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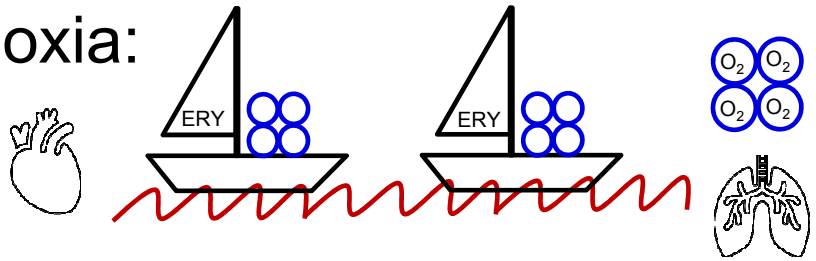
Respiratory system.

A22: Hypoxia and ischemia

- Hypoxia is a general name for a lack of oxygen in the body or individual tissues
- Ischemia, meaning insufficient blood flow to a tissue, can also result in hypoxia
- The most common types of hypoxia:
  - Hypoxic
  - Transport (anemic)
  - Ischemic (stagnation)
  - Histotoxic



ERY: ♀ 3.4 – 4.4 * 10^{12}/l
♂ 4.5 – 5.5 * 10^{12}/l
pO_2: 21kPa

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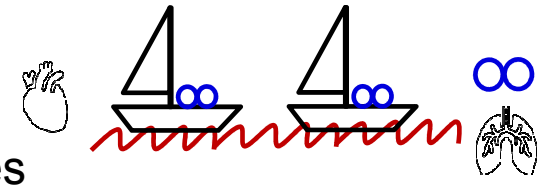
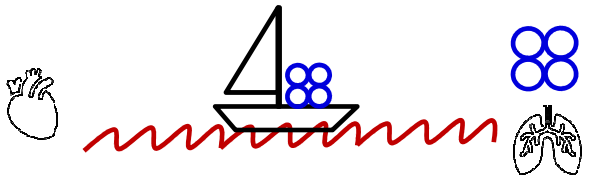
A22: Hypoxia and ischemia

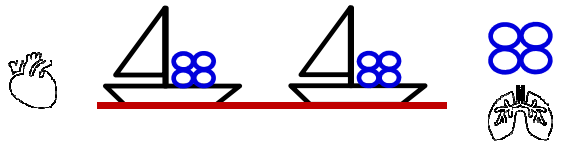
- Hypoxic:
  - physiological: stay at higher altitudes
  - ↓ pO_2; N Ery
  - pathological: hypoventilation during lung or neuromuscular diseases
  - ↓ ventilation; N pO_2; N Ery



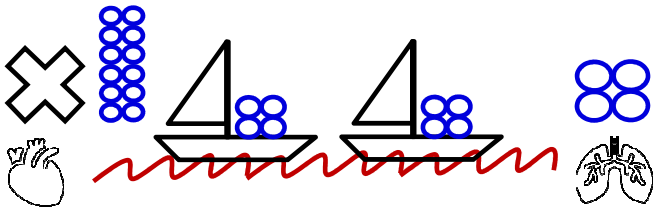
- Transport (anemic):
  - reduced transport capacity of blood for oxygen (anemia, blood loss)
  - N pO_2; ↓ Ery/Hb



- Ischemic (stagnation):
  - restricted blood flow to tissue (heart failure, obstruction of an artery)
  - N pO_2; N Ery



- Histotoxic
  - cells are unable to utilize oxygen (cyanide poisoning)
  - N pO_2; N Ery



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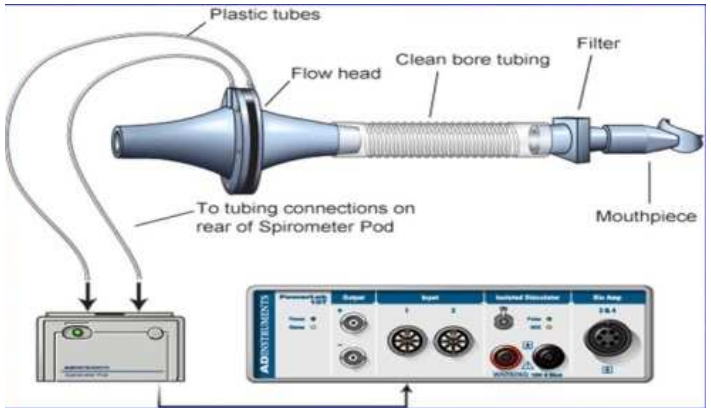
A25: Lung ventilation, volumes, measurement

- *Ventilation*, or breathing, is the movement of air through the conducting passages between the atmosphere and the lungs
- Principle: determination the air flow velocity from the measured pressure differences between the inner and outer spirometer membranes, the volumes being calculated (PowerLab spirometry)



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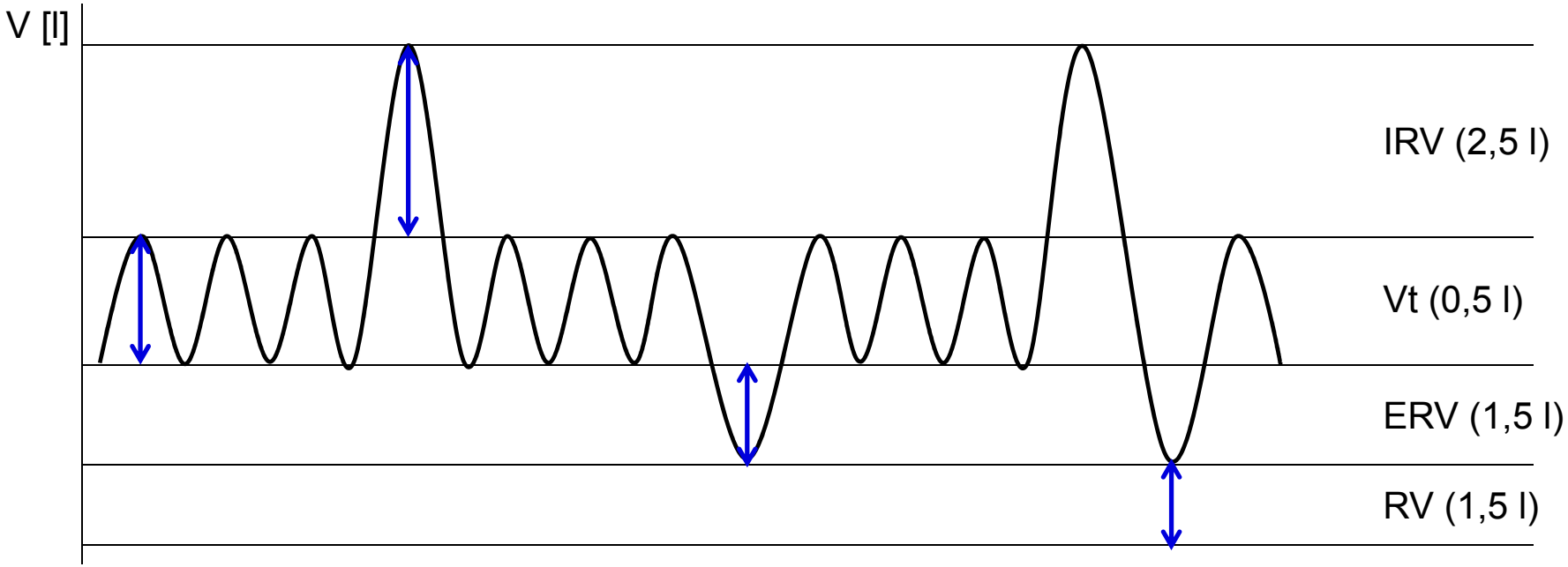
A25: Lung ventilation, volumes, measurement



- ***Tidal volume* (TV)** – the volume of air that enters the lungs during each inspiration (or the volume that is exhaled during every expiration).
- ***Inspiratory reserve volume (IRV)*** – the maximal amount of additional air that can be drawn into the lungs by determined effort after a normal inspiration at rest.
- ***Expiratory reserve volume (ERV)*** – the additional amount of air that can be exhaled from the lungs by determined effort after a normal expiration.
- ***Residual volume (RV)*** – the volume of air still remaining in the lungs after the most forcible expiration possible.

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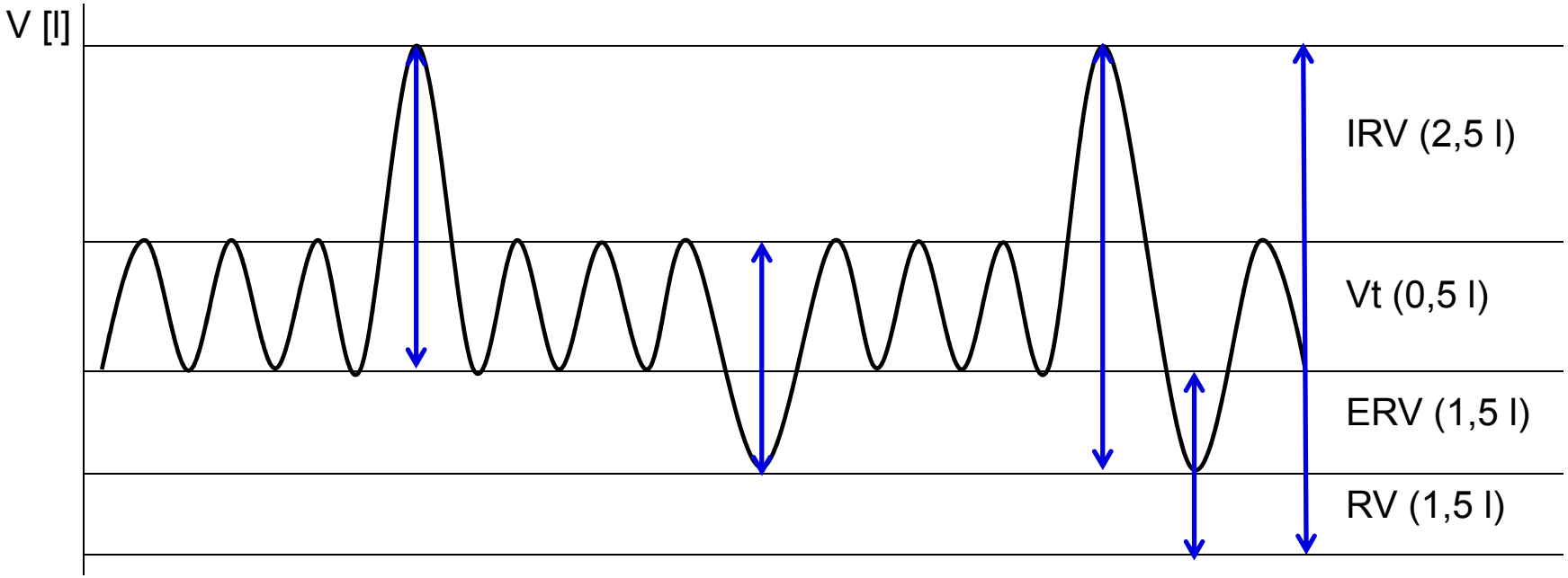
A25: Lung ventilation, volumes, measurement



Lung capacity:

- *VC = VT + IRV + ERV*
- *TLC = VC + RV*
- *FRC = ERV + RV*
- *IC = IRV + VT*
- *EC = ERV + VT*

Dynamic lung volumes:

- VE
- MMV

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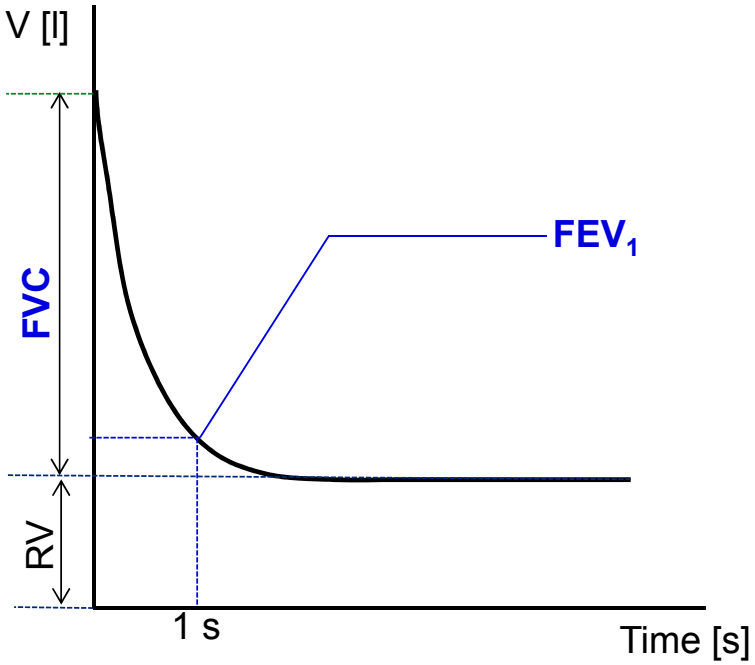
A25: Lung ventilation, volumes, measurement

Dynamic lung volumes



- **FVC** – the maximum volume of air that can be exhaled after maximum inhale
- **FEV_1** – the volume of air exhaled with the greatest effort in 1 second after maximum inhale
- **FEV_1/FVC (%)** – Tiffeneau index – around 0,8 (80 %)

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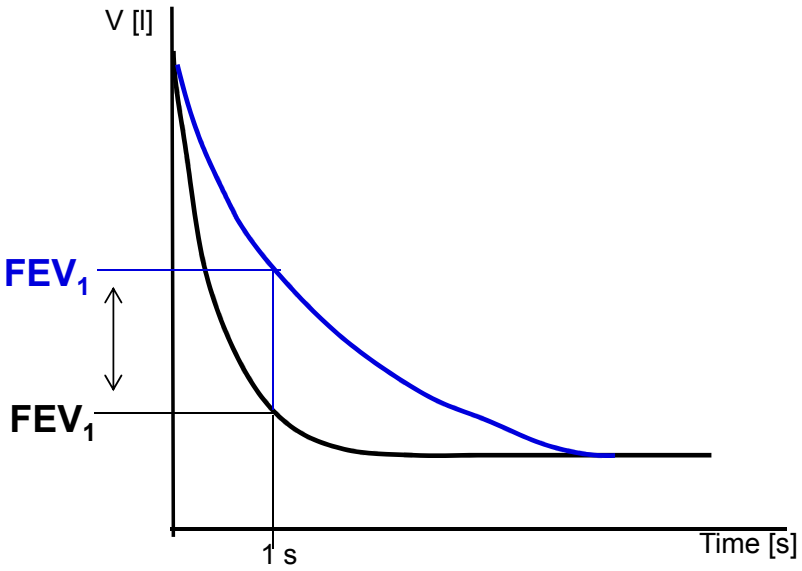
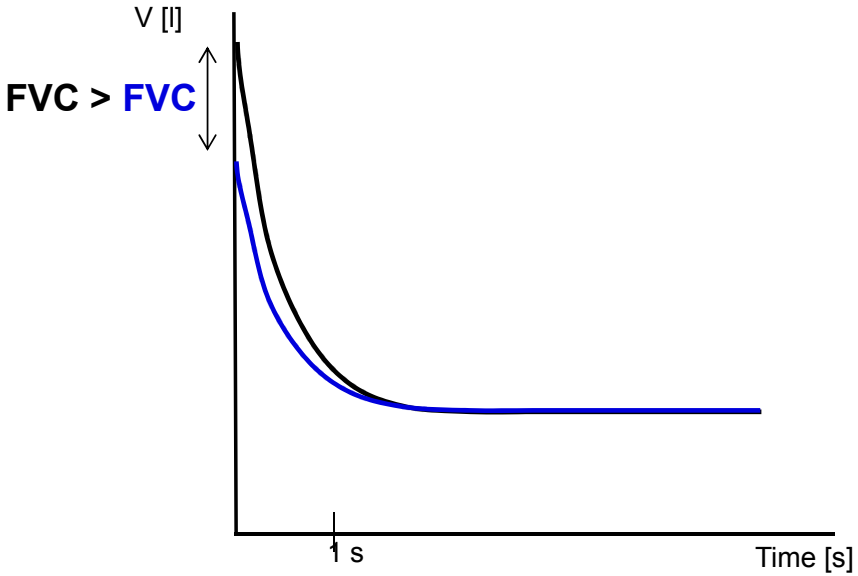
A25: Lung ventilation, volumes, measurement



Obstruction lung disease
(FVC=N; FEV_1=↓)
- tracheal stenosis
- astma bronchiale
- CHOPN
- tumor



Restrictive lung disease
(FVC=↓; FEV_1=N)

Pulmonarzy etiology
- pulmonary fibrosis
- lung resection
- pulmonary edema
- pneumonia

Extrapulmonary etiology
- ascites
- kyphoscoliosis
- burns
- high diaphragm condition

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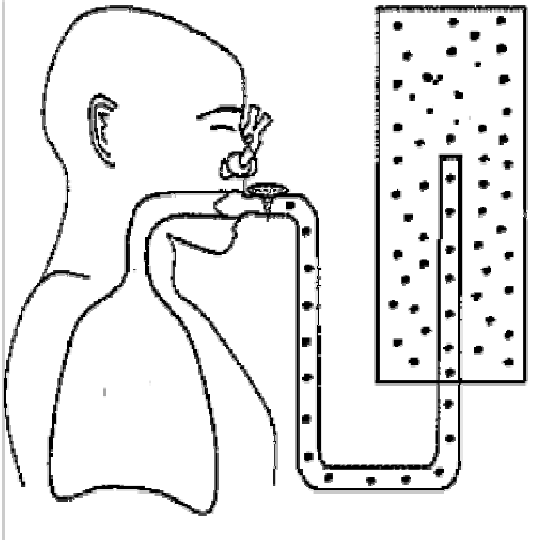
A25: Lung ventilation, volumes, measurement

Helium dilution method – residual volume

V_1
c_1

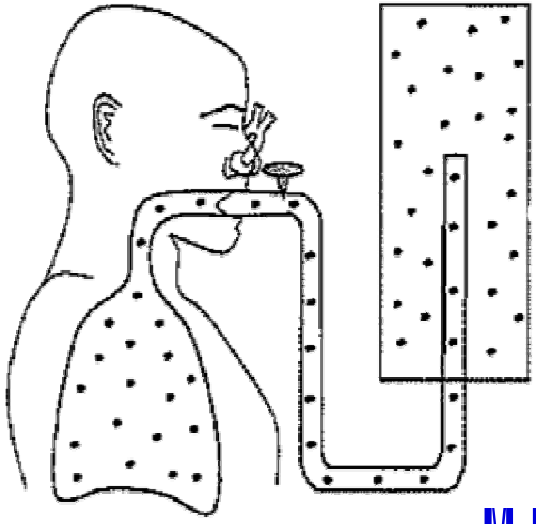


$$c=\frac{n}{V}$$

$$V_1 \times c_1 = (RV + V_1) \times c_2$$

$$RV = \frac{V_1 \times c_1}{c_2} - V_1$$

$V_2=RV+V_1$
c_2



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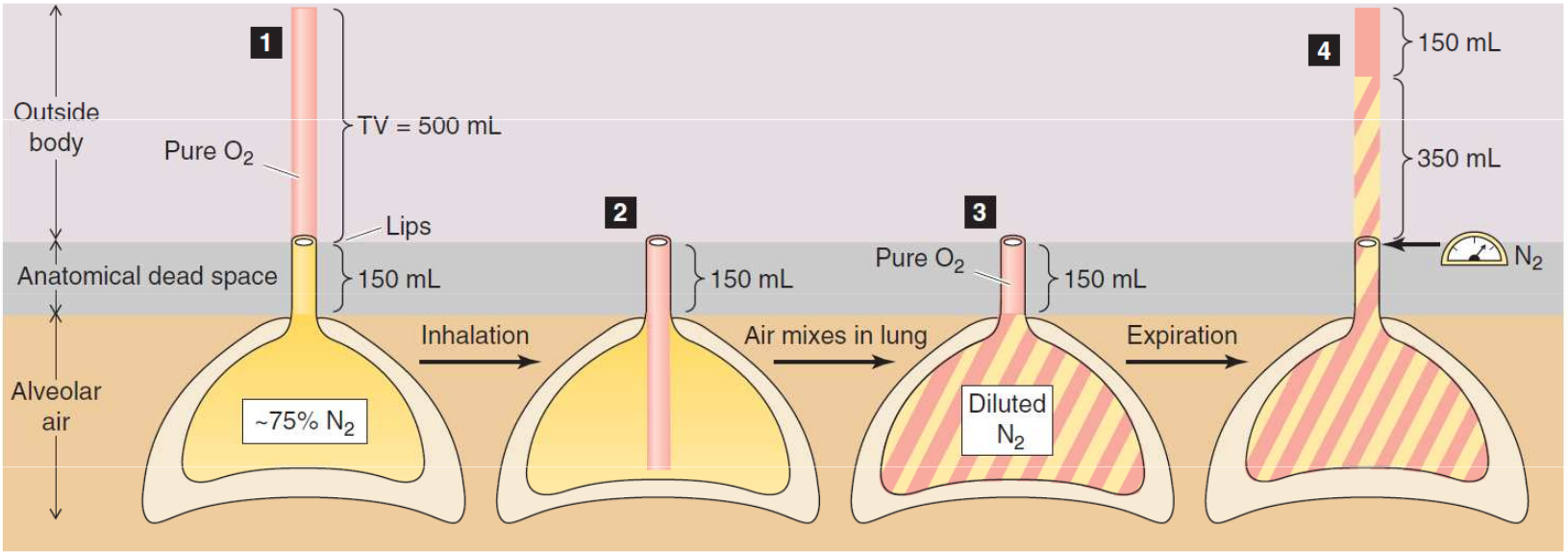
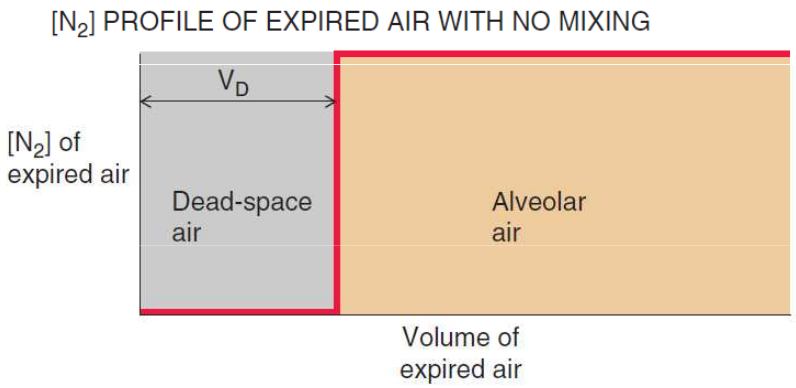
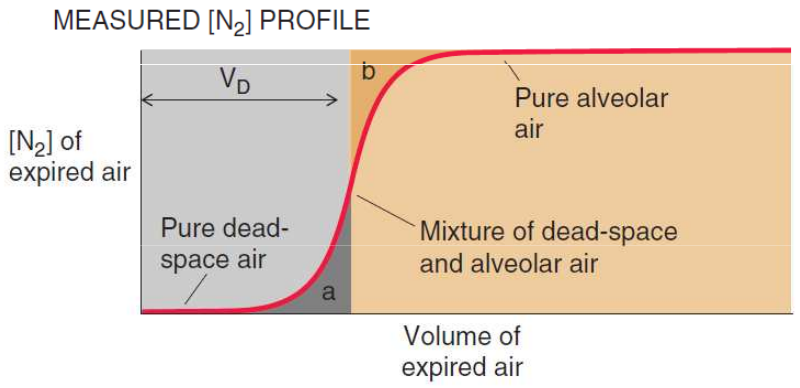
A26: Dead space, measurement







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A46: Compliance of lungs. Respiratory work. Pneumothorax

- According to etiology:
  - **traumatic** pneumothorax (due to an injury) occurs if the chest wall is perforated or during an injury of the esophagus, bronchi, and during rib fractures.
  - **spontaneous** pneumothorax
  - **primary** idiopathic pneumothorax (without any known cause) may occur in tall healthy young men with an incidence of pneumothoraxes in the family,
  - **secondary** pneumothorax arises as a consequence of lung diseases (such as COPD or cystic fibrosis),
  - **iatrogenic** pneumothorax (due to medical procedures) occurs during invasive medical examinations such as transparietal aspiration biopsy, subclavian vein catheterization, or mechanical ventilation with positive pressure.
  - **artificially induced** (deliberate) pneumothorax is used during thoracoscopy, an endoscopic examination the thoracic cavity.
- According to the communication of the pleural space with its surroundings
  - **open pneumothorax** (when the hole in the pleural space remains open, the air in the pleural cavity moves back and forth with each breath of the patient)
  - **closed pneumothorax** (when a small opening through which air enters the pleural cavity closes)
  - **valvular pneumothorax** (the tissue of the lungs or the chest wall covers the hole in such a way that a valve emerges, this valve allows air to flow inside during inspiration, but it prevents the air from leaving the pleural cavity during exhalation).

A47: Composition of atmospheric and alveolar air. Gas exchange in lungs and tissues.

COMPOSITION OF DRY ATMOSPHERIC AIR

O_2	20.95 %	$F_{O2} \cong 0,21$
N_2	78.09 %	$F_{N2} \cong 0,78$
CO_2	0.03 %	$F_{CO2} \cong 0,0004$

BAROMETRIC PRESSURE IN SEA LEVEL
1 atmosphere = 760 mm Hg

PARTIAL PRESSURE OF DRY AIR IN SEA LEVEL

P_{O2}	= 760 x 0,21	= ~160 mm Hg
P_{N2}	= 760 x 0,78	= ~593 mm Hg
P_{CO2}	= 760 x 0,0004	= ~ 0,3 mm Hg

12 1 *kPa* = 7,5 *mm Hg (torr)*

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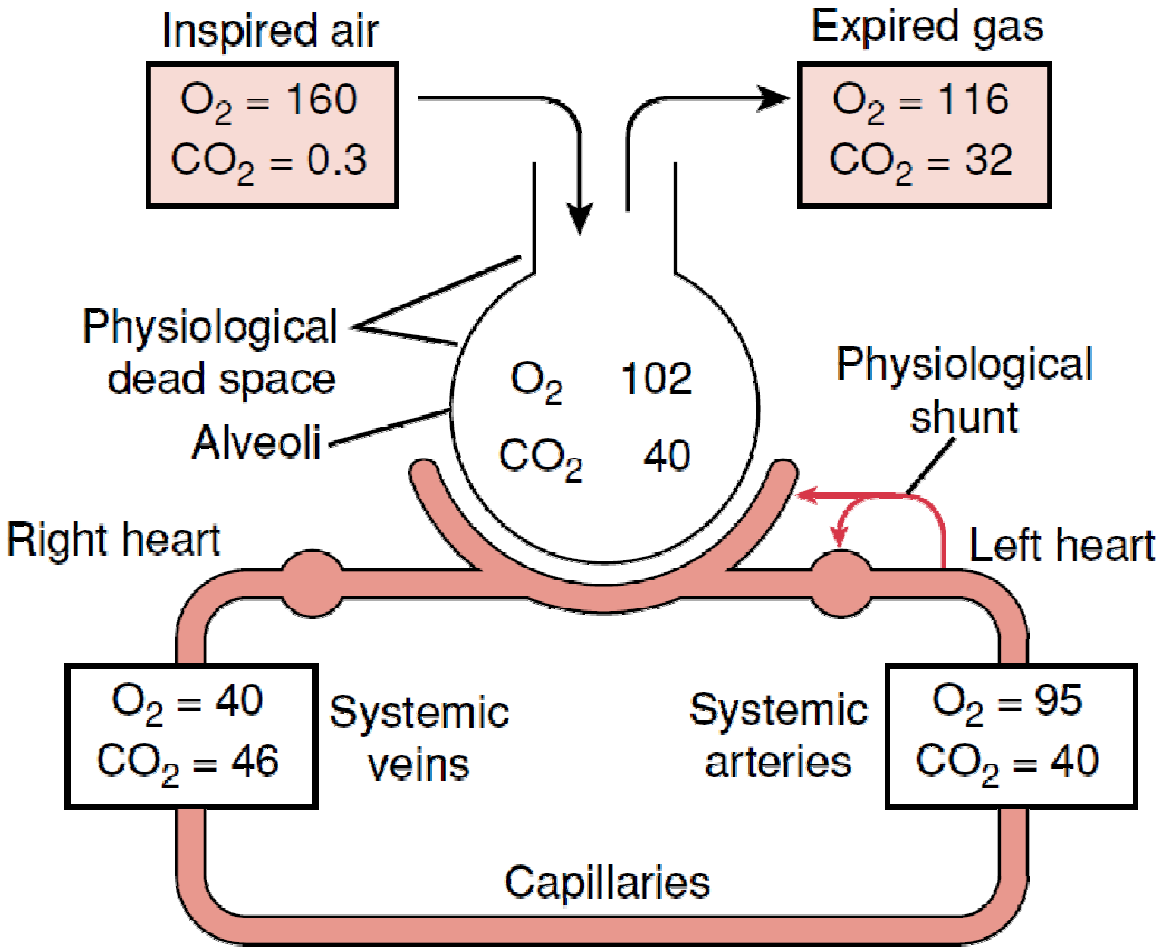
A47: Composition of atmospheric and alveolar air. Gas exchange in lungs and tissues.



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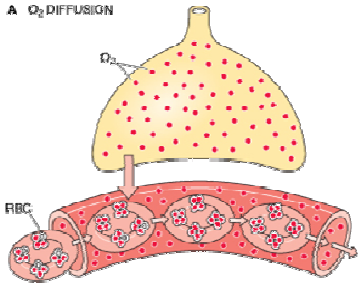
A48: Transport of O2. Oxygen - haemoglobin dissociation curve. Transport of CO2



O_2 is transported in two forms :

- physically dissolved(1%)
- in chemical bond with Hb (99%)

- Fetal hemoglobin(2α, 2γ)
- Methemoglobin (Fe^{3+})
- Carboxyhemoglobin (CO)
- Carbaminohemoglobin (CO_2)
- Oxyhemoglobin (O_2)
- Deoxyhemoglobin (without any gases)

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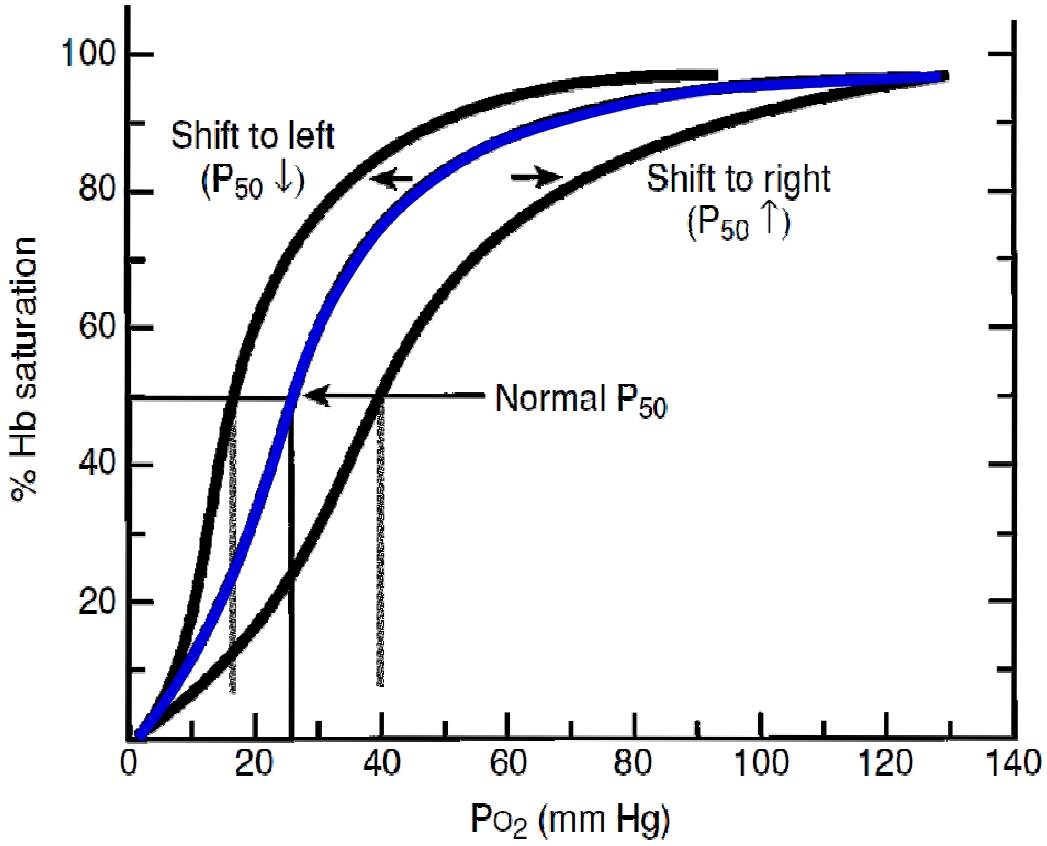
A48: Transport of O2. Oxygen - haemoglobin dissociation curve. Transport of CO2



Dissociation curve of Hb is influenced by:

- pH of blood
- pCO_2 of blood
- Temperature
- Concentration of 2,3 - BPG

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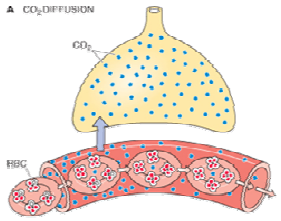
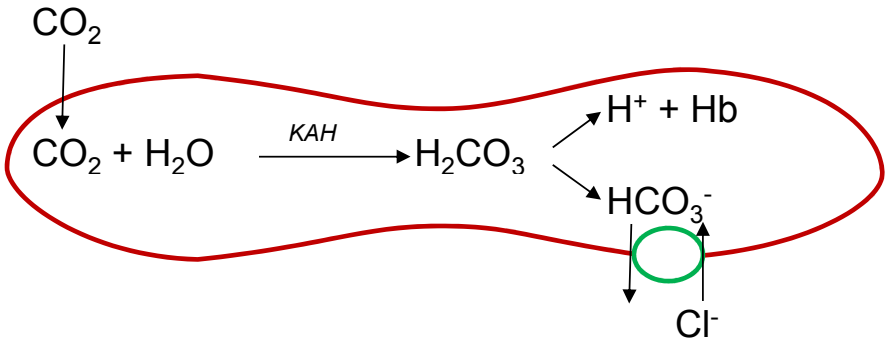
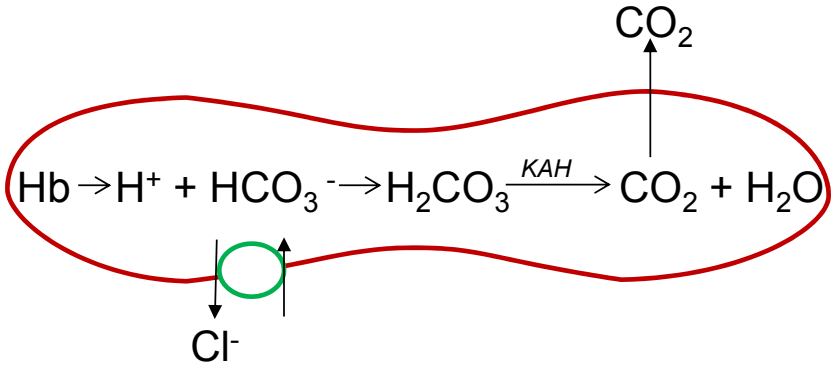
A48: Transport of O2. Oxygen - haemoglobin dissociation curve. Transport of CO2



CO_2 is transported in next forms :

- physically dissolved(5 %)
- in the form of bicarbonate anions (85%)
- in chemical bond with Hb (10%)





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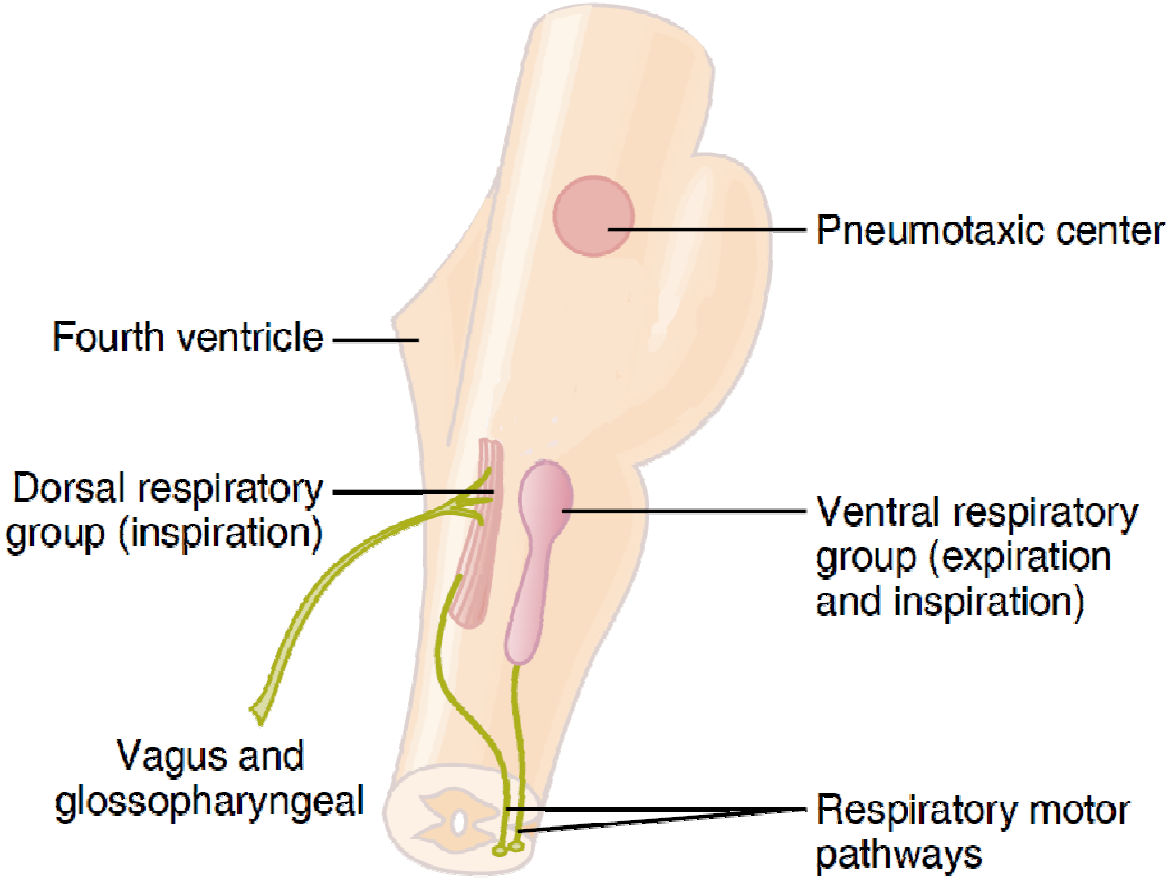
A49: Regulation of ventilation



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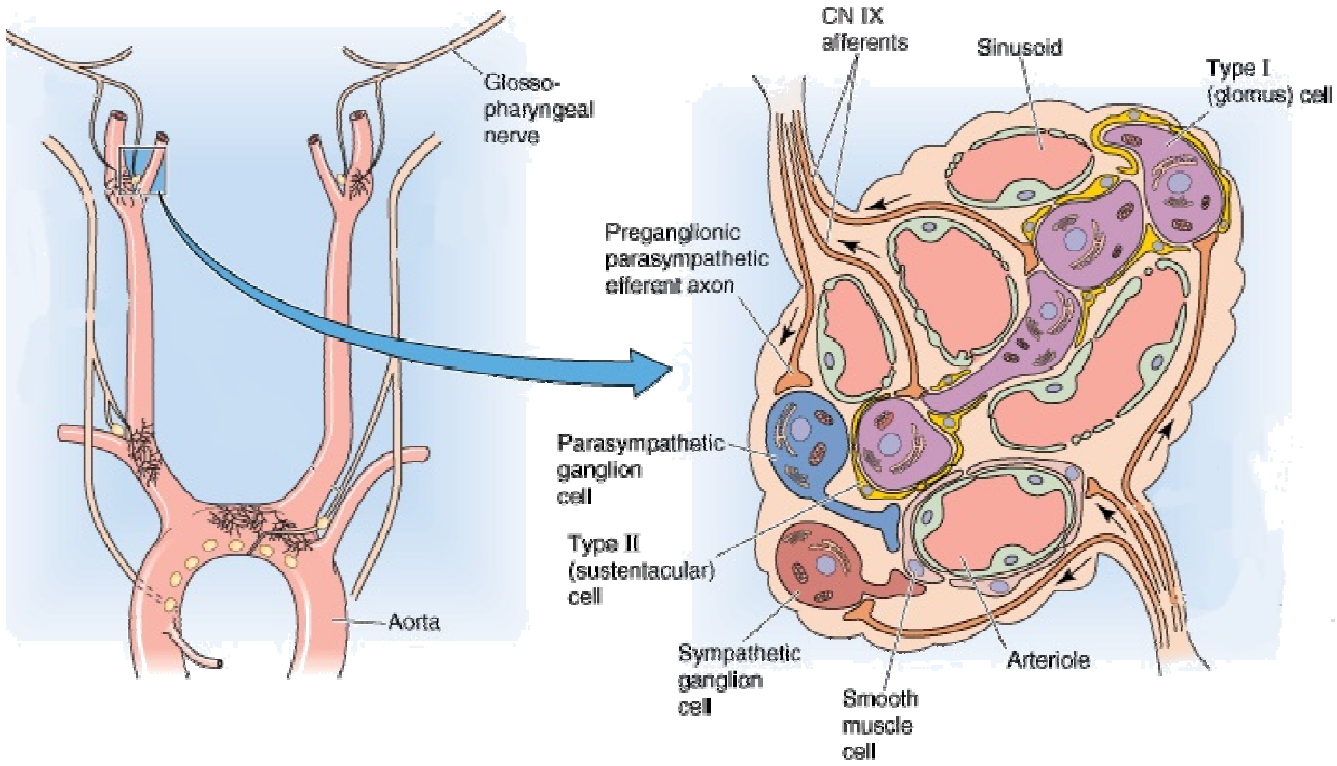
A49: Regulation of ventilation



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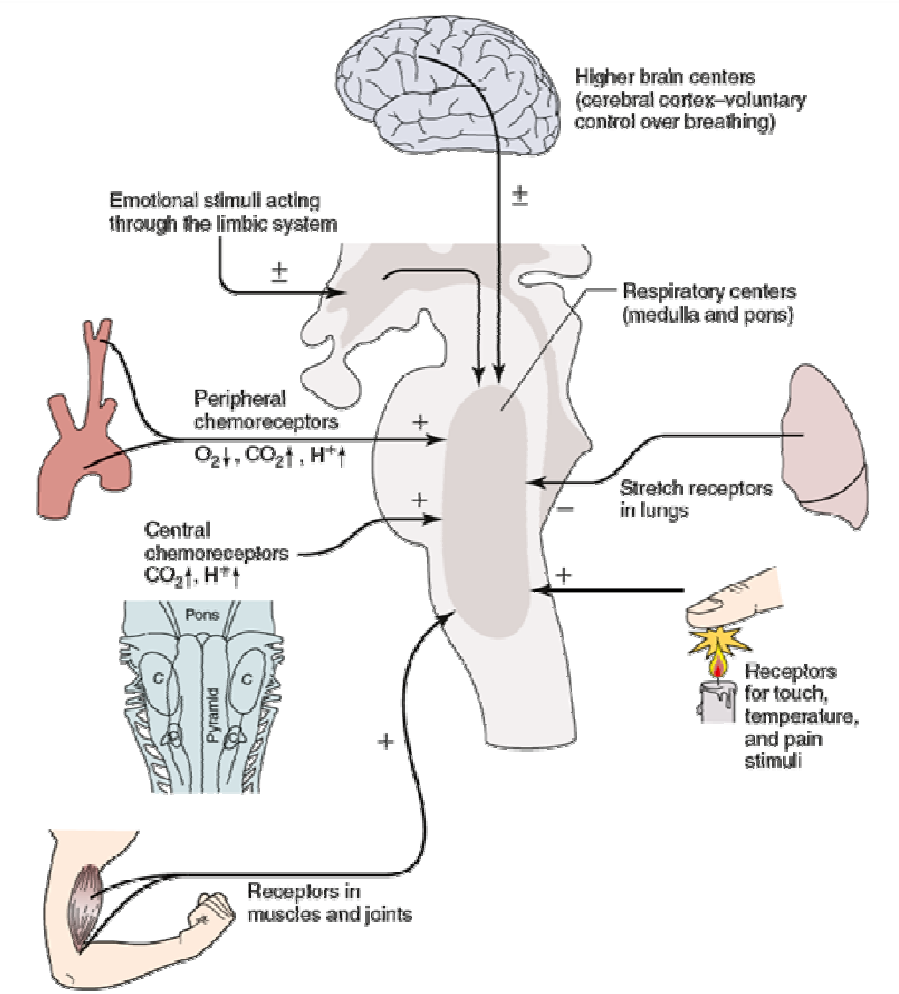
A49: Regulation of ventilation



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