

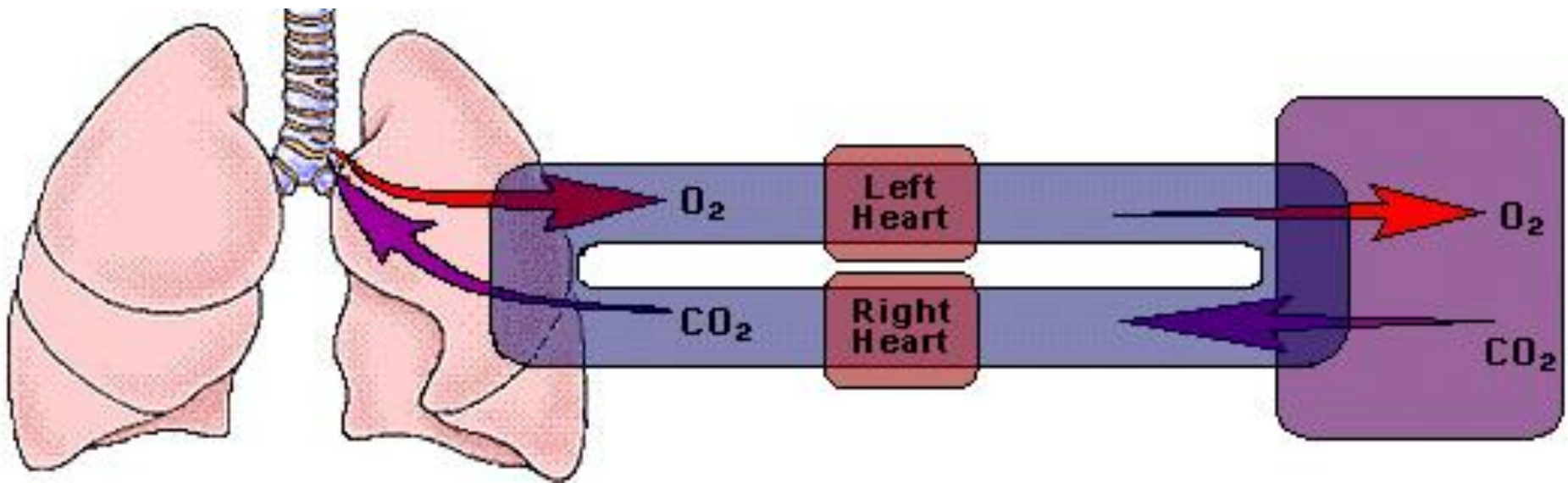
RESPIRATORY SYSTEM

Learning Objectives

- Functions and Organization of the Respiratory System
- Mechanics of breathing
- VENTILATION-REPERFUSION RELATIONSHIPS
- Oxygen and Carbon dioxide Transport
- Control of breathing
- Alveolar - Arterial equilibration-1
- Effects of low and high gas pressure on the body
- Effects of exercise on the respiratory system.

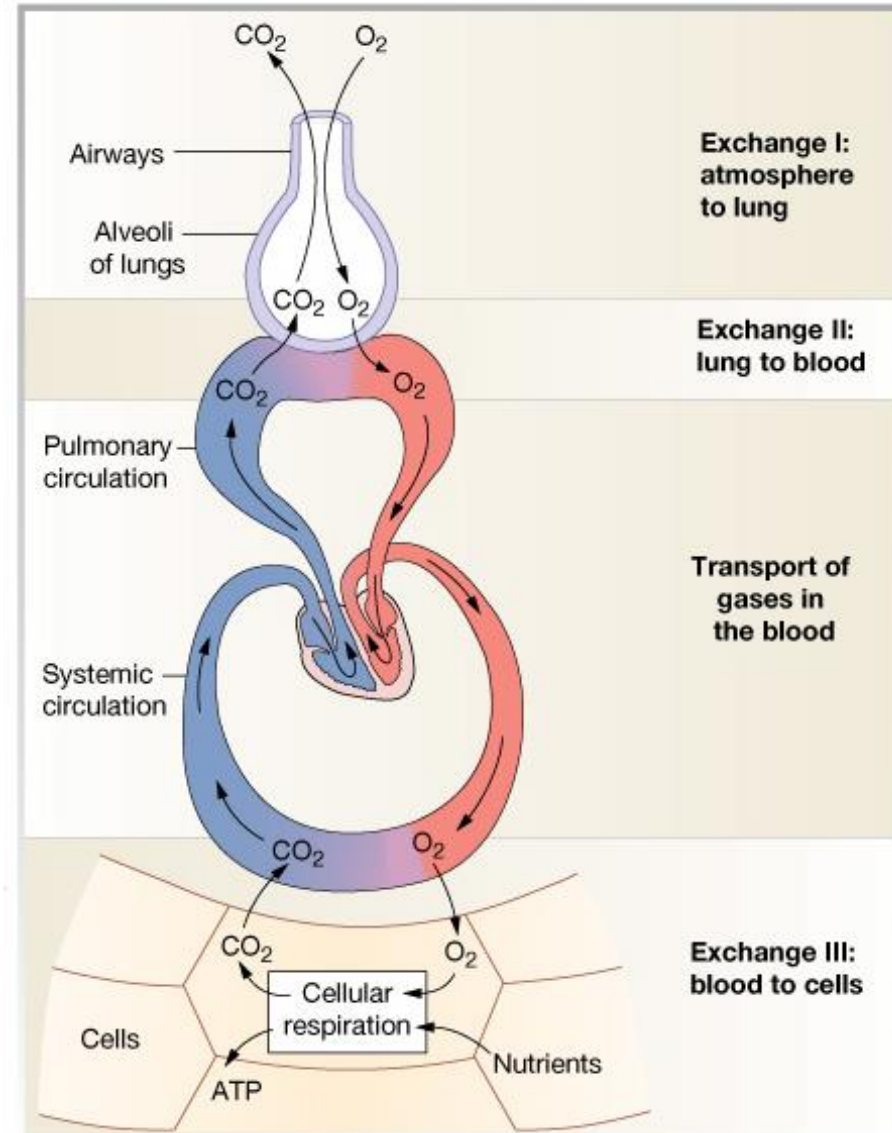
The Respiratory System

- Functions to supply the body w/ O_2 and remove CO_2
- “Respiration” is actually 4 distinct processes:
 1. *Ventilation* – Movement of air into & out of the lungs
 2. *External Respiration* – Gas exchange btwn blood and air-filled chambers of the lungs
 3. *Transport of Gases*
 4. *Internal Respiration* – Gas exchange btwn systemic blood and the tissue cells



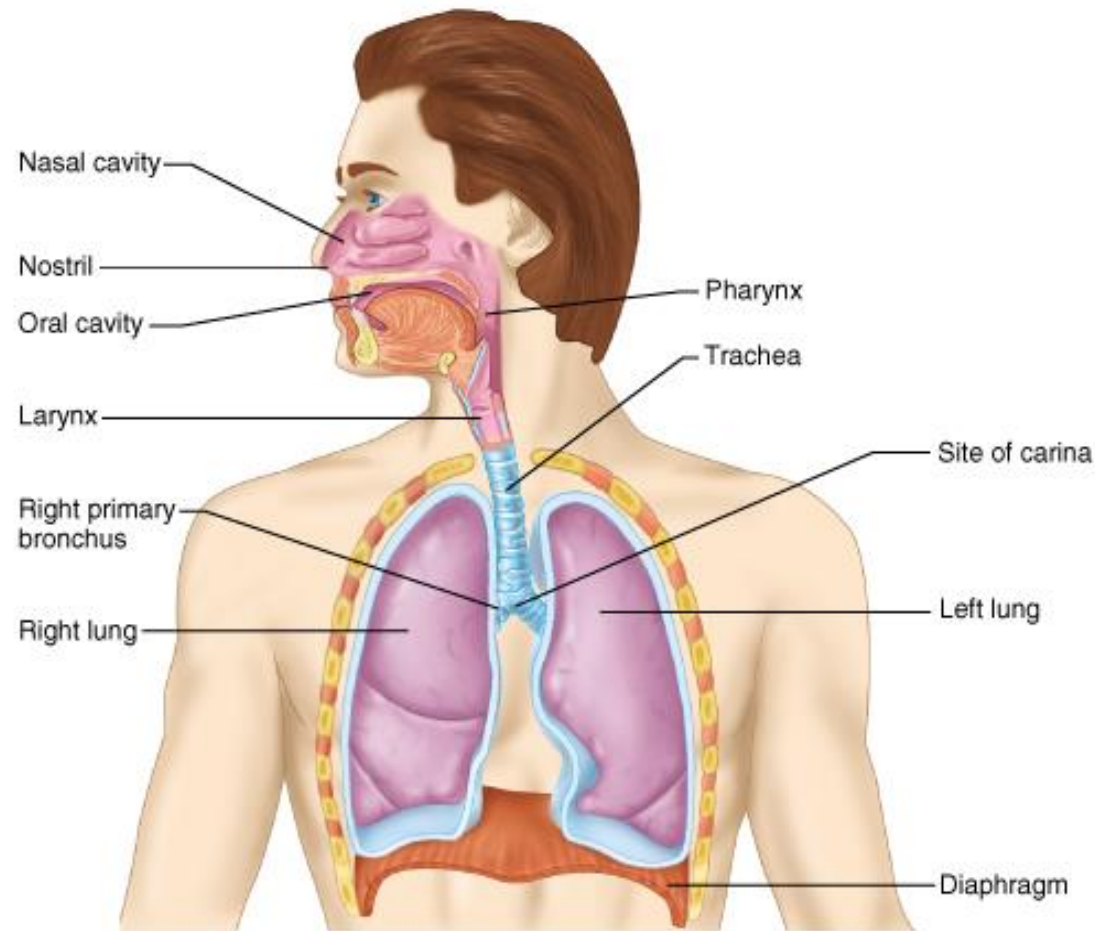
Functions of the Respiratory System: Overview

- Exchange O_2
 - Air to blood
 - Blood to cells
- Exchange CO_2
 - Cells to blood
 - Blood to air
- Regulate blood pH
- Vocalizations
- Protect alveoli



- Organs include: nose, nasal cavity, pharynx, trachea, bronchi, bronchioles, and the alveoli.
- Divided into **respiratory and conducting zones**.
- Gas exchange with the blood occurs in the respiratory zones. It does NOT occur in the conducting zones.
- The conducting zones transport, cleanse, warm and humidify the incoming air.

Functional Anatomy



The Airways:

Conduction of Air from Outside to Alveoli

- Filter, warm & moisten air
- Nose, (mouth), trachea, bronchi & bronchioles
- Huge increase in cross sectional area

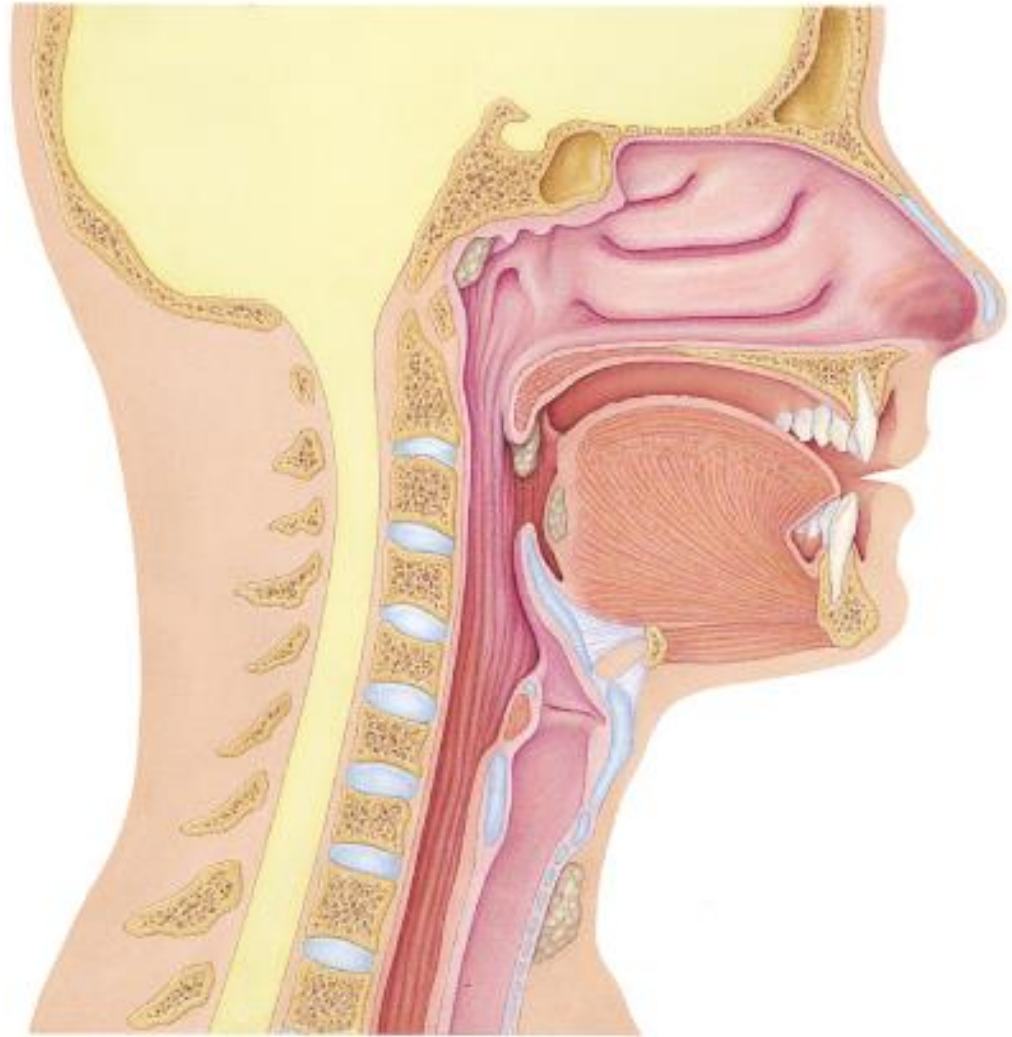
	Name	Division	Diameter (mm)	How many?	Cross-sectional area (cm)
Conducting system	Trachea	0	15-22	1	2.5
	Primary bronchi	1	10-15	2	↓
	Smaller bronchi	2	1-10	4	
		3			
		4			
		5			
		6-11			
↓			1×10^4	↓	
Exchange surface	Bronchioles	12-23	0.5-1	2×10^4 ↓ 8×10^7	100 ↓ 5×10^3
	Alveoli	24	0.3	$3-6 \times 10^8$	$>1 \times 10^6$

The Nose

- Only externally visible part of the respiratory system.
- Functions include:
 - Providing an airway for respiration
 - Moistening and warming air
 - Filtering inspired air
 - Serving as a resonating center for speech
 - Housing the olfactory receptors.

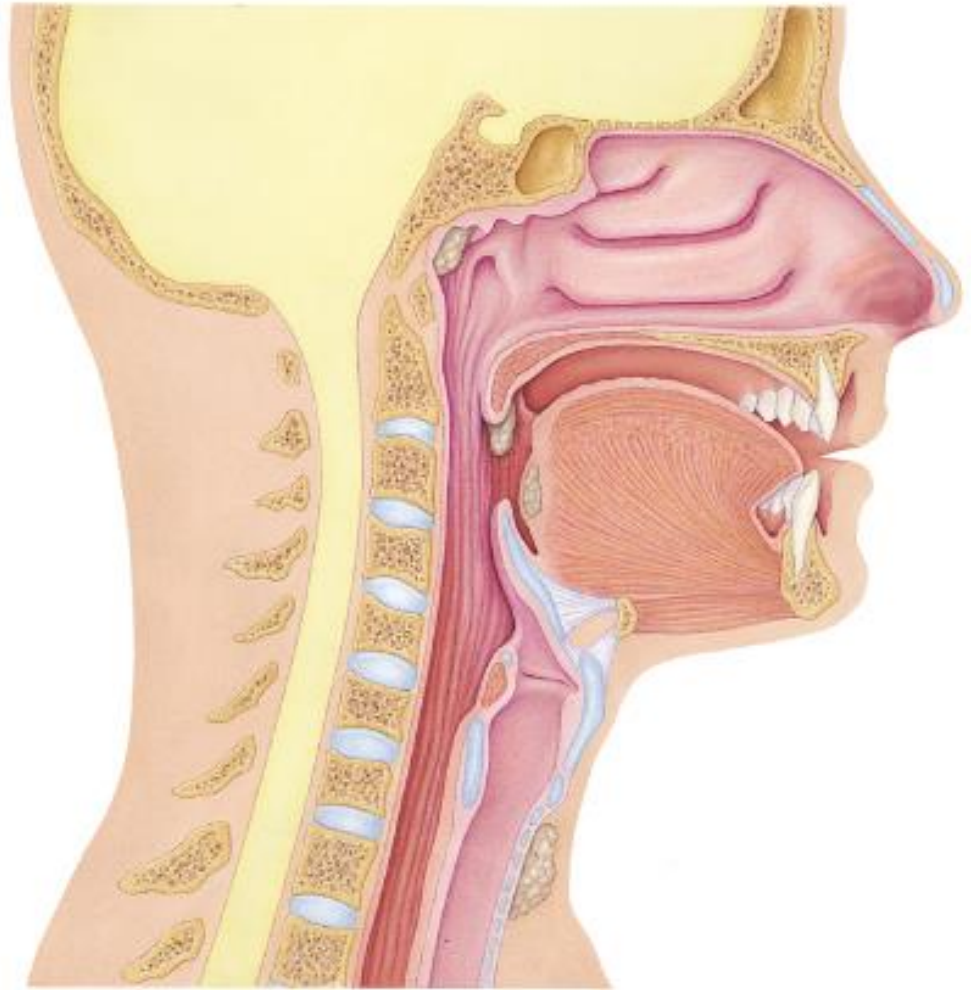
Pharynx

- Funnel-shaped.
- Connects the nasal cavity and mouth superiorly to the larynx and esophagus inferiorly
- 3 regions. From superior to inferior:
 - **Nasopharynx**
 - **Oropharynx**
 - **Laryngopharynx**



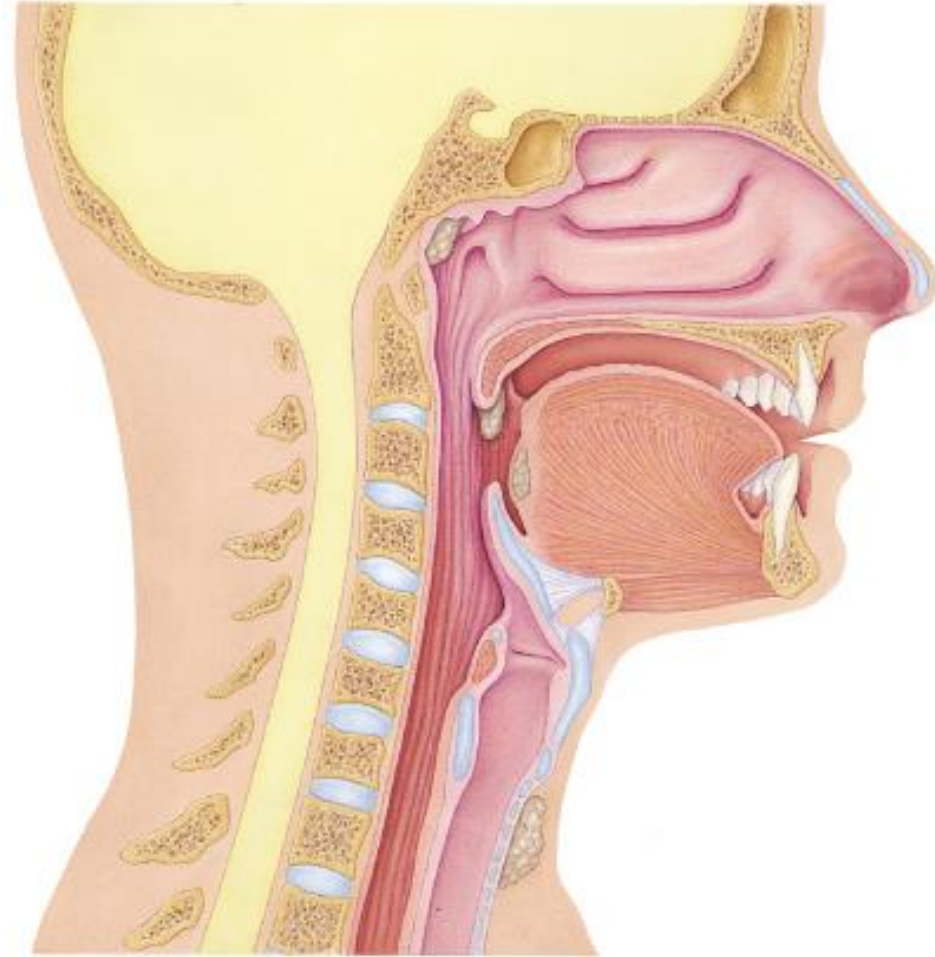
Nasopharynx

- Only an air passage. During swallowing, the soft palate and its uvula move superiorly and close it off.
- Lined by respiratory epithelium.
- High on its posterior wall is the pharyngeal tonsil (a.k.a. adenoids) which traps entering pathogens.
- The auditory tubes open into its lateral walls.



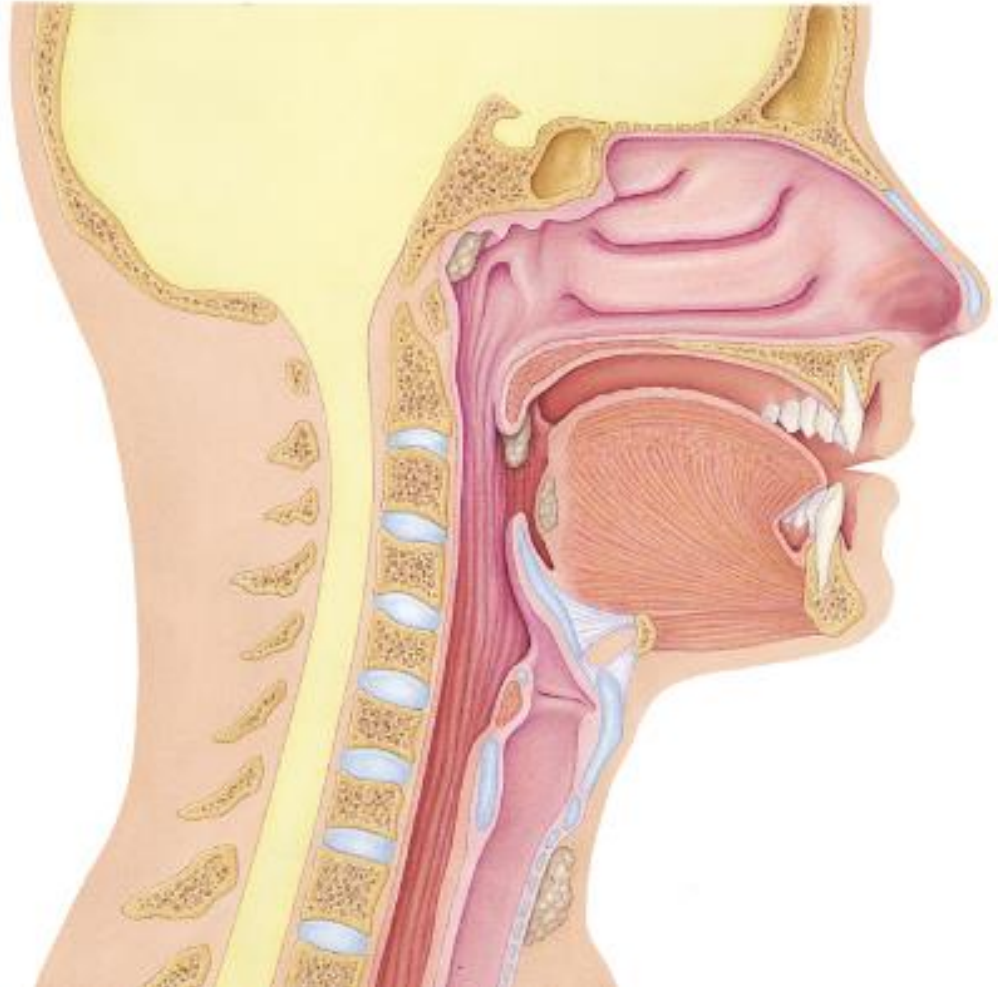
Oropharynx

- Lies posterior to the oral cavity
- Extends from the soft palate to the epiglottis and allows passage of food and air
- Lined by nonkeratinized stratified squamous epithelium



Laryngopharynx

- Lies posterior to the epiglottis and extends to the larynx where the respiratory and digestive paths diverge
- Common passage for both food and air
- Lined by stratified squamous epithelium

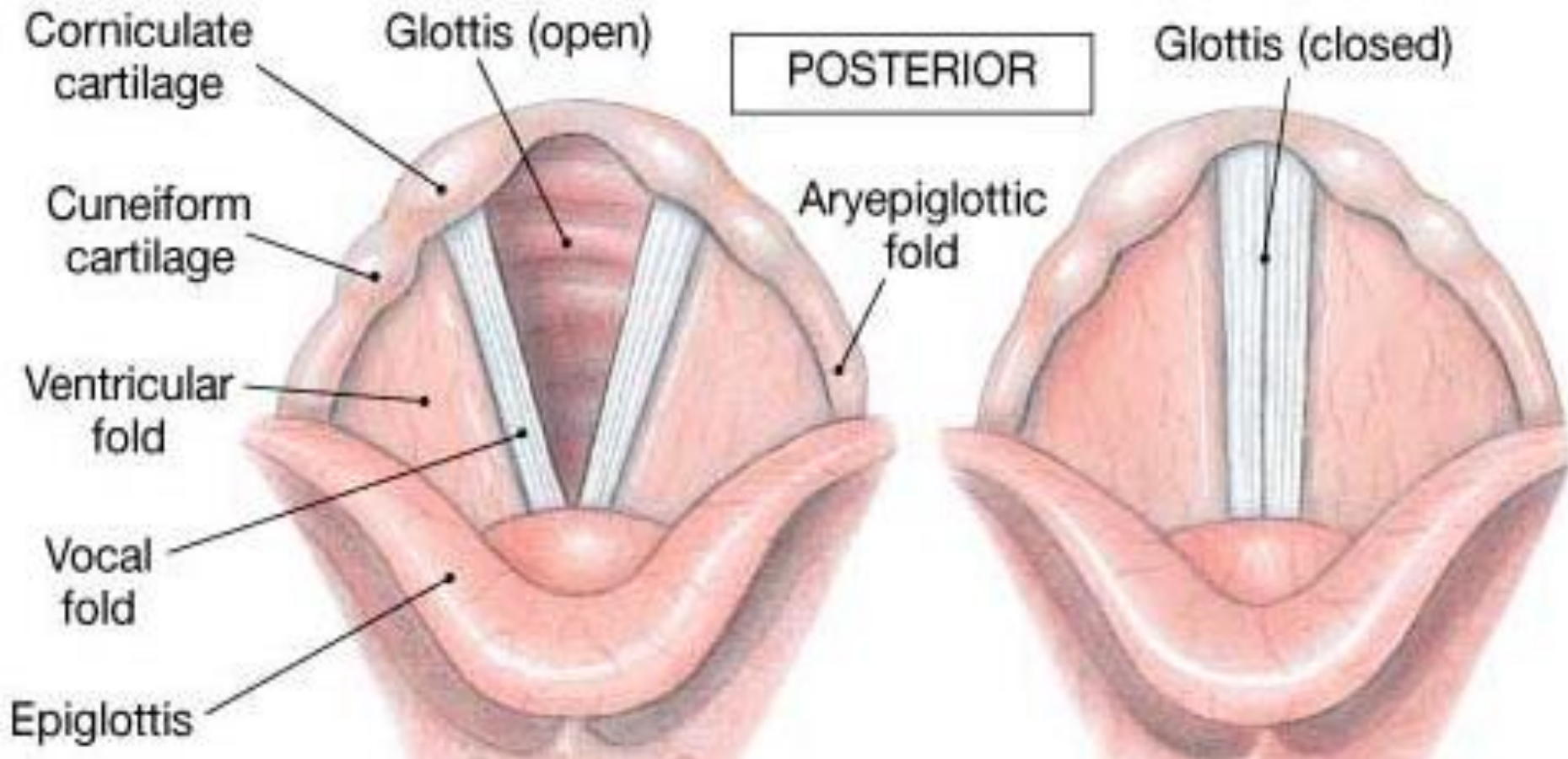


Larynx



- Superiorly attached to the hyoid bone and opens into the laryngopharynx.
- Inferiorly, it's continuous w/ the trachea
- Main tasks are:
 - Provision of a patent airway for air and food.
 - Routing of air and food to proper pathways.
 - Voice production.
- Consists of an intricate arrangement of 9 cartilages connected by membranes and ligaments.

- The larynx is closed by the epiglottis during swallowing.
- In addition to opening and closing the glottis for speech, the vocal folds can act as a sphincter during conditions such as coughing, sneezing or straining



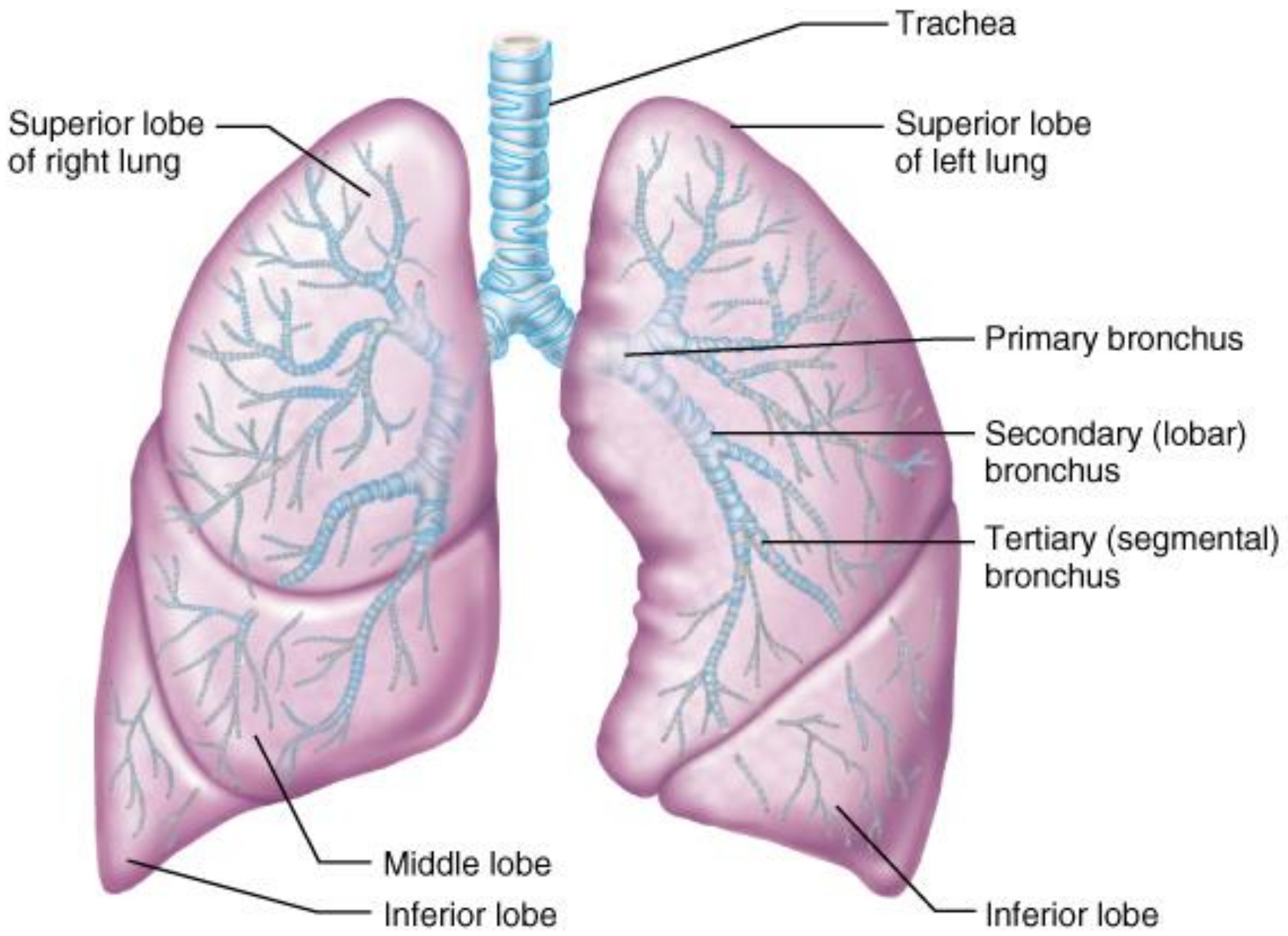
Trachea

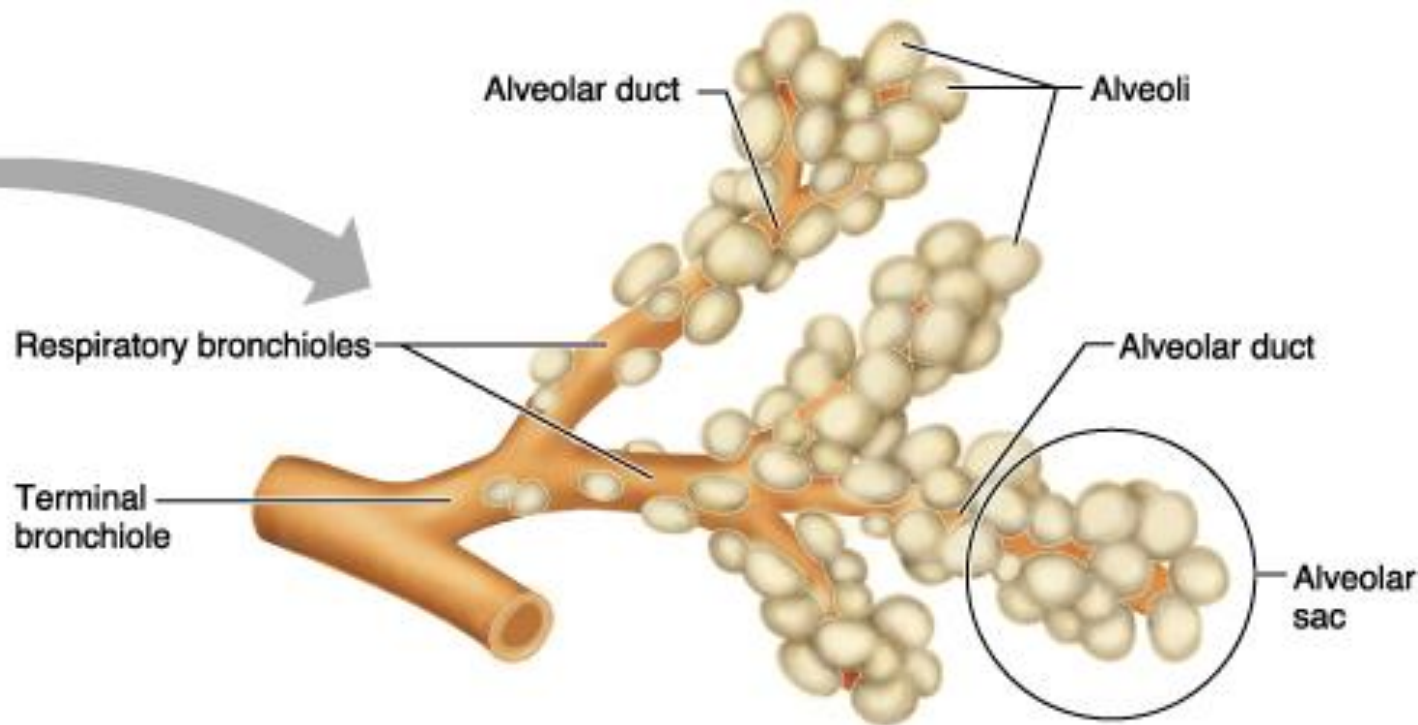


- Descends from the larynx to the mediastinum.
- Ends by dividing into the 2 primary bronchi at midthorax.
- Contains 3 layers: mucosa, submucosa, and adventitia
- Tracheal mucosa contains pseudostratified ciliated epithelium w/ goblet cells.
- Smoking destroys respiratory cilia – necessitates coughing for mucus propulsion
- Submucosa contains seromucous glands – produce the mucus that lines the trachea

Bronchi and Subdivisions

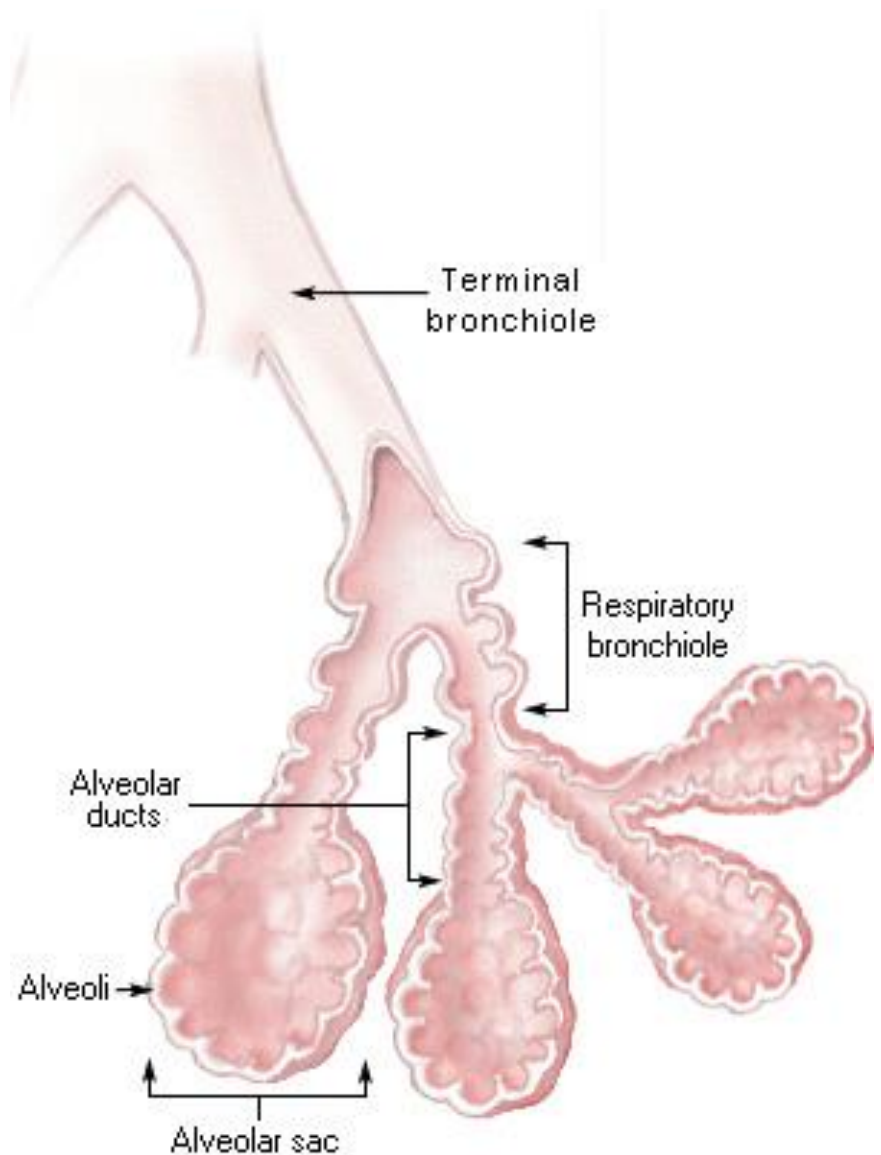
- Each bronchus runs obliquely into the mediastinum before plunging into the medial depression (hilus) of the lung on its own side.
- Inside the lungs, the primary bronchi divide into secondary bronchi – 3 on the right and 2 on the left – each of which supplies one lung lobe.
- The secondary bronchi become tertiary bronchi and so on until 23 branchings have occurred. This yields the bronchial tree.
- Passages with a diameter of $<1\text{mm}$ are bronchioles.
- Terminal bronchioles are the last portion of the conducting zone.



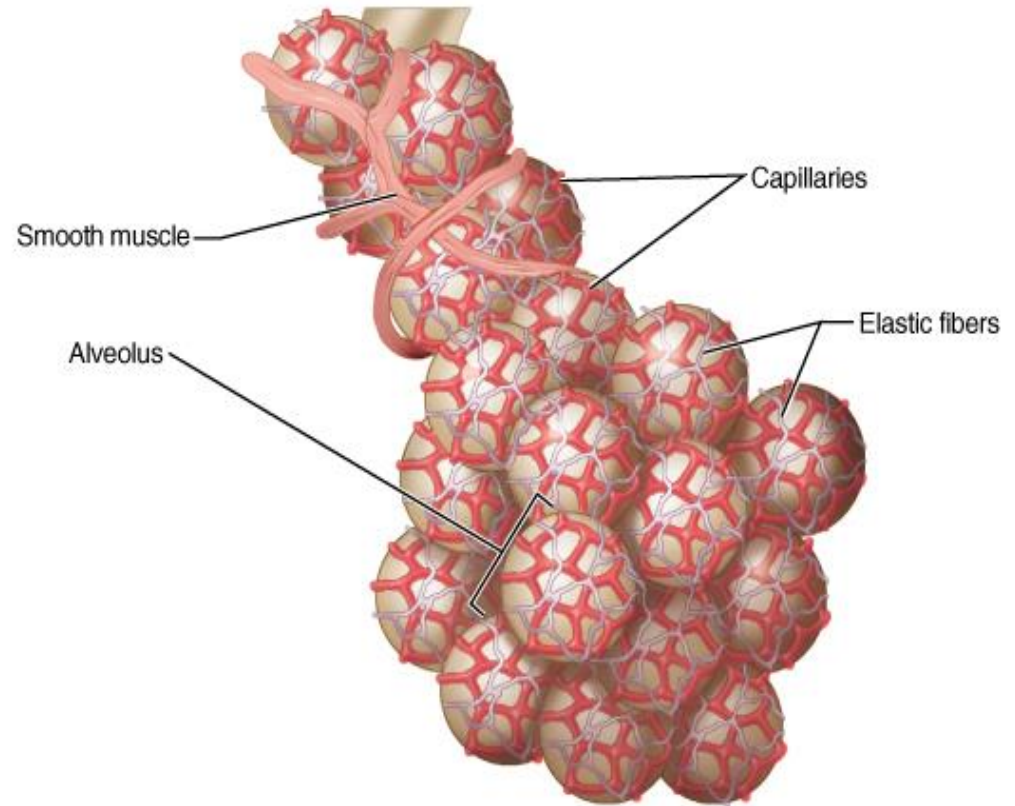


- Defined by the presence of thin-walled air sacs called alveoli.
- Begins at the transition from terminal bronchioles to respiratory bronchioles – which contain scattered alveoli.
- Respiratory bronchioles become alveolar ducts which lead into terminal clusters of alveoli called alveolar sacs.

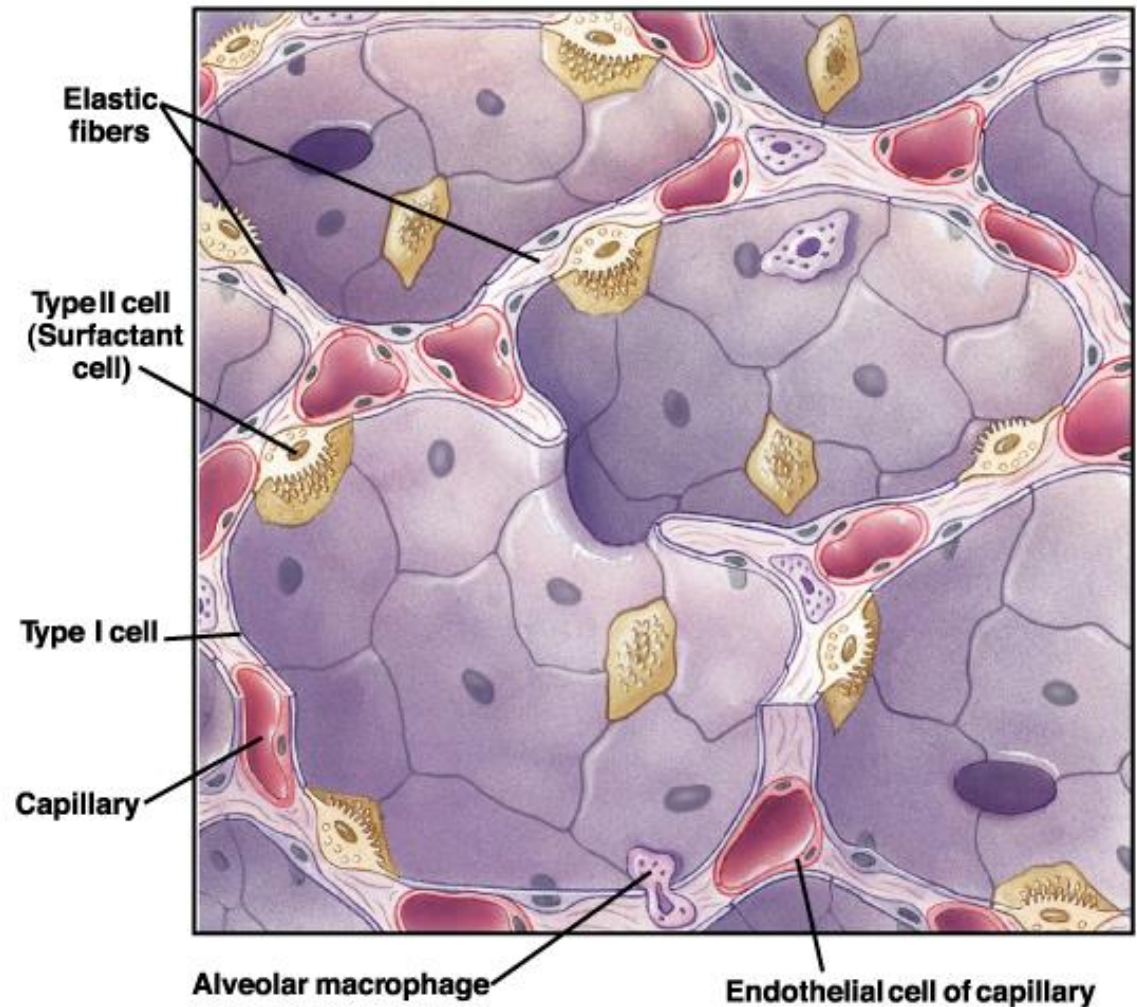
Respiratory Zone



- Alveoli are made of simple squamous epithelium consisting of 2 cell types: Type I and Type II alveolar cells.
- Type I alveolar cells
 - Extremely thin. Occupy most of the alveolar SA.
 - External surfaces are cobwebbed by pulmonary capillaries.
 - Together the alveolar and capillary PM's and their fused basal laminas form the respiratory membrane which has gas on 1 side and blood on the other.
 - Lung alveoli are surrounded by elastic fibers.

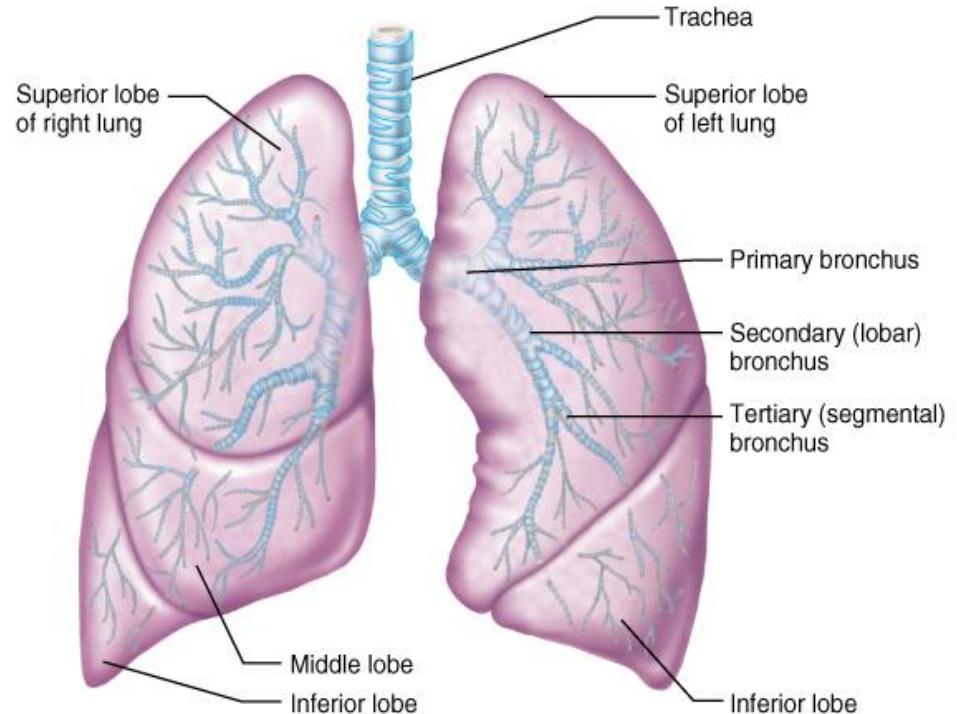


- Scattered among the Type I's are Type II cells which secrete surfactant.
- Alveolar pores connect adjacent alveoli.
- Alveolar macrophages (dust cells) crawl along the internal alveolar surfaces



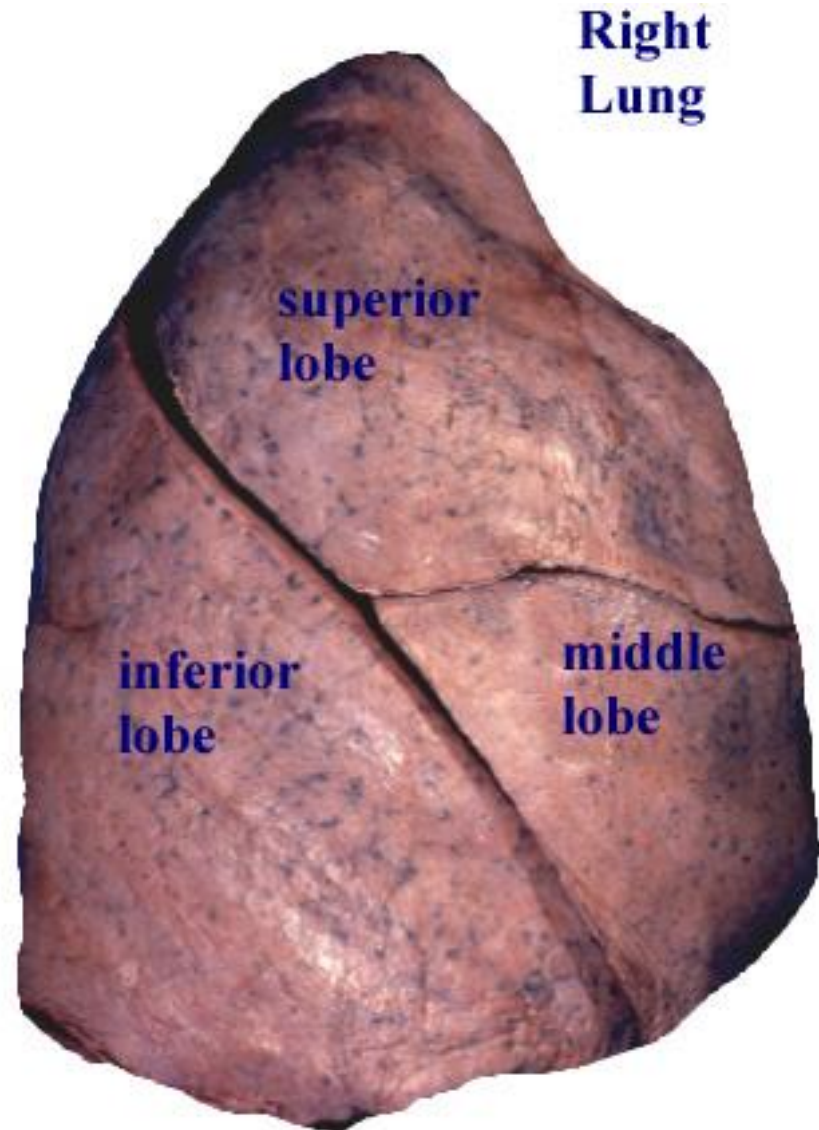
- Occupy all of the thoracic cavity except the mediastinum.
- Each lung is w/i its own pleural cavity
- Anterior, lateral, and posterior surfaces are costal
- Just deep to the clavicle is the superior tip – the apex.
- The concave bases sit on the diaphragm.
- On the medial surface is an indentation (hilus) where the primary bronchi enter and the blood vessels enter and exit.

Lung Gross Anatomy



Lung Gross Anatomy

- The left lung is smaller than the right and has an indentation (cardiac notch) where the heart sits.
- Left lung has an upper and a lower lobe
- Right lung has 3 lobes (upper, middle, and lower)
- The smallest subdivision of the lung visible to the naked eye is the lobule.

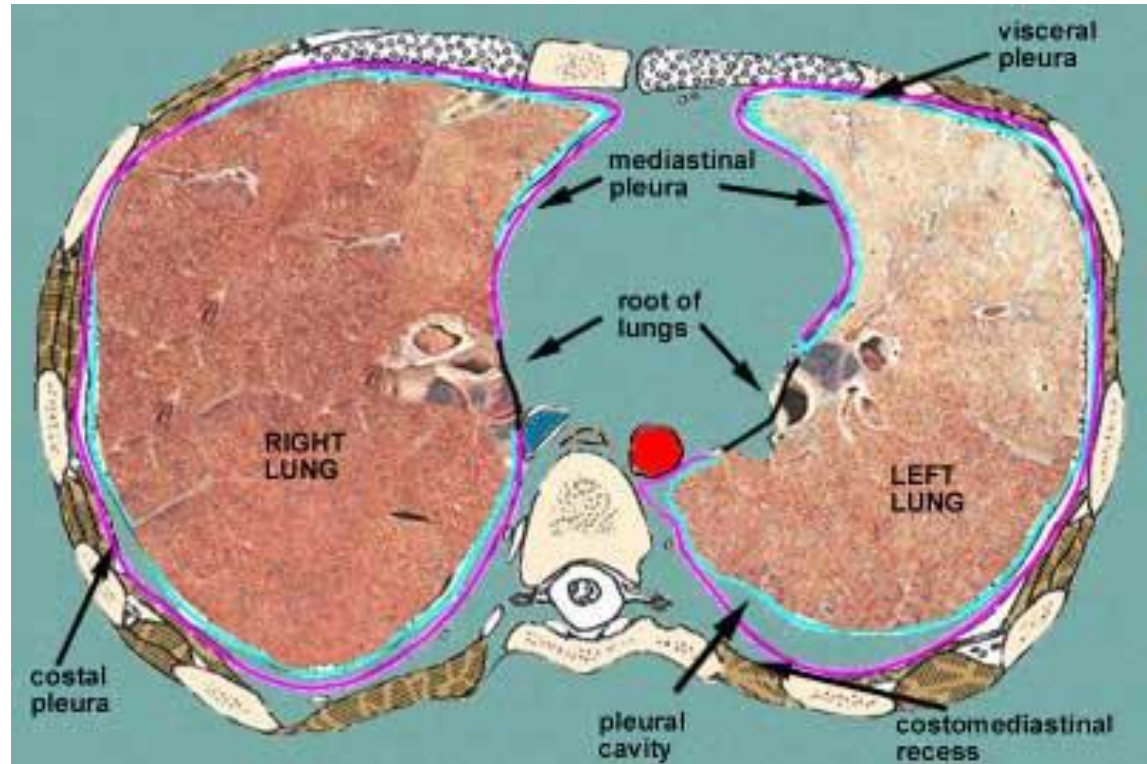


Innervation - Blood Supply

- Pulmonary arteries, capillaries and veins
- Bronchial arteries. Most blood that travels to the lungs in the bronchial arteries returns via the pulmonary veins.
- Parasympathetic activity causes bronchoconstriction while sympathetic activity causes bronchodilation.

- Thin, double-walled serosa.
- Parietal pleura covers the thoracic wall and superior diaphragm
- Visceral pleura covers the external lung surface
- Pleurae produce pleural fluid that fills the slit-like pleural cavity btwn them.
- Helps affix the lungs to the thorax and causes the lungs to move when thorax does.

The Pleurae



Important Pressures

- Atmospheric pressure (P_{atm}) is the pressure exerted by the air surrounding the body.
 - At sea level, it's 760 mmHg
- Intrapulmonary pressure (P_{alv}) is the pressure w/i the alveoli of the lungs.
 - It rises and falls during breathing but always equalizes with the atmospheric pressure
- Intrapleural pressure (P_{ip}) is the pressure w/i the pleural cavity.
 - It's always 4mmHg less than the pressure in the alveoli
 - Thus it's always lower than both P_{alv} and P_{atm}

