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Histology of the Respiratory Tract

M1 – Cardiovascular/Respiratory Sequence

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Medical School

Fall 2008

Objectives Respiratory Tract Histology:

- Know the general functions of the respiratory system and the overall organization of the respiratory tree
- Identify the histological features of the nasal cavity, the vocal cords and the trachea
- Know the cellular components of the respiratory epithelium and their functional importance
- Be able to recognize olfactory epithelium and know how it differs from regular respiratory epithelium
- Identify bronchi, bronchiole, terminal bronchiole, respiratory bronchiole, alveolar ducts and sacs and know their distinct histological features
- Be able to recognize Clara cells and know their functional significance
- Understand the structural organization of alveoli, including the air-blood barrier and alveolar pores
- Know the cellular components of the alveolar tissue and their individual functions and be able to recognize them
- Understand the organization of the intrapulmonary blood circulation and recognize its different parts

Major Functions of the Respiratory System:

1. Air conditioning (air warming, humidifying and filtering)
2. Oxygen/carbon dioxide exchange

Minor Functions of the Respiratory System:

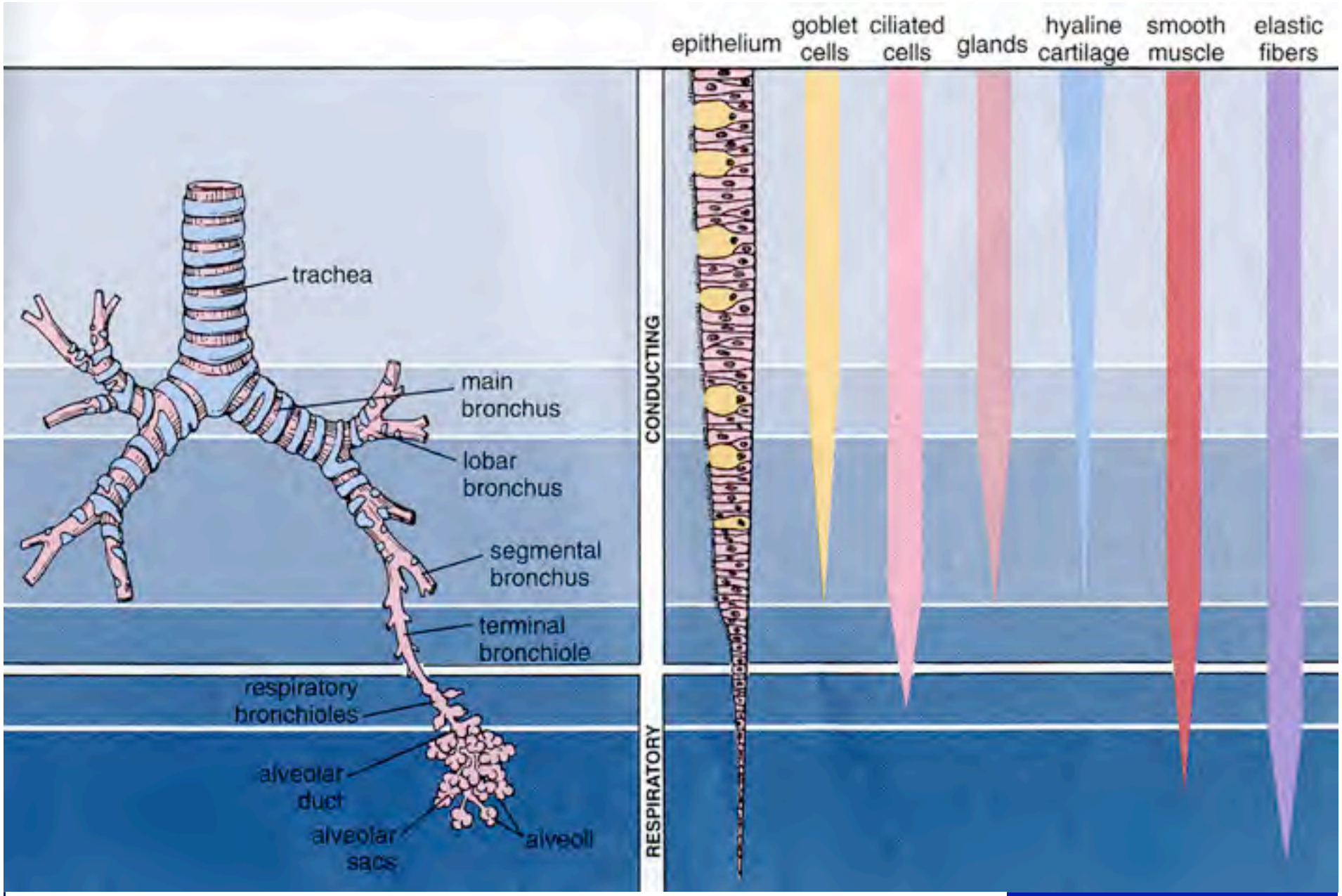
1. Perception of smell
2. Phonation
3. Endocrine functions, conversion of Angiotensin I into II

Cell and Tissue Biology – A Textbook of Histology; 6th edition; 1988; Weiss, Urban & Schwarzenberg Fig. 25-14 PD-INEL

Cast of a human bronchial tree

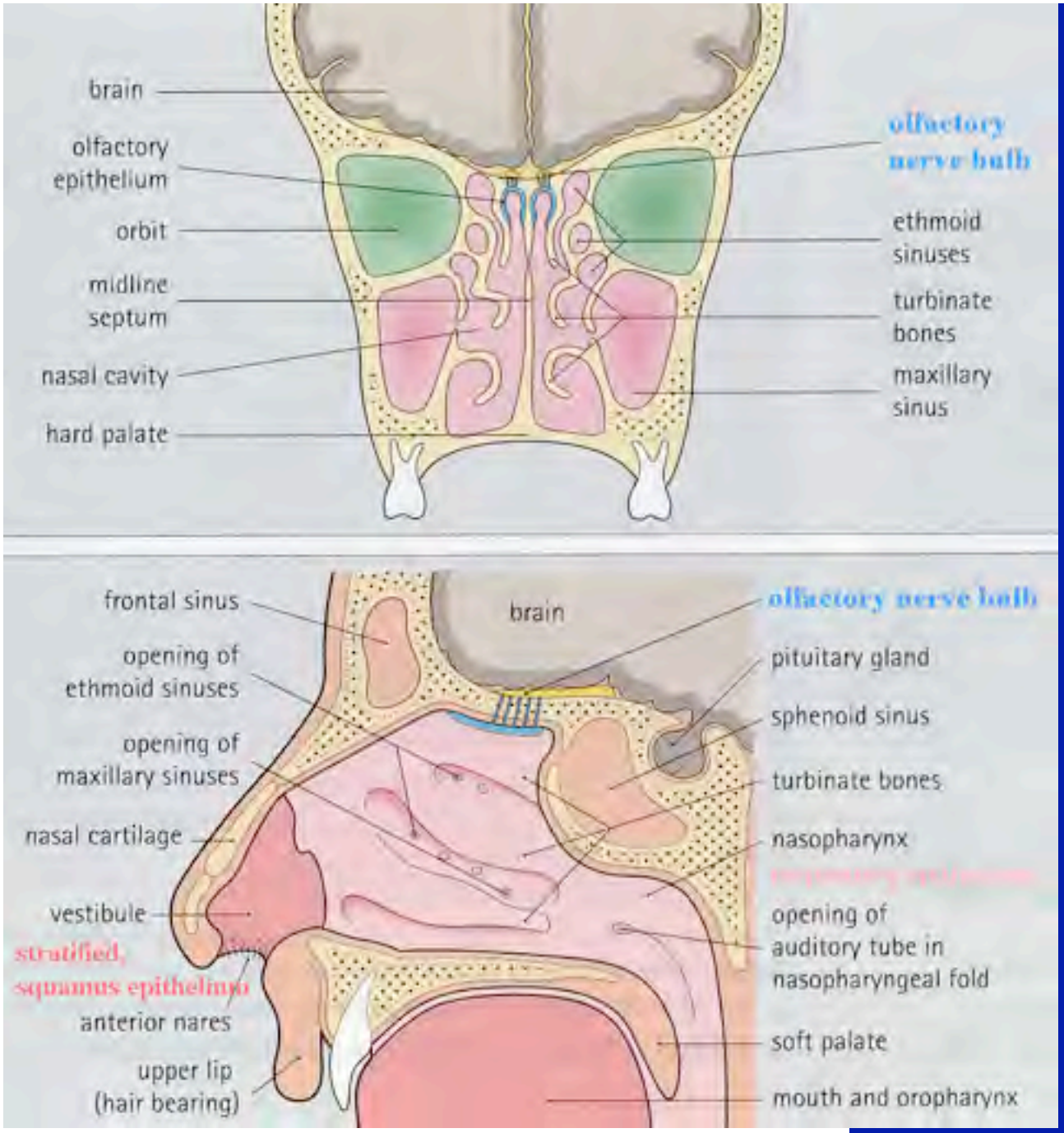
Arborization of respiratory tree

Original Image: Wheater's Functional Histology; 5th edition, 2006, Young, Lowe, Stevens and Heath; Churchill Livingstone Elsevier Fig. 12.1



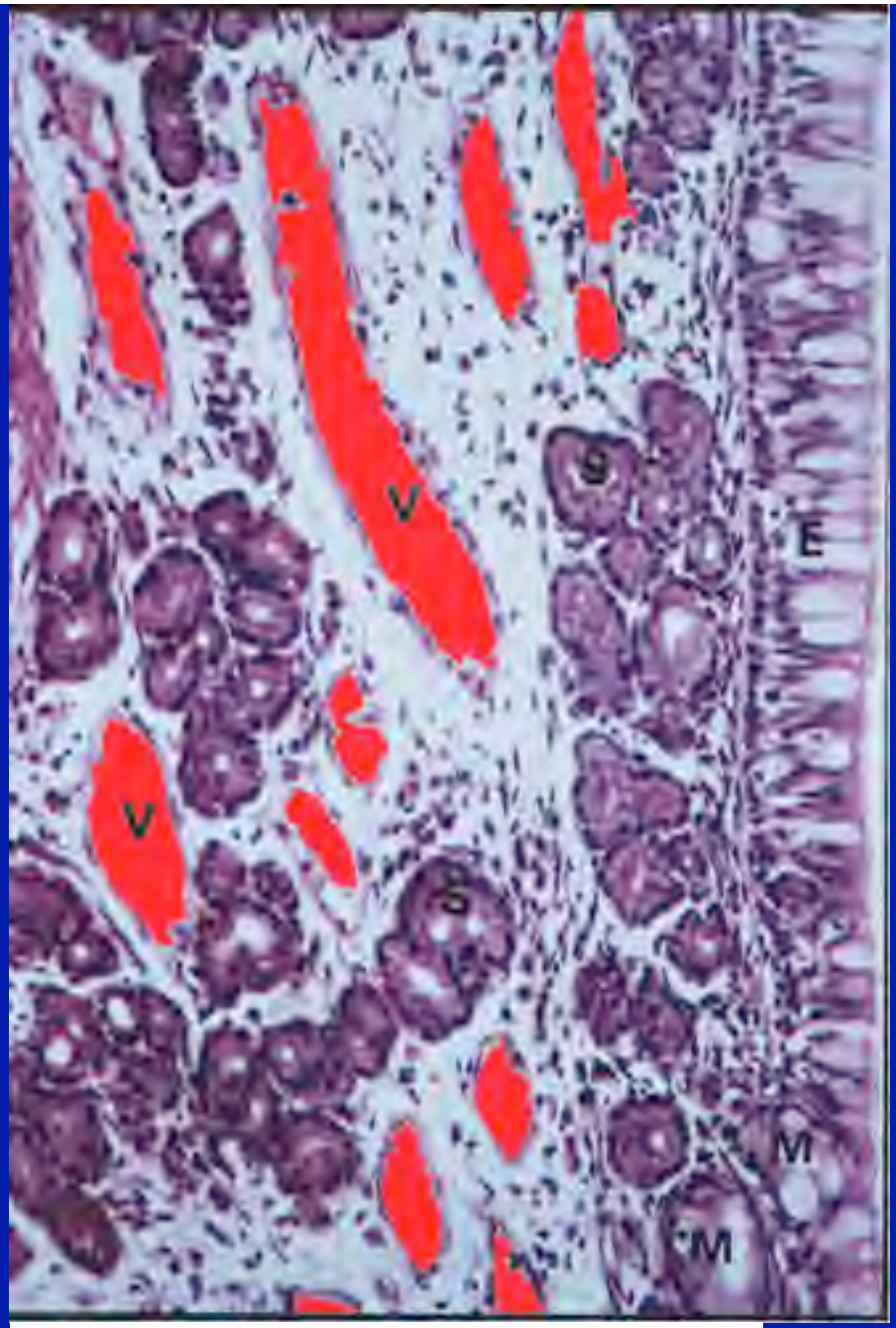
PD-INEL Histology – A Text and Atlas; 5th edition, 2006, Ross and Pawlina, Lippincott Williams and Wilkins Fig 19.1

Histological changes along the respiratory tree



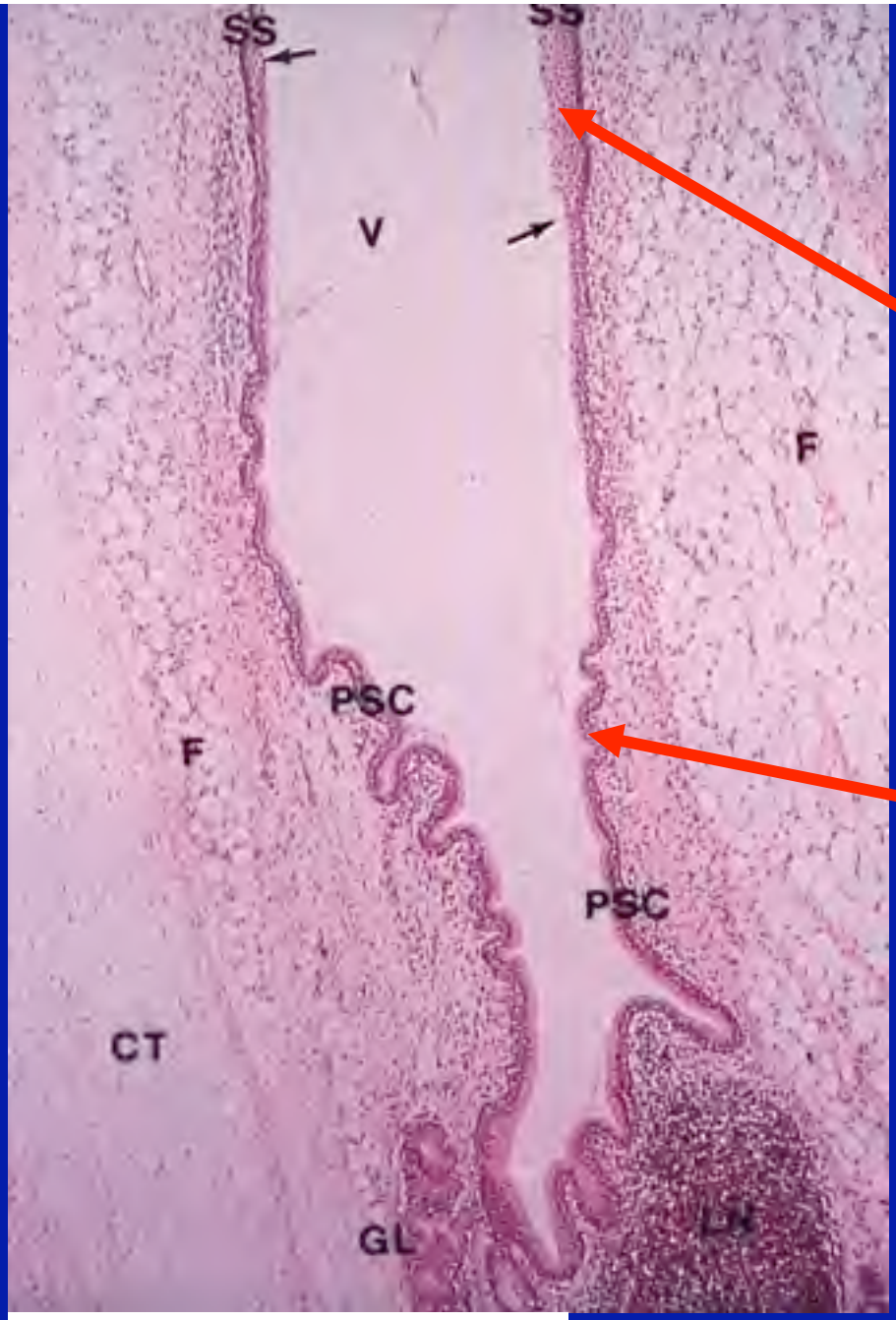
Histological features of the nasal cavity

 Human Histology, 2nd edition, 1997, Stevens and Lowe, Mosby Fig 10.4



Wheater's Functional Histology; 4th edition, 2000, Young and Heath; Churchill Livingstone Elsevier; Fig 12.3

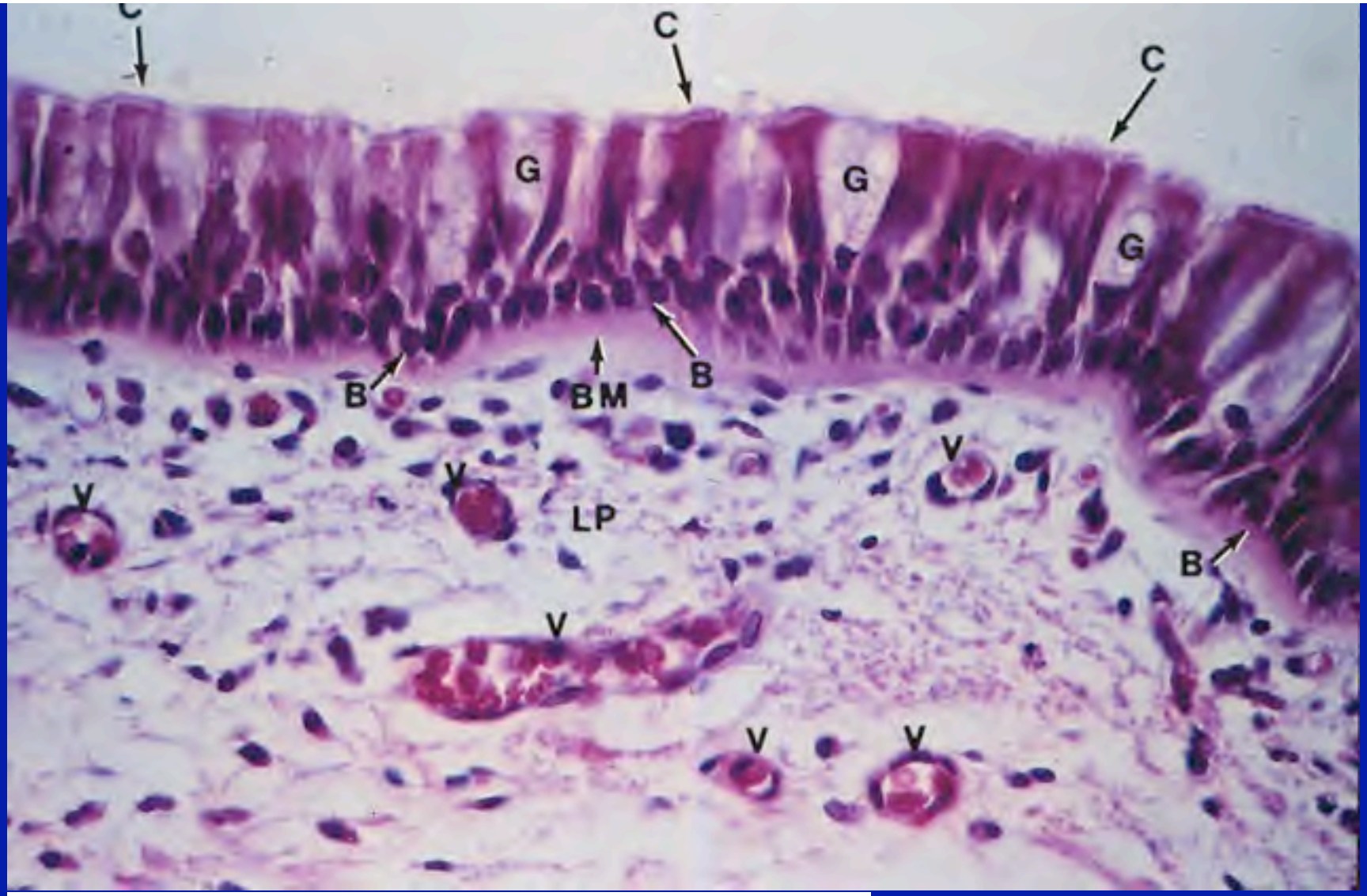
Nasal venous sinuses warm the incoming air



Color Atlas of Basic Histology; 1993; Berman; Appelton and Lange, Fig 14-3 PD-INEL

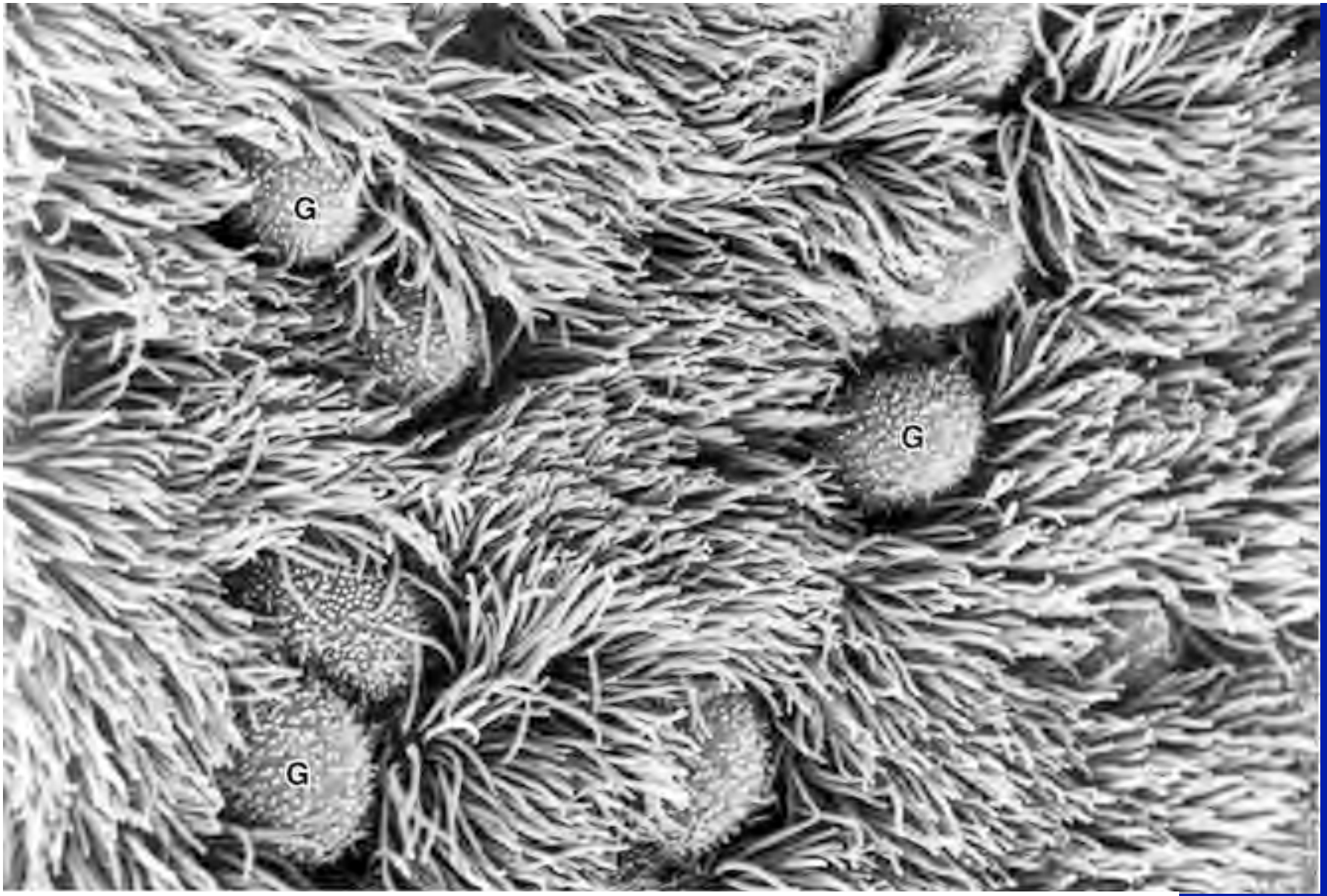
Transition from stratified squamous epithelium to the respiratory epithelium at the laryngeal ventricle

Resident cells of the respiratory epithelium



 Color Atlas of Basic Histology; 1993; Berman; Appelton and Lange; Fig 14-8

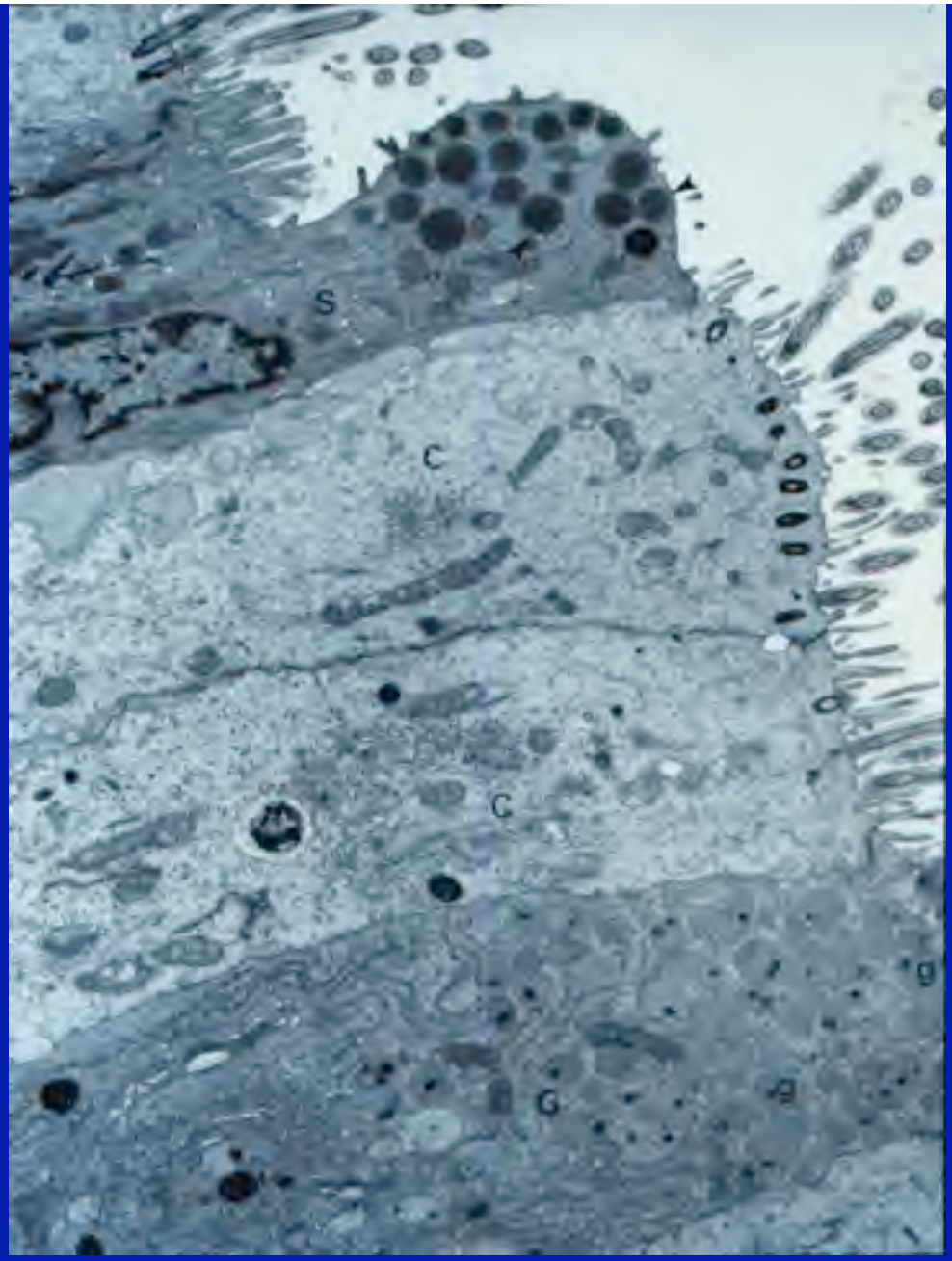
Light micrograph of the respiratory epithelium/mucosa



Basic Histology – Text & Atlas; 10th edition, 2003; Junqueira and Carneiro, Lange McGraw-Hill; Fig. 17-4 top

Scanning EM of the respiratory epithelium

G = goblet cell



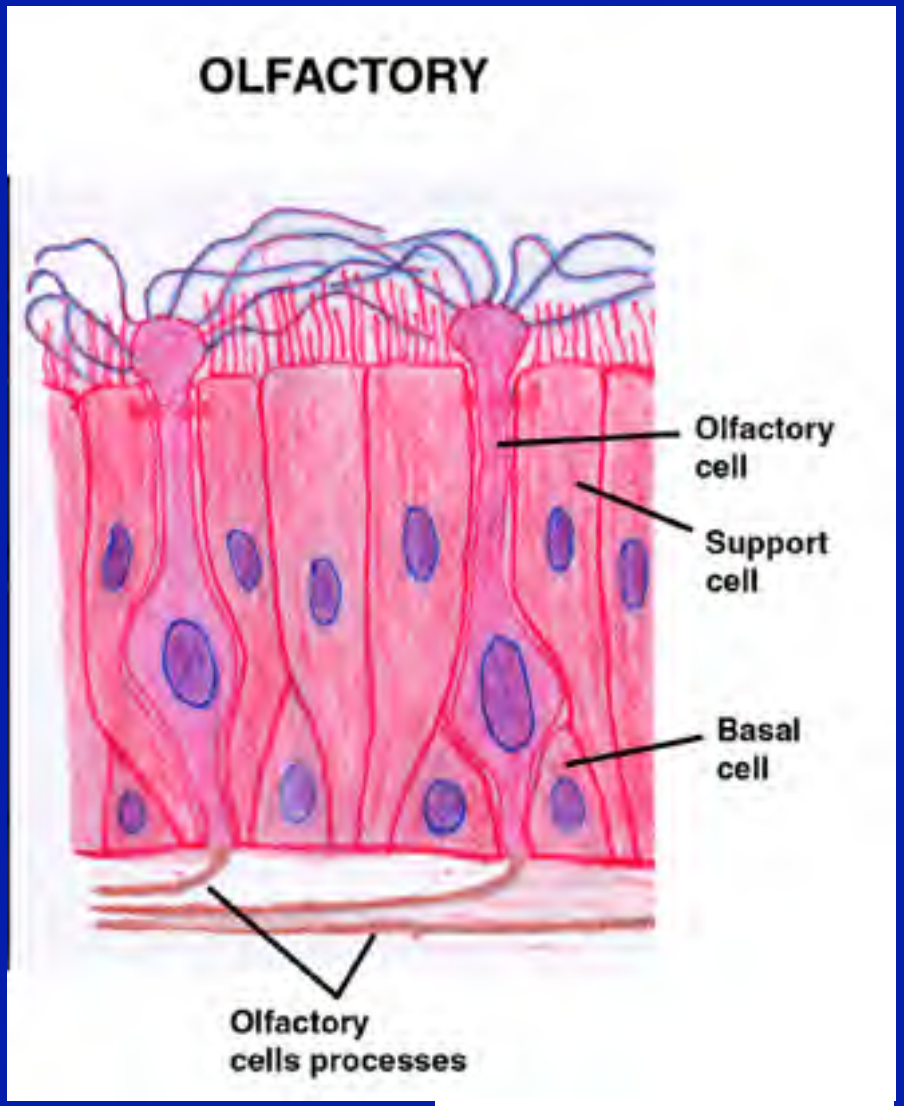
Cell and Tissue Ultrastructure – A Functional Perspective; 1993; Cross and Mercer, Freeman and Co.; page 305

Transmission EM of a respiratory epithelium

Diagram of the olfactory epithelium

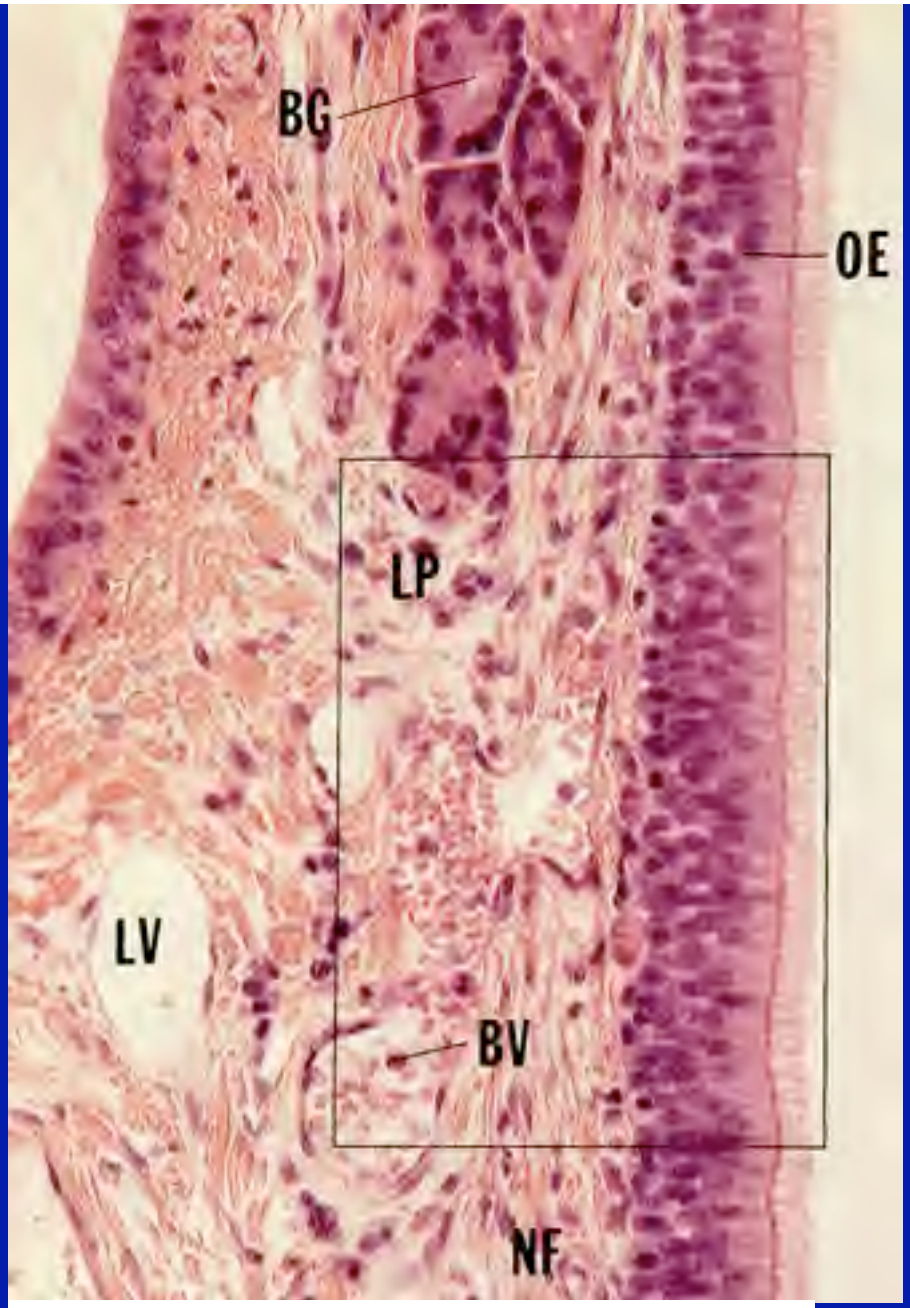
Sir William Bowman (1816-1892)

PD-EXP Wikipedia



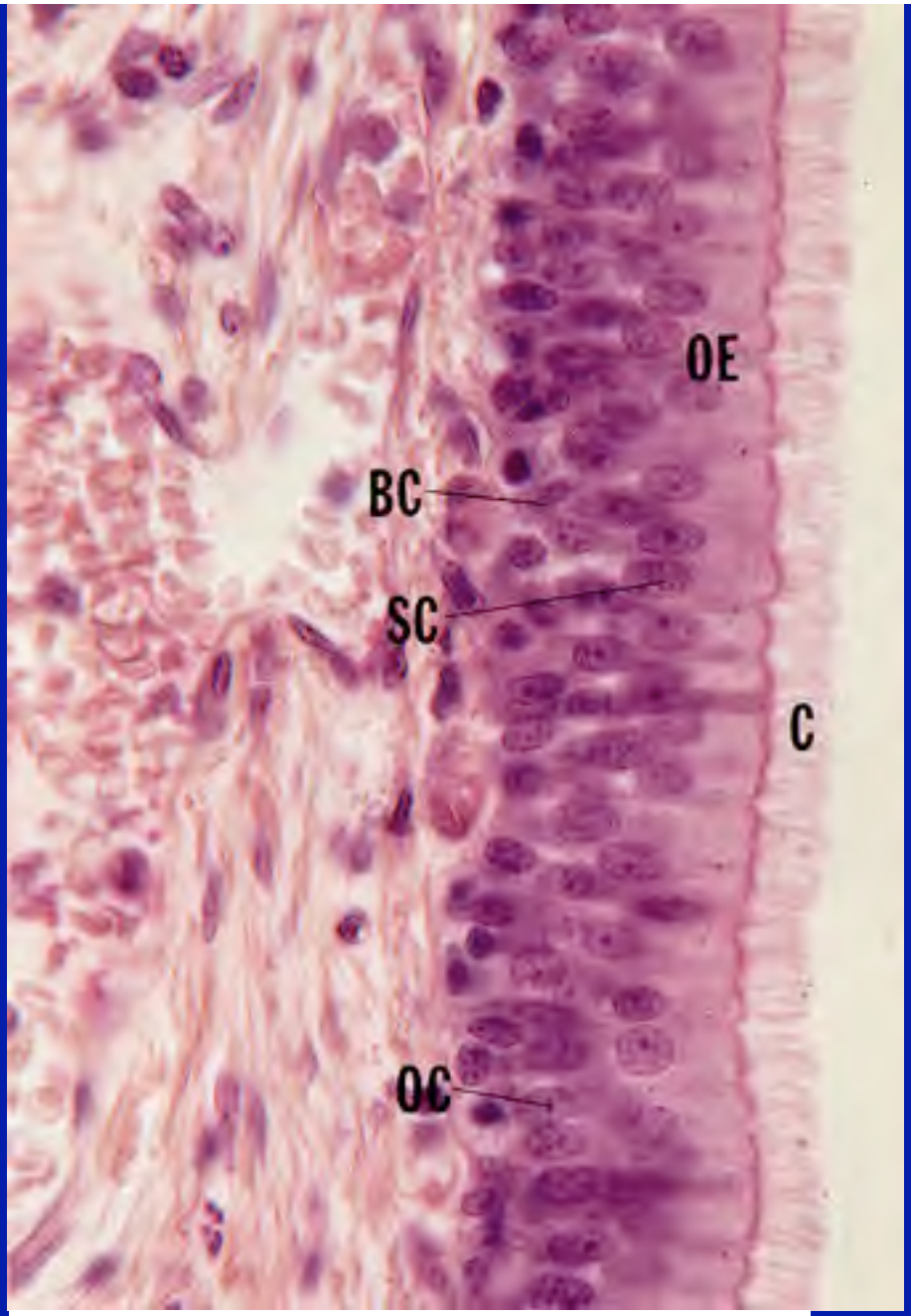
PD-INEL Dr. Thomas Caceci,

Original Image: Human Histology, 1st edition, 1992, Stevens and Lowe, Grower Medical Publishing , Fig. 9.5



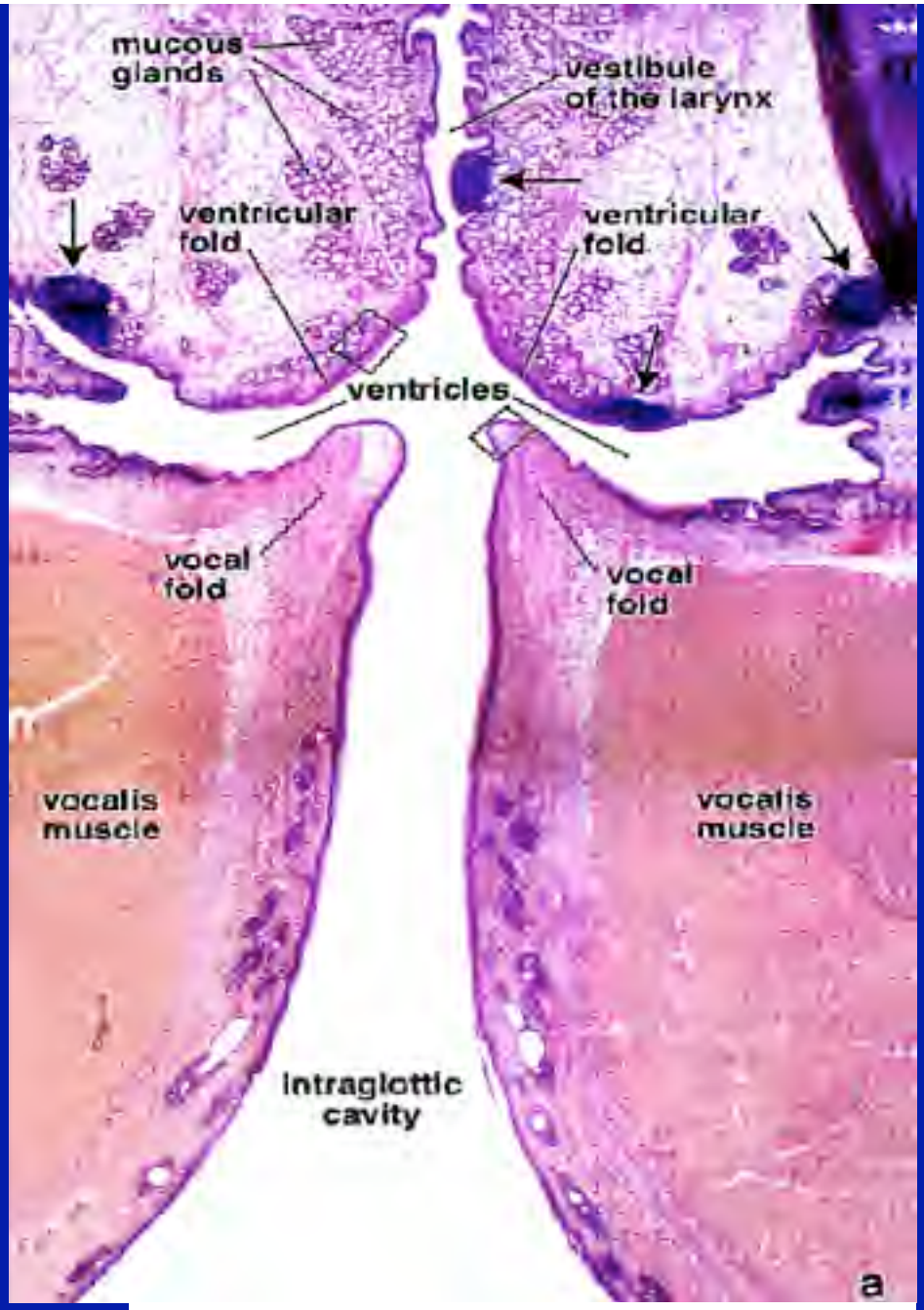
Color Textbook of Histology; 2nd edition, 1994; Gartner and Hiatt; Williams and Wilkins; Plate 12.1, Fig. 1

Light micrograph of olfactory epithelium (note the absence of goblet cells)



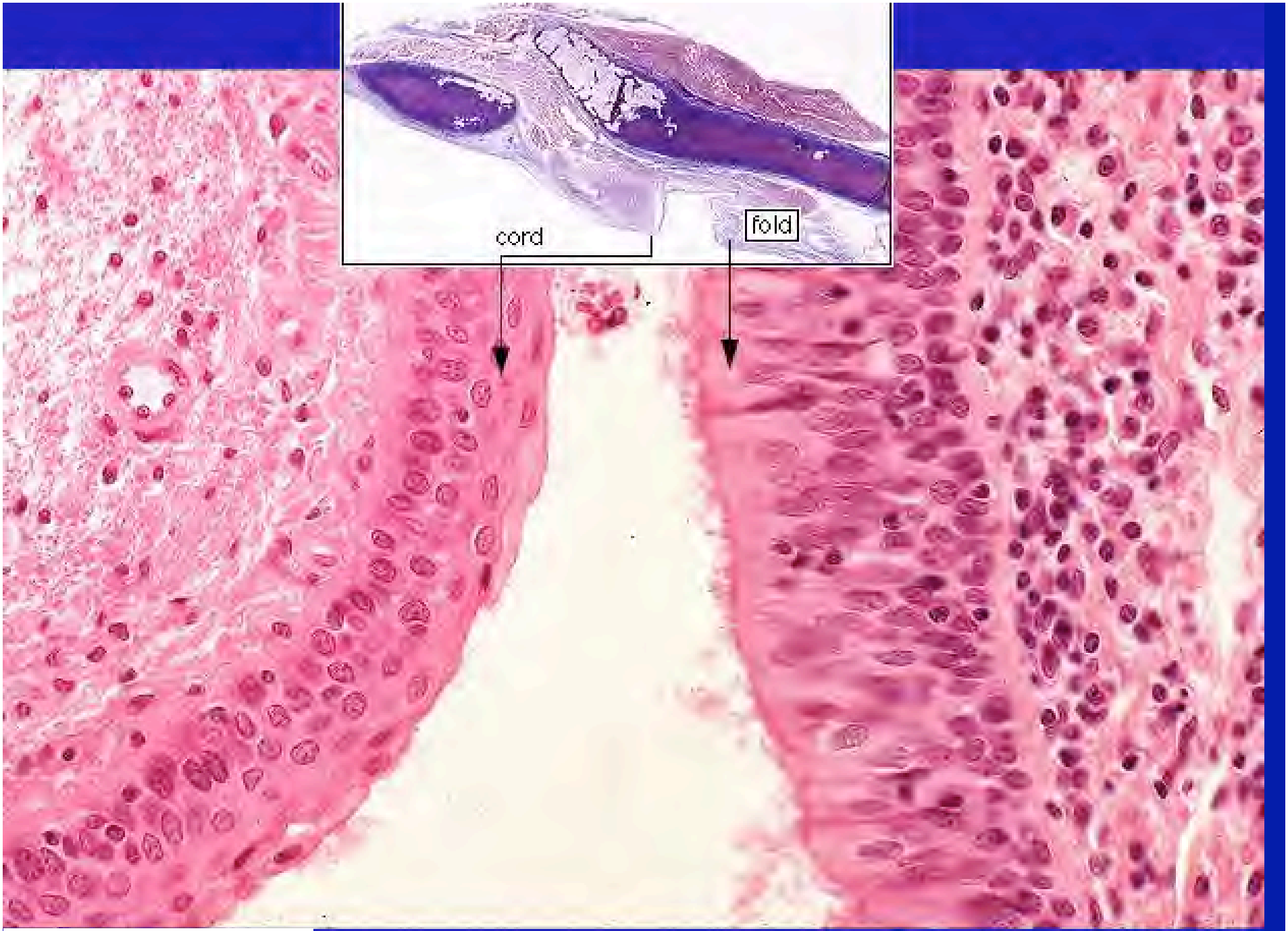
Color Textbook of Histology; 2nd edition, 1994; Gartner and Hiatt; Williams and Wilkins; Plate 12.1, Fig. 2

Light micrograph of olfactory epithelium (note the absence of goblet cells)



Histology – A Text and Atlas; 5th edition, 2006, Ross and Pawlina, Lippincott Williams and Wilkins; Fig 19.4

True vocal cords are not lines by a respiratory epithelium, but rather by a stratified non-keratinized squamous epithelium.



PD-INEL Color Atlas of Basic Histology; 1993; Berman; Appelton and Lange, Fig 14-2

Two types of glands are found in the lamina propria of the laryngeal and tracheal respiratory epithelium: Serous and mucus producing glands

Human Histology, 1st edition, 1992, Stevens and Lowe, Grower Medical Publishing , Fig 9.8

Trachea with C-shaped hyaline cartilage ring

Light micrograph of a smaller bronchus

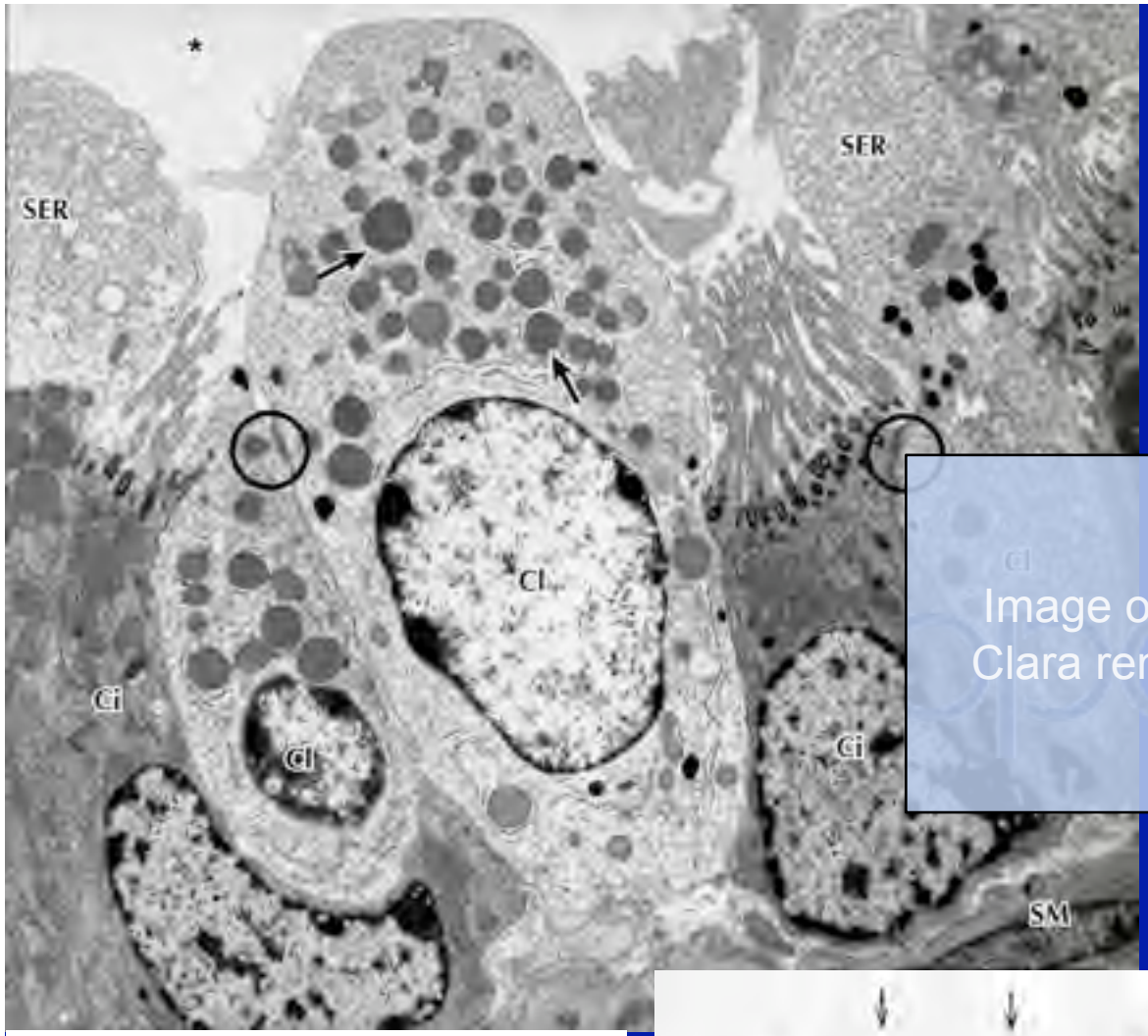
Color Atlas of Basic Histology; 1993; Berman; Appelton and Lange Fig 14-10

Color Atlas of Basic Histology; 1993; Berman; Appelton and Lange; Fig 14-11

Higher magnification of a bronchial wall

PD-INEL Color Atlas of Basic Histology; 1993; Berman; Appelton and Lange; Fig 14-13

Bronchiole (note the appearance of more abundant smooth muscle). This muscle layer is causally involved in asthma.



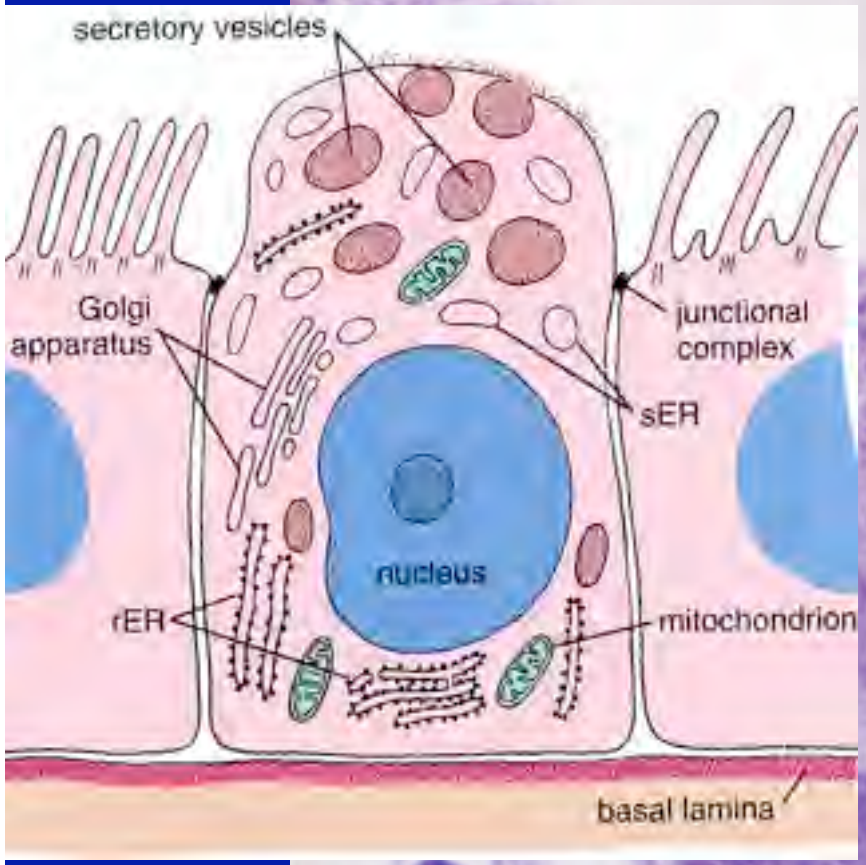
Netter's Essential Histology; 2008; Ovalle and Nahirney; Elsevier; page 346 PD-INEL

Transmission EM of bronchiolar epithelium with a Clara cell in the center. Clara cells are abundant, dome-shaped secretory cells in the terminal bronchioles.

Image of Max Clara removed

Max Clara (1937)
Zeitschr. mikro.-anat. Forsch.
41:321-47

PD-INEL M. Clara (1937) Zeitschr. Mikr0.-anat. Forschung 41: 321-47

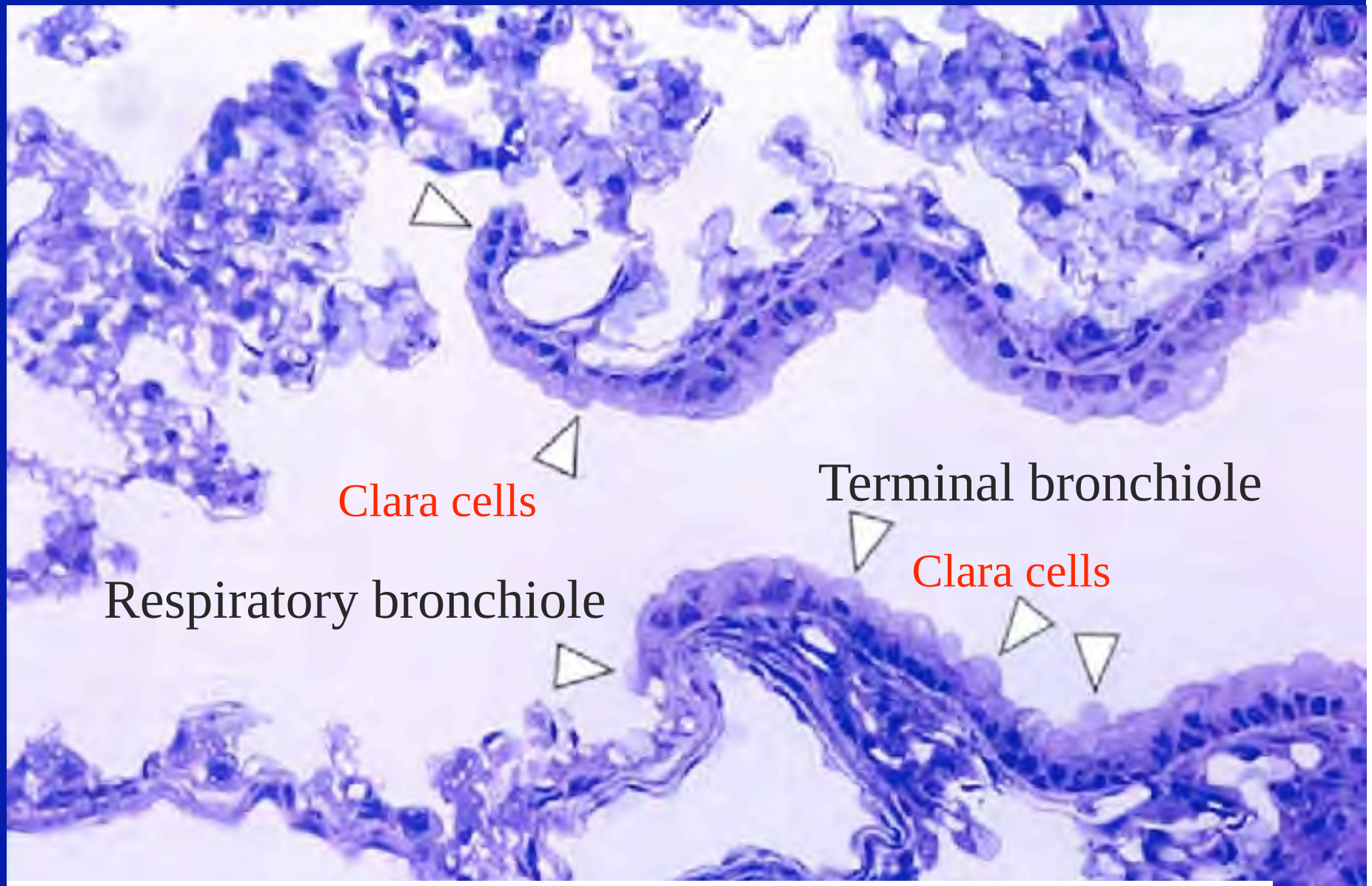


PD-INEL Histology – A Text and Atlas; 5th edition, 2006, Ross and Pawlina, Lippincott Williams and Wilkins; Fig 19.12

Clara cells are not ciliated and secrete “protective” proteins. They have an extensive smooth ER that is involved in the detoxification of inhaled substances. Furthermore, they act as progenitor/stem cells for ciliated and non-ciliated bronchiolar epithelial cells.

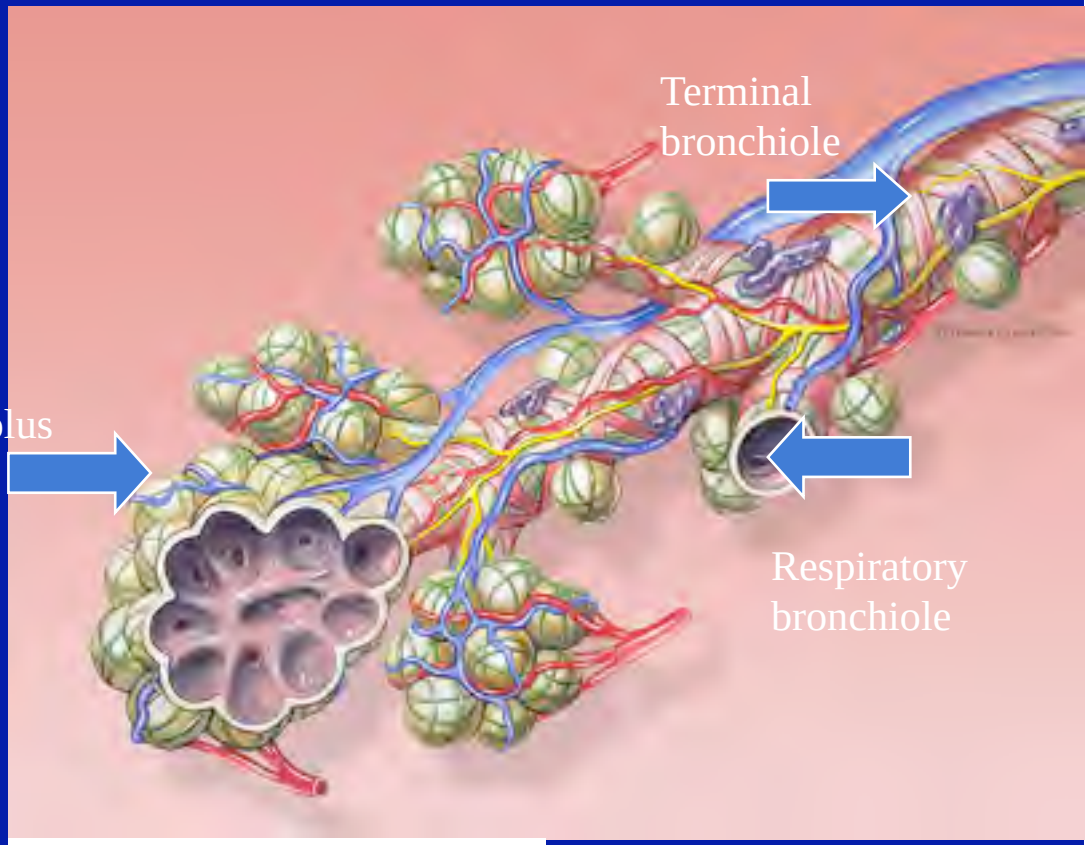
PD-INEL Clara cell image: Basic Histology – Text & Atlas; 10th edition, 2003; Junqueira and Carneiro, Lange McGraw-Hill; Fig 17-12

Clara cells in a terminal bronchiole

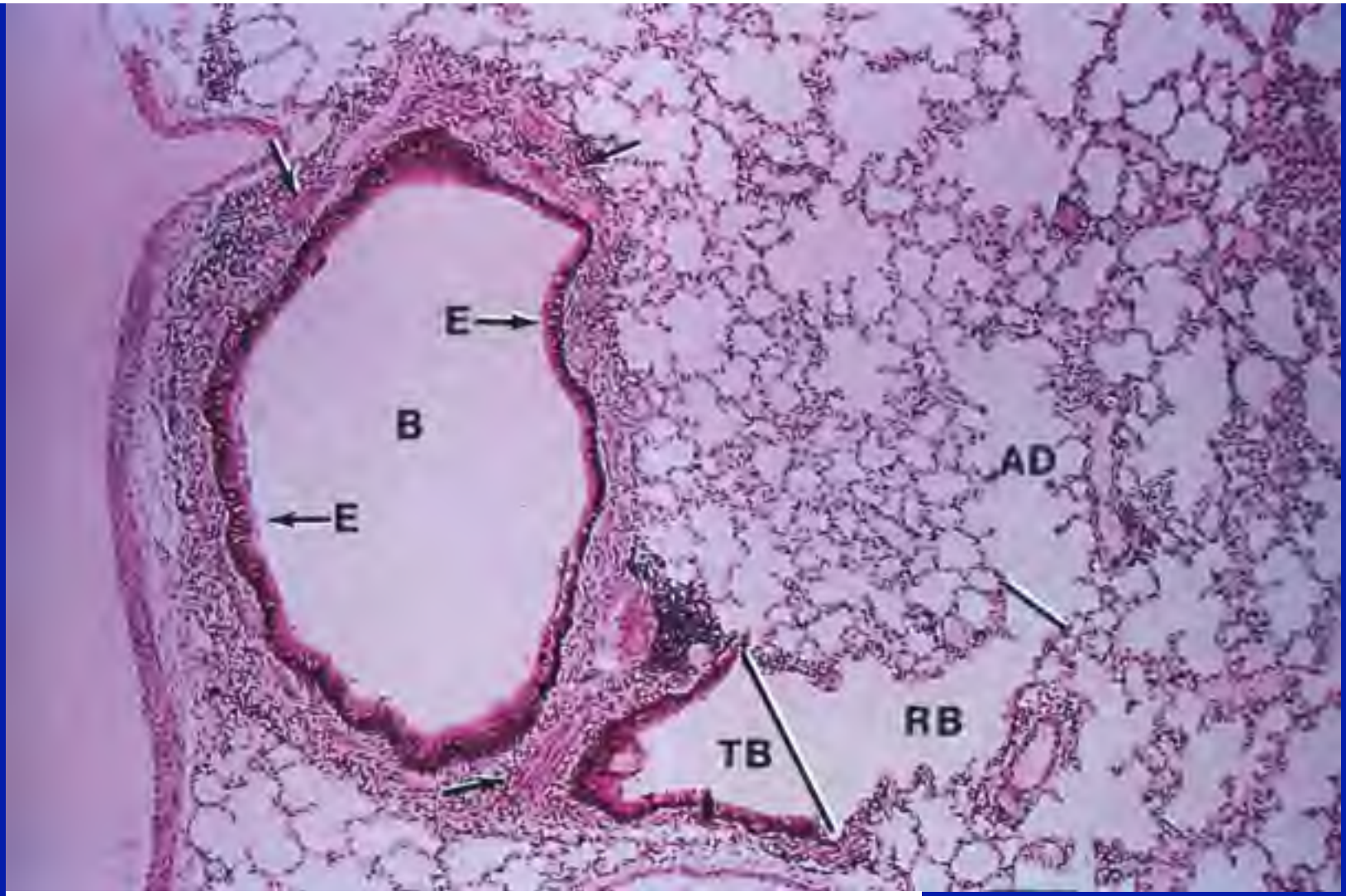


Basic Histology – Text & Atlas by Junqueira and Carneiro; 10th edition, 2003; Lange McGraw-Hill Modified from Fig 17-18

Transition from the conducting to the respiratory portion of the respiratory tract

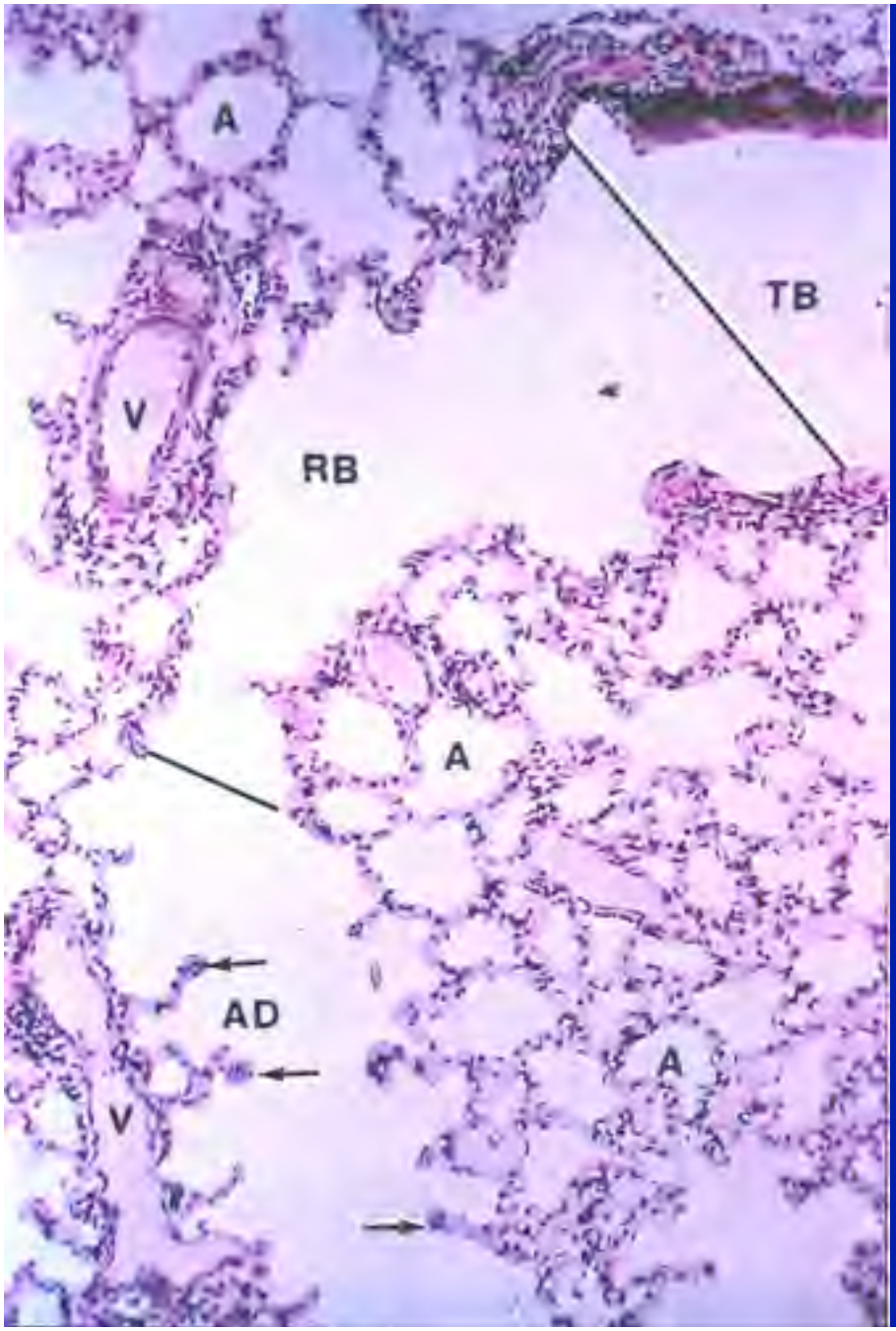


Original Image: Human Histology, 1st edition, 1992, Stevens and Lowe, Grower Medical Publishing ; Fig 9.12a



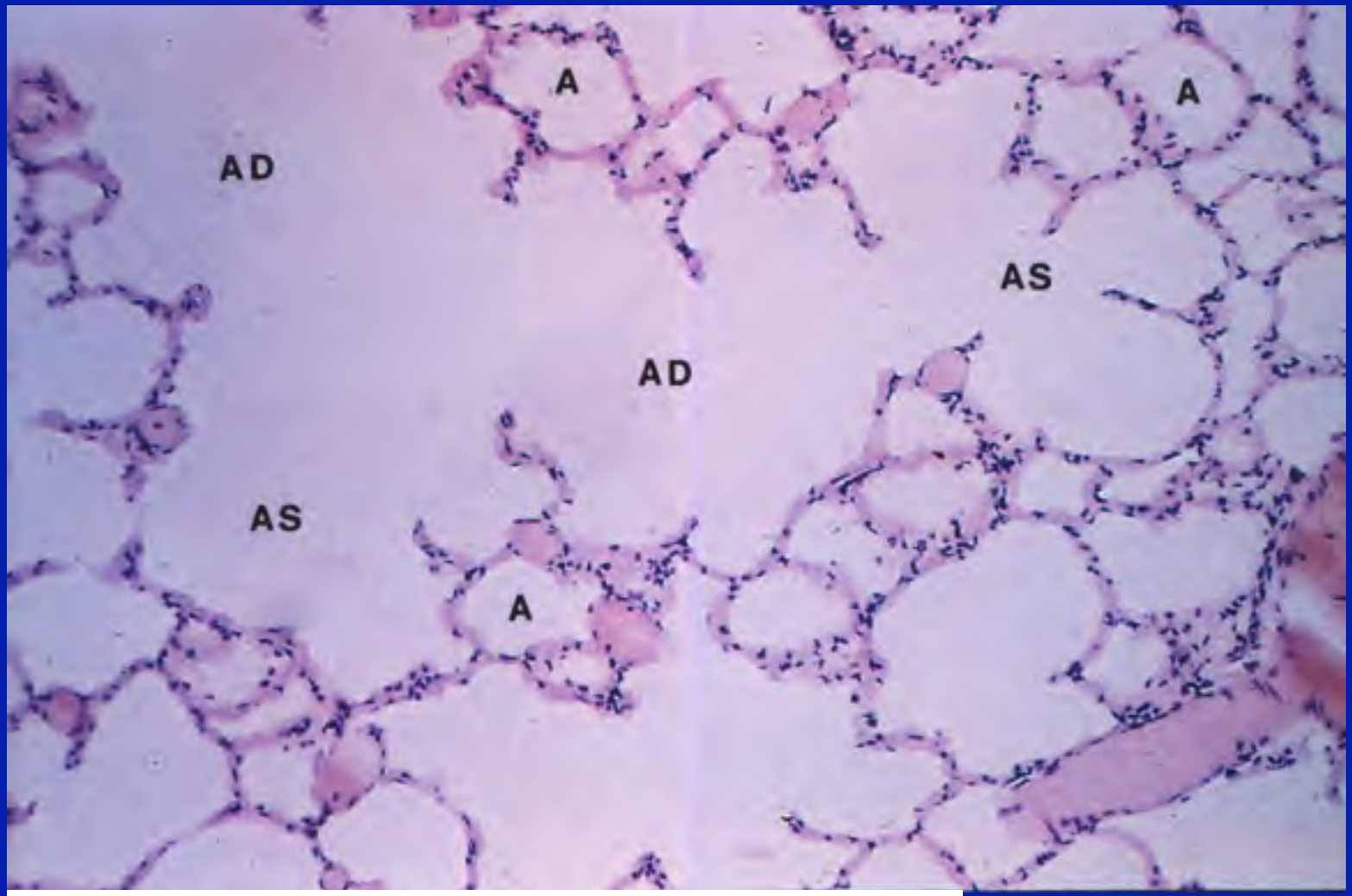
PD-INEL Color Atlas of Basic Histology, 1993, Berman, Appelton and Lange, Fig 14-15

Transition from the terminal (TB) to the respiratory bronchiole (RB)



PD-INEL Color Atlas of Basic Histology, 1993, Berman, Appelton and Lange, Fig 14-16

Structure of a respiratory bronchiole and an alveolar duct

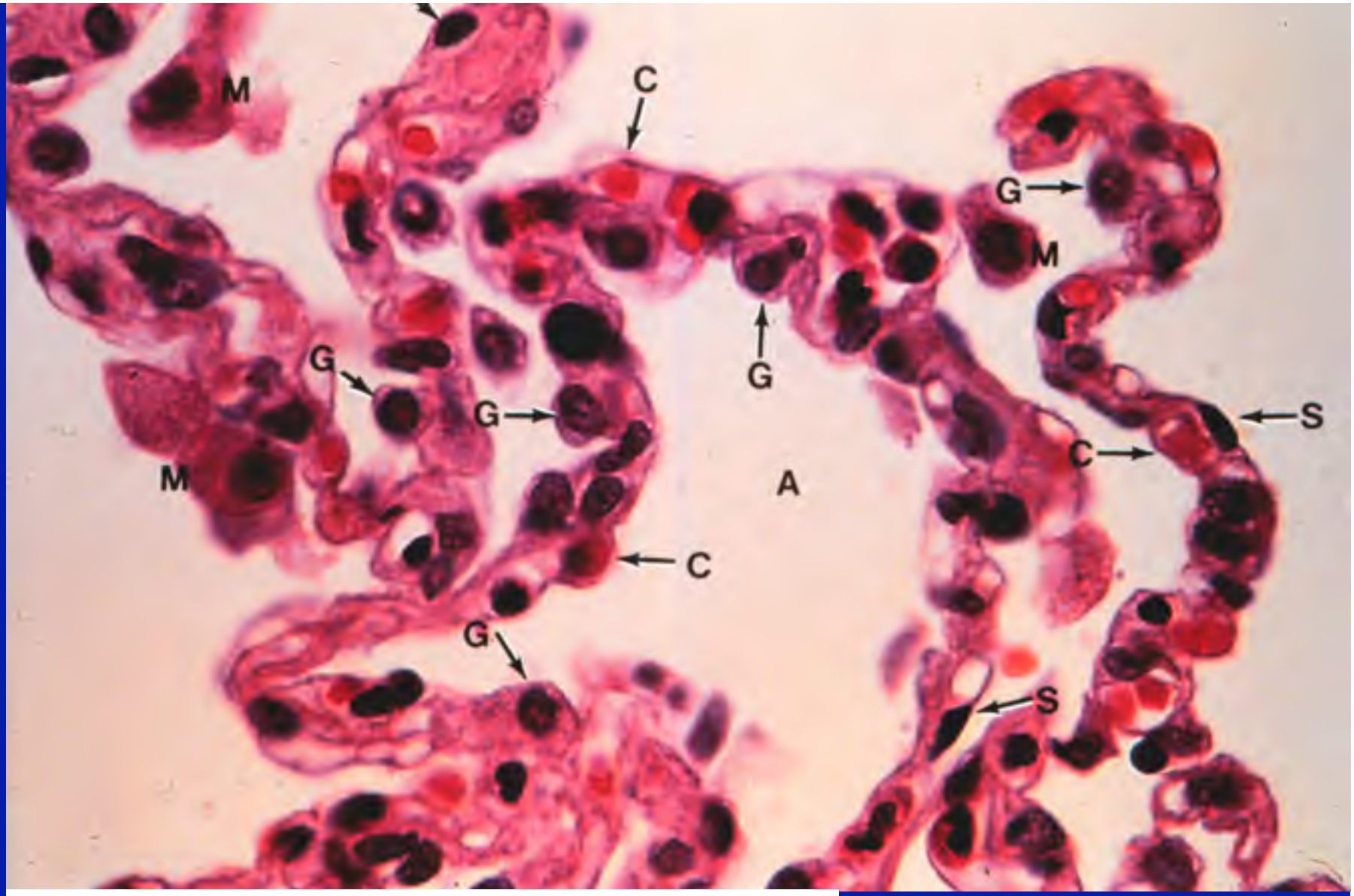


PD-INEL Color Atlas of Basic Histology, 1993, Berman, Appelton and Lange, Fig 14-19

Alveolar ducts branch further into alveolar sacs and single alveoli

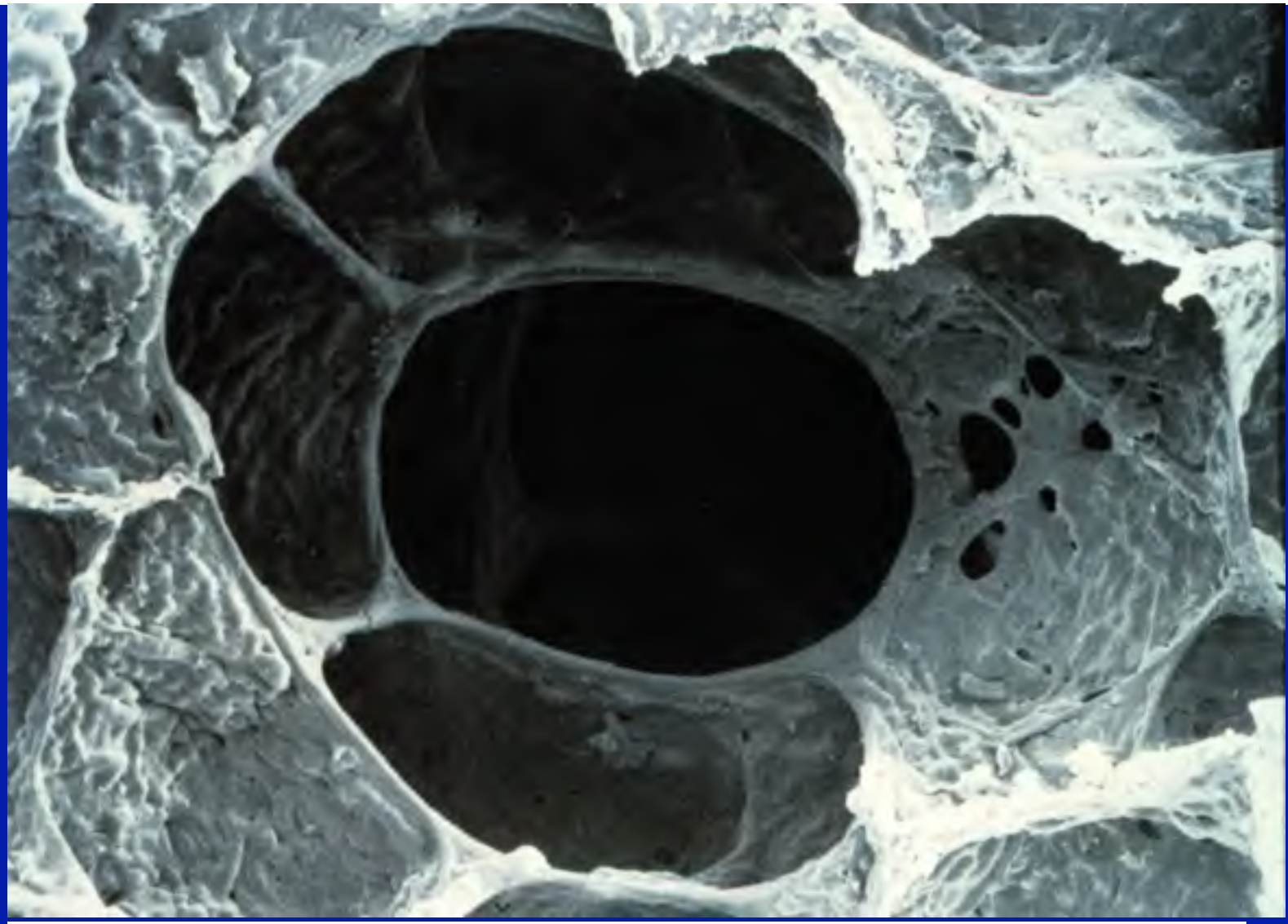
Color Atlas of Histology, 1992, Erlandsen and Magney, Mosby Book, Fig 17-20

Scanning EM of alveolar space



PD-INEL Color Atlas of Basic Histology, 1993, Berman, Appelton and Lange, Fig 14-20

Light micrograph of alveolar wall

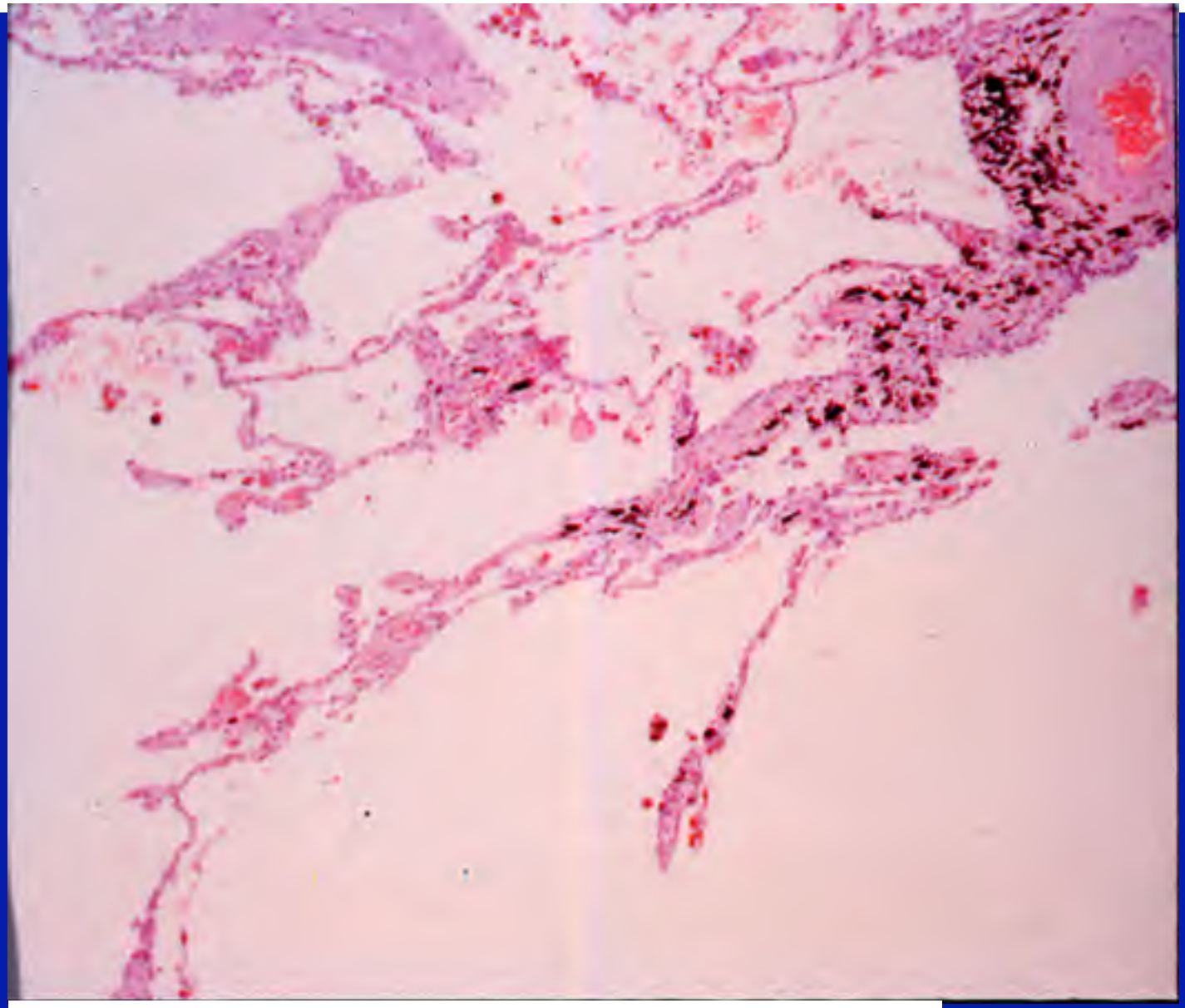


PD-INEL Cell and Tissue Ultrastructure – A Functional Perspective, 1993, Cross and Mercer, Freeman and Co., Fig 25-38

Scanning EM of an alveolus demonstrates “holes” in the alveolar wall.

Original Images: Human Histology, 1st edition, 1992, Stevens and Lowe, Grower Medical Publishing, Fig 9.14

Structure of the interalveolar septum with Pores of Kohn (allow collateral ventilation)



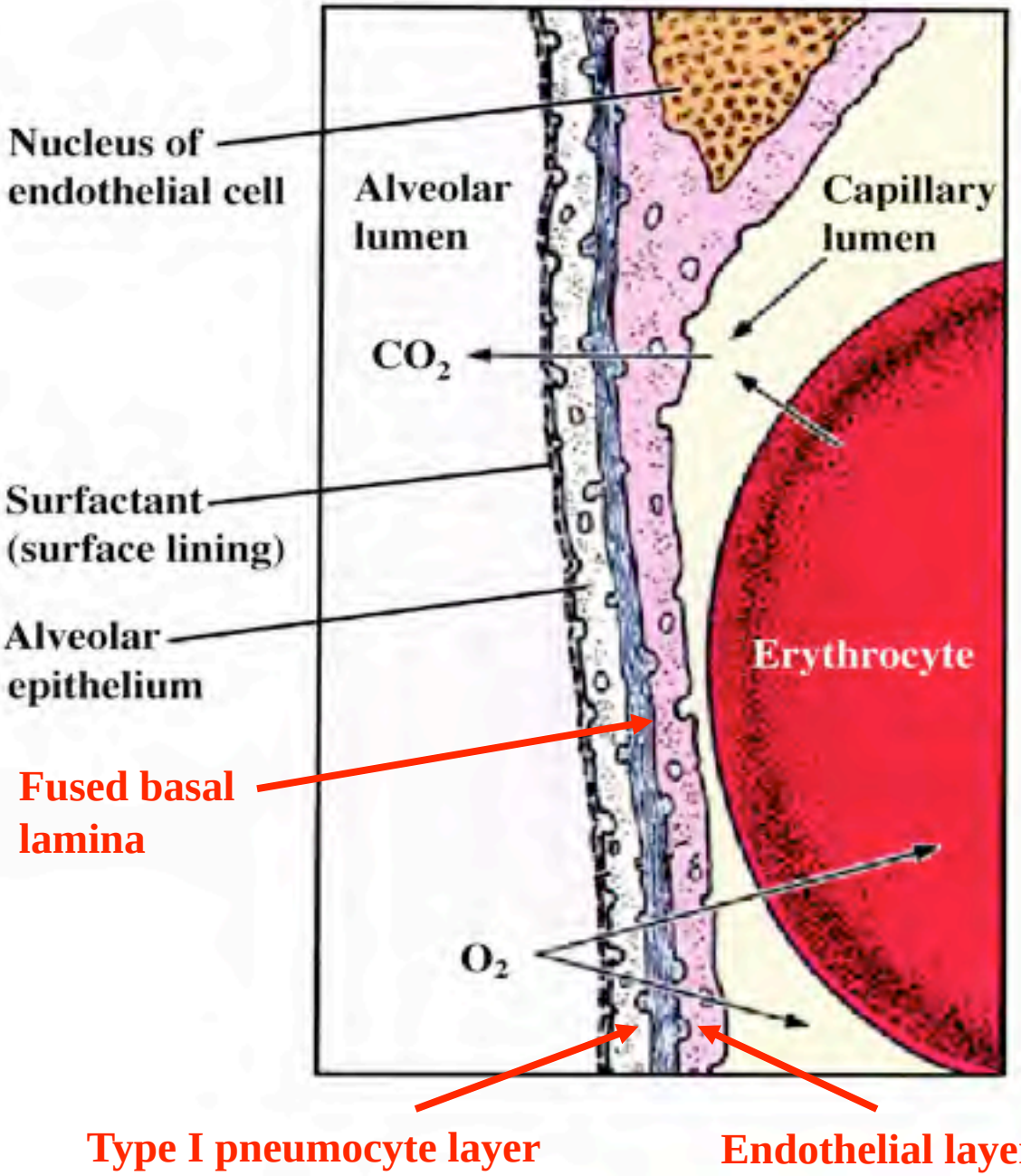
PD-INEL

Human Histology, 2nd edition, 1997, Stevens and Lowe, Mosby, Fig 10.15

Destruction of alveolar organization in emphysema patient

Original Image: Human Histology, 1st edition, 1992, Stevens and Lowe, Grower Medical Publishing, Fig 9.14

Air-blood barrier in the interalveolar septum

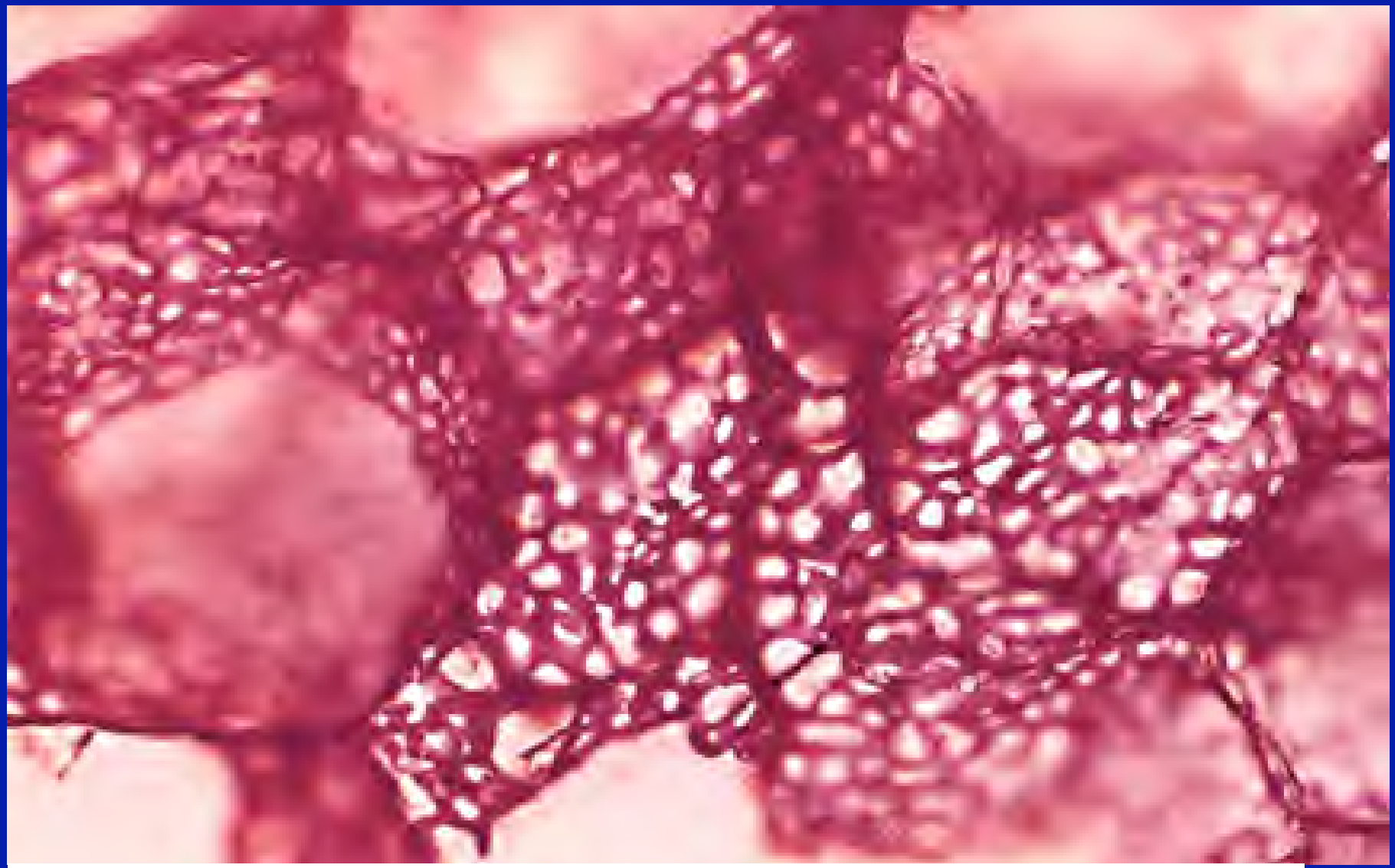


The air-blood barrier consists of three different components, two cellular and one acellular.

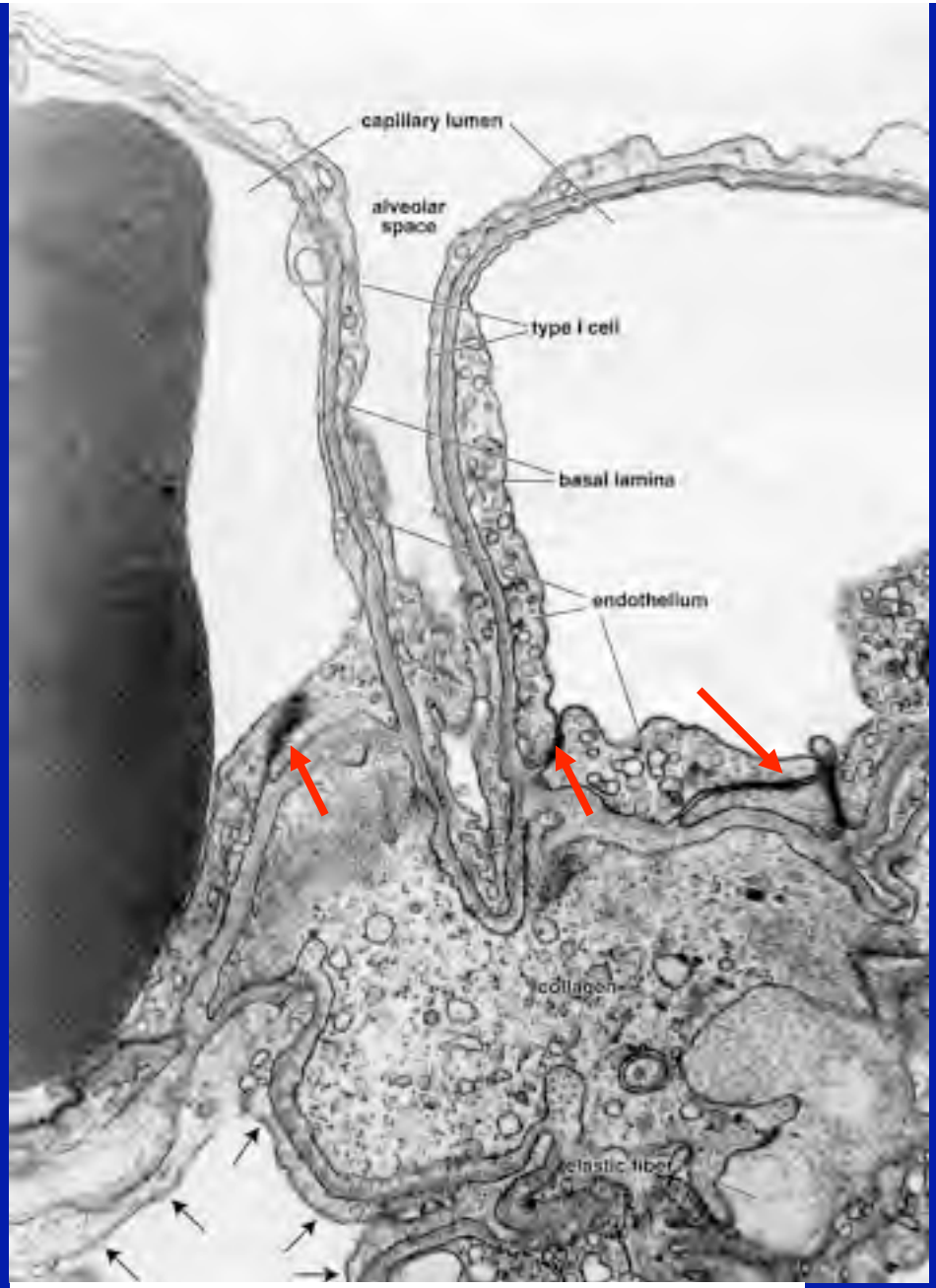
The endothelial, as well as the type I pneumocyte layer are sealed by tight junctions.

 Basic Histology – Text & Atlas, 10th edition, 2003, Junqueira and Carneiro, Lange McGraw-Hill, Fig 17-20

Capillary system in the alveolar septa.



Mammalian Histology-B408; Department of Biological Sciences; University of Delaware. Produced by Roger C. Wagner and Fred E. Hossler

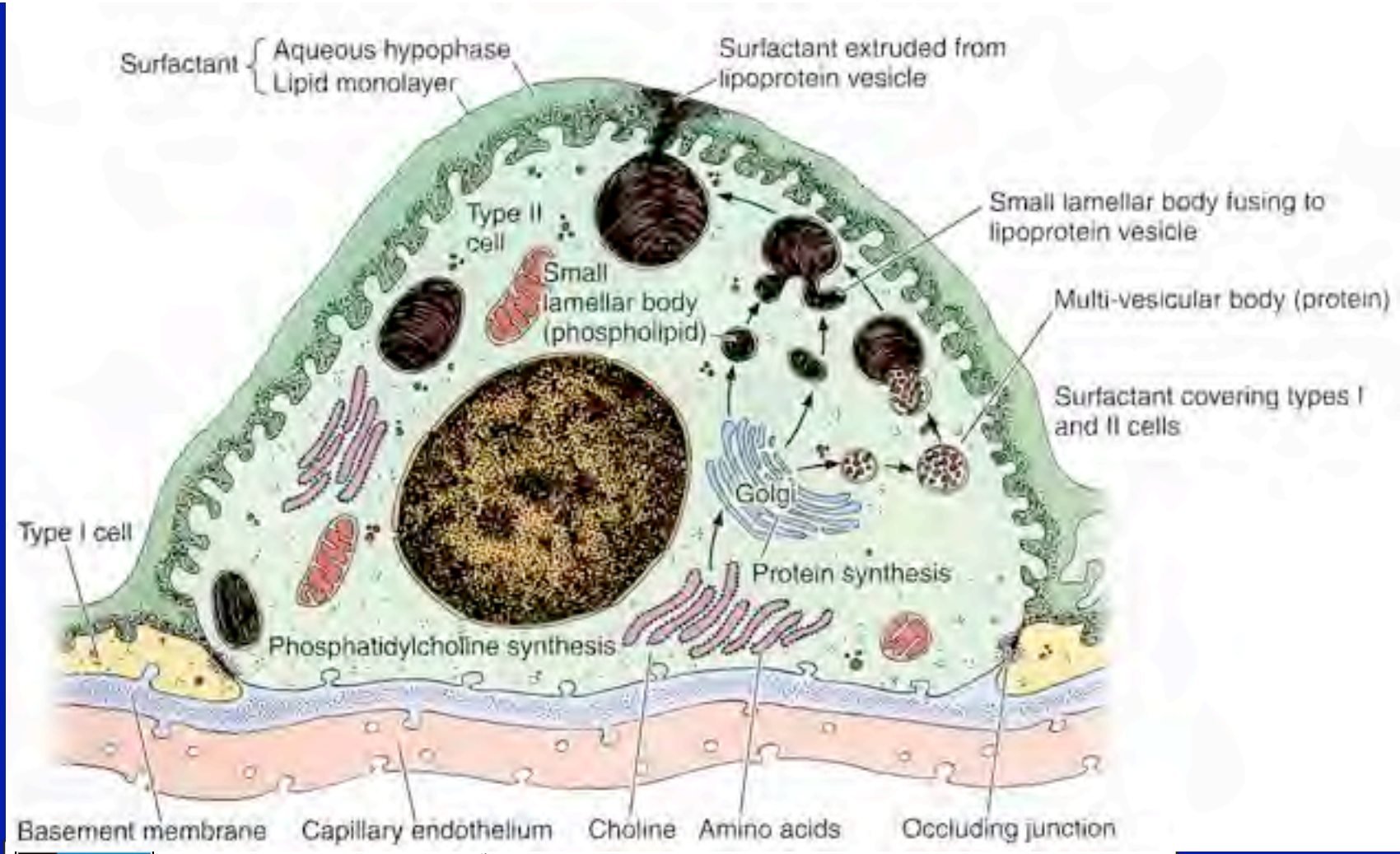


Histology – A Text and Atlas, 5th edition, 2006, Ross and Pawlina, Lippincott Williams and Wilkins, Fig 19.19 PD-INEL

Transmission EM of air-blood barrier

Gas exchange occurs by diffusion across the alveolar wall, which on average is only 0.1 to 1.5 µm thick.

The red arrows mark tight junctions



 Basic Histology – Text & Atlas, 10th edition, 2003, Junqueira and Carneiro, Lange McGraw-Hill, Fig 17-25

Type II pneumocytes are secretory cells, which produce a protein-lipid secretion product, called surfactant.

Composition of surfactant:

Lipids (90%)

Dipalmitoylphosphatidylcholine (DPPC), Phosphatidylglycerol, Cholesterol…

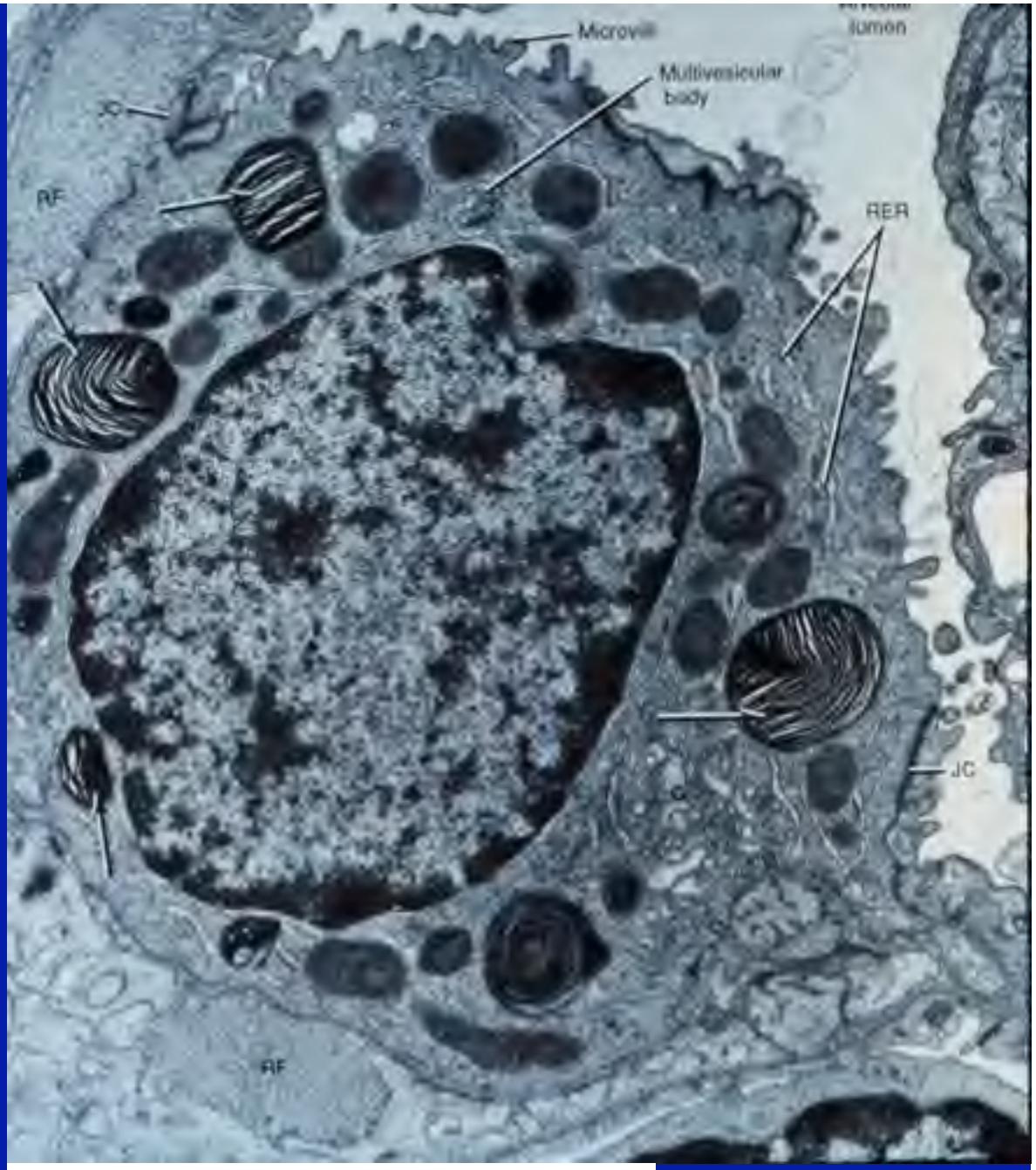
Proteins (10%)

Plasma proteins,

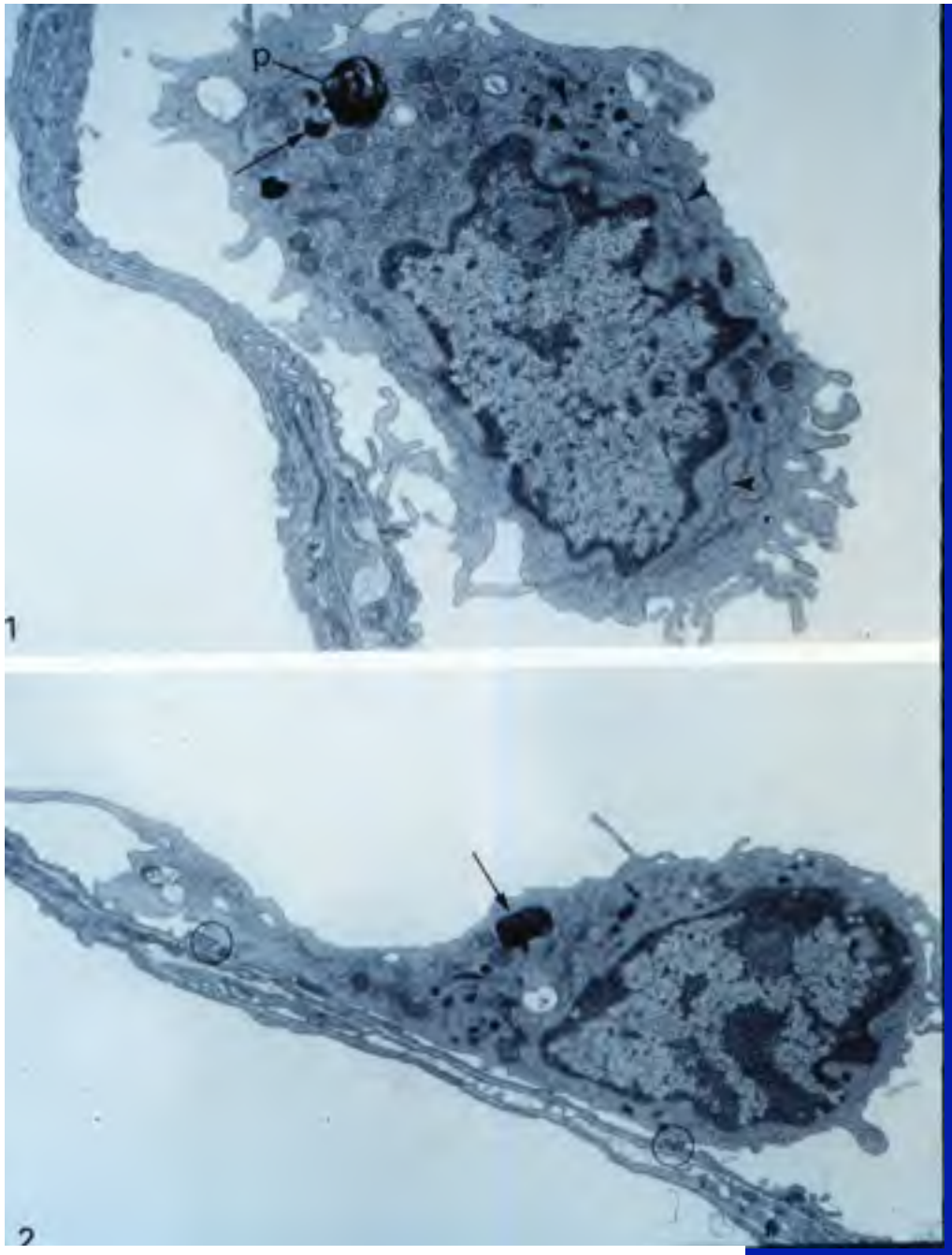
Surfactant proteins A, B, C and D

Lamellar bodies constitute the secretory vesicles of type II pneumocytes.

Infants born before 30 weeks of gestation often are unable to produce sufficient quantities of surfactant, a situation known as Infant respiratory distress syndrome (RDS).

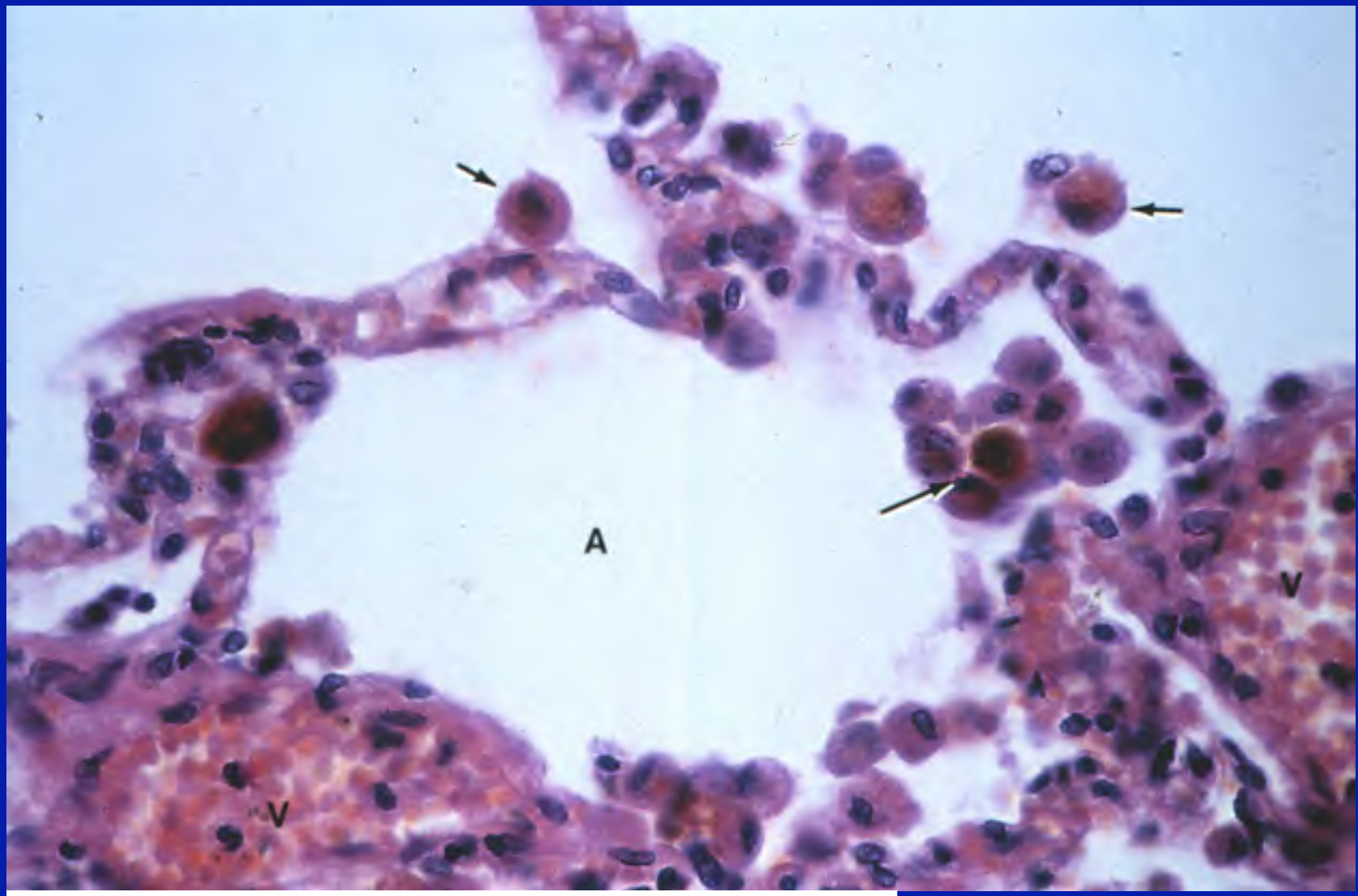


Basic Histology – Text & Atlas, 10th edition, 2003, Junqueira and Carneiro, Lange McGraw-Hill, Fig 17-26



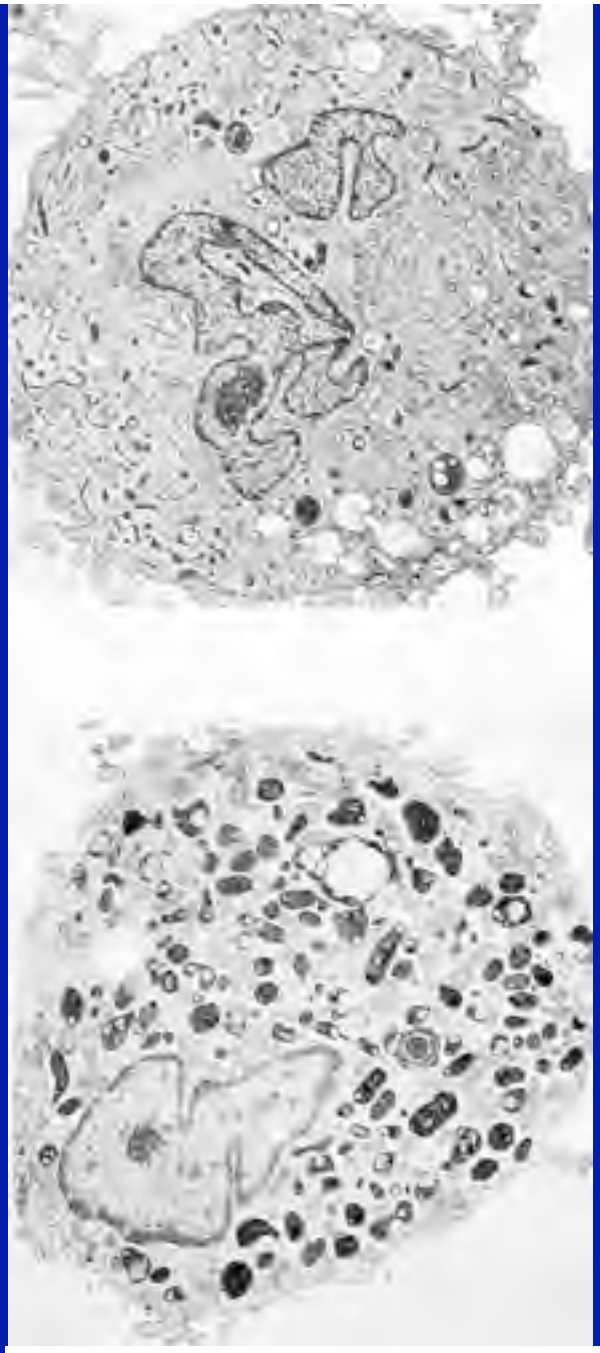
Cell and Tissue Ultrastructure – A Functional Perspective, 1993, Cross and Mercer, Freeman and Co., Page 317

Pulmonary macrophages or dust cells



 Color Atlas of Basic Histology, 1993, Berman, Appelton and Lange, Fig 14-21

Light micrograph of pulmonary macrophages



Pulmonary macrophage from a non-smoker

Pulmonary macrophage from a smoker

Color Atlas of Histology, 1992, Erlandsen and Magney, Mosby Book, Figs 17-15 and 17-16

Intrapulmonary Blood Circulation

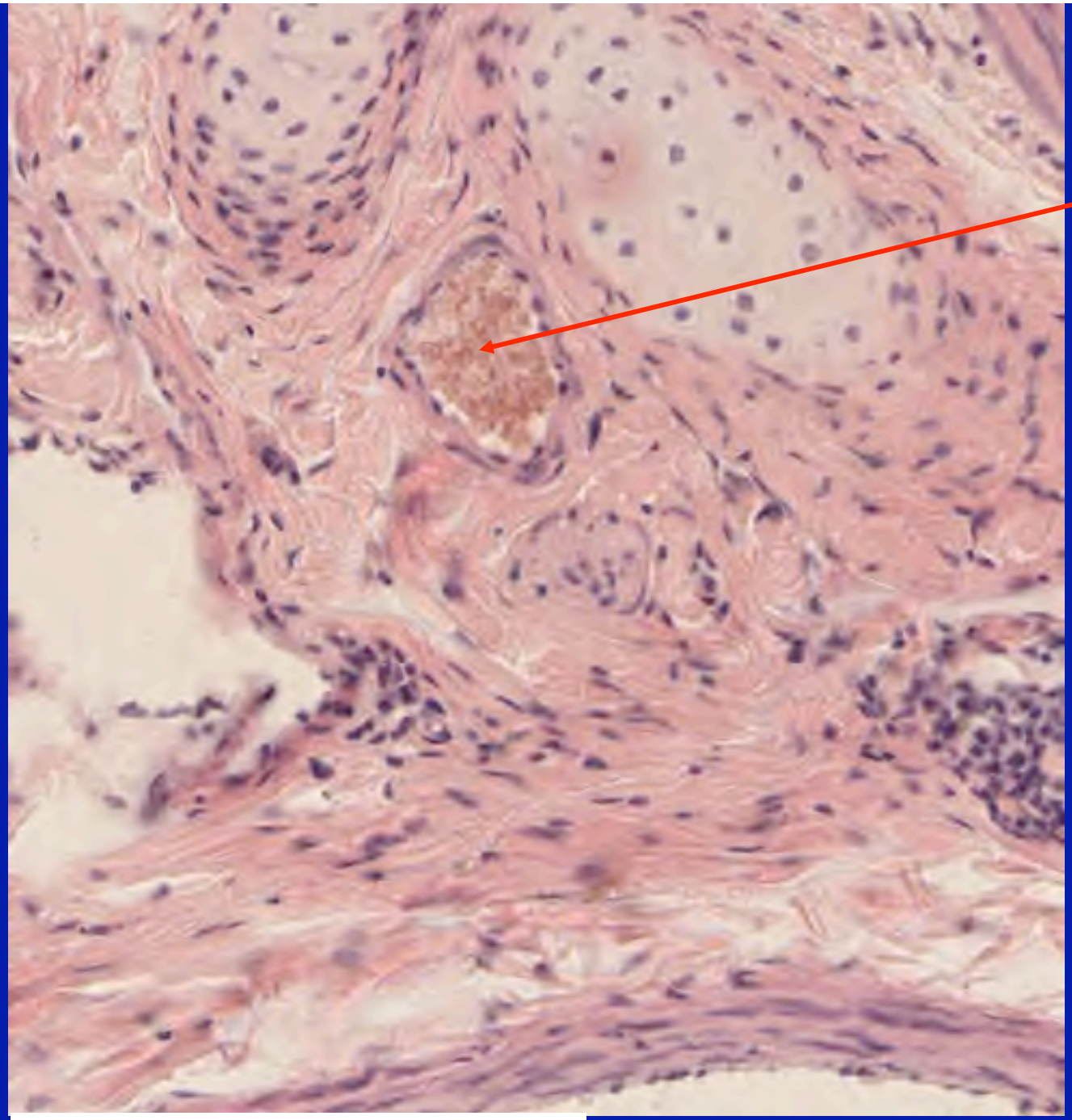
Original Image: Netter's Essential Histology, 2008, Ovalle and Nahirney, Elsevier, page 347

Bronchial arteries and Pulmonary arteries travel together along the bronchiolar system,

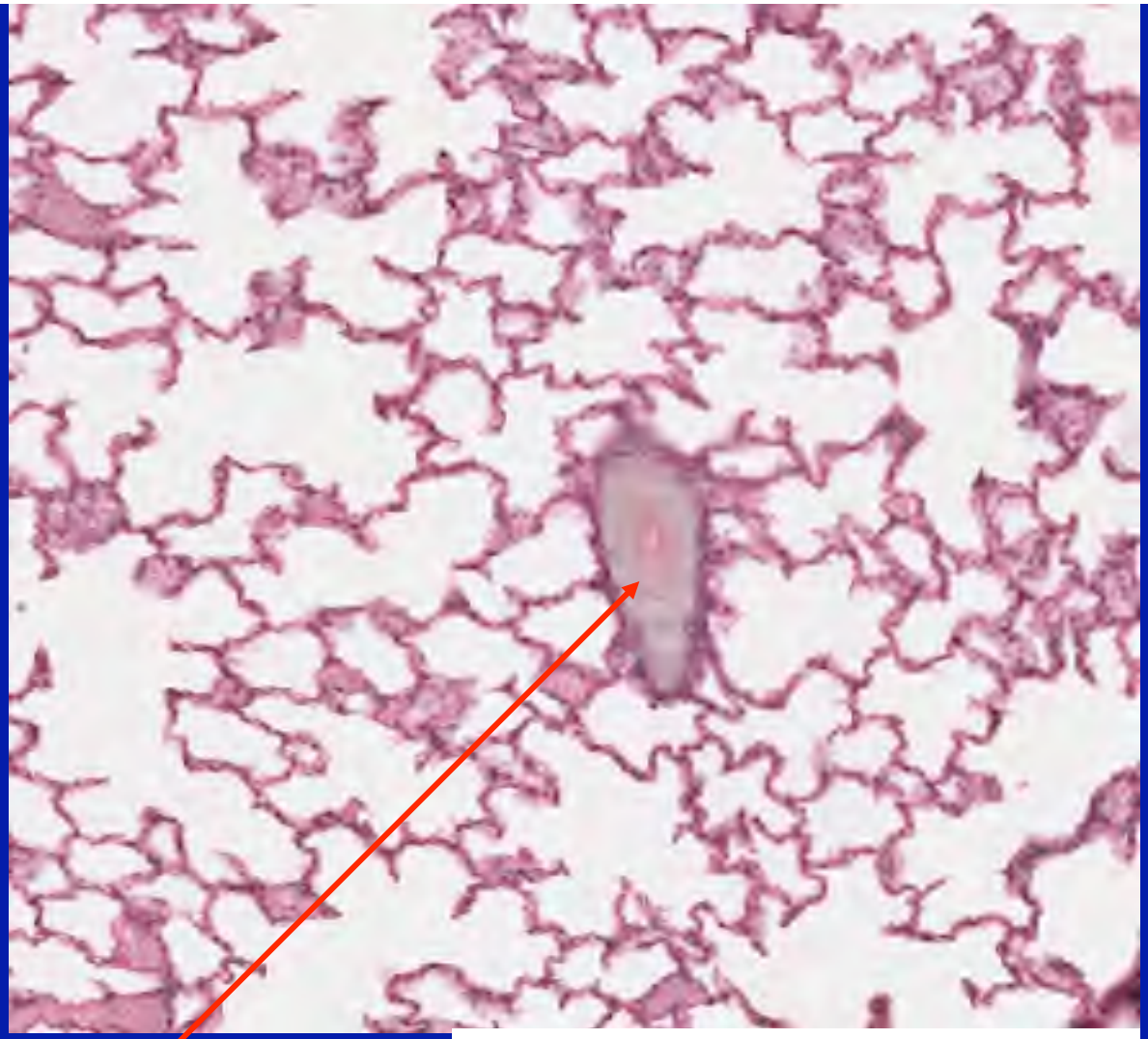
Pulmonary veins are usually not associated with the lower branches of the bronchiolar system

Pulmonary arteries supply deoxygenated blood.
Bronchial arteries supply oxygenated blood.
After oxygenation in the capillary plexuses, blood is drained by Pulmonary veins.

Pulmonary arteries are large and relatively thin-walled. They are associated with the bronchiolar tree.

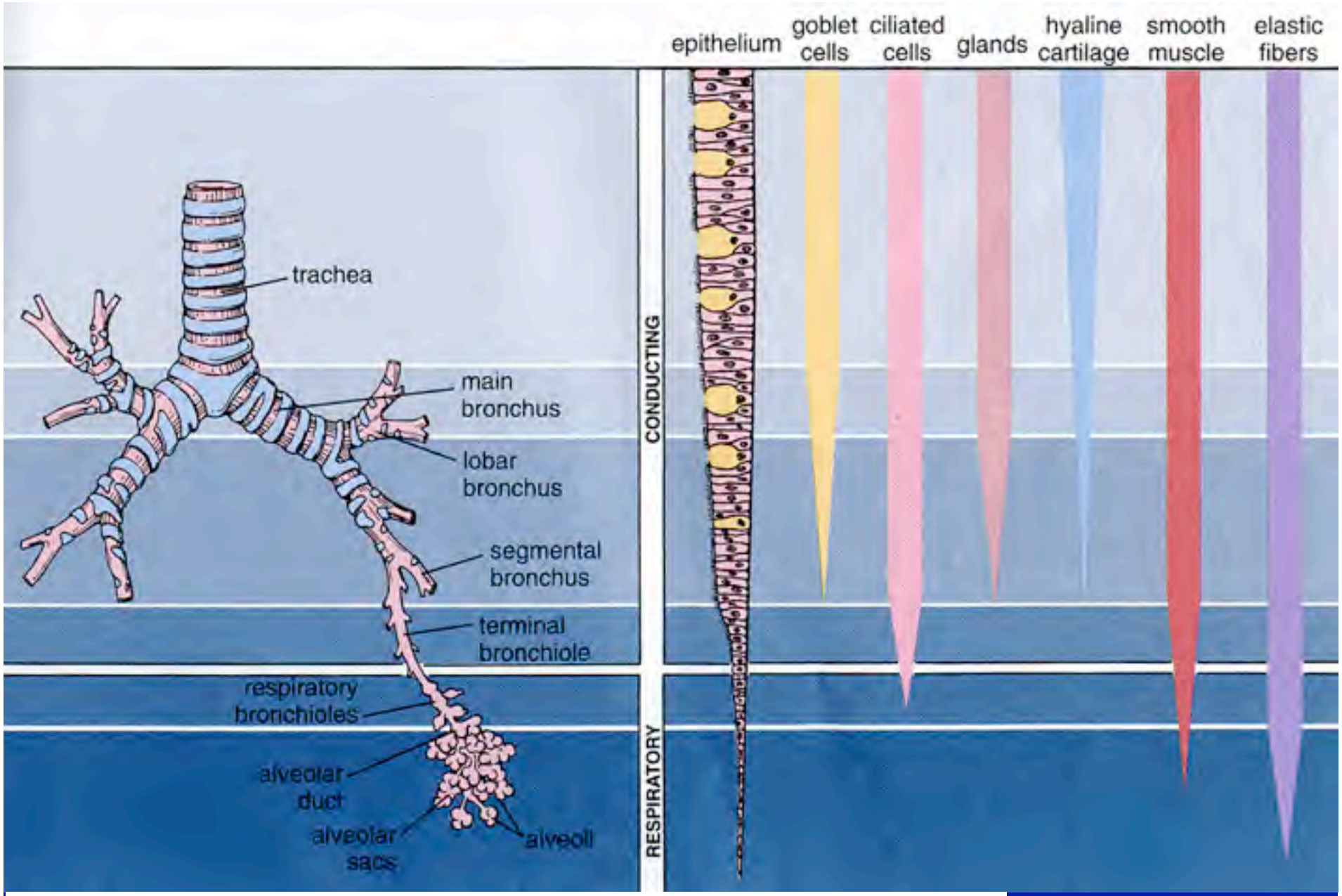


Bronchial arteries are much smaller and considering their size have a thicker wall. They also accompany the branches of the bronchiolar tree.



Pulmonary veins collect blood from both Pulmonary arteries and Bronchial arteries.

They are usually not associated with bronchioles.



PD-INEL Histology – A Text and Atlas; 5th edition, 2006, Ross and Pawlina, Lippincott Williams and Wilkins Fig 19.1

Histological changes along the respiratory tree

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Slide 9: Human Histology, 2nd edition, 1997, Stevens and Lowe, Mosby Fig 10.4
Slide 10: Wheater's Functional Histology, 4th edition, 2000, Young and Heath, Churchill Livingstone Elsevier, Fig 12.3
Slide 11: Color Atlas of Basic Histology, 1993, Berman, Appelton and Lange, Fig 14-3
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Slide 14: Basic Histology – Text & Atlas, 10th edition, 2003, Junqueira and Carneiro, Lange McGraw-Hill, Fig. 17-4 top
Slide 15: Cell and Tissue Ultrastructure – A Functional Perspective, 1993, Cross and Mercer, Freeman and Co., page 305
Slide 16: "Bowman" Wikipedia, http://en.wikipedia.org/wiki/Sir_William_Bowman,_1st_Baronet; Dr. Thomas Caceci, http://education.vetmed.vt.edu/curriculum/vm8054/labs/Lab25/lab25.htm
Slide 17: Color Textbook of Histology, 2nd edition, 1994, Gartner and Hiatt, Williams and Wilkins, Plate 12.1, Fig. 1
Slide 18: Color Textbook of Histology, 2nd edition, 1994, Gartner and Hiatt, Williams and Wilkins, Plate 12.1, Fig. 2
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Slide 24: Color Atlas of Basic Histology, 1993, Berman, Appelton and Lange, Fig 14-11
Slide 25: Color Atlas of Basic Histology, 1993, Berman, Appelton and Lange, Fig 14-13
Slide 26: Netter's Essential Histology, 2008, Ovalle and Nahirney, Elsevier, page 346; M. Clara (1937) Zeitschr. Mikr0.-anat. Forschung 41: 321-47
Slide 27: Histology – A Text and Atlas, 5th edition, 2006, Ross and Pawlina, Lippincott Williams and Wilkins, Fig 19.12; Clara cell image: Basic Histology – Text & Atlas; 10th edition, 2003; Junqueira and Carneiro, Lange McGraw-Hill; Fig 17-12
Slide 28: Basic Histology – Text & Atlas by Junqueira and Carneiro, 10th edition, 2003, Lange McGraw-Hill Modified from Fig 17-18
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