Medical School Histology Basics
Respiratory System

VIBS 289 lab

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Objectives

The histologic characteristics of the components of conducting portion and respiratory portion of the respiratory system

How these characteristics allow each component to contribute to the overall function of the respiratory system.
Function of the Respiratory System

All higher animals require a mechanism to:
1. Obtain $O_2$ from the environment
2. and get rid of $CO_2$

This “gas exchange” is the function of the respiratory system.

Oxygen diffuses out and Carbon Dioxide diffuses into the air space of the alveolus.
Respiratory System

The Respiratory System
Conducting portion
Respiratory portion

Alveoli: Gas Exchange

Capillary
Alveolus
Oxygen moving from alveolus into blood cell
Red blood cells
Carbon dioxide moving from blood cell into alveolus
Alveolar sac
Alveolar duct
Primary lobule

Air in alveolus
Capillary and alveoli walls are so thin that materials pass through them easily
Ventilation Mechanisms

Thoracic cage (boney cavity)

Intercostal muscles (inspiration and expiration)

Diaphragm (inspiration only)

Elastic components of lungs (lungs to partially deflate)
Conducting portion

Cleans air
Warms air
Humidifies air
Function Of Mucus in the Respiratory System

Detoxifies gases
Has protein that presents odor chemicals to receptors of olfactory cells
Washes away current chemicals to allow one to smell the next chemical odor
Traps dust and washes it away
Contains IgA antibodies to guard against infection
The Respiratory System
Respiratory Portion
- Site of Gases Exchange

Respiratory bronchioles
Alveolar ducts
Alveolar sacs
Alveoli

Alveolus (Air)
Capillary (Blood)

Oxygen
CO₂
Beyond its important role as the collector of olfactory information – such as whiffs of smoke that warn of impending danger or smells that whet the appetite – the nose acts as an air conditioner for the respiratory system. **Everyday**, it **treats** approximately **500 cubic feet 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.
Epithelium in the respiratory system

Respiratory epithelium

Olfactory

Stratified squamous

Pseudostratified columnar

Simple squamous
Epithelium in the respiratory system

Nose
Skin junction
Nasal cavity

Histo 36
Ciliated simple columnar epithelium
Conducting bronchiole
Respiratory epithelium
Olfactory

Air sacs
Olfactory epithelium has no goblet cells.
Conditioning Air By The Conducting Portion

Nasal fossae
- Superior conchae - olfactory epithelium long cilia, nervous cells
- Middle conchae - respiratory epithelium
- Inferior conchae - respiratory epithelium

Swell bodies
- Large venous plexus that direct air (occludes air way)
- Allergic reaction or inflammation restrict air flow

counter current system warms air
Animal Respiratory (Olfactory) mucosa and nasal septum

- Respiratory epithelium
- Highly vascular lamina propria
- Swell bodies
- Olfactory epithelium
- Bowman’s glands
- Histo 036 001
Histo 36 001: Respiratory (Olfactory) mucosa and nasal septum

- Olfactory epithelium
- Bowman's glands
- Highly vascular lamina propria
- Nerves
Hyaline cartilage provides flexible support in the respiratory system to hold the airway open.

Elastic cartilage in epiglottis

Hyaline cartilage
larynx

- Tracheal cartilages
- True vocal cords
- Vocal cord muscles
- Air space lumen
- Cricoid cartilage
- Thyroid cartilage
- The false vocal cords
- Laryngeal ventricle
429 Larynx

- Respiratory epithelium
- Stratified squamous epithelium
- Vocal cord muscles
- Thyroid cartilage
Larynx
(lower portion)

- Esophagus
- Cricoid cartilage
- Respiratory epithelium lining
- Tracheal cartilage

HISTO039
Esophagus and trachea, monkey – glands in trachea

- **Trachea**: whose lumen is lined with pseudostratified ciliated epithelium with goblet cells.
- **Submucosa**: with glands.
- **Elastic fiber layer**: beneath the epithelium.
- **Thick hyaline cartilage**: bridged by smooth muscle bundle posteriorly.

**Trachea**:
- Lumen lined with pseudostratified ciliated epithelium with goblet cells.
- Submucosa with glands.
- Elastic fiber layer beneath the epithelium.
- Thick hyaline cartilage bridged by smooth muscle bundle posteriorly.
Trachea, monkey

- Thick hyaline cartilage
- Submucosa with glands
- Trachea, whose lumen is lined with pseudostratified ciliated epithelium with goblet cells
Trachea, monkey

- Pseudostratified ciliated epithelium with goblet cells
- Thick basement membrane
- Rich vascular supply to warm air
- Goblet cell
- Plasma cells to produce antibodies
EM 8 trachea; 20630x

1. Mucous
2. Microvilli
3. Cilia
4. Goblet cell
Fig. 14-8 Lung (panoramic view). Stain: hematoxylin-eosin. Low magnification.
The air-conducting tubes of the respiratory system can be thought of as a series of ducts which carry air to the sites of gaseous exchange - the alveoli.
On Slide 432, identify the characteristics of the bronchus: 1) pseudostratified ciliated columnar epithelium with goblet cells; 2) smooth muscle band between the lamina propria and the cartilage. Notice that the smooth muscle is not continuous around the bronchus. This is because there are two layers of muscle which follow a left- and right-handed spiral path, respectively, down the bronchi. 3) A change from cartilage rings to cartilage plates surrounding the tube; 4) Glands in the submucosa.
Macrophages in Air Space of Alveoli
Bronchus:
1) pseudostratified ciliated columnar epithelium with goblet-cells;
2) smooth muscle band between the lamina propria and the cartilage. The smooth muscle is not continuous around the bronchus as it spirals.
3) a change from cartilage rings to cartilage plates surrounding the tube;
4) glands in the submucosa.

Bronchioles:
1) have a ciliated columnar epithelium;
2) do not have cartilage plates or glands;
3) have well organized muscle layers.
Cells in the respiratory portion

TERMINAL BRONCHIOLE

CLARE CELLS

Histo 41

Ciliated cells

Elastic fibers

Smooth muscle cells

Smooth muscle

Ciliated cells

Respiratory BRONCHIOLE
Slide Histo 41 and Histo 42: Lung

- Mesothelium and connective tissue of lung capsule
- Type I & Type II pneumocytes
- Capillary endothelial cells and fibroblasts
- Alveolar macrophage
Air

Blood

Capillaries

Alveolus

Air

Type I alveolar cell

Basal laminae

Capillary endothelial cell

Erythrocyte
Histo 42: Lung (mast cells)

1. Bronchus
2. Conducting bronchiole
3. Respiratory bronchiole
4. Alveolar duct
5. Alveolar sac
6. Alveoli
7. Mast cell
8. Mesothelium
9. Alveolar macrophage
10. Type I pneumocyte
11. Type II pneumocyte
12. Alveoli
13. Terminal bronchiole
14. Respiratory bronchiol
15. Alveolar duct
16. Alveolar sac
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.
1. Type I pneumonocyte
2. Type II pneumonocyte

Type II pneumocyte
Type II pneumonocyte (EM 18c).

1. Nucleus
2. Surfactant bodies
Type II pneumocytes

36722
Surfactant bodies in Type II cells
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, and antibodies).

Macrophages - contain hemosiderin, produce lytic enzymes in bronchoalveolar fluid.
Normal Airways

The bronchial tubes normally allow air to flow easily to reach the alveoli and to be returned and exhaled. To protect the lungs from inhaling poisonous particles and gases, the lining of the bronchial tubes is very sensitive. When the sensitivity is too high, the bronchials respond to particles and gases that are not poisonous. This is why about two-thirds of asthma cases occur in children whose sensitivity is much higher than many adults.

Obstructed Airways

When you have asthma, pollutants and allergens cause an increase in the production of mucus in the lining of the bronchials, and often cause the muscle surrounding the bronchials to constrict. When you have bronchitis, pollutants cause irritation and inflammation. This condition causes swelling of the bronchials, which narrows the air passageways. In older people, who have less mucus protecting the lining of the bronchials, an asthmatic constriction may occur with bronchitis.
Figure 42-5. Pulmonary changes in pneumonia and emphysema.
Respiratory Physiology Con’t

Emphysema - destruction of alveolar wall
Means too much air in the lungs.
Natural Defenses of Our Respiratory System

Large particles get trapped by **nose hairs**.

Smaller particles are trapped in **mucus** that lines our respiratory system. The mucous keeps harmful particles out of the lungs.

**Coughing** forcibly expels foreign particles trapped in our lungs and airways.

**Sneezing** removes bacteria trapped in mucus from our nasal passages. Sneeze travel at about 100 miles per hour and remove 100,000 bacteria.
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
In summary

Function of the Respiratory System

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Questions on the Respiratory System

The conducting portion of the respiratory system modifies the air in the following way(s):

a. warms
b. cleans
c. dries
d. a and b
e. a, b, and c

Which of the following are involved in both inspiration and expiration? Contraction of

a. intercostal skeletal muscle between the ribs
b. diaphragm
c. smooth muscle
d. a and b
e. a, b, and c

Variation in the epithelium lining the respiratory system facilitates varied functions.
Which epithelium-function does not match?

a. simple squamous - alveolar ducts
b. goblet cells - humidifies air
c. stratified squamous - false vocal cords
d. ciliated cells - move dust-laden mucus
e. hair follicle - filtration of air
Many illustrations in these VIBS Histology YouTube videos were modified from the following books and sources: Many thanks to original sources!

The Respiratory System:
Conducting portion
Respiratory portion

The Respiratory System

- Nose
- Pharynx
- Epiglottis
- Larynx
- Trachea
- Bronchus
- Lung
Defense Mechanism (con’t)

Specific

Elaborate immunological processes occur in lymphoid tissue (T & B lymphocytes)

Tumor of the lung

• More often in males
• Related in cigarette smoking
Routes of Environmental Exposure

Graph #1
Route of Human Exposure

- Skin
- Inhalation
- Eye
- Bites/Stings
- Other
- Ingestion/Swallowing
Small pieces of lungs from a non-smoker and from a smoker.
• https://www.youtube.com/watch?v=gYSIWceGMxY
“Conditioning Air” by the Conducting Portion

Specialized respiratory epithelium
Numerous mucous and serous gland
• Traps particulate and gaseous impurities
• Prevents alveolar lining from desiccation

Rich superficial vascular network in lamina propria - warms blood in a counter current system (blood flows against inspired air)