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Histology of the Respiratory Tract

M1 – Cardiovascular/Respiratory Sequence
Michael Hortsch, Ph.D.
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
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
Histological changes along the respiratory tree

Histology – A Text and Atlas; 5th edition, 2006, Ross and Pawlina, Lippincott Williams and Wilkins  Fig 19.1
Histological features of the nasal cavity
Nasal venous sinuses warm the incoming air.
Transition from stratified squamous epithelium to the respiratory epithelium at the laryngeal ventricle
Resident cells of the respiratory epithelium
Light micrograph of the respiratory epithelium/mucosa
Scanning EM of the respiratory epithelium

G = goblet cell
Transmission EM of a respiratory epithelium
Diagram of the olfactory epithelium
Light micrograph of olfactory epithelium (note the absence of goblet cells)
Light micrograph of olfactory epithelium (note the absence of goblet cells)
True vocal cords are not lines by a respiratory epithelium, but rather by a stratified non-keratinized squamous epithelium.
Two types of glands are found in the lamina propria of the laryngeal and tracheal respiratory epithelium: Serous and mucus producing glands.
Trachea with C-shaped hyaline cartilage ring
Light micrograph of a smaller bronchus
Higher magnification of a bronchial wall
Bronchiole (note the appearance of more abundant smooth muscle). This muscle layer is causally involved in asthma.
Clara cells are abundant, dome-shaped secretory cells in the terminal bronchioles. Transmission EM of bronchiolar epithelium with a Clara cell in the center. Clara cells are abundant, dome-shaped secretory cells in the terminal bronchioles.

Max Clara (1937) Zeitschr. mikro.-anat. Forsch. 41:321-47
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.
Clara cells in a terminal bronchiole

Clara cells

Terminal bronchiole

Respiratory bronchiole

Clara cells
Transition from the conducting to the respiratory portion of the respiratory tract
Transition from the **terminal** (TB) to the **respiratory bronchiole** (RB)
Structure of a respiratory bronchiole and an alveolar duct
Alveolar ducts branch further into alveolar sacs and single alveoli
Scanning EM of alveolar space
Light micrograph of alveolar wall
Scanning EM of an alveolus demonstrates “holes” in the alveolar wall.
Structure of the interalveolar septum with Pores of Kohn (allow collateral ventilation)

Destruction of alveolar organization in emphysema patient
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.
Capillary system in the alveolar septa.
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.
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).

Pulmonary macrophages or dust cells
Light micrograph of pulmonary macrophages
Pulmonary macrophage from a non-smoker

Pulmonary macrophage from a smoker

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.
Histological changes along the respiratory tree
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Slide 9: Human Histology, 2nd edition, 1997, Stevens and Lowe, Mosby Fig 10.4
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Slide 13: Color Atlas of Basic Histology, 1993, Berman, Appelton and Lange, Fig 14-8
Slide 14: Basic Histology – Text & Atlas, 10th edition, 2003, Junqueira and Carneiro, Lange McGraw-Hill, Fig. 17-4 top
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
Slide 19: Histology – A Text and Atlas, 5th edition, 2006, Ross and Pawlina, Lippincott Williams and Wilkins, Fig 19.4
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