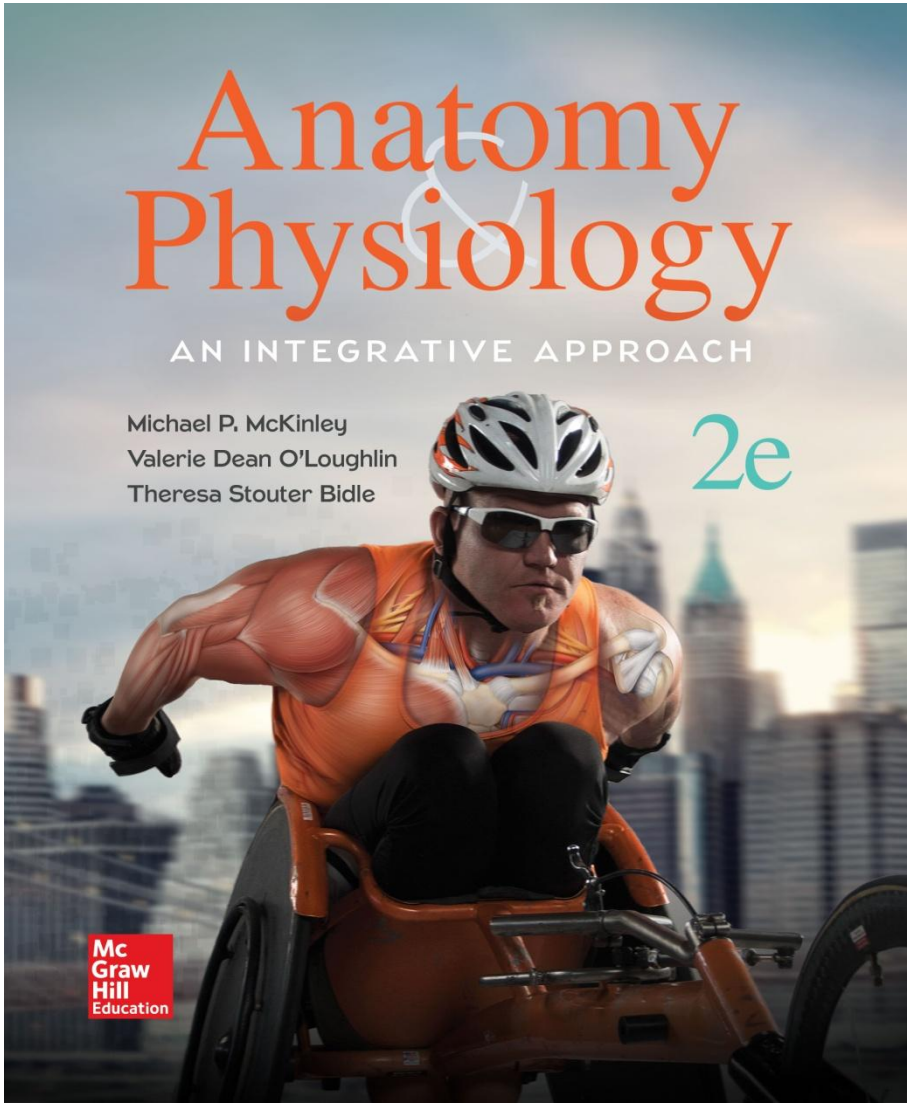
Chapter 23 - Part 1 Lecture Outline

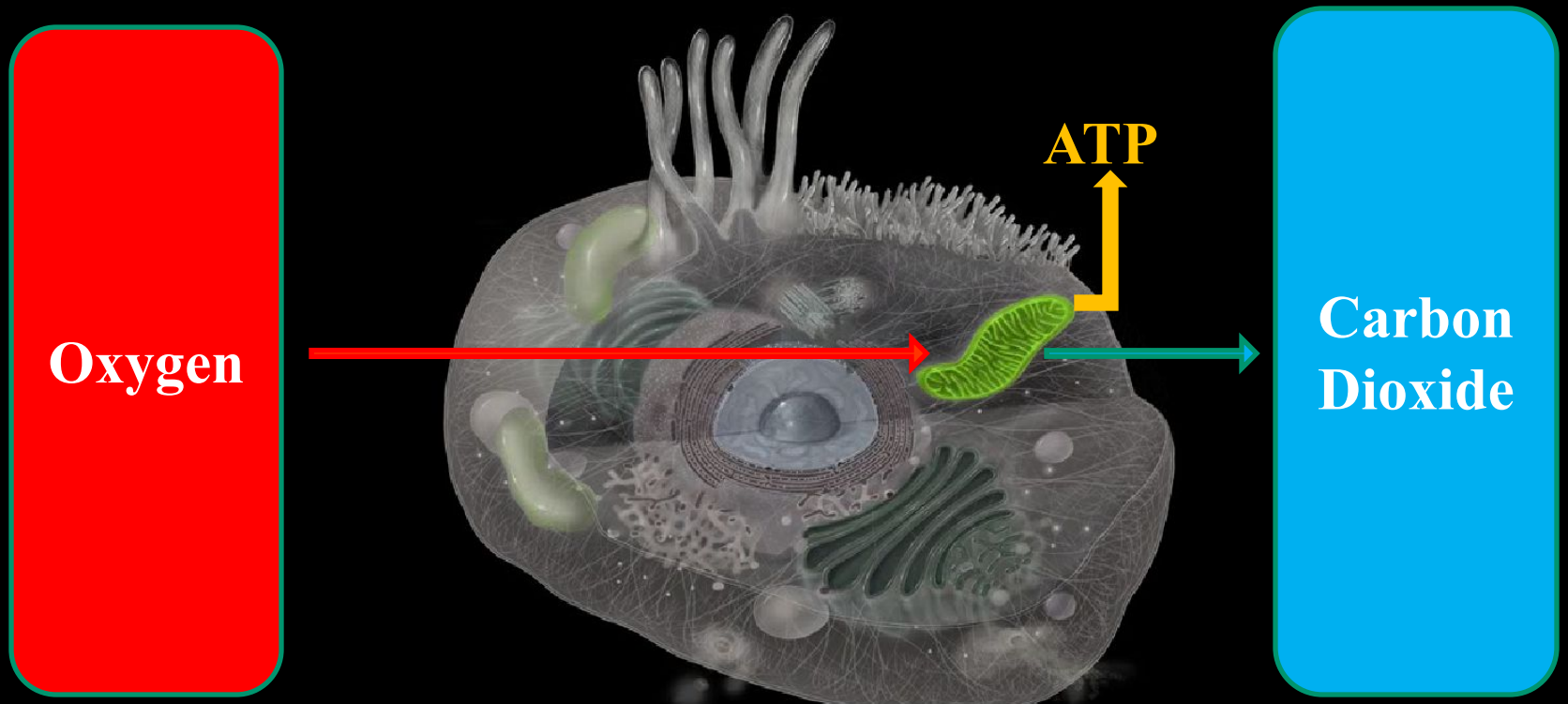
See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.



The Respiratory System

- Respiration is gas exchange: O_2 for CO_2
  - Occurs between atmosphere and body cells
- Cells need O_2 for aerobic ATP production and need to dispose of CO_2 that process produces
- The **respiratory system** provides the means for gas exchange
  - Consists of respiratory passageways in head, neck, and trunk, and the lungs

Aerobic Cellular Respiration



23.1 Introduction to the Respiratory System

Learning Objectives:

1. State the functions of the respiratory system.
2. Distinguish between the structural organization and the functional organization of the respiratory system.
3. Describe the structure of the mucosa that lines the respiratory tract and the structural changes observed along its length.
4. Explain the function of mucus produced by the mucosa.

23.1a General Functions of the Respiratory System

- Air passageway
  - Air moves from atmosphere to alveoli as we breathe in
  - Air moves from lungs to atmosphere as we breathe out
- Site for oxygen and carbon dioxide exchange (alveoli and pulmonary capillaries)
  - Oxygen diffuses from alveoli into blood
  - Carbon dioxide diffuses from blood into alveoli
- Odor detection
  - Olfactory receptors in superior nasal cavity
  - Sensory input is relayed to the brain

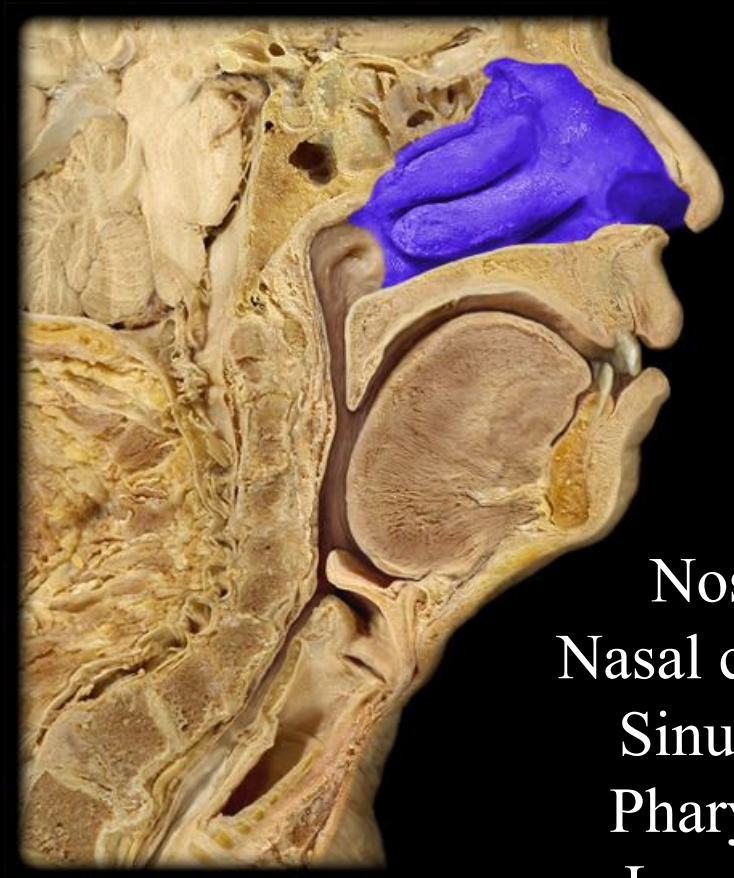
23.1a General Functions of the Respiratory System

- Sound production
  - Air moves across vocal cords of the larynx (voice box)
  - Vocal cords vibrate, producing sound
  - Sounds resonate in the upper respiratory structures
- Rate and depth of breathing influence
  - Blood levels of O_2, CO_2, H^+
  - Venous return of blood; lymphatic return of fluid to blood

23.1b General Organization of the Respiratory System

- Structural organization
  - **Upper respiratory tract**
    - Larynx and above
  - **Lower respiratory tract**
    - Trachea and below
- Functional organization
  - The **conducting zone** transports air
    - Nose to terminal bronchioles
  - The **respiratory zone** participates in gas exchange
    - Respiratory bronchioles to alveoli

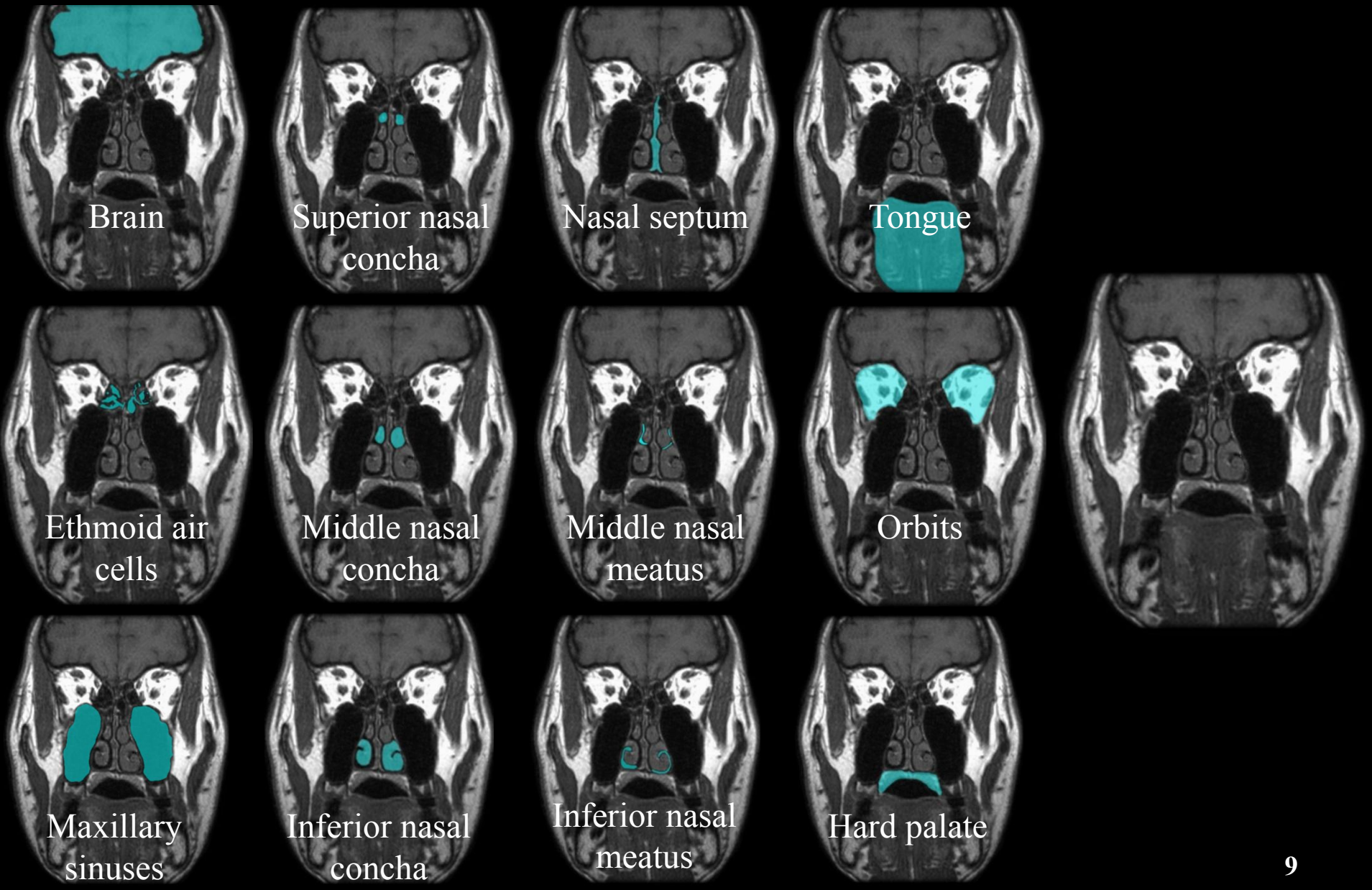
Upper Respiratory Tract



Nose
Nasal cavity
Sinuses
Pharynx
Larynx

MRI

Upper Respiratory MRI: Coronal



Lower Respiratory

X-ray: Posterior – Anterior View

Trachea
Bronchial Tree
Lungs

General Anatomy of the Respiratory System

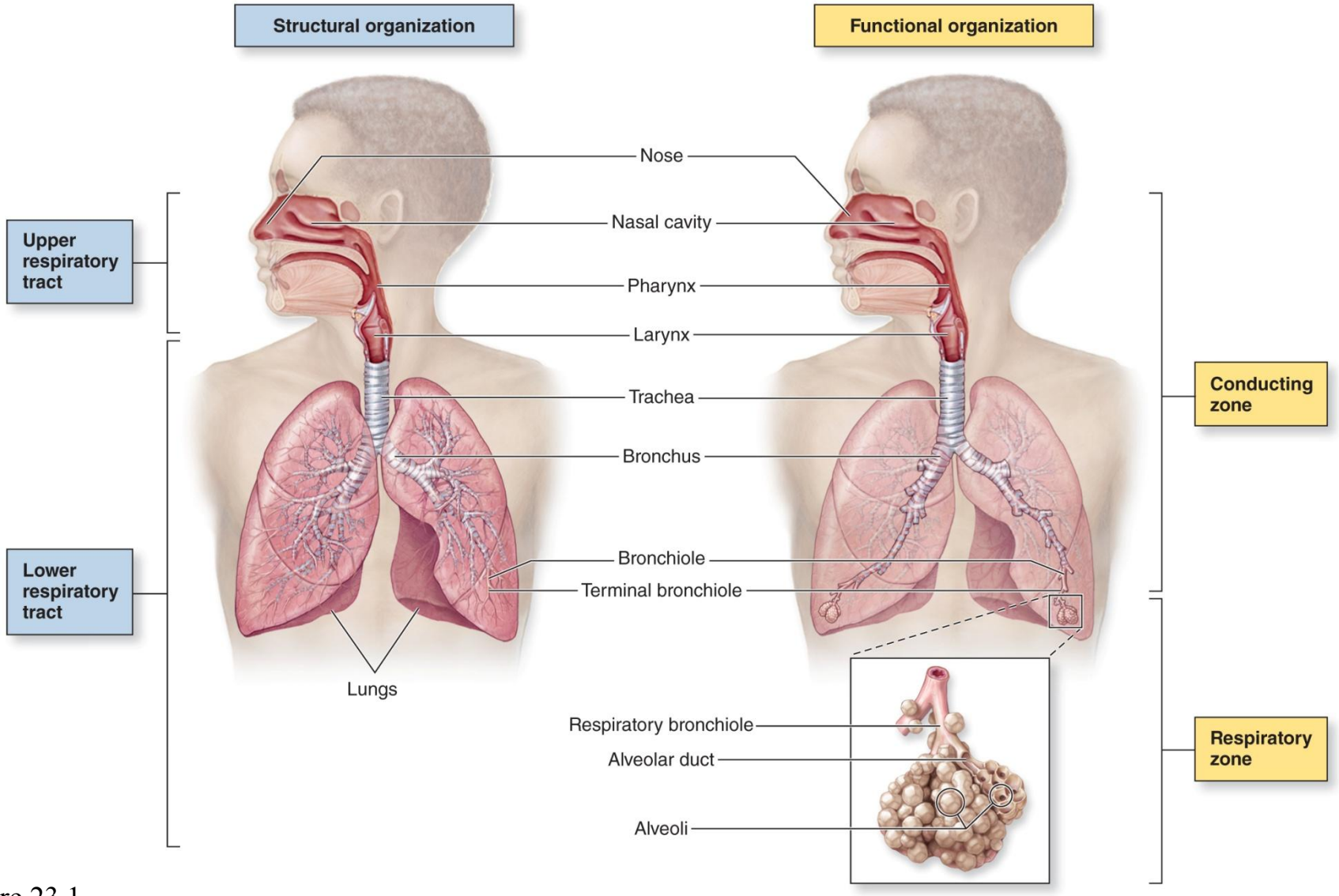


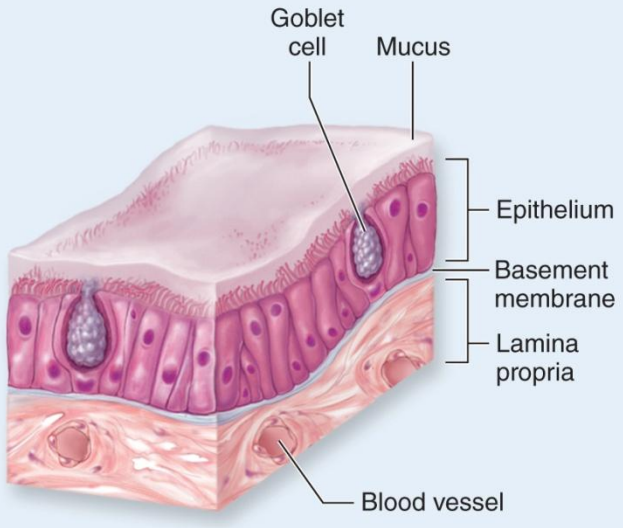
Figure 23.1

23.1c Respiratory Mucosa

- **Mucosa** = **mucous membrane:** respiratory lining
  - Epithelium resting on a basement membrane
  - Underlying lamina propria made of areolar connective tissue
- Respiratory epithelium
  - Becomes thinner from the nose to the alveoli
    - Starts out as pseudostratified ciliated columnar
    - Changes to simple ciliated columnar
    - Changes to simple cuboidal
    - Changes to simple squamous
    - Exceptions: stratified squamous found in high abrasion areas of pharynx and on and around vocal cords

Respiratory Mucosa

General structure of the respiratory mucosa



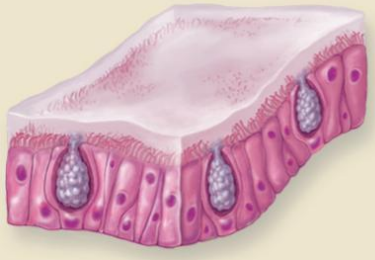
The mucosa is composed of an epithelium resting on a basement membrane and an underlying lamina propria composed of areolar connective tissue. The epithelium becomes progressively thinner from the nasal cavity to the alveoli with some exceptions.

(a)

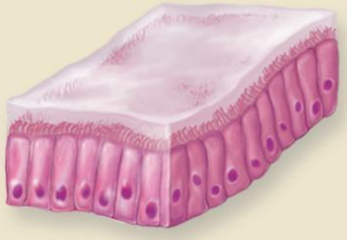
Figure 23.2a

Respiratory Mucosa

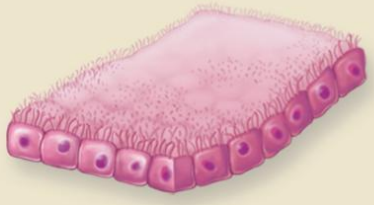
Progressively thinner epithelium



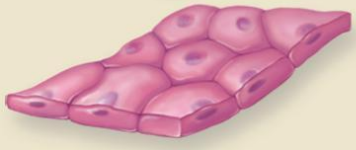
Pseudostratified ciliated columnar epithelium lines the nasal cavity, paranasal sinuses, nasopharynx, trachea, inferior portion of larynx, main bronchi, and lobar bronchi.



Simple ciliated columnar epithelium lines the segmental bronchi, smaller bronchi, and large bronchioles.



Simple ciliated cuboidal epithelium lines the terminal and respiratory bronchioles (a progressive loss of cilia is observed).



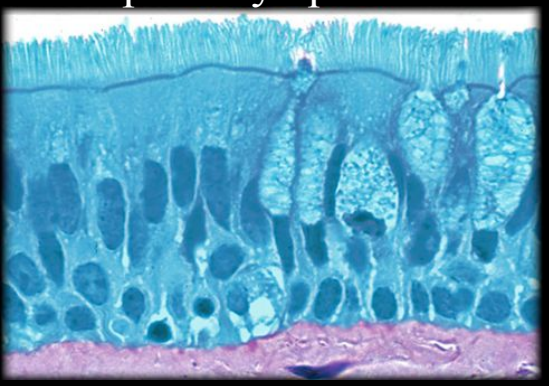
Simple squamous epithelium forms both the alveolar ducts and alveoli.

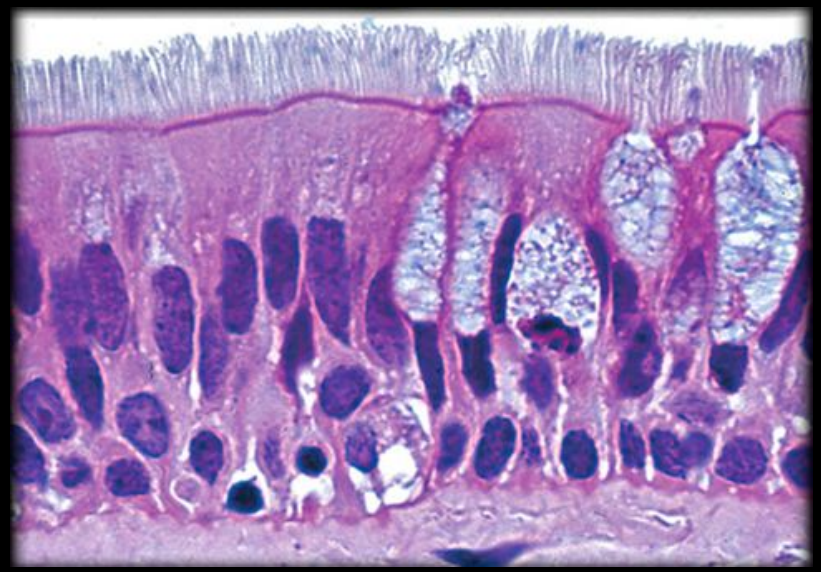
(b)

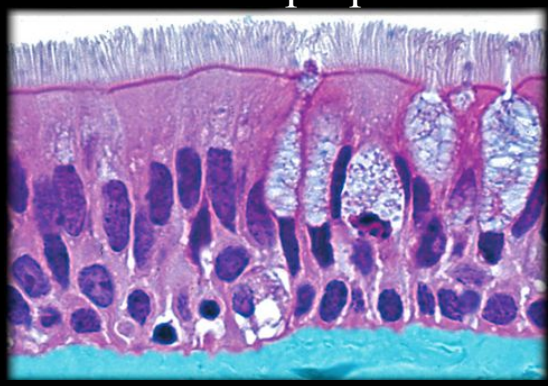
Figure 23.2b

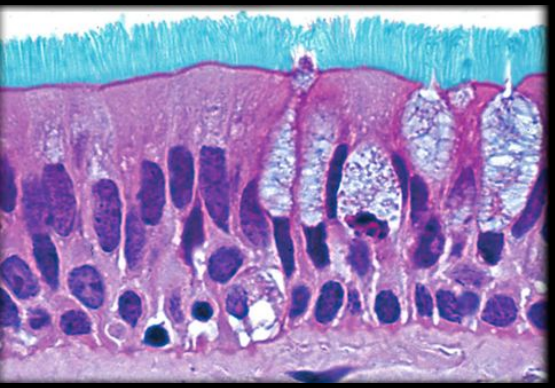
Respiratory Epithelium

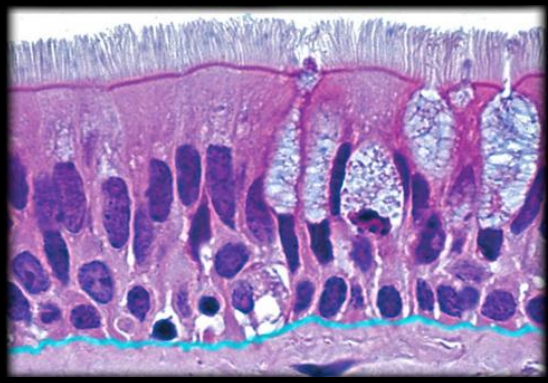
High Magnification

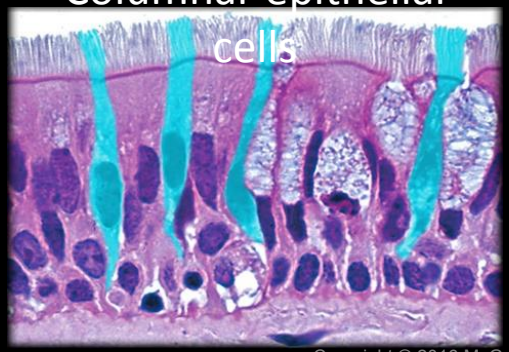


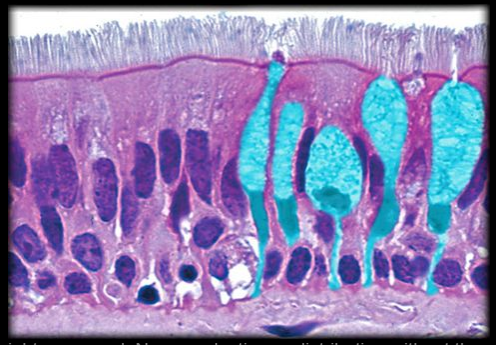


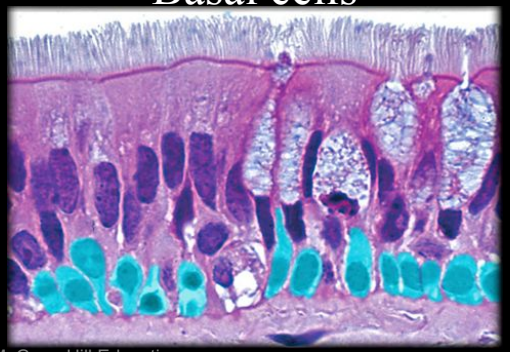












23.1c Respiratory Mucosa

- Mucous secretions
  - Produced from secretions of
    - Goblet cells of epithelial lining
    - Mucous and serous glands of the lamina propria
  - Contain **mucin** protein
    - Increases mucus viscosity and serves to trap dust, dirt, pollen, etc.
  - 1 to 7 tablespoons produced daily
  - Contains defenses against microbes
    - Lysozyme (antibacterial enzyme)
    - Defensins (antibacterial proteins)
    - Immunoglobulin A (antibody)
  - Called **sputum** when coughed up with saliva and trapped substances

What did you learn?

- What is the difference between the conducting and respiratory zones?
- How does the respiratory mucosa change along its course?
- Is the trachea in the upper or lower respiratory tract?
- What is sputum?

23.2 Upper Respiratory Tract

Learning Objectives:

1. Describe the structure and function of the nose.
2. Provide a general description of the structure and function of the nasal cavity.
3. Describe the structure and function of the four paired paranasal sinuses.
4. Compare the three regions of the pharynx, and describe their associated structures.

23.2a Nose and Nasal Cavity

- **Nose:** first conducting structure for inhaled air
  - Formed by bone, hyaline cartilage, dense irregular connective tissue, and skin
  - Bridge of nose formed by paired nasal bones
  - One pair of **lateral cartilages** and two pairs of **alar cartilages**
  - Flared part of **nostrils** (*nares*) made of dense irregular connective tissue

Upper Respiratory Tract

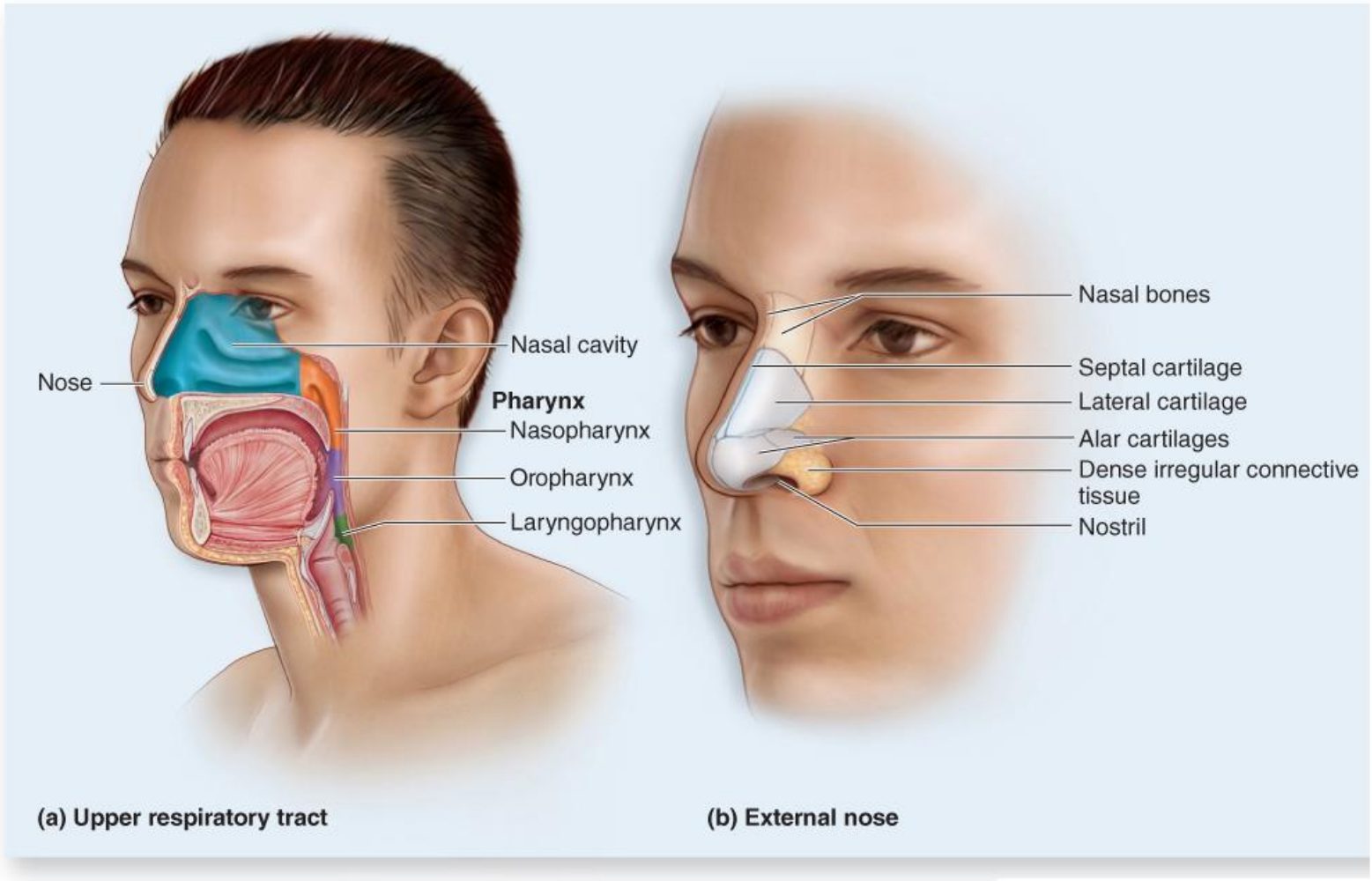
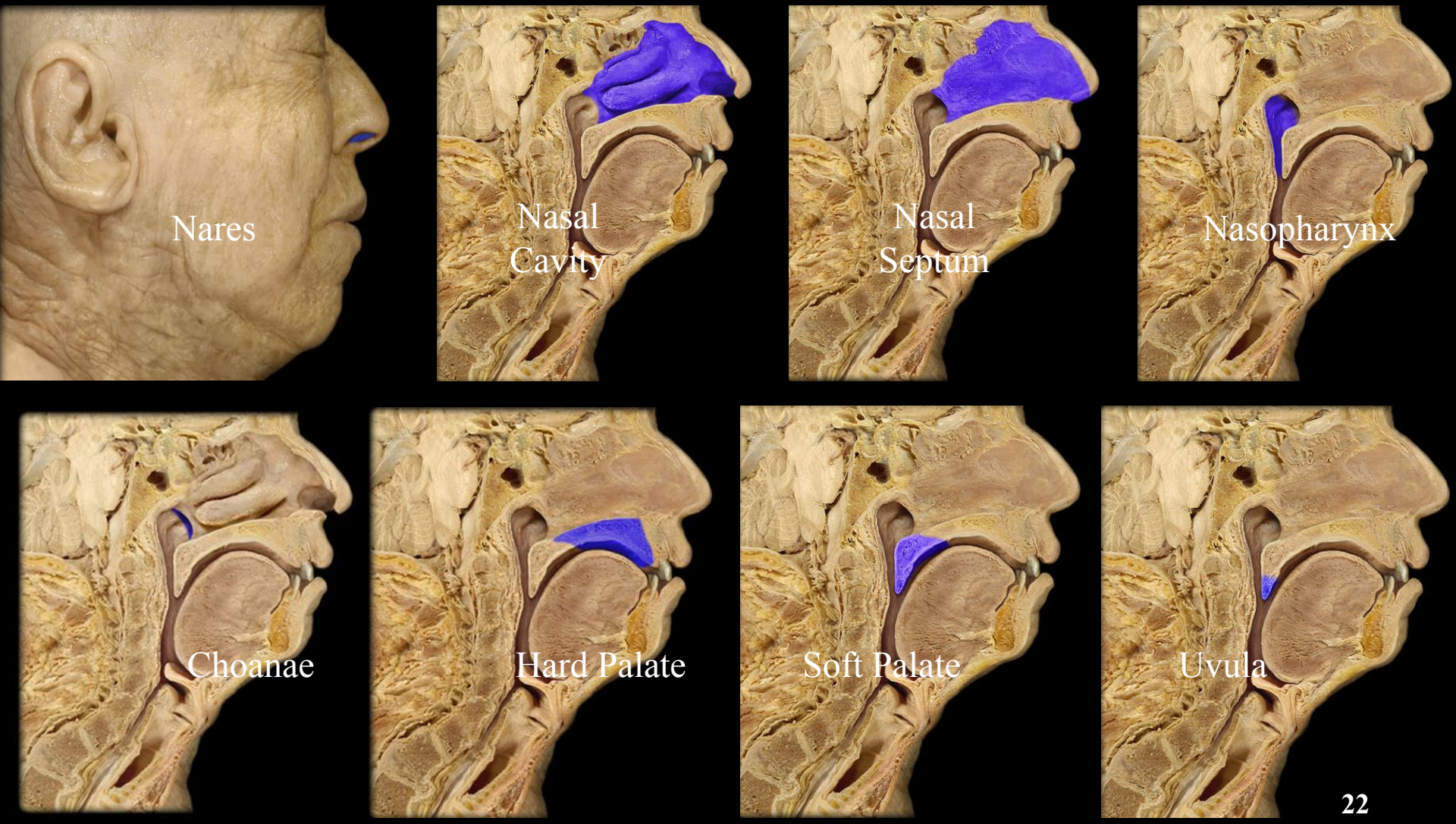


Figure 23.3a,b

23.2a Nose and Nasal Cavity

- **Nasal cavity:** from nostrils to choanae
  - An oblong-shaped internal space
  - **Choanae** (*posterior nasal apertures*) lead to pharynx
  - Floor formed by palate
  - Roof made of nasal, frontal, ethmoid, and sphenoid bones plus some cartilage
  - **Nasal septum** divides left and right sides
    - Anterior part is **septal nasal cartilage**
    - Posterior part is bony perpendicular plate of ethmoid plate and vomer bone

Nasal Cavity and Choanae



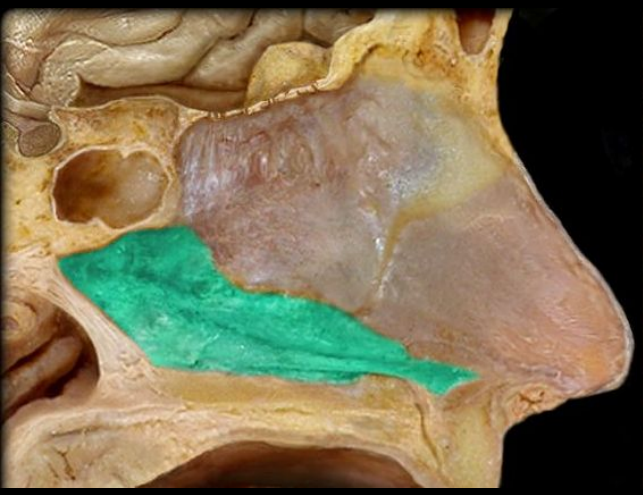
Nasal Septum

Perpendicular plate of ethmoid

Vomer

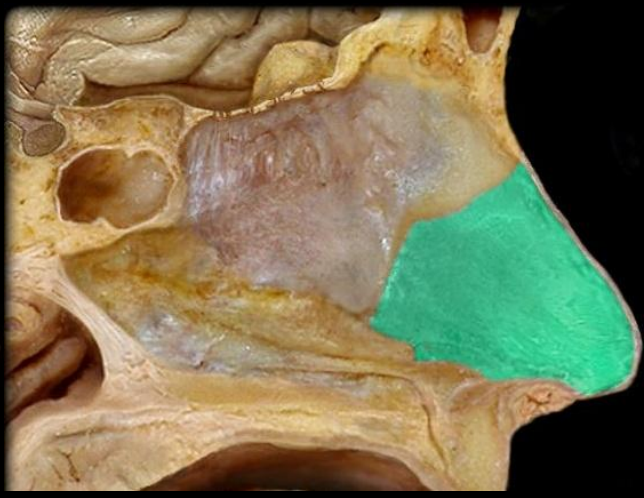
Nasal Septum

Vomer



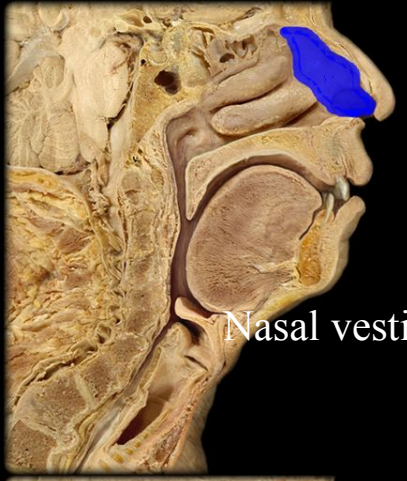
Perpendicular plate

Septal nasal cartilage



23.2a Nose and Nasal Cavity

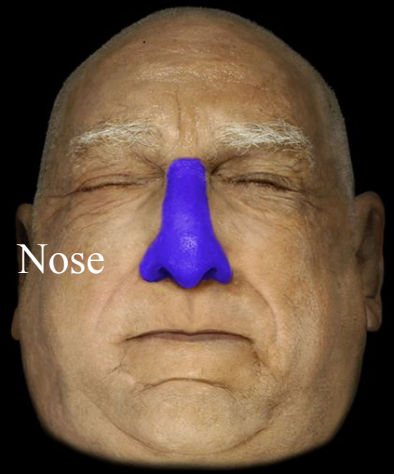
- The **nasal conchae**
  - Three paired, bony projections on lateral walls of nasal cavity
    - **Superior, middle,** and **inferior conchae**
  - Also called *turbinate* bones
    - Produce turbulence in inhaled air
  - Partition the nasal cavity into separate passages
    - Each passage called a **nasal meatus**
    - Each meatus immediately inferior to its corresponding concha



Nasal vestibule

Superior nasal concha

Superior nasal meatus

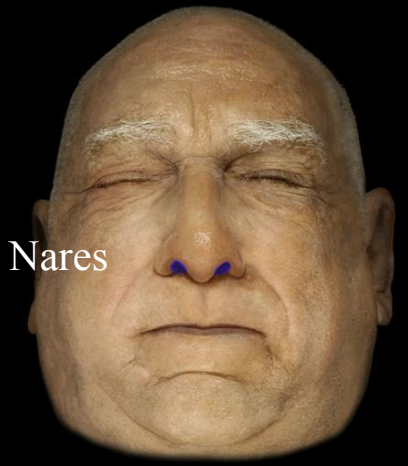


Nose

Choana

Middle nasal concha

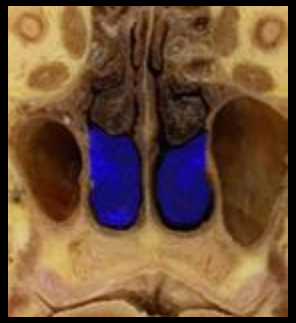
Middle nasal meatus



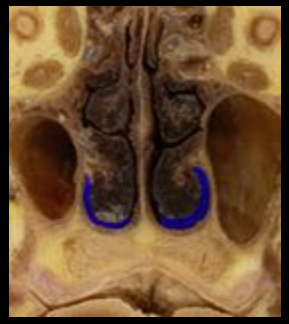
Nares

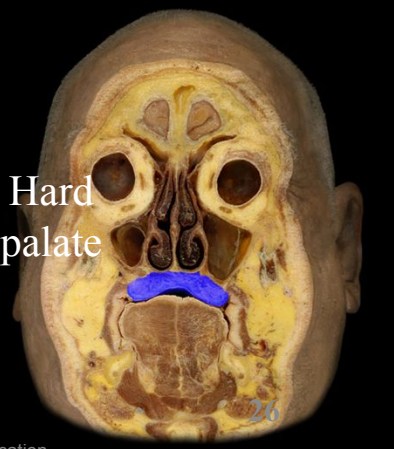
Nasal septum

Inferior nasal concha



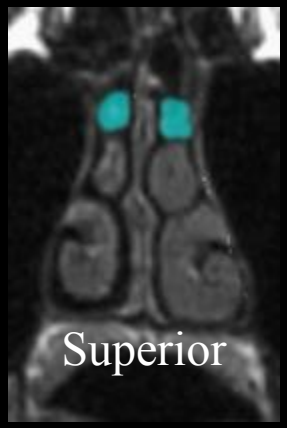
Inferior nasal meatus

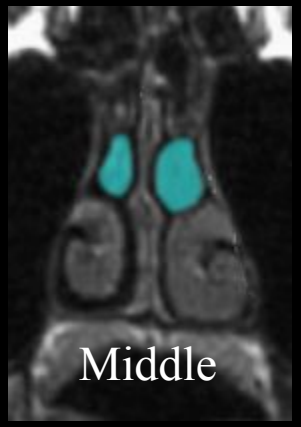


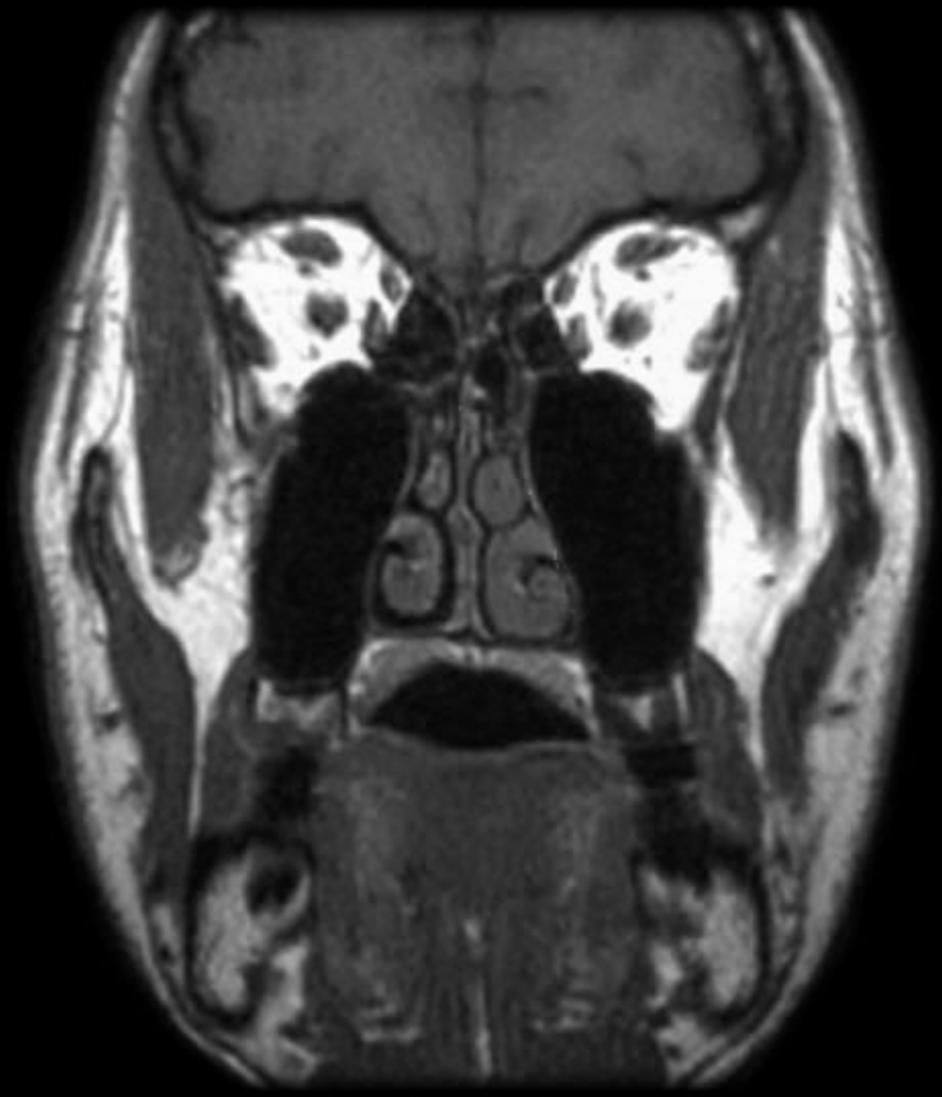


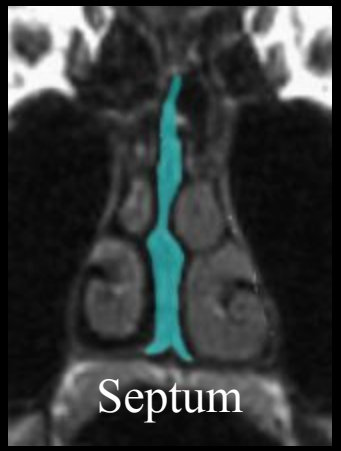
Hard palate

Nasal Conchae-MRI









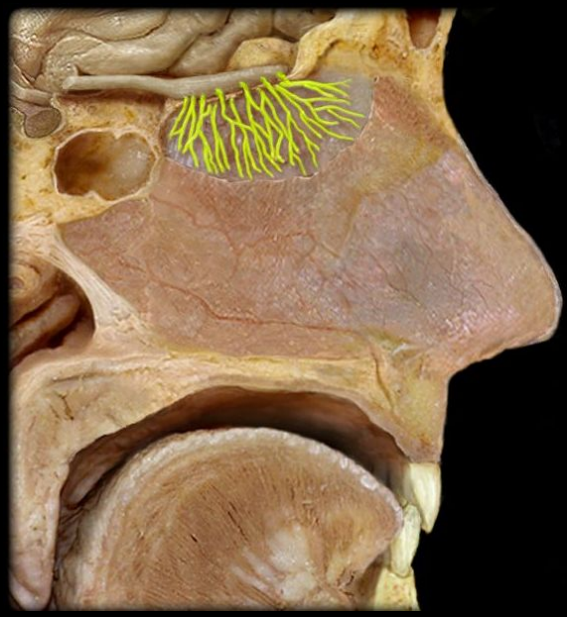
23.2a Nose and Nasal Cavity

- Nasal cavity parts
  - **Nasal vestibule:** just inside nostrils
    - Lined by skin and particle-trapping hairs called **vibrissae**
  - **Olfactory region**
    - Superior part of nasal cavity containing olfactory epithelium
    - Airborne molecules stimulate receptors for odor detection
  - **Respiratory region**
    - Lined by pseudostratified ciliated columnar epithelium
    - Has an extensive vascular network
      - Nosebleeds (*epistaxis*) common due to large numbers of superficial vessels

Olfactory Region

Olfactory mucosa

Olfactory nerves



Olfactory bulb

Olfactory tract

Upper Respiratory Tract

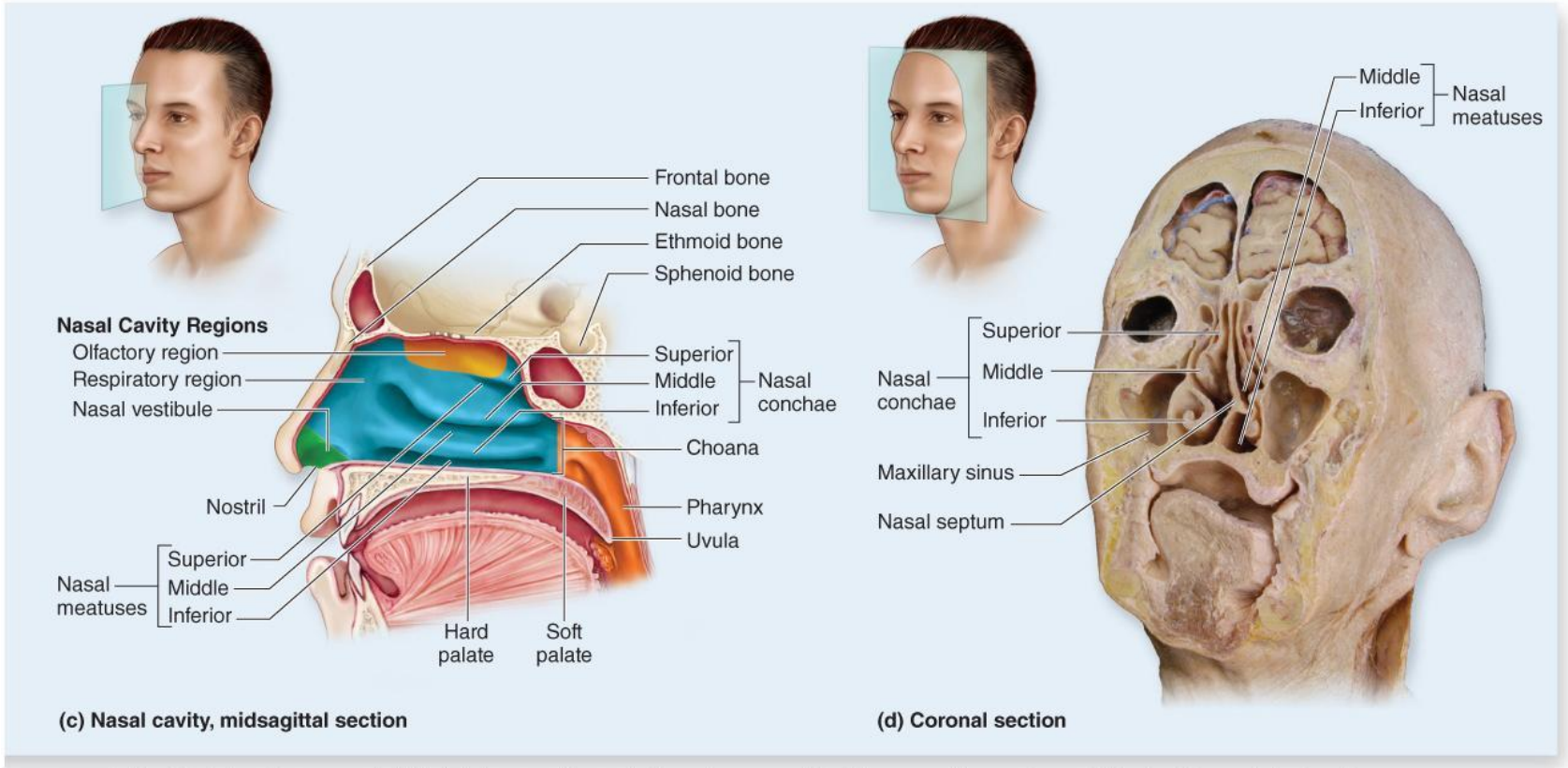


Figure 23.3c,d

23.2a Nose and Nasal Cavity

- **Nasolacrimal ducts**
  - Drain lacrimal secretions from eye surfaces to nasal cavity
- Nasal cavity warms, cleanses, and humidifies
  - Air is warmed by extensive blood vessels
  - Mucus traps dust, microbes, and foreign material
  - Cilia sweep mucous toward the pharynx to be swallowed
  - Moist environment humidifies
  - Air turbulence created by conchae enhances all three processes

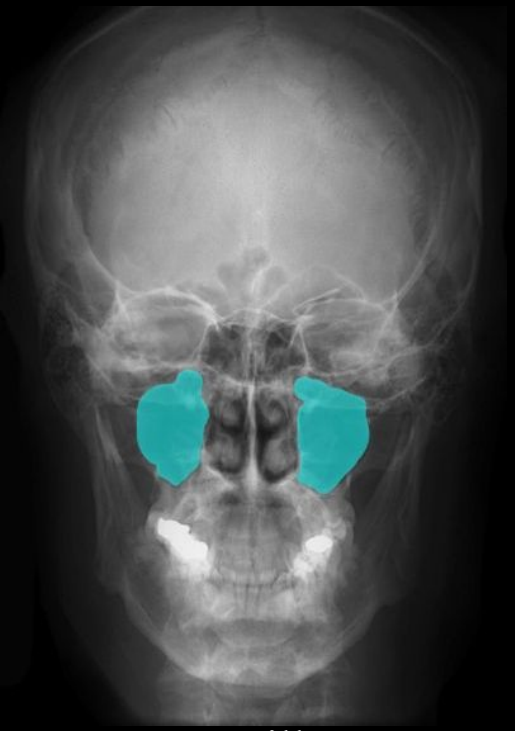
Clinical View: Runny Nose

- **Rhinorrhea** (*runny nose*) occurs as a result of
  - Increased production of mucus (allergies, virus)
  - Increased secretions from lacrimal glands draining into the nasal cavity (crying)
  - Exposure to cold air (water condensation + less effective cilia)

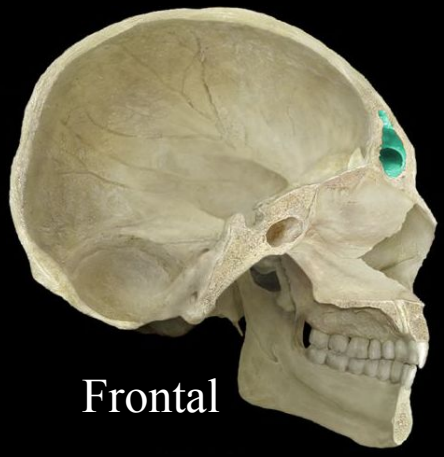
23.2b Paranasal Sinuses

- **Paranasal sinuses:** spaces within skull bones
  - Named for specific bone in which they are housed
  - All connected by ducts to nasal cavity
- From superior to inferior
  - **Frontal sinuses**
  - **Ethmoidal sinuses**
  - **Sphenoidal sinuses** posterior to ethmoidal sinuses
  - **Maxillary sinuses**

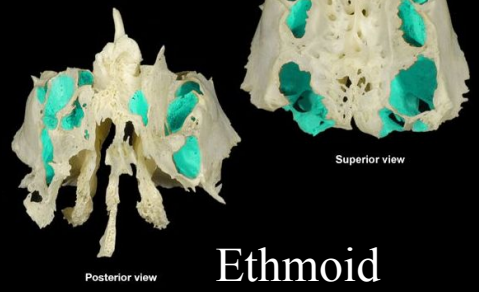
Paranasal Sinuses



Maxillary



Frontal



Ethmoid

Sphenoid

23.2b Paranasal Sinuses

- Lined by pseudostratified ciliated columnar epithelium
- Mucus swept into pharynx and swallowed

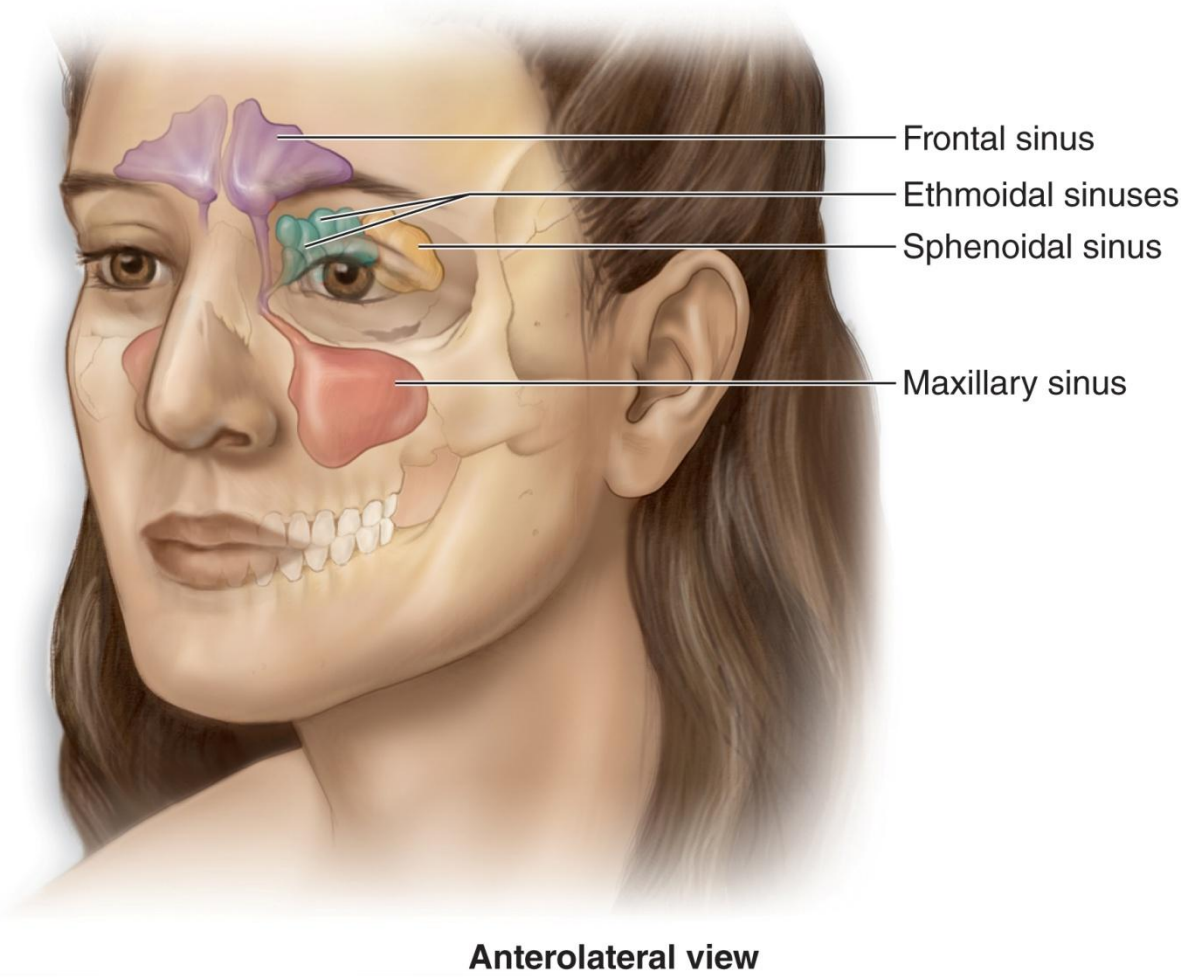
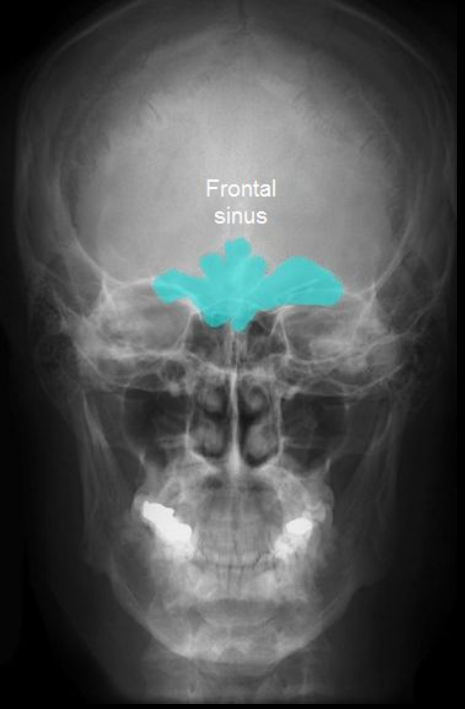
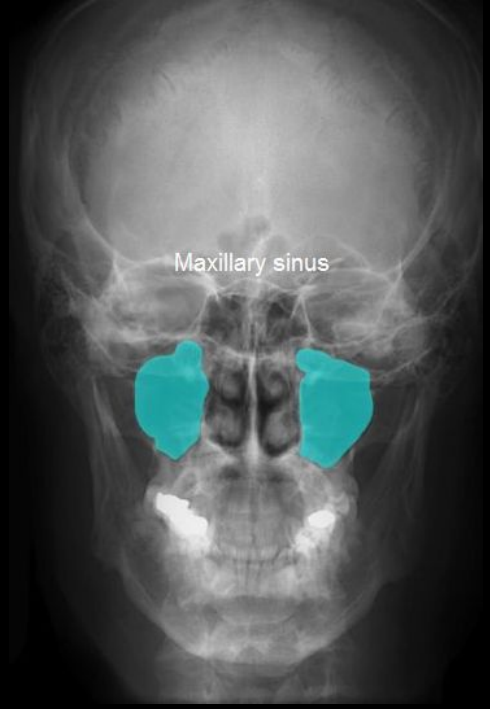
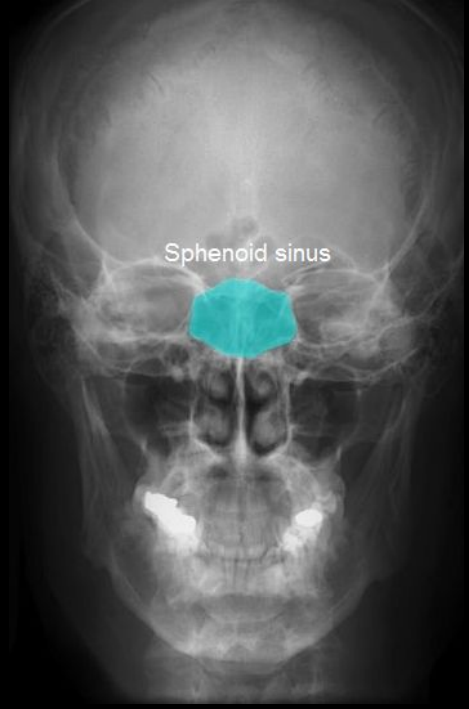


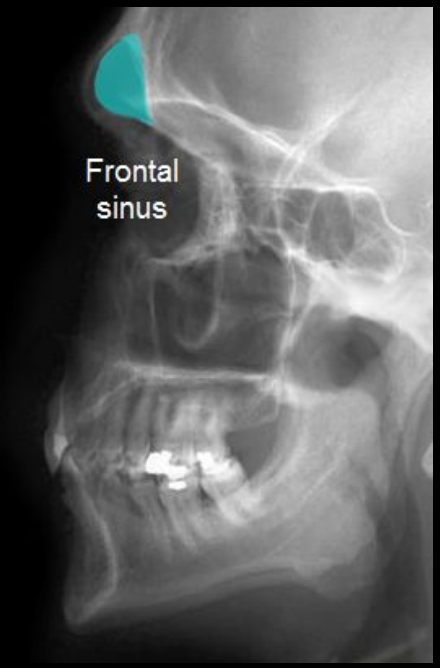
Figure 23.4

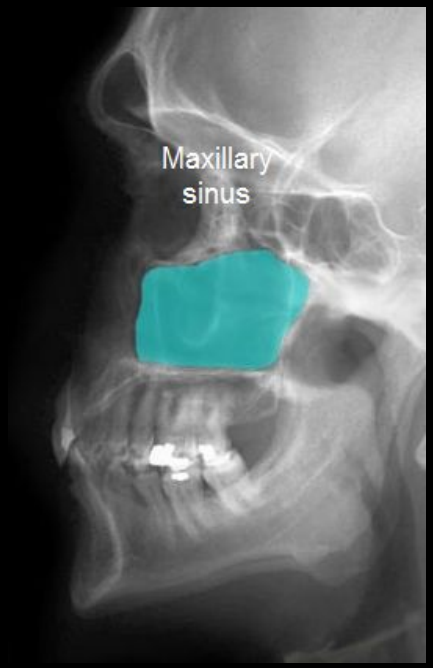
Paranasal sinuses











Clinical View: Sinus Infections and Sinus Headaches

- Respiratory infection or allergy can cause inflammation of the ducts that drain from the paranasal sinuses.
- Drainage of mucus decreases and accumulates in the sinuses.
- Germs can grow in the accumulated mucous, causing a **sinus infection.**
- Inflamed and blocked sinuses and pressure changes can cause **sinus headaches.**

23.2c Pharynx

- **Pharynx** (*throat*)
  - Funnel-shaped passageway posterior to nasal cavity, oral cavity, and larynx
  - Lateral walls composed of skeletal muscles
  - Partitioned into
    - Nasopharynx
    - Oropharynx
    - Laryngopharynx

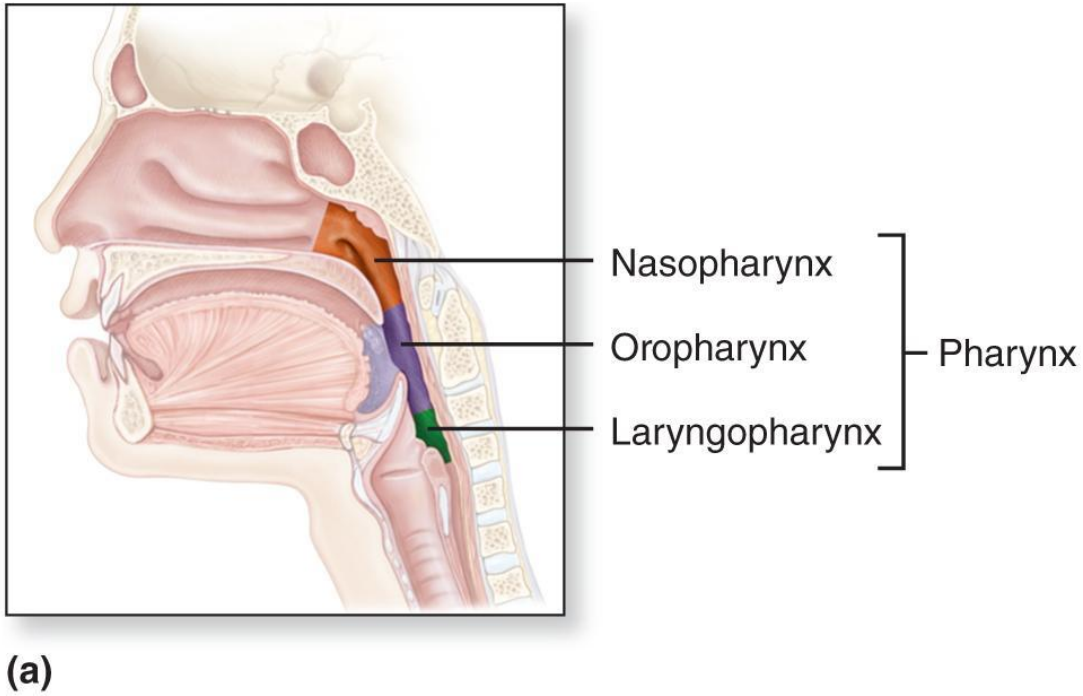
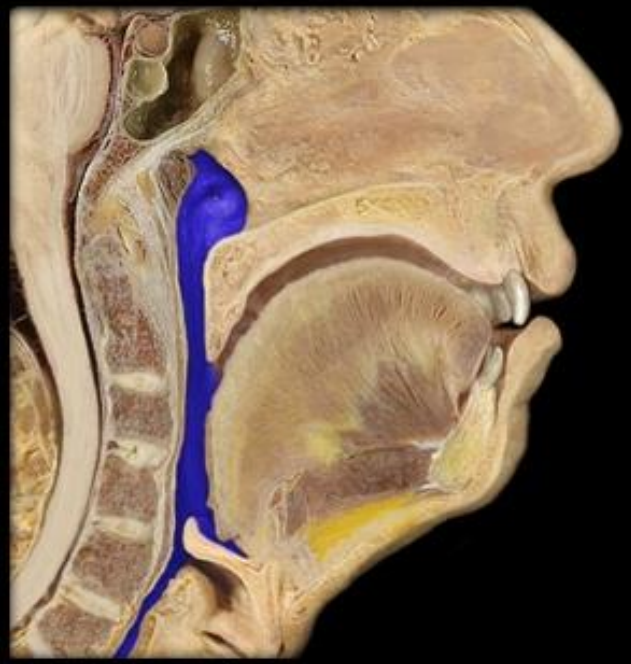
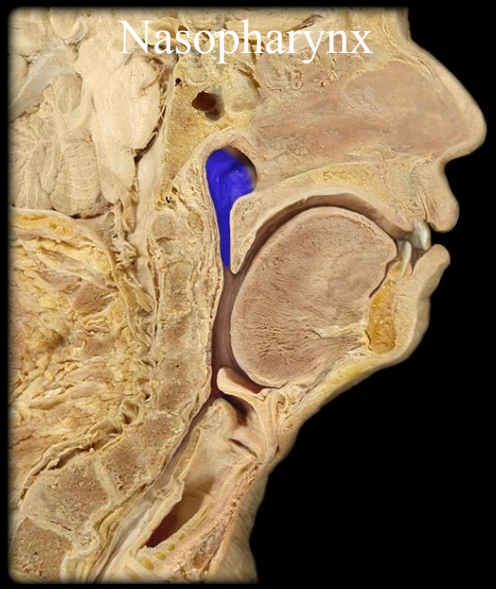
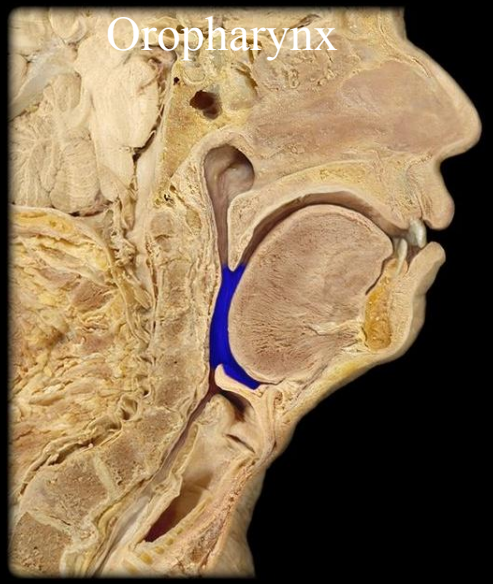


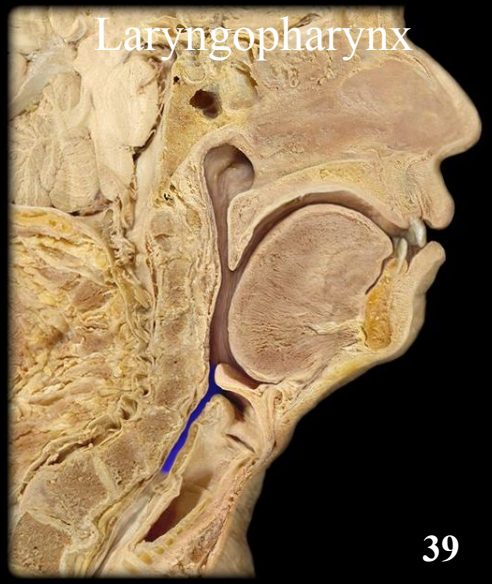
Figure 23.5a



Pharynx
(throat)







Pharynx

23.2c Pharynx

- **Nasopharynx:** most superior part of pharynx
  - Posterior to nasal cavity, superior to soft palate
  - Lined by pseudostratified ciliated columnar epithelium
  - An air passage—not for food
    - Soft palate elevates during swallowing, blocking food or drink
  - Connects to middle ear via **auditory** (*eustachian*) **tube**
    - Opening tubes allows equalization of pressure on each side of tympanic membrane
  - Contains tonsils—infection-fighting lymphatic tissue
    - Tubal tonsils located near auditory tube opening
    - **Pharyngeal tonsil** on posterior nasopharynx wall
      - Called **adenoids** when enlarged

23.2c Pharynx

- **Oropharynx:** middle pharyngeal region
  - Posterior to oral cavity
    - Extends from soft palate to hyoid bone
  - Passageway for both food and air
  - Lined by nonkeratinized stratified squamous epithelium
  - Contains tonsils
    - **Palatine tonsils** on the lateral walls
    - **Lingual tonsils** at base of tongue

23.2c Pharynx

- **Laryngopharynx:** inferior, narrow region of pharynx
  - Posterior to the larynx
  - From level of hyoid down to esophagus
  - Passageway for both food and air
  - Lined by nonkeratinized stratified squamous epithelium

Pharynx

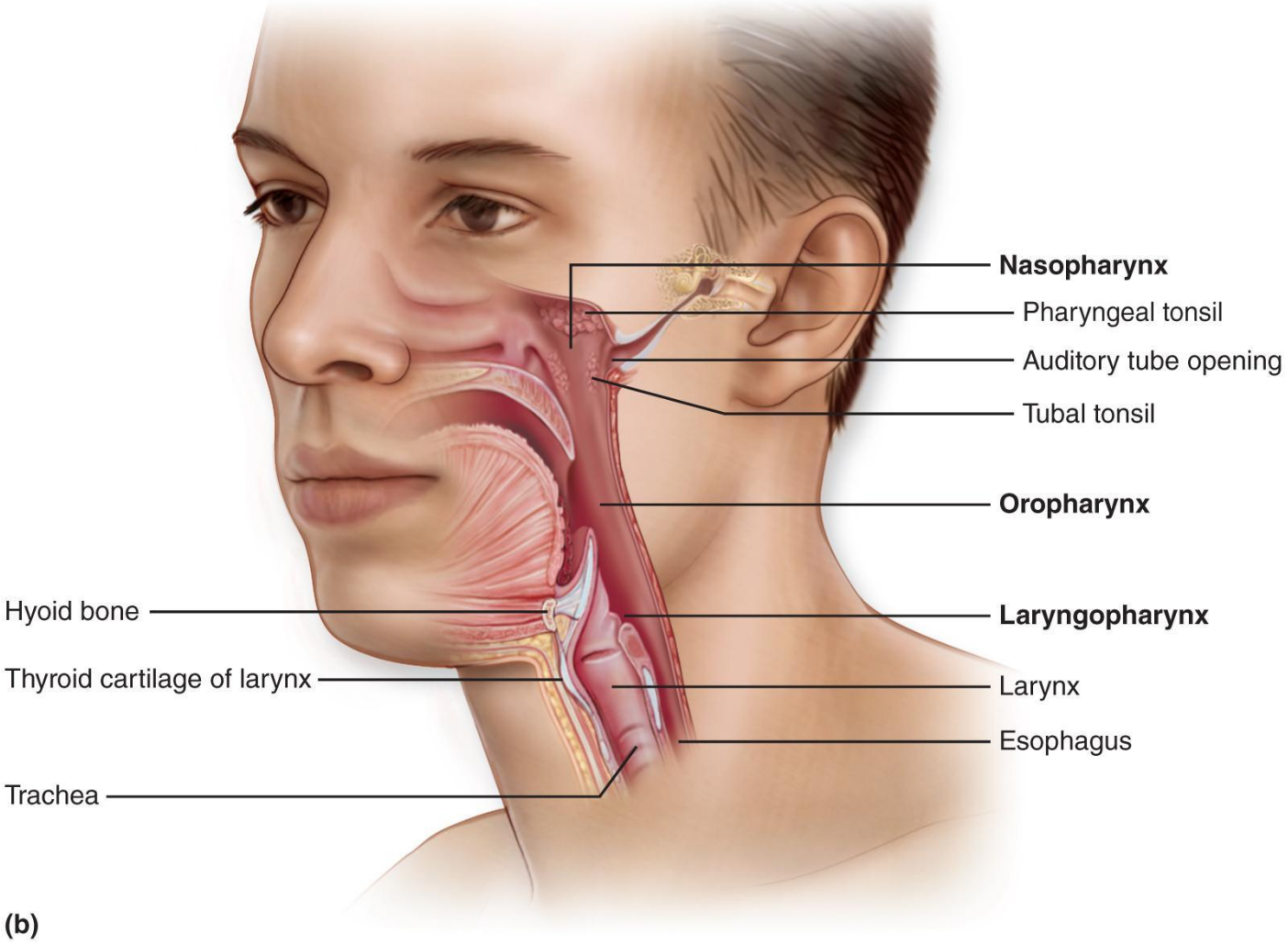


Figure 23.5b

What did you learn?

- What are vibrissae?
- Between which conchae is the middle nasal meatus located?
- What is the difference between the lining of the oropharynx and that of the nasopharynx?
- In which part of the pharynx are the pharyngeal tonsils located?

23.3 Lower Respiratory Tract

Learning Objectives:

1. Describe the general functions and structure of the larynx.
2. Explain how the larynx functions in sound production.
3. Describe the structure of the trachea.
4. Explain the structure and function of the tracheal cartilages.
5. Describe the structural divisions of the bronchial tree.

23.3 Lower Respiratory Tract (*continued*)

Learning Objectives:

6. Explain the processes of bronchoconstriction and bronchodilation.
7. Describe the structure and function of the components of the respiratory zone.
8. List three types of cells found in alveoli, and describe the function of each.
9. Explain the structure of the respiratory membrane.

23.3 Lower Respiratory Tract

- Includes conducting pathways from larynx to terminal bronchioles
- Includes structures involved in gas exchange: respiratory bronchioles, alveolar ducts, and alveoli

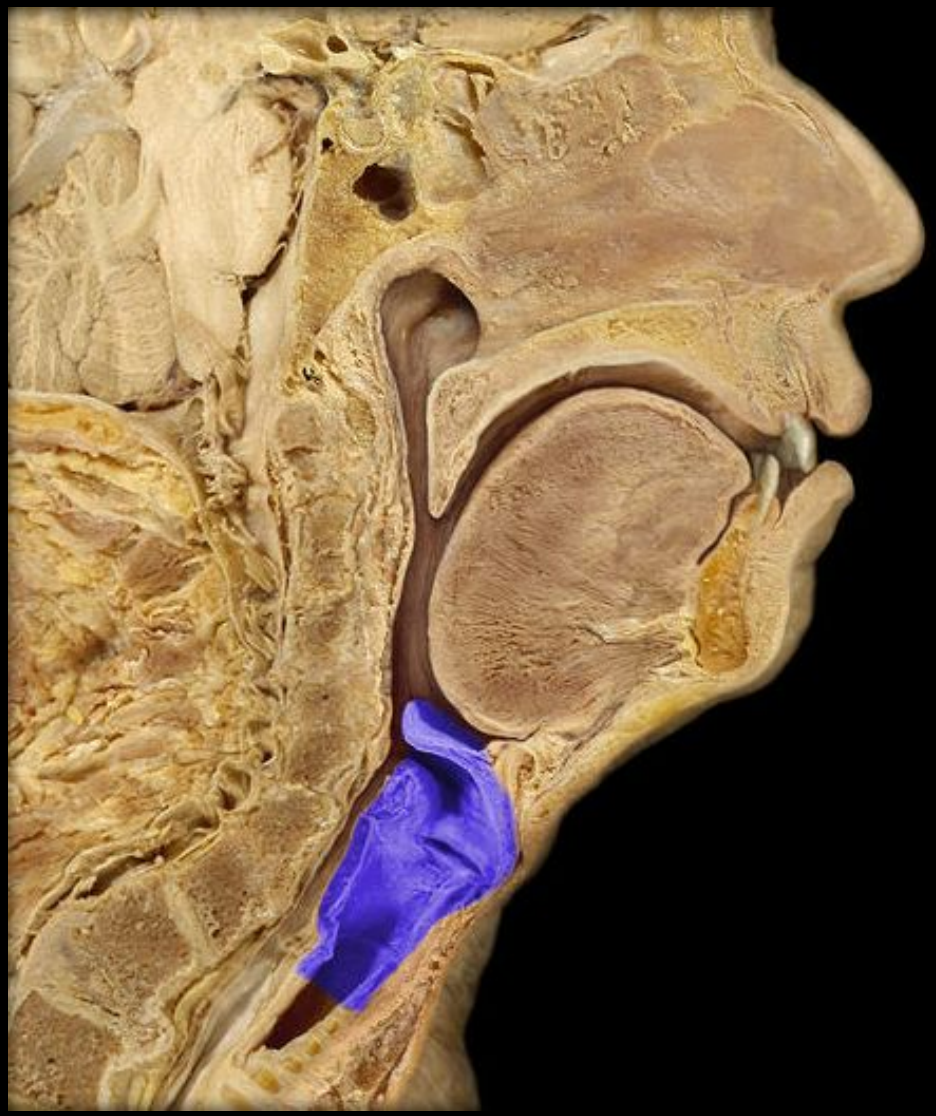
23.3a Larynx

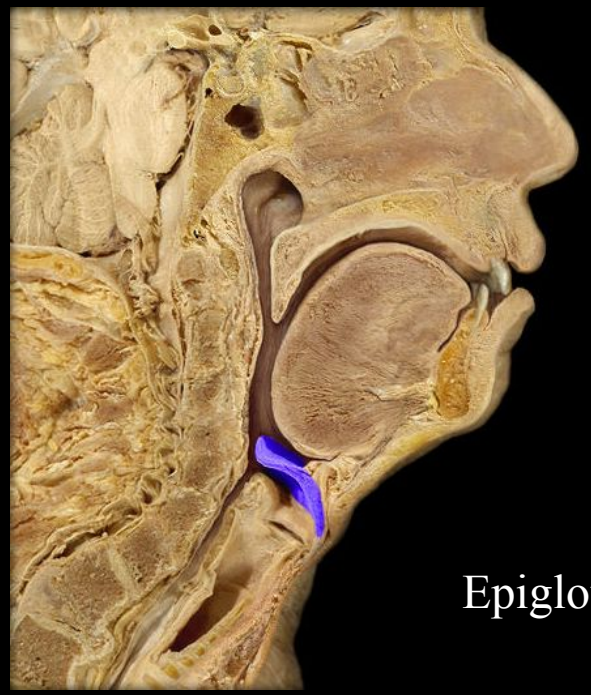
- **Larynx** (*voice box*)
  - Cylindrical airway between laryngopharynx and trachea
  - Several functions
    - Air passageway (usually open)
    - Prevents ingested materials from entering respiratory tract
      - Epiglottis covers superior opening during swallowing
    - Produces sound for speech
      - Vocal cords (ligaments) vibrate during expiration
    - Assists in increasing pressure in the abdominal cavity
      - **Valsalva maneuver:** simultaneous closure of laryngeal opening (by the epiglottis) and contraction of abdominal muscles
      - Increased pressure facilitates urination, defecation, childbirth

22.3a Larynx

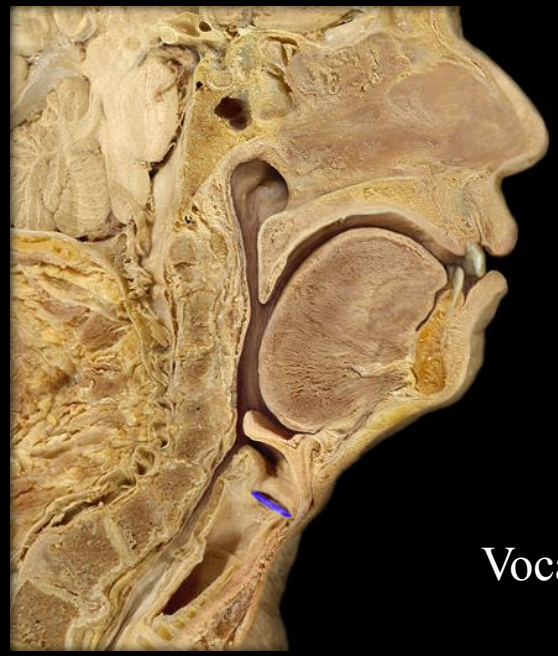
- Several functions (*continued*)
  - Participates in sneeze and cough reflexes
    - Help remove irritants from nasal cavity or lower respiratory tract
    - Abdominal muscles contract increasing thoracic pressure
    - Vocal cords are forcibly opened by pressure from below
    - Explosive blast of exhaled air is a cough or sneeze

Larynx





Epiglottis



Vocal cords

Larynx

23.3a Larynx

- Larynx anatomy
  - **Laryngeal inlet** (*laryngeal aperture*) connects pharynx and larynx
  - Larynx formed and supported by nine pieces of cartilage
    - Cartilages held in place by ligaments and muscles
    - Single thyroid, cricoid, and epiglottis cartilages
    - Paired arytenoid, corniculate, and cuneiform cartilages

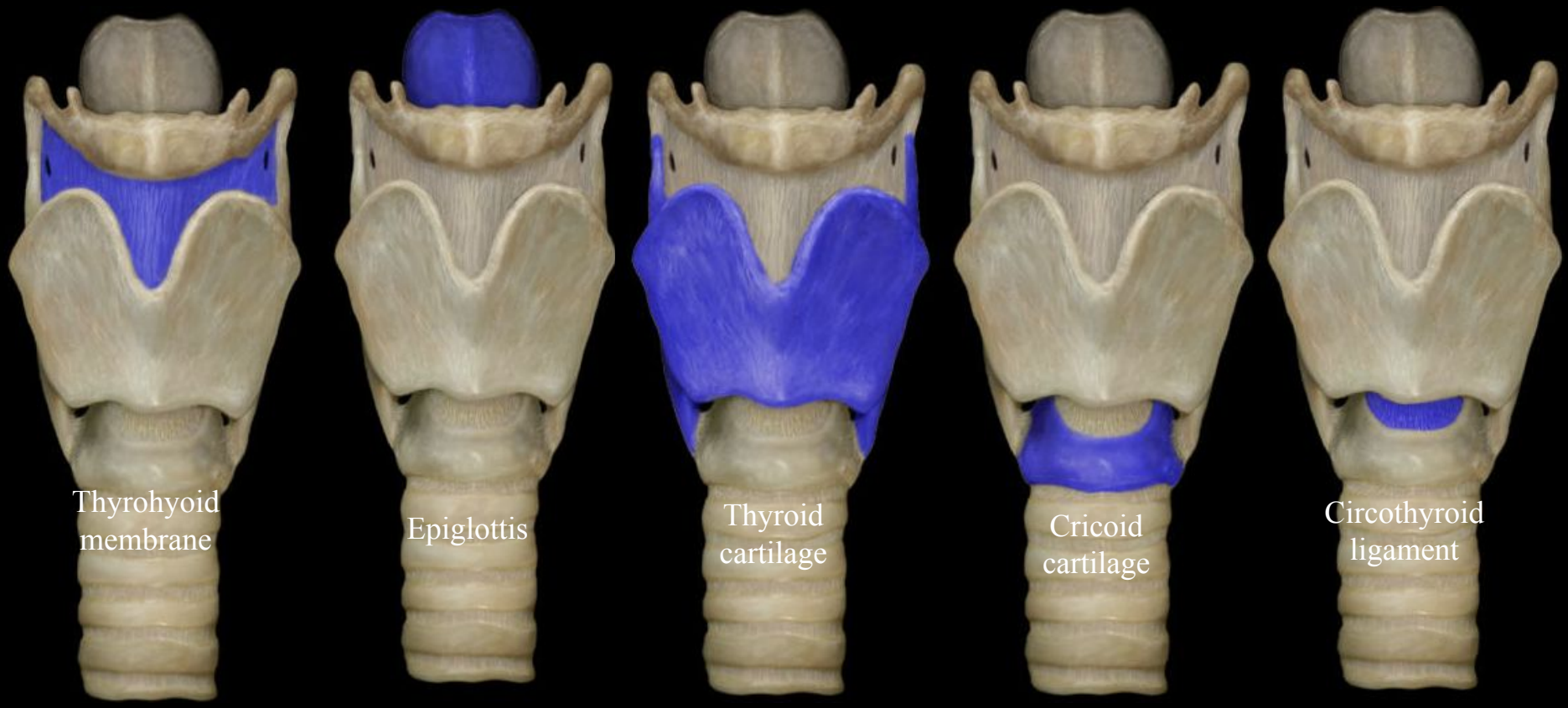
23.3a Larynx

- Larynx anatomy (*continued*)
  - **Thyroid cartilage:** large, shield-shaped
    - Forms lateral and anterior walls of larynx
      - Attached to lateral surface of cricoid cartilage
    - Anterior protrusion is **laryngeal prominence,** or *Adam's apple*
      - Generally larger in males
        - » Enlarges during puberty; has sharper angle in males
  - **Cricoid cartilage:** ring-shaped
    - Just inferior to thyroid cartilage
  - **Epiglottis:** spoon-shaped
    - Anchored to inner aspect of thyroid cartilage
    - Projects posterosuperiorly into the pharynx
    - Closes over laryngeal inlet during swallowing

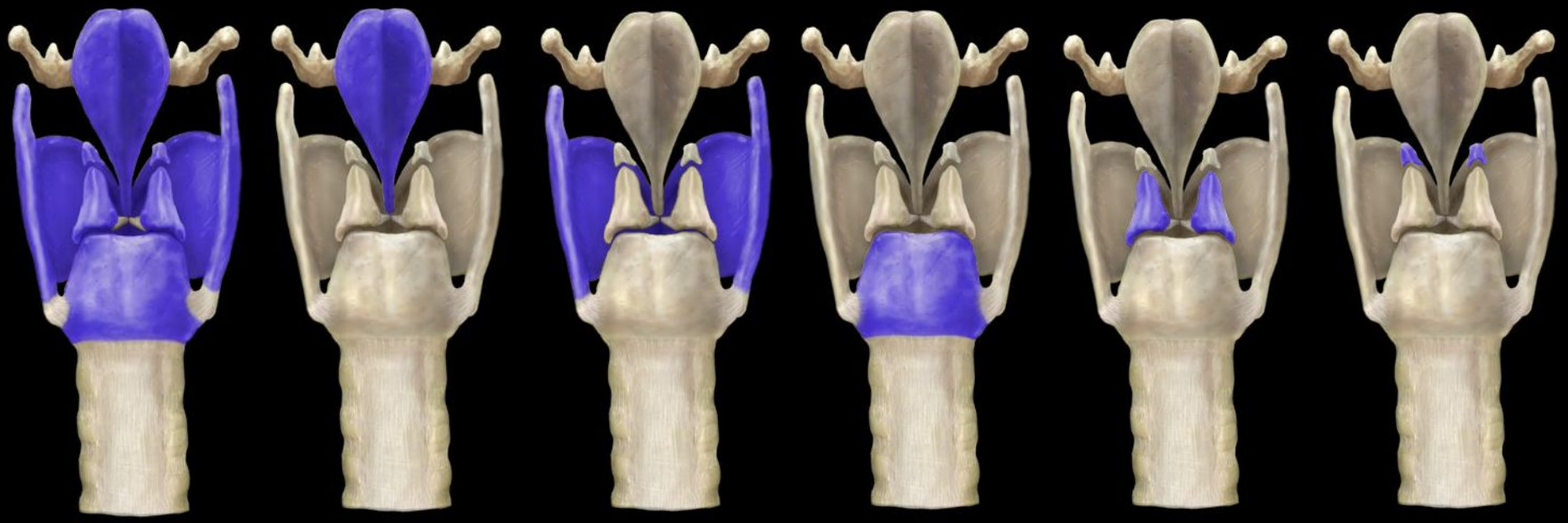
23.3a Larynx

- Larynx anatomy (*continued*)
  - Smaller, paired cartilages located internally
    - **Arytenoid, corniculate,** and **cuneiform**
  - All laryngeal cartilages are made of hyaline cartilage, except the epiglottis, which is made of elastic cartilage
  - Laryngeal ligaments are extrinsic or intrinsic
    - **Extrinsic ligaments**
      - Attach external surface of larynx to other structures (e.g., hyoid bone)
    - **Intrinsic ligaments** are located within the larynx
      - Include the **vocal ligaments** and the **vestibular ligaments**

Larynx - Anterior



Larynx - Posterior



Laryngeal cartilages | Epiglottis | Thyroid | Cricoid | Arytenoid | Corniculate

Larynx

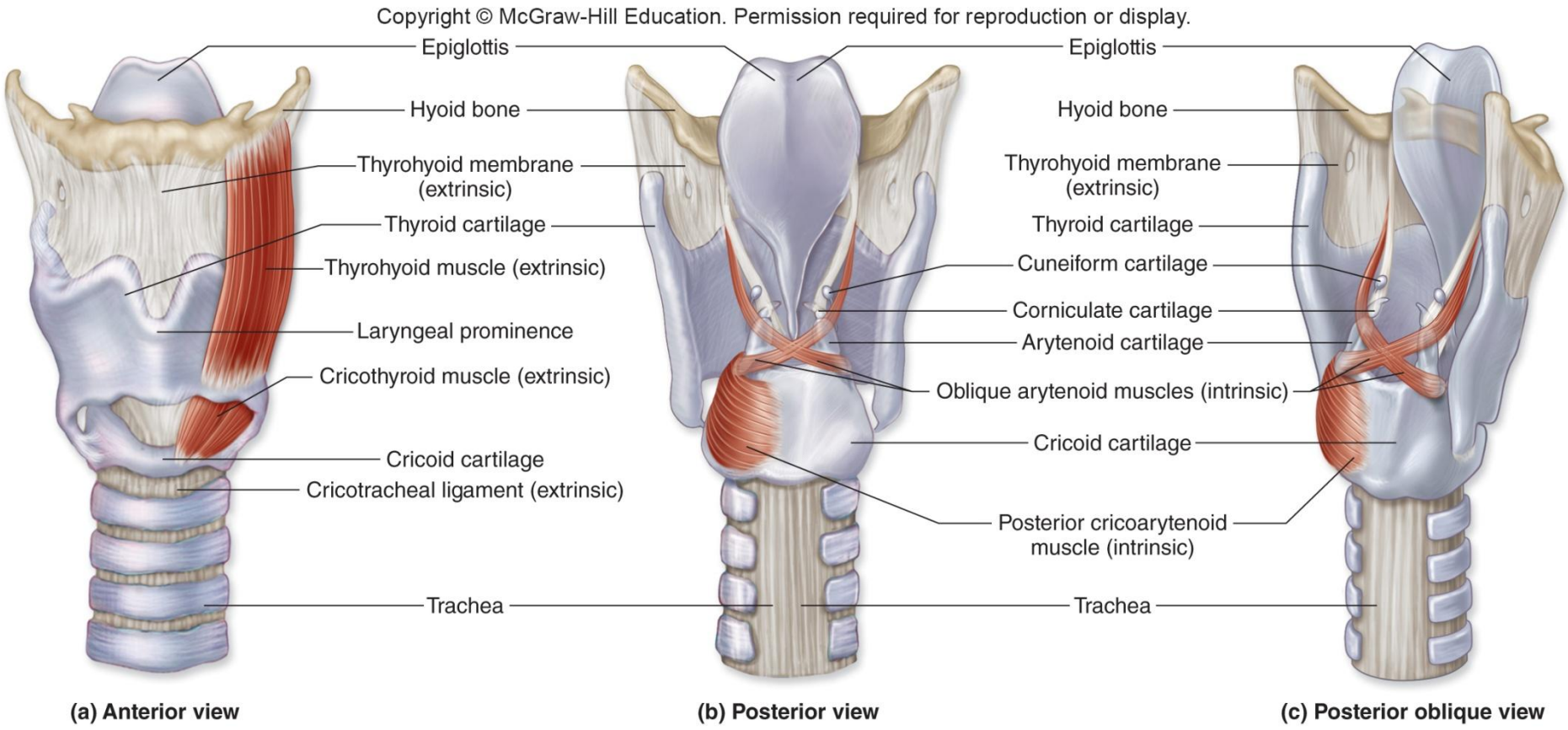
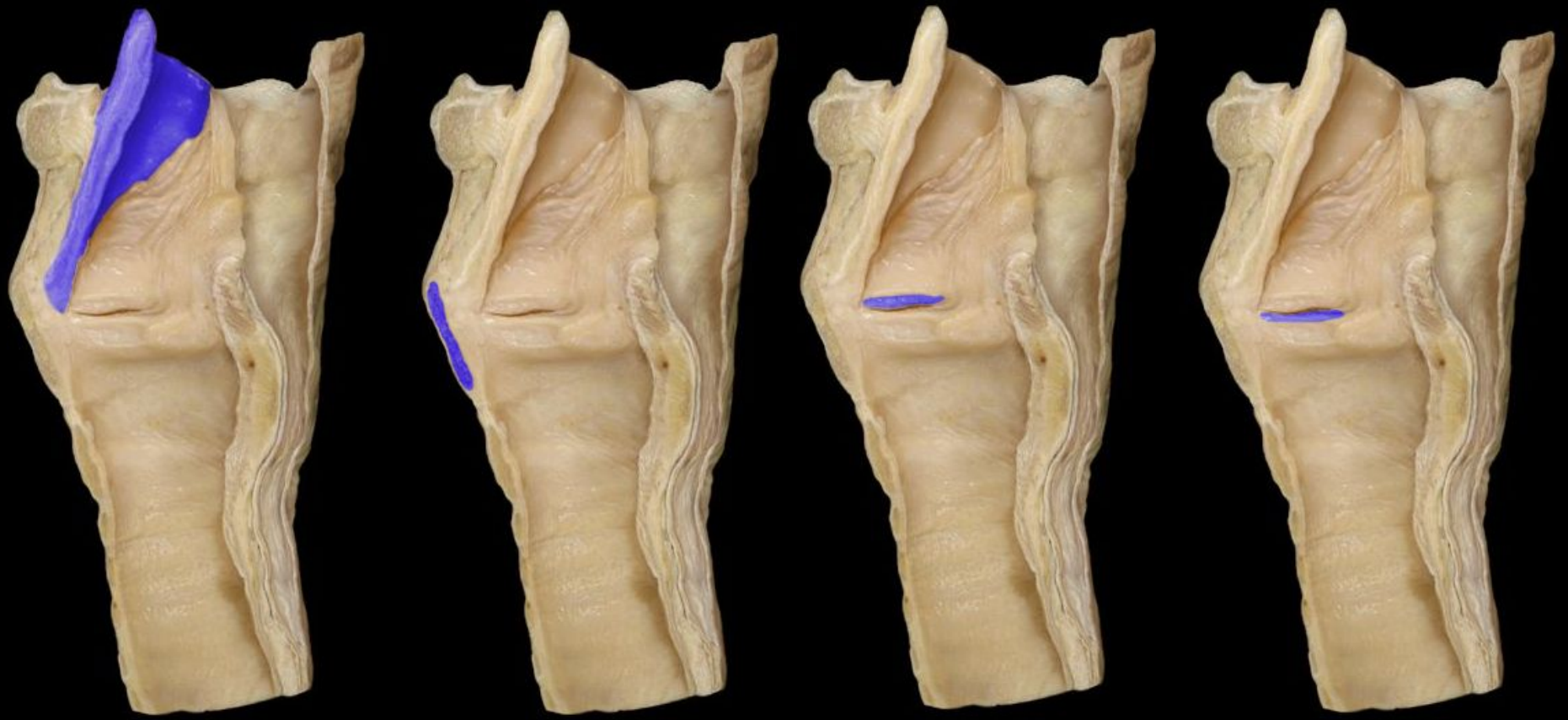


Figure 23.6

Larynx - Lateral



Epiglottis

Thyroid cartilage

Vestibular fold

Vocal fold

23.3a Larynx

- Larynx anatomy: **ligaments** (*continued*)
  - **Vocal ligaments** extend between thyroid and arytenoid cartilages
    - Composed primarily of avascular elastic connective tissue
    - Covered with mucosa to form the **vocal folds** (*true vocal cords*)
    - Produce sound when air passes between them
    - Opening between ligaments = **rima glottidis**
    - **Rima glottidis** + **vocal folds** = **glottis**
  - **Vestibular ligaments** extend from thyroid cartilage to arytenoid and corniculate cartilages (superior to vocal folds)
    - Covered with mucosa to form the **vestibular folds** (*false vocal cords*)
    - Play no role in sound production
    - Protect vocal cords
    - Opening between vestibular folds = *rima vestibuli*

Vocal Folds

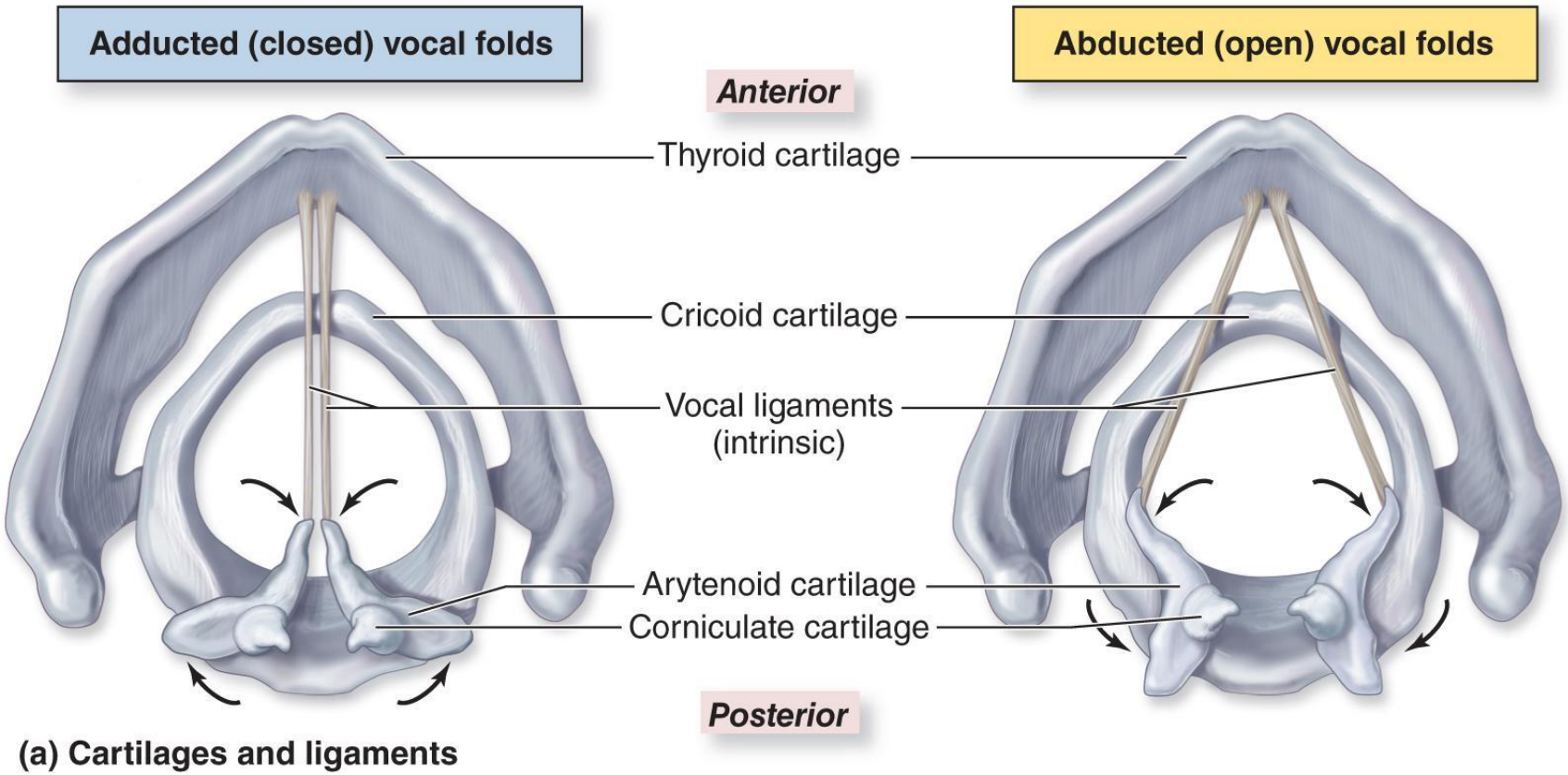
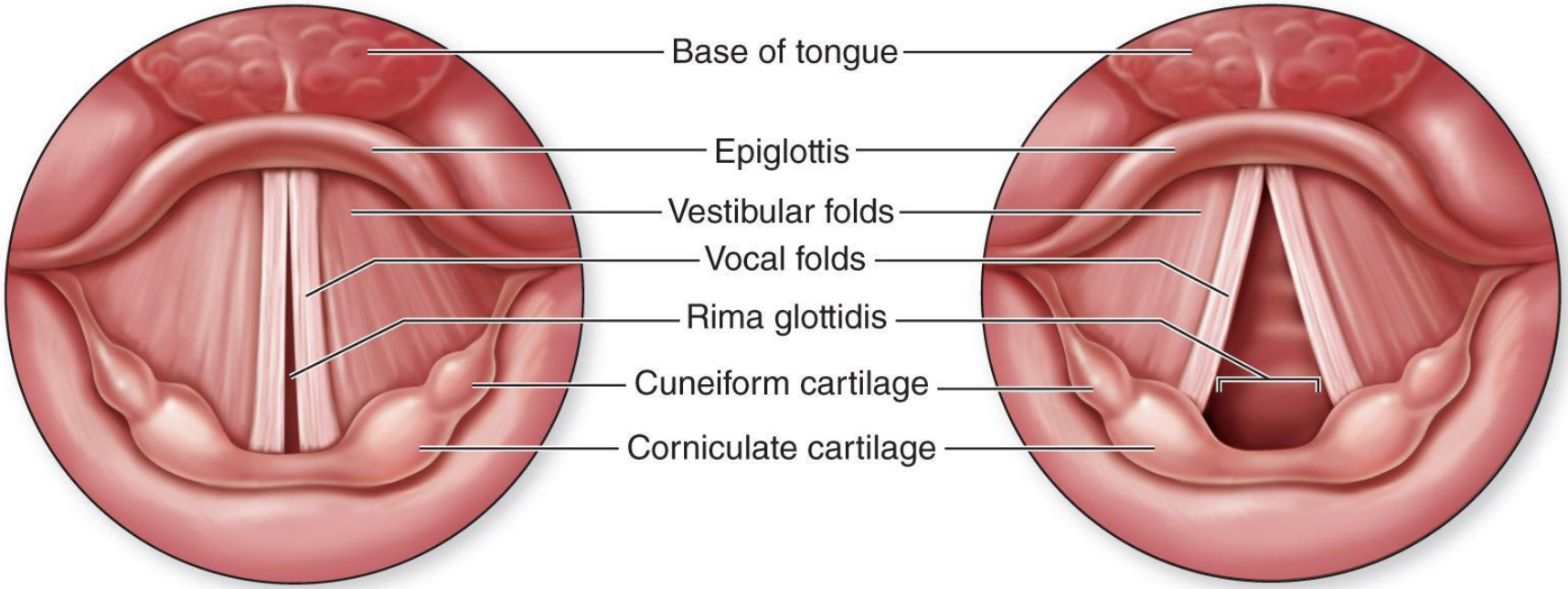


Figure 23.7a

Vocal Folds



(b) Laryngoscopic view

Figure 23.7b

23.3a Larynx

- Larynx anatomy (*continued*)
  - **Extrinsic skeletal muscles**
    - Stabilize larynx and help it move during swallowing
    - Originate on hyoid bone or sternum; insert on thyroid cartilage
  - **Intrinsic skeletal muscles**
    - Located within larynx
    - Attach to arytenoid and corniculate cartilages
    - Contraction results in change in dimension of rima glottidis
      - Narrowing with adduction; widening with abduction
    - Involved in voice production and swallowing

23.3a Larynx

- **Sound production:** vocal cord vibration
  - Intrinsic laryngeal muscles narrow opening of rima glottidis
  - Air is forced past vocal cords during expiration
  - **Range** of voice determined by length, thickness of vocal cords
    - Males have longer and thicker folds, and so deeper voices
    - Folds increase in length with growth, deepening range
  - **Pitch** (frequency) determined by tension on vocal cords
    - Increased tension = folds vibrate more = higher pitch
    - Regulated by intrinsic laryngeal muscles
  - **Loudness** depends on force of air passing across vocal cords
    - More air = louder sound

23.3a Larynx

- **Sound production** (*continued*)
  - Other structures are also necessary for speech
    - Pharynx, nasal and oral cavities, and paranasal sinuses serve as resonating chambers
    - Lips, teeth, and tongue help form speech sounds

Clinical View: Laryngitis

- Inflammation of the larynx
- Symptoms of hoarse voice, sore throat, sometimes fever
- Caused by bacterial or viral infection, or overuse (yelling)
- Severe cases can extend to the epiglottis
  - May lead to sudden airway obstruction, especially in children

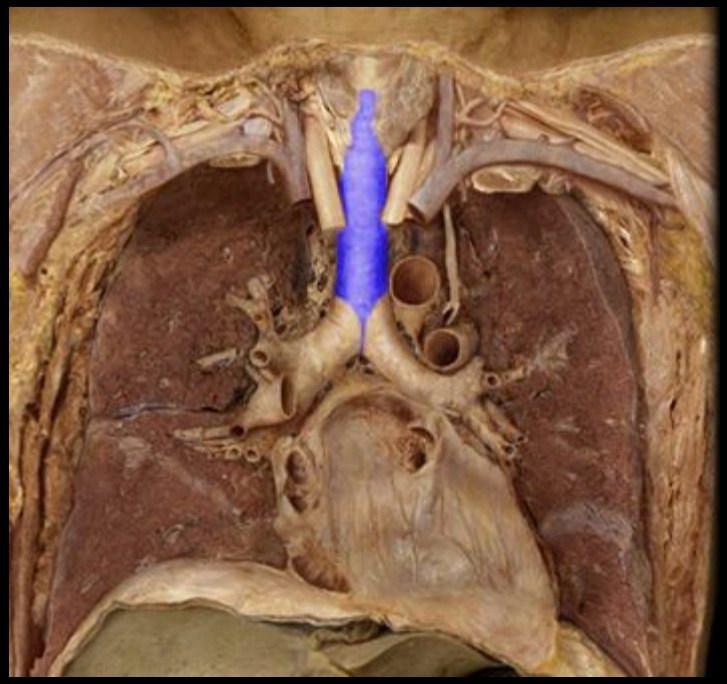
23.3b Trachea

- Gross anatomy of **trachea** (windpipe)
  - Flexible, slightly rigid, tubular organ
  - Goes from larynx to main bronchi
    - Anterior to esophagus, posterior to part of sternum
  - About 13 cm long, 2.5 cm in diameter
  - **Tracheal cartilages** support anterior and lateral walls
    - C-shaped rings of hyaline cartilages
      - Ensheathed in perichondrium and dense fibrous membrane
    - Ensure trachea is always open
    - Rings are connected to each other (above and below) by **anular ligaments**

23.3b Trachea

- Gross anatomy of the trachea (*continued*)
  - **Carina:** internal ridge at inferior end of trachea (where it splits) containing many sensory receptors
    - Initiates cough reflex when irritants are present
  - **Trachealis muscle** and ligamentous membrane on trachea's posterior surface
    - Connects open ends of C-shaped cartilages
    - Allow accommodation for esophagus when bulge of food passes
    - Trachealis contracts during coughing
  - **Tracheotomy:** incision in trachea to facilitate breathing
    - Done when airway is blocked or compromised

Trachea



Trachea

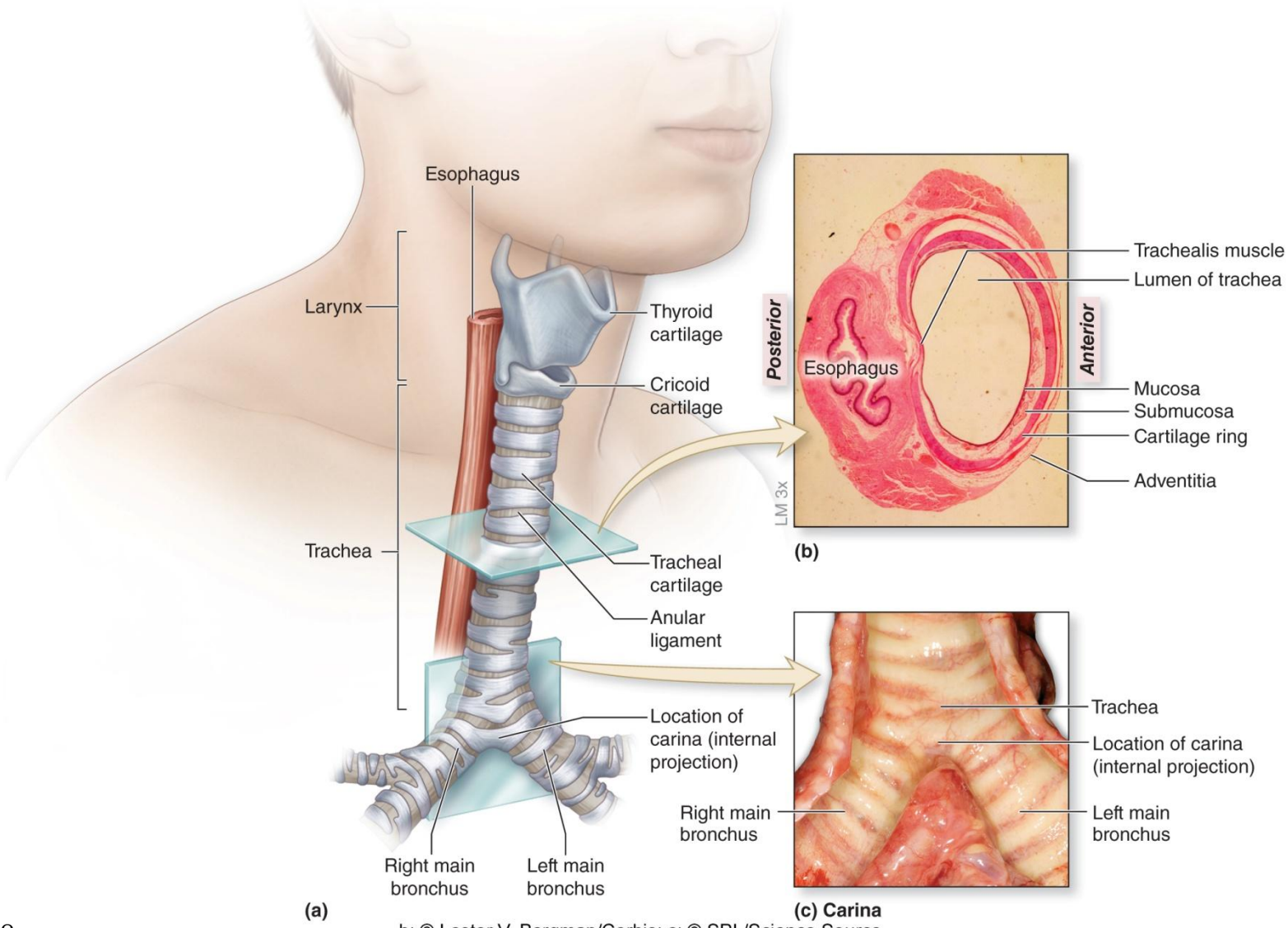


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Figure 23.8a-c

23.3b Trachea

- Histology of the tracheal wall
  - Layers, inner to outer
    - **Mucosa:** pseudostratified ciliated columnar epithelium and lamina propria
    - **Submucosa:** areolar connective tissue with blood vessels, nerves, serous and mucous glands, lymphatic tissue
    - **Tracheal cartilage**
    - **Adventitia:** elastic connective tissue

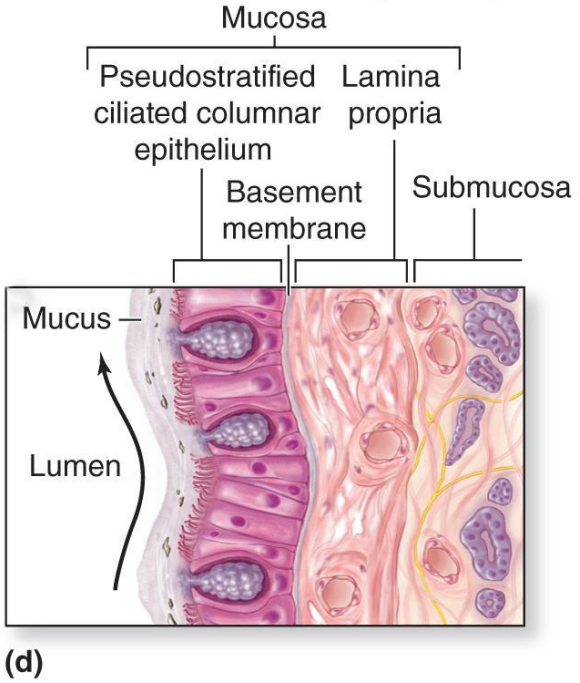
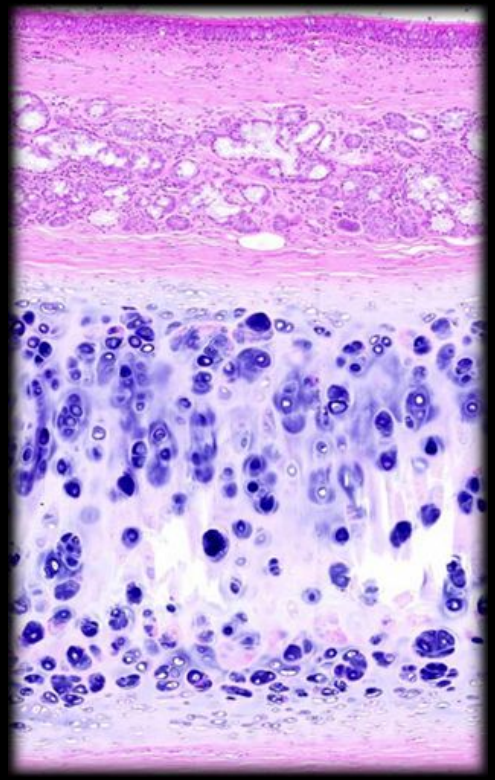
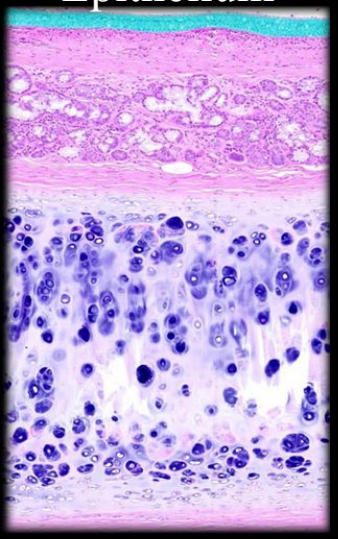


Figure 23.8d

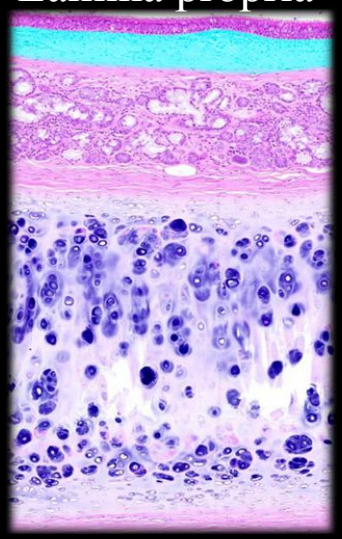
Trachea
Low Magnification



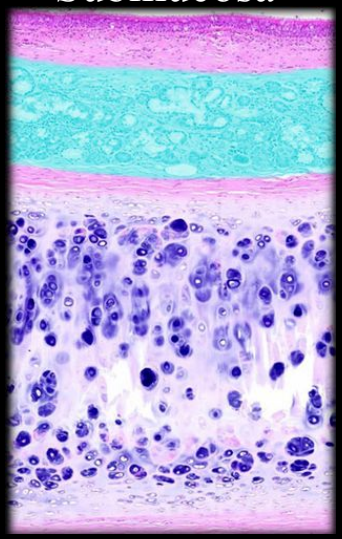
Epithelium



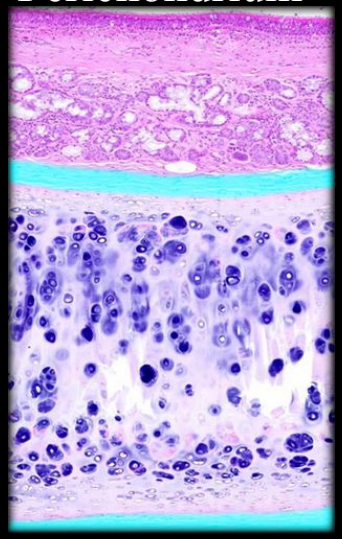
Lamina propria



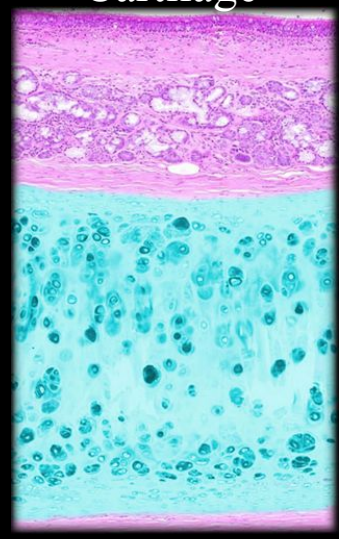
Submucosa



Perichondrium

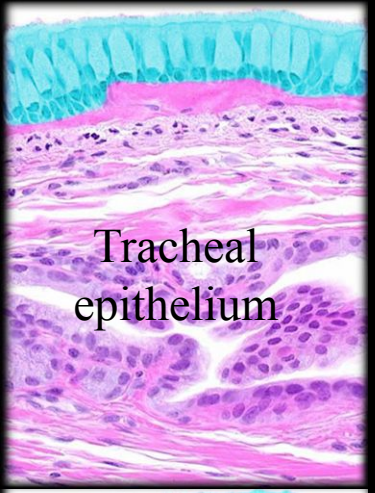


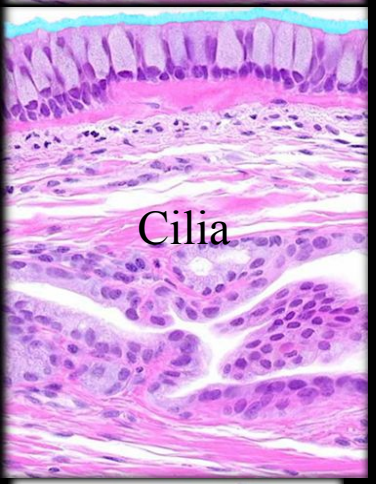
Cartilage

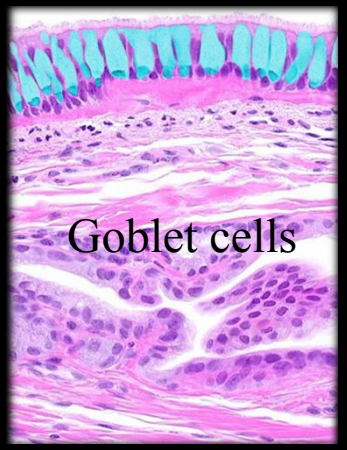


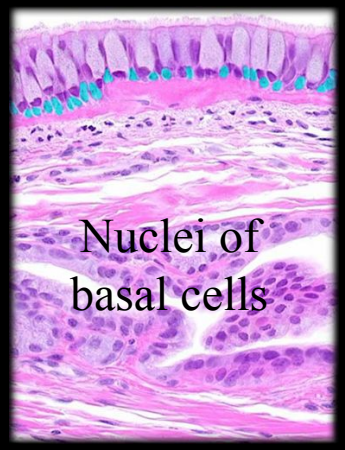
Trachea

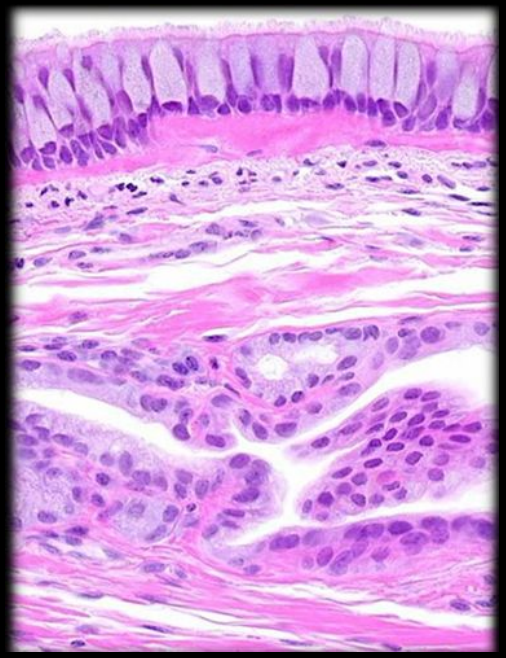
High Magnification









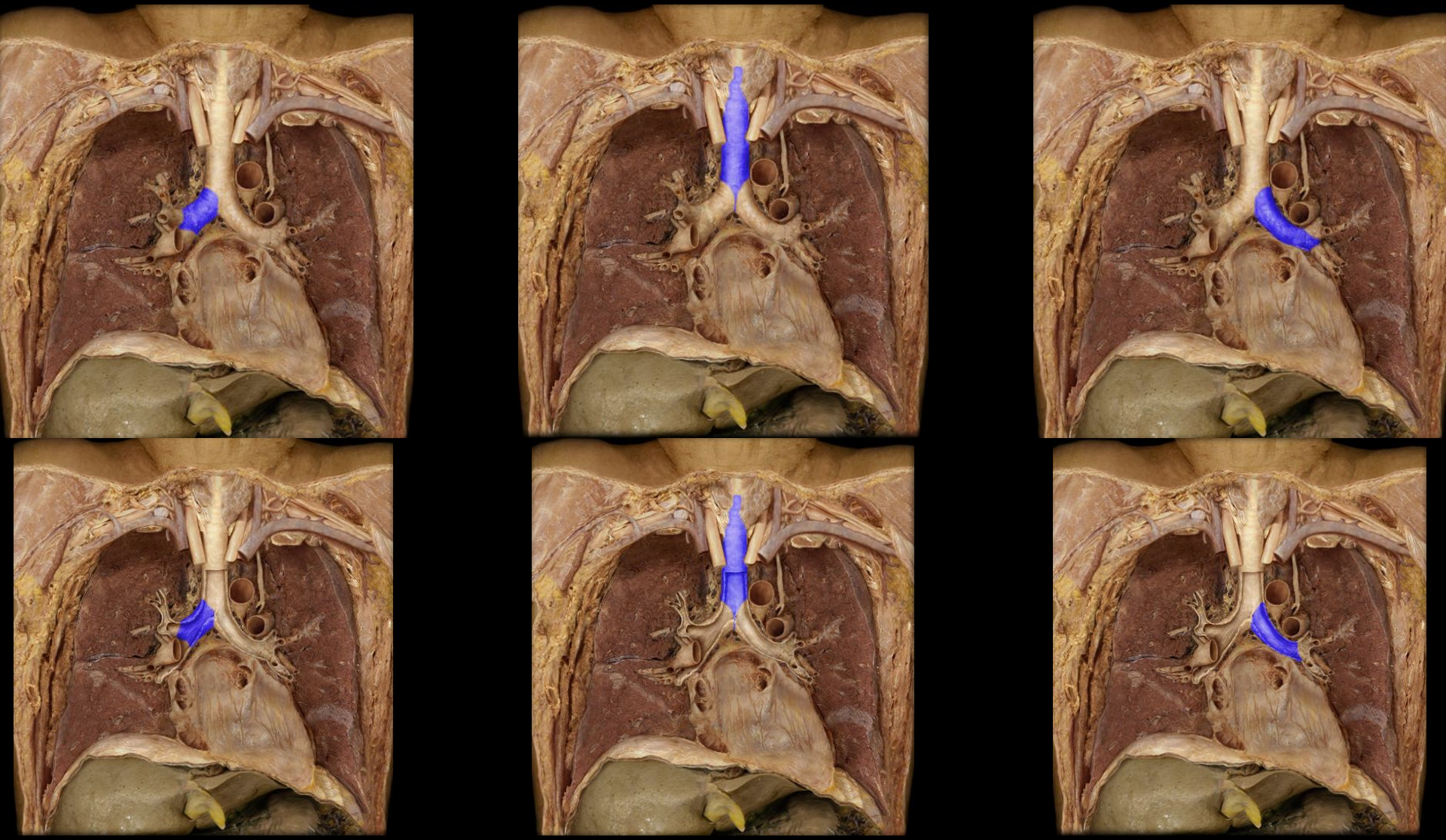


23.3c Bronchial Tree

- **Bronchial tree:** system of highly branched air passages
  - Originates at main bronchi, branches to more narrow tubes
  - Ends in small bronchiole passageways
- Gross anatomy of bronchial tree
  - Trachea splits into right and left **main bronchi** (*primary bronchi*) at level of sternal angle
    - Each bronchus enters a lung on its medial surface
    - Right bronchus shorter, wider, and more vertically oriented
      - Foreign particles more likely to lodge here

Chest X-ray and Bronchogram

Trachea and Main (Primary) Bronchi



23.3c Bronchial Tree

- Gross anatomy of the bronchial tree (*continued*)
  - Each main bronchus branches into **lobar bronchi** (*secondary bronchi*)
    - Each extends into a lobe of the lung
    - Smaller in diameter than main bronchi
    - Further divide into **segmental bronchi** (*tertiary bronchi*)
  - Tree continues to divide into smaller passageways
    - Leads to tubes of <1mm, the **bronchioles**
    - Leads to **terminal bronchioles** (last part of conducting zone)
    - Leads to respiratory bronchioles (first part of respiratory zone)

Bronchial Tree

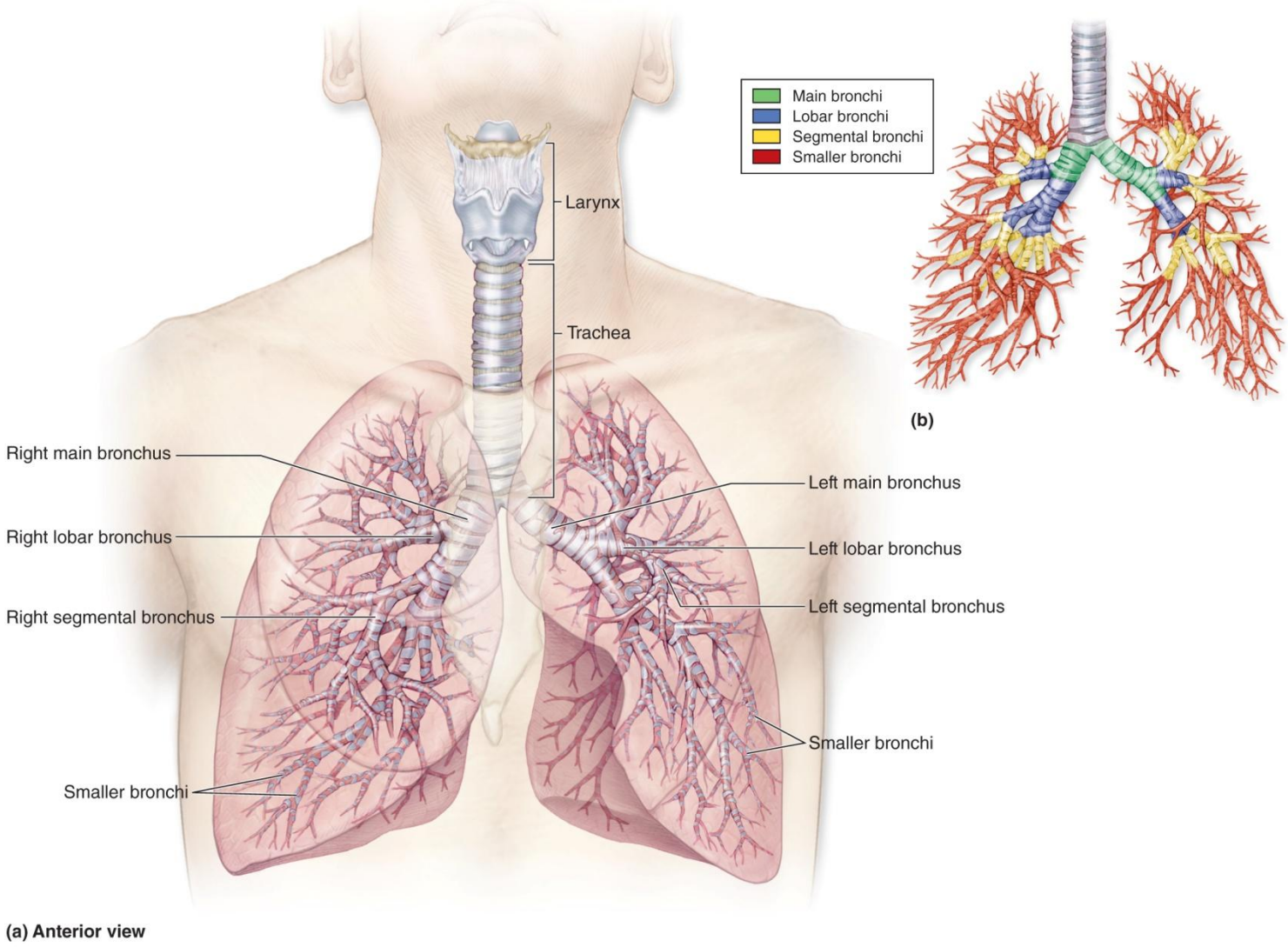


Figure 23.9

Clinical View: Bronchitis

- Inflammation of the bronchi caused by bacterial or viral infection or inhaled irritants
- **Acute bronchitis**
  - Occurs during or after an infection
  - Coughing, sneezing, pain with inhalation, fever
  - Most cases resolving in 10 to 14 days
- **Chronic bronchitis**
  - Occurs after long-term irritant exposure
  - Large amounts of mucus, and cough lasting >3 months
  - Permanent changes to bronchi occur
  - Increases likelihood of future bacterial infections

23.3c Bronchial Tree

- Histology of the bronchial tree
  - Main bronchi are supported by incomplete rings of hyaline cartilage (keep them open)
  - Wall support (cartilage) lessens as bronchi divide
  - Bronchioles have no cartilage
    - Have proportionally thicker layer of smooth muscle
    - Muscle contraction narrows bronchiole diameter
      - **Bronchoconstriction** = less air through bronchial tree (less entry of potentially harmful substances)
    - Muscle relaxation increases bronchiole diameter
      - **Bronchodilation** = more air through the bronchial tree

Structure of the Bronchial Wall

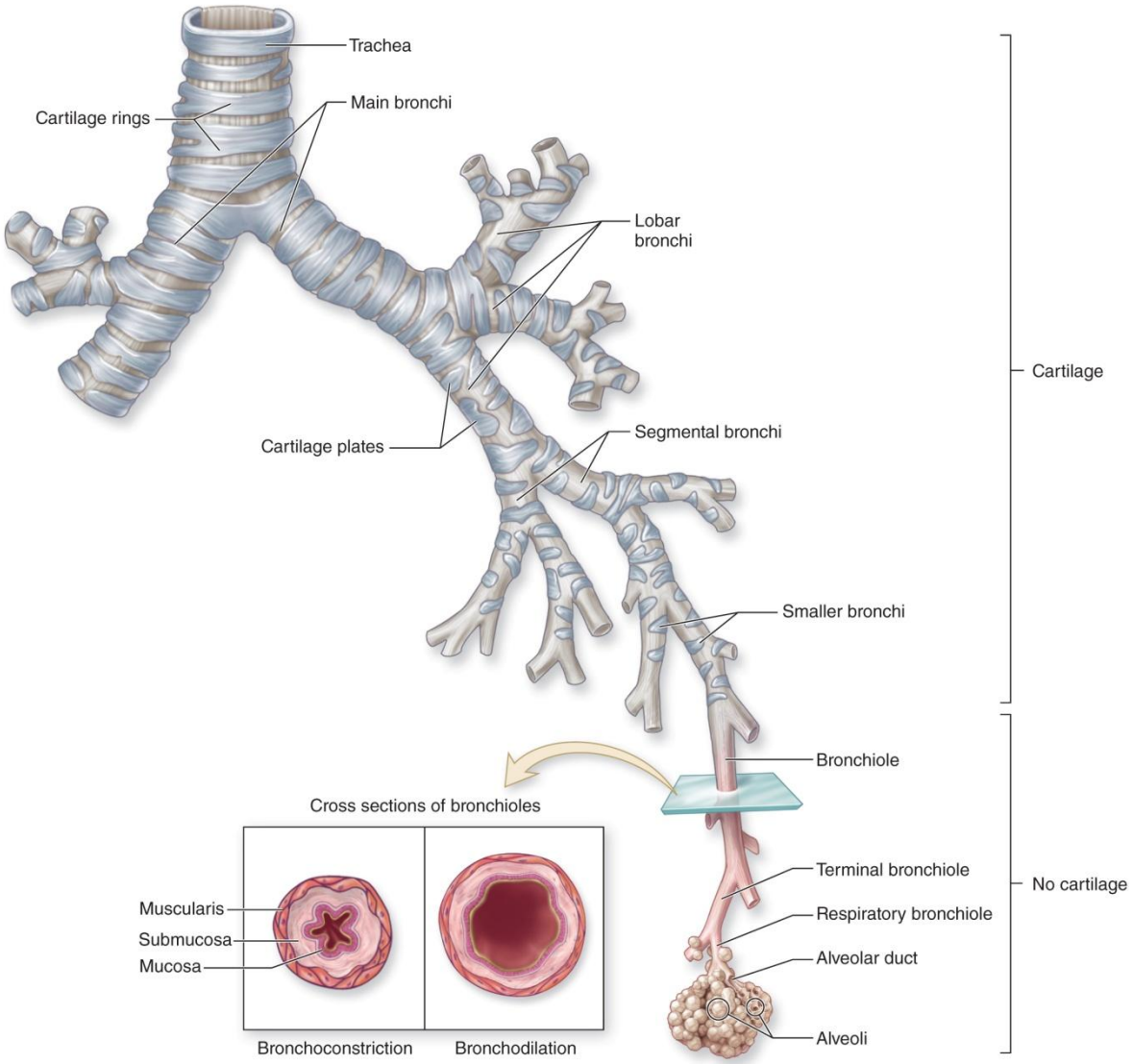


Figure 23.10

Clinical View: Asthma

- Episodes of bronchoconstriction, wheezing, coughing, shortness of breath, and excess mucus
- Asthmatic with sensitivity to airborne agent
- Localized immune reaction occurs in bronchi and bronchioles
- Walls of the bronchi becoming permanently thickened
- Primary treatments
  - Inhaled steroids
  - Bronchodilators

23.3d Respiratory Zone: Respiratory Bronchioles, Alveolar Ducts, and Alveoli

- Respiratory zone structures are microscopic
  - **Respiratory bronchioles** subdivide to **alveolar ducts**
  - Alveolar ducts lead to **alveolar sacs,** clusters of alveoli
  - **Alveoli** = saccular outpocketings
- Epithelium
  - Respiratory bronchioles lined with simple cuboidal epithelium
  - Alveoli and alveolar ducts lined by simple squamous
  - Thinness facilitates gas exchange

Bronchioles and Alveoli

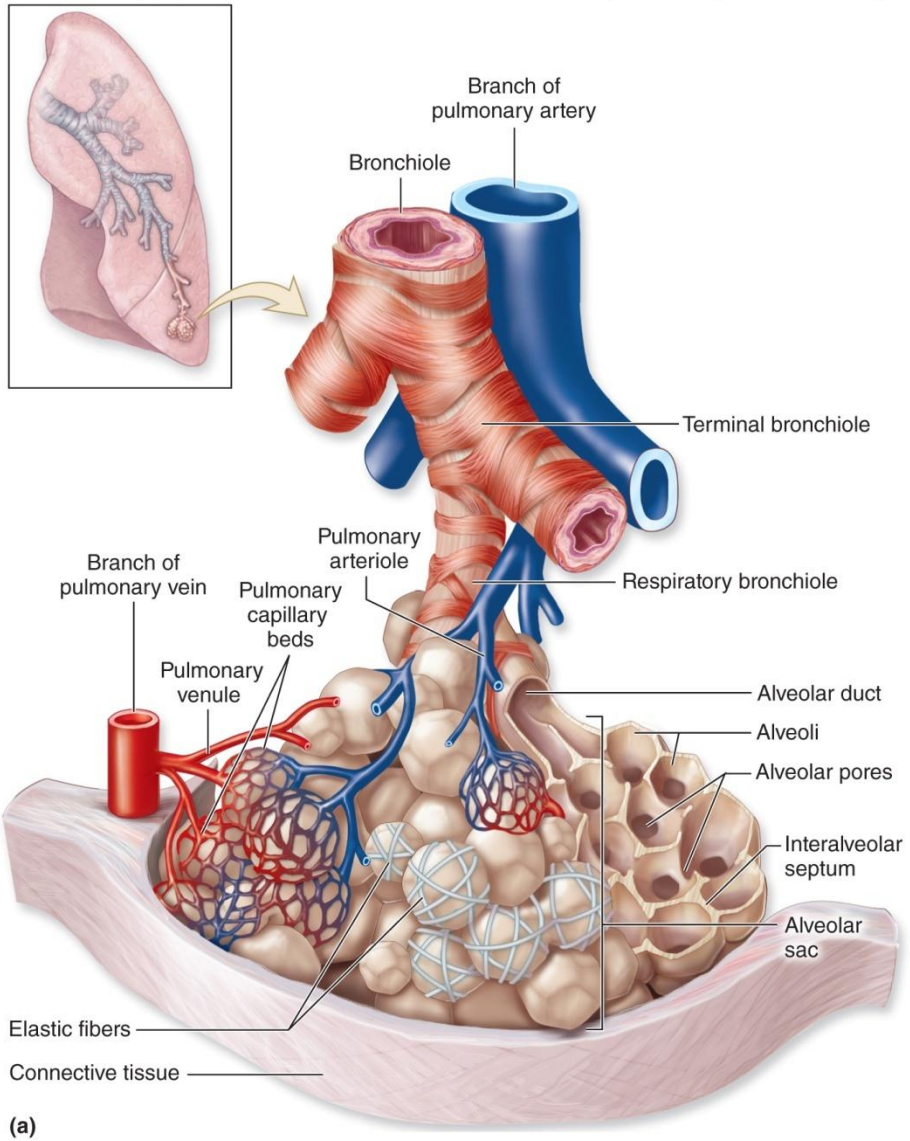


Figure 23.11a

23.3d Respiratory Zone: Respiratory Bronchioles, Alveolar Ducts, and Alveoli

- **Alveoli**
  - Each lung contains 300 to 400 million
  - **Alveolar pores:** openings providing collateral ventilation
  - Surrounded by pulmonary capillaries
  - Divided by **interalveolar septum**
    - Contain elastic fibers

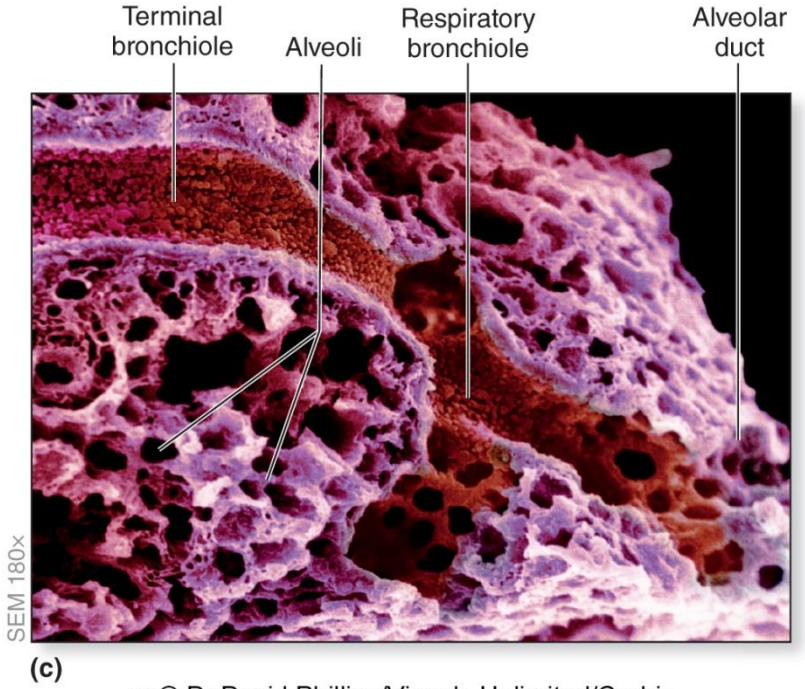


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Figure 23.11c

23.3d Respiratory Zone: Respiratory Bronchioles, Alveolar Ducts, and Alveoli

- Cell types of alveolar wall
  - Simple squamous **alveolar type I cells**
    - 95% of alveolar surface area
    - Part of thin barrier separating air from blood
  - **Alveolar type II cells** (*septal cells*)
    - Secrete oily **pulmonary surfactant**
      - Coats inside of alveolus and opposes collapse during expiration
  - **Alveolar macrophage** (*dust cells*)
    - Leukocytes that engulf microorganisms
    - Either fixed in alveolar wall or free to migrate

23.3e Respiratory Membrane

- The **respiratory membrane**
  - Thin barrier between alveoli and pulmonary capillaries
  - Consists of
    - Alveolar epithelium and its basement membrane
    - Capillary epithelium and its basement membrane
  - Oxygen diffuses from alveolus into capillaries
    - Erythrocytes become oxygenated
  - Carbon dioxide diffuses from blood to alveolus
    - Expired to external environment

Alveoli and Respiratory Membrane

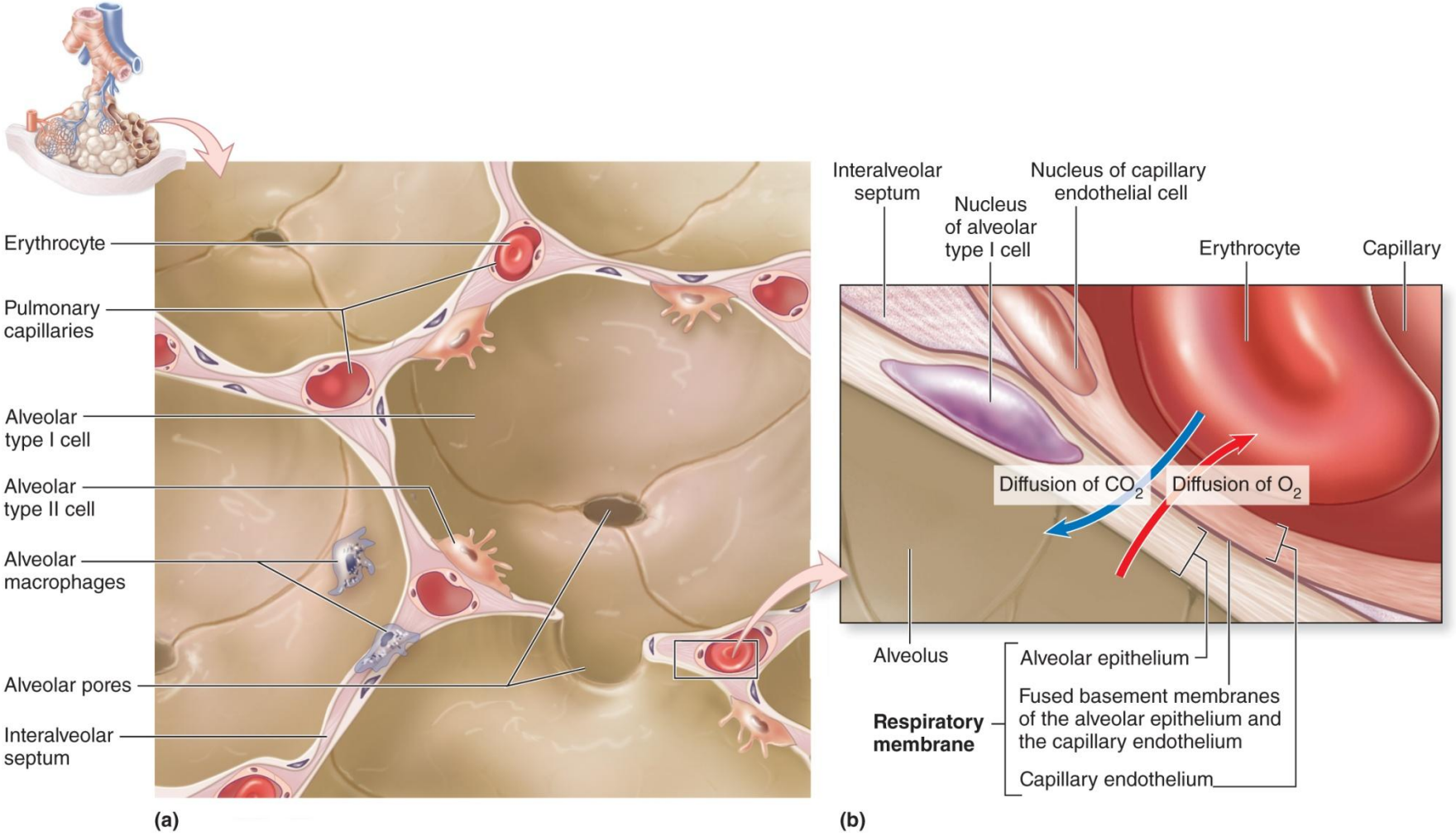


Figure 23.12

What did you learn?

- What makes one speech sound have a higher pitch than another?
- How does the structure of tracheal cartilages complement their function?
- How do bronchi and bronchioles differ?
- What are the differences between Type I and Type II cells in alveoli?

23.4 Lungs

Learning Objectives:

1. Describe the location and general structure of the lungs.
2. Compare and contrast the right versus left lung.
3. Distinguish between the two types of blood circulation through the lungs.
4. Describe the innervation of lung structures by the autonomic nervous system.

23.4 Lungs (*continued*)

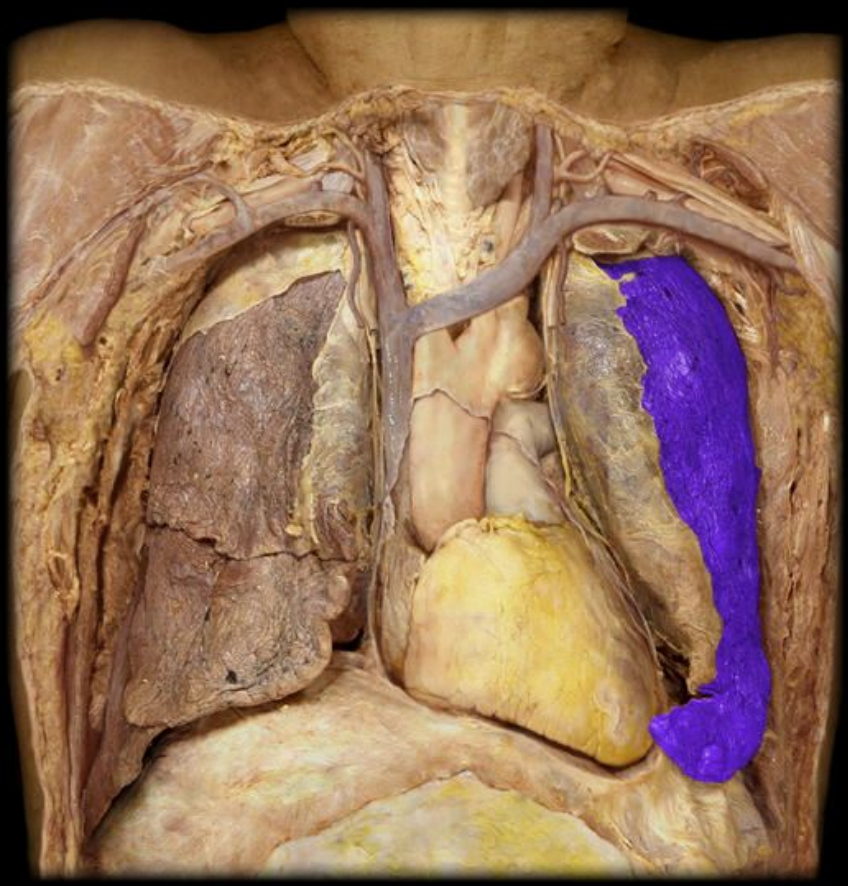
Learning Objectives:

5. Describe the pleural membranes and pleural cavity.
6. Explain the function of serous fluid in the pleural cavity.
7. Explain the anatomic properties that keep the lungs inflated.

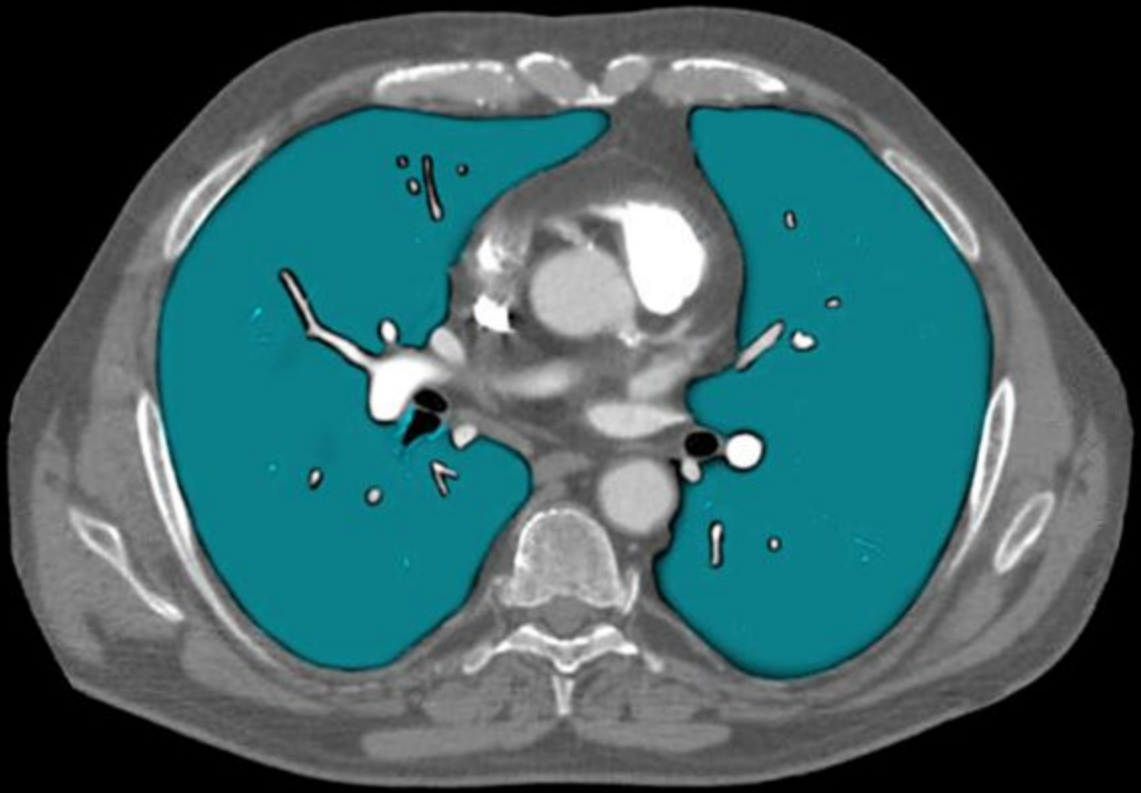
23.4a Gross Anatomy of the Lung

- Lungs are in thorax on either side of mediastinum
  - House bronchial tree and all respiratory portions of respiratory system
  - Each lung has a conical shape
    - Wide concave **base** atop diaphragm
    - **Apex** (*cupula*) points superiorly just behind clavicle

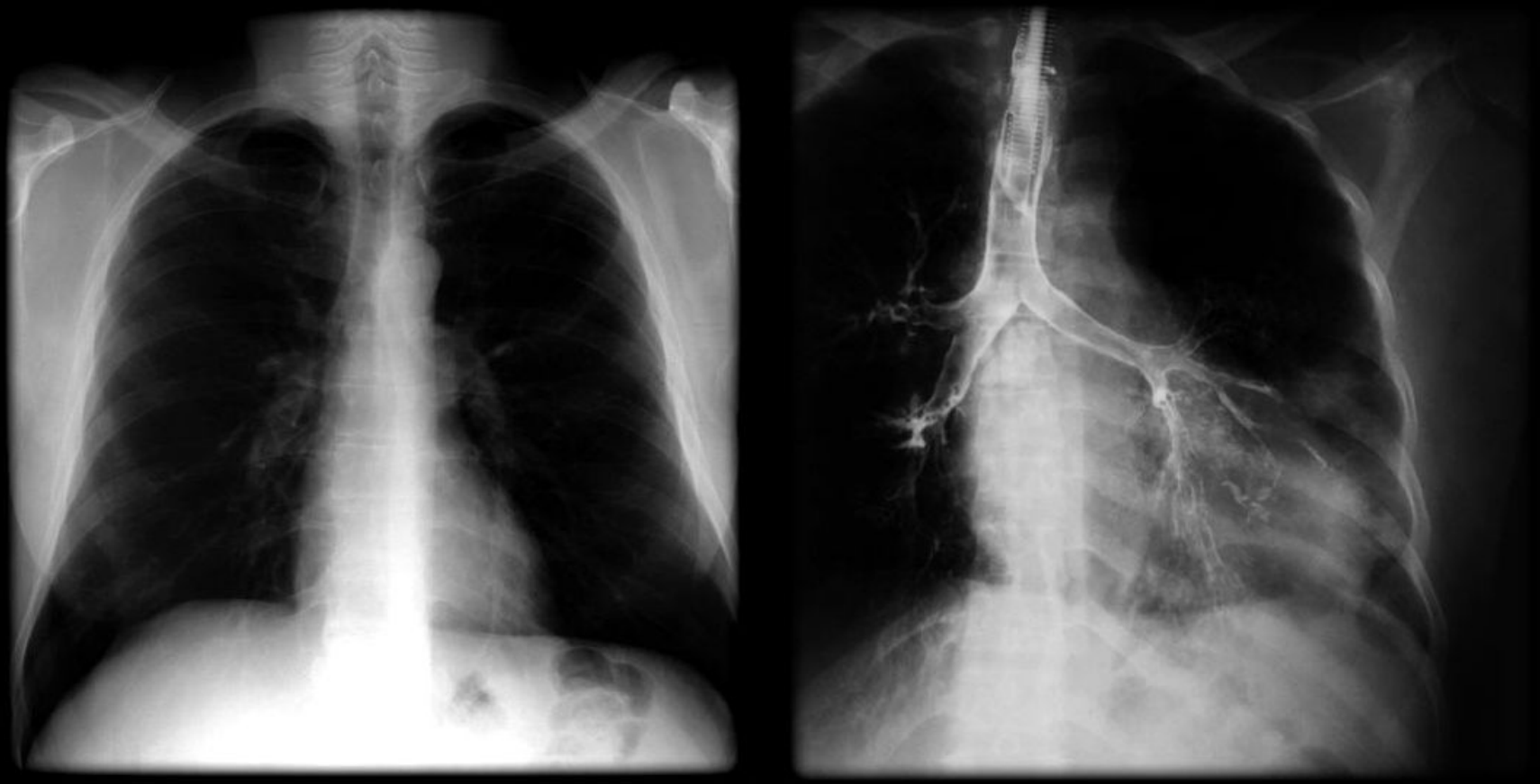
Rt. and Lt. Lungs



Lungs



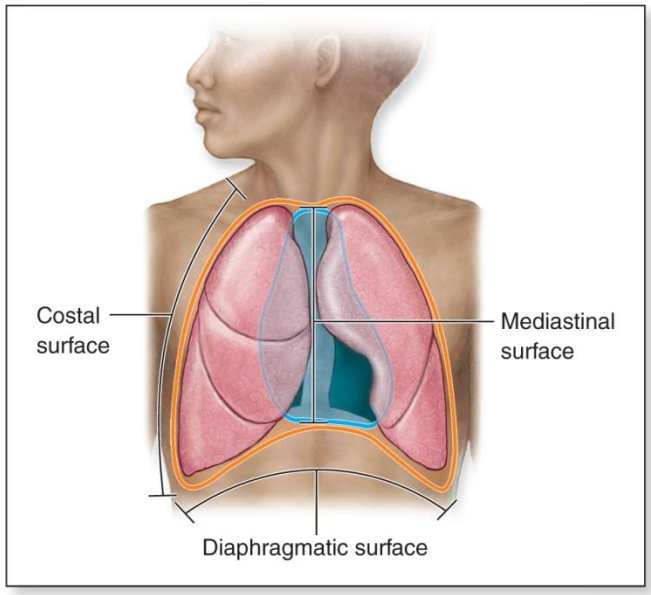
Chest X-ray and Bronchogram



23.4a Gross Anatomy of the Lung

- Lung surfaces
  - **Costal surface** adjacent to ribs
  - **Mediastinal surface** adjacent to mediastinum
  - **Diaphragmatic surface** adjacent to diaphragm
- **Hilum**
  - Indented region on lung's mediastinal side
  - Bronchi, pulmonary vessels, autonomic nerves, lymph vessels pass through here
    - These structures collectively termed the **root** of the lung

Position of the Lungs



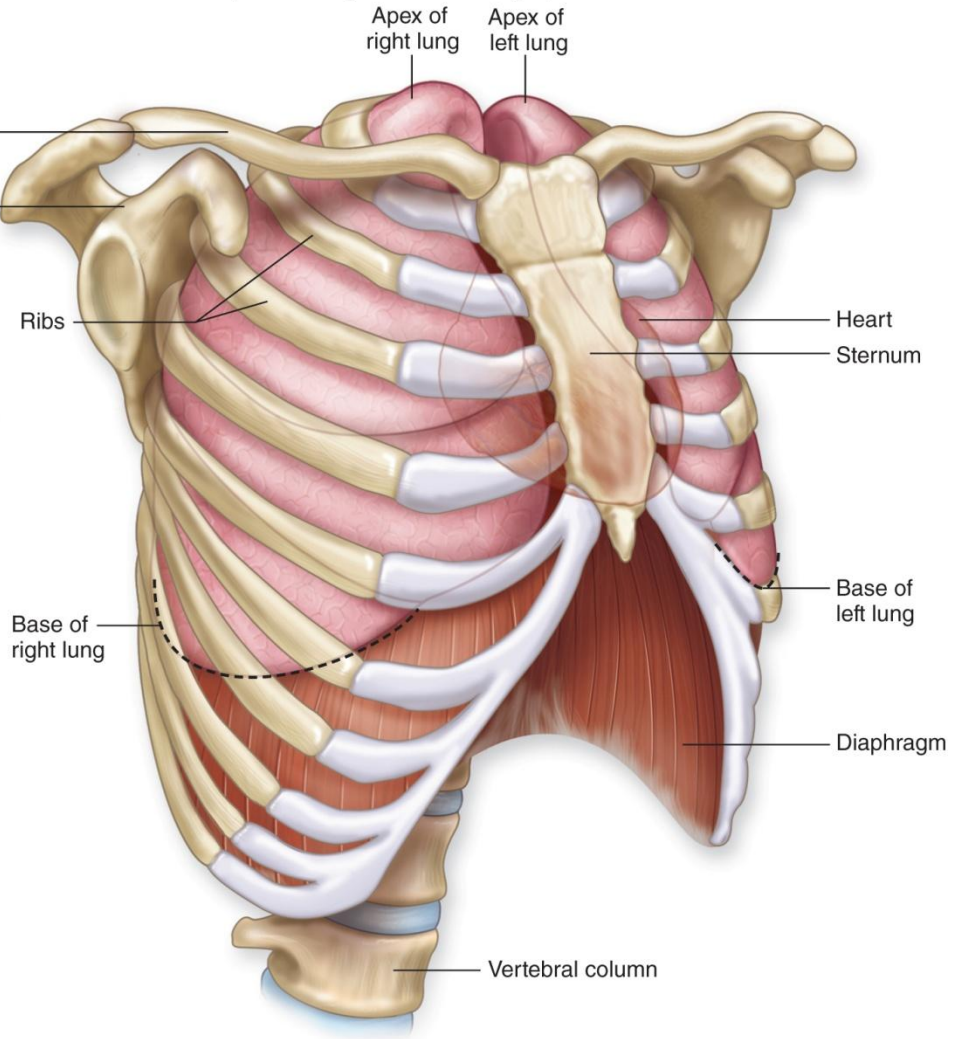


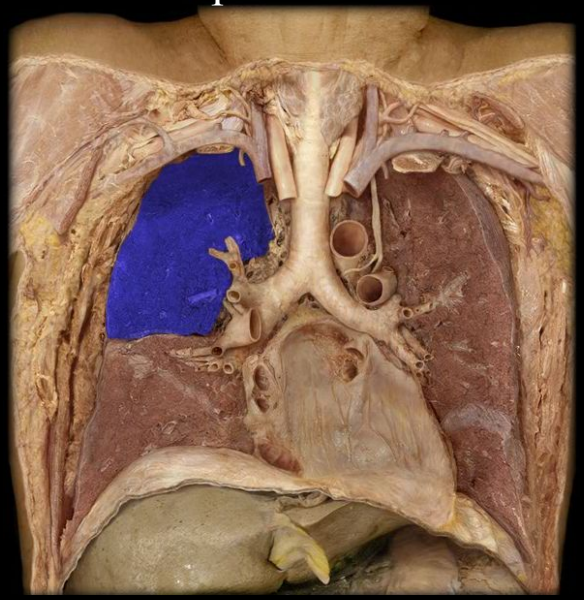
Figure 23.13

23.4a Gross Anatomy of the Lung

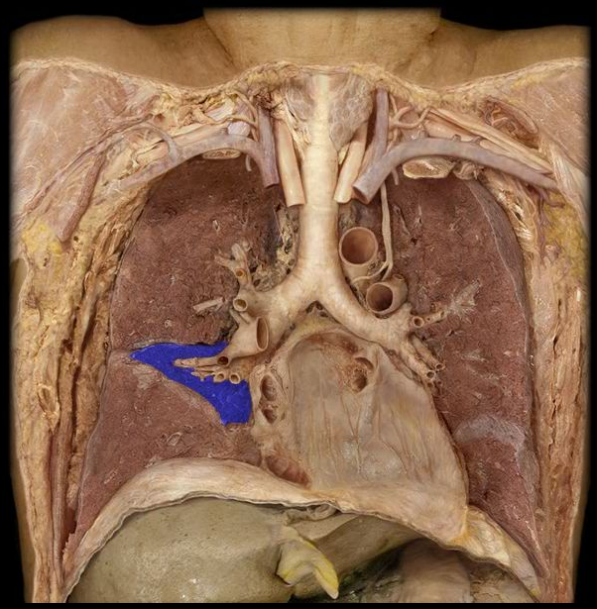
- Right lung is larger and wider than left lung
  - Has three lobes divided by two fissures
    - **Horizontal fissure** separates **superior** (*upper*) **lobe** from **middle lobe**
    - **Oblique fissure** separates middle lobe from **inferior** (*lower*) **lobe**
- Left lung is smaller than right due to heart's position
  - Has two lobes divided by one fissure
    - Oblique fissure separates superior and inferior lobes
    - **Lingula:** projection from superior lobe that is homologous to right lung's middle lobe
  - Three surface indentations accommodate heart and aorta
    - **Cardiac impression** on medial surface
    - **Cardiac notch** on anterior surface
    - Groovelike impression for aorta on medial surface

Right Lung

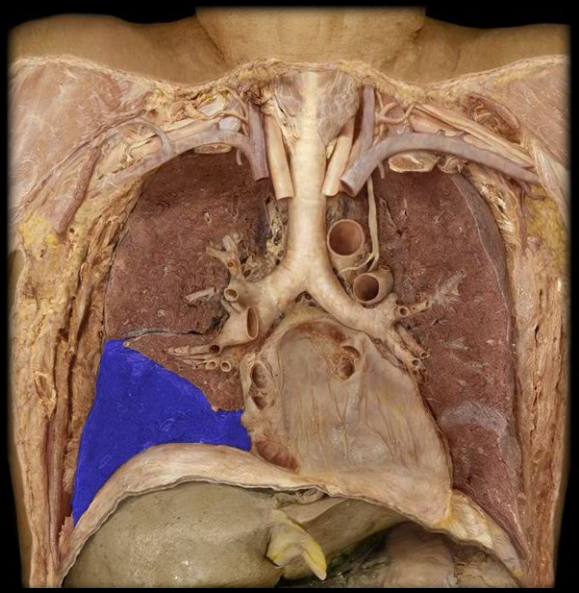
Superior lobe



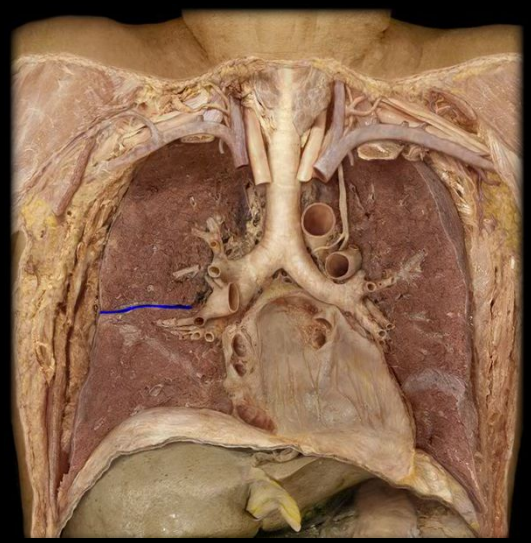
Middle lobe

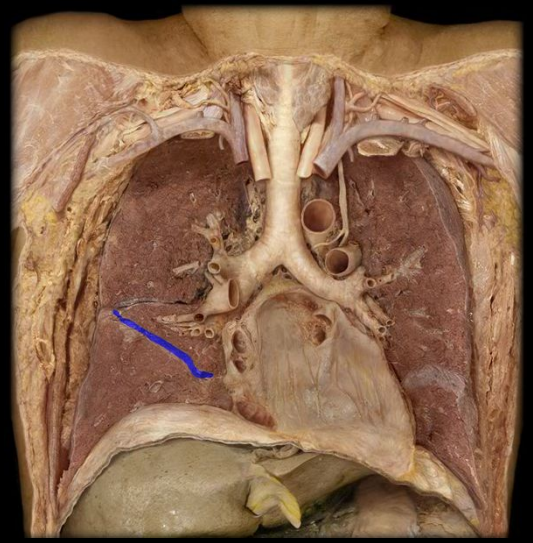


Inferior lobe



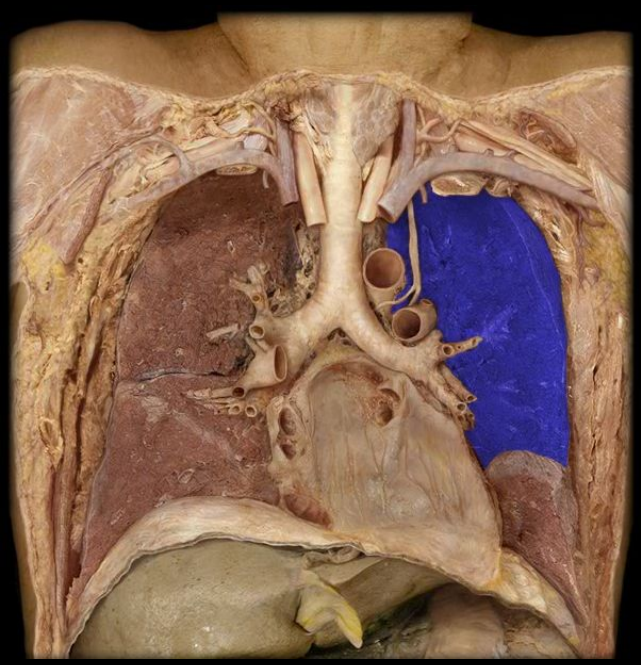
Horizontal fissure



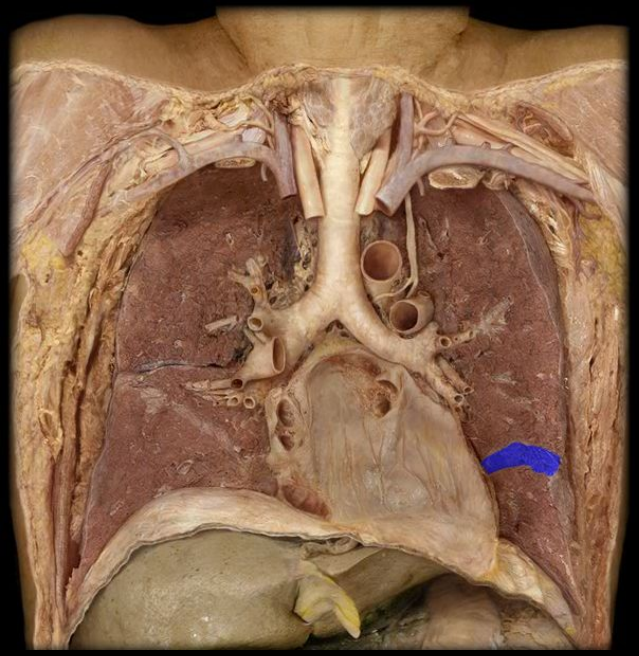


Oblique fissure

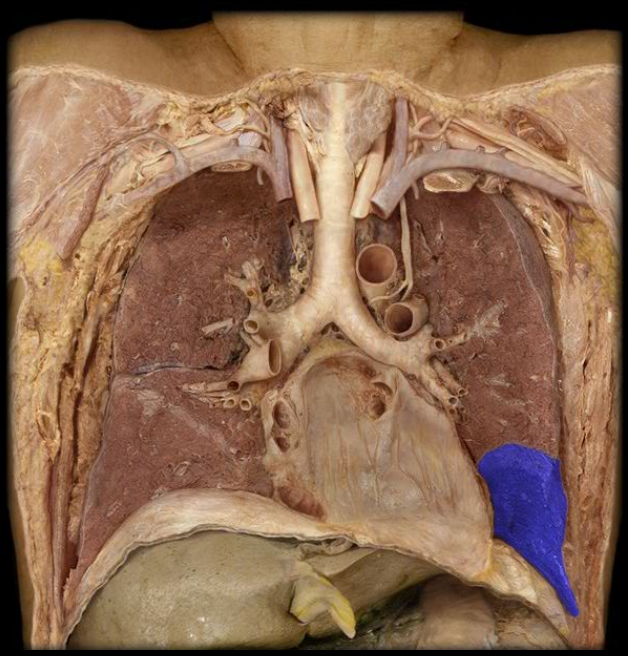
Left Lung



Superior lobe

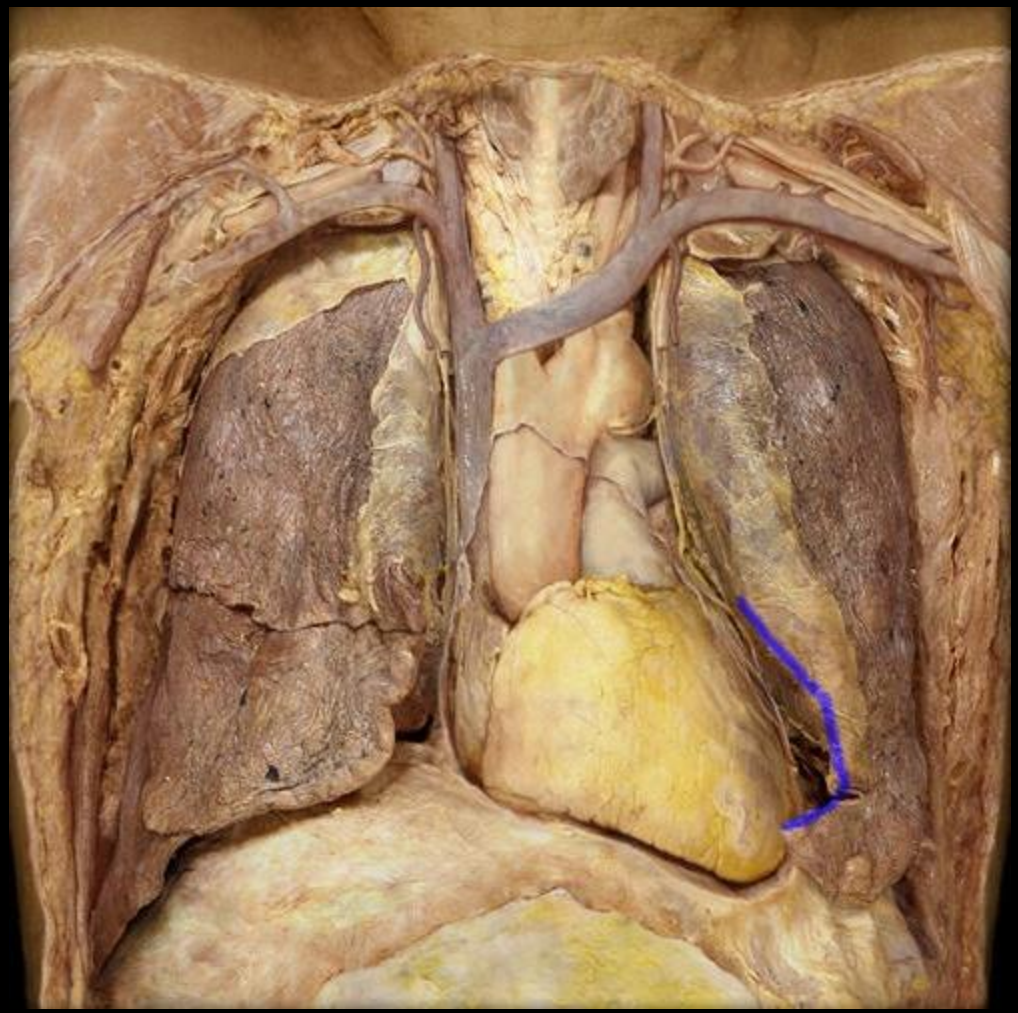


Oblique fissure

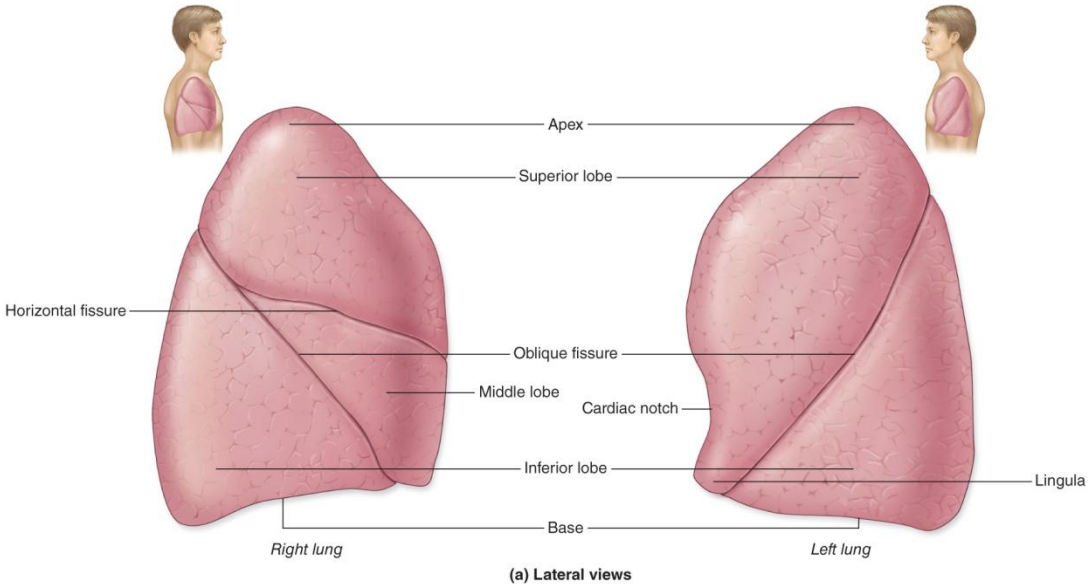


Inferior lobe

Cardiac Impression



Lungs



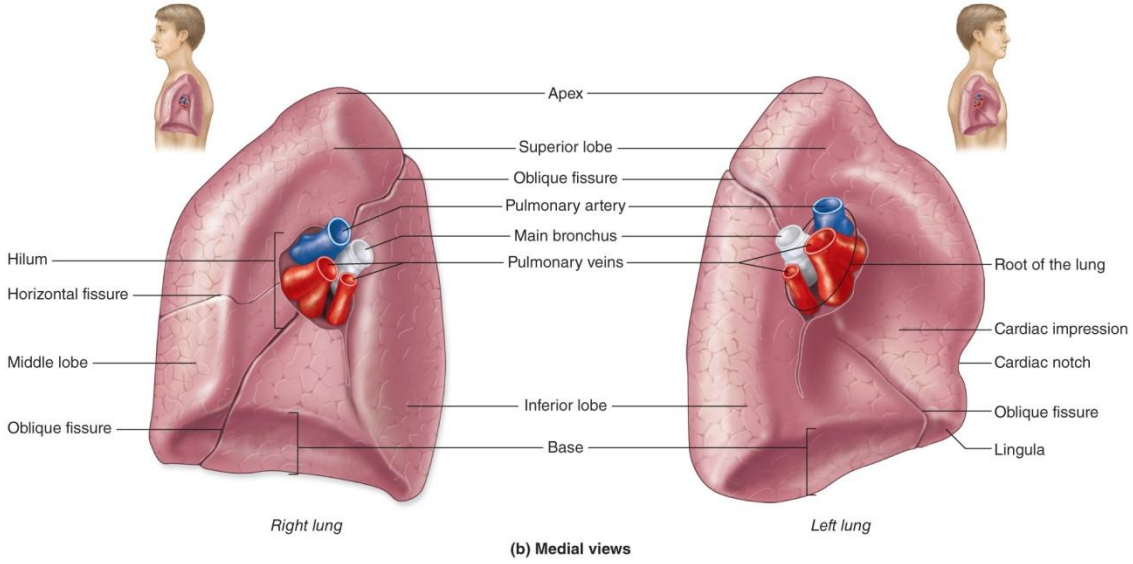


Figure 23.14

23.4a Gross Anatomy of the Lung

- Each lung has multiple **bronchopulmonary segments**
  - 10 segments in right lung; 8 to 10 in left lung
  - Autonomous units encapsulated with connective tissues
  - Each supplied with its own segmental bronchus
  - Supplied with its own pulmonary artery and vein and lymph vessels
  - Can be removed individually in cases of disease
  - Each segment organized into **lobules**
    - Each supplied by a terminal bronchiole, arteriole, venule, and lymph vessel

Bronchopulmonary Segments and Lobules of the Lungs

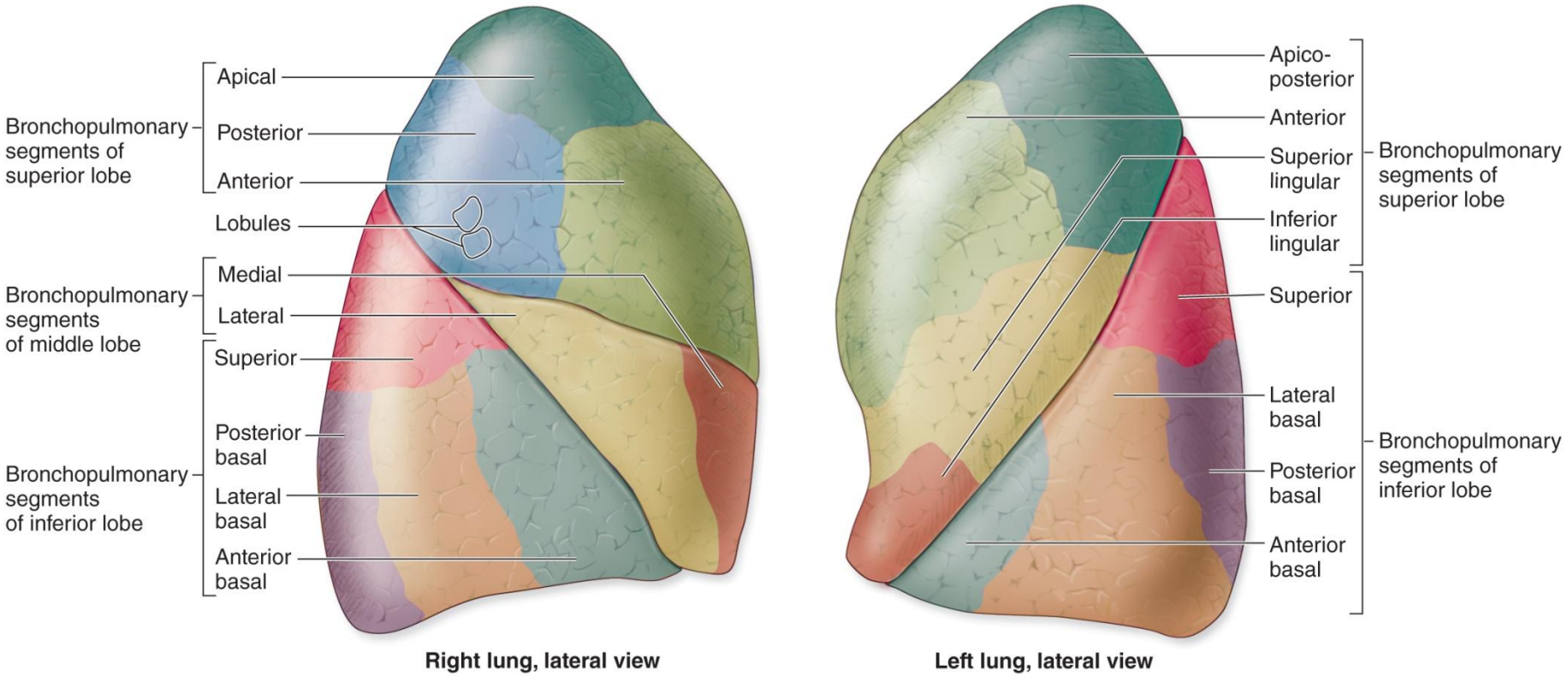


Figure 23.15

Clinical View: Smoking

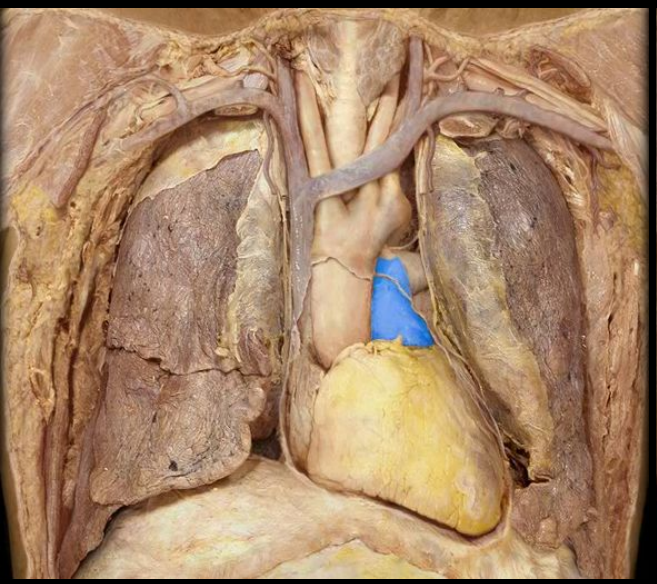
- Causes respiratory changes with increased chance of
  - Respiratory infections
  - Cellular or genetic changes to the lungs
  - Emphysema
  - Cancer of the lungs, esophagus, stomach, and pancreas
  - Stomach ulcers
  - Atherosclerosis
  - Lower birth weight babies in pregnant women
  - Poor delivery of oxygen and nutrients to all systemic tissues
  - Bronchitis, asthma, and ear infections from secondhand smoke

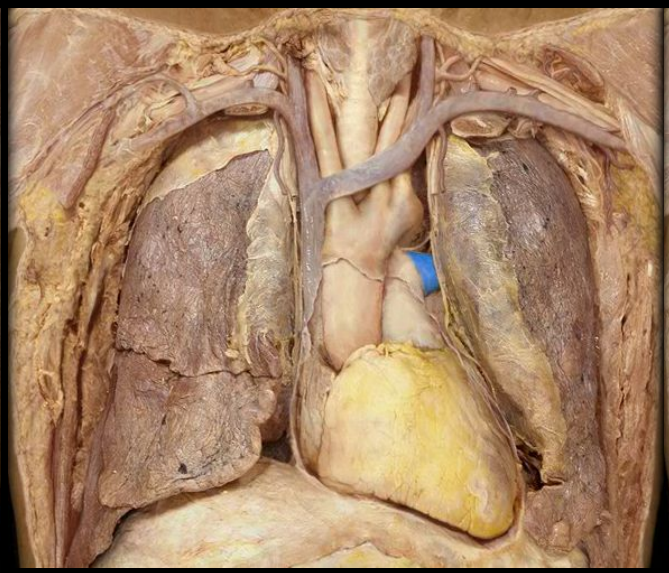
23.4b Circulation to and Innervation of the Lungs

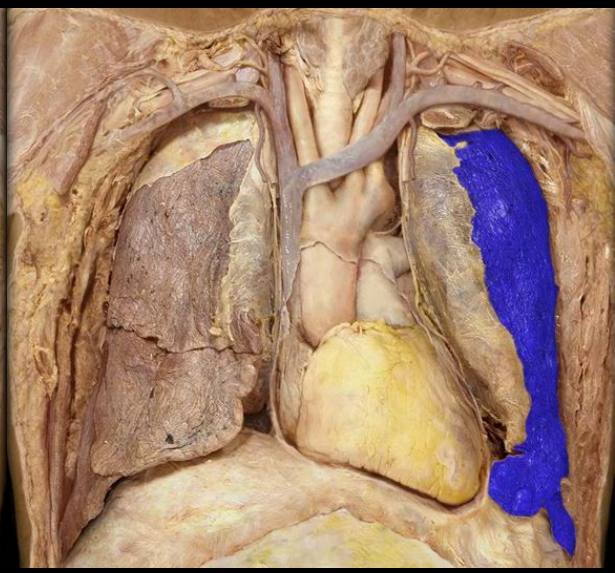
Blood supply

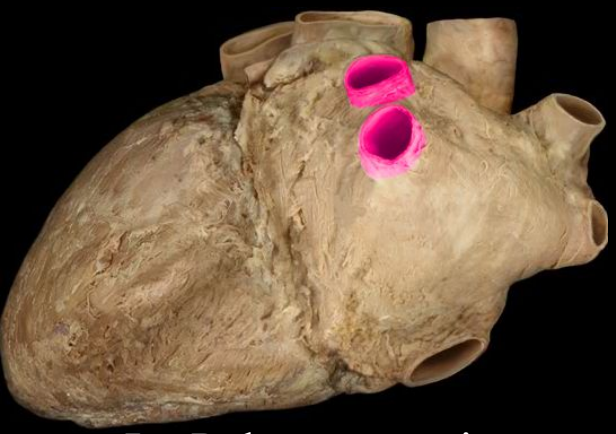
- Two types of circulation in the lungs
  - Pulmonary circulation
  - Bronchial circulation
- **Pulmonary circulation** replenishes O_2, eliminates CO_2
  - Pulmonary arteries carry deoxygenated blood to pulmonary capillaries
  - Blood is reoxygenated
  - Blood enters pulmonary venules and veins, returns to left atrium

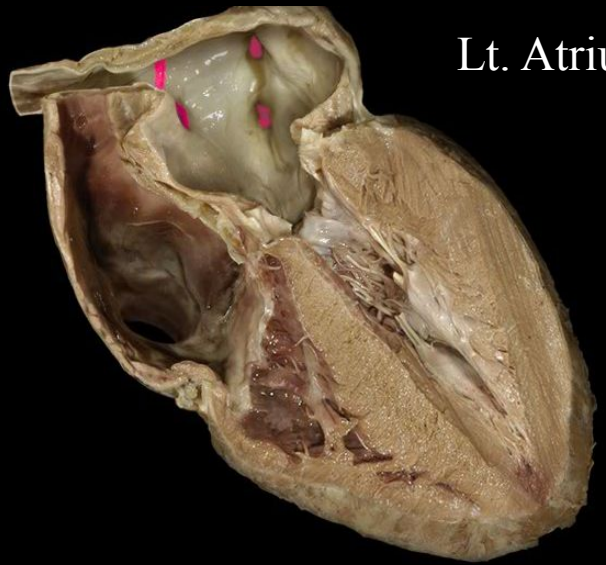
Pulmonary Circulation











23.4b Circulation to and Innervation of the Lungs

Blood supply (*continued*)

- **Bronchial circulation** transports oxygenated blood to tissues of lungs
  - **Bronchial arteries** (3 or 4) branch off descending aorta
  - **Bronchial veins** collect venous blood
    - Some drains into the pulmonary veins

Pulmonary Circulation of the Lungs

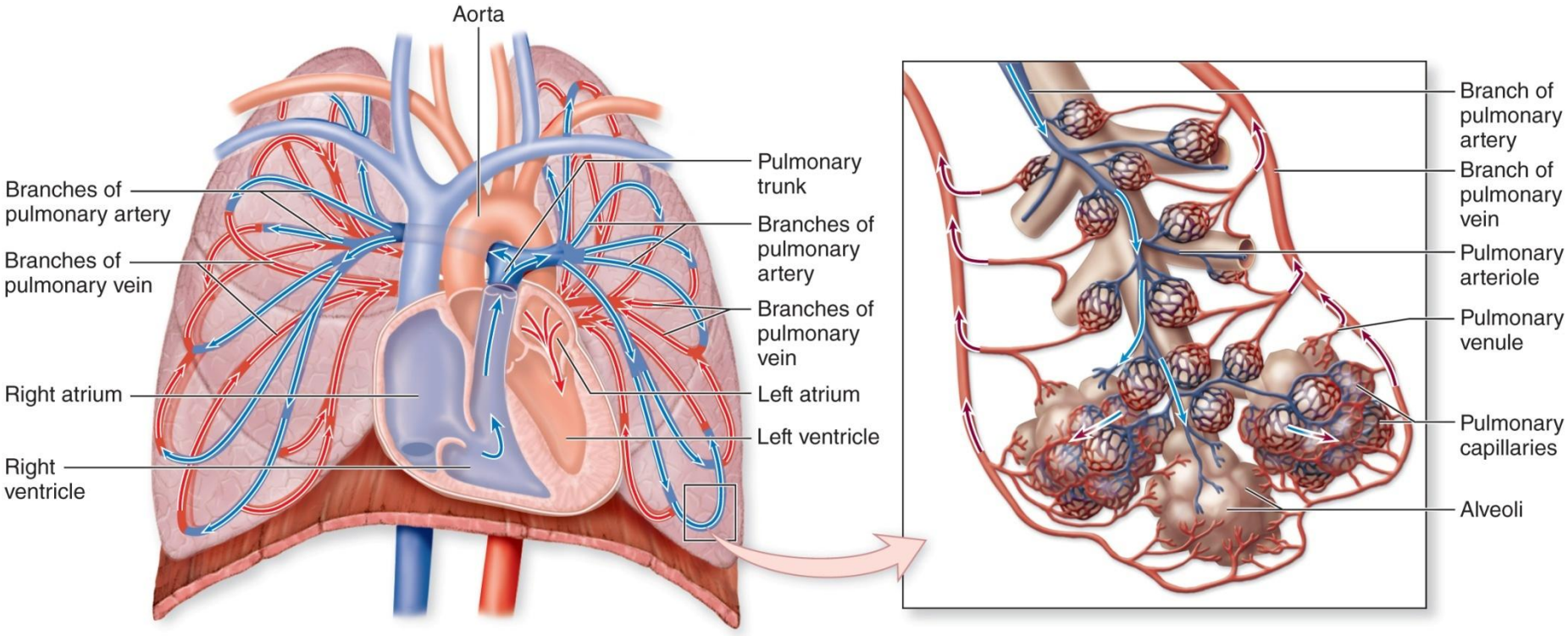


Figure 23.16

Clinical Views: Lung Cancer

- Highly aggressive malignancy with early metastasis
- Originates in respiratory epithelium
- Caused by smoking in 85% of cases
- Symptoms of chronic cough, coughing up blood, excess pulmonary mucus, increased pulmonary infections
- Three basic patterns
  - **Squamous cell carcinoma**
    - Most common; arises from pseudostratified columnar epithelium; changes to stratified squamous to withstand chronic injury
  - **Adenocarcinoma**
    - Arises from mucin-producing glands
  - **Small-cell carcinoma**
    - Originates from neuroendocrine cells in the bronchi

23.4b Circulation to and Innervation of the Lungs

- **Lymph drainage**
  - Lymph vessels and nodes located:
    - Within lung's connective tissue
    - Around bronchi
    - In pleura
  - Important in removing excess fluid from the lungs
  - Lymph filtered through lymph nodes
  - Collects particles and pollutants not removed by cilia

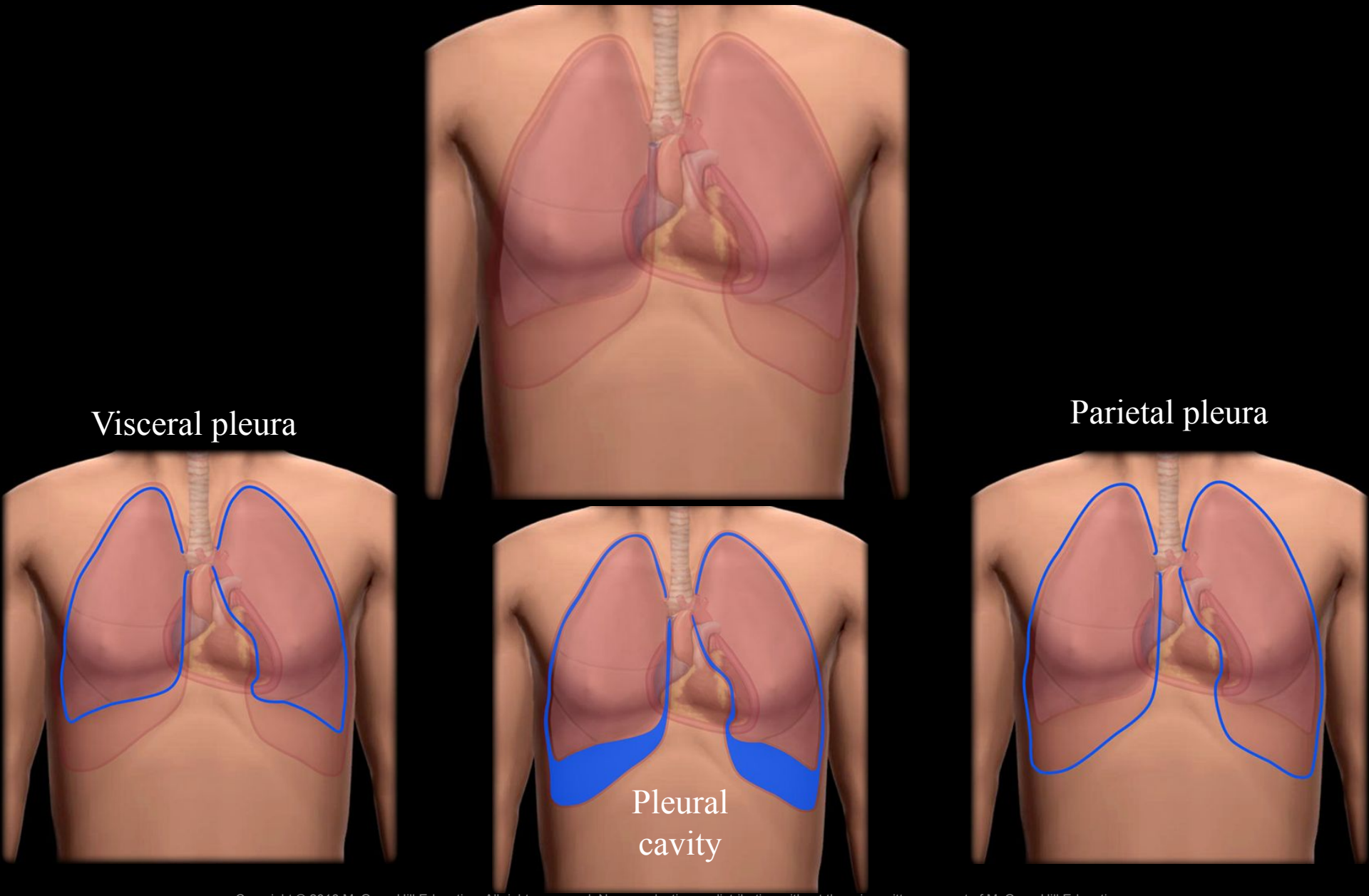
23.4b Circulation to and Innervation of the Lungs

- Innervation of the respiratory system
  - Autonomic nervous system innervates smooth muscles and glands of respiratory structures
    - Sympathetic input from T1–T5 generally causes bronchodilation
    - Parasympathetic from vagus causes bronchoconstriction
    - Sends signals to larynx from vagus nerve

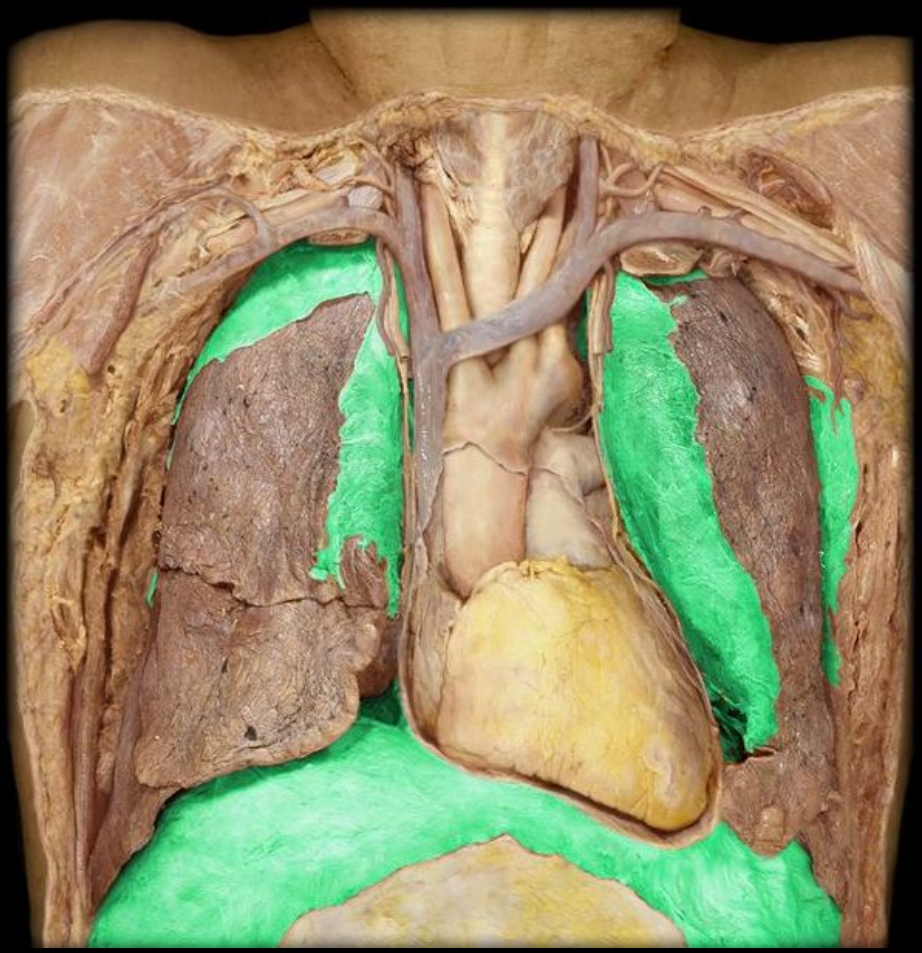
23.4c Pleura Membranes and Pleural Cavity

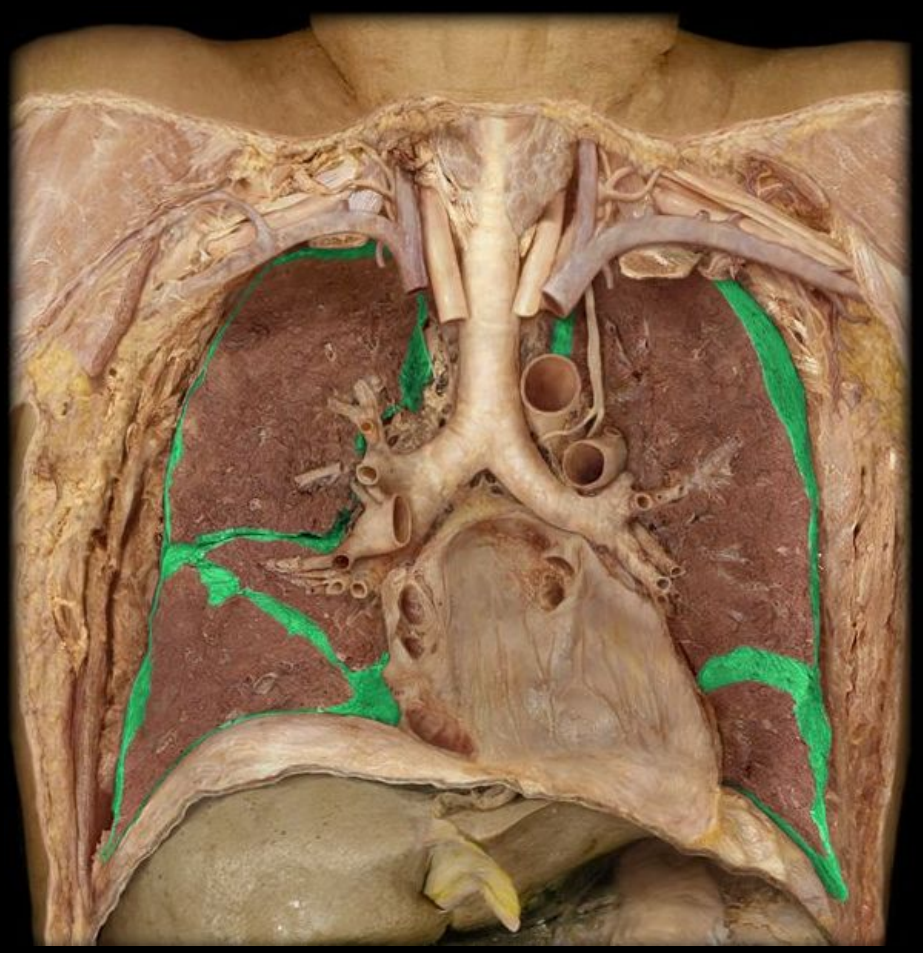
- **Pleura:** serous membrane
  - Outer lining of lung surfaces and adjacent thoracic wall
  - Composed of simple squamous epithelium
  - **Visceral pleura** adheres to lung surface
  - **Parietal pleura** lines
    - Internal thoracic walls
    - Lateral surface of mediastinum
    - Superior surface of diaphragm
  - Each lung enclosed in a separate visceral pleural membrane
    - Helps limit spread of infections

Pleura Membranes



Parietal and Visceral Pleurae





23.4c Pleura Membranes and Pleural Cavity

- **Pleural cavity**
  - Located between visceral and parietal serous membranes
  - When lungs are inflated, considered a potential space
    - Visceral and parietal layers almost touching
- Serous fluid produced by serous membranes
  - Covers pleural cavity surface
  - Lubricates, allowing pleural surfaces to slide by easily
  - Each pleural cavity has <15 mL fluid
  - Drained continuously by lymph

Clinical View: Pleurisy and Pleural Effusion

- **Pleurisy** = inflammation of the pleural membranes
  - Severe chest pain with breathing
  - Inflamed membranes with increased friction between visceral and parietal pleura
  - Usually only one side affected
- **Pleural effusion** = excess fluid in the pleural cavity
  - Can cause shortness of breath and chest pain
  - Potential causes
    - Systemic factors: failure of the left side of the heart, pulmonary embolism, cirrhosis of the liver
    - Lung infections or lung cancer

23.4d How Lungs Remain Inflated

- **Intrapleural pressure** (between membranes) is low
  - Chest wall configured to expand outward
    - Lungs cling to chest wall due to serous fluid's surface tension
  - Elastic tissue of lungs pulls inward
- Because **intrapulmonary pressure** (in alveoli) is greater than intrapulmonary pressure, lungs remain inflated

Pleural Membranes and Pressures Associated with Lungs

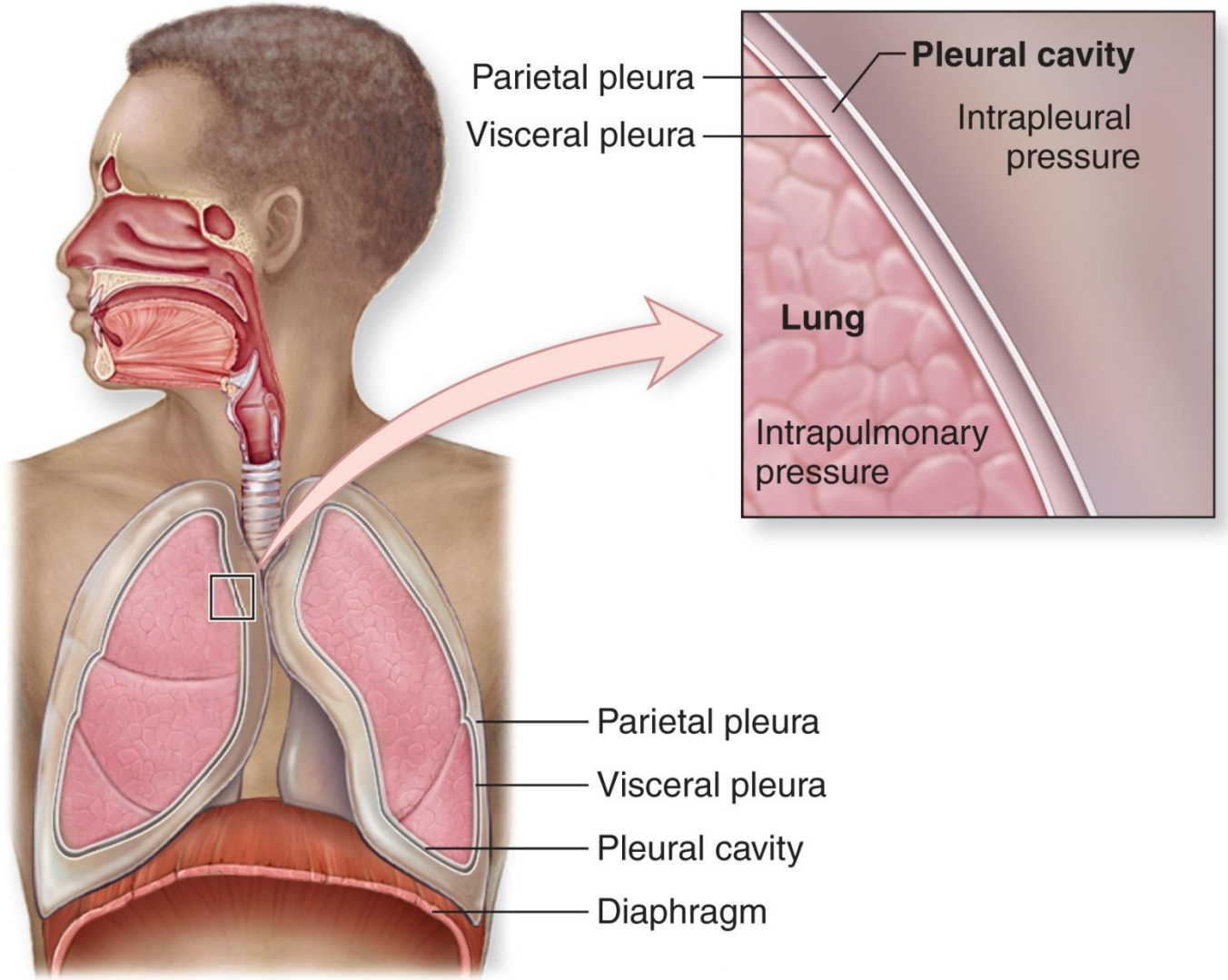


Figure 23.17

Clinical Views: Pneumothorax and Atelectasis

- **Pneumothorax** = free air in the pleural cavity
  - Air introduced externally—penetrating wound to the chest
  - Air introduced internally—rib lacerates lung or alveolus ruptures
  - May cause intrapleural and intrapulmonary pressures to equalize
  - Small pneumothorax resolves spontaneously
  - Large pneumothorax is a medical emergency
    - Need to insert a tube into the pleural space to remove air
- **Atelectasis** = deflated lung portion
  - Occurs if intrapleural and intrapulmonary pressures equalize
  - Remains collapsed until air removed from pleural space

What did you learn?

- How many lobes are there in each lung?
- What will happen to the diameter of bronchioles if the vagus nerve fires more action potentials?
- What is the pleural cavity and what is inside it?