REVIEW OF FUNCTIONAL RESPIRATORY PHYSIOLOGY

ACADEMY OF
NEONATOLOGY

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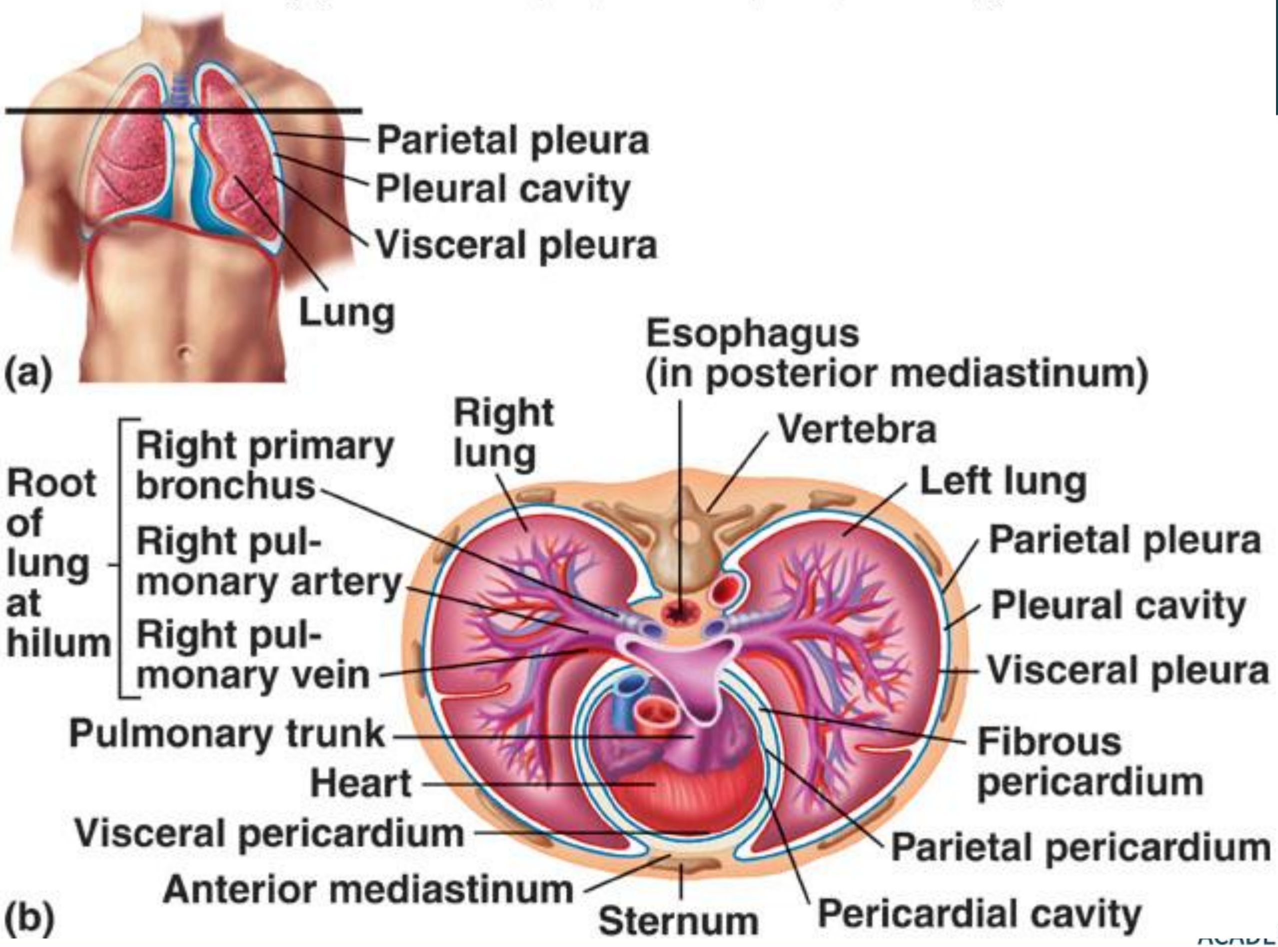
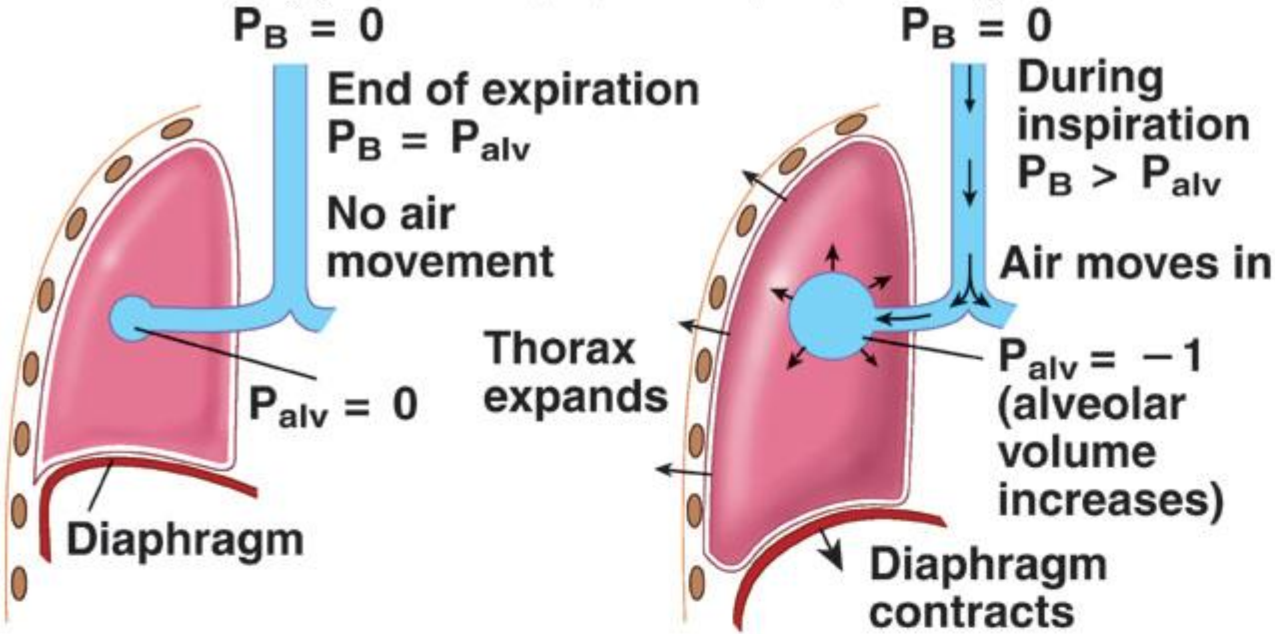
ACADEMY OF
NEONATOLOGY

FUNCTIONAL ANATOMY


Parietal pleura
Pleural cavity
Visceral pleura
Lung
(a)
Esophagus
(in posterior mediastinum)
Right lung
Vertebra
Left lung
Root of lung at hilum
Right primary bronchus
Right pul-monary artery
Right pul-monary vein
Parietal pleura
Pleural cavity
Visceral pleura
Pulmonary trunk
Heart
Visceral pericardium
Anterior mediastinum
Fibrous pericardium
Parietal pericardium
Sternum
Pericardial cavity
(b)

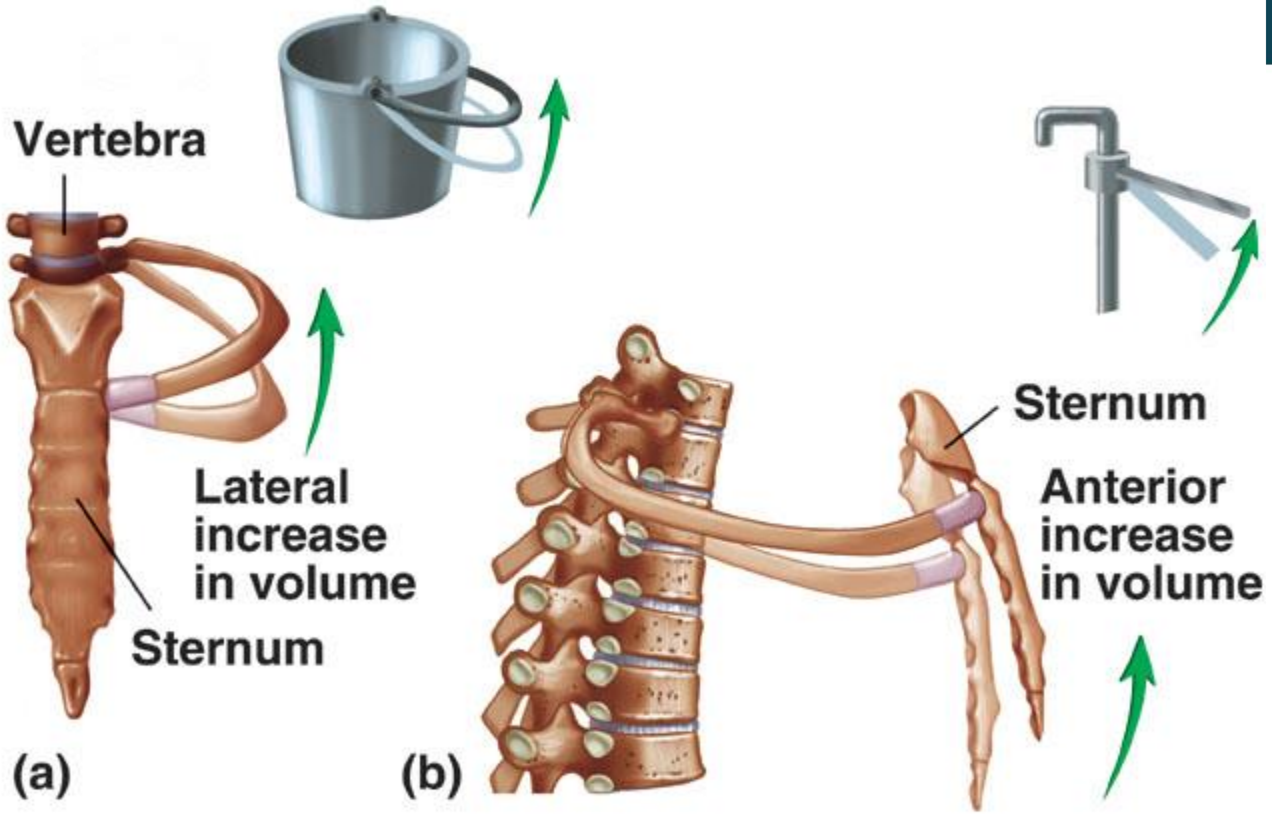
Inspiration/Inhalation

- Diaphragm & Intercostal muscles
- Increases volume in thoracic cavity as muscles contract
- Volume of lungs increases
- Intrapulmonary pressure decreases (758 mm Hg)



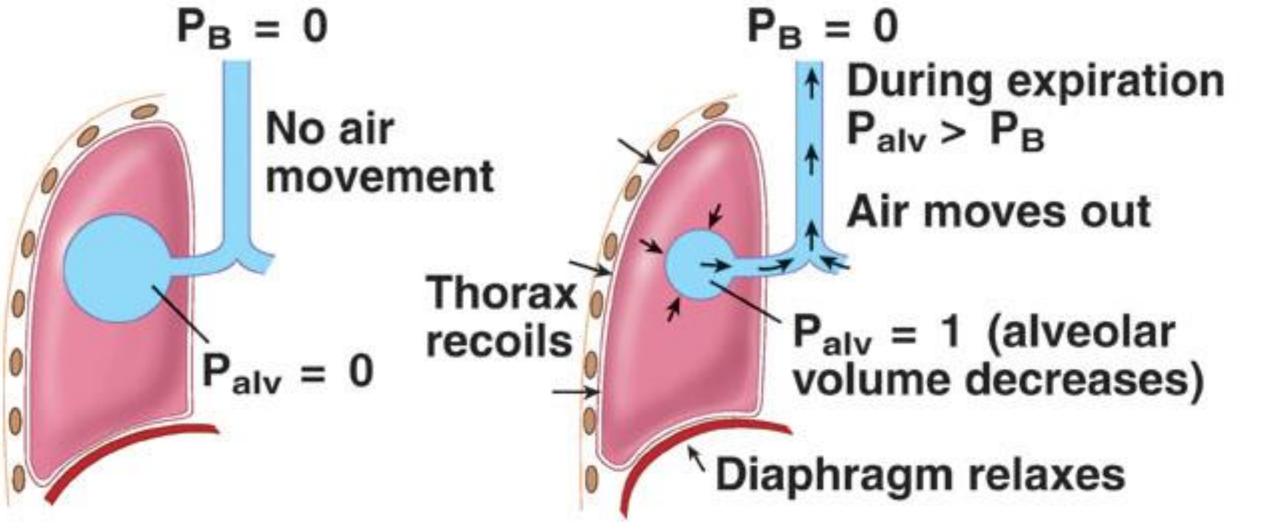
1. Barometric air pressure (P_B) is equal to alveolar pressure (P_{alv}) and there is no air movement.

2. Increased thoracic volume results in increased alveolar volume and decreased alveolar pressure. Barometric air pressure is greater than alveolar pressure, and air moves into the lungs.


Vertebra
Lateral increase in volume
Sternum
(a)
Sternum
Anterior increase in volume
(b)

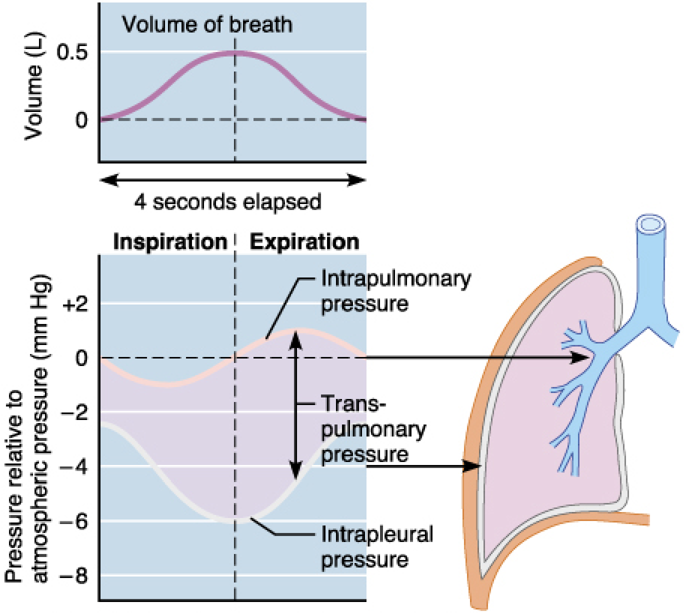
Expiration/Exhalation

- Muscles relax
- Volume of thoracic cavity decreases
- Volume of lungs decreases
- Intrapulmonary pressure increases (763 mm Hg)
- Forced expiration is active

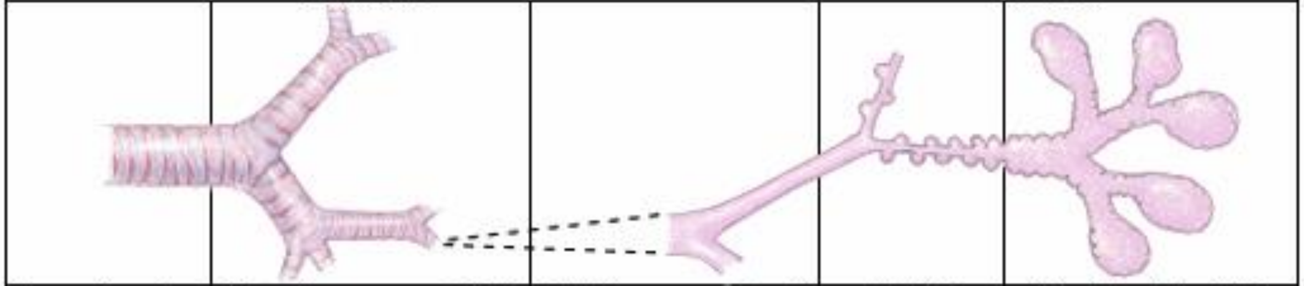


3. End of inspiration.

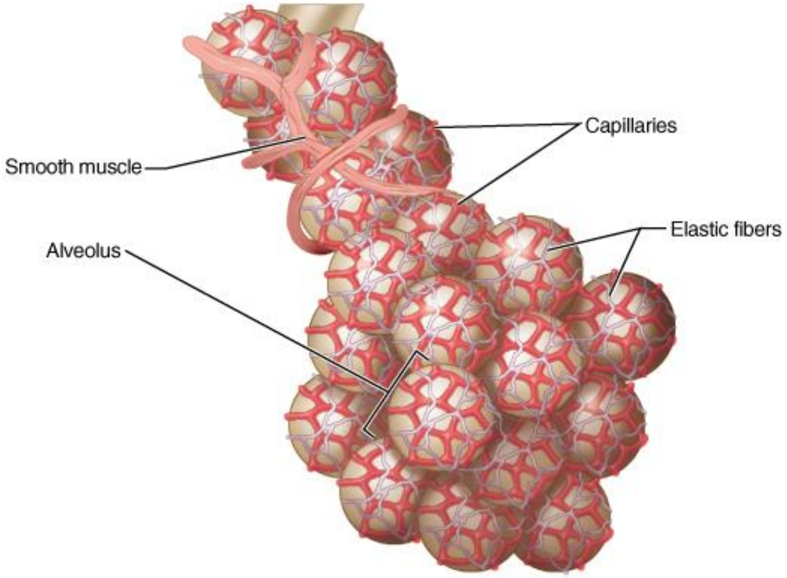
4. Decreased thoracic volume results in decreased alveolar volume and increased alveolar pressure. Alveolar pressure is greater than barometric air pressure, and air moves out of the lungs.


Volume of breath
Volume (L)
0.5
0
4 seconds elapsed
Inspiration
Expiration
Pressure relative to atmospheric pressure (mm Hg)
+2
0
−2
−4
−6
−8
Intrapulmonary pressure
Trans-pulmonary pressure
Intrapleural pressure

Conductive and Gas Exchange Airways

Conducting Airways			Gas Exchange Airway		
Cartilagenous		Membranous	Terminal Respiratory Unit		
Trachea	Bronchi	Bronchioles	R. Bronchioles	A. Ducts	A. Sacs
No alveoli			Alveoli		
					
Generation 0	1 2 → 10	11-13 → 16	17-19	20 22 23 24	
Bronchial Circulation			Pulmonary Circulation		
Air volume – – – 150 ml			1500 ml	3000 ml	
Smooth muscle					

Ventilation and Oxygenation



(b)

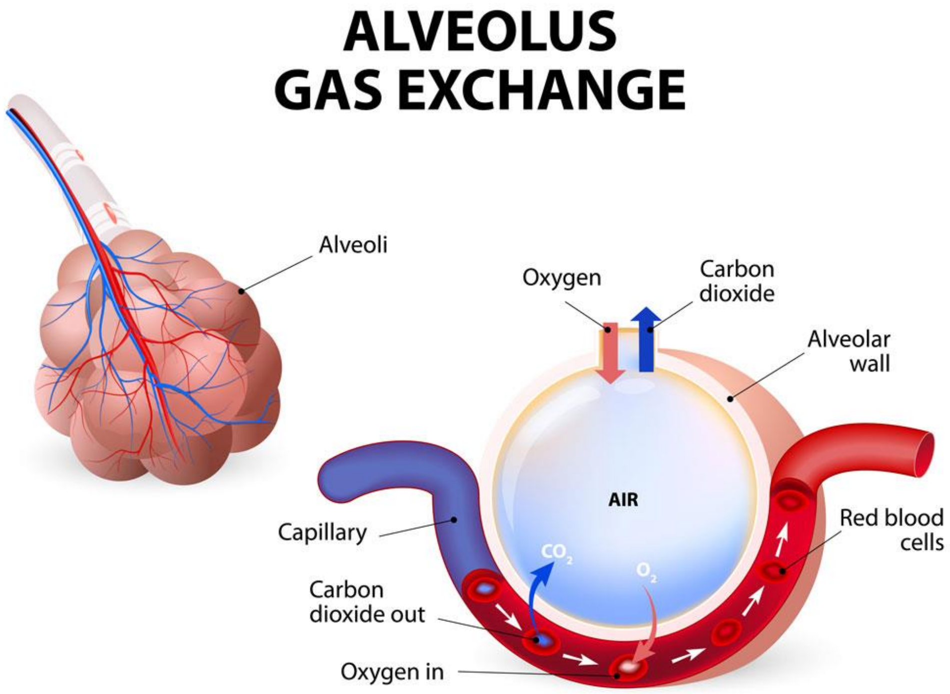
ACADEMY OF NEONATOLOGY

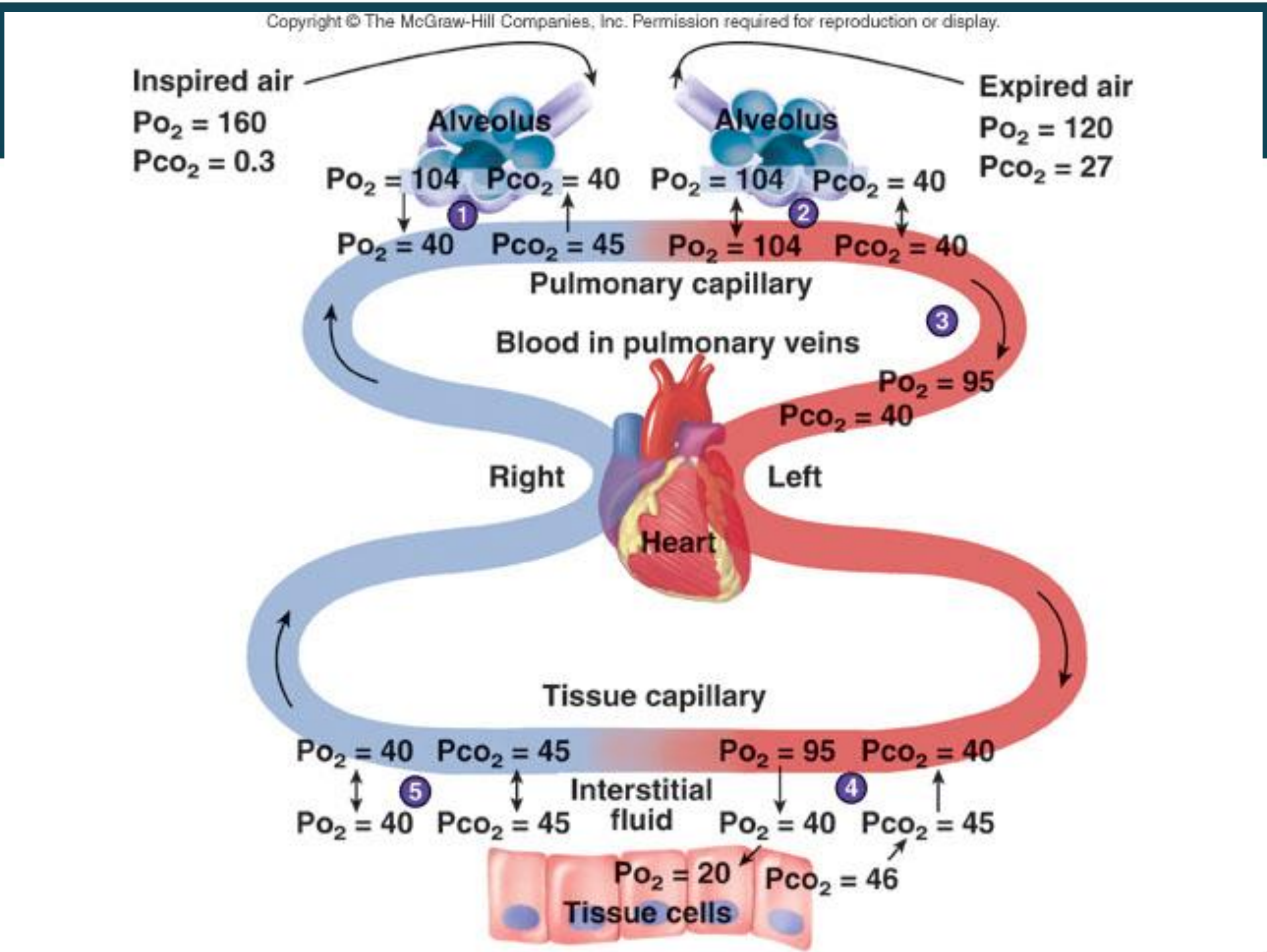
BASIC PHYSIOLOGY (PHYSICS)

Steady State

- Lung O_2 Uptake rate
  = Cell O_2 Utilization rate

- Cell CO_2 Production rate
  = Lung CO_2 Release rate





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Inspired air
$Po_2 = 160$
$Pco_2 = 0.3$
Alveolus
Alveolus
Expired air
$Po_2 = 120$
$Pco_2 = 27$
$Po_2 = 104$
$Pco_2 = 40$
$Po_2 = 104$
$Pco_2 = 40$
1
2
$Po_2 = 40$
$Pco_2 = 45$
$Po_2 = 104$
$Pco_2 = 40$
Pulmonary capillary
3
Blood in pulmonary veins
$Po_2 = 95$
$Pco_2 = 40$
Right
Left
Heart
Tissue capillary
$Po_2 = 40$
$Pco_2 = 45$
$Po_2 = 95$
$Pco_2 = 40$
5
Interstitial fluid
4
$Po_2 = 40$
$Pco_2 = 45$
$Po_2 = 40$
$Pco_2 = 45$
$Po_2 = 20$
$Pco_2 = 46$
Tissue cells

Gaseous Environment

- Atmosphere: Nitrogen and Oxygen, negligible Carbon Dioxide.
- $$P_{I_{O_2}} = F_{I_{O_2}} \bullet (P_B - 47)$$
- Clinical Relevance of Environment

  - Altitude: PO_2 depends on P_B

  - Suffocation: PO_2 depends on fractional O_2

  - Oxygen therapy: PO_2 depends on fractional O_2

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CLINICAL USE OF IDEAL ALVEOLAR GAS VALUES

USE #1
Compare P_AO_2 to P_aO_2

- Healthy people: $P_AO_2 = P_aO_2$

- Two Approaches to Comparison

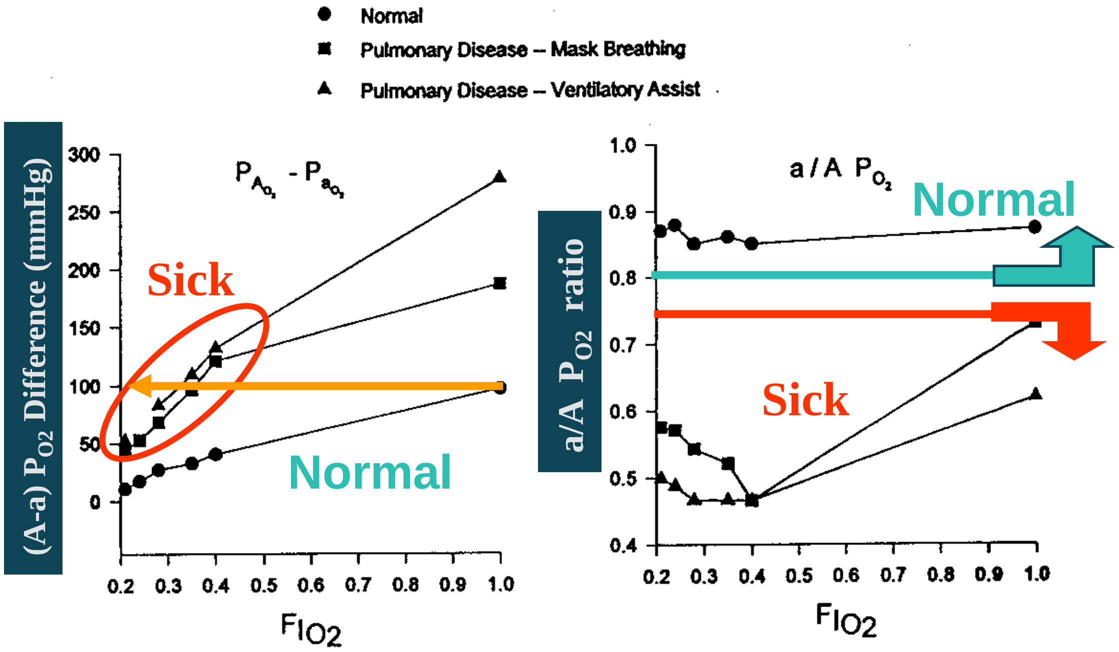
  - $(P_AO_2 - P_aO_2)$ difference

  - P_aO_2 / P_AO_2 ratio

A-a Difference

- P_AO_2 - P_aO_2
- Normally 5-20 mmHg
  - Because of normal anatomical shunt
  - Ventilation/Perfusion mismatching.
- A-a difference increases with pulmonary disease.
- Problem: Normal range changes on 100% O_2.

(A-a) Difference vs. a/A Ratio



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OXYGENATION

Quiz

- Baby is on 40% O_2 , Saturation 90%
- Next day he is on 60% O_2 , Saturation 90%
- What can we tell about his oxygenation state?

- Improved
- Deteriorated
- Same
- Don't know

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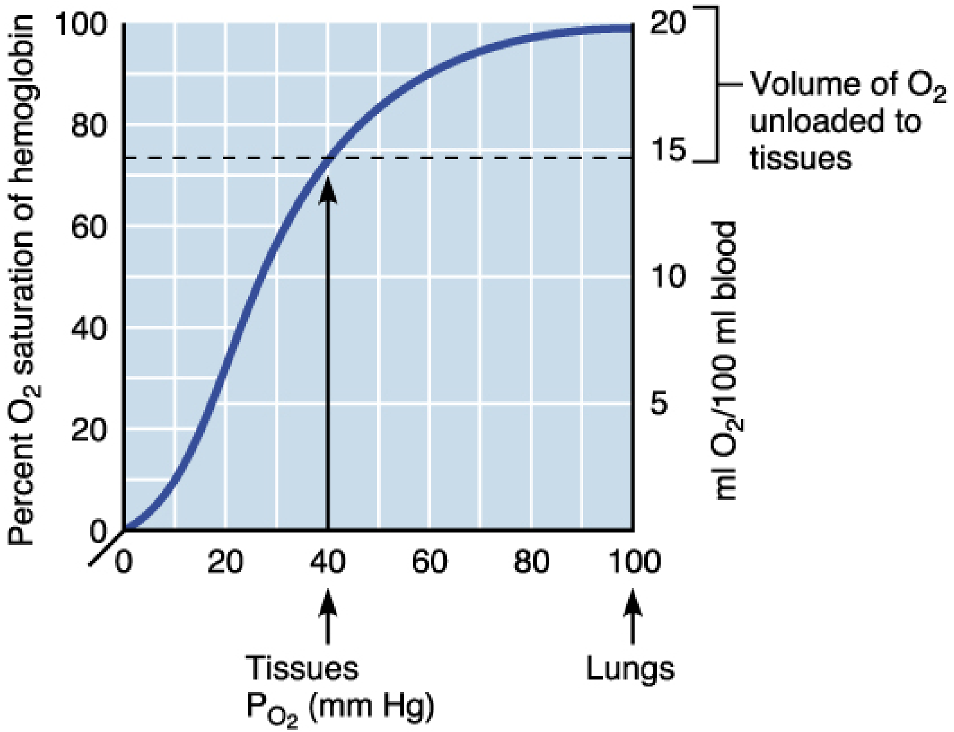
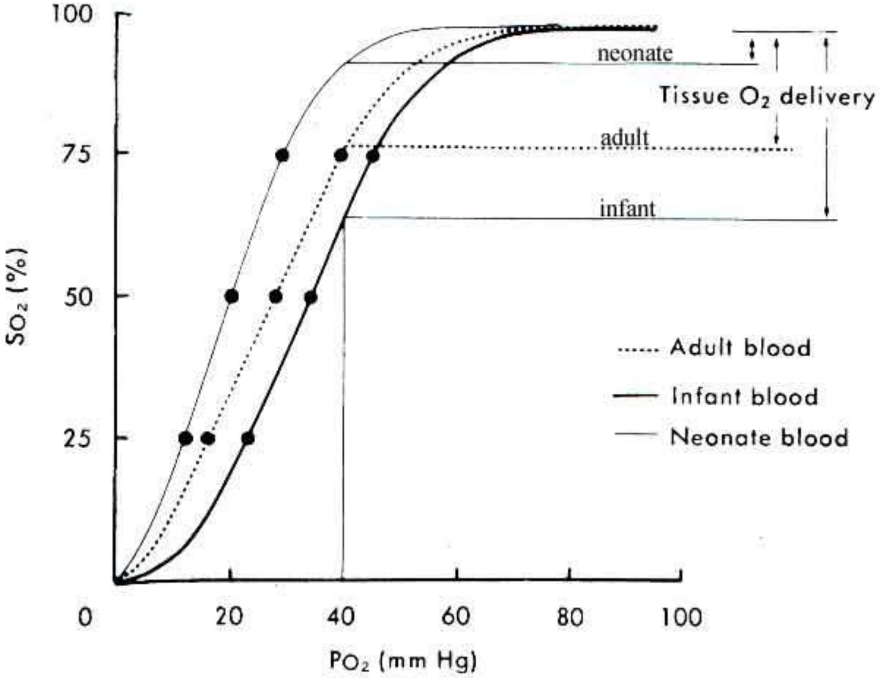
SATURATION



Percent O_2 saturation of hemoglobin
100
80
60
40
20
0
0
20
40
60
80
100
20
15
10
5
Volume of O_2 unloaded to tissues
ml O_2/100 ml blood
Tissues
Lungs
P_{O_2} (mm Hg)

Oxygen transport

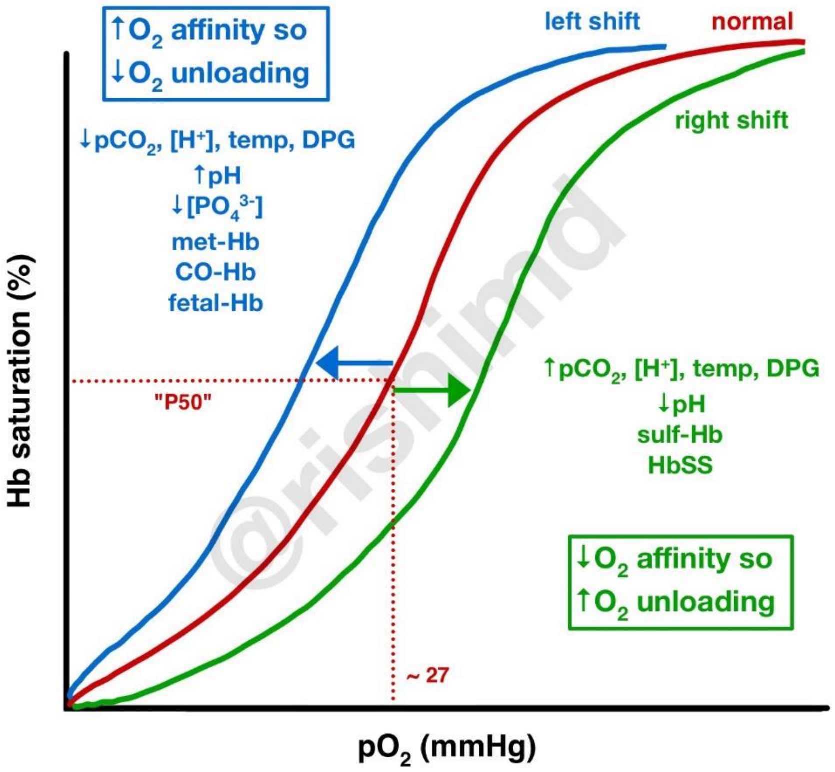


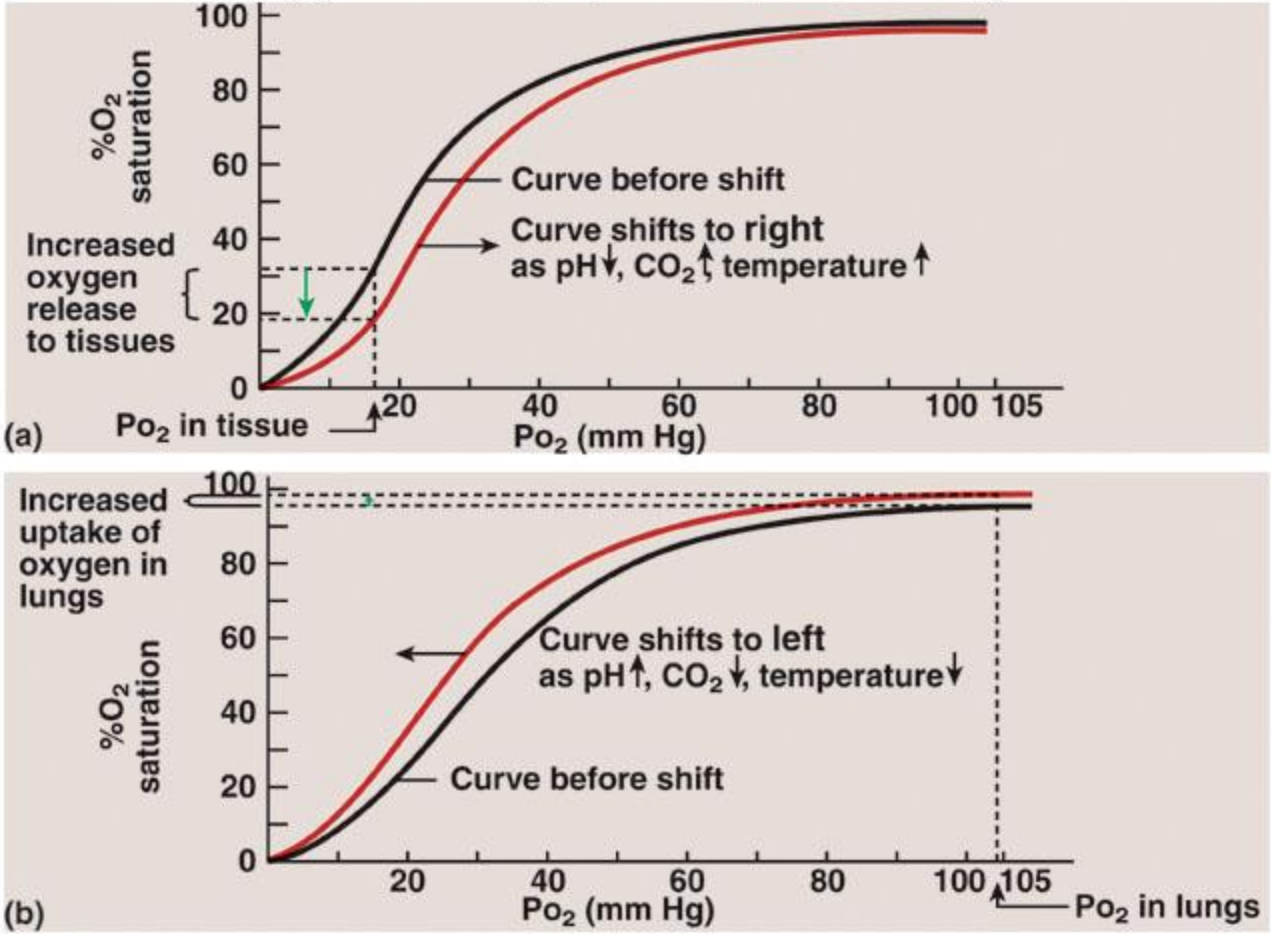
Schematic representation of oxygen-hemoglobin dissociation curves

If SpO_2 = 91
then = PaO_2 =

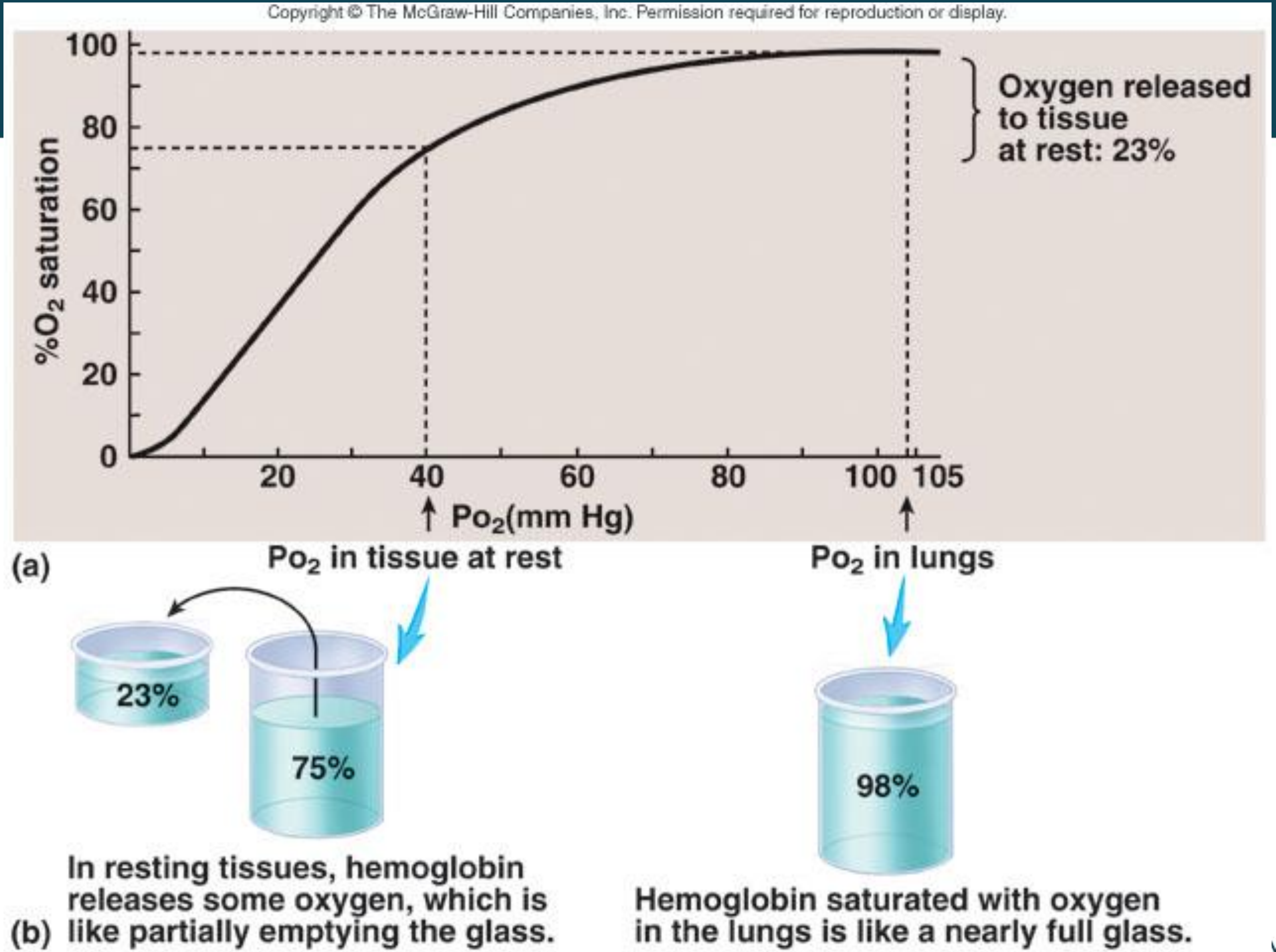
Adult	60
6 months	66
6 weeks	55
6 hours	41

Hb Dissociation Curve





%O2 saturation
100
80
60
40
20
0
Curve before shift
Curve shifts to right
as pH↓, CO2↑, temperature↑
Increased oxygen release to tissues
20
40
60
80
100 105
(a)
Po2 in tissue
Po2 (mm Hg)
Increased uptake of oxygen in lungs
%O2 saturation
Curve shifts to left
as pH↑, CO2↓, temperature↓
Curve before shift
(b)
Po2 (mm Hg)
Po2 in lungs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100
80
60
40
20
0
%O_2 saturation
20
40
60
80
100 105
Po_2(mm Hg)
Oxygen released to tissue at rest: 23%
(a)
Po_2 in tissue at rest
Po_2 in lungs
23%
75%
98%
(b) In resting tissues, hemoglobin releases some oxygen, which is like partially emptying the glass.
Hemoglobin saturated with oxygen in the lungs is like a nearly full glass.

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HEMOGLOBIN

Gas Transport

- O_2 transport in blood
- Hemoglobin – O_2 binds to the heme group on hemoglobin, with 4 oxygens/Hb
- PO_2
- PO_2 is the most important factor determining whether O_2 and Hb combine or dissociate
- O_2-Hb Dissociation curve

Defining Content and Capacity

$$C_{O_2} = 1.36 \bullet [Hb] \bullet \frac{\%S_{O_2}}{100\%}$$

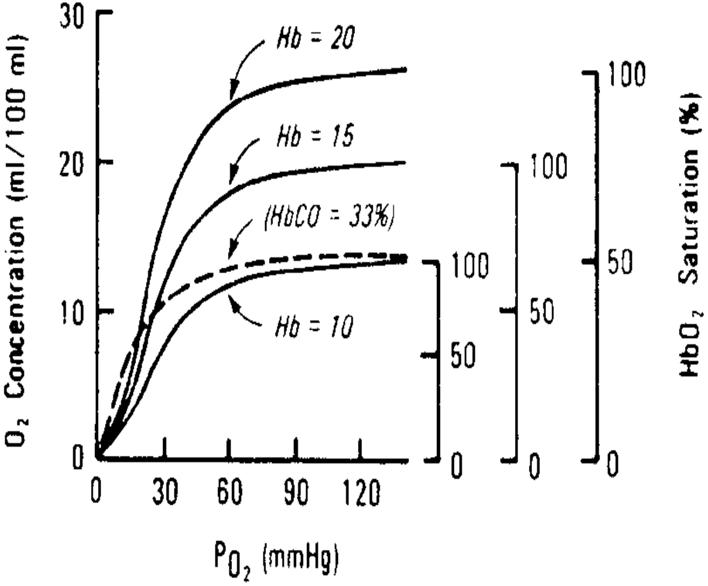
Oxygen Blood Gas Quantities

- Partial Pressure
- Saturation
- Content

- Carrying Capacity: O_2 content at 100% saturation.

Three Things That Change O_2 Carrying Capacity

- Changes in Hb Concentration
- Presence of Carbon Monoxide
- Formation of Methemoglobin



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VENTILATION

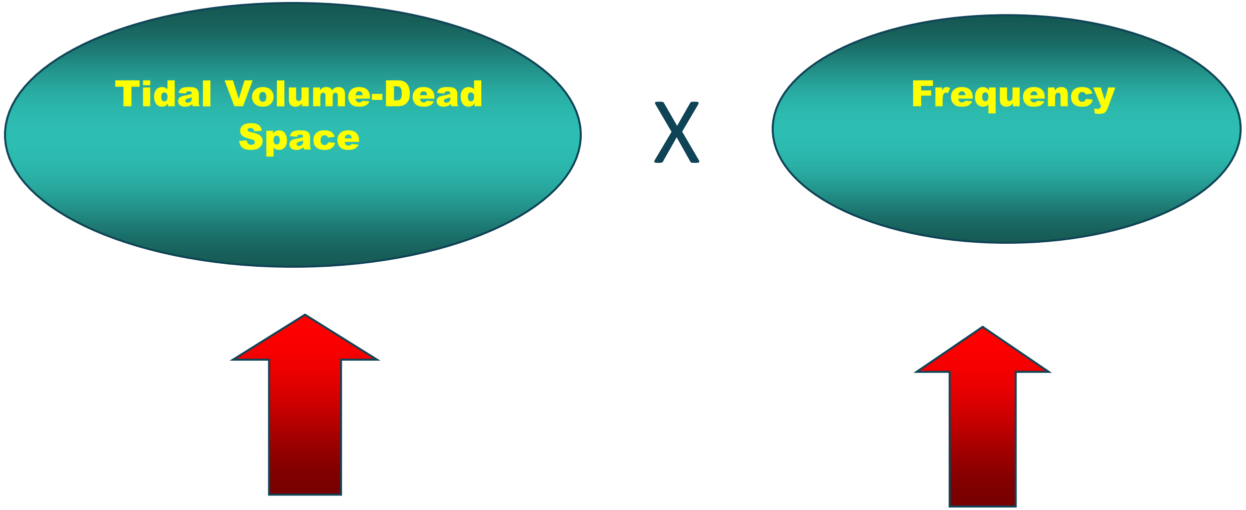
Volume of gas inhaled

Tidal Volume-Dead Space X **Frequency**

Part of V_T not involved in gas exchange

# of breath per minute

Alveolar Minute Ventilation



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COMPLIANCE

Compliance

$$C = \frac{\Delta V}{\Delta P}$$

$$C_{DYN} = \frac{V_T}{(\text{peak pressure} - \text{PEEP})}$$

Pressure-Volume Curves after Air v. Liquid Lung Expansion

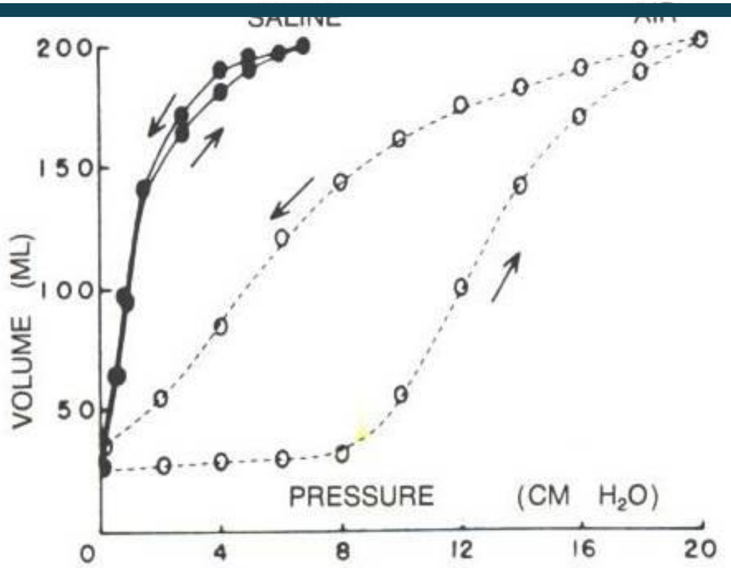

FIG. 17–3. Pressure–volume curves after air versus liquid expansion of the lung. (From ref. 210.)

Matching Alveolar air flow with blood flow

- Pulmonary vessels
  - Vessels can constrict in areas where oxygen flow is low
- Respiratory passageways
  - Airways can dilate where carbon dioxide levels are high

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RESPIRATION CONTROL

Controls of Respiration

- Medullary Rhythmicity Area

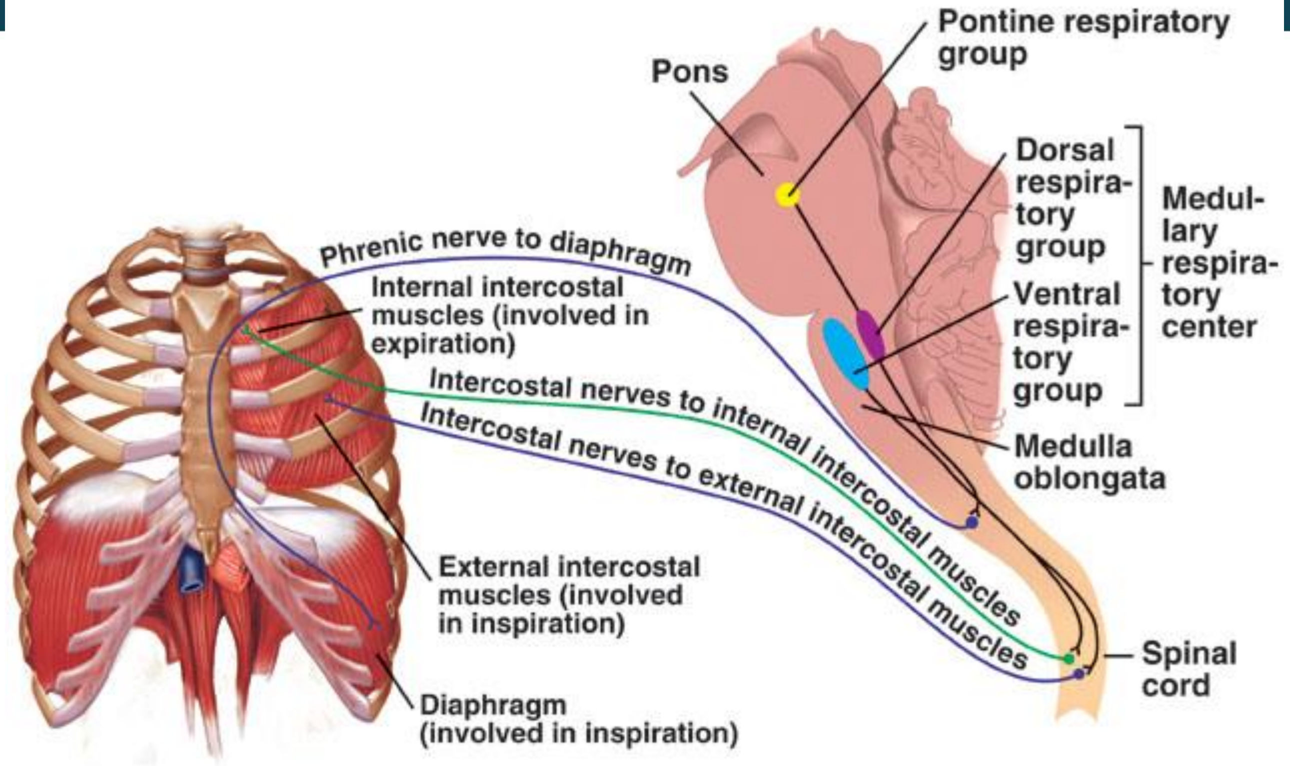
  - Medullary Inspiratory Neurons are main control of breathing

    - Pons neurons influence inspiration, with Pneumotaxic area limiting inspiration and Apneustic area prolonging inspiration.
    - Lung stretch receptors limit inspiration from being too deep

- Medullary Rhythmicity Area

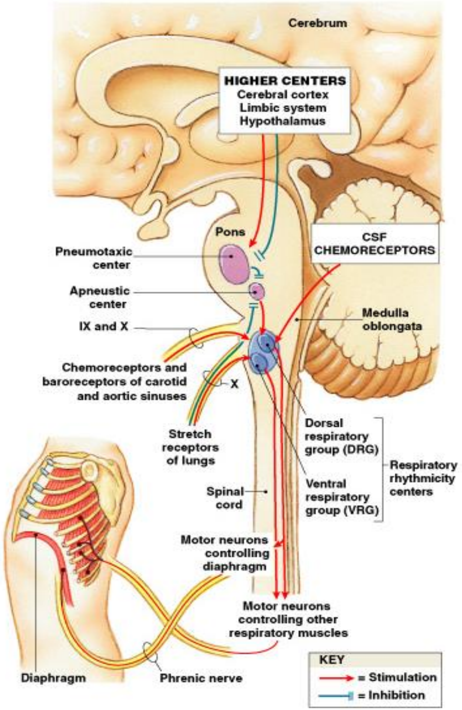
  - Medullary Expiratory Neurons

    - Only active with exercise and forced expiration


Pontine respiratory group
Pons
Dorsal respira-tory group
Ventral respira-tory group
Medul-lary respira-tory center
Phrenic nerve to diaphragm
Internal intercostal muscles (involved in expiration)
Intercostal nerves to internal intercostal muscles
Intercostal nerves to external intercostal muscles
Medulla oblongata
External intercostal muscles (involved in inspiration)
Diaphragm (involved in inspiration)
Spinal cord

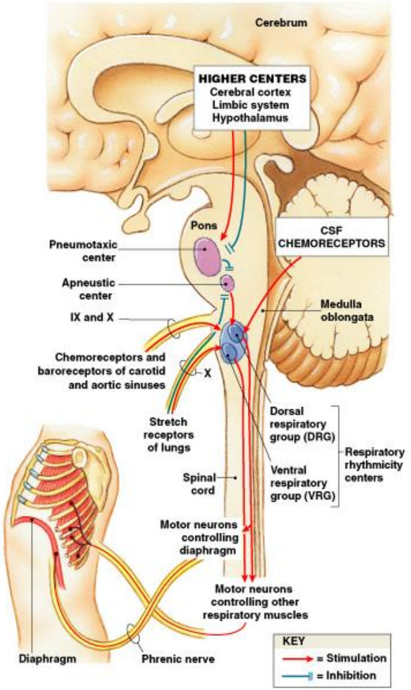
Respiratory centers

- Basic rhythm of ventilation controlled by medullary rhythmicity area (medulla oblongata)
- Inspiratory area (Dorsal Resp.Group)
  - determines basic rhythm of breathing
  - causes contraction of diaphragm and external intercostals
- Expiratory area (Ventral Resp. Group)
  - Inactive during normal quiet breathing
  - Activated by inspiratory area during forceful breathing
  - Causes contraction of internal intercostals and abdominal muscles

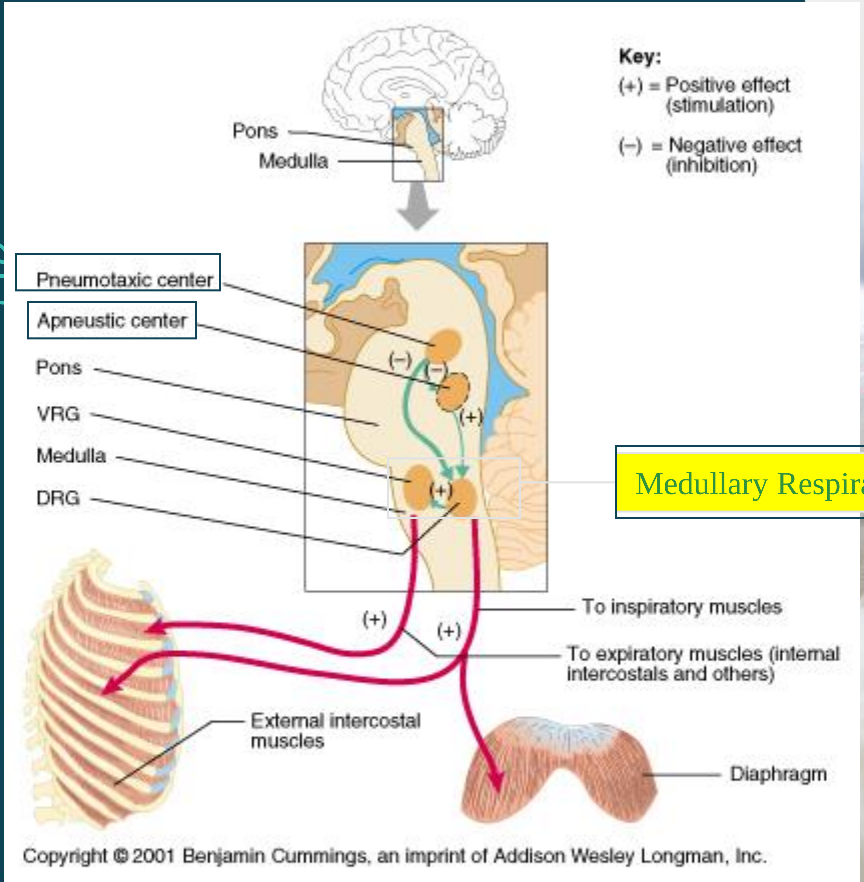


Respiratory centers

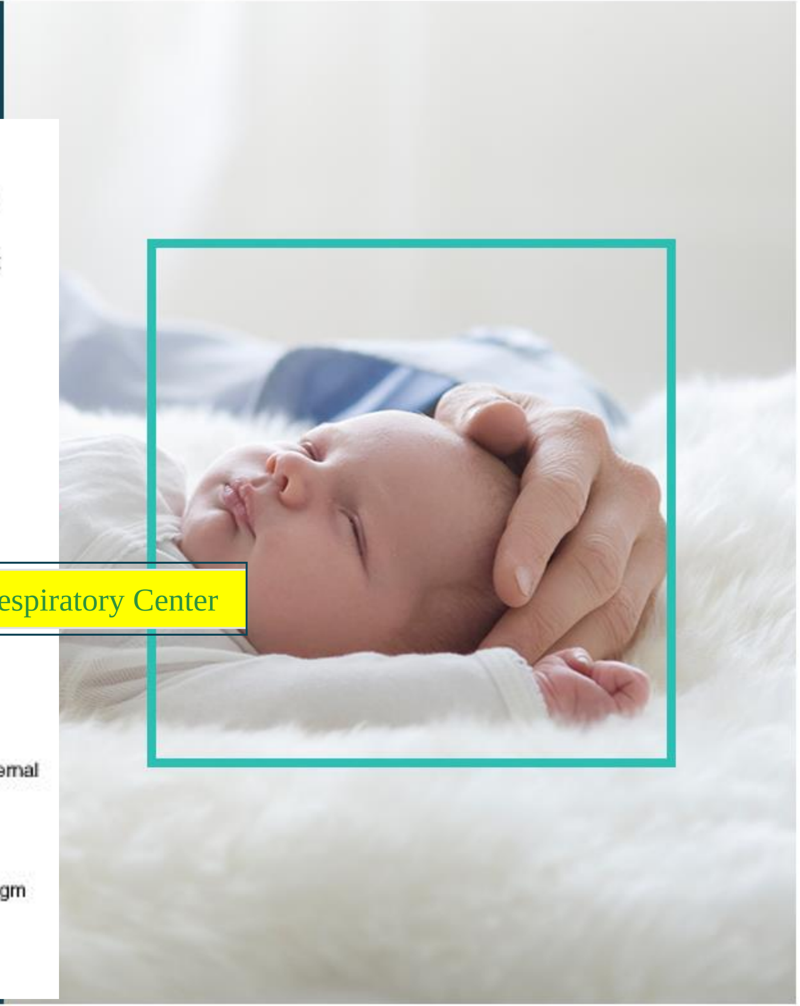
- Transition between inhalation and exhalation controlled by:
  - Pneumotaxic area
    - located in pons
    - inhibits inspiratory area of medulla to stop inhalation
      - Breathing more rapid when pneumotaxic area active
  - Apneustic area
    - located in pons
    - stimulates inspiratory area of medulla to prolong inhalation



RESPIRATORY CENTERS



Medullary Respiratory Center



Controls of rate and depth of respiration

- Arterial PO_2

  - When PO_2 is VERY low, ventilation increases

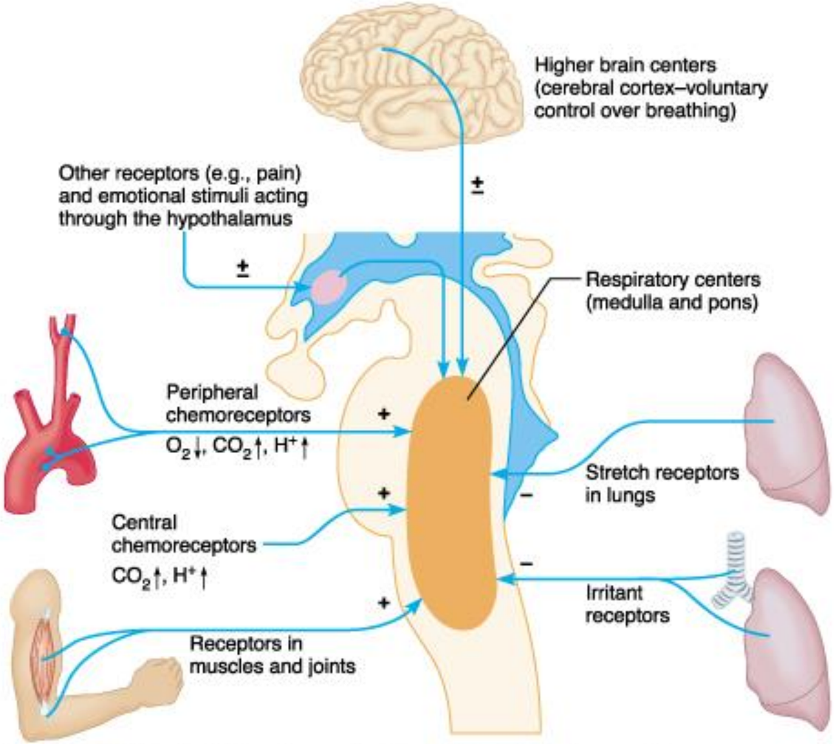
- Arterial PCO_2

  - The most important regulator of ventilation, small increases in PCO_2, greatly increases ventilation

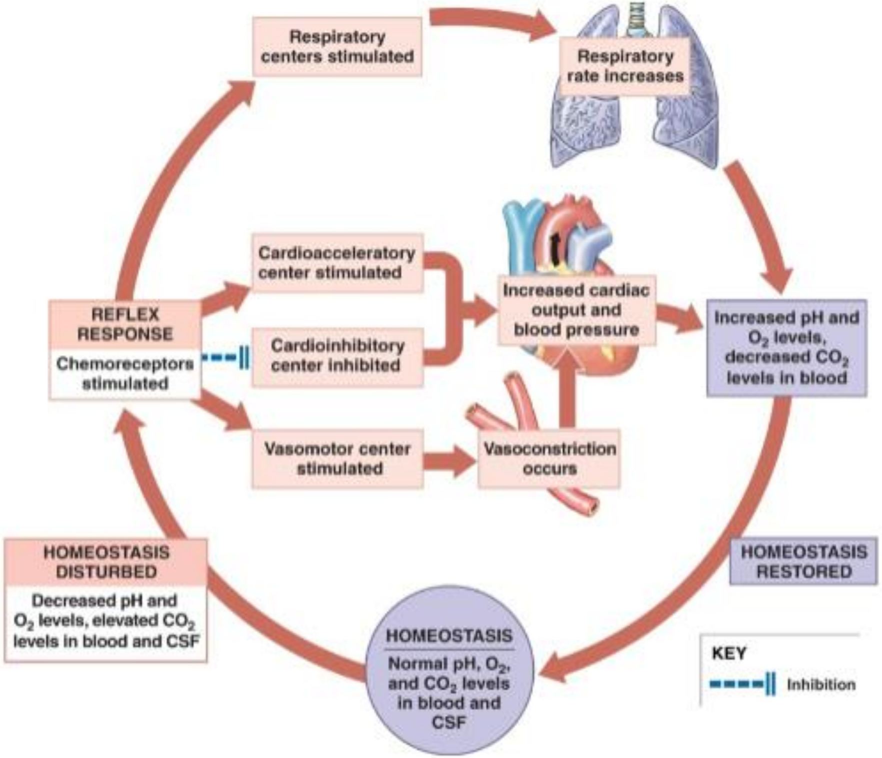
- Arterial pH

  - As hydrogen ions increase, alveolar ventilation increases, but hydrogen ions cannot diffuse into CSF as well as CO_2

Factors Influencing Respiration



All Together




Are there any Questions?
Yes?
Use Google

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QUESTIONS?

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THANK YOU

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