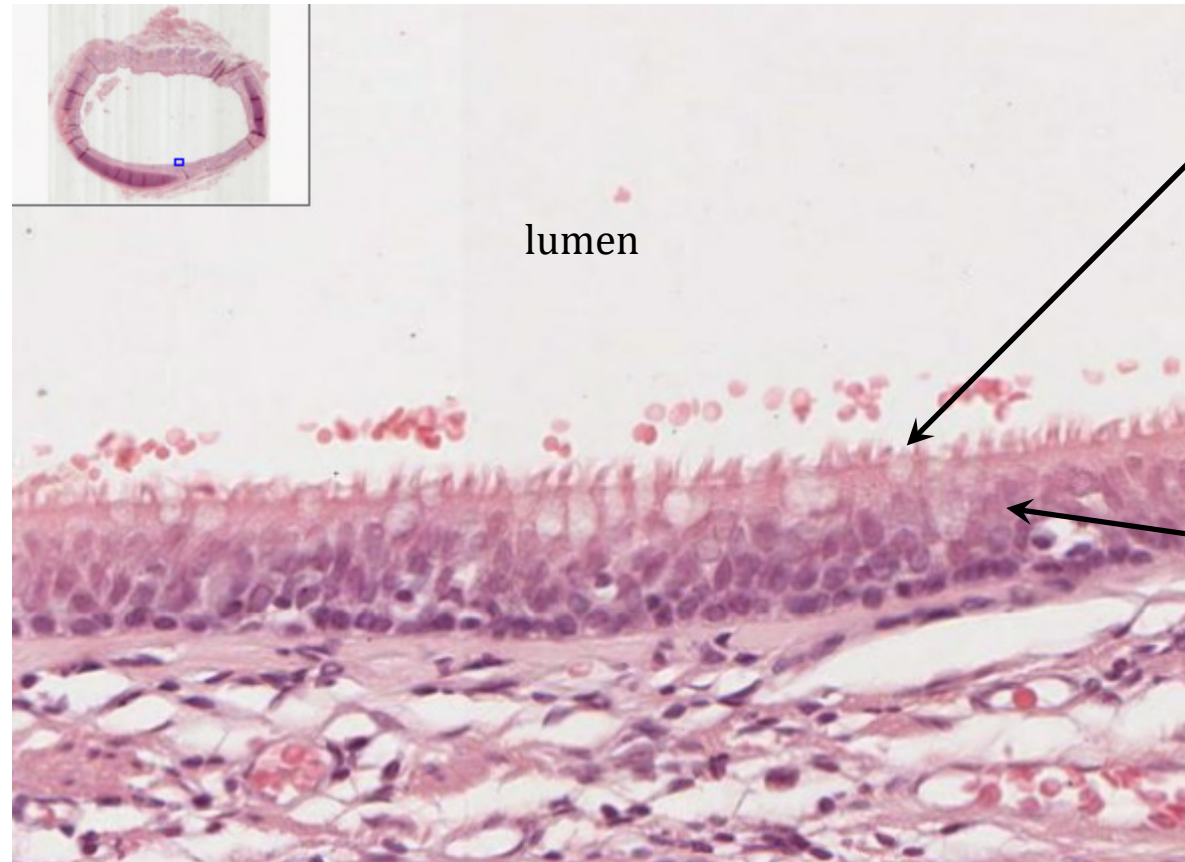
a. Tubular

b. Acinar

c. Tubulo-acinar

V. Summary

Slide 140: Trachea, H&E



cilia are the small hair-like projections into the lumen off the apical surface of the epithelium

pseudostratified ciliated columnar epithelium (PCCE)
also known as **respiratory epithelium**

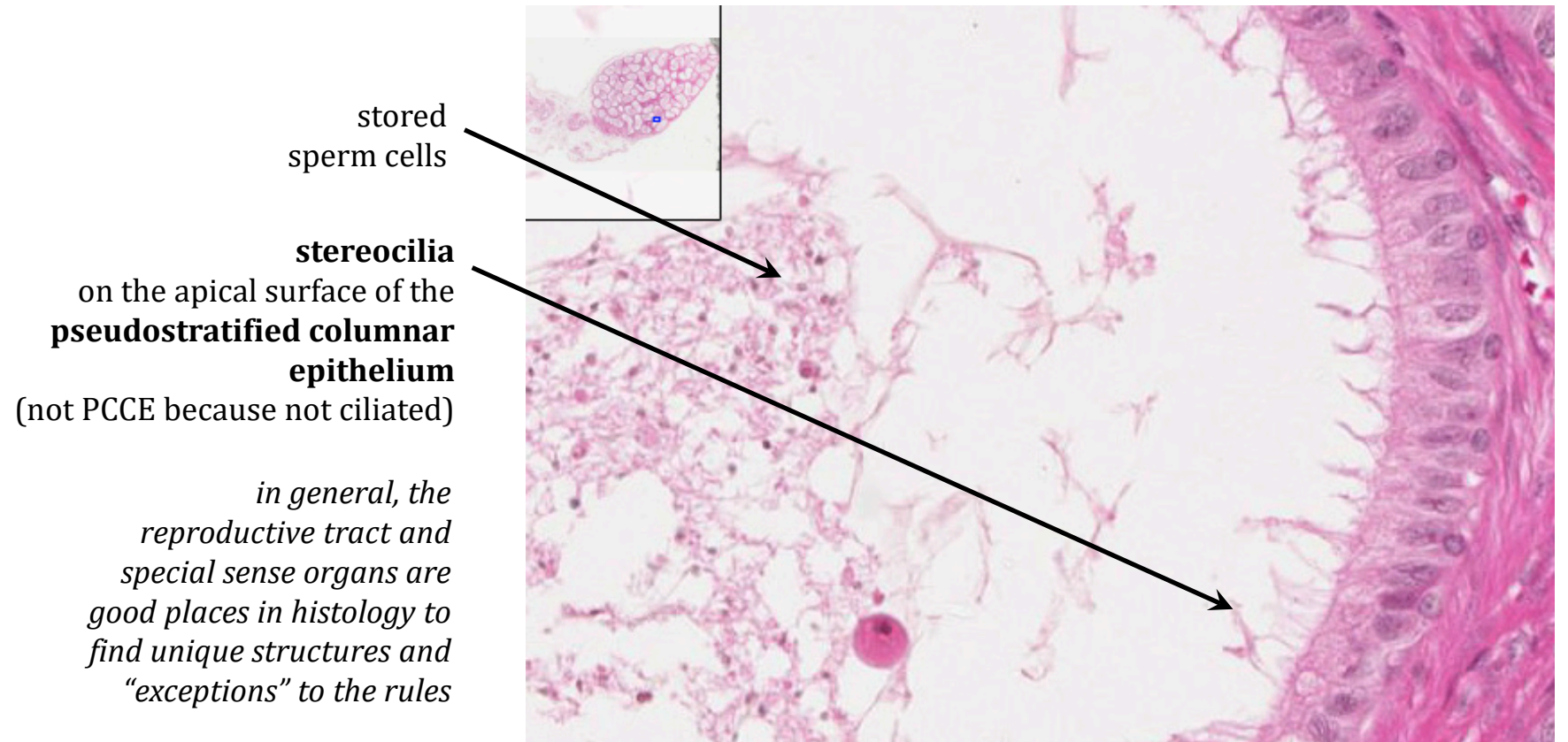
even though the **PCCE** appears to be stratified, it is a simple epithelium because all the cells are directly attached to the basement membrane (thin pink line); also note that the red blood cells seen in the tracheal lumen are an *artifact* – they are the result of the slide preparation when they leaked out of the blood vessels seen in the tissue below

Lab 4 - Epithelia and Glands

IUSM - 2016

- I. Introduction
- II. Learning Objectives
- III. Keywords
- IV. Slides
 - A. Epithelia
 1. Simple
 - a. Simple squamous
 - b. Simple cuboidal
 - c. Simple columnar
 - d. **Pseudostratified columnar**
 2. Stratified
 - a. Stratified squamous
 - b. Stratified cuboidal
 - c. Stratified columnar
 - d. Transitional
 - B. Exocrine Glands
 1. Simple (unbranched duct)
 - a. Tubular
 - b. Branched tubular
 - c. Coiled tubular
 - d. Branched acinar
 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. Summary

Slide 39: Epididymis, H&E



stored
sperm cells

stereocilia
on the apical surface of the
pseudostratified columnar
epithelium
(not PCCE because not ciliated)

*in general, the
reproductive tract and
special sense organs are
good places in histology to
find unique structures and
"exceptions" to the rules*

stereocilia vs. **cilia**: stereocilia are not actually cilia but a rare, unusually long, immotile type of microvilli (contain actin filaments) found only in the male reproductive tract (epididymis and ductus deferens) and the hair cells of the inner ear

Lab 4 - Epithelia and Glands

IUSM - 2016

I. Introduction

II. Learning Objectives

III. Keywords

IV. Slides

A. Epithelia

1. Simple

- a. Simple squamous
- b. Simple cuboidal
- c. Simple columnar
- d. Pseudostratified columnar

2. Stratified

- a. **Stratified squamous**
- b. Stratified cuboidal
- c. Stratified columnar
- d. Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

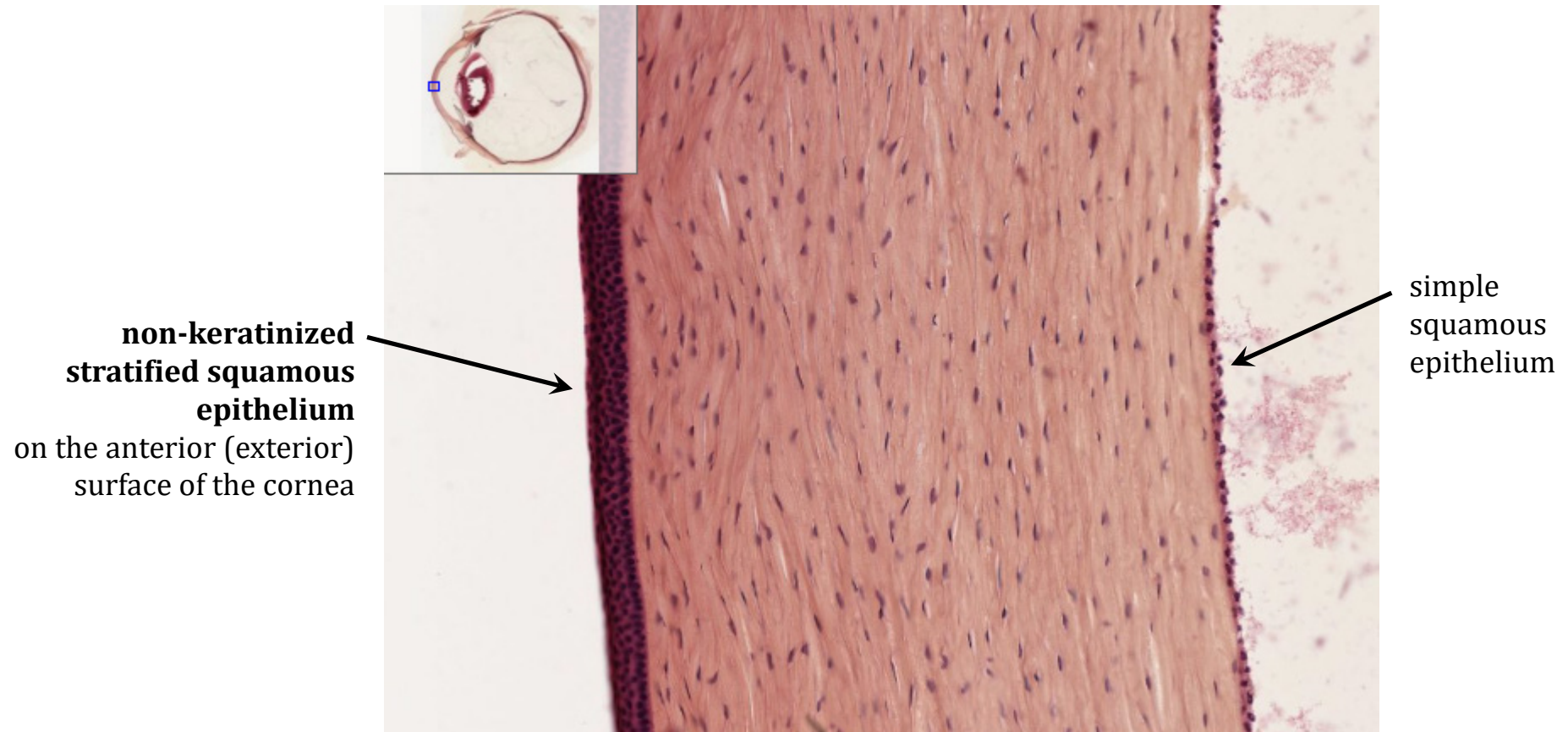
- a. Tubular
- b. Branched tubular
- c. Coiled tubular
- d. Branched acinar

2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

V. Summary

Slide 120: Eye, H&E

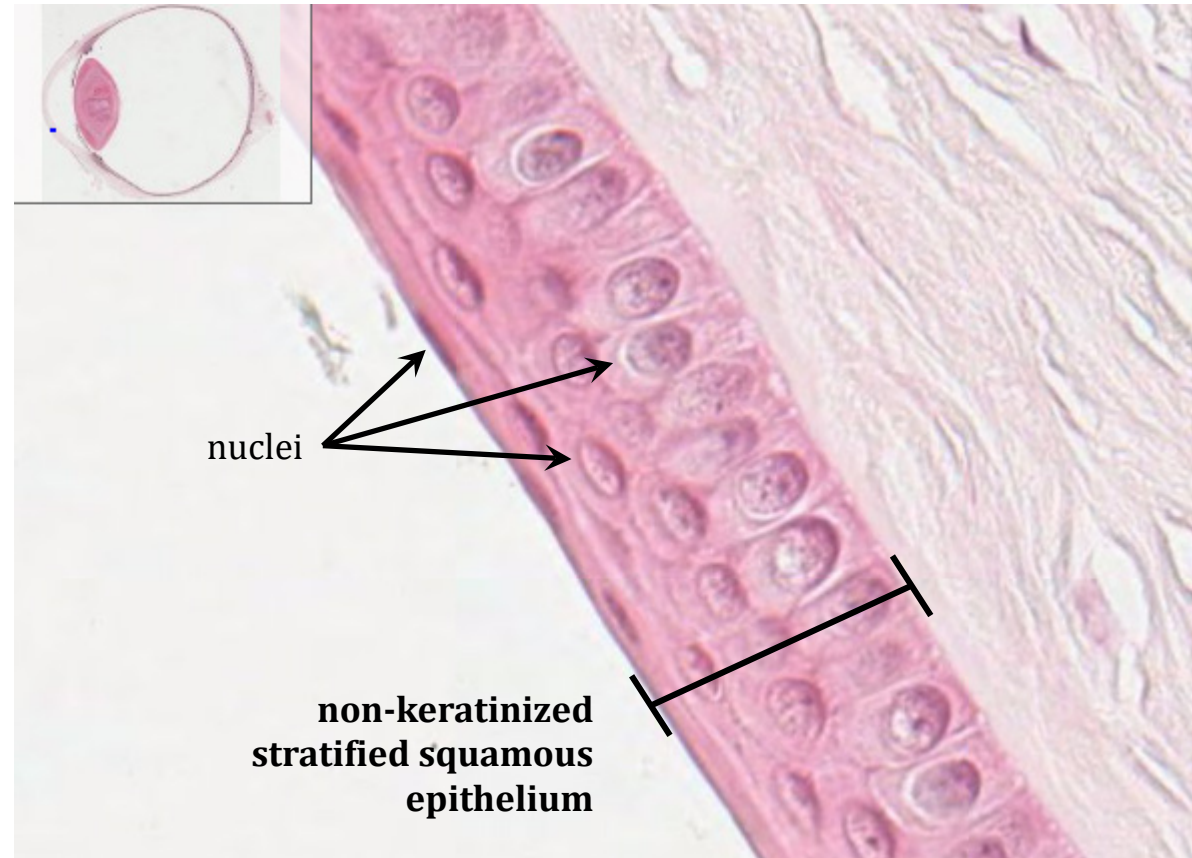


Lab 4 – Epithelia and Glands

IUSM – 2016

- I. Introduction
- II. Learning Objectives
- III. Keywords
- IV. Slides
 - A. Epithelia
 1. Simple
 - a. Simple squamous
 - b. Simple cuboidal
 - c. Simple columnar
 - d. Pseudostratified columnar
 2. Stratified
 - a. **Stratified squamous**
 - b. Stratified cuboidal
 - c. Stratified columnar
 - d. Transitional
 - B. Exocrine Glands
 1. Simple (unbranched duct)
 - a. Tubular
 - b. Branched tubular
 - c. Coiled tubular
 - d. Branched acinar
 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. Summary

Slide 78: Eye, H&E



clearly this epithelium is stratified, but should it be classified as stratified cuboidal or stratified squamous?

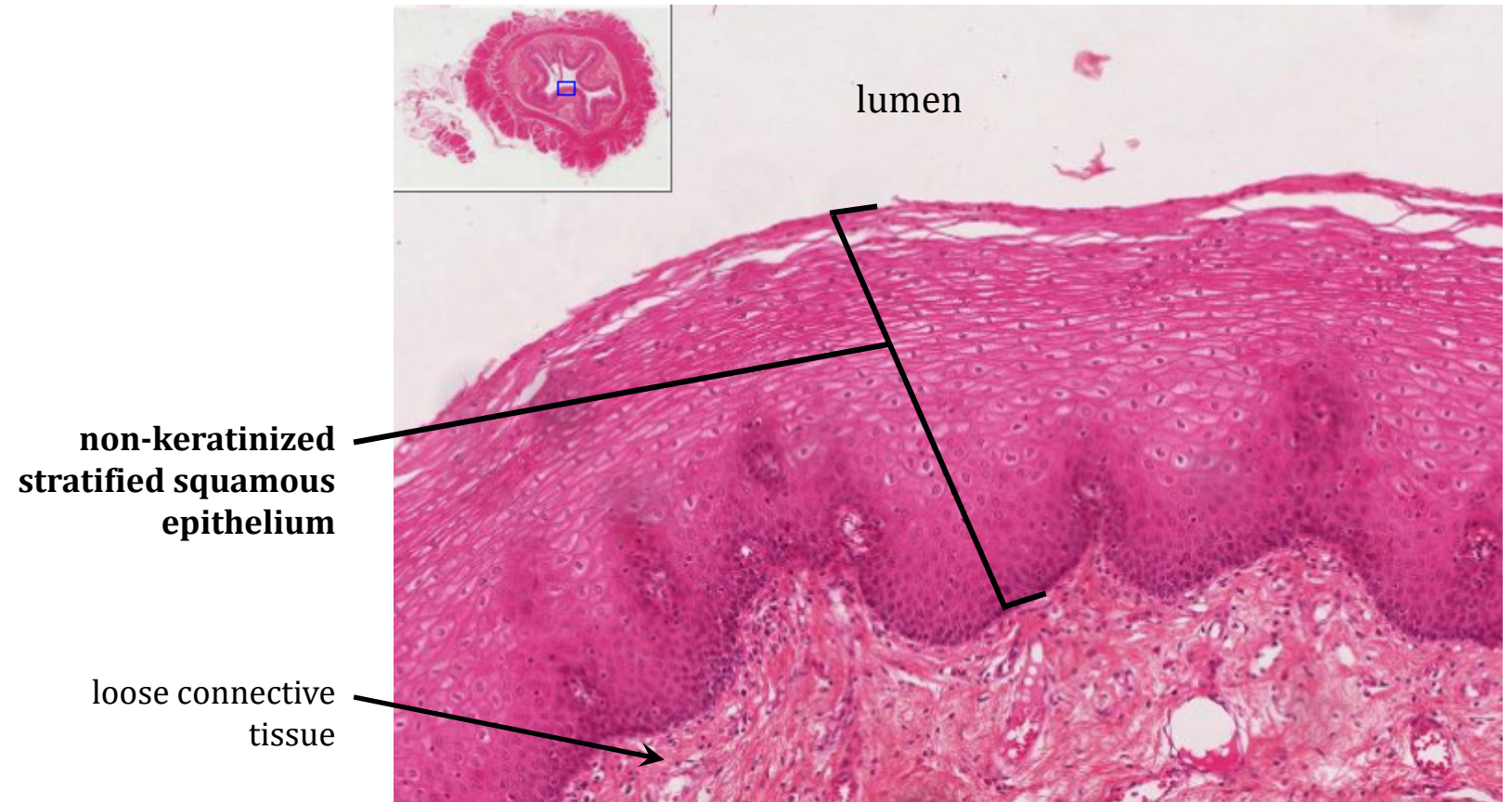
the convention is to classify epithelium based upon the appearance of the apical layers of cells, not the basal – so while the basal cells of this epithelium are cuboidal in shape, it is classified as squamous because of the very flat (“squashed”) apical layers; also note that true stratified cuboidal epithelium is very rarely ever more than two layers thick and this epithelium is at least four cell layers thick

Lab 4 - Epithelia and Glands

IUSM - 2016

- I. Introduction
- II. Learning Objectives
- III. Keywords
- IV. Slides
 - A. Epithelia
 1. Simple
 - a. Simple squamous
 - b. Simple cuboidal
 - c. Simple columnar
 - d. Pseudostratified columnar
 2. Stratified
 - a. **Stratified squamous**
 - b. Stratified cuboidal
 - c. Stratified columnar
 - d. Transitional
 - B. Exocrine Glands
 1. Simple (unbranched duct)
 - a. Tubular
 - b. Branched tubular
 - c. Coiled tubular
 - d. Branched acinar
 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. Summary

Slide 43: Esophagus, H&E



notice that nuclei can be seen in all the strata of the epithelium from the basement membrane all the way to the apical surface at the lumen; as nuclei are still present in the apical cells, they cannot be keratinized, therefore this is a **non-keratinized** stratified squamous epithelium

Lab 4 – Epithelia and Glands

IUSM – 2016

I. Introduction

II. Learning Objectives

III. Keywords

IV. Slides

A. Epithelia

1. Simple

- a. Simple squamous
- b. Simple cuboidal
- c. Simple columnar
- d. Pseudostratified columnar

2. Stratified

- a. **Stratified squamous**
- b. Stratified cuboidal
- c. Stratified columnar
- d. Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

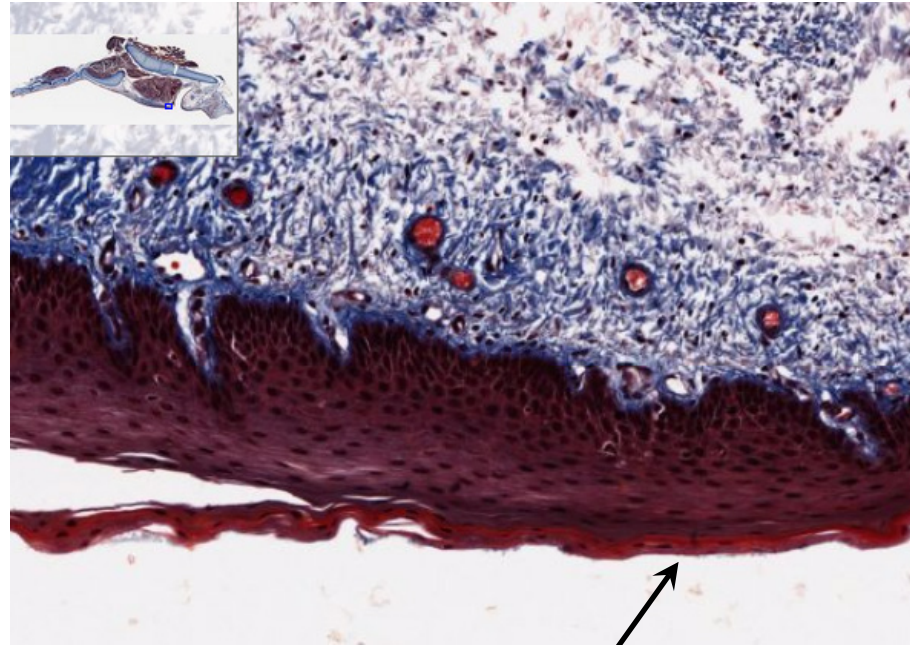
- a. Tubular
- b. Branched tubular
- c. Coiled tubular
- d. Branched acinar

2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

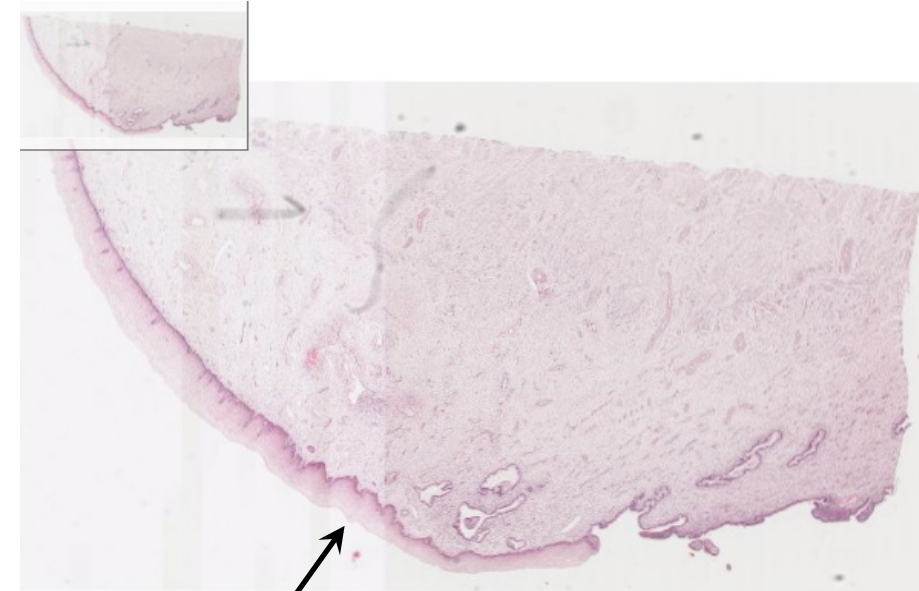
V. Summary

Slide 7: Larynx, Trichrome



look within the larynx to find the *vocal cords/folds* which are composed of **non-keratinized stratified squamous epithelium**

Slide 133: Uterine Cervix, H&E



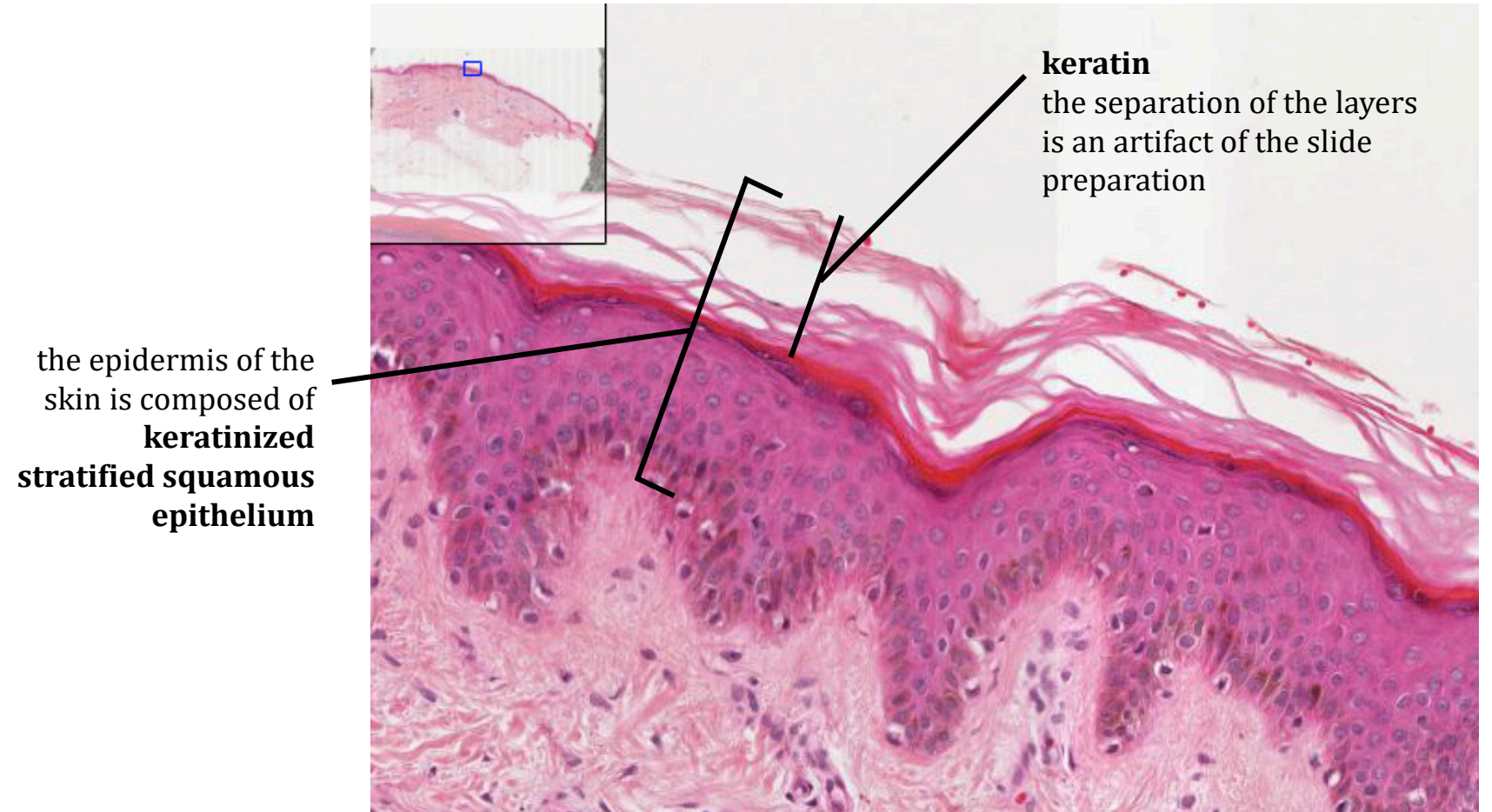
look at the cervix (opening to uterus) and vaginal wall to see additional examples of **non-keratinized stratified squamous epithelium**

Lab 4 - Epithelia and Glands

IUSM - 2016

- I. Introduction
- II. Learning Objectives
- III. Keywords
- IV. Slides
 - A. Epithelia
 1. Simple
 - a. Simple squamous
 - b. Simple cuboidal
 - c. Simple columnar
 - d. Pseudostratified columnar
 2. Stratified
 - a. **Stratified squamous**
 - b. Stratified cuboidal
 - c. Stratified columnar
 - d. Transitional
 - B. Exocrine Glands
 1. Simple (unbranched duct)
 - a. Tubular
 - b. Branched tubular
 - c. Coiled tubular
 - d. Branched acinar
 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. Summary

Slide 36: Thin Skin, H&E



notice that nuclei cannot be seen in the apical layers of the tissue; the organelles of these cells have been replaced by large amounts of keratin proteins, thus this is a **keratinized** stratified squamous epithelium

Lab 4 – Epithelia and Glands

IUSM – 2016

- I. Introduction
- II. Learning Objectives
- III. Keywords
- IV. Slides

A. Epithelia

1. Simple

- a. Simple squamous
- b. Simple cuboidal
- c. Simple columnar
- d. Pseudostratified columnar

2. Stratified

- a. Stratified squamous
- b. **Stratified cuboidal**
- c. Stratified columnar
- d. Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

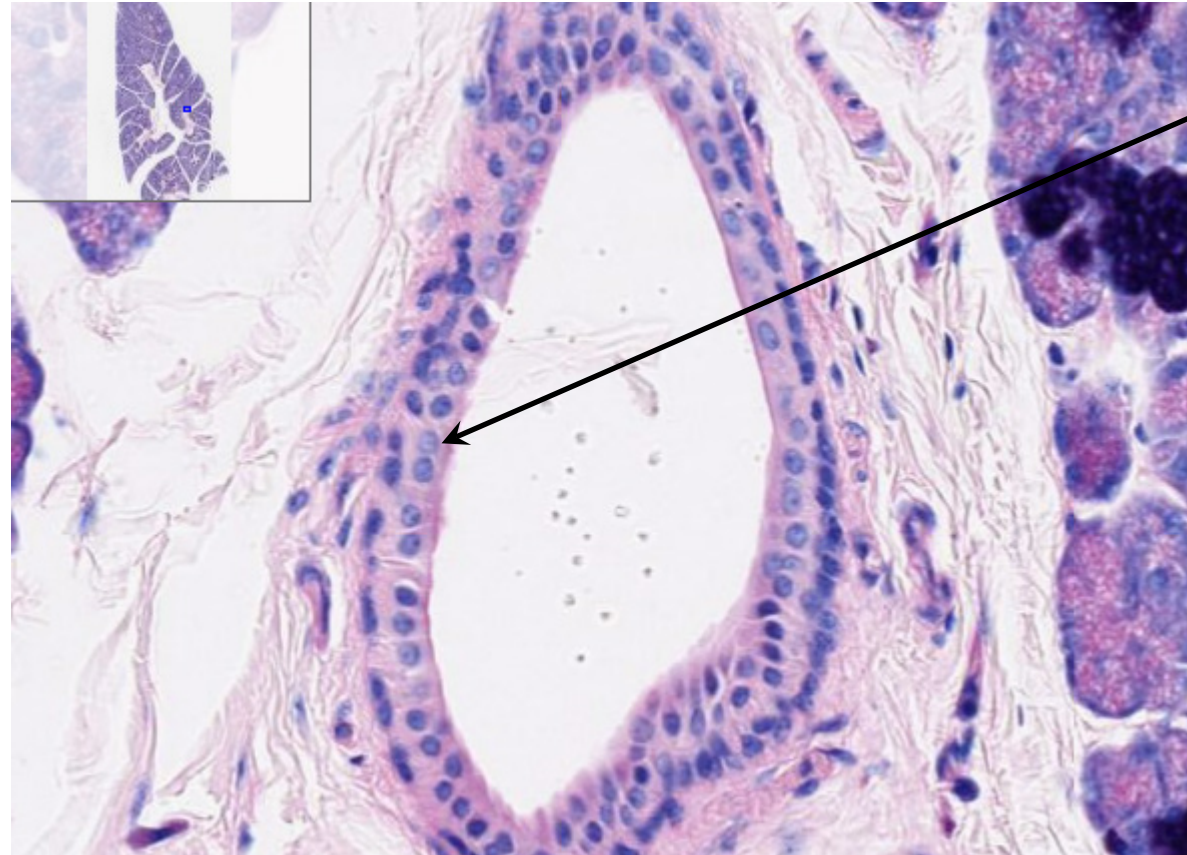
- a. Tubular
- b. Branched tubular
- c. Coiled tubular
- d. Branched acinar

2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

V. Summary

Slide 11: Submandibular Gland, PAS & AB



stratified cuboidal epithelium

stratified epithelium are named after the shape of the most apical cell layer, so these are stratified cuboidal even though the more basal cells may appear squamous

stratified cuboidal epithelia are generally only found in the ducts of sweat glands and in large ducts of exocrine glands, such as the submandibular salivary gland seen here; stratified cuboidal (and stratified columnar, which is even more rare) are usually never more than two cell layers thick and usually lack any apical modifications

Lab 4 – Epithelia and Glands

IUSM – 2016

I. Introduction

II. Learning Objectives

III. Keywords

IV. Slides

A. Epithelia

1. Simple

- a. Simple squamous
- b. Simple cuboidal
- c. Simple columnar
- d. Pseudostratified columnar

2. Stratified

- a. Stratified squamous
- b. Stratified cuboidal
- c. **Stratified columnar**
- d. Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

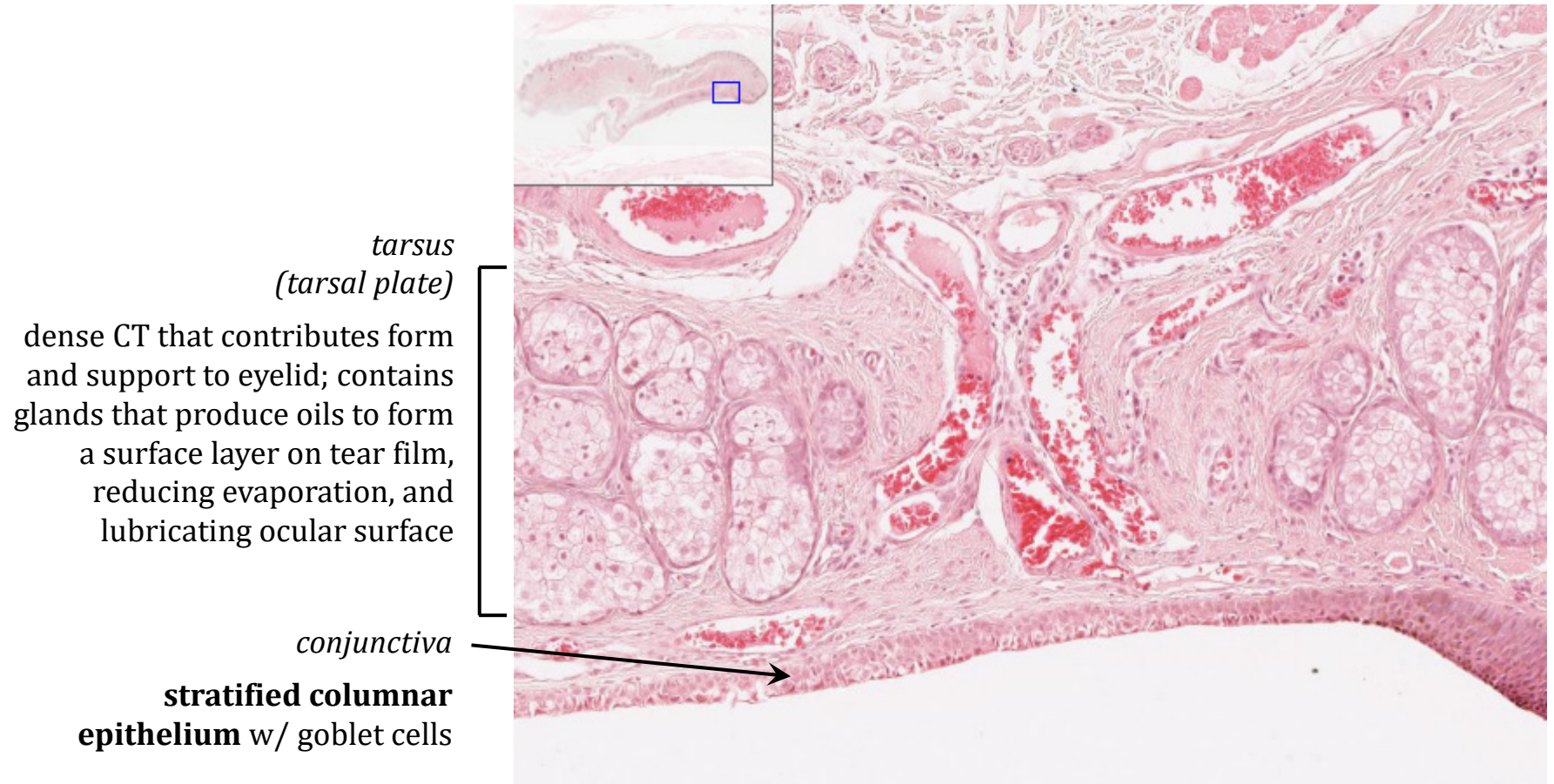
- a. Tubular
- b. Branched tubular
- c. Coiled tubular
- d. Branched acinar

2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

V. Summary

Slide 138: Eyelid, H&E



stratified columnar epithelia are very rare and generally only found in very large ducts of exocrine glands or within the reproductive tract; additionally, it can be found composing the *conjunctiva* which is a mucous membrane that lines the inside of the eyelid and the anterior portion of the sclera (white part) of the eye; because stratified columnar epithelium is so rare, if trying to identify an epithelium, it is much more likely to be pseudostratified columnar than true stratified columnar (especially if apical modifications are present)

Lab 4 - Epithelia and Glands

IUSM - 2016

- I. Introduction
- II. Learning Objectives
- III. Keywords
- IV. Slides

A. Epithelia

1. Simple

- a. Simple squamous
- b. Simple cuboidal
- c. Simple columnar
- d. Pseudostratified columnar

2. Stratified

- a. Stratified squamous
- b. Stratified cuboidal
- c. Stratified columnar
- d. **Transitional**

B. Exocrine Glands

1. Simple (unbranched duct)

- a. Tubular
- b. Branched tubular
- c. Coiled tubular
- d. Branched acinar

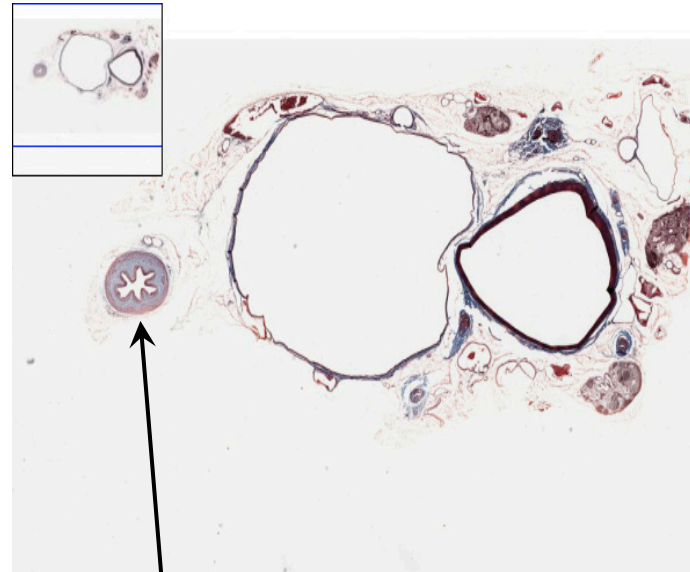
2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

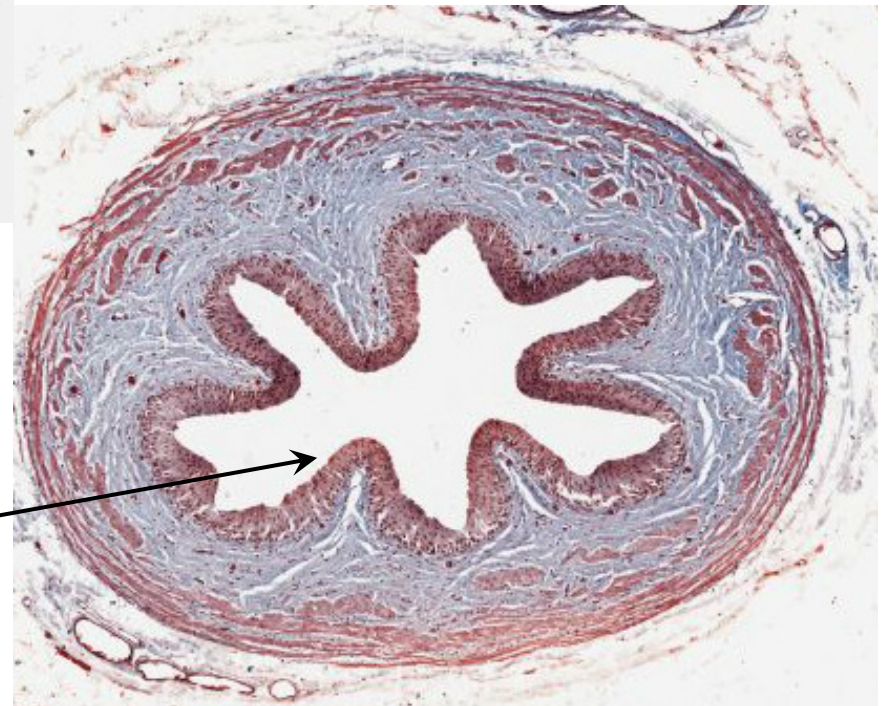
V. Summary

Slide 16: Aorta, Vena Cava, Ureter

Slide Overview



look here for the *ureter*, which carries urine from the kidney to the urinary bladder



transitional epithelium lines the lumen of all urinary organs, so it is sometimes referred to simply as **urinary epithelium**

Lab 4 – Epithelia and Glands

IUSM – 2016

I. Introduction

II. Learning Objectives

III. Keywords

IV. Slides

A. Epithelia

1. Simple

- Simple squamous
- Simple cuboidal
- Simple columnar
- Pseudostratified columnar

2. Stratified

- Stratified squamous
- Stratified cuboidal
- Stratified columnar
- Transitional**

B. Exocrine Glands

1. Simple (unbranched duct)

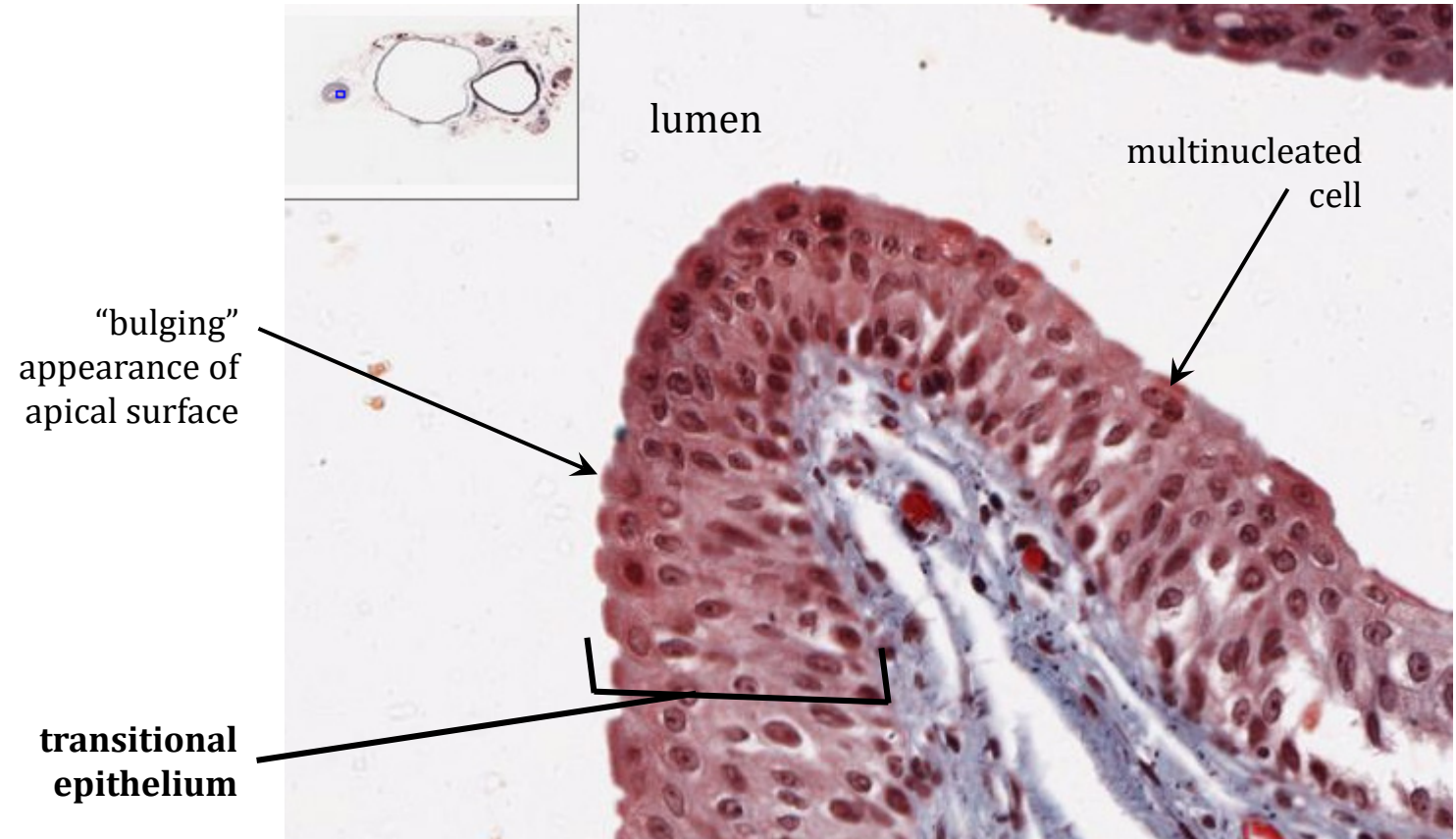
- Tubular
- Branched tubular
- Coiled tubular
- Branched acinar

2. Compound (branched ducts)

- Tubular
- Acinar
- Tubulo-acinar

V. Summary

Slide 16: Aorta, Vena Cava, Ureter



transitional epithelium (or **urinary epithelium**) is found only within the organs of the urinary system, and its appearance changes as it stretches and flattens out; the apical cells are sometimes referred to as *umbrella cells* and may be multinucleated, and when not stretched, have a characteristic “bulging” or “pear-shaped” protrusion into the lumen; individual strata are difficult to clearly define, but there are generally 6-8 cell layers (much more than seen in stratified cuboidal or columnar)

Lab 4 - Epithelia and Glands

IUSM - 2016

I. Introduction

II. Learning Objectives

III. Keywords

IV. Slides

A. Epithelia

1. Simple

- a. Simple squamous
- b. Simple cuboidal
- c. Simple columnar
- d. Pseudostratified columnar

2. Stratified

- a. Stratified squamous
- b. Stratified cuboidal
- c. Stratified columnar
- d. **Transitional**

B. Exocrine Glands

1. Simple (unbranched duct)

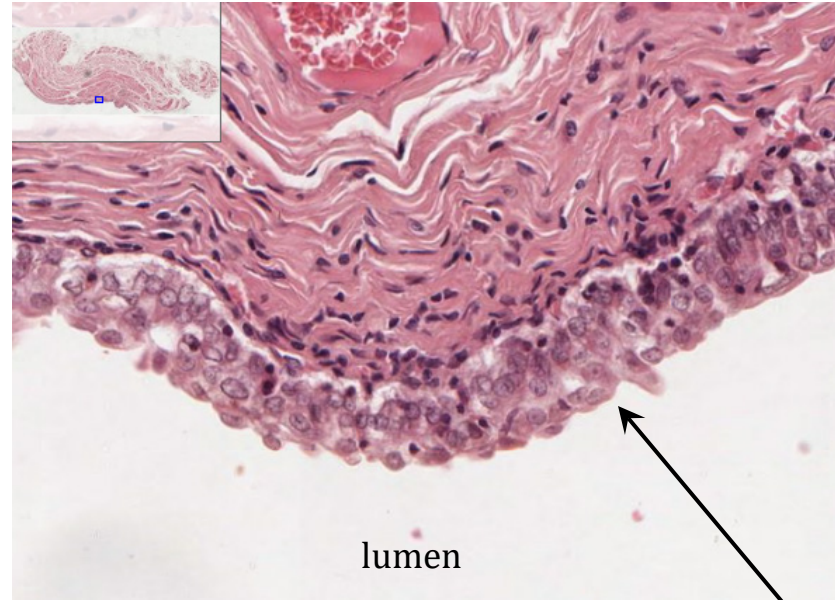
- a. Tubular
- b. Branched tubular
- c. Coiled tubular
- d. Branched acinar

2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

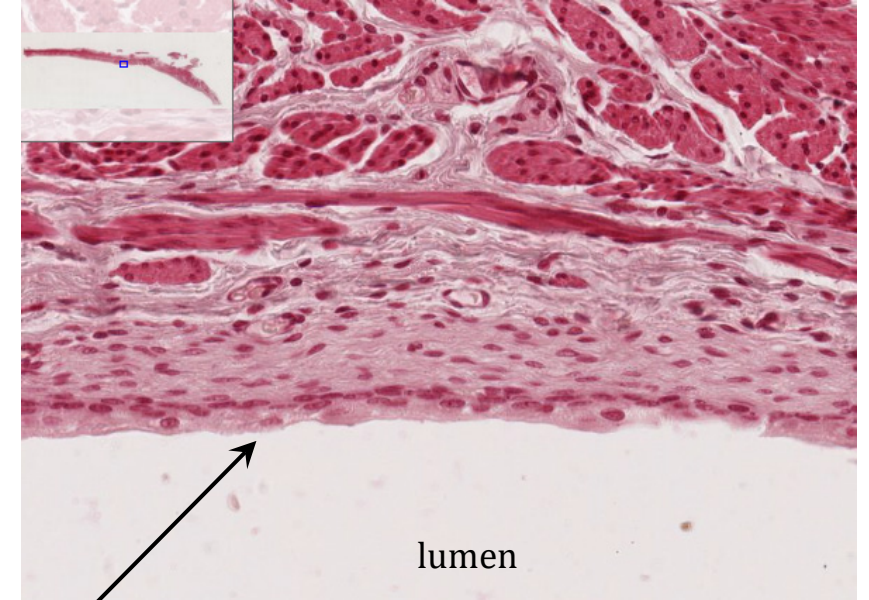
V. Summary

Slide 118: Bladder, H&E



non-distended (empty) bladder

Slide 70 (464): Bladder, H&E



distended (full) bladder

**transitional
epithelium**

notice the change in the appearance of the epithelium as the bladder goes from being empty to being full; *why is the ability of this epithelium to stretch and rebound so important?*

Lab 4 – Epithelia and Glands

IUSM – 2016

- I. Introduction
- II. Learning Objectives
- III. Keywords
- IV. Slides
 - A. Epithelia
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 - a. Simple squamous
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 - c. Simple columnar
 - d. Pseudostratified columnar
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 - a. Stratified squamous
 - b. Stratified cuboidal
 - c. Stratified columnar
 - d. Transitional
 - B. **Exocrine Glands**
 1. Simple (unbranched duct)
 - a. Tubular
 - b. Branched tubular
 - c. Coiled tubular
 - d. Branched acinar
 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. Summary

Classifying Exocrine Glands

1. There are three principal ways of classifying exocrine glands: (1) based upon the nature of their secretory product (e.g., **mucous** and **serous**); (2) based upon their mode of secretion (e.g., **merocrine**, **apocrine**, and **holocrine**); or (3) based upon their morphology.
2. When categorizing glands based upon morphology, glands are described both by the shapes of their duct portions (parts of the gland which are non-secretory) and their secretory portions:
 - a. Ducts, which are non-secretory epithelial cells that conduct the secretory product onto the epithelial surface, may be unbranched (**simple**) or branched (**compound**).
 - b. Secretory portions, which are the epithelial cells responsible for the production of the glandular product (e.g., saliva, digestive enzymes, etc.), can be arranged in either **tubular** or rounded (**acinar**) configurations.
 - c. Additionally, the secretory portions can be themselves be **branched** or **coiled** in shape.
3. Several configurations of glands are rarely seen; for instance, **simple, acinar glands** are seen during development of urethral glands but are otherwise generally not seen.

Lab 4 – Epithelia and Glands

IUSM – 2016

- I. Introduction
- II. Learning Objectives
- III. Keywords
- IV. Slides

A. Epithelia

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- b. Simple cuboidal
- c. Simple columnar
- d. Pseudostratified columnar

2. Stratified

- a. Stratified squamous
- b. Stratified cuboidal
- c. Stratified columnar
- d. Transitional

B. Exocrine Glands

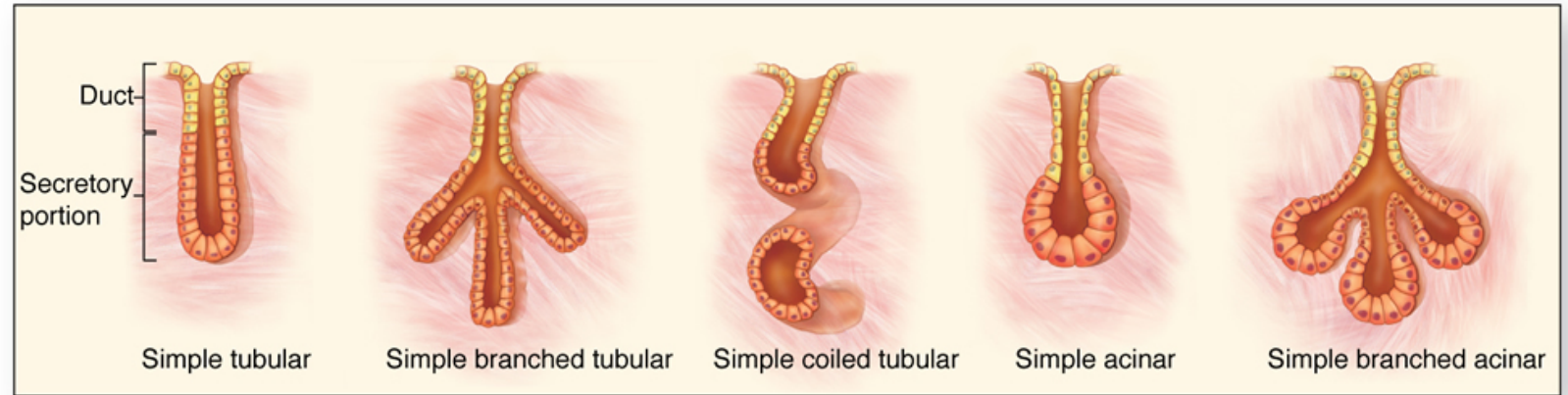
1. Simple (unbranched duct)

- a. Tubular
- b. Branched tubular
- c. Coiled tubular
- d. Branched acinar

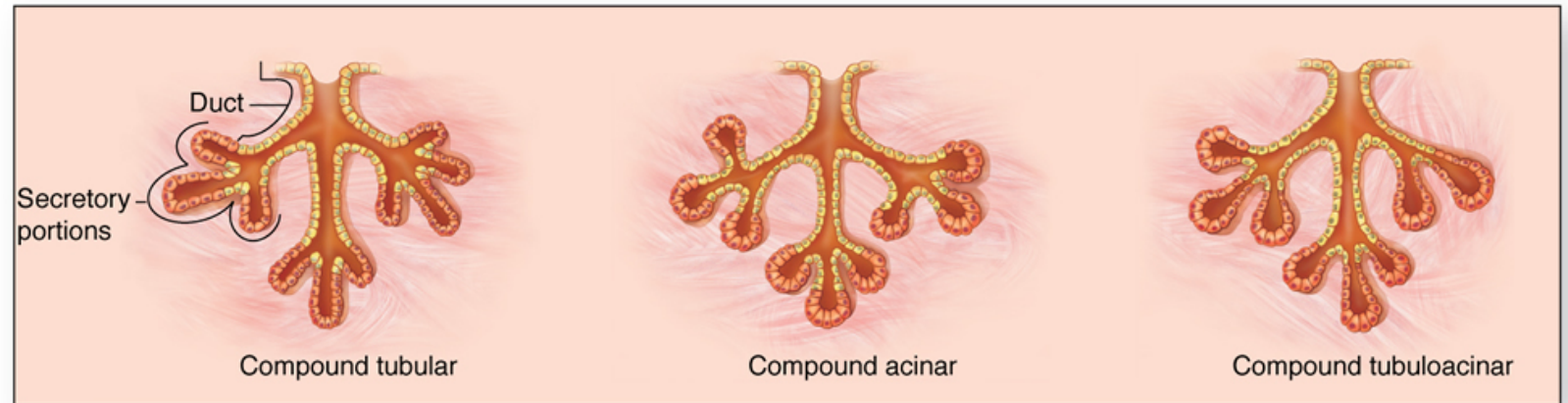
2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

V. Summary



a Simple glands



b Compound glands

Junqueira, 13th ed.

Lab 4 – Epithelia and Glands

IUSM – 2016

I. Introduction

II. Learning Objectives

III. Keywords

IV. Slides

A. Epithelia

1. Simple

- Simple squamous
- Simple cuboidal
- Simple columnar
- Pseudostratified columnar

2. Stratified

- Stratified squamous
- Stratified cuboidal
- Stratified columnar
- Transitional

B. Exocrine Glands

1. **Simple (unbranched duct)**

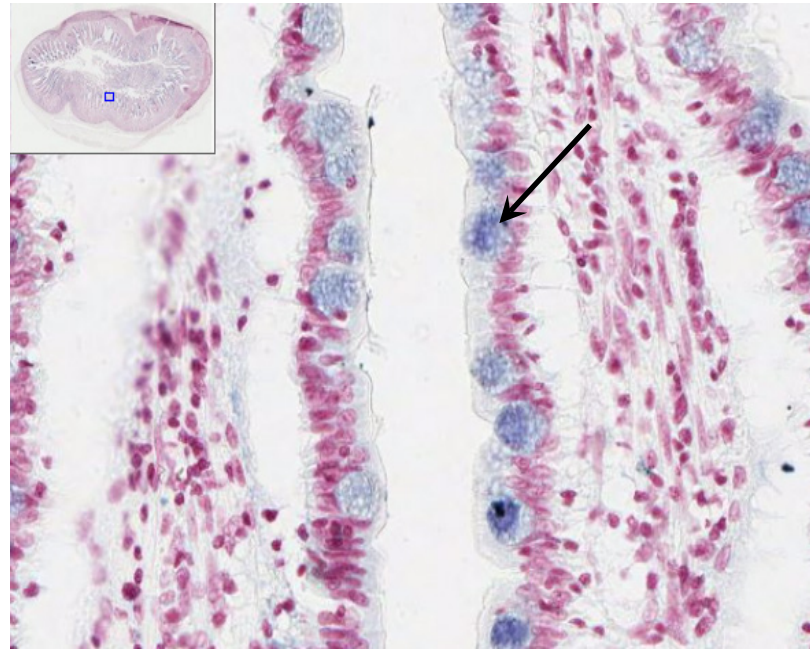
- Tubular
- Branched tubular
- Coiled tubular
- Branched acinar

2. Compound (branched ducts)

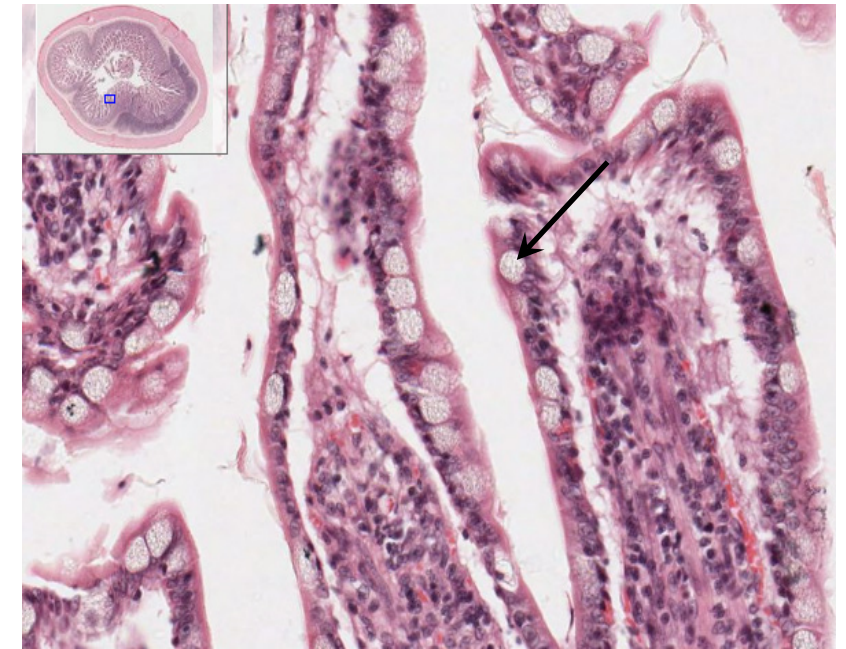
- Tubular
- Acinar
- Tubulo-acinar

V. Summary

Slide 26: Ileum, PAS



Slide 27: Ileum, H&E



goblet cells are the simplest type of exocrine gland; they are unicellular glands consisting of only a single, specialized epithelial cell (epithelial cells are the major component of all the glands of the body) and are found interspersed amongst other epithelial cells, such as the simple columnar cells seen above in the ileum; they secrete *mucins* (glycosylated proteins), the main components of mucus

the apical portion of the cell fills with the secretory product, displacing the cytoplasmic organelles to the basal region of the cell, giving the cell the general appearance of a goblet/chalice

what accounts for the difference in staining between the goblet cells seen above in PAS staining and in H&E?

Lab 4 - Epithelia and Glands

IUSM - 2016

- I. Introduction
- II. Learning Objectives
- III. Keywords
- IV. Slides

A. Epithelia

1. Simple

- a. Simple squamous
- b. Simple cuboidal
- c. Simple columnar
- d. Pseudostratified columnar

2. Stratified

- a. Stratified squamous
- b. Stratified cuboidal
- c. Stratified columnar
- d. Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

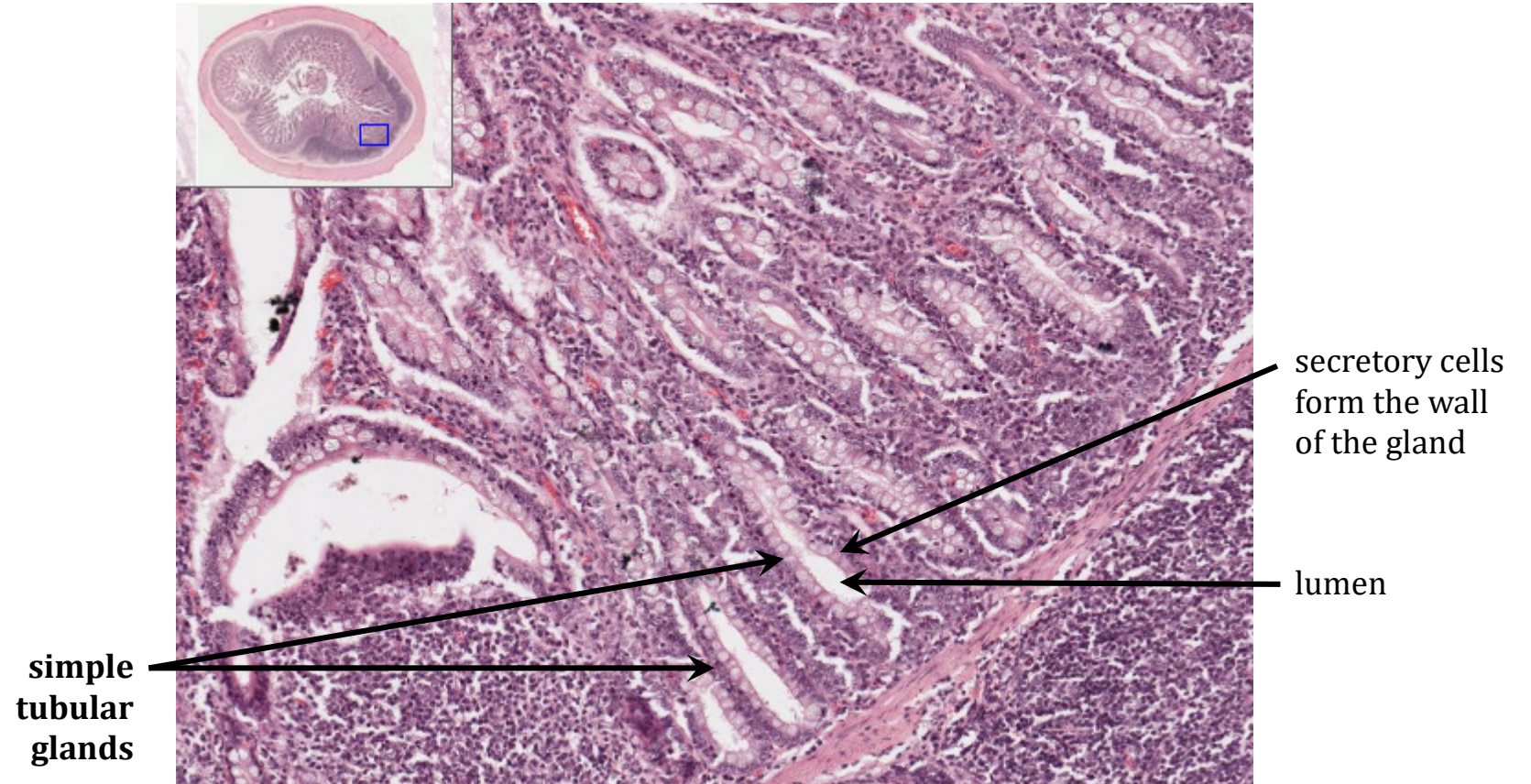
- a. **Tubular**
- b. Branched tubular
- c. Coiled tubular
- d. Branched acinar

2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

V. Summary

Slide 27: Ileum, H&E



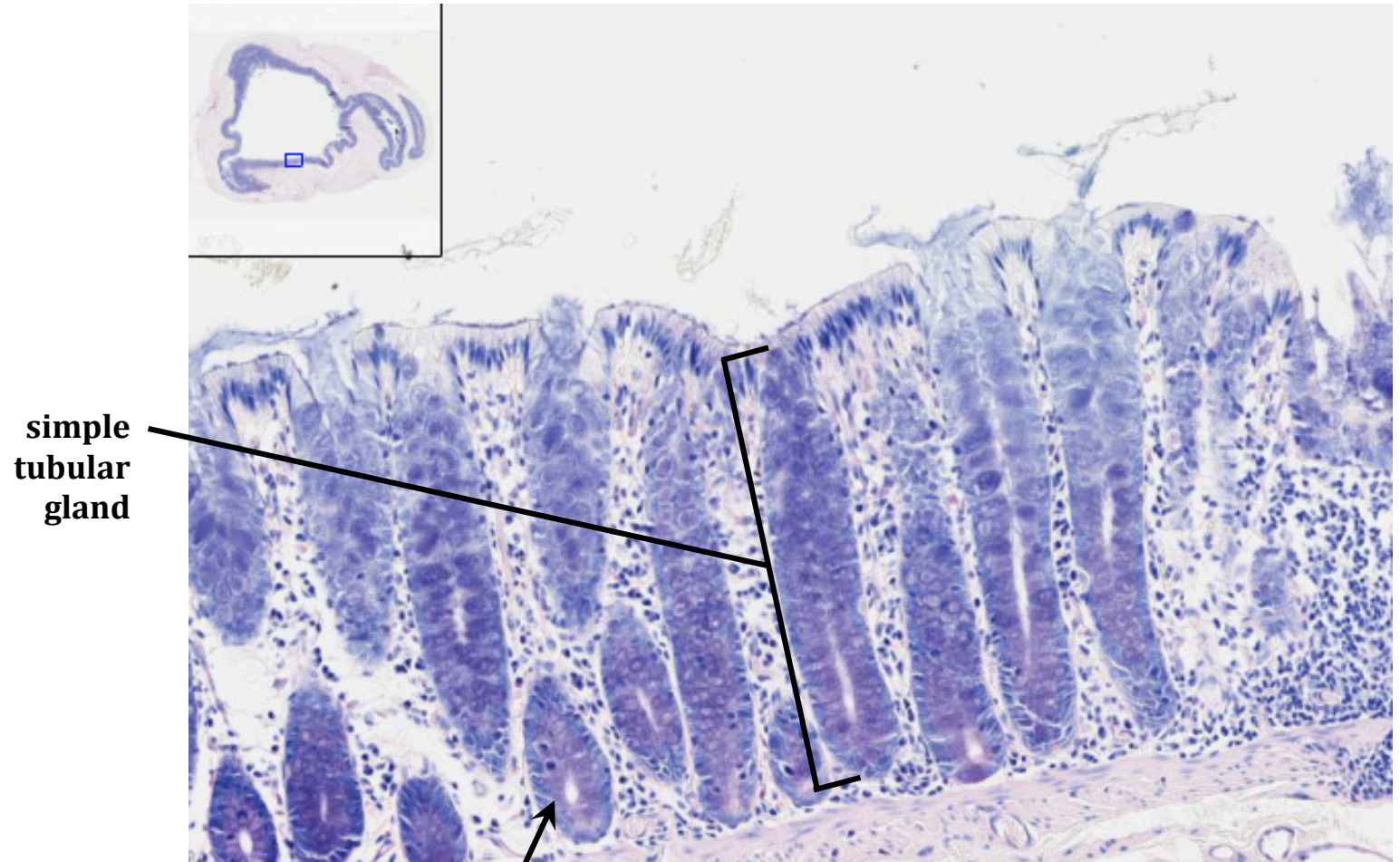
the secretory cells of **simple, tubular glands** discharge their product into the straight, tubular lumen which they line; the lumen then empties via a short duct portion onto the apical surface of the epithelium (the lumen of the ileum); the glands are seen in longitudinal section but may also be seen in cross-section

Lab 4 - Epithelia and Glands

IUSM - 2016

- I. Introduction
- II. Learning Objectives
- III. Keywords
- IV. Slides
 - A. Epithelia
 1. Simple
 - a. Simple squamous
 - b. Simple cuboidal
 - c. Simple columnar
 - d. Pseudostratified columnar
 2. Stratified
 - a. Stratified squamous
 - b. Stratified cuboidal
 - c. Stratified columnar
 - d. Transitional
 - B. Exocrine Glands
 1. Simple (unbranched duct)
 - a. **Tubular**
 - b. Branched tubular
 - c. Coiled tubular
 - d. Branched acinar
 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. Summary

Slide 6: Colon, PAS & Azure Blue



**simple
tubular
gland**

due to sectioning, it is common to not be able to see the entire gland extending to the apical surface (lumen)

Lab 4 - Epithelia and Glands

IUSM - 2016

I. Introduction

II. Learning Objectives

III. Keywords

IV. Slides

A. Epithelia

1. Simple

- a. Simple squamous
- b. Simple cuboidal
- c. Simple columnar
- d. Pseudostratified columnar

2. Stratified

- a. Stratified squamous
- b. Stratified cuboidal
- c. Stratified columnar
- d. Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

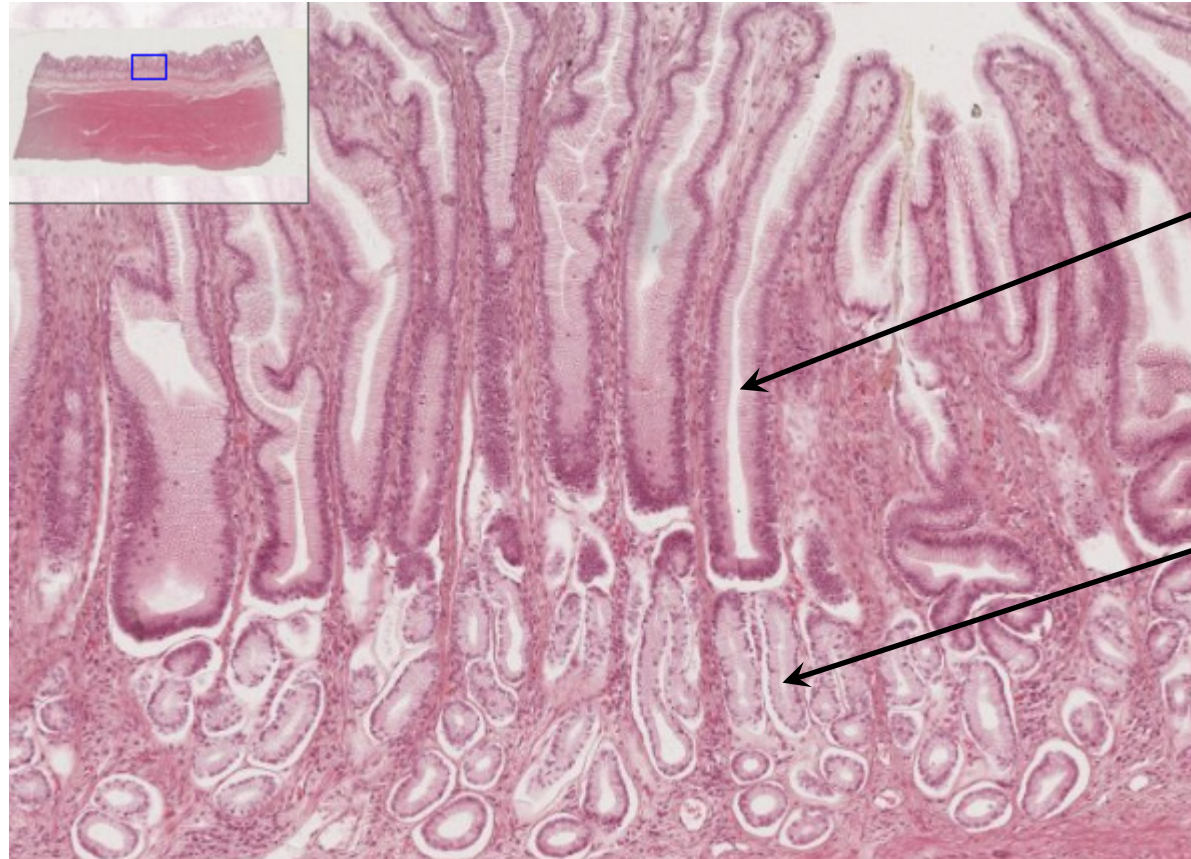
- a. Tubular
- b. **Branched tubular**
- c. Coiled tubular
- d. Branched acinar

2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

V. Summary

Slide 42 (464): Pyloric Stomach, H&E



gastric pits are the **duct** portions of the glands, emptying into the lumen of the stomach

pyloric (gastric) glands are lined almost entirely by mucus-secreting cells and are generally classified as **branched tubular**

simple, branched tubular glands are found almost exclusively in the stomach; several tubular secretory portions drain together into a single, unbranched duct which then empties onto the surface of the gland (the stomach lumen)

Lab 4 - Epithelia and Glands

IUSM - 2016

I. Introduction

II. Learning Objectives

III. Keywords

IV. Slides

A. Epithelia

1. Simple

- Simple squamous
- Simple cuboidal
- Simple columnar
- Pseudostratified columnar

2. Stratified

- Stratified squamous
- Stratified cuboidal
- Stratified columnar
- Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

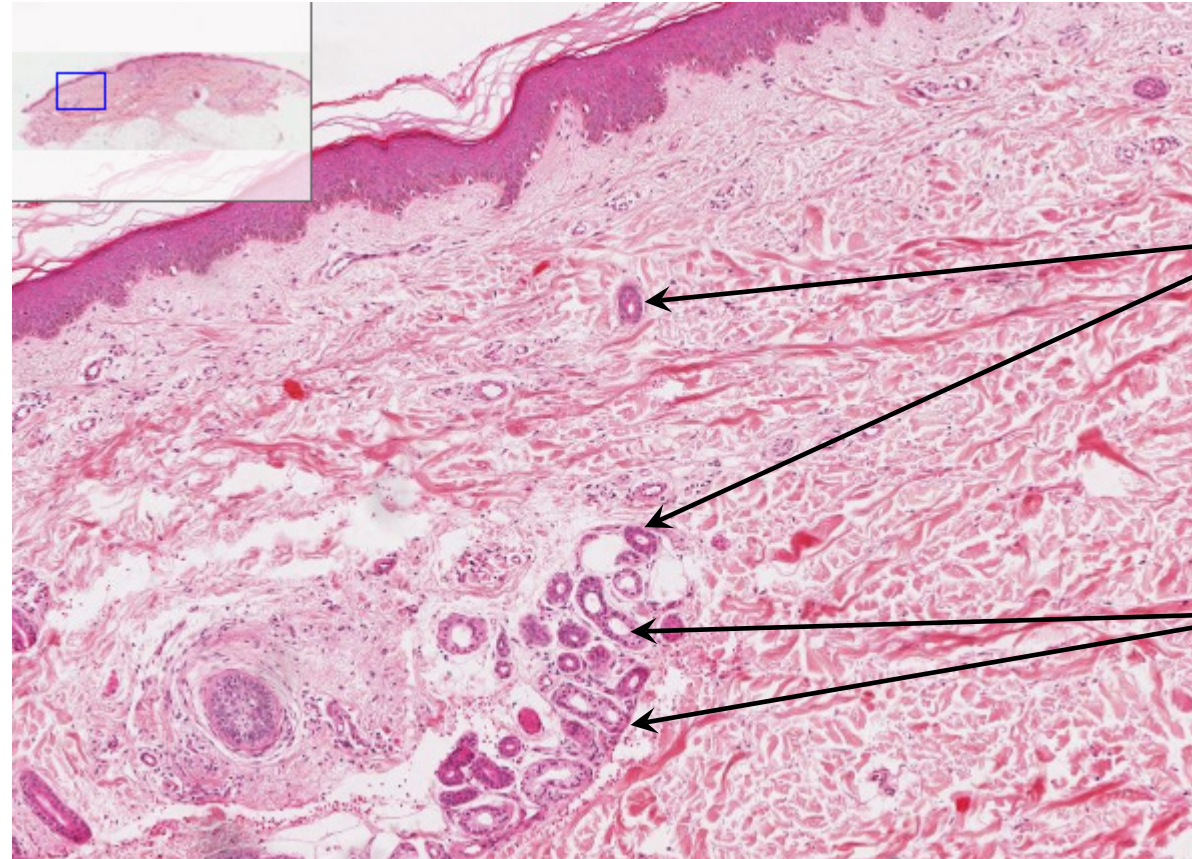
- Tubular
- Branched tubular
- Coiled tubular**
- Branched acinar

2. Compound (branched ducts)

- Tubular
- Acinar
- Tubulo-acinar

V. Summary

Slide 36: Thin Skin, H&E



unbranched **duct portion**
of simple coiled tubular
sweat gland

coiled tubular
secretory portion

sweat glands are almost the only example of **simple, coiled tubular glands**; their secretory portions are highly-coiled simple cuboidal epithelium which drain into the unbranched, non-secretory duct portion (darker staining) which is lined by stratified cuboidal epithelium and empties onto the surface of the skin

Lab 4 - Epithelia and Glands

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A. Epithelia

1. Simple

- a. Simple squamous
- b. Simple cuboidal
- c. Simple columnar
- d. Pseudostratified columnar

2. Stratified

- a. Stratified squamous
- b. Stratified cuboidal
- c. Stratified columnar
- d. Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

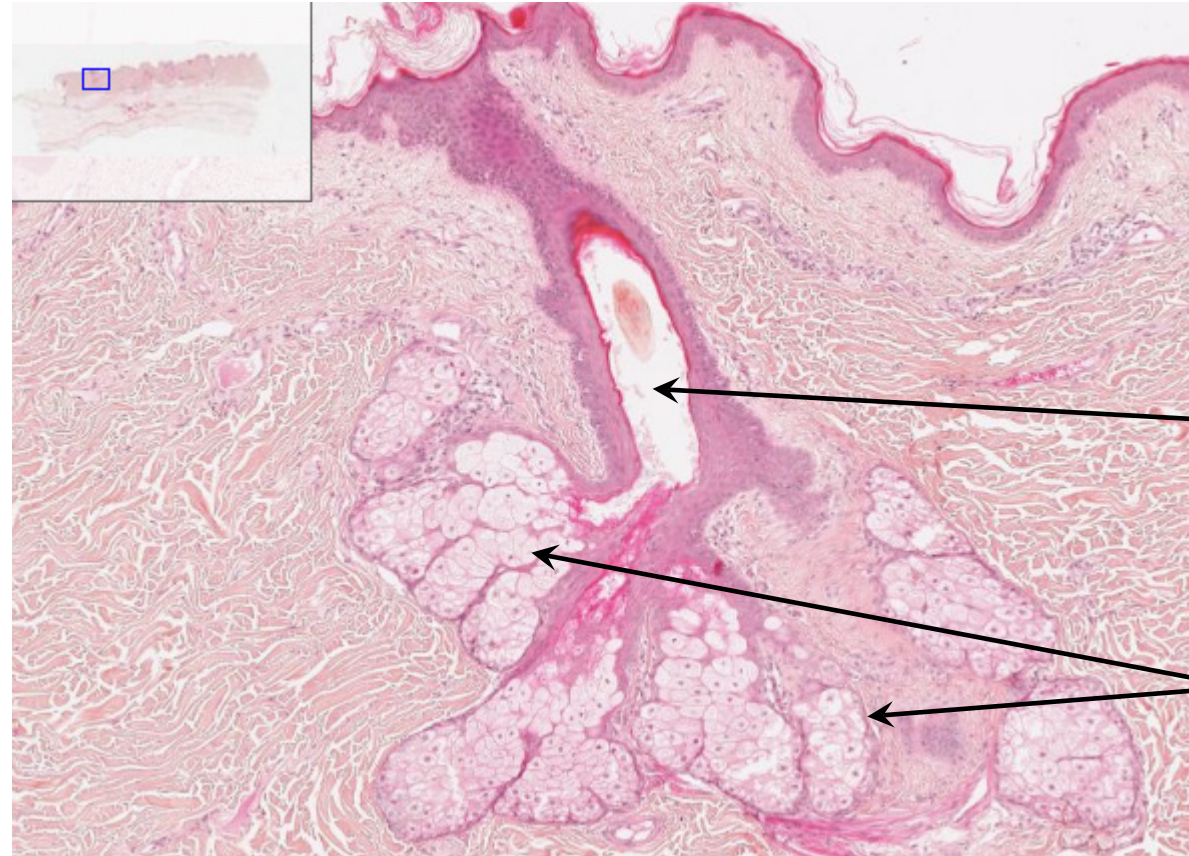
- a. Tubular
- b. Branched tubular
- c. Coiled tubular
- d. **Branched acinar**

2. Compound (branched ducts)

- a. Tubular
- b. Acinar
- c. Tubulo-acinar

V. Summary

Slide 51: Thin Skin, H&E



hair follicle

sebaceous glands are **simple branched acinar glands**

sebaceous glands are **simple, branched acinar glands** consisting of several secretory acini surrounding a hair follicle, which serves as the single, unbranched duct; the acini empty their product (*sebum*) into their excretory duct (the hair follicle) via *holocrine secretion*

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2. Stratified

- Stratified squamous
- Stratified cuboidal
- Stratified columnar
- Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

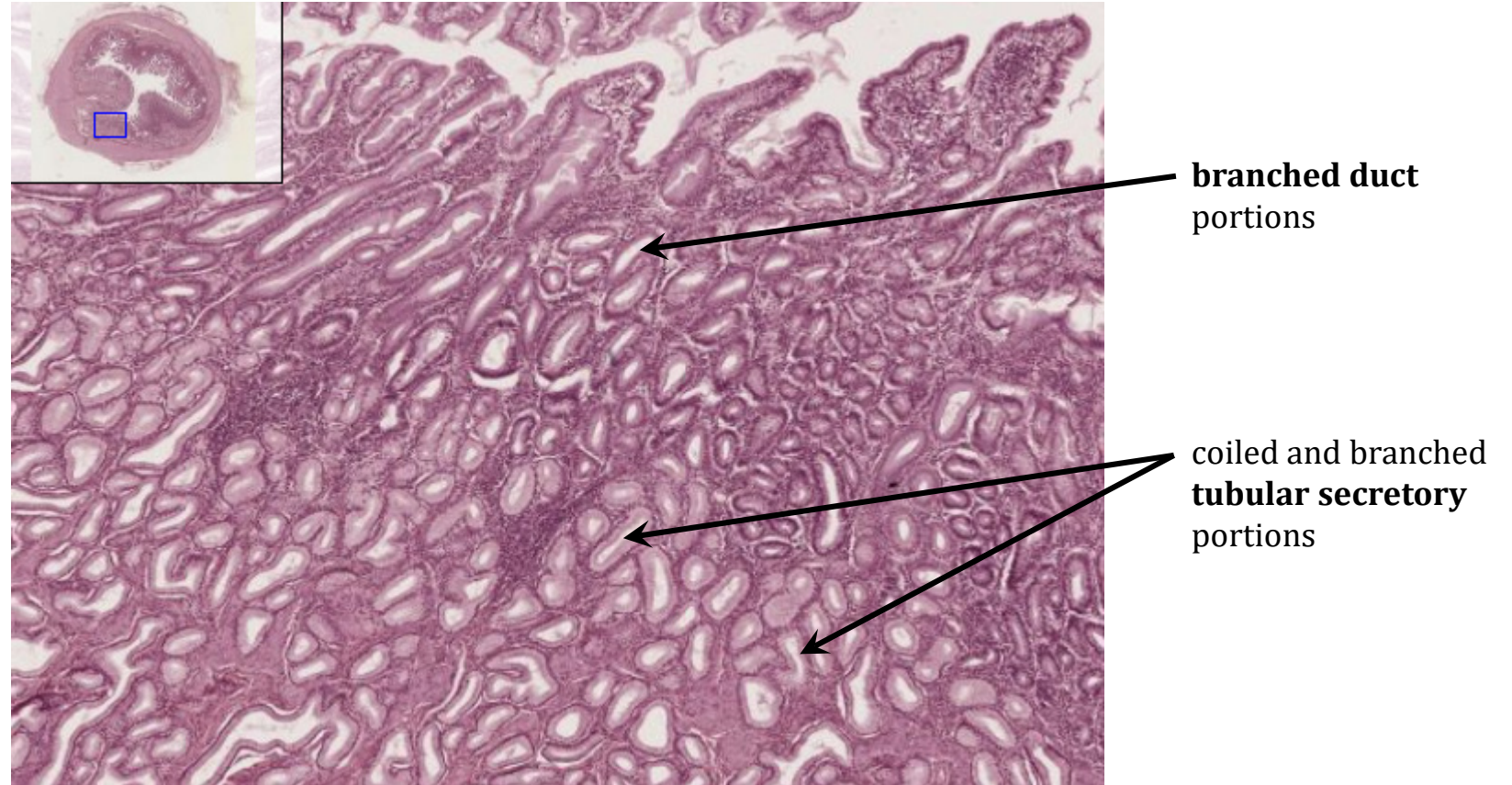
- Tubular
- Branched tubular
- Coiled tubular
- Branched acinar

2. Compound (branched ducts)

- Tubular**
- Acinar
- Tubulo-acinar

V. Summary

Slide 43 (464): Duodenum, H&E



Brunner's glands of the duodenum (the first segment of the small intestine) are **compound, tubular glands** (more specifically, they are compound, branched coiled tubular glands); there are extensive secretory portions that secrete a mucus-rich alkaline product to neutralize the acidic contents emptying into the duodenum from the stomach

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2. Stratified

- a. Stratified squamous
- b. Stratified cuboidal
- c. Stratified columnar
- d. Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

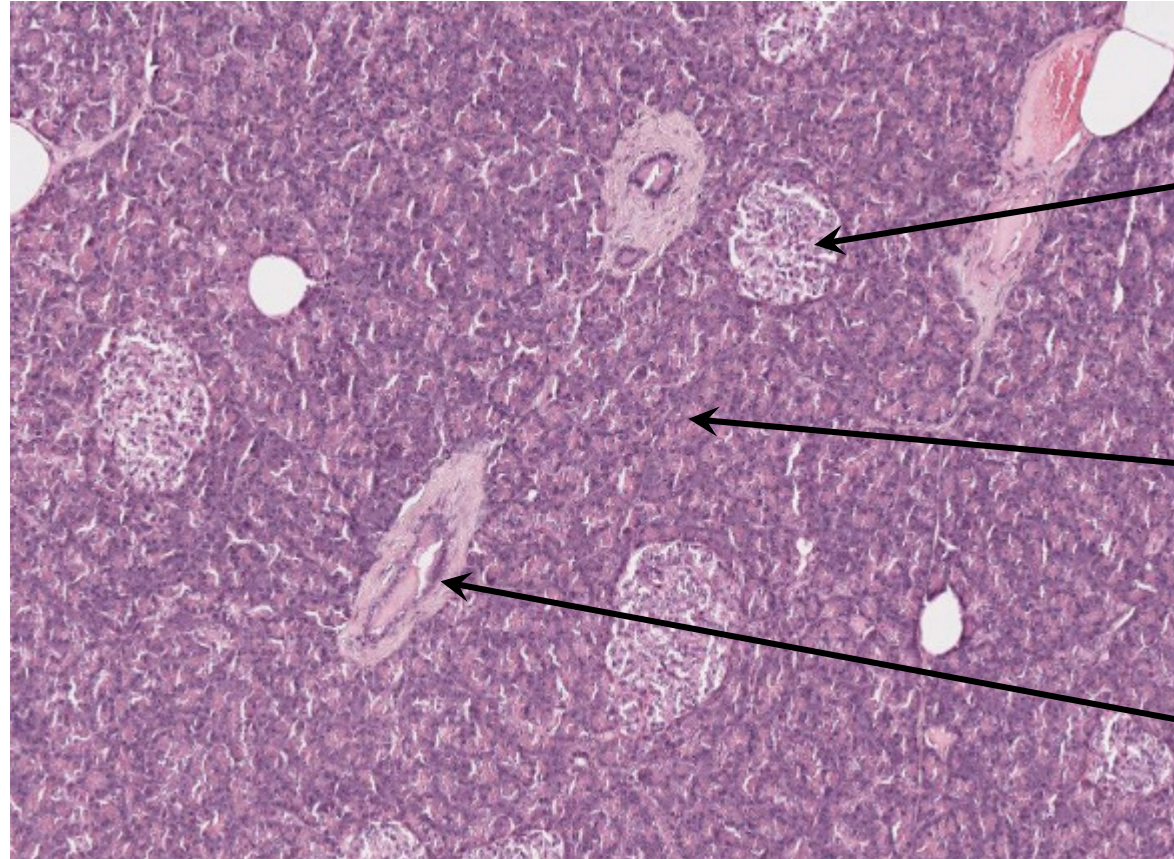
- a. Tubular
- b. Branched tubular
- c. Coiled tubular
- d. Branched acinar

2. Compound (branched ducts)

- a. Tubular
- b. **Acinar**
- c. Tubulo-acinar

V. Summary

Slide 154: Pancreas, H&E



pancreatic
island
(endocrine)

secretory acini
compose the majority
of the parenchyma of
the pancreas

exocrine duct

the exocrine portion of the pancreas is a **compound, acinar gland** composed of secretory epithelial cells arranged in an acinar (Lt. “grape”) configuration; at the center of the acini are small ducts which are not usually able to be seen; these small ducts drain into larger ducts, lined by simple cuboidal epithelium, which form the branched duct system; eventually all the ducts converge into the main pancreatic duct which empties into the duodenum

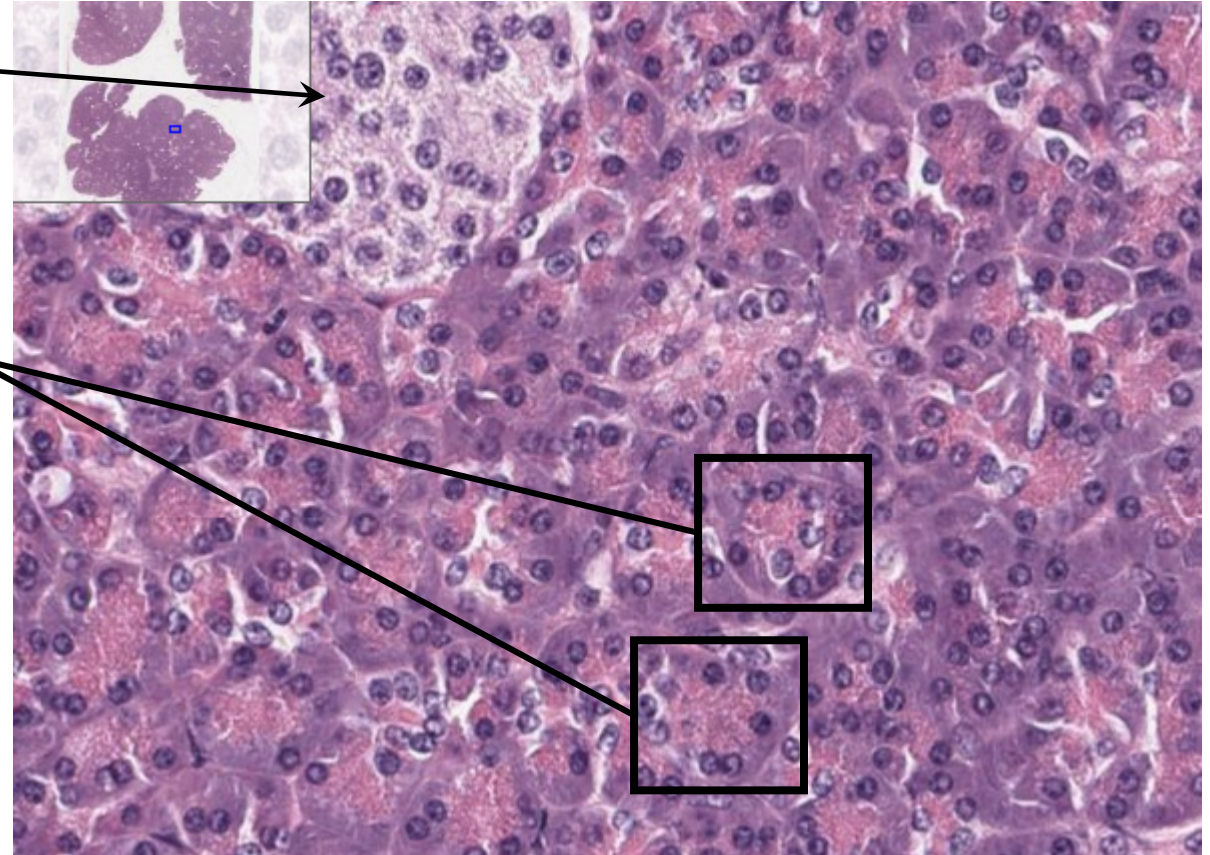
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 - d. Pseudostratified columnar
 2. Stratified
 - a. Stratified squamous
 - b. Stratified cuboidal
 - c. Stratified columnar
 - d. Transitional
 - B. Exocrine Glands
 1. Simple (unbranched duct)
 - a. Tubular
 - b. Branched tubular
 - c. Coiled tubular
 - d. Branched acinar
 2. Compound (branched ducts)
 - a. Tubular
 - b. **Acinar**
 - c. Tubulo-acinar
- V. Summary

Slide 154: Pancreas, H&E

light-staining group of cells are an *endocrine* pancreatic islet



acini
(serous)

serous secretory acini comprise the majority of parenchyma of pancreas

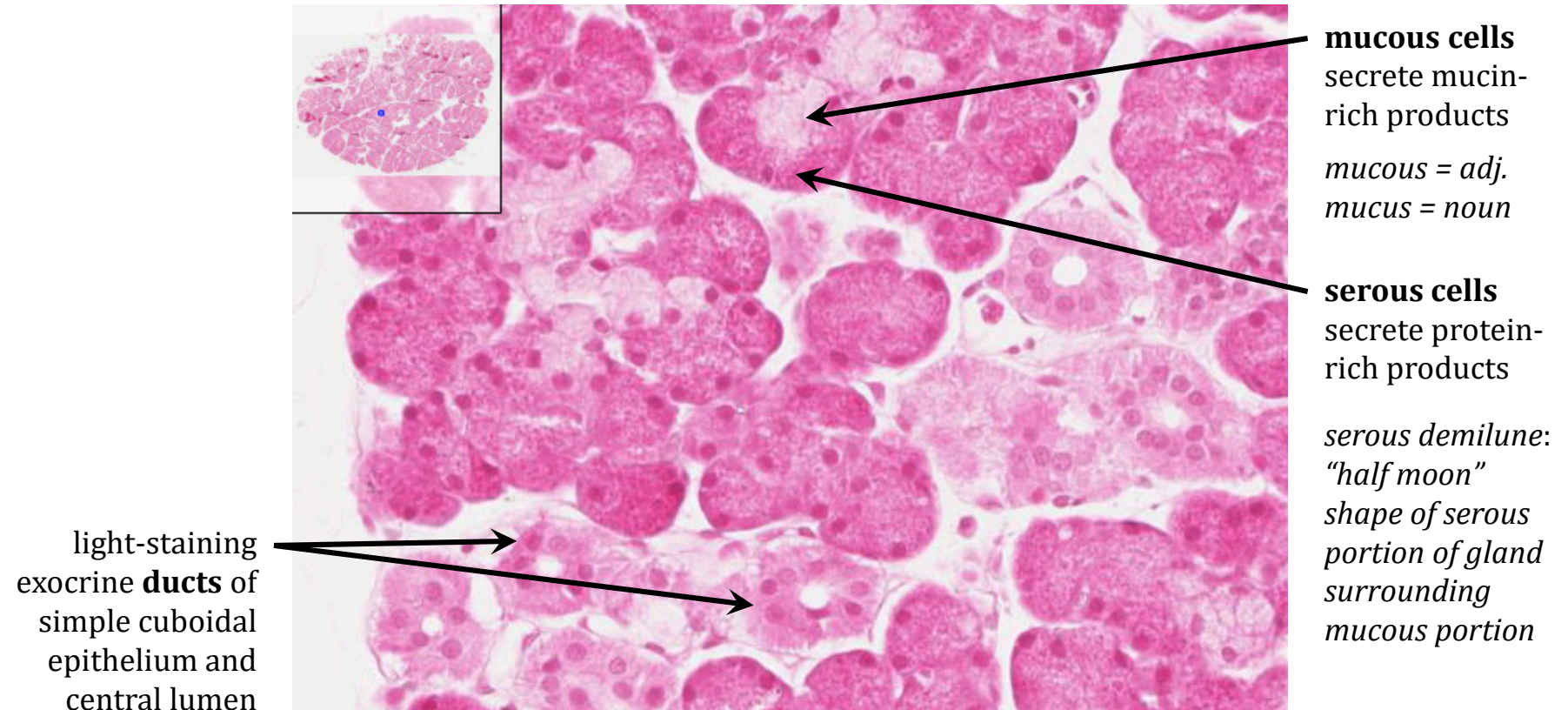
the serous **acini** (plural of acinus) have 5-10 secretory cells surrounding a small central duct (lumen is not readily visible); the apical ends are eosinophilic due to the presence of secretory granules, while the basal ends are basophilic due to the nucleus and rER

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 - B. Exocrine Glands
 1. Simple (unbranched duct)
 - a. Tubular
 - b. Branched tubular
 - c. Coiled tubular
 - d. Branched acinar
 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. **Tubulo-acinar**
- V. Summary

Slide 72: Submandibular Gland, H&P



the submandibular gland is an example of a **compound, tubulo-acinar gland**; it is composed of secretory units arranged as branched tubular, branched acinar, and combined tubular units capped by acinar ends; there are both **serous** (eosinophilic-staining) and **mucous** (pale-staining) secretory cells; the mucous cells tend to form the tubular components and the serous cells form the acinar components; all the secretory portions converge into branched ducts which converge and empty into the oral cavity

Lab 4 – Epithelia and Glands

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A. Epithelia

1. Simple

- Simple squamous
- Simple cuboidal
- Simple columnar
- Pseudostratified columnar

2. Stratified

- Stratified squamous
- Stratified cuboidal
- Stratified columnar
- Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

- Tubular
- Branched tubular
- Coiled tubular
- Branched acinar

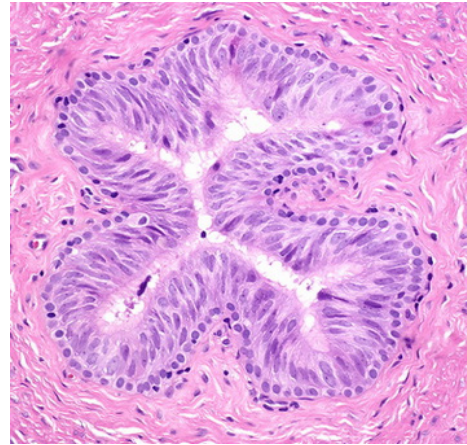
2. Compound (branched ducts)

- Tubular
- Acinar
- Tubulo-acinar

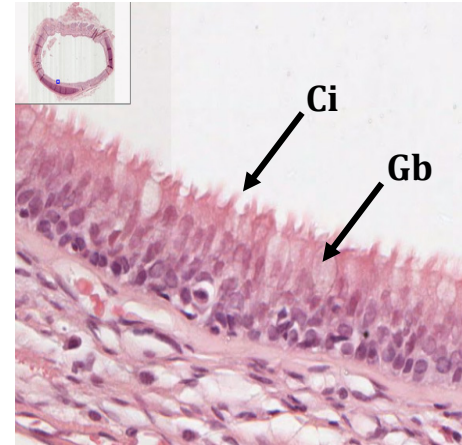
V. Summary

Common Confusion:

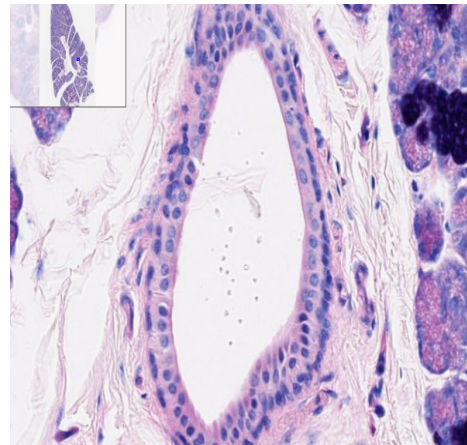
Pseudostratified vs. Stratified Cuboidal/Columnar Epithelium



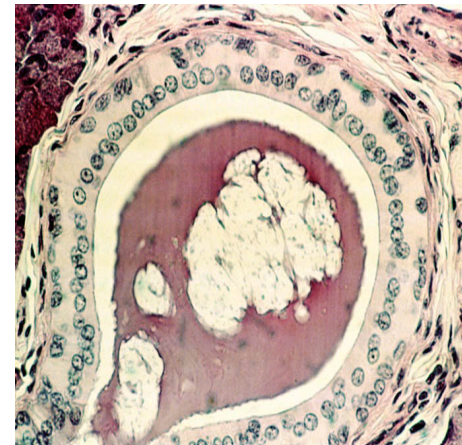
Ductus Deferens



Trachea



Stratified cuboidal



Stratified cuboidal

Pseudostratified: simple epithelium with all cells attached to basement membrane; found in upper respiratory tract and reproductive system (rare)

Look for: (1) nuclei give appearance of multiple layers (more than two) but are not in-line forming strata; (2) nuclei are generally confined to basal 2/3 of epithelium; (3) cilia (**Ci**) are usually present (PCCE), while never present on true stratified epithelia; (4) goblet cells (**Gb**) are often interspersed

Stratified cuboidal/columnar: stratified cuboidal and columnar epithelia are rare and mainly restricted to large ducts and parts of the reproductive system; sectioning may skew appearance, so look at thinnest portion of epithelium to visualize true organization

Look for: (1) generally no more than two cell layers thick; (2) clearly defined strata; (3) apical nuclei are in-line and have characteristic shape; (4) lack apical modifications

Lab 4 – Epithelia and Glands

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A. Epithelia

1. Simple

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- Simple cuboidal
- Simple columnar
- Pseudostratified columnar

2. Stratified

- Stratified squamous
- Stratified cuboidal
- Stratified columnar
- Transitional

B. Exocrine Glands

1. Simple (unbranched duct)

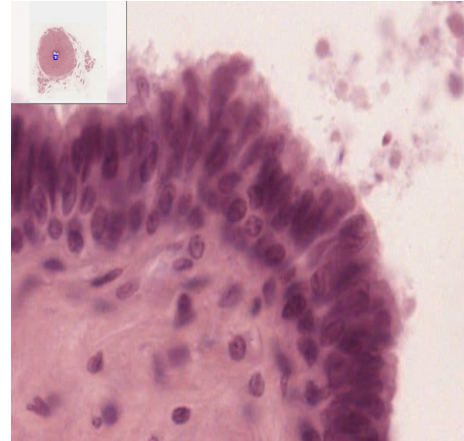
- Tubular
- Branched tubular
- Coiled tubular
- Branched acinar

2. Compound (branched ducts)

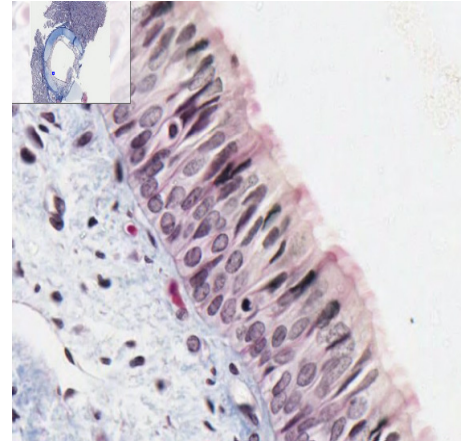
- Tubular
- Acinar
- Tubulo-acinar

V. Summary

Common Confusion: Pseudostratified vs. Transitional Epithelium



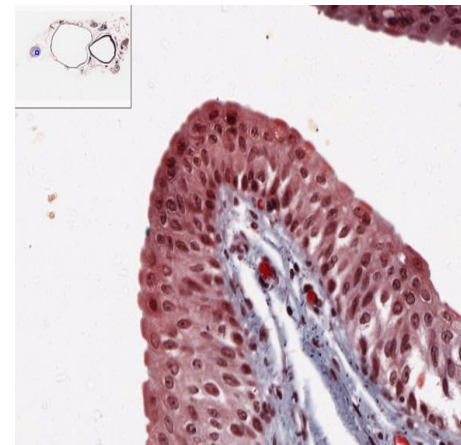
Ductus Deferens



Trachea



Bladder



Ureter

Pseudostratified: simple epithelium with all cells attached to basement membrane; found in upper respiratory tract and reproductive system (rare)

Look for: (1) all cells are directly attached to basement membrane so nuclei normally do not appear directly stacked above one another; (2) nuclei are generally confined to basal 2/3 of epithelium; (3) more apical nuclei have columnar appearance instead of rounded; (4) cilia are usually present (PCCE); (5) goblet cells are often interspersed

Transitional: stratified epithelium found only within organs of the urinary system

Look for: (1) multiple layers of nuclei generally with rounded appearance (but more layers and less in-line nuclei than stratified cuboidal epithelium); (2) multinucleated cell may be present at apical surface; (3) when tissue is relaxed: “bulging” of apical surface into lumen; (4) when tissue is stretched: may give appearance of stratified squamous epithelium, but nuclei are more round and there are fewer overall layers of cells; also stratified squamous “undulates” with the underlying connective tissue but stretched transitional is more flat as is the underlying connective tissue

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 - B. Exocrine Glands
 1. Simple (unbranched duct)
 - a. Tubular
 - b. Branched tubular
 - c. Coiled tubular
 - d. Branched acinar
 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. **Summary**

Summary

1. Epithelium is polarized (different **apical** and **basal** surfaces), avascular tissue composed of sheets of closely aggregated cells (one or more layers) upon a **basement membrane** (basal lamina + reticular lamina); it covers body surfaces, lines body cavities, and forms glands.
2. For **simple** epithelia, all the epithelial cells are directly attached to the basement membrane (i.e., only one cell layer thick); for **stratified** epithelia, not all the cells are directly attached to the basement membrane (i.e., more than one cell layer thick).
3. Epithelia are classified according to the shape of the cells (the most apical cells for stratified epithelia): **squamous** (flattened), **cuboidal**, **columnar**, and **pseudostratified** (simple but may appear stratified).
4. Epithelial apical modifications include: **microvilli** (short, finger-like cytoplasmic processes containing actin which may be visible as a brush/striated border), **stereocilia** (rare, long microvilli containing actin), and **cilia** (hair-like extensions of plasma membrane containing an axoneme – core of 9+2 microtubule doublets).
5. The type of epithelium (thickness, shape, and apical modifications) can be used in inferring the function of a tissue or organ.
6. Intercellular junctions are seen in EM and include: **tight/occluding junctions** (apical; prevent substances passing down and between cells), **anchoring junctions** (zona adherens; hold cells together and to basement membrane), and **communicating junctions** (channels allowing small molecules to pass between adjacent cells).

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 - b. Acinar
 - c. Tubulo-acinar
- V. **Summary**

Summary (cont.)

7. Glandular epithelium is specialized for secretion and classified according to how products are released: the secretory portions of **exocrine glands** maintain contact via ducts/tube onto the apical surface of the epithelium where the products are released; **endocrine glands** lack ducts so secrete their products (hormones) into the surrounding connective tissue from which they enter the bloodstream.
8. Exocrine glands are either unicellular (**goblet cells**) or multicellular, which are further classified morphologically according to the branching of their ducts (**simple** – have unbranched ducts; **compound** – have branched ducts) and the configuration of their secretory portions (e.g., tubular or acinar in shape).
9. Exocrine glands may also be classified according to: (1) the nature of their secretory product (**serous glands** produce watery, poorly-glycosylated or nonglycosylated proteins which generally stain eosinophilic; **mucous glands** produce viscous, glycosylated proteins and oligosaccharides and stain with PAS but poorly in H&E), or (2) the mode of secretion (**merocrine** – via exocytosis of vesicular contents; **apocrine** – via membrane-coated vesicles, or **holocrine** – via rupture and expulsion of entire cellular contents).

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 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. **Summary**

Appearance, Function, and Locations of Epithelial Tissues

	Epithelium	Draw and Label (& possible apical modifications)	Functions	Locations
Simple	Squamous			
	Cuboidal			
	Columnar			
	Pseudostratified			
Stratified	Squamous			
	Cuboidal			
	Transitional			

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 - 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. **Summary**

Epithelial Terminology Compare and Contrast

Terms	Compare and Contrast (Similarities? Distinctive differences?)
Simple vs. Stratified epithelia	
Microvilli vs. Stereocilia vs. Cilia	
Merocrine vs. Apocrine vs. Holocrine secretion	
Mucous vs. Serous acini	
Occluding vs. Anchoring vs. Communicating junctions	
Parenchyma vs. Stroma	
Brush border vs. Terminal web	

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 2. Compound (branched ducts)
 - a. Tubular
 - b. Acinar
 - c. Tubulo-acinar
- V. **Summary**

Exocrine Gland Morphology and Characteristics

	Gland	Draw and Label (Duct and Secretory portions)	Locations	Function / Features
Simple	Tubular			
	Coiled tubular			
	Branched tubular			
	Acinar			
	Branched acinar			
Compound	Tubular			
	Acinar			
	Tubuloacinar			