Western

UNIVERSITY · CANADA

Tutorial 17
Sections 009/010

TA: Greydon Gilmore

Physiology 2130

Feb 11th, 2020

Western

Your TA reminding you…

- **3rd Peerwise assignment** (1.5%)
  - Post 2 MC questions: due Feb 12th @ midnight
  - Answer 5 MC questions: due Feb 14th @ midnight
- **3rd Quiz** (1%)
  - Opens: Feb 24th @ 4pm
  - Closes: Feb 25th @ 4pm
- **3rd Midterm** (15%)
  - When: Feb 28th @ 6pm-7pm
- **3rd Midterm Review Session**
  - When: Monday Feb 24th from 6pm-8pm
  - Where: Auditorium C, University Hospital 3rd floor

Today

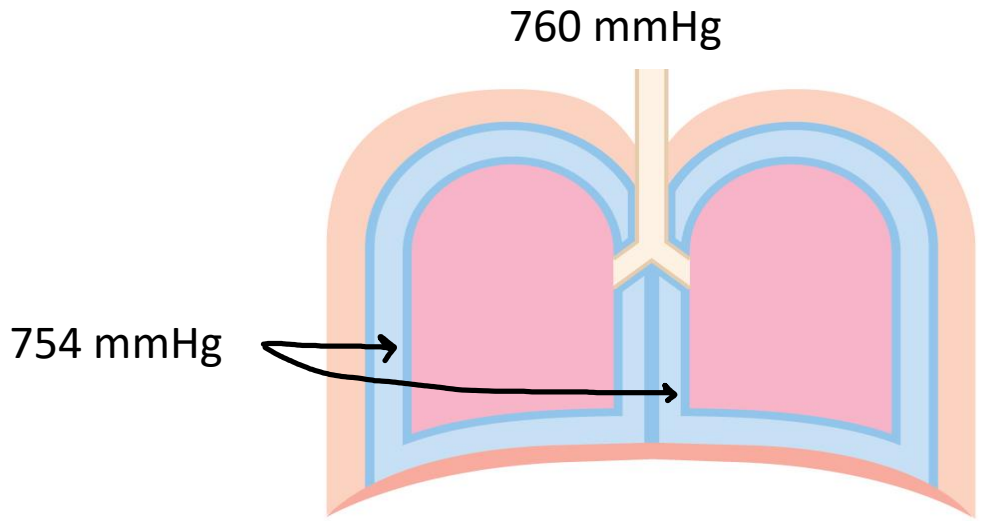
- Group work activity
- Learning Catalytics Question
- Respiratory Physiology

Answers From Last Week

Question 1

Based on what you learned in class, what is the state of this person's lungs in the above scenario?

A. This person is inhaling
B. This person is exhaling
C. This person has a pneumothorax
D. This person is not breathing

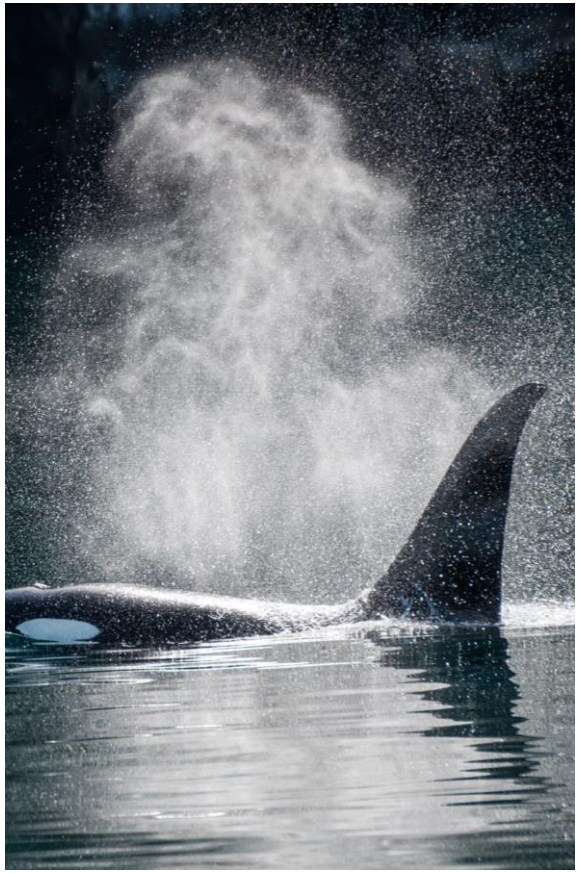


Atmospheric pressure is 760 mmHg, intrapleural pressure is 754 mmHg. At rest, the intrapleural pressure is 757 mmHg. When you breath in, the volume gets larger and the pressure gets lower (Boyle's law). Thus, this person has to be breathing inward, since the intrapleural pressure lower than at rest.

Question 2

Air is moving through your lungs but not a single muscle involved in breathing is contracting. Why?

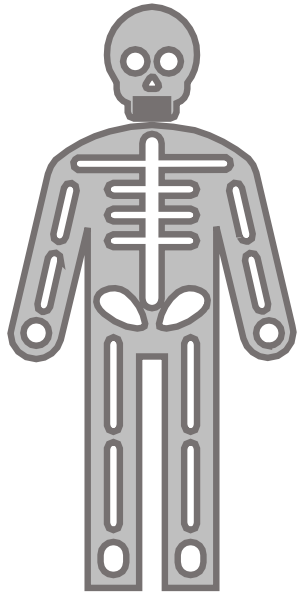
A. you are inhaling at rest
B. you are exhaling at rest
C. you are inhaling while swimming hard
D. you are exhaling while swimming hard



When exhaling (passively) the diaphragm and external intercostal muscles relax. Swimming hard would be active breathing.

Question 3

Dorothy has a genetic condition that causes her to not produce pulmonary surfactant. What is true about Dorothy's lungs?



A. Dorothy has low surface tension in her lungs
B. Dorothy has excellent lung compliance
C. Dorothy has poor gas exchange into her blood
D. Dorothy has too much elastin in her lungs

Pulmonary surfactant reduces surface tension, without it tension would be higher. Compliance would decrease due to the increase in surface tension. The decrease in compliance would result in poor gas exchange.

Question 4

What is true about the visceral pleura?

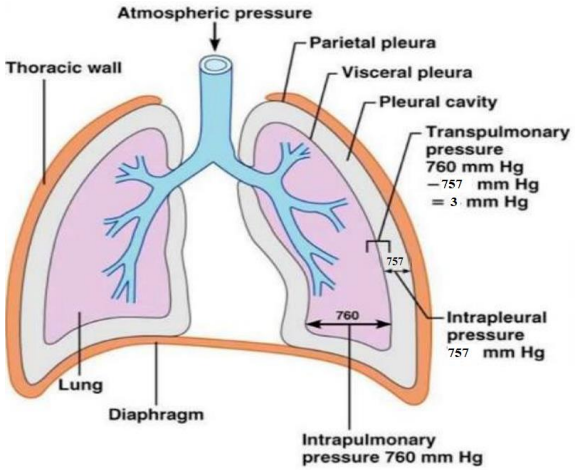
A. On one side is the lung and the other side is fluid

B. A hole in this membrane would cause a pneumothorax, as long as the chest wall was also punctured

C. This membrane directly contacts/covers the diaphragm

D. One membrane surrounds both lungs forming one compartment in the thoracic cavity

A hole in the visceral pleura OR parietal pleura would cause pneumothorax. Visceral pleura is next to the lung and pleural cavity.



Question 5

Four roommates are running. They each breathe 700 mL per breath. Based on this information alone, who likely has the best gas exchange?

A. They all have the same gas exchange
B. Matt, because he is the heaviest runner
C. Kate, because she breathes the slowest
D. Tim, because he is the lightest runner

Hint is how you calculate anatomical dead space (weight * Resp rate.). With lower resp rate the dead space would be less, meaning the alveolar ventilation would be higher! $V_A = V_E - V_D$

Practice Calculations

Patrick Mahomes has finished his season. In a post-game physical, his lung function test shows he has a resting tidal volume of 600 mL and breathes at 15 breaths/min. He weighs 104 kg (230 pounds).

A. What is his pulmonary ventilation per minute?
B. What is his alveolar ventilation per minute?
C. How much anatomical dead space does he have in his lungs?

Practice Calculations

Patrick Mahomes has finished his season. In a post-game physical, his lung function test shows he has a resting tidal volume of 600 mL and breathes at 15 breaths/min. He weighs 104 kg (230 pounds).

A. What is his pulmonary ventilation per minute?

$V_E = V_T$ x RR = 600 mL x 15 breaths/min = 9000 mL/min or 9 L/min

B. What is his alveolar ventilation per minute?

$V_E = V_A + V_D$

9 L/min = ? + (230 mL * 15 breaths/min)

9 L/min = ? + (3.45 L/min)

9L/min – 3.45 L/min = V_A

V_A = 5.55 L/min

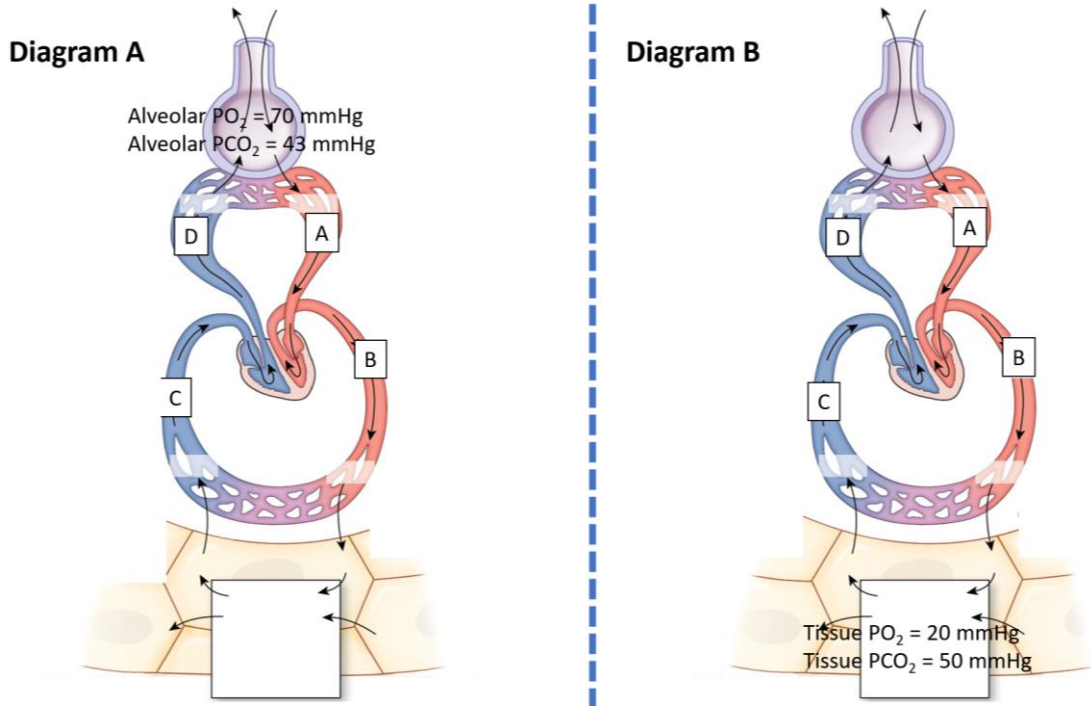
C. How much anatomical dead space does he have in his lungs?

Since he weighs 230 pounds, he has 230 mL of dead space in one breath.

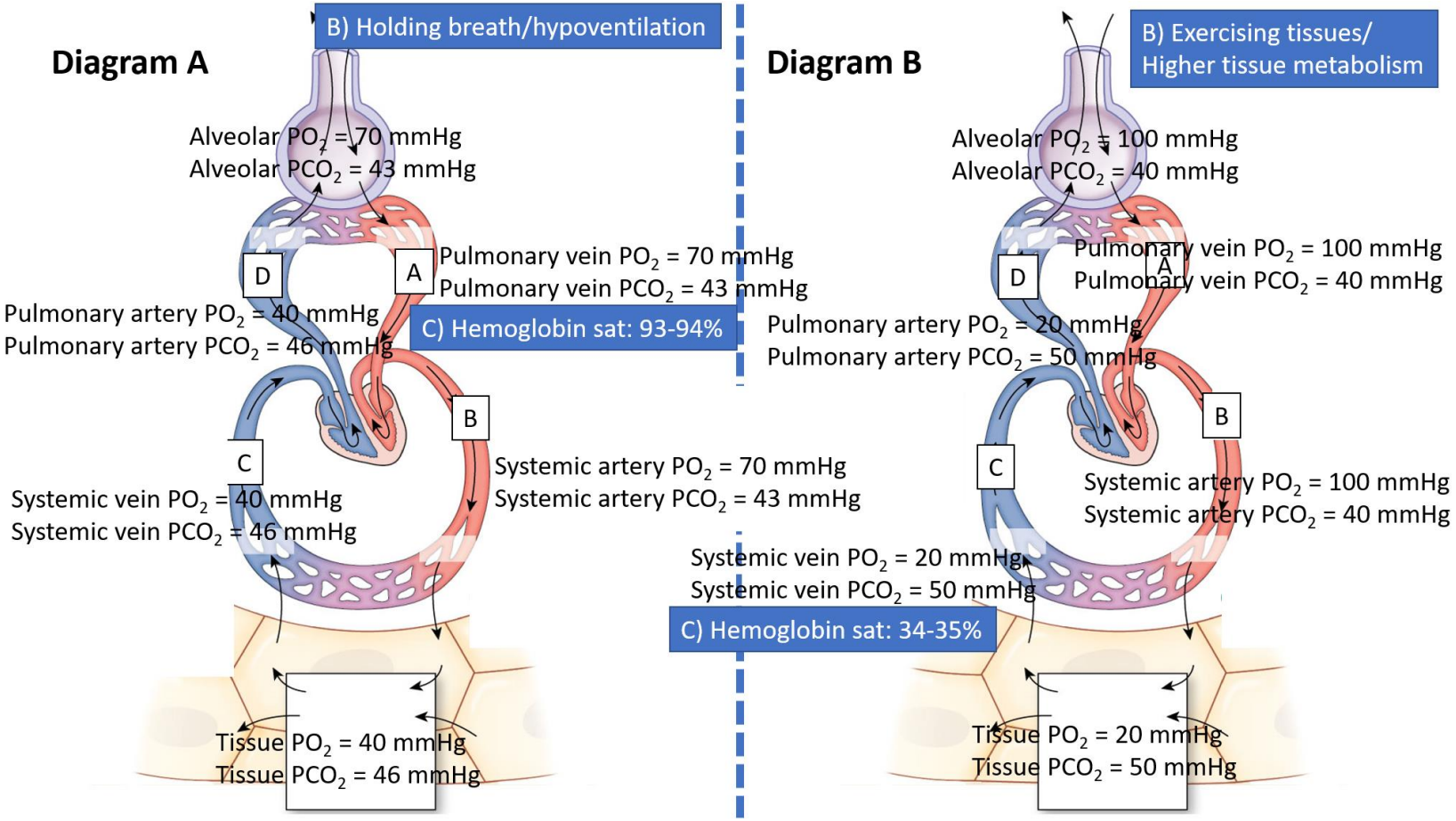
Group Work

Pulmonary Diagrams

1. What are the blood vessels labelled A, B, C, D? Label on the figure.
2. Diagram A: *(Assume the tissue PO_2 and PCO_2 is normal)*
   a) Fill in the PO_2 and PCO_2 for the tissues and blood vessels.
   b) What situation might cause the partial pressures seen in the alveoli here?
   c) What would the hemoglobin saturation be in the pulmonary vein?
      - *(p 312-ignore any possible curve shifts to keep simple)*
3. Diagram B**:** *(Assume the alveolar PO_2 and PCO_2 is normal)*
   a) Fill in the PO_2 and PCO_2 for the alveoli and blood vessels.
   b) What situation might cause the partial pressures seen in the tissue here?
   c) What would the hemoglobin saturation be in the systemic veins?
      - *(p 312-ignore any possible curve shifts to keep simple)*



Pulmonary Diagrams Answers



Learning Catalytic Question

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Respiratory System: Anatomy

Chapter 9: Dr. Beye

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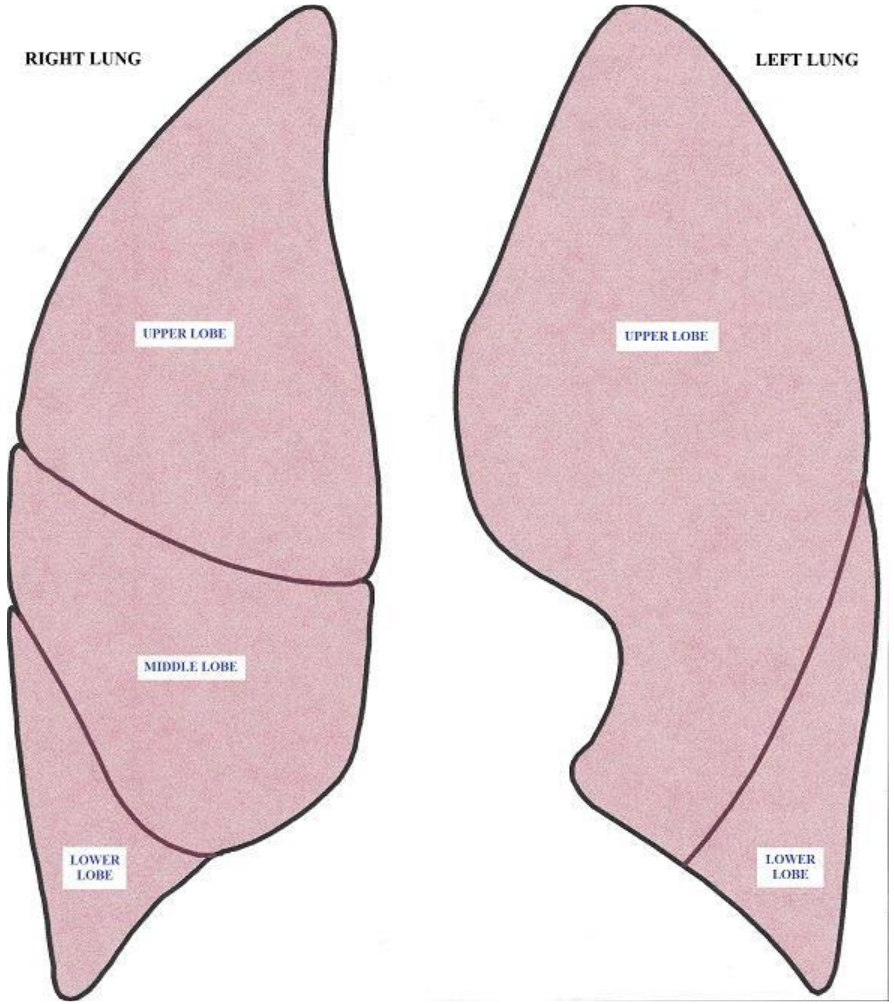
Functions of Respiratory System

1. Provides oxygen
2. Removes carbon dioxide
3. Regulates blood pH
4. Speech
5. Microbial defense
6. Chemical messenger concentrations
7. Traps and dissolves small blood clots

Lung Anatomy

Right Lung
3 Lobes



Left Lung
2 Lobes

Why? The heart sits on the left side of thoracic cavity

Lung Anatomy

Muscles

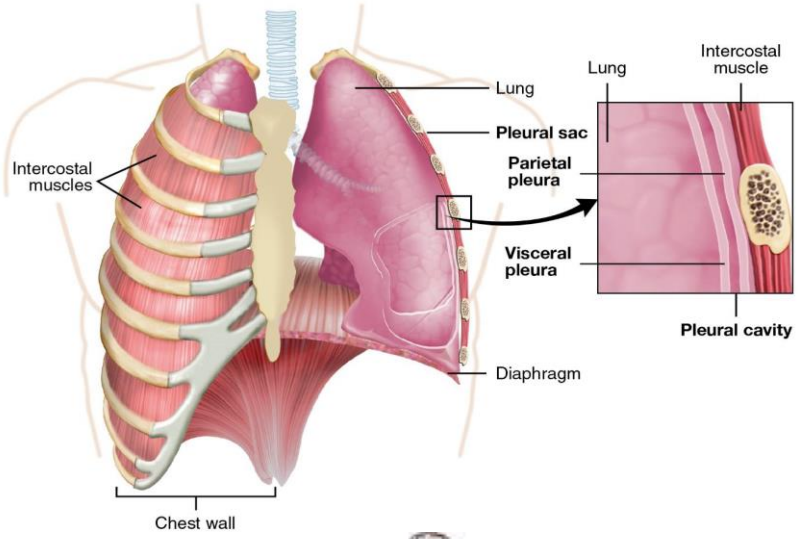
- Intercostal muscles (between ribs)
- Diaphragm (bottom)

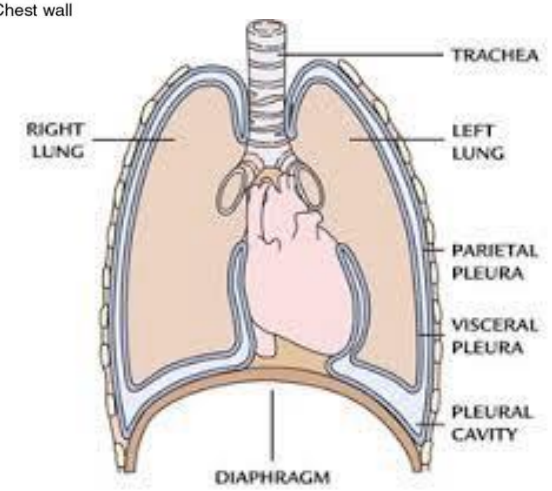
Pleural Layers

- Visceral pleura (against lungs)
- Intrapleural space/cavity
- Parietal pleura (against chest wall)

Visceral = Very close

Parietal = Pretty close

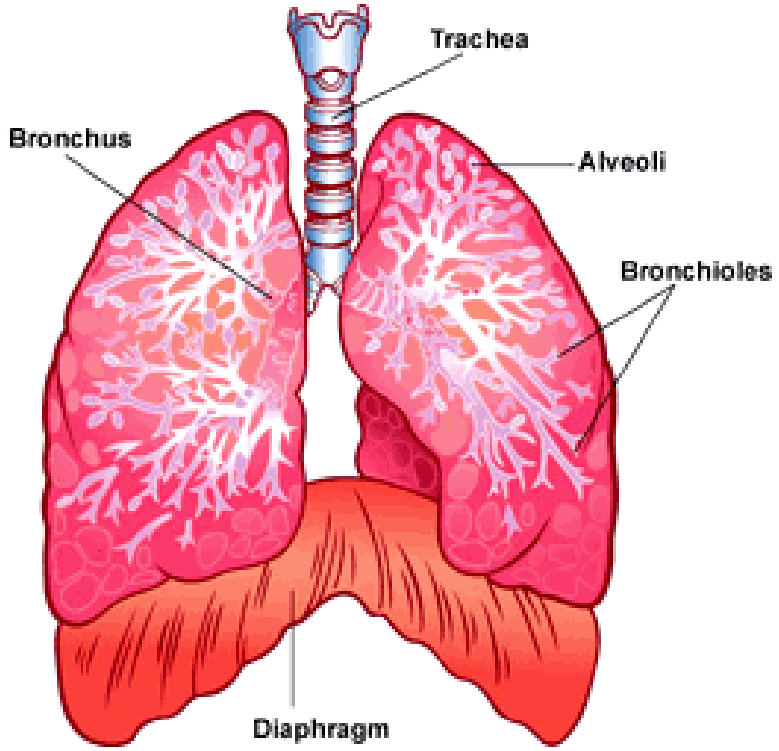




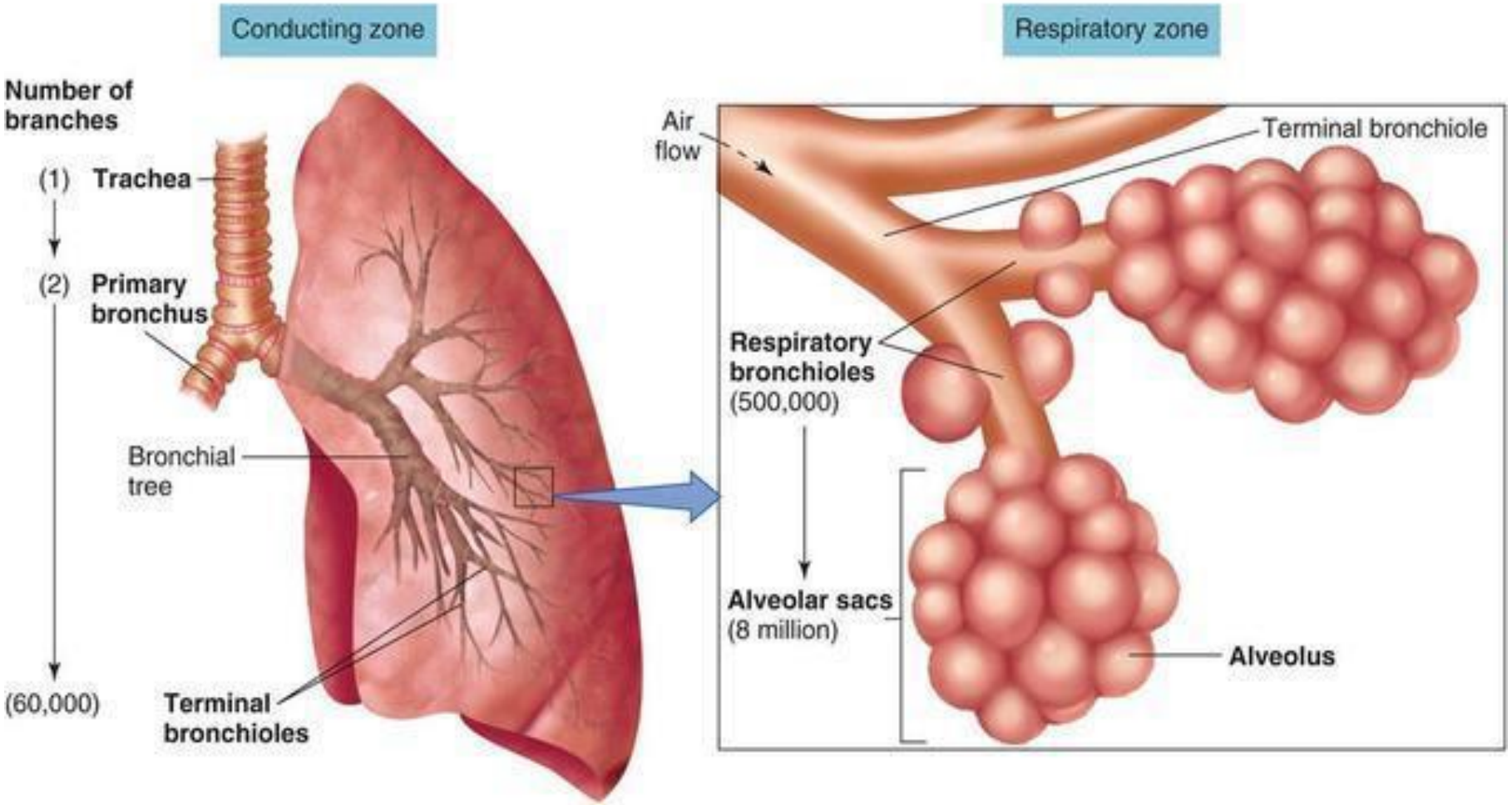
Lung Anatomy

Respiratory tract can be divided into two sections:

1. Conducting Zone
2. Respiratory Zone



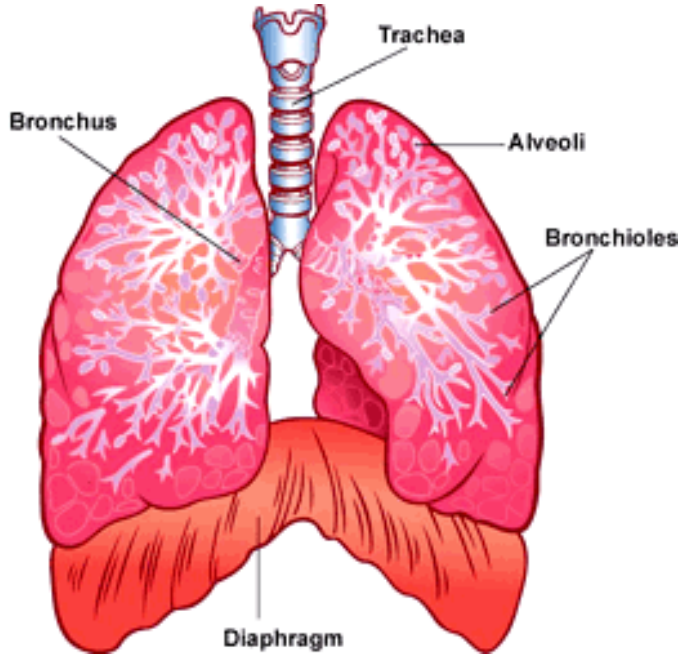
Zones of Respiratory Tract



Conducting Zone

Trachea → Primary Bronchus (Left and Right) → 2^0 Bronchi → 3^0 Bronchi → Bronchioles → Terminal Bronchioles

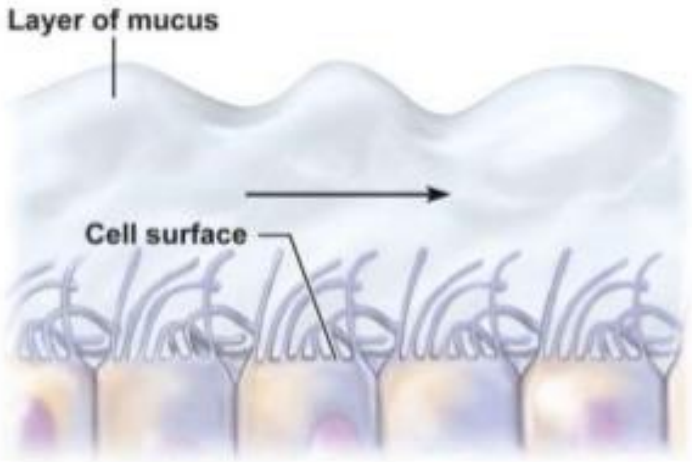
"Conducting zone terminates at terminal bronchioles"



Conducting Zone

Functions

- Transport air to lungs
- Filter, warm and moisten air
- Microbial defense:
  - Bronchial epithelial cells are ciliated
  - Cilia sweeps mucus with trapped micro-organisms towards the trachea
  - Smoking reduces function of cilia

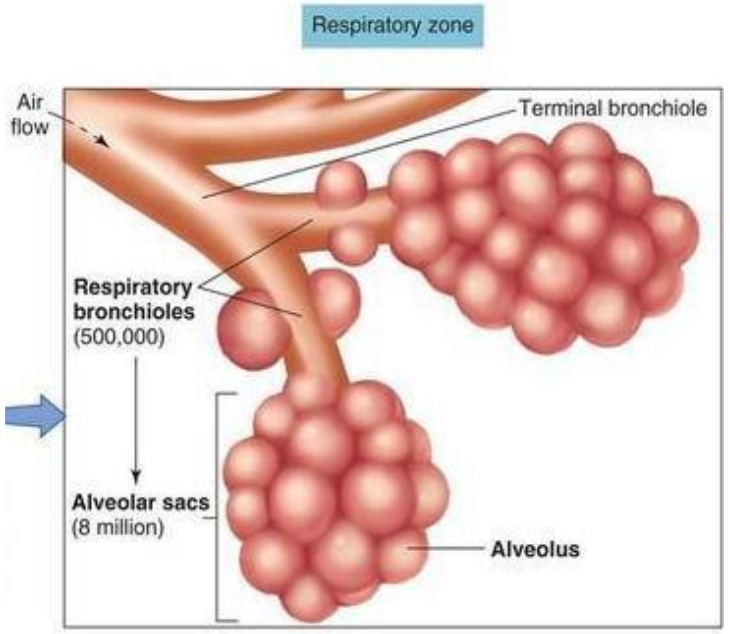


(b) Traveling wave created by the activity of many cilia acting together propels mucus across cell surfaces.

Respiratory Zone

Respiratory Bronchioles → Alveolar Ducts → Alveolar Sacs → Alveoli

"Respiratory zone begins at respiratory bronchioles"



The walls of the alveoli are composed of two types of cells, type I and II. The function of type II is to _____.

A. Secrete surfactant
B. Trap dust and other debris
C. Replace mucus in the alveoli
D. Protect the lungs from bacterial invasion

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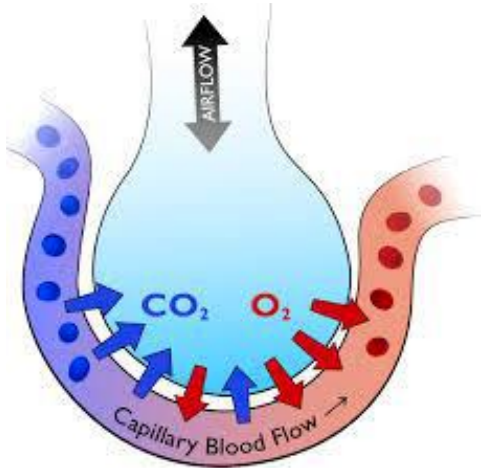
Respiratory Zone

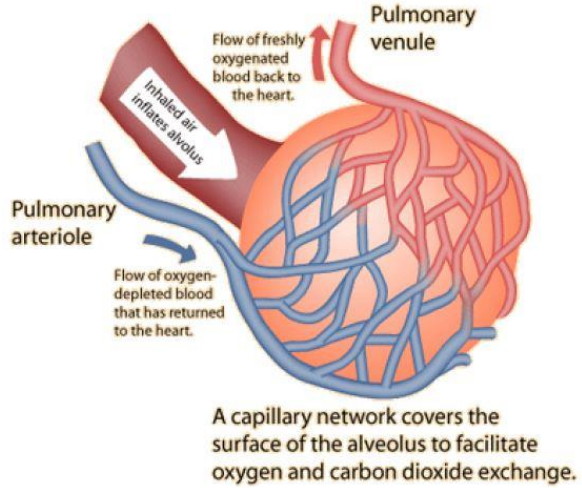
Function

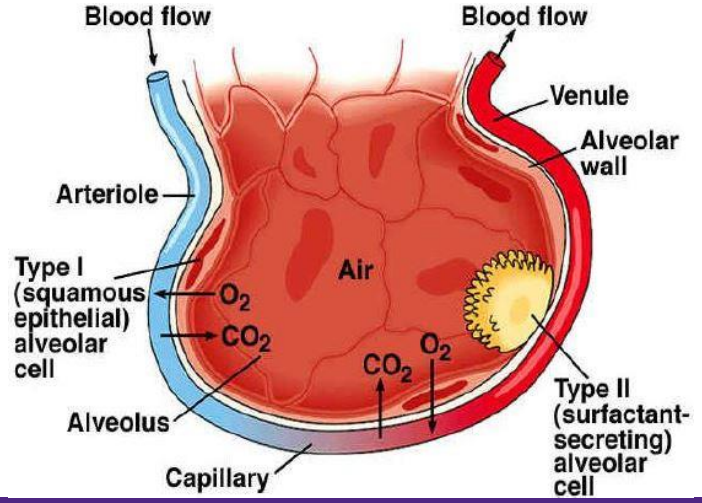
- Gas exchange in the alveoli at the blood gas barrier
  - CO^2 leaves blood supply into air
  - O^2 leaves air into blood supply

Cells

- Type 1 cell: flat and thin cells that form alveolar wall and allow for easy gas exchange between alveoli and capillary
- Type 2 cell: secrete surfactant
- Macrophages: destroy microorganisms







Mechanisms of Breathing

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Ventilation Calculations

- Tidal Volume: Amount of air entering lungs in one breath during normal inhalation
- Respiratory Rate: # of breaths per minute
- Pulmonary Ventilation (V_E): Amount of air entering lungs (both zones) per minute

$$V_E = \text{Tidal Volume} \times \text{Respiratory Rate}$$

- Anatomical Dead Space Ventilation (V_D): Amount of air not involved in gas exchange (Anatomical dead space = 1 mL/pound)

$$V_D = \text{Weight} \times \text{Respiratory Rate}$$

- Alveolar Ventilation (V_A): Amount of air entering only the respiratory zone per minute

$$V_A = V_E - V_D$$

Ventilation Calculations

Example: For a 150 lb individual with respiratory rate of 30 breaths/min and tidal volume of 200 mL/breath

V_E = Tidal Volume x Respiratory Rate

= 200 x 30

= 6000 mL/min

V_D = Weight x Respiratory Rate

= 150 x 30

= 4500 mL/min

$V_A = V_E - V_D$

= 6000 – 4500

= 1500 mL/min

By changing your pattern of breathing, you can alter how much air is actually available for gas exchange (V_A)

Complete the following statement using the choices below. Air moves out of the lungs when the pressure inside the lungs is…

A. Less than the pressure in the atmosphere.
B. Greater than the pressure in the atmosphere.
C. Equal to the pressure in the atmosphere.
D. Greater than the intra-alveolar pressure.

Complete the following statement using the choices below. Air moves out of the lungs when the pressure inside the lungs is…

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Pressure

- Gases move down a pressure gradient
  - For air to move into and out of our lungs, there must be a pressure gradient
- Atmospheric pressure: 760 mmHg
- Intrapulmonary pressure: 760 mmHg
- Since atmosphere pressure is fixed, intrapulmonary pressure must change to create a pressure gradient during respiration
- Boyle's Law:

  P = 1/V (Change volume of thoracic cavity to alter pressure)

Inhalation

Diaphragm and external intercostal muscles contract (Diaphragm moves down and intercostals pull ribcage up and out)

⬇

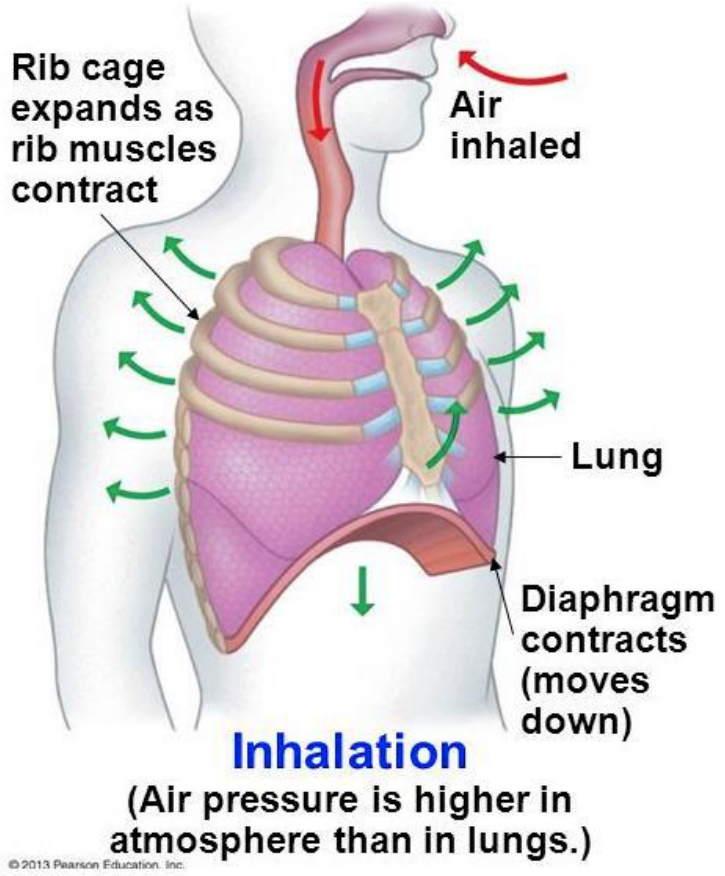
Thoracic cavity expands (Increase volume)

⬇

Decrease intrapulmonary pressure by Boyle's law (<760 mmHg)

⬇

Air moves in



Exhalation (Passive)

Diaphragm and external intercostal muscles relax (Diaphragm moves up and ribcage gets smaller)

⬇

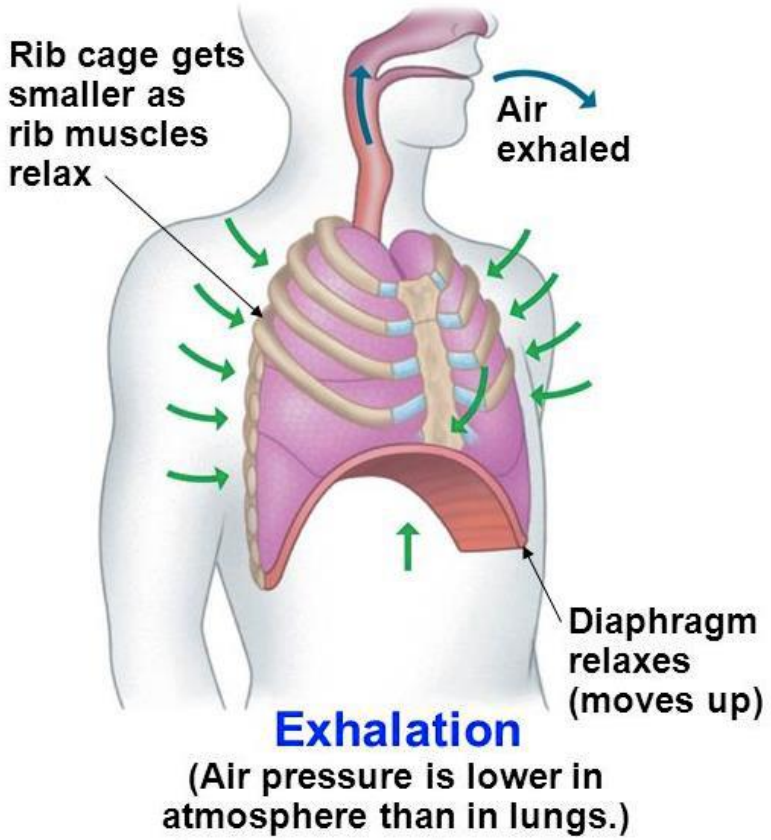
Thoracic cavity decreases in volume

⬇

Increase intrapulmonary pressure by Boyle's law (>760 mmHg)

⬇

Air moves out



Exhalation (Active - Exercise)

Diaphragm and external intercostal muscles relax

Internal intercostals, obliques and rectus abdominus contract

⬇

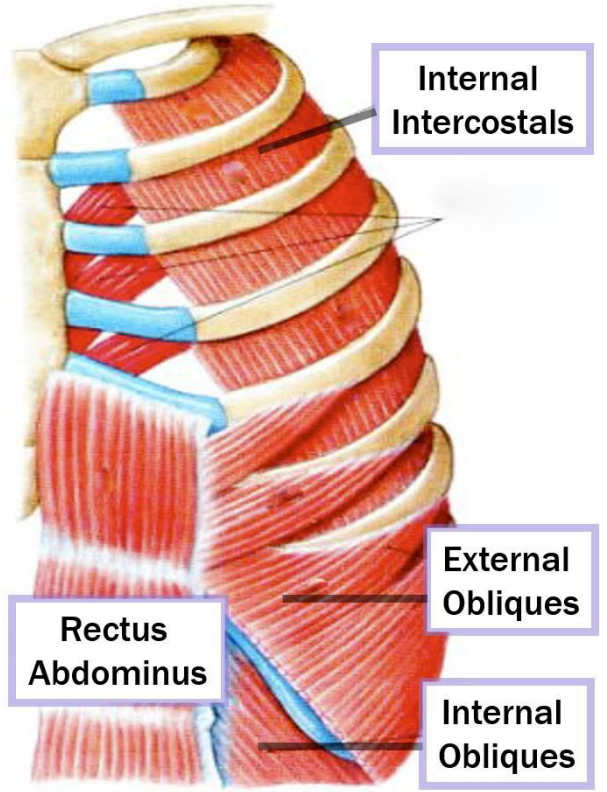
Thoracic cavity decreases in volume

⬇

Increase intrapulmonary pressure by Boyle's law (>760 mmHg)

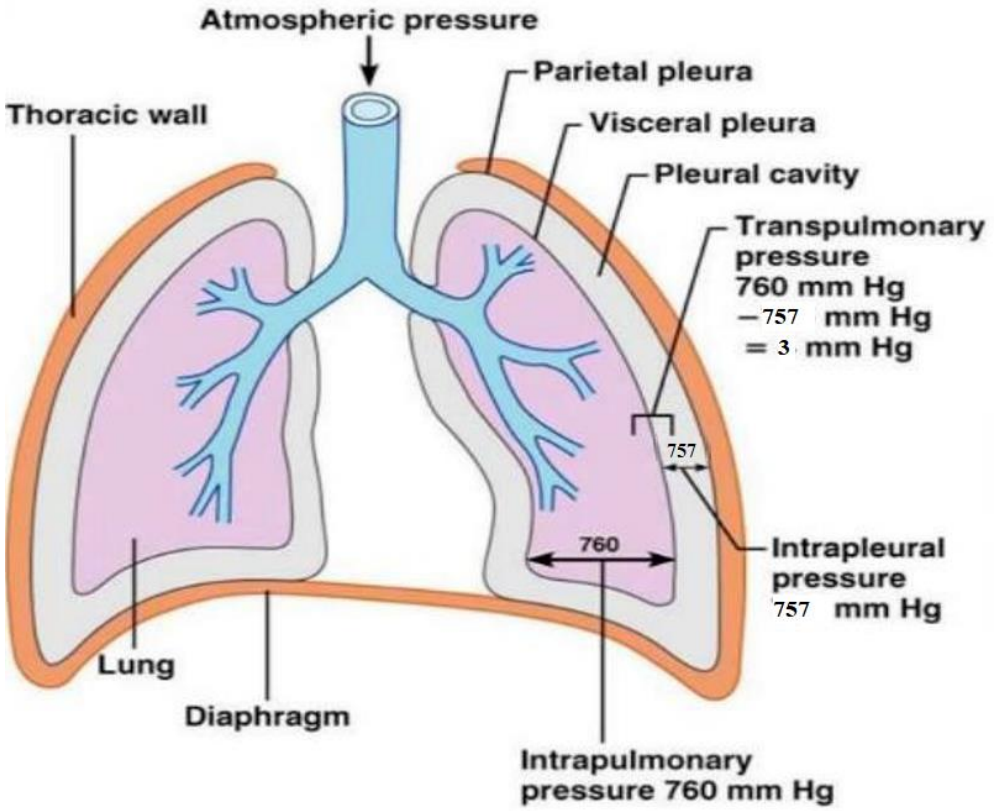
⬇

Air moves out



Intrapleural and Transpulmonary Pressure

- Intrapleural Pressure: Pressure in intrapleural space; 757 mmHg
  - Prevents lung from collapsing at the end of expiration
  - Allows for easy expansion of the lung
- Transpulmonary Pressure: Pressure across the lung; +3 mmHg
  - Intrapulmonary Pressure (760) – Intrapleural Pressure (757)



Pneumothorax

Spontaneous hole in visceral pleura or puncture hole in parietal pleura

⬇

Air rushes into intrapleural space

⬇

Transpulmonary pressure becomes 0 mmHg

⬇

Lung collapses in and chest wall springs out

During active exhalation (exercise), which of the following muscles are contracting?

1. Obliques
2. Diaphragm
3. Internal intercostals
4. External intercostals

A. 1, 2 and 3 are correct
B. 1 and 3 are correct
C. 2 and 4 are correct
D. Only 4 is correct
E. All are correct

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The blood gas barrier is:

A. Formed by alveolar type I cells
B. Formed by alveolar type II cells
C. Formed by alveolar macrophages
D. Found in the conducting zone of the respiratory system

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What is true regarding a pneumothorax?

A. It can only occur due to damage in the visceral pleura
B. Transpulmonary pressure becomes 0 mmHg
C. Lungs balloon out and presses severely against chest cavity
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Which of the following is correct regarding expiration/exhalation at rest?

A. Relaxation of the diaphragm increases pressure inside the lungs
B. External intercostal muscles contract to increase the volume of the chest cavity
C. Expiration at rest requires contraction of abdominal muscles
D. Internal intercostal muscles contract to decrease the volume of the chest cavity

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Respiratory System: Measurements and Pathology

Chapter 9: Dr. Beye

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Which of the following would increase lung compliance?

1. Increase in elastin
2. Increase in surfactant
3. Increase in surface tension
4. Decrease in collagen

A. 1, 2 and 3 are correct
B. 1 and 3 are correct
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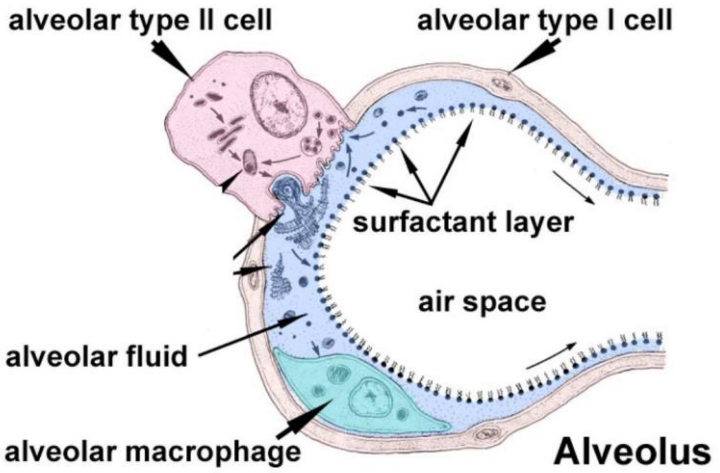
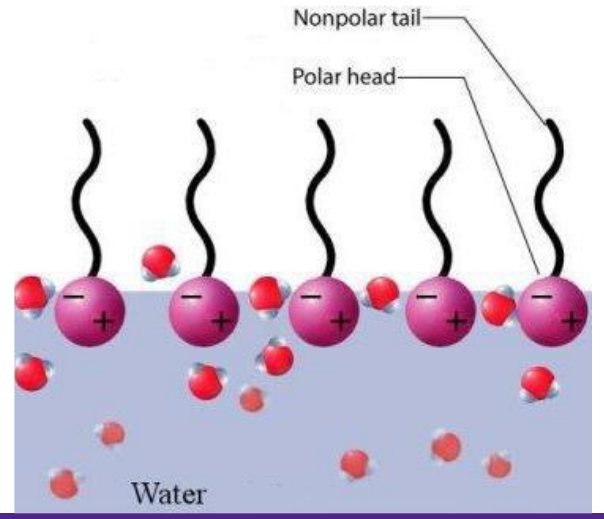
Lung Compliance

- Compliance is the “stretchability” of the lung
- Compliance = Change in volume / Change in pressure
- Affected by 2 factors:
  1. Elastic tissue of lungs (33%)
     - Caused by presence of elastin and collagen
  2. Surface tension in alveoli (66%)
     - Surfactant reduces surface tension
- An increase in these 2 factors decreases compliance and increases likelihood of lung collapse

Pulmonary Surfactant

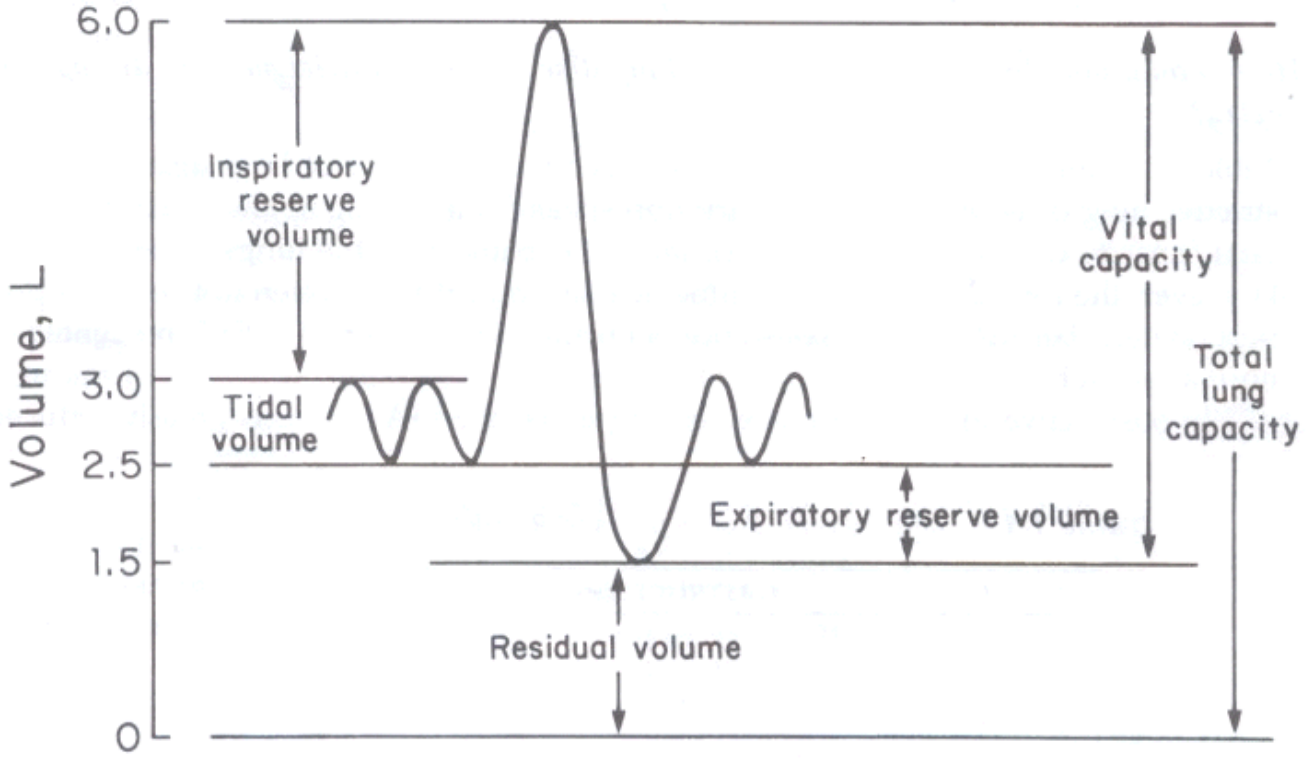
- Released by type 2 cells
- Layer is spread across air-water interface in alveoli
- Surfactant = phospholipids + proteins
- Phospholipids: hydrophilic head towards water; hydrophobic head towards air
- Proteins: help with microbial defense
- Functions:
  1. Reduce surface tension
     - Improve compliance and prevent alveolar collapse
  2. Improves microbial defense function
     - Proteins help identify foreign particles for macrophages
- Neonatal respiratory distress syndrome (nRDS): premature infants lack mature surfactant system, which leads to poor lung function, alveolar collapse and hypoxemia (treatment = surfactant)



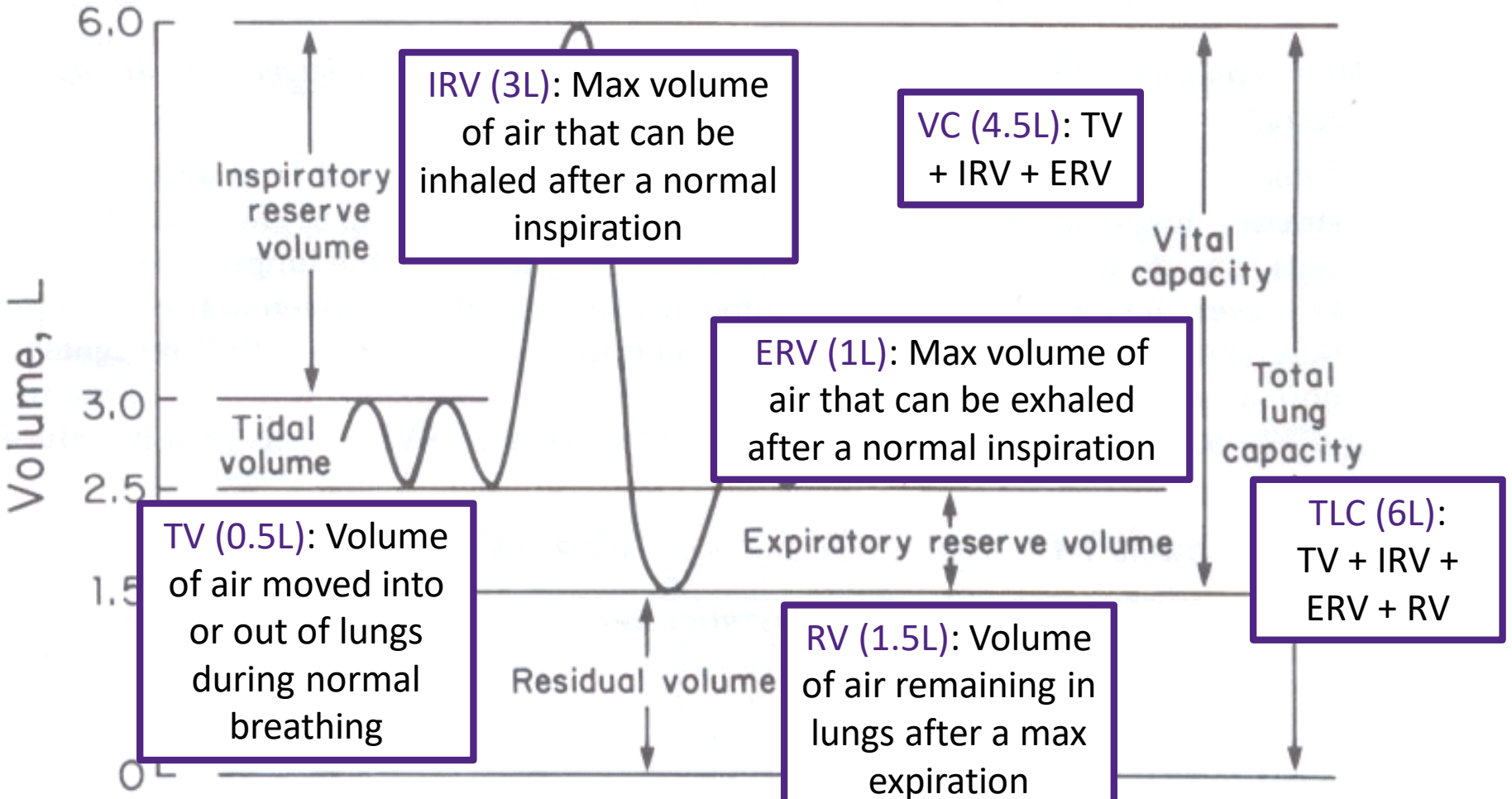


Spirometry

- Spirometer is used to measure lung volumes and diagnose some respiratory diseases



Spirometry



IRV (3L): Max volume of air that can be inhaled after a normal inspiration

VC (4.5L): TV + IRV + ERV

ERV (1L): Max volume of air that can be exhaled after a normal inspiration

TV (0.5L): Volume of air moved into or out of lungs during normal breathing

TLC (6L): TV + IRV + ERV + RV

RV (1.5L): Volume of air remaining in lungs after a max expiration

Other Lung Measurements

- Forced vital capacity (FVC): how much air a person can exhale as fast as possible during a forced breath
- Forced expiratory volume (FEV_1): volume of exhalation over 1 second

What is true of a restrictive lung disease?

A. Emphysema is an example of a restrictive lung disease
B. Lungs can become floppy due to Loss of elastin
C. FEV1 decreases
D. FVC decreases

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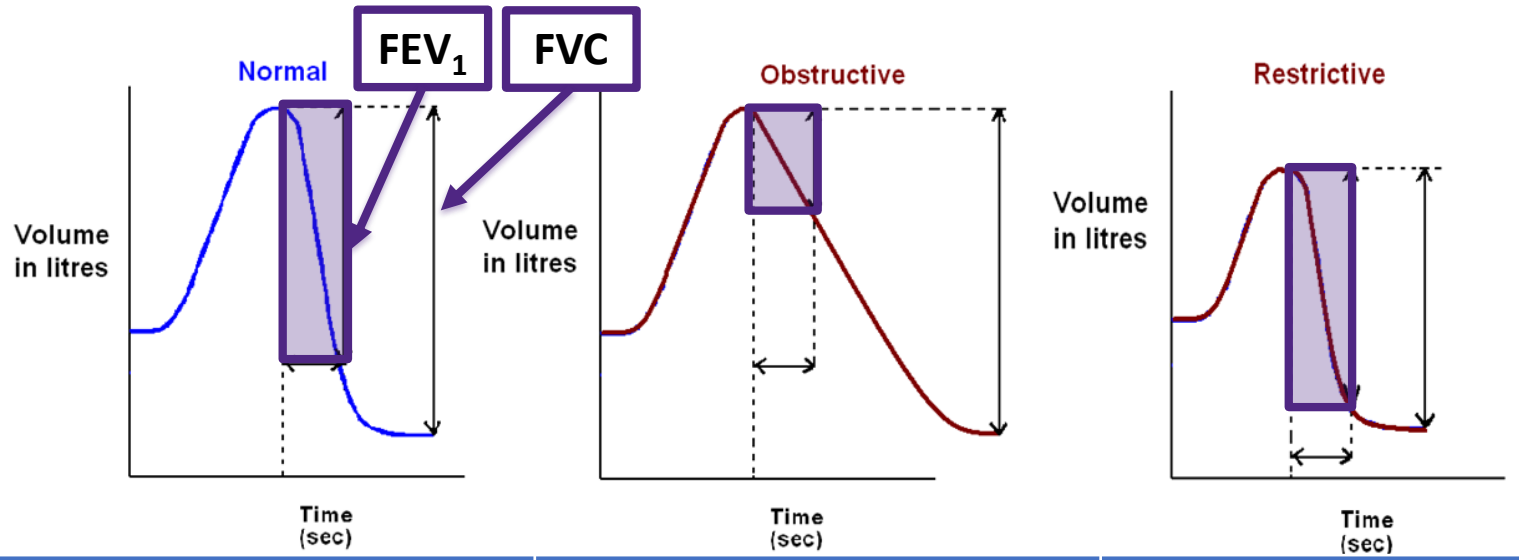
Normal vs. Diseases



FEV_1 = Volume in 1 sec

FVC = Amount air in forced breath

Normal	Obstructive	Restrictive
FEV1	Decreases	No Change
FVC	No Change	Decreases
FEV1/FVC = 80 %	FEV1/FVC < 80%	FEV1/FVC > 80%
Examples	Asthma, chronic bronchitis, emphysema	Pulmonary fibrosis

Lung Diseases: Obstructive

- Air flow obstruction during exhalation
- Diameter of bronchioles decreases (lumen constricted)

	Cause	Effect
Asthma	Spasms triggered by exercise, air pollution and allergies	• Airway inflammation and hyper-responsiveness
Chronic Bronchitis	Smoking	• Excessive mucus and inflammation
Emphysema	Smoking	• Alveolar wall break down creates large air sacs (↓surface area = poor gas exchange) • Loss of elastin reduces elastic recoil (↑compliance so lungs fill but can't empty)

Compliance = Volume / ↓Pressure

Lung Diseases: Restrictive

- **Air flow restriction during inhalation**

	Cause	Effect
Pulmonary Fibrosis	Chronic inhalation of asbestos, coal, dust, pollution or sometimes unknown	• Fibrous scar tissue (thickened tissue) in alveoli and other lung tissue • Due to thick walls, poor gas exchange (similar to emphysema but different reason) • Lungs become stiff due to ↑ in collagen = ↓ compliance (opposite to emphysema)

Compliance = ↓ Volume / Pressure

Next Tutorial (Feb 25th)

- More respiratory physiology!

What Questions Do You Have?

You can ask in the **Owl forums** as well!

Also anonymously ask questions in the **online dropbox**!!

Western