

Physiology of Respiratory System

By

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3rd year\ Lecture 1

Introduction

Why do we breathe?

- All body processes directly or indirectly require ATP
 - Aerobic respiration produces much more ATP than anaerobic respiration
 - Aerobic ATP synthesis requires oxygen and produces carbon dioxide
 - Drives the need to breathe to take in oxygen, and eliminate carbon dioxide



Anatomy of the Respiratory System

- Expected Learning Outcomes
 - State the functions of the respiratory system
 - Name and describe the organs of this system
 - Trace the flow of air from the nose to the pulmonary alveoli
 - Relate the function of any portion of the respiratory tract to its gross and microscopic anatomy

Anatomy of the Respiratory System

- The respiratory system consists of a system of tubes that delivers air to the lung
 - Oxygen diffuses into the blood, and carbon dioxide diffuses out
- Respiratory and cardiovascular systems work together to deliver oxygen to the tissues and remove carbon dioxide
 - Considered jointly as cardiopulmonary system
 - Disorders of lungs directly effect the heart and vice versa
- Respiratory system and the urinary system collaborate to regulate the body's acid–base balance

Anatomy of the Respiratory System

- Respiration has three meanings
 - Ventilation of the lungs (breathing)
 - External respiration = exchange of gases in the alveoli of the lungs
 - Internal respiration = exchange of gases in between the blood and the tissues
 - Cellular respiration = The use of oxygen in to drive the chemical reactions of cellular metabolism

Anatomy of the Respiratory System

- Functions - Primarily
 - Provides O₂ and CO₂ exchange between blood and air
- Secondarily:
 - Serves for speech and other vocalizations
 - Provides the sense of smell
 - Affects pH of body fluids by eliminating CO₂
 - Respiratory pump
 - Production of Angiotensin Converting Enzyme

Anatomy of the Respiratory System

- Nose, pharynx, larynx, trachea, bronchi, lungs
 - Incoming air stops in the alveoli
 - Millions of thin-walled, microscopic air sacs
 - Exchanges gases with the bloodstream through the alveolar wall, and then flows back out
- Conducting division of the respiratory system
 - Those passages that serve only for airflow
 - No gas exchange
 - Nostrils through major bronchioles



Anatomy of the Respiratory System

- Respiratory division of the respiratory system
 - Consists of alveoli and other gas exchange regions
- Upper respiratory tract—in head and neck
 - Nose through larynx
- Lower respiratory tract—organs of the thorax
 - Trachea through lungs

The Respiratory System

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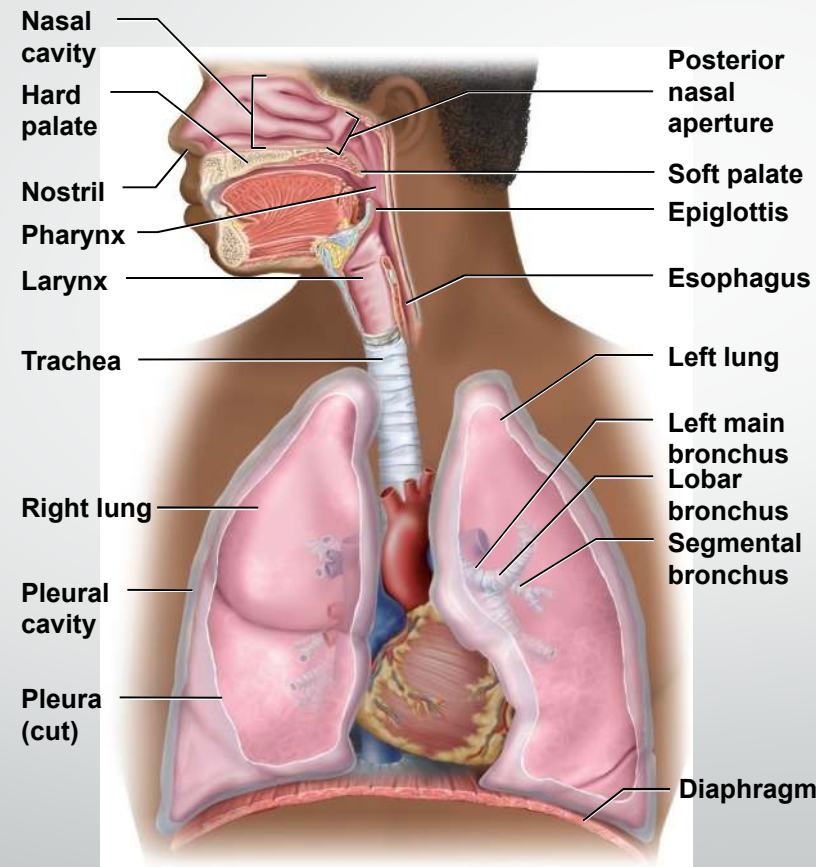


Figure 22.1

- Nose, pharynx, larynx, trachea, bronchi, lungs

The Bronchial Tree

- Bronchial tree—a branching system of air tubes in each lung
 - From main bronchus to 65,000 terminal bronchioles
- Main (primary) bronchi—supported by C-shaped hyaline cartilage rings
 - Rt. main bronchus is a branch 2 to 3 cm long, arising from fork of trachea
 - Right bronchus slightly wider and more vertical than left
 - Aspirated (inhaled) foreign objects lodge right bronchus more often than the left
 - Lt. main bronchus is about 5 cm long
 - Slightly narrower and more horizontal than the right

The Bronchial Tree

- Lobar (secondary) bronchi—supported by crescent-shaped cartilage plates
 - Three rt. lobar (secondary) bronchi: superior, middle, and inferior
 - One to each lobe of the right lung
 - Two lt. lobar bronchi: superior and inferior
 - One to each lobe of the left lung
- Segmental (tertiary) bronchi—supported by crescent-shaped cartilage plates
 - 10 on right, 8 on left
 - Bronchopulmonary segment: functionally independent unit of the lung tissue

The Bronchial Tree

- All bronchi are lined with ciliated pseudostratified columnar epithelium
 - Cells grow shorter and the epithelium thinner as we progress distally
 - Lamina propria has an abundance of mucous glands and lymphocyte nodules (bronchus-associated lymphoid tissue, BALT)
 - Positioned to intercept inhaled pathogens
 - All divisions of bronchial tree have a large amount of elastic connective tissue
 - Contributes to the recoil that expels air from lungs

The Bronchial Tree

Cont.

- Mucosa also has a well-developed layer of smooth muscle
 - Muscularis mucosae contracts or relaxes to constrict or dilate the airway, regulating airflow
- Pulmonary artery branches closely follow the bronchial tree on their way to the alveoli
- Bronchial artery services bronchial tree with systemic blood
 - Arises from the aorta

The Bronchial Tree

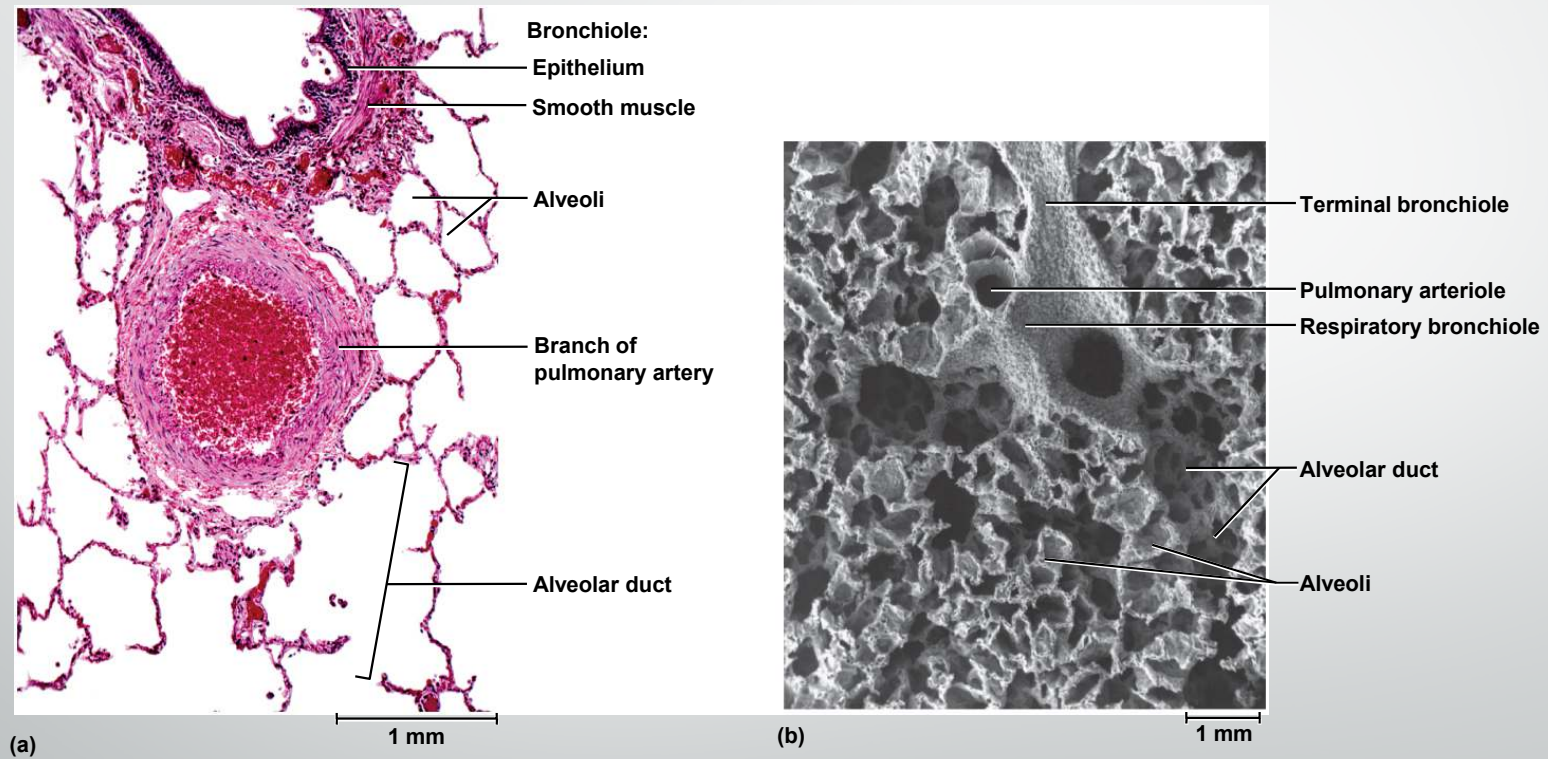
- Bronchioles
 - Lack cartilage
 - 1 mm or less in diameter
 - Pulmonary lobule: portion of lung ventilated by one bronchiole
 - Have ciliated cuboidal epithelium
 - Well-developed layer of smooth muscle
 - Divides into 50 to 80 terminal bronchioles
 - Final branches of conducting division
 - Measure 0.5 mm or less in diameter
 - Have no mucous glands or goblet cells
 - Have cilia that move mucus draining into them back by mucociliary escalator
 - Each terminal bronchiole gives off two or more smaller respiratory bronchioles

The Bronchial Tree

- Respiratory bronchioles
 - Have alveoli budding from their walls
 - Considered the beginning of the respiratory division since alveoli participate in gas exchange
 - Divide into 2 to 10 alveolar ducts
 - End in alveolar sacs: grapelike clusters of alveoli arrayed around a central space called the atrium

Histology of the Lung

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Figure 22.11a,b

Alveoli

- 150 million alveoli in each lung, providing about 70 m² of surface for gas exchange
- Cells of the alveolus
 - Squamous (type I) alveolar cells
 - Thin, broad cells that allow for rapid gas diffusion between alveolus and bloodstream
 - Cover 95% of alveolus surface area

Alveoli

Cont.

- Great (type II) alveolar cells (a.k.a. *septal cells*)
 - Round to cuboidal cells that cover the remaining 5% of alveolar surface
 - Repair the alveolar epithelium when the squamous (type I) cells are damaged
 - Secrete pulmonary surfactant
 - A mixture of phospholipids and proteins that coats the alveoli and prevents them from collapsing during exhalation

Alveoli

Cont.

- Alveolar macrophages (dust cells)
 - Most numerous of all cells in the lung
 - Wander the lumen and the connective tissue between alveoli
 - Keep alveoli free from debris by phagocytizing dust particles
 - 100 million dust cells perish each day as they ride up the mucociliary escalator to be swallowed and digested with their load of debris

Pulmonary Alveoli

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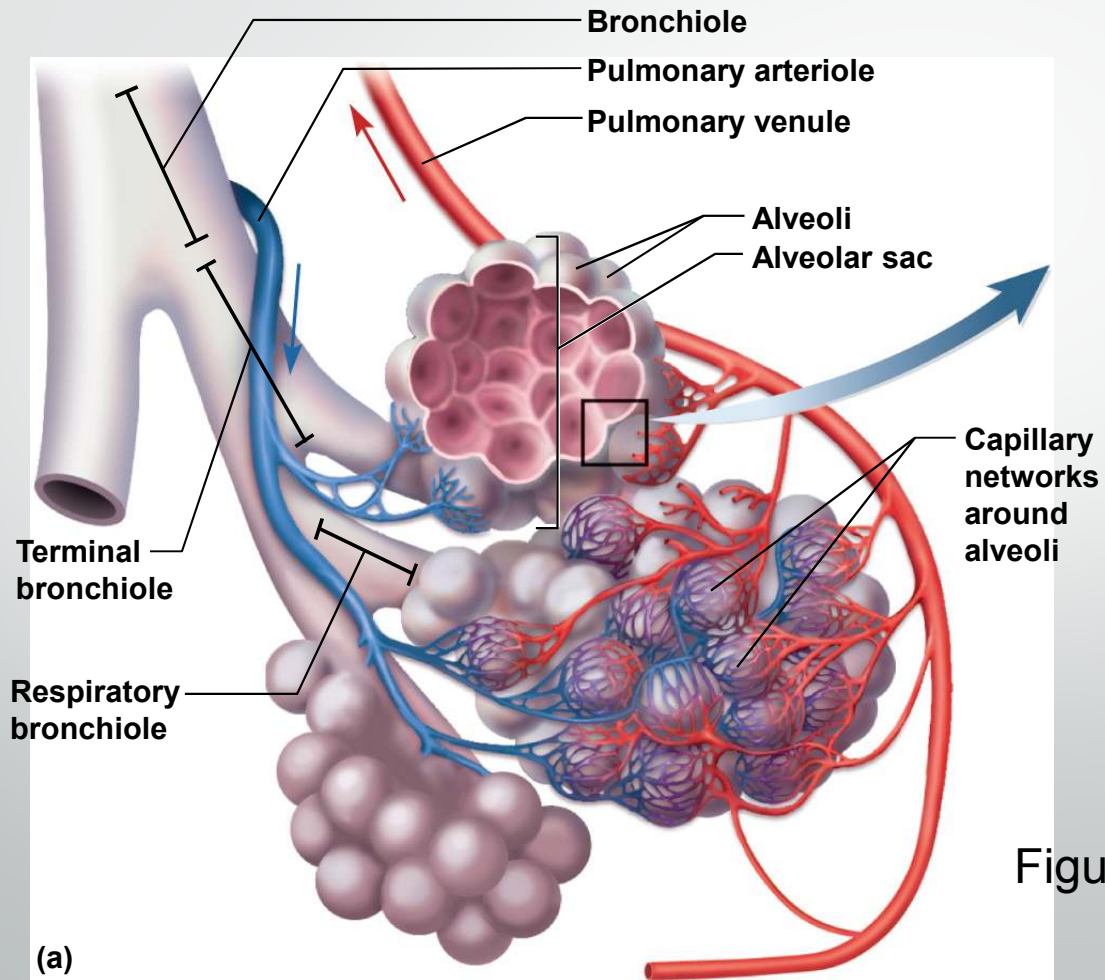


Figure 22.12a

Alveoli

- Each alveolus surrounded by a basket of blood capillaries supplied by the pulmonary artery
- Respiratory membrane—the barrier between the alveolar air and blood
- Respiratory membrane consists of:
 - Squamous alveolar cells
 - Endothelial cells of blood capillary
 - Their shared basement membrane

Alveoli

- Important to prevent fluid from accumulating in alveoli
 - Gases diffuse too slowly through liquid to sufficiently aerate the blood
 - Alveoli are kept dry by absorption of excess liquid by blood capillaries
 - Lungs have a more extensive lymphatic drainage than any other organ in the body
 - Low capillary blood pressure also prevents the rupture of the delicate respiratory membrane

Pulmonary Alveoli

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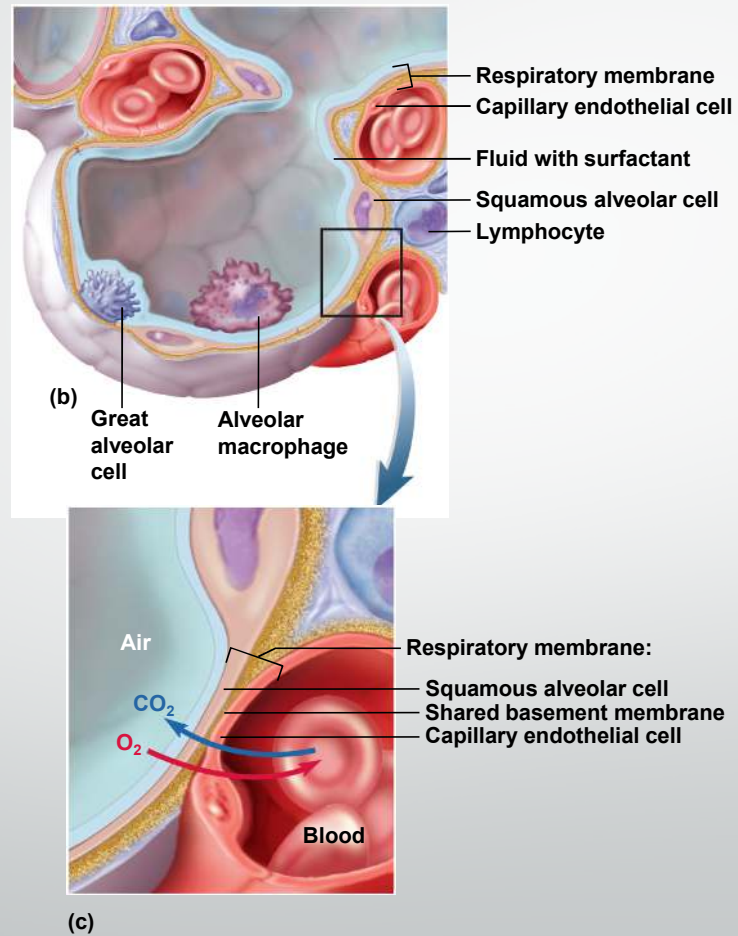


Figure 22.12b,c

Pulmonary Ventilation

- Breathing (pulmonary ventilation)—consists of a repetitive cycle: one cycle of inspiration (inhaling) and expiration (exhaling)
- Respiratory cycle—one complete inspiration and expiration
 - Quiet respiration: while at rest, effortless, and automatic
 - Forced respiration: deep, rapid breathing, such as during exercise
- Flow of air in and out of lung depends on a pressure difference between air pressure within lungs and outside body
- Breathing muscles change lung volumes and create differences in pressure relative to the atmosphere

The Respiratory Muscles

- Diaphragm
 - Prime mover of respiration
 - Contraction flattens diaphragm, enlarging thoracic cavity and pulling air into lungs
 - Relaxation allows diaphragm to bulge upward again, compressing the lungs and expelling air
 - Accounts for two-thirds of airflow

The Respiratory Muscles

- Internal and external intercostal muscles
 - Synergist to diaphragm
 - Between ribs
 - Stiffen the thoracic cage during respiration
 - Prevent it from caving inward when diaphragm descends
 - Contribute to enlargement and contraction of thoracic cage
 - Add about one-third of the air that ventilates the lungs
- Scalenes
 - Synergist to diaphragm
 - Quiet respiration holds ribs 1 and 2 stationary

The Respiratory Muscles

- Accessory muscles of respiration act mainly in forced respiration
- Forced inspiration
 - Erector spinae, sternocleidomastoid, pectoralis major, pectoralis minor, and serratus anterior muscles and scalenes
 - Greatly increase thoracic volume

The Respiratory Muscles

- Normal quiet expiration
 - An energy-saving passive process achieved by the elasticity of the lungs and thoracic cage
 - As muscles relax, structures recoil to original shape and original (smaller) size of thoracic cavity, results in airflow out of the lungs
- Forced expiration
 - Rectus abdominis, internal intercostals, and other lumbar, abdominal, and pelvic muscles
 - Greatly increased abdominal pressure pushes viscera up against diaphragm increasing thoracic pressure, forcing air out

The Respiratory Muscles

- Valsalva maneuver—consists of taking a deep breath, holding it by closing the glottis, and then contracting the abdominal muscles to raise abdominal pressure and push organ contents out
 - Childbirth, urination, defecation, vomiting

The Respiratory Muscles

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