THE RESPIRATORY SYSTEM (CH.22)

INTRODUCTION

• Major function of respiratory system is to supply O_2 and dispose of CO_2

• **4 distinct processes:**

Lungs:

1) **Pulmonary ventilation:** (breathing) movement of air in and out of lungs (inspiration and expiration)
2) **External respiration:** exchange of gases between blood & air of alveoli (oxygen from lungs to tissues, and carbon dioxide from blood to lungs)

Cardiovascular System:

3) **Transport of respiratory gases:** role of blood in transport of gases between lungs & tissues of body (oxygen from lungs to tissues, carbon dioxide from tissue cells to lungs)

4) **Internal respiration:** at the level of the tissues, exchange of gases between blood in systemic capillaries and tissue cells (oxygen from blood to tissue cells, carbon dioxide from tissue cells to blood)

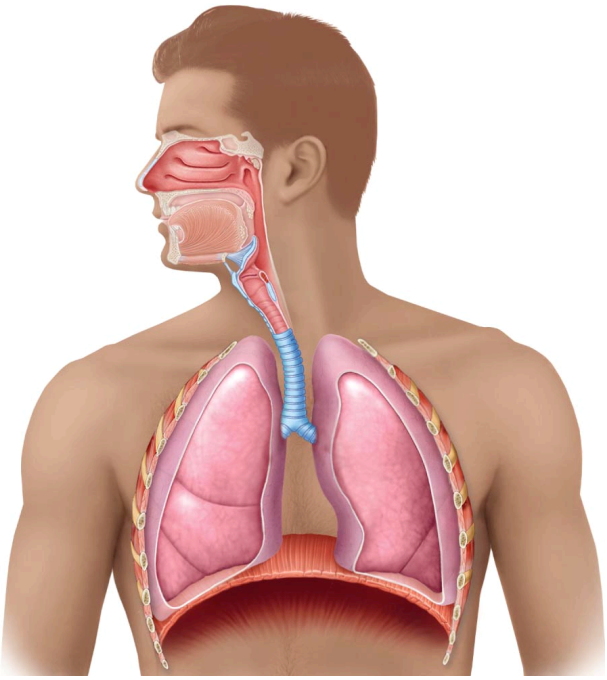
• First 2 functions handled by respiratory system; other two by CV system

6.1 STRUCTURE OF THE COMPONENTS OF THE CONDUCTION AND RESPIRATORY ZONES

- **respiratory zone:** (= site of gas exchange) »» composed of respiratory bronchioles, alveolar ducts & alveoli (microscopic)- air sacs of gas exchange

- **conducting zone:** (passageways) »» nose, nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles, terminal bronchioles (lead into respiratory zone)

- as well as providing a passageway, conducting zone organs also **cleanse**, **humidify** & **warm** incoming air



1.NOSE

Functions:

a) airway for respiration

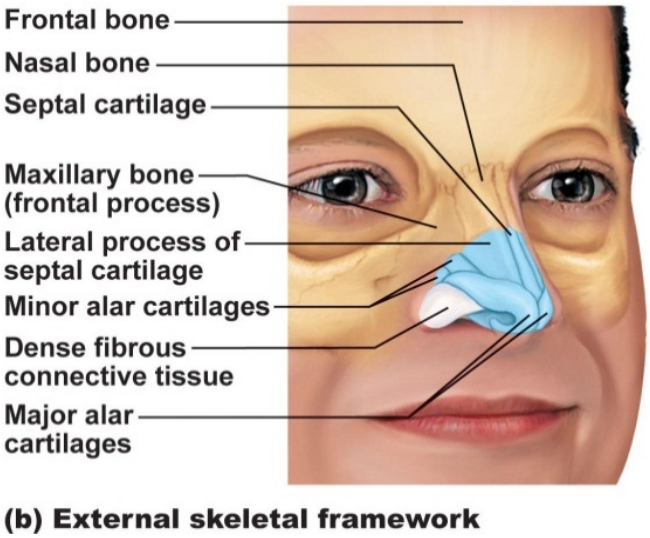
b) moistens & warms incoming air

c) filters & cleans inspired air

d) resonating chamber for speech

e) olfactory (smell) receptors

- a lot of sense of taste is associated with smell, so sometimes meals don't taste the same when one has cold



(b) External skeletal framework

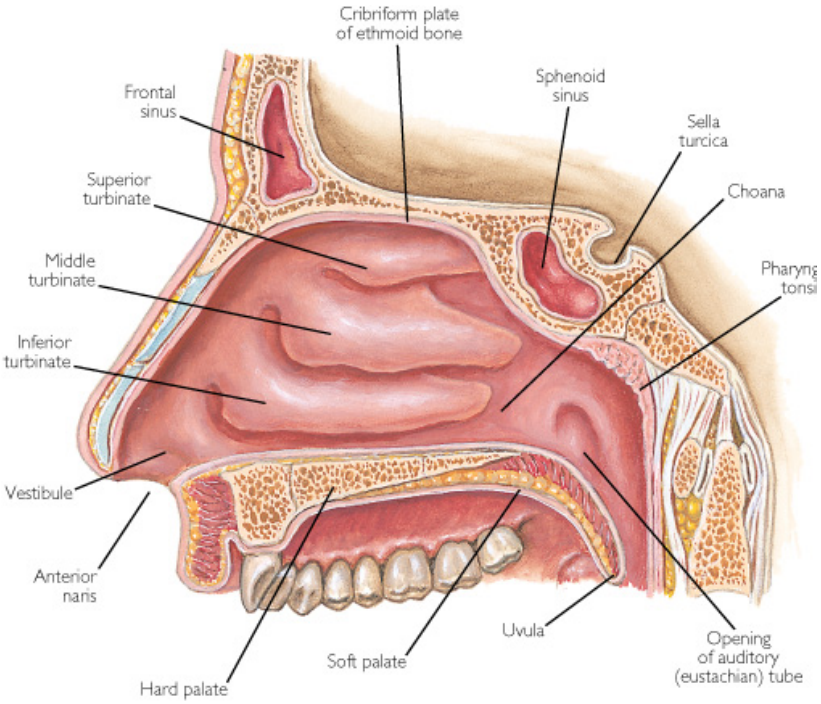
- structure of **external** nose: differences in nose size/shape due to differences in nasal cartilages
- air enters **nasal cavity** via **external nares** (**nostrils**) - divided by midline **nasal septum** (cartilage » bone); air then goes via **internal nares** to **nasopharynx**
- **roof** of nasal cavity formed by **ethmoid** & **sphenoid** bones of skull
- **floor** of nasal cavity formed by **palate** (anterior is hard; posterior is soft)
- **vibrissae**: fine hairs present inside nasal cavities
- nasal cavity lined by 2 types of mucosa
  - **olfactory mucosa:** found in the superior region, contains receptors for sense of smell
  - **respiratory mucosa:** see below

On diagram:

Base= tonsils, be able to label palinate and lingual tonsils

Hollow spaces= sinuses (frontal and sphenoid), air cavities in bone that help to lighten the skull, pressure changes in these cavities due to infection can cause headaches

Be able to label hard and soft palata, types of skull bone (ethmoid and sphenoid)



RESPIRATORY MUCOSA

respiratory mucosa: pseudostratified ciliated columnar epithelium with goblet cells; lamina propria has mucous & serous glands (1 L/day sticky mucus containing lysozyme→enzyme that destroys bacteria

- resp mucosa cilia move contaminated mucus posteriorly to pharynx
- **cold** air slows cilia activity and not moving mucus along → runny nose

- thin-walled veins under nasal epithelium→ role: warms incoming air as it flows across mucosal surface, cold air incites heavier engorgement of capillary beds, & nosebleeds are common due to the abudancy and superficiality of the vessels.

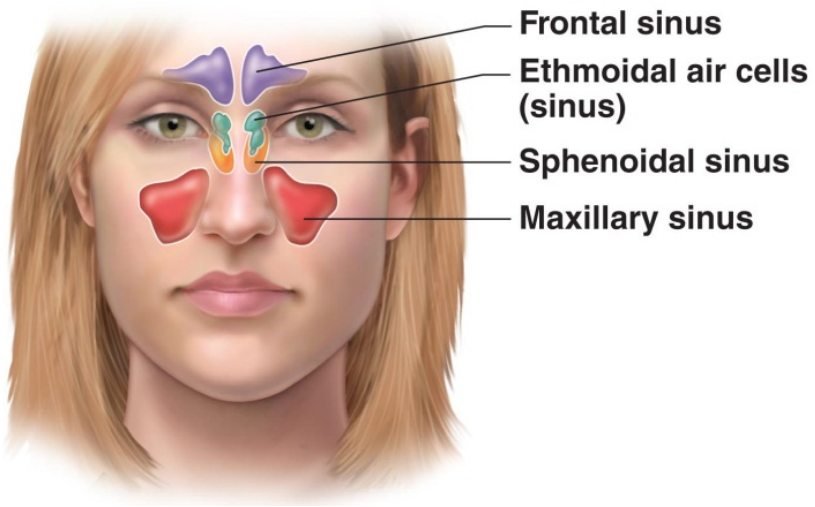
- What are nasal conchae: 3 sets of bony projections into the lumen of the nasal cavities, easier to trap dust and debris,

- nasal mucosa richly supplied with sensory nerves→ irritants trigger sneeze reflex to get rid of debris

2. PARANASAL SINUES

Paranasal Sinuses

- surround nasal cavity
- frontal, sphenoid, ethmoid, maxillary bones
- lighten skull, produce mucus, also warm & moisten air
- sinus mucosa continuous with nasal mucosa »» spread of infections
- ***sinus headache:*** passageways connecting sinuses to nasal cavity blocked » air in sinus absorbed » partial vacuum



3. PHARYNX

- common pathway for food **and** air, can only breathe OR swallow
- wall composed of skeletal muscle throughout ~13 cm length; mucosal lining varies

3A)NASOPHARYNX

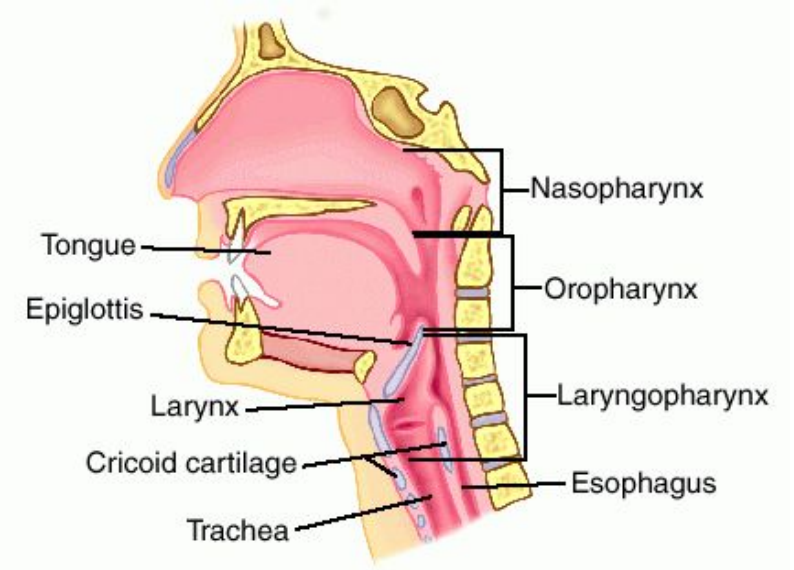
- **only** an **air** passageway
- below sphenoid bone, above soft palate

- what happens when swallowing:
    - uvula closes off and prevents food from entering nasal cavity
- pseudostratified ciliated epithelium→ mucus propulsion
- **pharyngeal tonsils**: located at the entry points of pharyngotympanic tubes
- **pharyngotympanic** (auditory) **tubes** drain from middle ear
    - bug in throat area can therefore cause ear infection

3B) OROPHARYNX

Area of common passageway,

- fauces connects oral cavity with oropharynx, archway into the opropharynx
- from soft palate to epiglottis (air **and** food)
- epithelium becomes stratified squamous→allows protection from scraping action of food against tissue, causing peeling, but stratification of this tissue allows several layers and regeneration.
- paired **palatine tonsils** + single **lingual tonsil**



3C) LARYNGOPHARYNX

- also both food **and** air
- stratified squamous
- from epiglottis to larynx – then respiratory & GI pathways **diverge**
- during swallowing, food has "right-of-way"

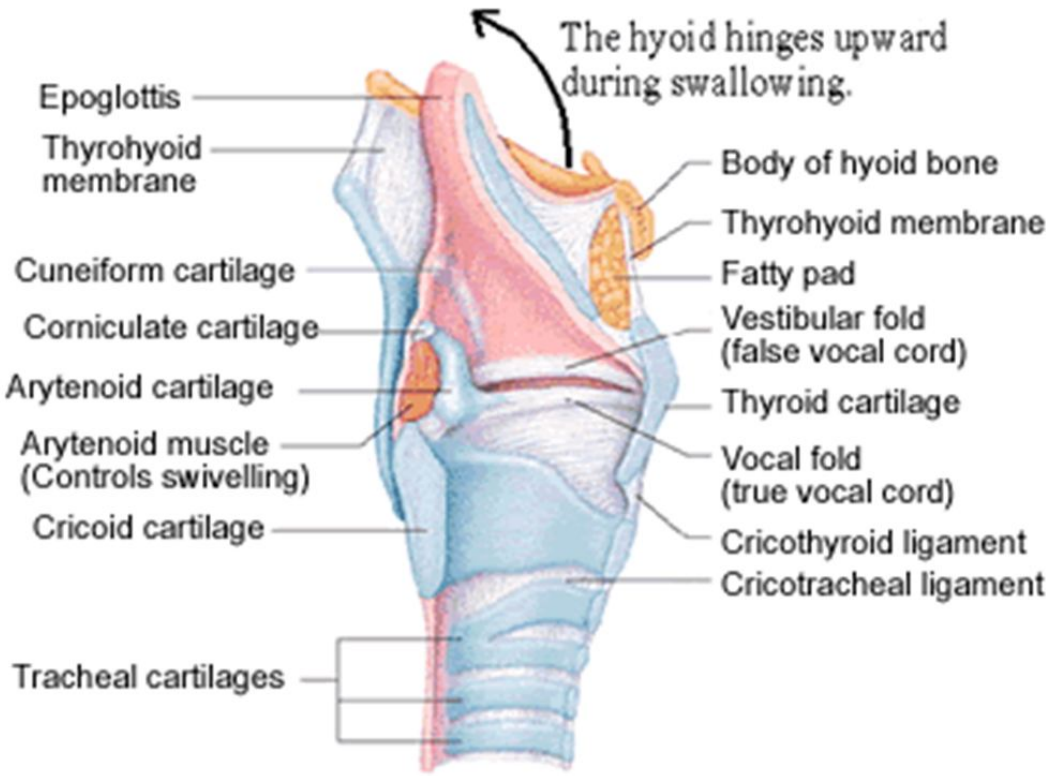
4. LARYNX

- ~5 cm (4th-6th cervical vertebrae)
- attached to hyoid bone (above); continuous with trachea (below)
- <u>3 functions:</u>
    - open, 2-directional airway
    - switching: food vs air
    - voice production

<u>9 cartilages in total (key ones listed below)</u>

- ***thyroid cartilage:*** large, shield-shaped cartilage in front (puberty in males, testosterone stimulated growth in size, deepening of voice)

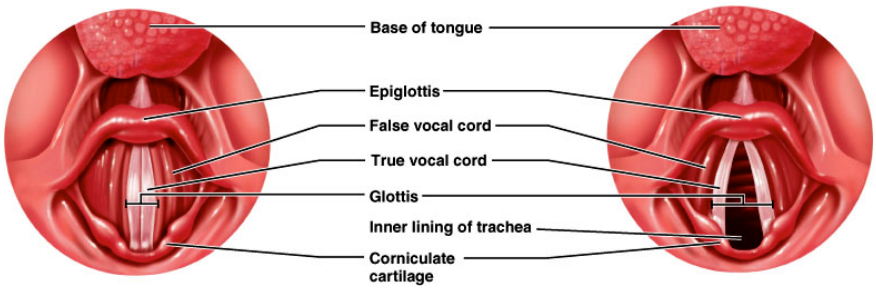
- ***arytenoid cartilages (2):*** lateral, pyramid-shaped, anchor vocal cords
- ***9th cartilage*** is ***epiglottis***: elastic cartilage, anchored to anterior rim of thyroid cartilage & extends **up** to base of tongue
- ***true vocal cords:*** white (avascular); vibrate in response to air movement up from lungs (what is the **glottis: opening through which air travels, composed of both the true vocal chords and the opening between them, we breath in then allow air to slowly escape through passage and pass over cords to make sound**)
- ***false vocal cords:*** above true vocal cords
    - Epithelial lining of upper versus lower larynx: upper stratified squamous , lower part and rest of tract = psuedostratified ciliated columnar epithelial, (trap dust and propel mucus in lungs)
    - Help in closing of glottis
- **Cricoid cartilage** under the thyroid cartilage, start of the rings that make up the structure of the wall of the esophagus



VOICE PRODUCTION:

- speech = intermittent release of expired air + opening & closing of glottis
- length of vocal cords & size of glottis altered by action of laryngeal muscles that move **arytenoid** cartilages

- male voice at puberty: vocal cords vibrate more slowly – why→ stimulates thickening of the vocal cords, thicker vocal cords vibrate more slowly as air passes over them
- **loudness** of voice: force of air across vocal cords, increases volume of sound
- **laryngitis:** inflammation of vocal cords ⇒ vibration impaired, cords irritated by infection or overuse
- **sphincter functions** of vocal cords:
  - epiglottis closes respiratory tract during swallowing
  - Valsalva's maneuver: *What is this→closing of glottis to promote defecation by increasing abdominal pressure*
  - Heimlich maneuver: trying to expel air upwards through (common pathway) and dislodge object stuck, out through the mouth



5. TRACHEA

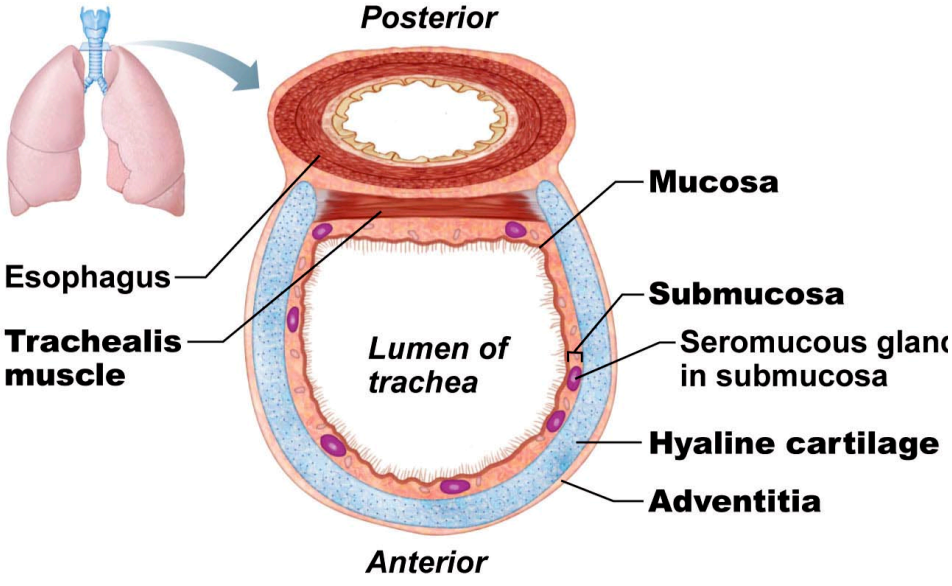
- 10-12 cm long; ~2.5 cm diameter; flexible, mobile

- pseudostratified ciliated columnar; cilia move mucus **up** to pharynx

smoking inhibits & then destroys cilia; only coughing to clear mucus

they kill off the pseudostratified tissue cilia, cilia no longer available to clear mucus

- submucosa is CT with seromucous glands



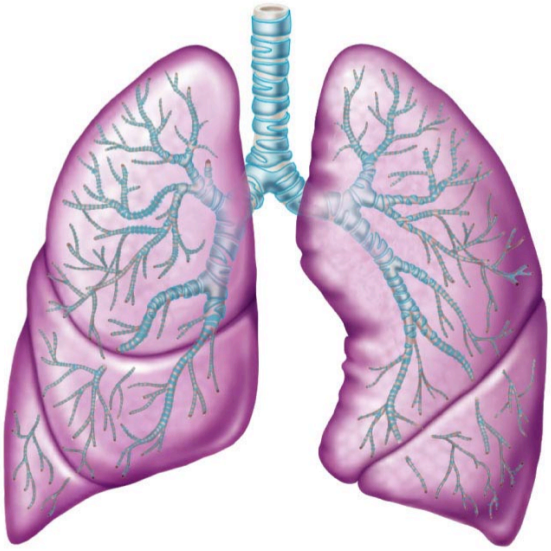
(a) Cross section of the trachea and esophagus

- outer adventitia reinforced internally by 16-20 C-shaped cartilaginous rings; keep airway open during pressure changes associated with breathing

Why C Shaped? → Gives some space for the esophagus to stretch

THE BRONCHIAL TREE

1. Conducting Zone Structures



- right primary bronchus is wider, shorter, more vertical than left
- air in bronchi is warm, cleansed of most impurities & humidified
- ~23 orders of branching air passages in lungs = **bronchial** or **respiratory tree**

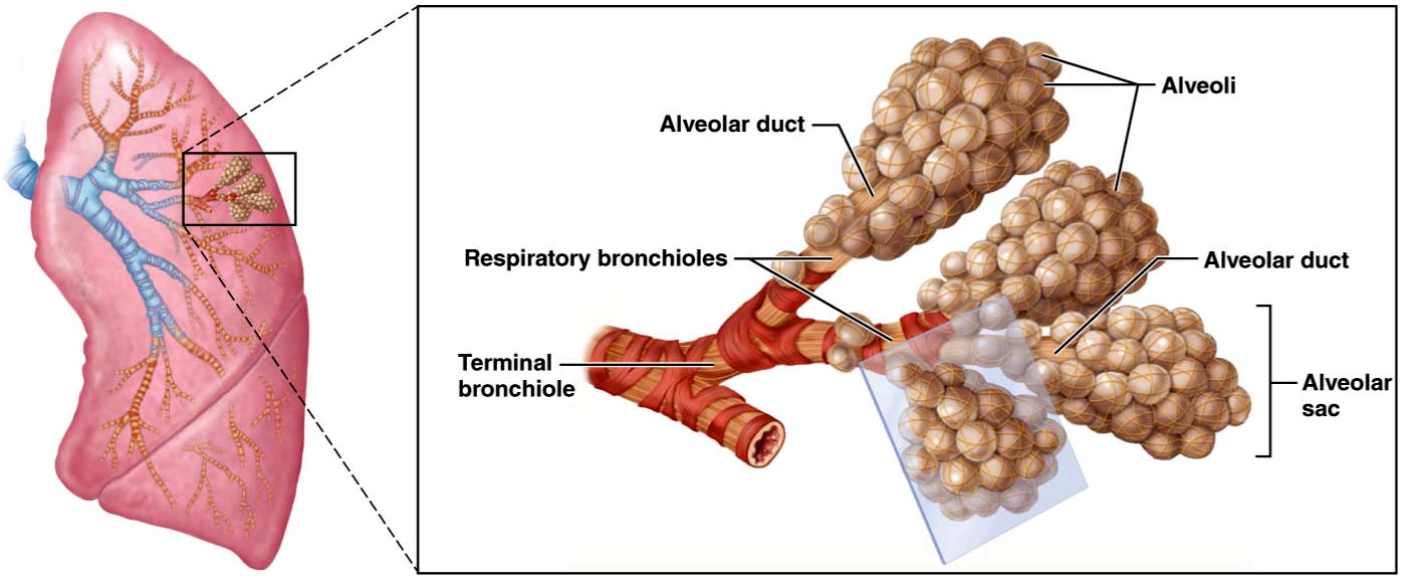
bronchi (1^o, 2^o, . .)
↓
bronchioles (< 1 mm diam)
↓
terminal bronchioles (< 0.5 mm diam)

- changes in wall composition as one moves through tree:

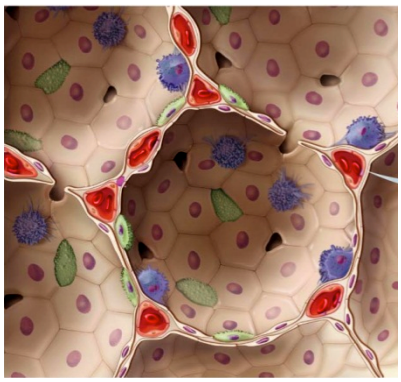
a) **cartilage: rings** to **plates** to **none (thinner and thinner)**

b) **epithelium:** pseudostratified columnar to columnar to cuboidal; no cilia or mucous cells in bronchioles (to hard to propel mucus all the way back up)

c) **smooth muscle:** **relative** amount increases as passages become smaller, we need more relative muscle to make up the walls as we lose cartilage



2. Respiratory Zone
    - **terminal bronchioles** branch into **respiratory bronchioles which lead into alveolar ducts which lead to alveol**
        - ~300 million alveoli = huge surface for gas exchange, hollow gas filled sacs
        - they have elastic fibers to allow for stretching and contracting when breathing in and out
    - Type 1 cells = Squamous cells that make up wall (beige cells) and provide physical barrier
    - Type 2 cells; secrete Surfactant: molecule that helps to keep alveoli open (green)
    - Type 3 cells: Macrophages: dust cells that are responsible for cleaning the inner face of each alveolus (blue)
    - Blood vessels (cross section) –(red)



Surfactant is a fluid that gets between the water molecules inside the alveoli, it prevents the inner walls of the alveoli from sticking together which makes it harder to breath. If they stick, it is very hard to separate them (like trying to inflate a balloon, very hard at first but then easy after).

respiratory membrane = alveolar wall + capillary wall + basal laminae

• respiratory membrane is an **air-blood barrier**; gas exchange by simple diffusion

• **type II cells:** scattered among type I cells; secrete **surfactant**

• other characteristics of lung alveoli:

(i) surrounded by fine **elastic** fibers

(ii) **alveolar pores:** allow equalization of air pressure throughout lung; alternate air routes if bronchi collapsed. If one of the entry points of the alveoli is blocked, air can still enter through pores between the alveoli (helpful in sickness where excess mucus formed like bronchitis and pneumonia)

(iii) alveolar **macrophages** = dust cells; **inner alveolar surface**; *clear & swallow > 2 million dust cells/hour!*

6.2 GROSS ANATOMY & STRUCTURE OF THE LUNGS AND THE PLEURAL CAVITIES

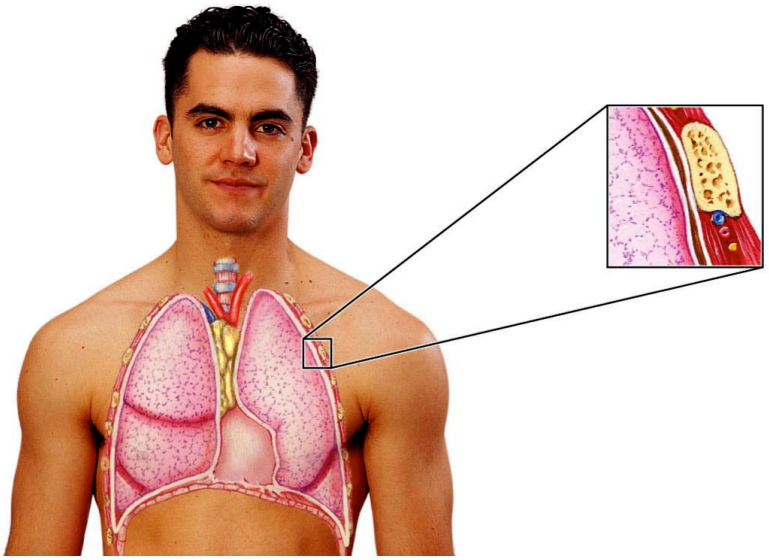
- paired lungs occupy entire thoracic cavity except mediastinum (occupied by heart)
- each lung suspended in own **pleural cavity**; connected to mediastinum by vascular & bronchial attachments (= **root**). If one lung collapses, the other will still be able to function
- **costal surface** = anterior, lateral & posterior lung surfaces in close contact with ribs

apex, **base**; also **hilum (between lungs)** »» blood vessels enter & leave lungs

The base of the lungs largely associated with the diaphragm (most important in respiration, ribs very little effect compared to diaphragm)

1^0 bronchus enters lungs

fissures: oblique, horizontal, left lung only has 1 oblique » **septa** subdivide each lung into 10 bronchopulmonary segments (connective tissue divisions; own artery & vein), lung may appear as one large moving sac, but actually segmented, some parts will move more than others if infected/injured



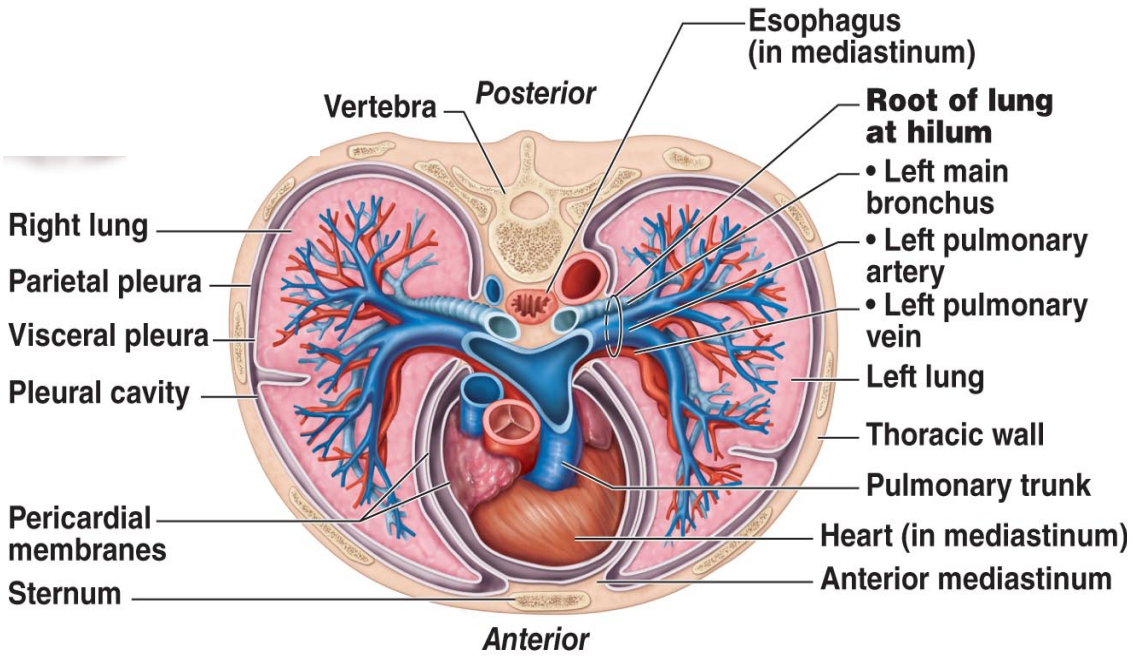
pulmonary disease often segmental & can be treated that way, making it harder for disease to spread, only one segment affected and can be removed

lobule: smallest subdivision that is visible by eye,

lung : primarily air spaces; rest is elastic CT

Blood Supply & Innervation

- **pulmonary arteries** bring blood to be oxygenated
- **pulmonary veins** return oxygenated blood
- **bronchial arteries** provide systemic blood to lungs ⇒ **bronchial veins**
- innervation primarily parasympathetic (restricting, when large air volume not needed) + some sympathetic (expanding, allowing more air volume in times of high activity)



PLEURA

- thin, double-layered (**parietal** & **visceral**) serosa
- **pleural fluid:** serous secretion that fills pleural cavity »» lungs slide easily during breathing; **surface tension** keeps pleurae from separating
- 3 chambers: central **mediastinum** + 2 lateral **pleural compartments**
- **pleurisy:** inflammation of pleurae, interferes with production of fluid, making it uncomfortable