Respiratory physiology I.

Respiratory mechanics, ventilation
Learning objectives: 25-26.

prof. Gyula Sáry

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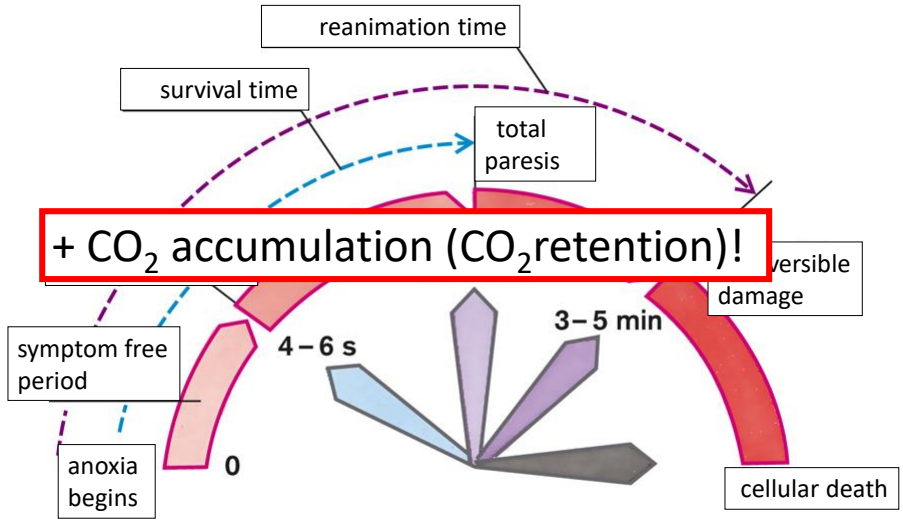
- Respiratory muscles and movements
- Lung volumes
- Compliance of the lung and chest
- Surface tension in the airways

- Pressure changes during respiration
- Airway resistance
- Dead space of ventilation
- Respiratory minute volume

2



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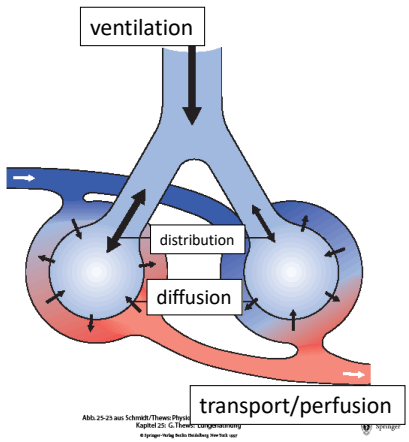
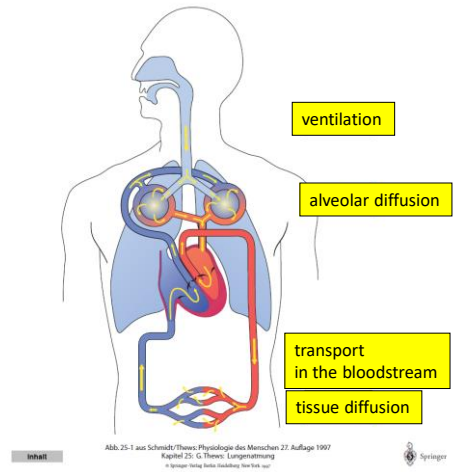
Respiration: main phases





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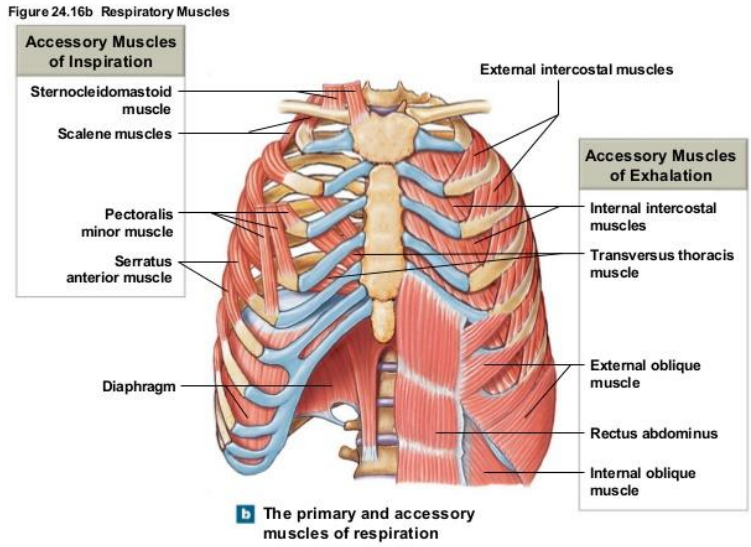
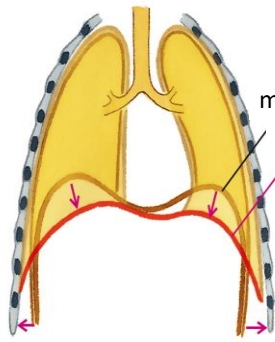
Muscles of inspiraton and (active) expiration



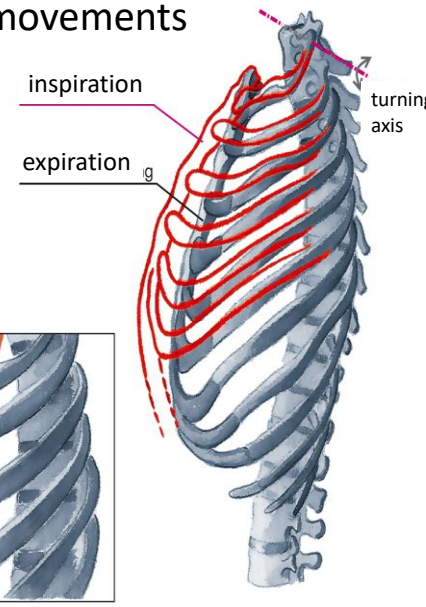
Respiratory movements

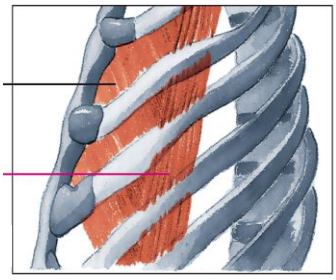


maximal expiration

maximal inspiration

diaphragma





intercostal muscles

chest movements

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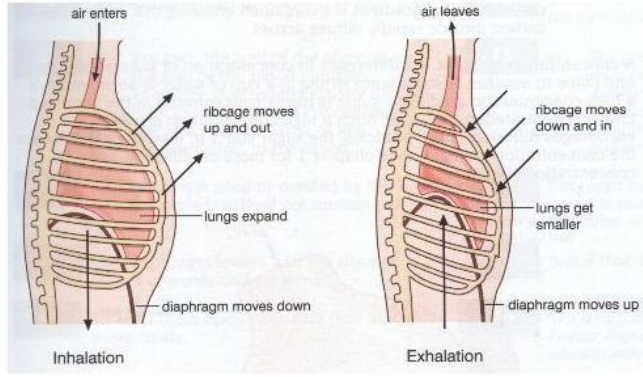
Volume changes during respiration



diaphragma: vertical movements

chest: antero-posterior and sideways movements

chest breathing / diaphragma breathing

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The principle of spirometry, measuring lung volumes

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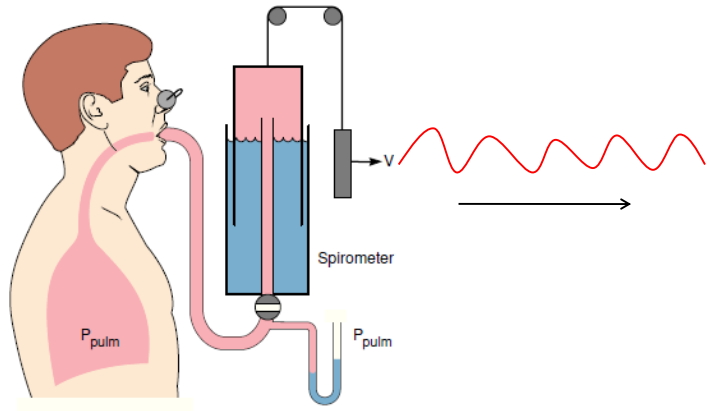

Abb. 8-6 Messung von Lungenvolumina und intrapulmonalem Druck mit Spirometer und Manometer.

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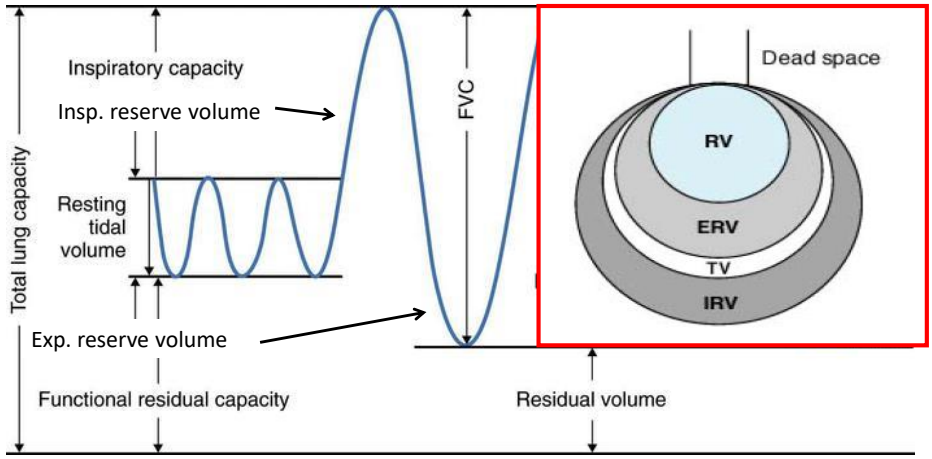
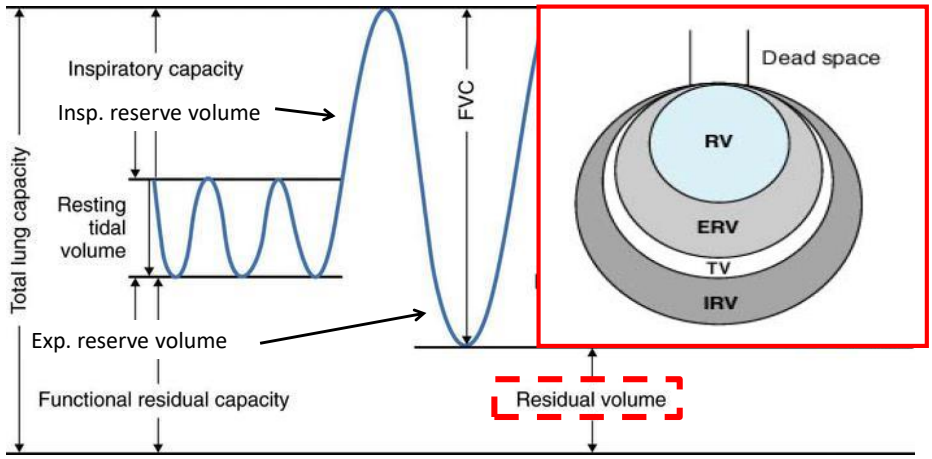
The normal spirogram



capacity= volume$_1$+volume$_2$+volume$_3$+….

Lung volumes that can not be determined directly by spirometry

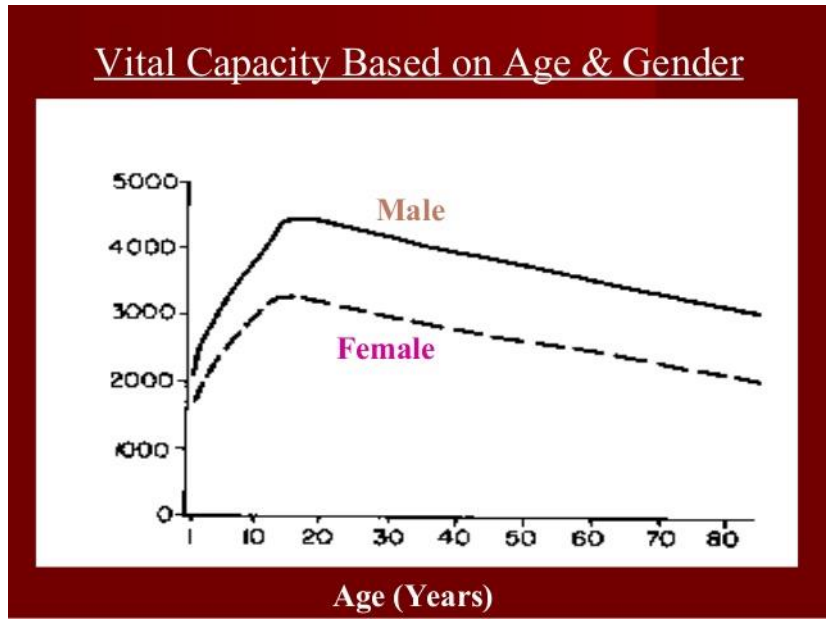


$$RV = V_0 \times \frac{C_a - C_e}{C_e}$$

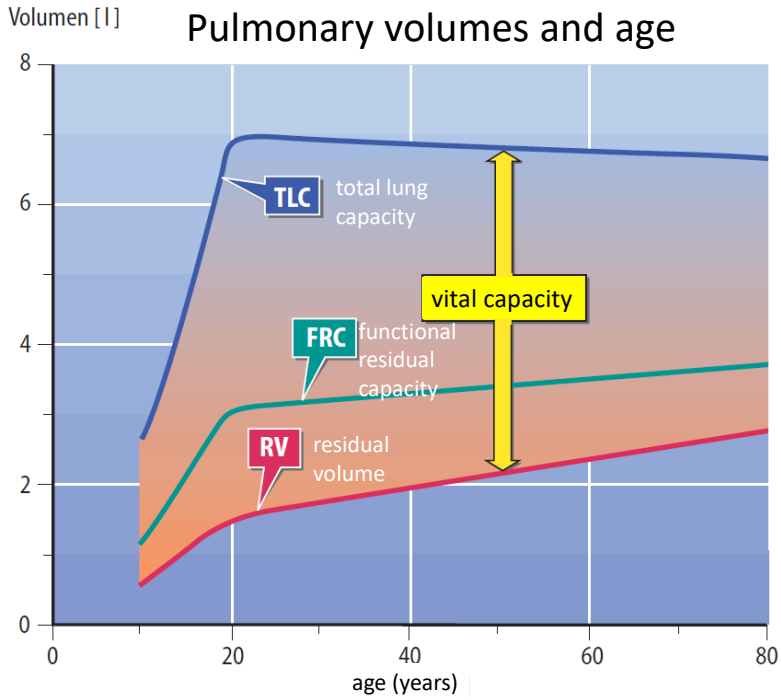
V_0= spirometer volume

C_a and C_e helium concentration at beginning and after equibrium

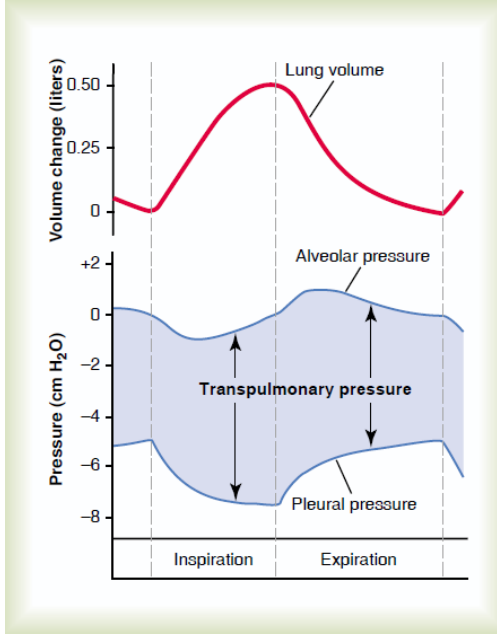
Pulmonary volumes and age



Pulmonary volumes and age



Changes in volume and pressure during respiration



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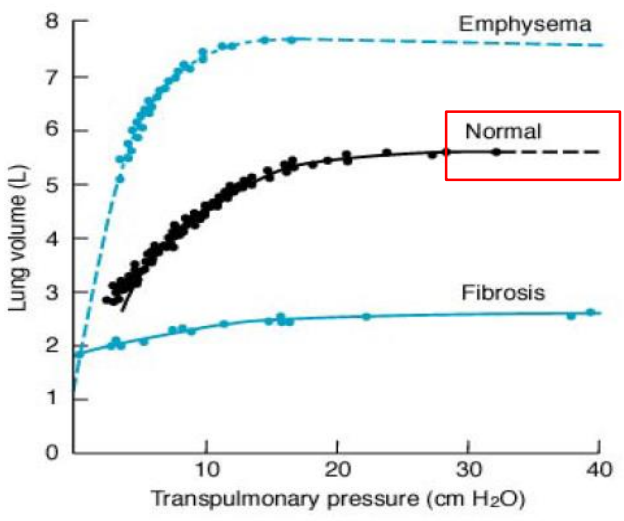
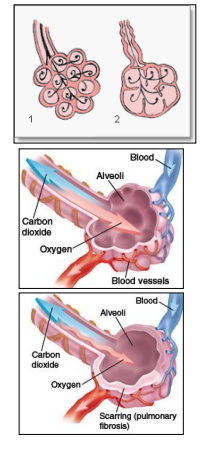
A distensibility of the lung (compliance)





Volume changes per pressure units (L/cm H_2O)

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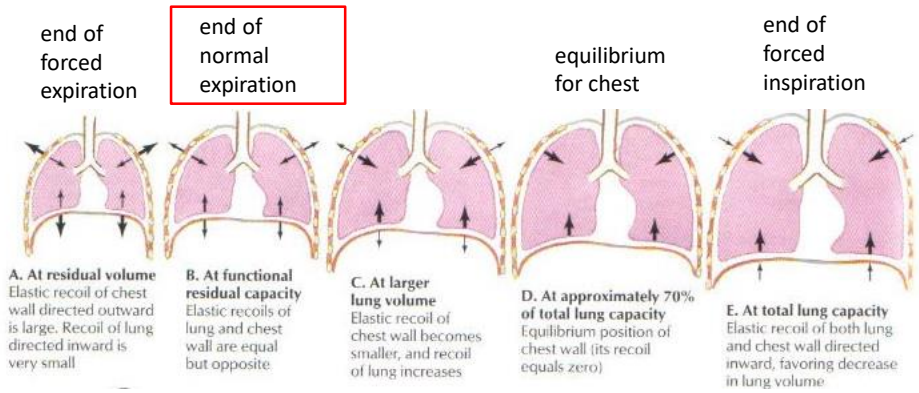
Elastic forces in the lung and in the chest during breathing



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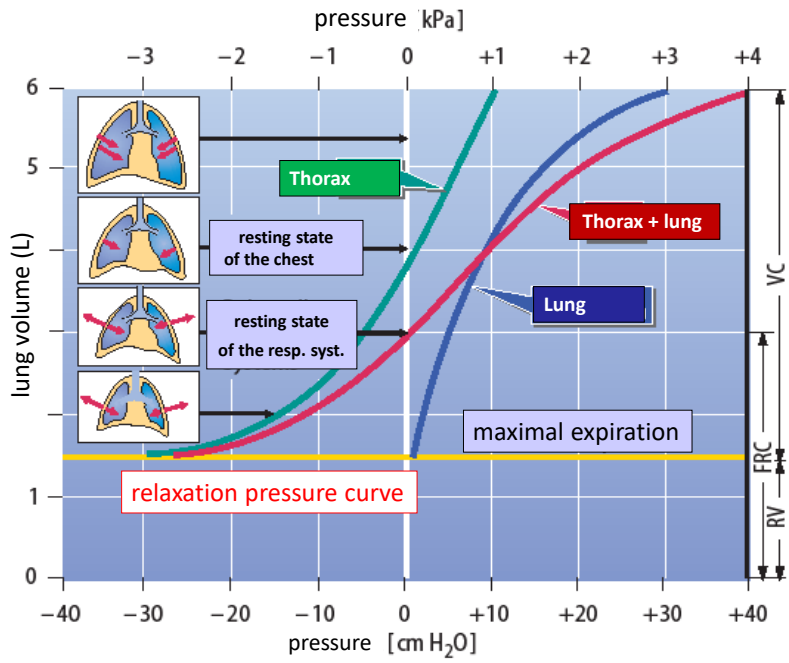

Summary

- Functional residual capacity (end of normal expiration) is determined by the interaction between lung tissue and chest.
- Total lung capacity (end of forced inspiration) is detemined by the balance between chest-lung recoil and the force of inspiratory muscles.
- Residual volumen (end of forced expiration) is determined by the interaction between expiratory muscles and the elasticty of the chest.

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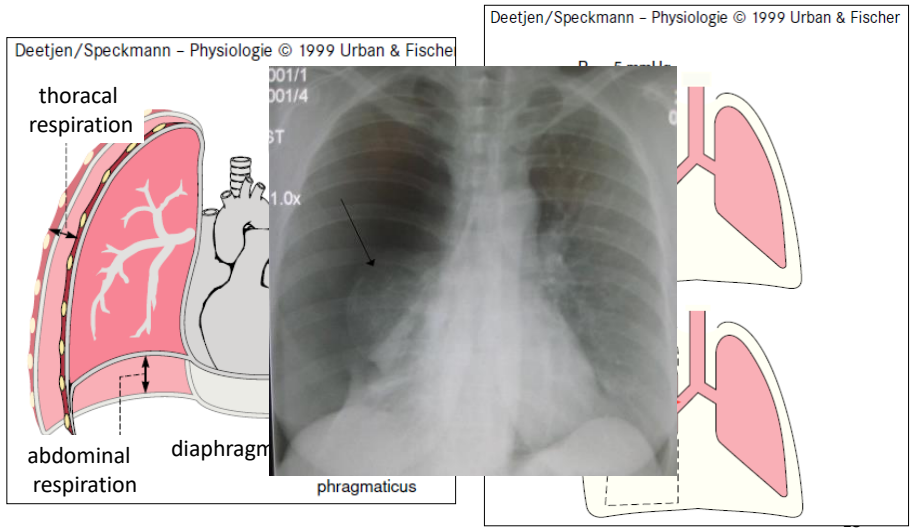
The role of the negative intrapleural pressure; pneumothorax



Positive pressure ventilation (anesthesia)

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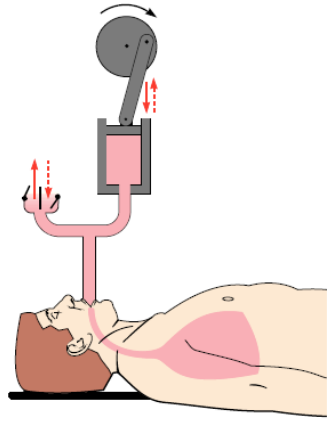

Abb. 8-11 Prinzip der Überdruckbeatmung.

- volume controlled
- pressure controlled
-
-

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Negative pressure ventilation (the „iron lung”)

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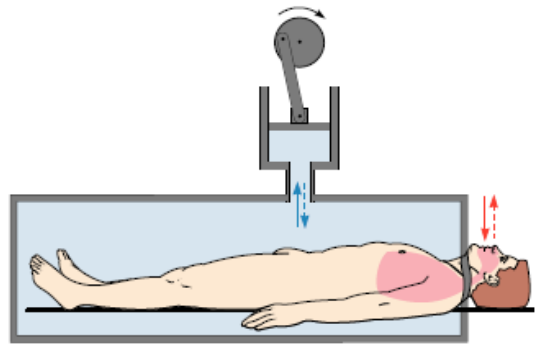

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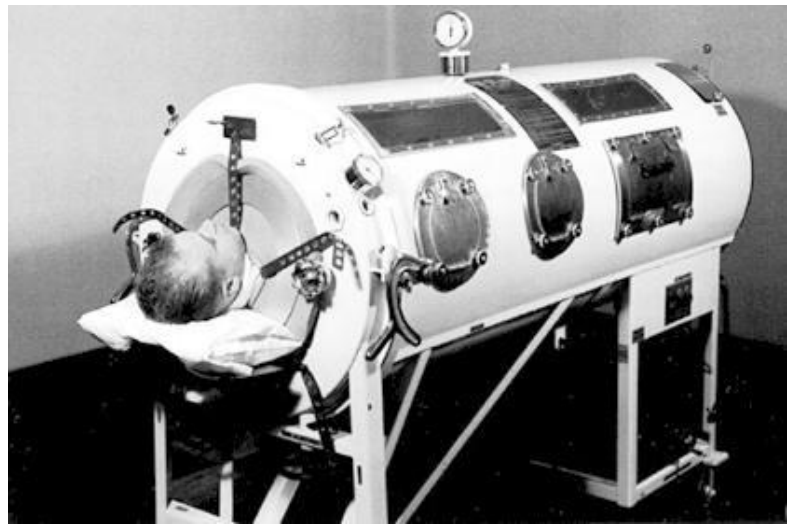

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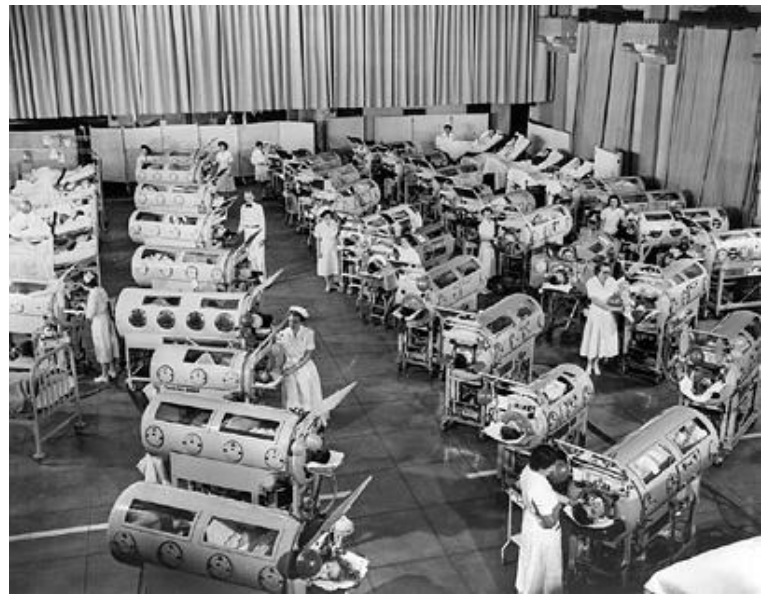

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Elasticity of the lung

Determined by:

elastic fibres of the lung

surface tension and surfactant

interdependency of the alveoli

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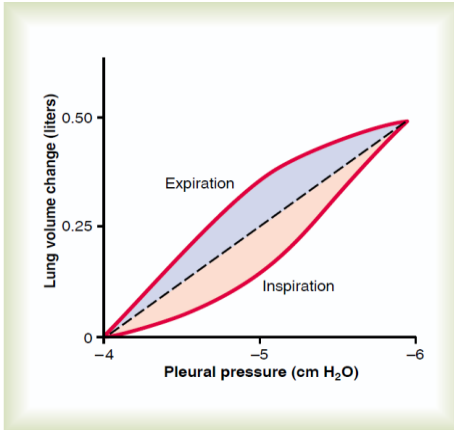
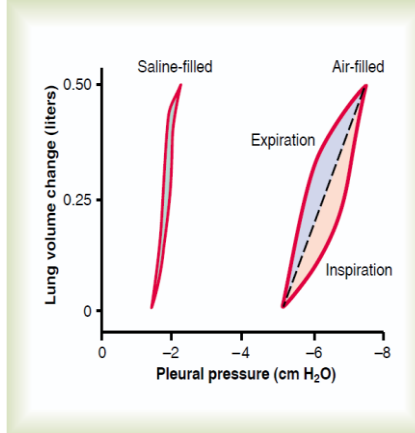
Distensibility of the lung





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Surfactant, surface tension

Surface tension: why do falling water drops have a spherical shape?

Type II. alveolar cells: production of surfactant

Surfactant:

- surface tension drops to 1/10 of the original value
- prevents edema

Premature babies:

- infant respiratory distress syndrom (IRDS)
- atelectasis (no air in the alveoli)
- PEEP ventilation

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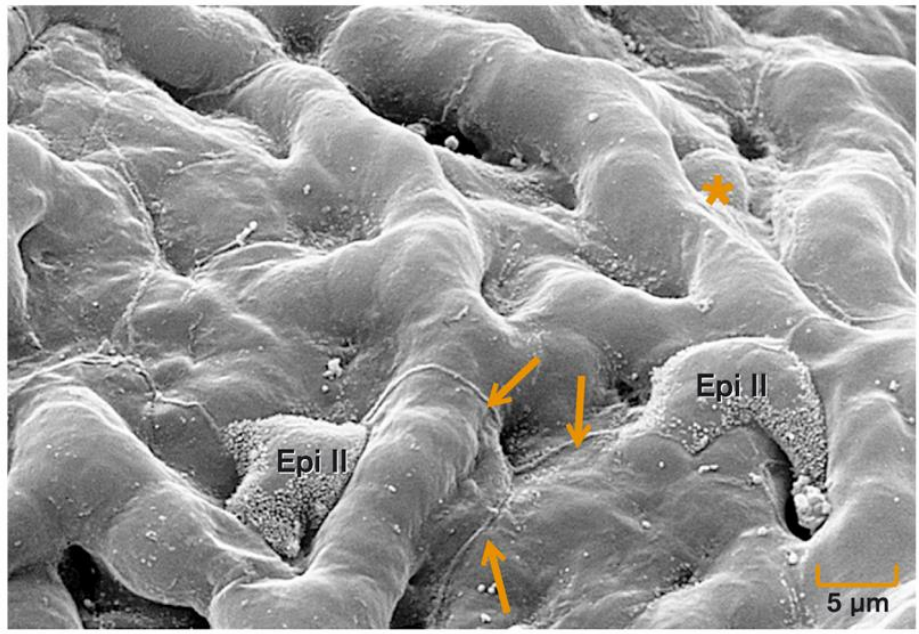

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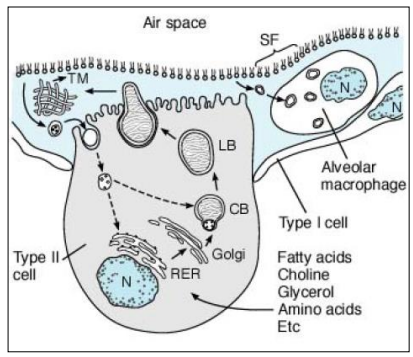
Production of surfactant



- produced by type II. alveolar cells
- LB= lamellar bodies
- exocytosis (stimulus: distension of the lung)
- formes a thin film
- surface tension drops to 1/10
- phosphatidilcholine, albumin, IgA, apoproteins
- removed by phagocitosis (recycling!)
- produced from the 6.-7. intrauterine month
- premature babies:
  infant respiratory distress syndrome (IRDS)
  atelectasis
  glycocorticoids stimulate

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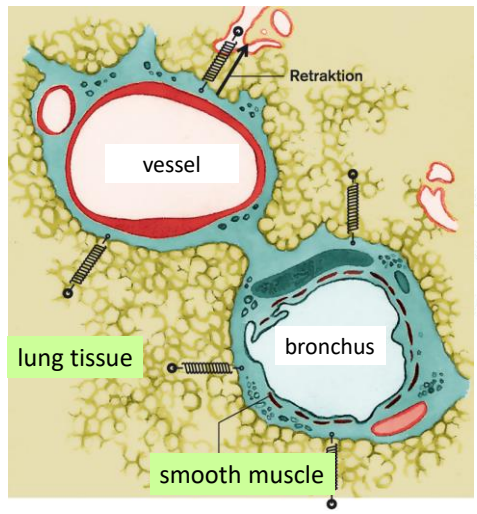
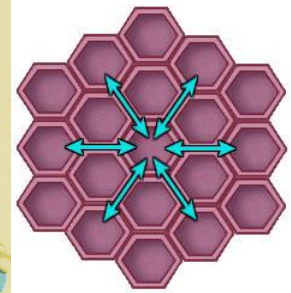
Interdependence of the alveoli





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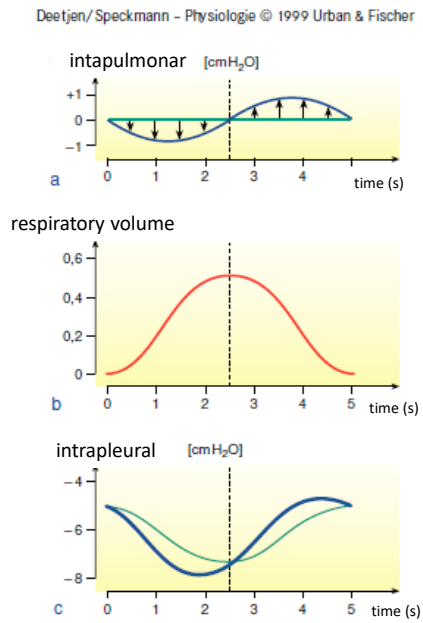
Pressure changes during respiration



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Resistance of the lung against change in volume

elastic resistance:
chest and lung elasticity

viscous (non elastic) resistance:
most importantly against airflow

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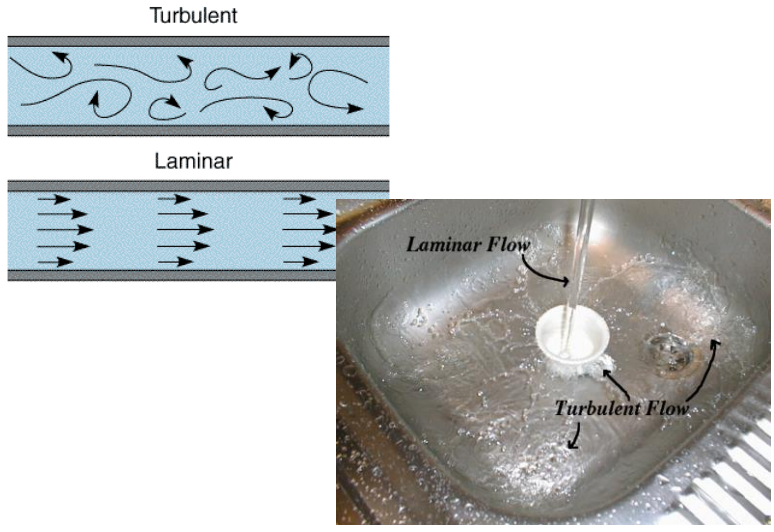

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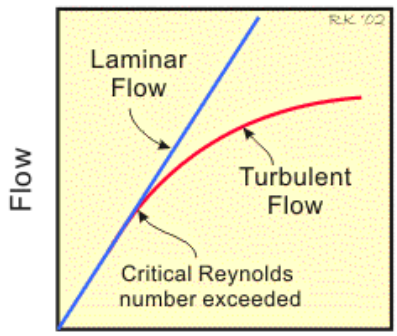

Reynolds number

v= flow velocity
ρ= density
d= diameter
η= viscosity

$$\text{Reynolds number} = \frac{\text{velocity x density x diameter}}{\text{viscosity}}$$

$$Re = \frac{V \rho d}{\eta}$$

2000

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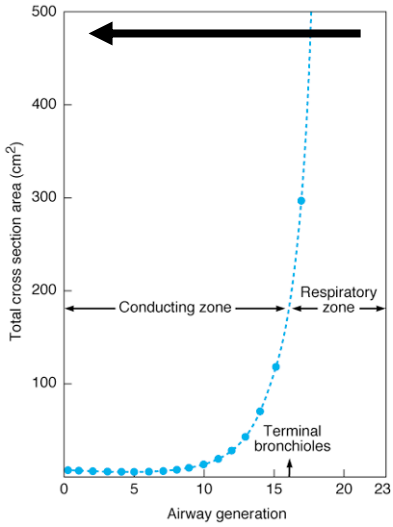
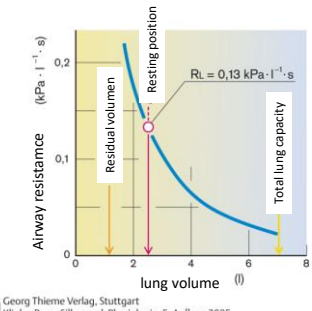
Resistance against airflow





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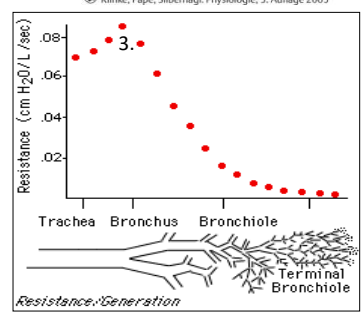

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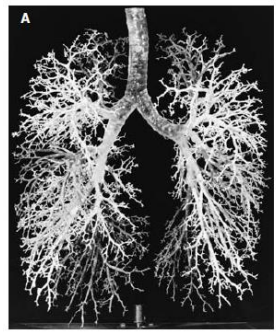
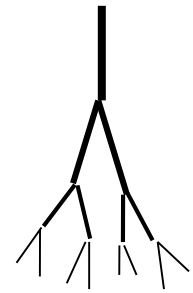
Resistance against airflow





individual diameter > individual diameter

total cross section area << total cross section area

airway resistance > airway resistance

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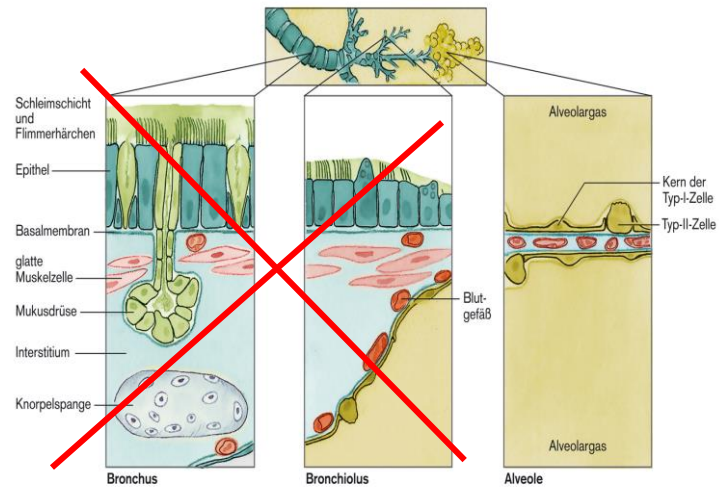
Dead space of respiration



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no gas exchange

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Dead space of respiration

- Anatomical and physiological dead space
- Respiratory rate
- Respiratory minute volume
- Dead space ventilation
- Alveolar minute volume

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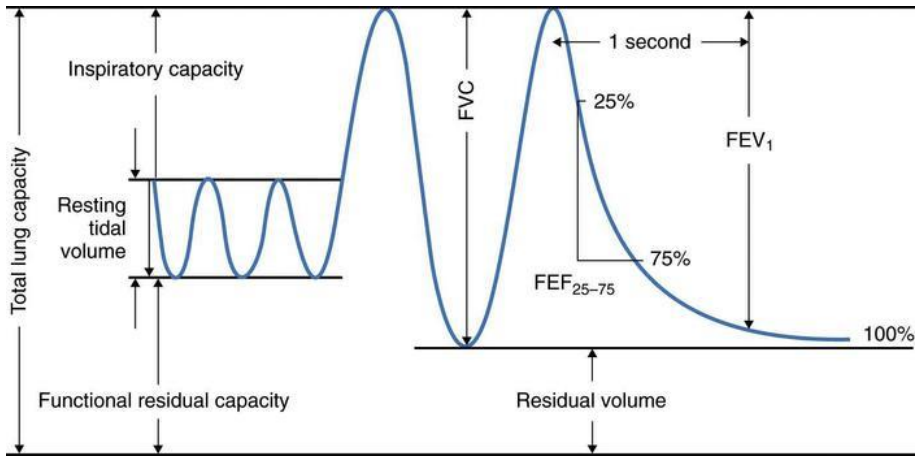
Spirogram: dynamic components



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Timed vital capacity