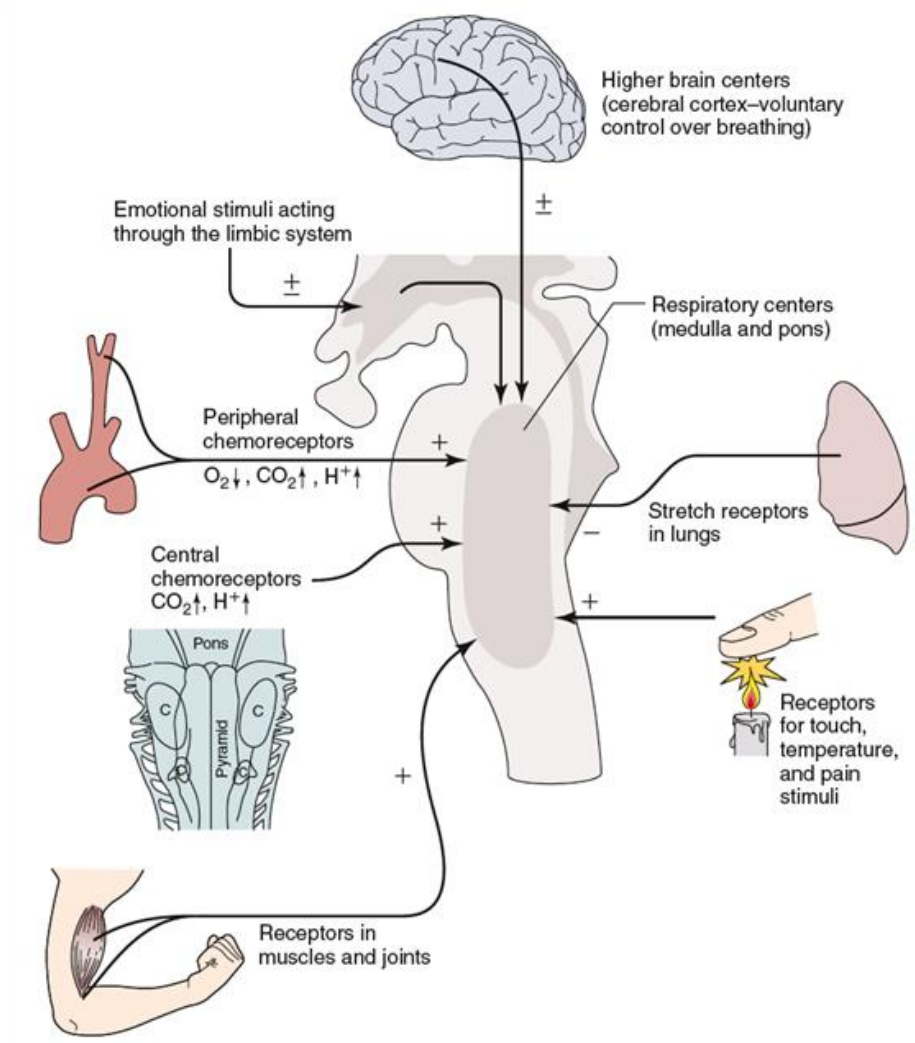
Determination of the sensitivity of the respiratory center to hypoxia and to hypercapnia

Control of ventilation



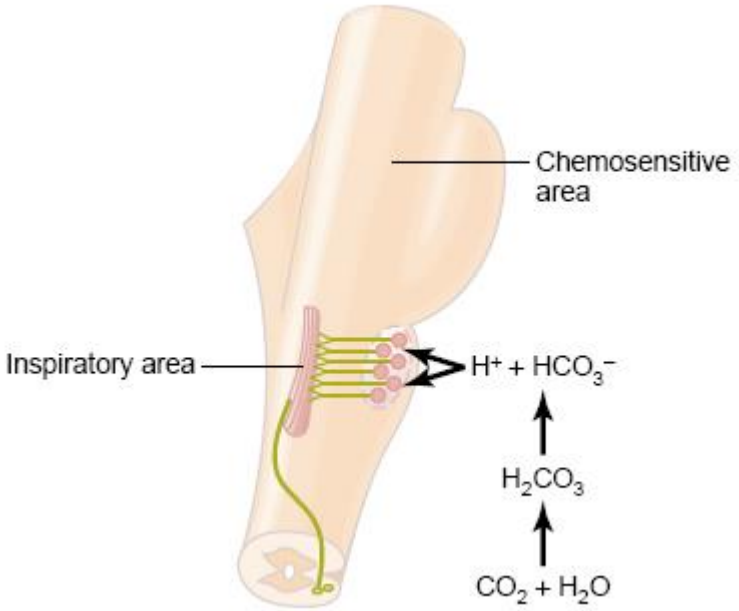
https://sleep.sharepoint.com/siteimages/Chapter%203.png

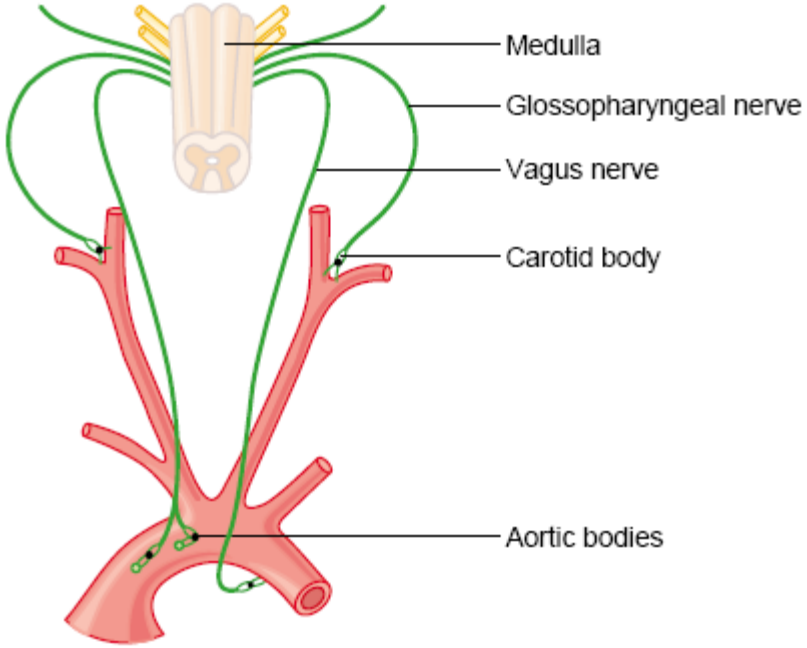
- Breathing is an automatic process that takes place unconsciously. Automaticity of breathing comes from regular (rhythmic) activity of groups of neurons anatomically localized in the medulla and its vicinity. They can be divided into three main groups:
  - *dorsal respiratory group* – placed bilaterally on the dorsal side of the medulla oblongata, only inspiratory neurons, sending axons to motoneurons of inspiratory muscles (diaphragm, external intercostal muscles; their activation=inspiration, their relaxation=expiration; participates on inspiration at rest and forced inspiration
  - *ventral respiratory group* - located on the ventrolateral part of the medulla oblongata, the upper part: neurons whose axons of motor neurons activate the main and auxiliary inspiratory muscles; the lower part: expiratory neurons which innervate expiratory muscles (internal intercostal muscles). Neurons in this group operate only during forced inspiration and forced expiration.
  - *Pontine respiratory group - pneumotaxic center -* dorsally placed on top of the pont, contributes to the frequency and depth of breathing; affects the activity of respiratory neurons in the medulla oblongata.

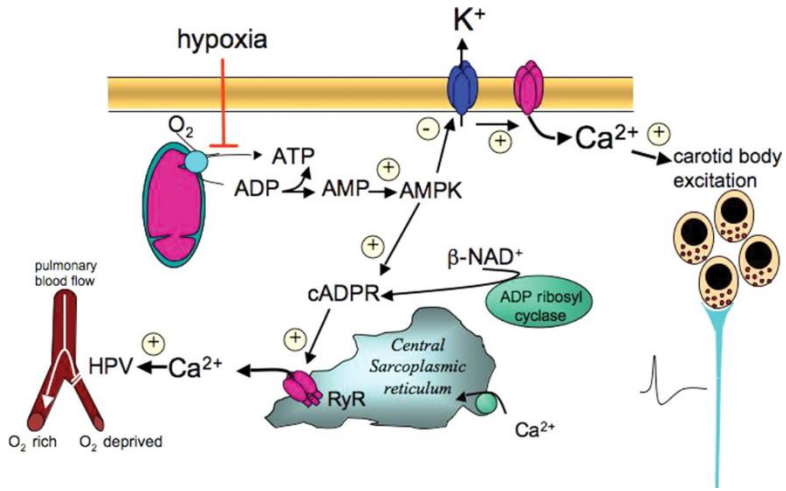
Chemical factors affecting the respiratory center:

Central chemoreceptors

- on the front side of the medulla
- sensitive only to increase of arterial pCO_2 (by increasing H^+)
- central chemoreceptor are stimulated by other types of acidosis (lactate acidosis, ketoacidosis)
- pCO_2 sudden change does not take effect immediately, changes in ventilation through central chemoreceptors occur after 20-30 s







Peripheral chemoreceptors

– located in the aortic and carotid bodies

-primarily sensitive to decrease in arterial pO_2, particularly to decrease of O_2 under 10-13 kPa in the arterial blood.

They convey their sensory information to the medulla via the vagus nerve and glossopharyngeal nerve.

Mechanism of action: Decreased ATP production in mitochondria leads to depolarization of receptors membrane and to excitation of chemoreceptor

http://www.medicine.mcgill.ca/physio/resp-web/sect8.htm,

Hypoxia, hypoxemia

11-16 kPa

- Hypoxia is a general name for a lack of oxygen in the body or individual tissues.
- Hypoxemia is lack of oxygen in arterial blood.
- Complete lack of oxygen is known as anoxia.

The most common types of hypoxia:

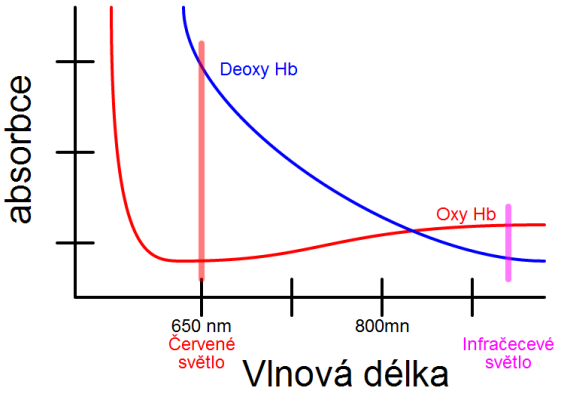
1. Hypoxic - physiological: stay at higher altitudes, pathological: hypoventilation during lung or neuromuscular diseases
2. Transport (anemic) - reduced transport capacity of blood for oxygen (anemia, blood loss, CO poisoning)
3. Ischemic (stagnation) - restricted blood flow to tissue (heart failure, shock states, obstruction of an artery)
4. Histotoxic - cells are unable to utilize oxygen (cyanide poisoning - damage to the respiratory chain)

Hypercapnia 5.3-6.65 kPa

- Hypercapnia - increase of concentration of carbon dioxide in the blood or in tissues that is caused by retention of CO_2 in the body
- possible causes: total alveolar hypoventilation (decreased respiration or extension of dead space)
- mild hypercapnia (5 -7 kPa) causes stimulation of the respiratory center (therapeutic use: pneumoxid = mixture of oxygen + 2-5% CO_2)
- hypercapnia around 10 kPa - CO_2 narcosis - respiratory depression (preceded by headache, confusion, disorientation, a feeling of breathlessness)
- hypercapnia over 12 kPa - significant respiratory depression - coma and death.

Pulse oxymetry

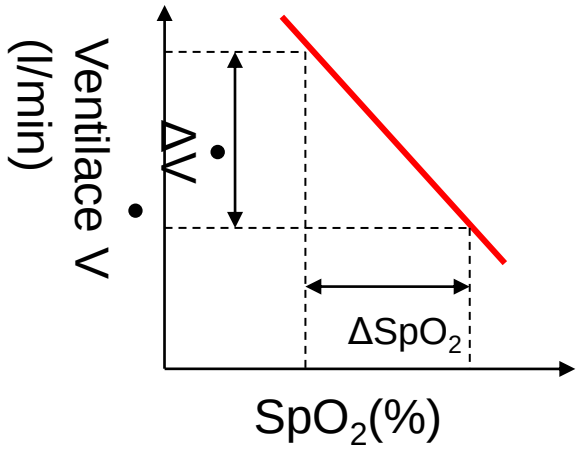
- Is a photometric non-invasive method of measuring the oxygen saturation of hemoglobin in the arterial circulation.
- The method is based on evaluation of the absorption of light of two different wavelengths after passage through the tissue (finger, ear lobe). Reduced hemoglobin absorbs more light at a wavelength of 660 nm (red spectrum), oxygenated hemoglobin at 940 nm (infrared spectrum).
- Thus the pulse oxymeter emits beams of two wavelengths to the tissue and different absorption ratios are the basis for calculating the factor by which the final value of hemoglobin saturation is obtained .
- To achieve the targeted measurement of saturation values only in arterial blood, the measured values between the individual pulses from the value at the peak of the pulse (pulse wave) is further used for reading. Calculated component is then equal to the absorption of the variable component, which is arterial blood.



Pathology <90% SpO_2

I. Determination of the sensitivity of the respiratory center to hypoxia

- Objective is to demonstrate changes in ventilation during induction of hypoxia and to compare the sensitivity of the respiratory center by different subjects.
- Hypoxia is induced by re-breathing of air expired into Krogh respirometer, wherein (when closed circuit of respirometer is used) naturally decreases O_2 concentration (to avoid rise of the CO_2 soda lime which absorbs CO_2 is inserted into Krogh respirometer).
- The sensitivity of the respiratory center is expressed as Ks parameter that indicates the slope of the curve



$$K_s = \frac{\Delta V}{\Delta SpO_2}$$

II. Determination of the sensitivity of the respiratory center to hypoxia

- Objective is to demonstrate the changes in ventilation during induced hypercapnia and to compare the sensitivity of the respiratory center to hypercapnia in several subjects.
- Hypercapnia is induced by re-breathing of air expired into Krogh respirometer with closed circuit (Krogh respirometer with oxygen, without the soda lime - naturally decreases the concentration of O_2 and CO_2 increases)
- Interpretation: The slope of the curve shows the sensitivity of the respiratory center to hypercapnia (see hypoxia)
- Clinical Note: the sensitivity of the respiratory center to change of partial pressure of CO_2 is reduced in patients with chronic end-stage lung disease, in patients with heart failure as well as in subjects training breath holding (e.g. divers without oxygen tanks).