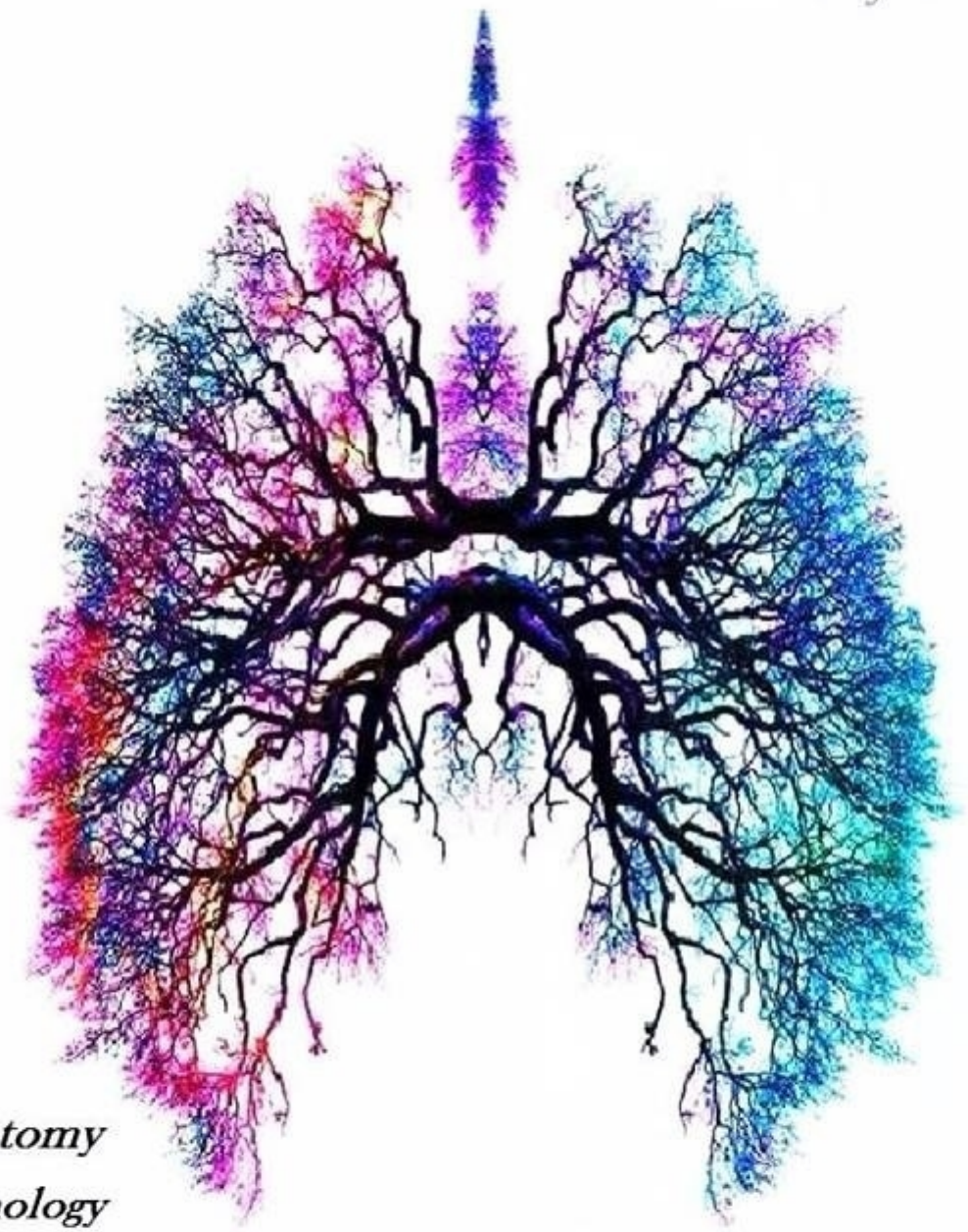
RESPIRATORY SYSTEM

Cover by: Aseil Khatib



- ○ Anatomy
- ○ Pathology
- ● Physiology
- ○ Pharmacology
- ○ Microbiology
- ○ PBL

Dr Name: Dr. Yanal Shafagoj

Lecture # 4+5

Sheet ☐

Slide ■

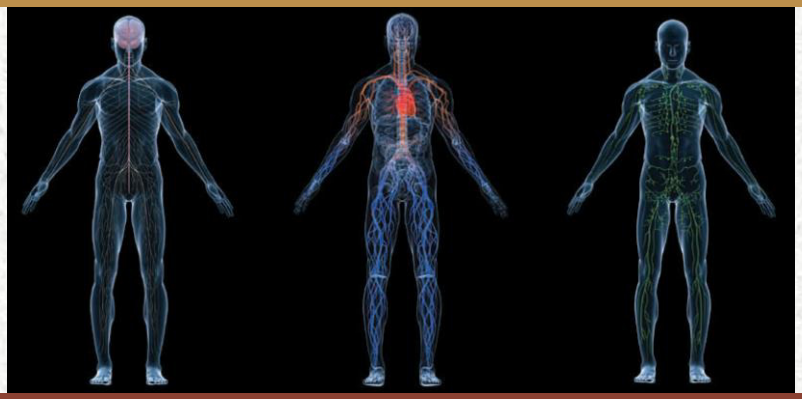
Other ☐

UNIT VII

GUYTON AND HALL *Textbook of*

Medical Physiology

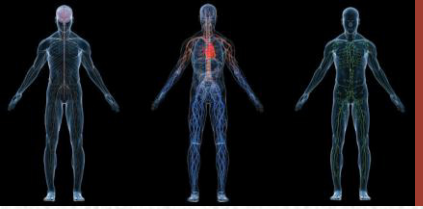
TWELFTH EDITION



Chapter 37:

Lung Compliance

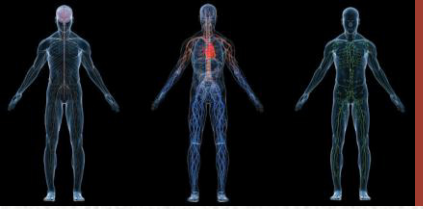
Slides by Robert L. Hester, PhD



Lung Compliance

Lecture-4

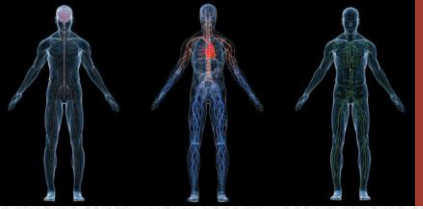
- Yanal A. Shafagoj MD. PhD



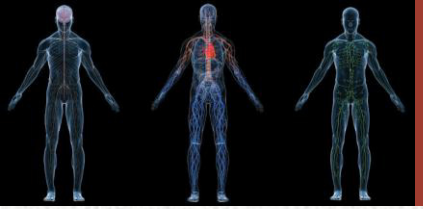
Work of breathing

Work in the respiratory system is of 2 major types:

1. *Work to overcome elastic forces (70%):* that required to expand the lungs against the lung and chest elastic forces. Two third is duo to T and one third is the elastic fibers
2. *Work to overcome non-elastic forces (30%):* that required to overcome
    1. The viscosity of the lung and chest wall structures (20%).
    2. *Airway resistance work (80%):* that required to overcome airway resistance to movement of air into the lungs.



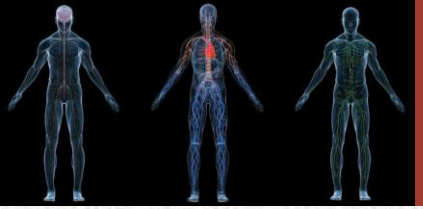
- The lungs, if alone, (outside the body) or in open-chest surgery, it will collapse up to 150 ml air **= minimal volume**. This volume is used for medico legal purposes…also known as unstressed volume



Compliance

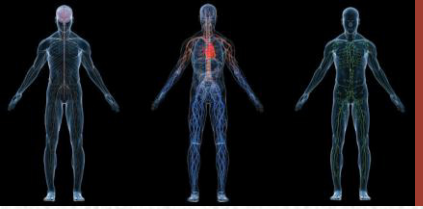
- Distensibility (stretchability):
  - Ease with which the lungs can expand.
- Change in lung volume per unit change in transpulmonary pressure.

  $\Delta V/\Delta P$
- Lung is 100 x more distensible than a balloon. **This means, 100 times more distending pressure is required to inflate a child toy balloon than to inflate the lung.**
  - Compliance is reduced by factors that produce resistance to distension.



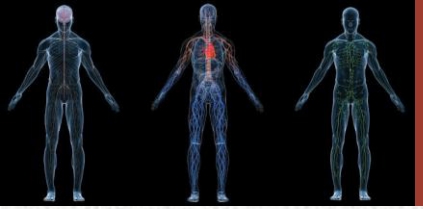
Compliance

COMPLIANCE is the ability of the lung to stretch; its distensibility=stretchability, and is reciprocal to elasticity
Specific compliance = C/FRC to correct for differences in lung volume between child and adult.
C_L = 200ml/cm H_2O.
C_W = 200ml/cm H_2O.
C_S = 100ml/cm H_2O. S stands for lung-thorax system
To inflate one balloon is easier than inflating two balloons inside each others. The two balloons are the lung and the thorax.



Elasticity

- Tendency to return to initial size after distension.
- High content of elastin proteins.
  - If the lung is very elastic and resist distension…this means high recoil tendency…high collapsing forces
- Elastic tension increases during inspiration and is reduced by recoil during expiration.



- **<u>BINDING BETWEEN LUNGS & THORAX.</u>**
- Lungs are covered by a visceral pleura & the mediastinum & chest wall are lined by parietal pleura. Both pleural surfaces are covered with a thin film of fluid & the intermolecular forces of this film between the two surfaces holds the lungs against the thorax. It is like two glasses slide over each others but not easily separated.
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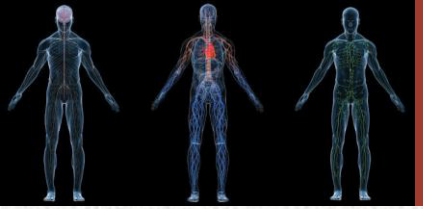
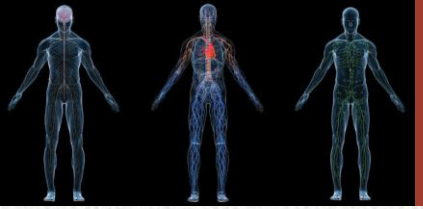
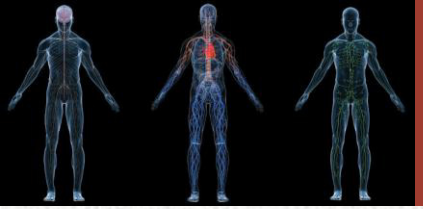


- The magnitude of the intrapleural pressure equals the separate elastic forces of the lungs or chest wall rather than the sum of their combined forces. It reflects either the strength of the collapsing elastic lung tissue or the strength of the expanding chest wall force
- Since chest wall elasticity usually remains unchanged in respiratory pathology, "P_{pl}" reflects the elastic strength of the lungs. At all volume P_{pl} reflects how strongly the lungs are tending to collapse. P_{pl} can be measured using a tube inside the esophagus.

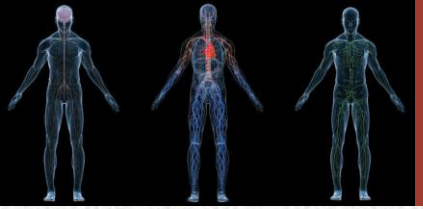


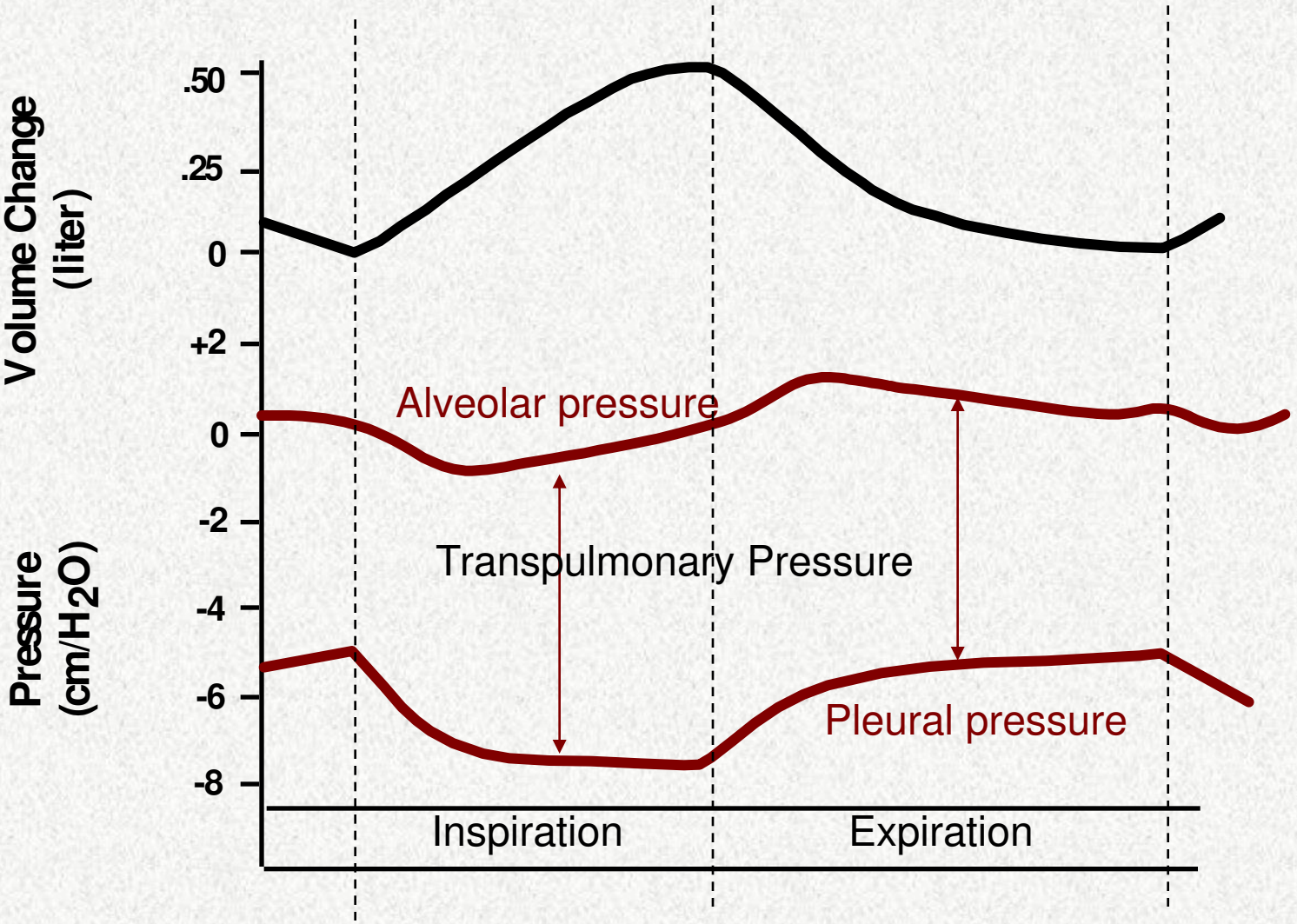
Relaxation Curve

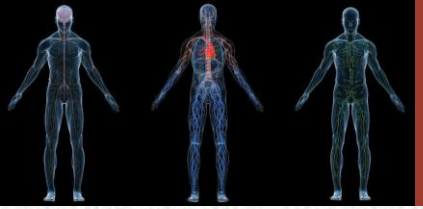
- When generating the **Relaxation Curve**, all muscles (inspiratory & expiratory) are relaxed and we plot volume versus intra-alveolar pressure.
- At each lung volume we can study whether the lung-chest wall system is tending to expand or to relax.
- Relaxation curve is generated under static conditions when no air flow occurs.
- Under these conditions, Ppl reflects the strength of the elastic forces of the chest wall



- In vivo, we can't measure P_{alv} below residual volume.
- To move the system from FRC you need to apply force such as muscle contraction…to bring it back to its resting volume (FRC) is passive. This is another way to look at expiration being passive process.

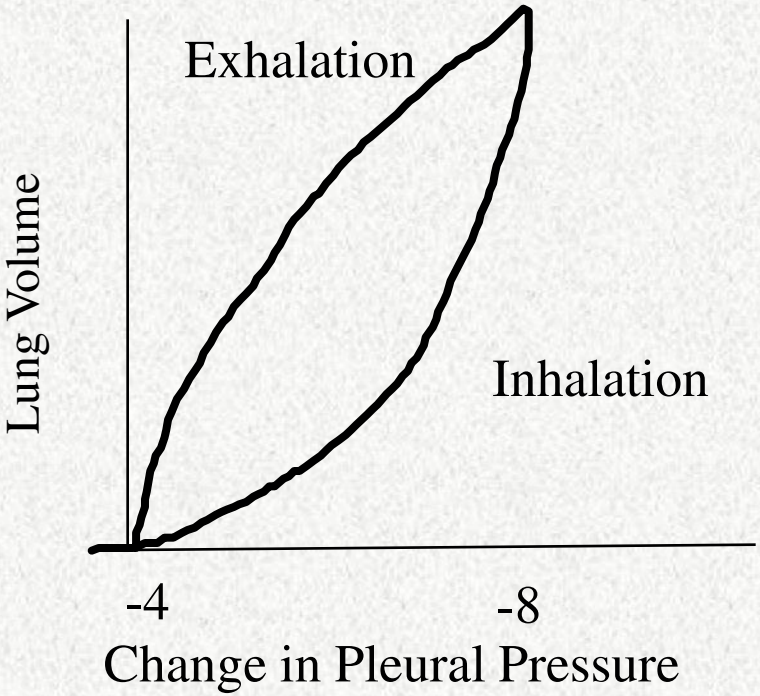


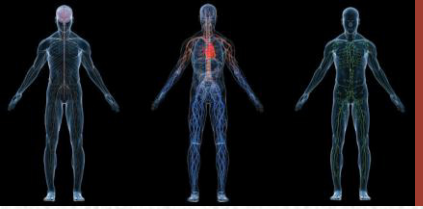




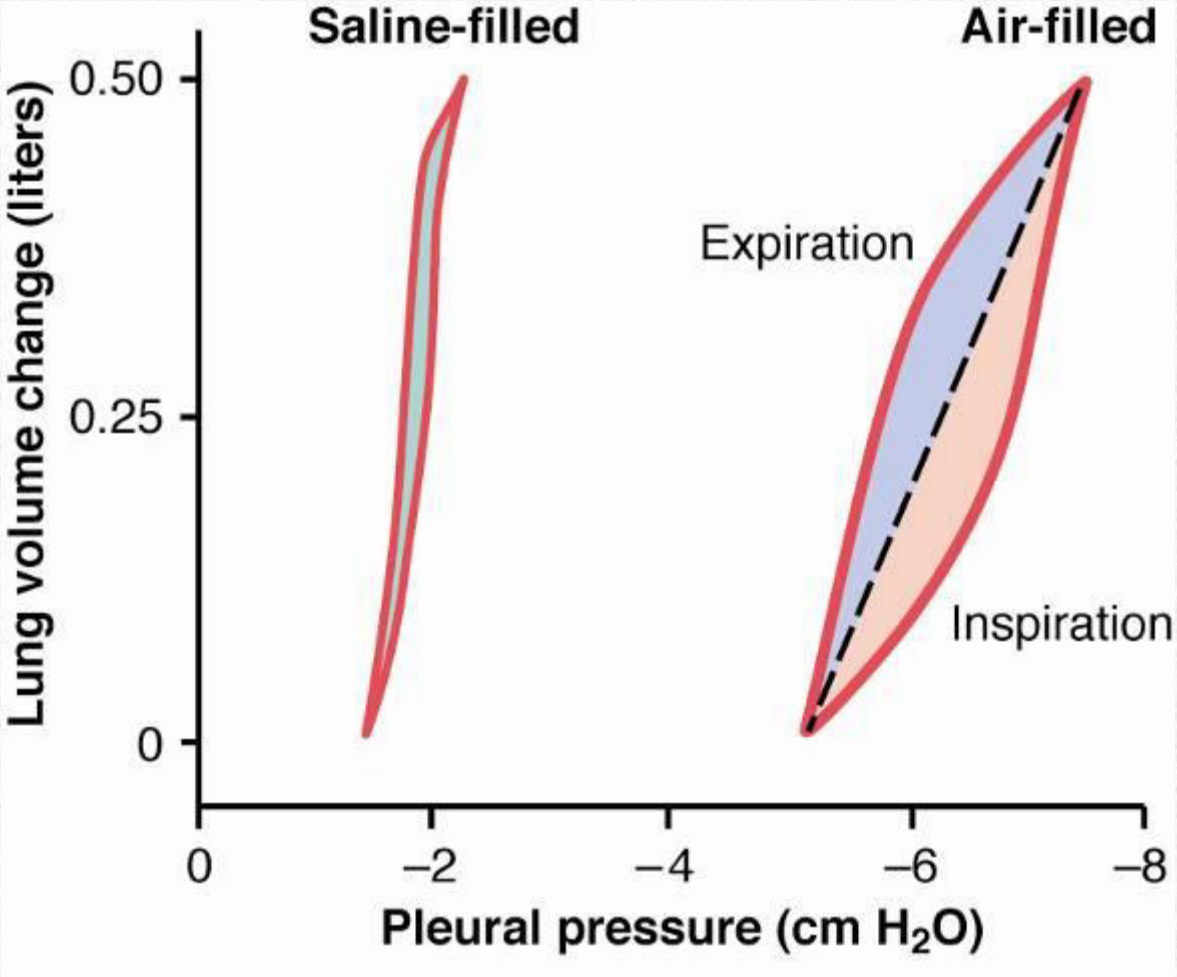
COMPLIANCE OF LUNGS

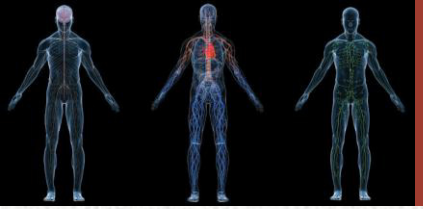
- Determined by elastic forces
- Elastic forces
  - lung tissue… one third
  - surface tension…two thirds

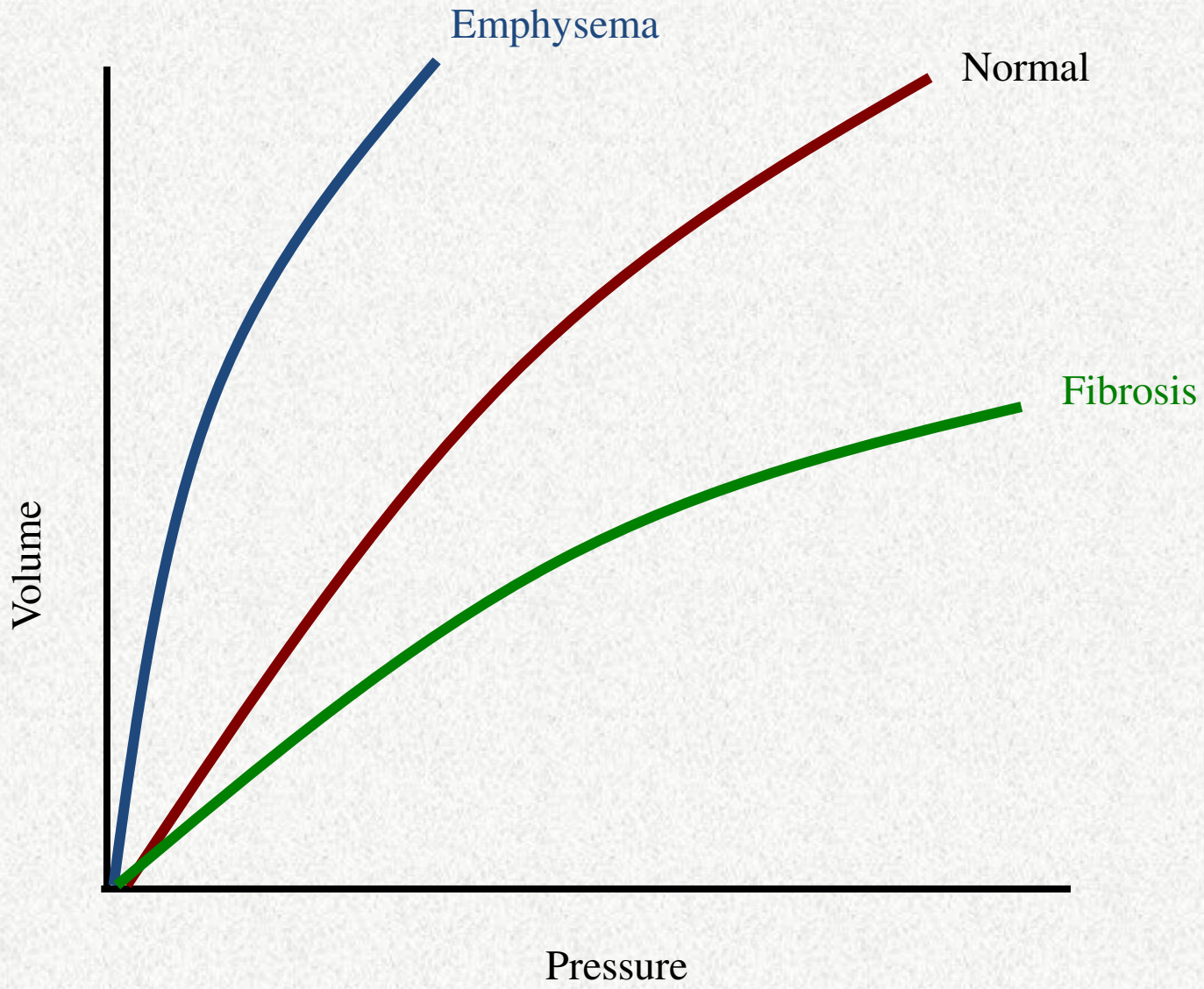


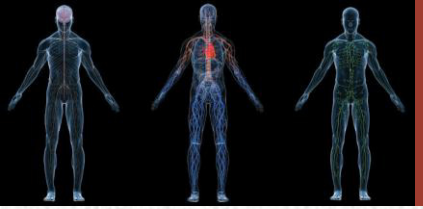


Compliance of Lungs





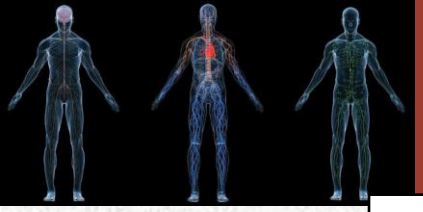




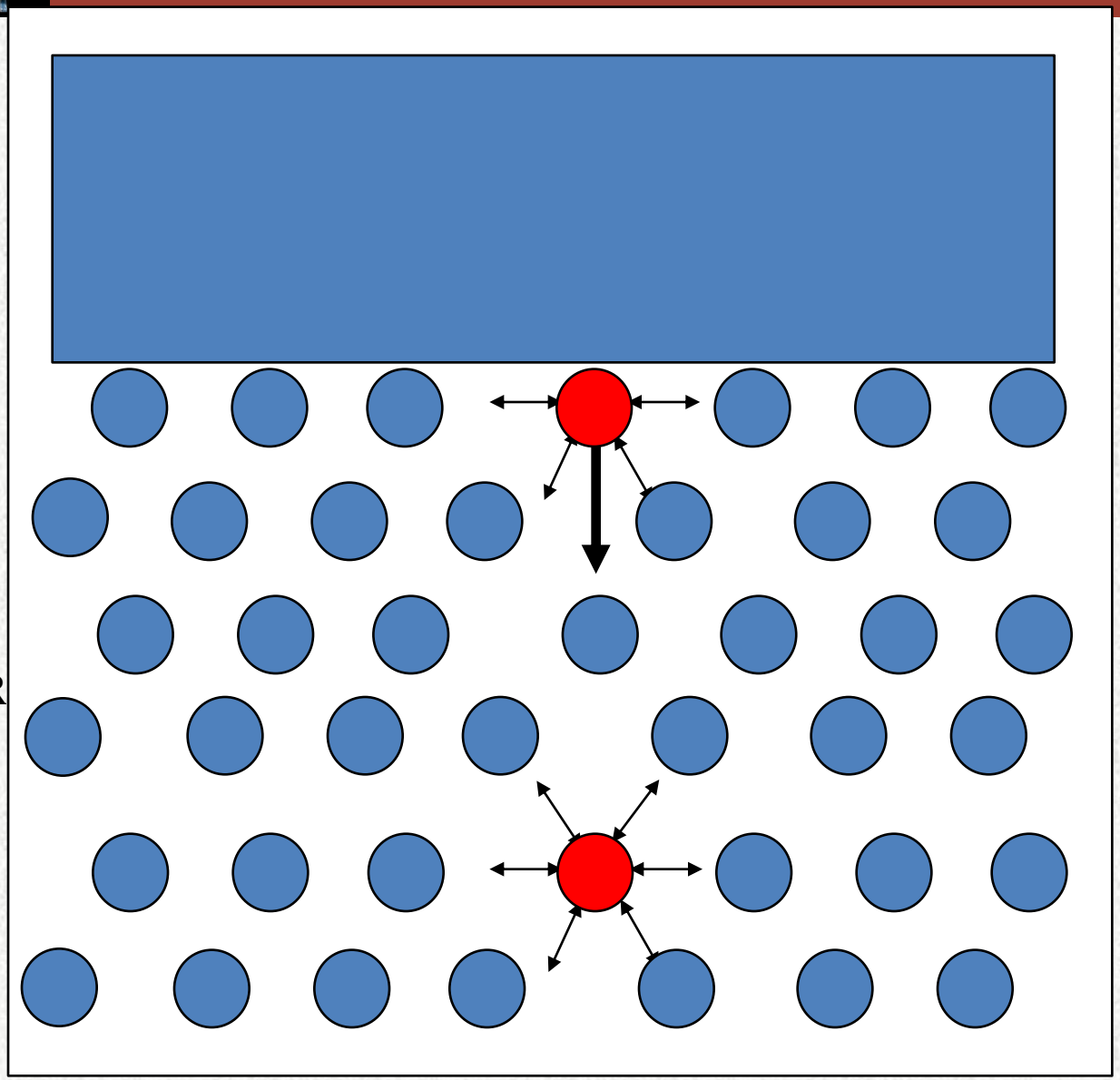
Compliance of Lungs

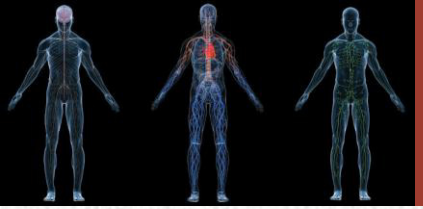
Surface tension…is a collapsing force

- Attraction of water molecules at air-water interface
- Will result in collapse of alveoli
- Prevented by surfactant



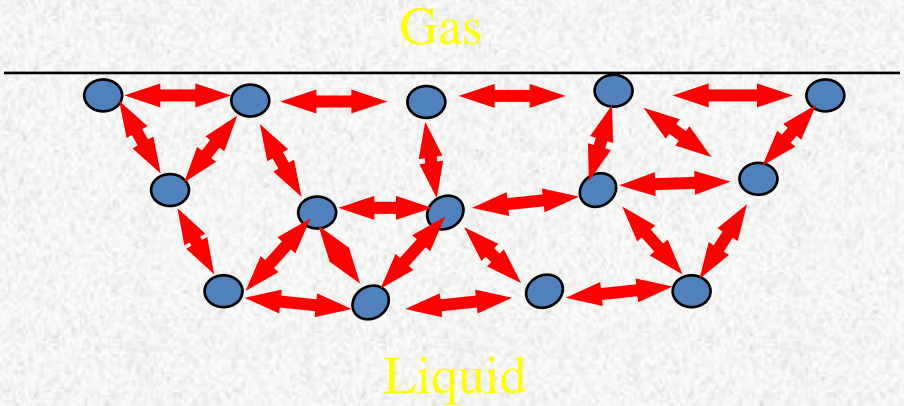
SURFACE TENSION- asymetrical forces acting at an air/water interface produce a net force acting to decrease surface area



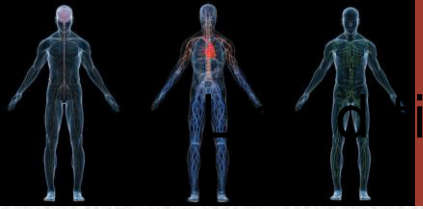


Surface Tension and recoil of the lung

Molecular interactions resulting from hydrogen bonds between water molecules in liquid but not between water and air.

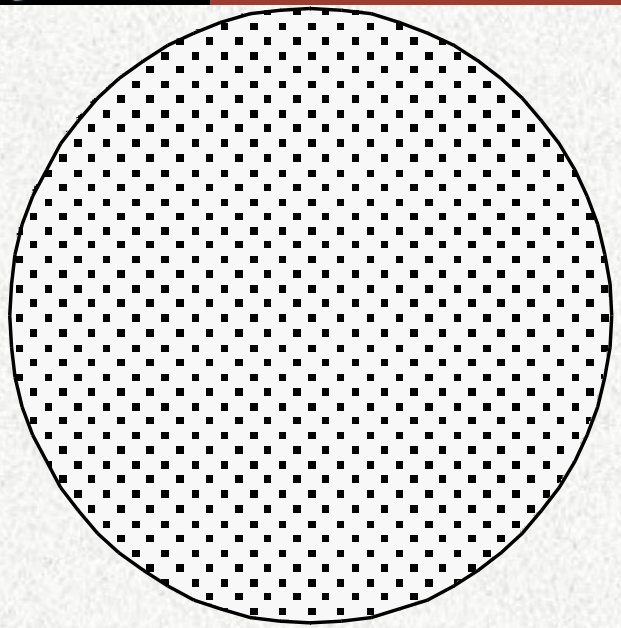


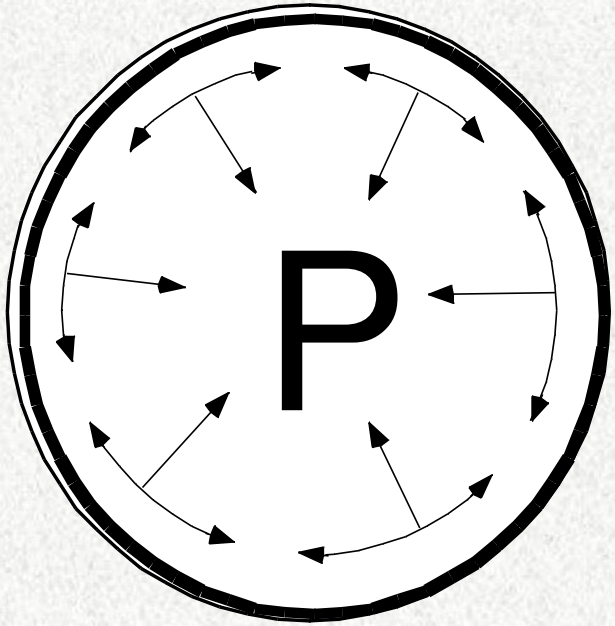
When water forms a surface with air, the water molecules on the surface of the water have an especially strong attraction for one another. Therefore, the water surface is always attempting to contract.



Gas filled alveolus

Gas filled alveolus with thin liquid layer





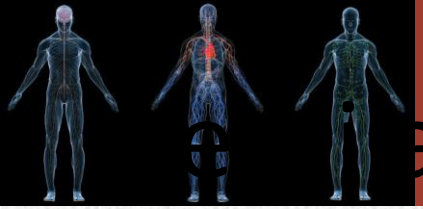
No Surface Tension

Because there is no air/water interface

+ Surface Tension

↑ Recoil Pressure

↓ Compliance



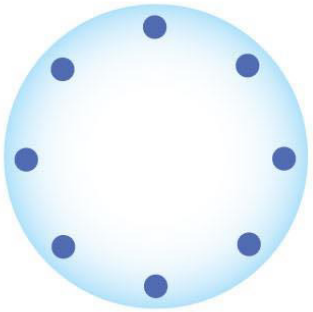
ation

- Surfactant is produced by the septal cells Alveolar type II
  - ***Surfactant***: Means surface-active agent
  - It is Glyco(2%)-lipo(90%)-protein(8%) plus calcium ions.
  - Disrupts the surface tension & cohesion of water molecules
  - Impact?
  - Maturation of surfactant needs T_4, prolactin, estrogen, and other steroids
    - prevents alveoli from sticking together during expiration

Law of LaPlace: P = 2T/r

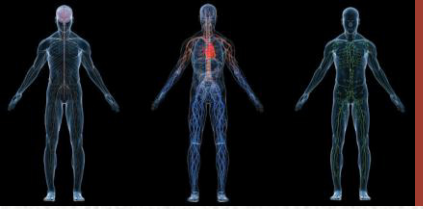
P = pressure
T = surface tension
r = radius

According to the law of LaPlace, if two bubbles have the same surface tension, the small bubble will have higher pressure.



r = 2
T = 2
P = (2 × 2)/2

r = 1
T = 1
P = (2 × 1)/1



Laplace's Law

$T = P \times r / 2$ or $P = 2T/r$

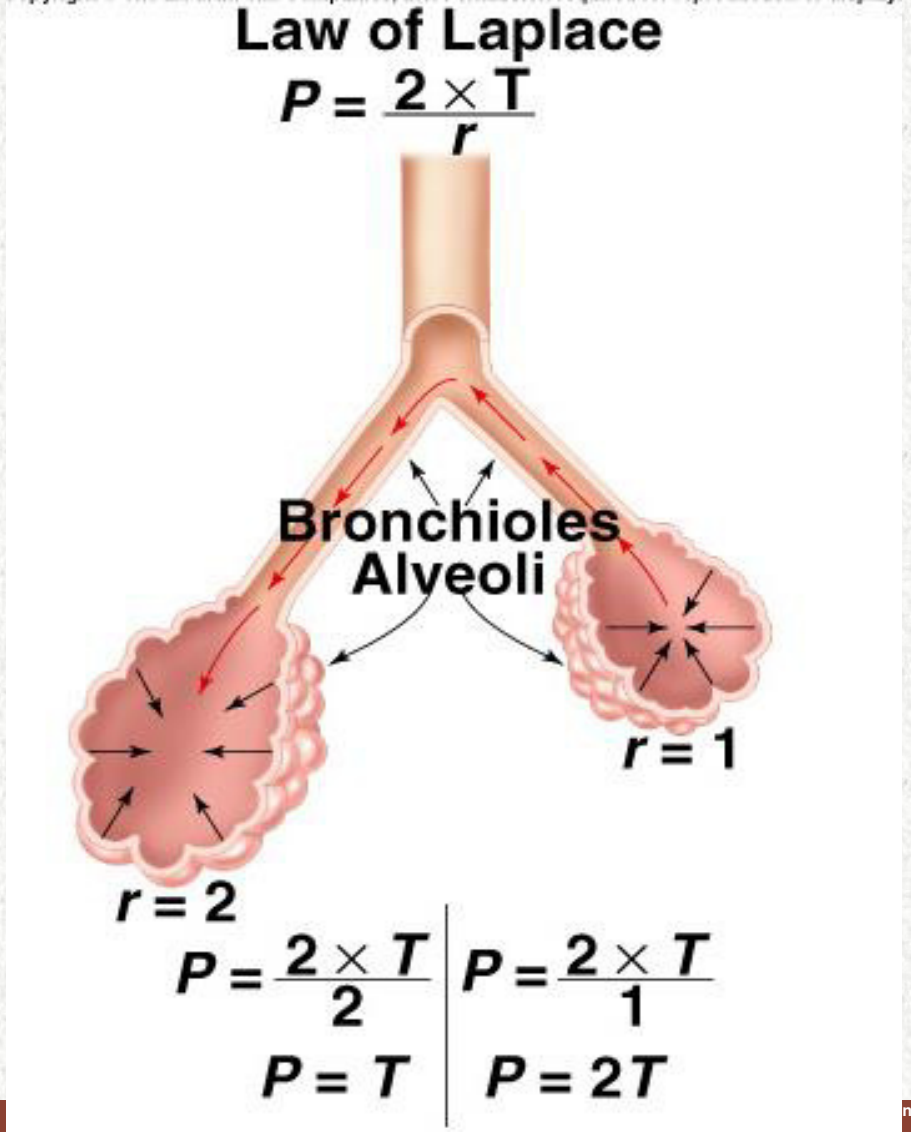
P = pressure required to prevent alveolar collapse <u>at rest</u>
T = surface tension
r = radius…

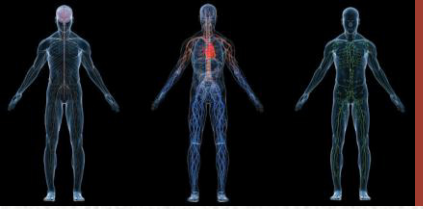
- **The smaller the radius, the larger the pressure required to prevent collapse**

- **If T = 2; r = 2; P = 2**
- **If T = 2; r = 4; P = 1**

Surface Tension (continued)

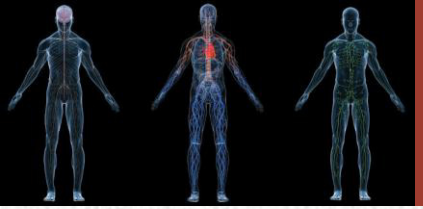
- Law of Laplace:
  - Pressure in alveoli is directly proportional to surface tension; and inversely proportional to radius of alveoli.
  - Pressure in smaller alveolus would be greater than in larger alveolus, if surface tension were the same in both.





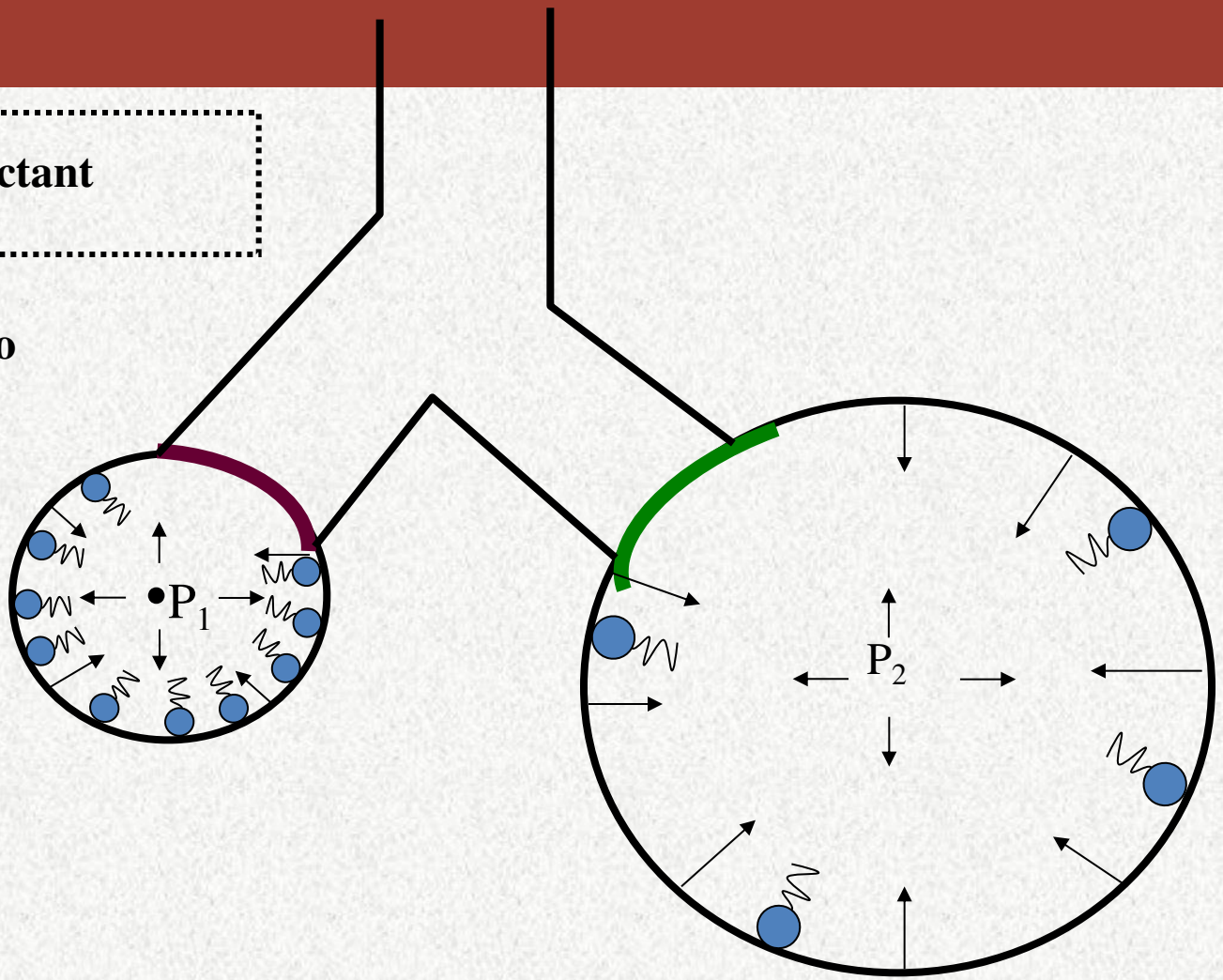
Pulmonary Surfactant

- Detergent-like substance
- Secreted by type II alveolar epithelial cells in the lungs
- Reduces surface tension at the alveolar – air interface
- Interferes with hydrogen-bonding between H_2O molecules



Pulmonary surfactant

P_1 = Pressure required to prevent alveoli #1 from collapsing.



P_2 = Pressure required to prevent alveoli #2 from collapsing.

Deficiency of Surfactant causes collapse of the lungs

- Respiratory distress syndrome (premature babies) IRDS
- ARDS
- Since lung inflation requires large pleural pressure drops, deep breaths are difficult for patients with Restrictive Ventilatory Defects RVD; These patients exhibit shallow and rapid breathing patterns.