Objectives

• Characterize each subdivision of the respiratory system (larynx, trachea, bronchus, bronchioles, alveolar ducts, alveoli).

• Identify each of the cell types and matrix components that are involved with respiratory conduction and conditioning of the inspired air.

• Describe the structure and function of each of the components of the alveolar septum including alveolar macrophages, Type I and II alveolar cells, capillaries, fibroblasts, mast cells and matrix fibers (collagen III and elastin).

• Identify the air passages found in the lungs. These include the respiratory bronchioles, alveolar ducts, and alveoli.
Respiratory System

• Conduction
  o Maintenance of an open lumen
  o Ability to accommodate expansion and contraction,
  o Warming, moisturizing and filtering of the inspired air

• Respiration
  o Rapid exchange of atmospheric gases
  o Alveolar wall cells secrete surfactant

• Structure
  o Skeletal components (cartilage, etc.)
  o Vascularization
  o Glands in lamina propria
Epithelium in the respiratory system

Respiratory epithelium
Epithelium in the respiratory system

Respiratory epithelium

Stratified squamous

Pseudostratified columnar
Epithelium in the respiratory system

Respiratory epithelium

- Stratified squamous
- Pseudostratified columnar
- Simple squamous
Epithelium in the respiratory system

- Olfactory epithelium
- Respiratory epithelium

Types of epithelium:
- Stratified squamous
- Pseudostratified columnar
- Simple squamous
Epithelium in the respiratory system

Skin junction
True vocal cords

False vocal cords
Respiratory epithelium of trachea

1. Basement membrane
2. Ciliated cell
3. Goblet cell
EM 8 trachea; 20630x

1. Mucous
2. Microvilli
3. Cilia
4. Goblet cell
The highly vascular nature of the lamina propria is important for conditioning inhaled air. A complex vasculature with loops of capillaries near the epithelial surface carries blood in a general direction counter to the flow of inspired air and releases heat to warm that air. Also, the swell bodies reduce the flow of air on either side of the nose and switches every 30 min to allow rehydration on one side as air flow is shifted to the other side.
Respiratory epithelium
Slide 36: Respiratory (Olfactory) mucosa and nasal septum

Cartilaginous nasal septum
Hyaline cartilage

Highly vascular lamina propria
Swell bodies

Bowman’s glands

Pseudostratified columnar epithelium
What does your nose do for you?

Beyond its important role as the collector of olfactory information—as whiffs of smoke that warn of impending danger or smells of cooks that whet the appetite—the nose acts as an air conditioner for the respiratory system. Every day, it treats approximately 500 cubic feet (15 cubic meters) of air, the amount enclosed in a small room. It filters dust, traps bacteria from the air, brings air to the temperature of the body and also adds moisture. And then, the nose has some lesser-known functions. Among them, it gives your voice resonance, adding a richness of tone that would otherwise be lacking.

[Diagram of nasal anatomy]

Odor receptors on the roof of the nasal passages communicate through a bony plate to the olfactory bulbs, which lead directly to the brain.

Hairlike cilia in the smell patch messages upward. There are a few such patches, together taking up much space as a postage stamp.
Slide 36: Respiratory (Olfactory) mucosa and nasal septum

- Highly vascular lamina propria
- Swell bodies
- Olfactory epithelium
- Bowman’s glands
Slide 36 001: Respiratory (Olfactory) mucosa and nasal septum

- Highly vascular lamina propria
- Swell bodies
- Olfactory epithelium
- Bowman's glands
- Nerves
Slide 36: Respiratory (Olfactory) mucosa and nasal septum

- Respiratory mucosa
- Olfactory mucosa
- Bowman’s glands
- Swell bodies
LARYNX - IRREGULAR TUBE CONNECTS PHARYNX TO TRACHEA

CARTILAGE

• LARGE - HYALINE - THYROID, CRICOID

• SMALLER - ELASTIC - EPIGLOTTIS
Slide 37: Epiglottis

- Elastic cartilage
- Lamina propria with mucous glands
- Nonkeratinized stratified squamous lingual epithelium
- Respiratory epithelium
Superior (lingual) surface: nonkeratinized stratified squamous epithelium; when the epiglottis is covering the larynx, this layer is exposed and acts as a barrier to prevent swallowed food or fluid from entering the larynx.

Inferior (laryngeal) surface: pseudostratified columnar respiratory epithelium; this layer is exposed during breathing, when the epiglottis is not covering the larynx, and acts as respiratory epithelium.
Two types of cartilage are found in the larynx. Elastic cartilage occurs only in the epiglottis of the larynx. All other cartilage in the respiratory system is hyaline.
CRICOID cartilage

THYROID cartilage

true

false
Slide 38: Larynx

- False vocal cord with laryngeal glands
- Tracheal hyaline cartilage
- Vocalis muscle and vocal ligament of true vocal cord
- False vocal cord pseudostratified ciliated columnar epithelium
- True vocal cord nonkeratinized stratified squamous epithelium
- Laryngeal ventricle
Slide 39: Lower Larynx (trichrome)

1. Thyroid
2. Skeletal muscle
3. Hyaline cartilage
4. Connective tissue
5. Respiratory epithelium
6. Esophagus
7. Brown fat

Psuedostratified ciliated columnar respiratory epithelium
Glands
Lymphoid nodules
Hyaline cartilage
TRACHEA

THIN WALLED TUBE
16-20 C-SHAPED RINGS OF HYALINE
TRACHEALIS MUSCLE
• SMOOTH MUSCLE
• ALLOWS FOR REGULATION OF SIZE OF LUMEN FOR COUGH REFLEX
The capacity to narrow the lumen of the trachea by contraction of the trachealis muscle is important in the cough reflex. Narrowing the tracheal lumen increases the velocity of the expelled air and better loosening of material in the air passage.
Slide 40: Trachea

- Pseudostratified ciliated columnar epithelium
- Lamina propria composed of loose CT
- Gland in submucosa
- Hyaline cartilage
- Trachealis muscle
Slide 40: Trachea

- Goblet cells
- Blood vessel
- Lymph nodule
- Large nerve
Bronchial tree

- Larynx
- Trachea
- Right primary bronchus
- Right superior secondary bronchus
- Right middle secondary bronchus
- Right inferior secondary bronchus
- Right tertiary bronchus
- Smaller bronchi
- Left primary bronchus
- Left superior secondary bronchus
- Left tertiary bronchus
- Left inferior secondary bronchus
- Smaller bronchi
Cells in the respiratory portion

TERMINAL BRONCHIOLE
CLARE CELLS

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Ciliated cells

Elastic fibers

Smooth muscle

Respiratory BRONCHIOLE
Cells in the respiratory portion

- Type I cells
- Type II cells
- Endothelium
- Macrophages
Slide 41: Lung

- Bronchus
- Conducting bronchiole
- Respiratory bronchioles
- Alveoli
- Alveolar sac
- Alveolar duct
BLOOD-AIR BARRIER

SURFACE LINING AND CYTOPLASM OF ALVEOLAR CELLS

FUSED BASAL LAMINAE

CYTOPLASM OF ENDOTHELIAL CELL
• Mast cells function in the localized release of many bioactive substances with roles in the local inflammatory response, innate immunity, and tissue repair.
• Mast cell granules normally contain: heparin, histamine, serine proteases, eosinophil and neutrophil chemotactic factors, cytokines, etc.
19714 lung macrophages

macrophages
macrophages
Type II pneumocytes produce surfactant which helps prevent alveolar collapse at exhalation by reducing surface tension and allows alveoli to be inflated with less respiratory force, easing the work of breathing.
Slide 41 and 42: Lung

- **Mesothelium and connective tissue**
- **Type I & Type II pneumocytes**
- **Capillary endothelial cells and fibroblasts**
- **Alveolar macrophage**
Type II

Type I

MACROPHAGES
Slide 42: Lung (mast cells)
19714 lung

Alveolar macrophages phagocytize erythrocytes lost from damaged capillaries and airborne particulate matter that has penetrated as far as the alveoli. In congestive heart failure, the lungs become congested with blood, and erythrocytes pass into the alveoli, where they are phagocytized by alveolar macrophages. In such cases, these macrophages are called heart failure cells.
Numerous small lysosomes.
Small pieces of lungs from a non-smoker and from a smoker
The Lungs on the left have Empysema.
The one on the right has cancer - both from Smoking
Type I pneumocytes cover about 95% of the alveolar surface as this cell is primary contributor to the alveolar lining.
RESPIRATORY PHYSIOLOGY

SURFACTANT FUNCTIONS IN REDUCING SURFACE TENSION, REDUCES WORK OF BREATHING, AND HELPS KEEP ALVEOLI OPEN AND MAY HAVE A BACTERICIDAL EFFECT
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HYALINE MEMBRANE DISEASE - PREMATURE INFANTS CANNOT GET OR MAKE SUFFICIENT SURFACTANT
RESPIRATORY PHYSIOLOGY

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HYALINE MEMBRANE DISEASE - PREMATURE INFANTS CANNOT GET OR MAKE SUFFICIENT SURFACTANT

BRONCHOALVEOLAR FLUID - CLEARED BY CILIARY ACTION TOWARD ORAL CAVITY (CONTAIN LYSOSOME, COLLAGENASE, GLUCURONIDASE)
RESPIRATORY PHYSIOLOGY

SURFACTANT FUNCTIONS IN REDUCING SURFACE TENSION, REDUCES WORK OF BREATHING, AND HELPS KEEP ALVEOLI OPEN AND MAY HAVE A BACTERICIDAL EFFECT

HYALINE MEMBRANE DISEASE - PREMATURE INFANTS CANNOT GET OR MAKE SUFFICIENT SURFACTANT

BRONCHOALVEOLAR FLUID - CLEARED BY CILIARY ACTION TOWARD ORAL CAVITY (CONTAIN LYSOSOME, COLLAGENASE, GLUCURONIDASE)

MACROPHAGES - CONTAIN HEMOSIDERIN, PRODUCE LYtic ENZYMES IN BRONCHOALVEOLAR FLUID
Clinical Correlation

A patient has been smoking for 30 years. He develops a hoarse voice and, upon examination, the larynx is inflamed.

The patient’s larynx may now contain nonkeratinized stratified squamous epithelium. This change in epithelial state is termed metaplasia.

Because of his excessive smoking, this patient has also developed emphysema.
Figure 42-5. Pulmonary changes in pneumonia and emphysema.
Respiratory Diseases

Emphysema (means too much air in the lungs due to loss of alveolar walls) involves dilation and permanent enlargement of the bronchioles leading to pulmonary acini and accompanying loss of cells in the alveoli and other parts of the airway walls, leading to irreversible loss or respiratory function.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Microbe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumococcal Pneumonia</td>
<td>Streptococcus pneumoniae</td>
</tr>
<tr>
<td>Severe Acute Respiratory Syndrome</td>
<td>Unknown</td>
</tr>
<tr>
<td>The Flu</td>
<td>Influenza Virus</td>
</tr>
<tr>
<td>Bronchitis</td>
<td>Various Viruses</td>
</tr>
<tr>
<td>The Cold</td>
<td>Mainly Rhinovirus or Coronavirus</td>
</tr>
</tbody>
</table>
Many illustrations in these VIBS Histology YouTube videos were modified from the following books and sources: Many thanks to original sources!

- Douglas P. Dohrman and TAMHSC Faculty 2012 Structure and Function of Human Organ Systems, Histology Laboratory Manual - Slide selections were largely based on this manual for first year medical students at TAMHSC
The End!