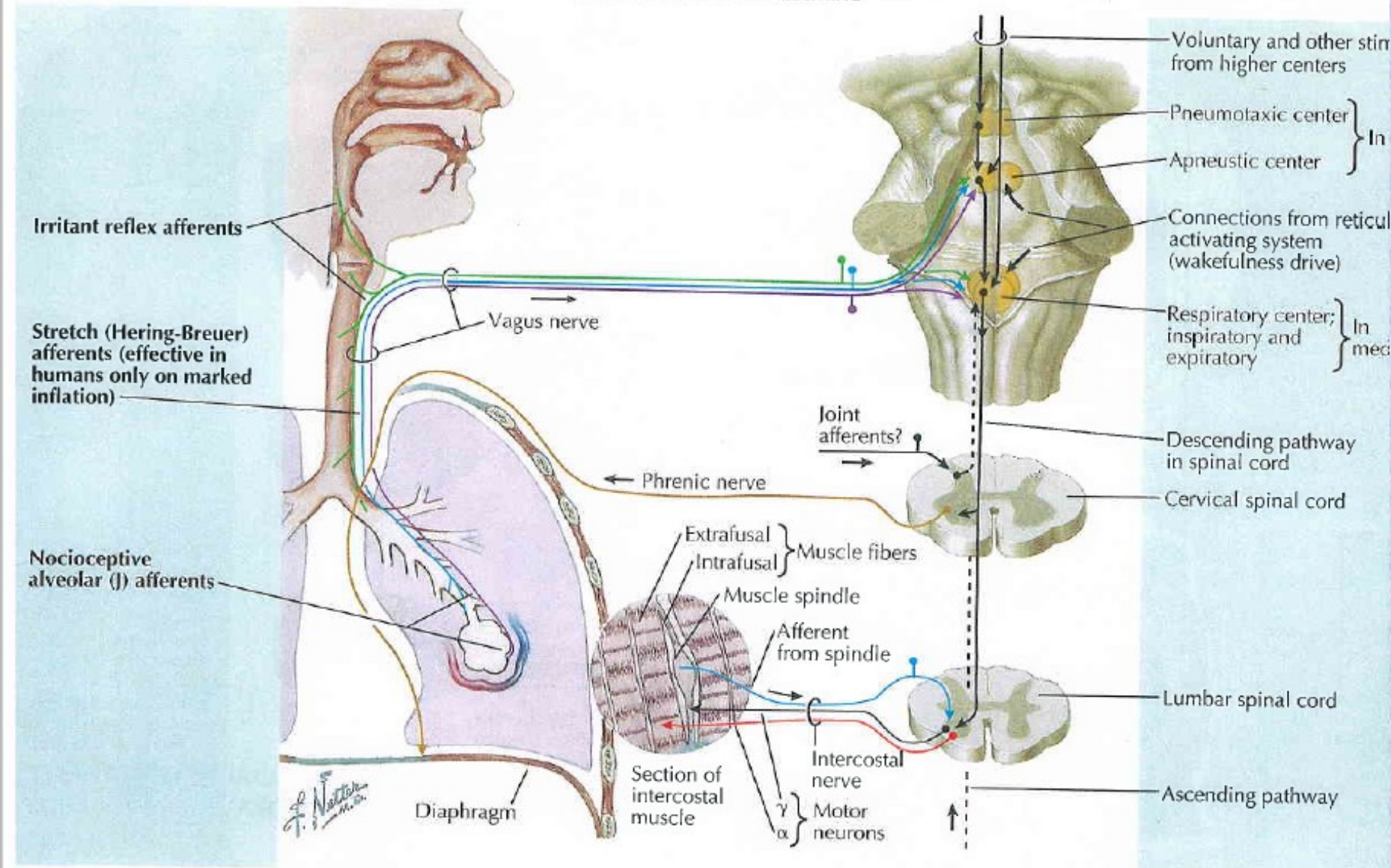
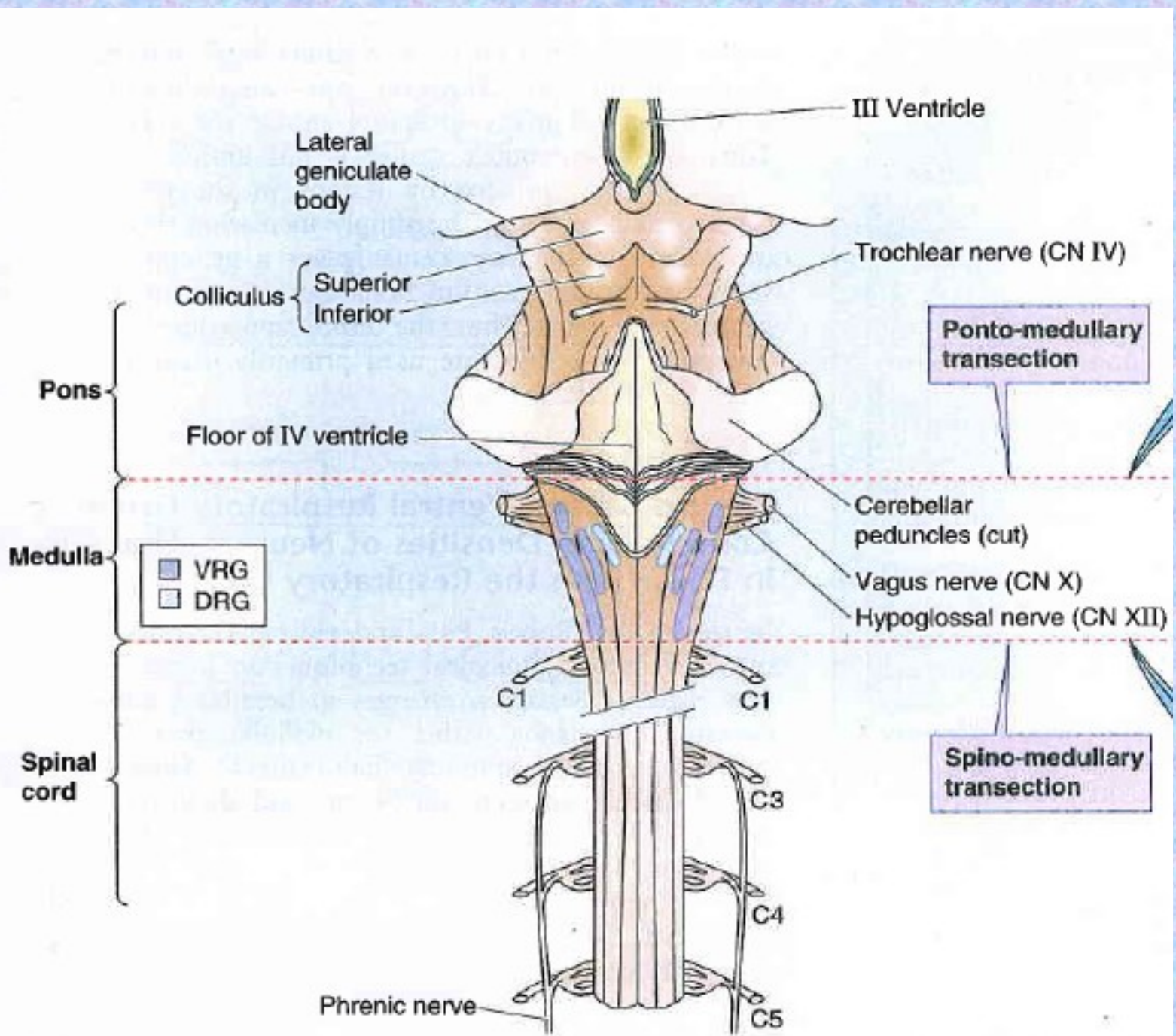


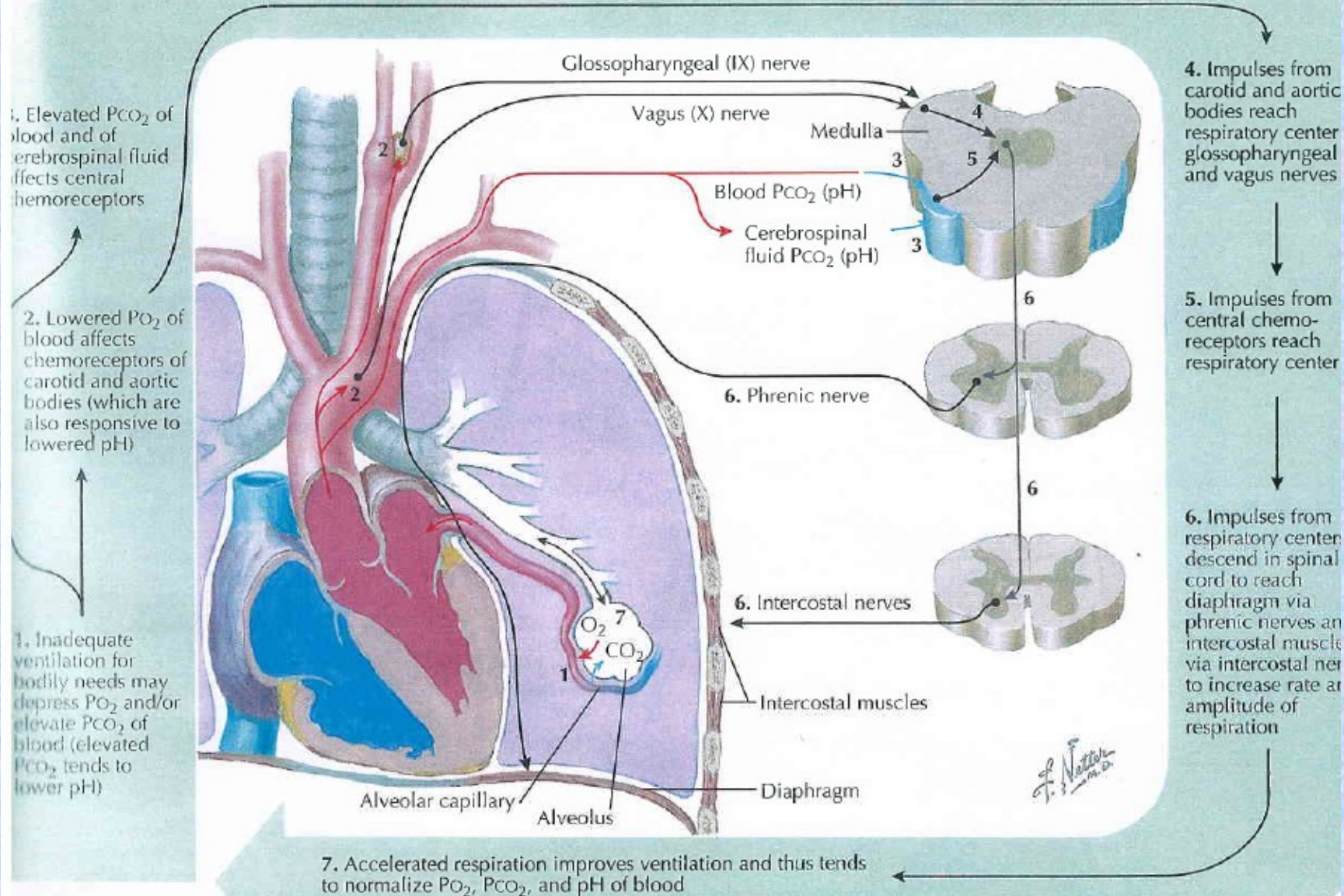
**Respiration under various  
(physiological) condition**

NEURAL CONTROL OF BREATHING





## CHEMICAL CONTROL OF RESPIRATION (FEEDBACK MECHANISM)



# Modulation of respiratory output

Major parameters for feedback control – classical gases:  $pO_2$ ,  $pCO_2$ , pH

In addition to these, the respiratory system receives input from two other major sources:

- 1. variety of stretch and chemical/irritant receptors** that monitor the size of airways and the presence of noxious agents receptors in respiratory system
- 2. Higher CNS centers** that modulate respiratory activity for the sake of nonrespiratory activities

**Irritants receptors** on mucosa of respiratory system – rapidly adapting

Stimulus: agents - chemical substances (histamine, serotonin, prostaglandins, ammonia, cigarette smoke).

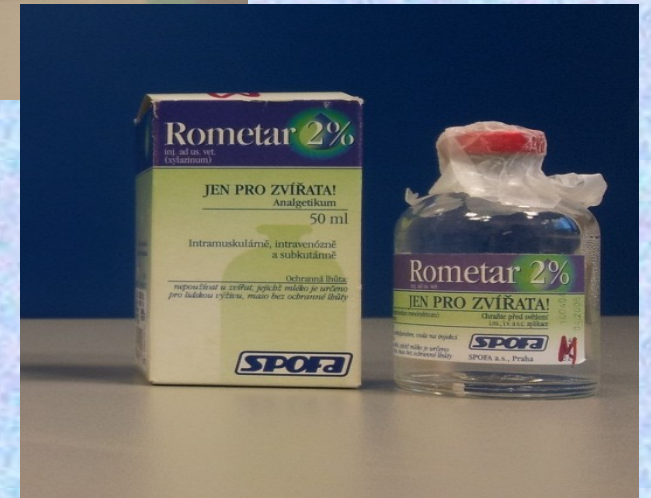
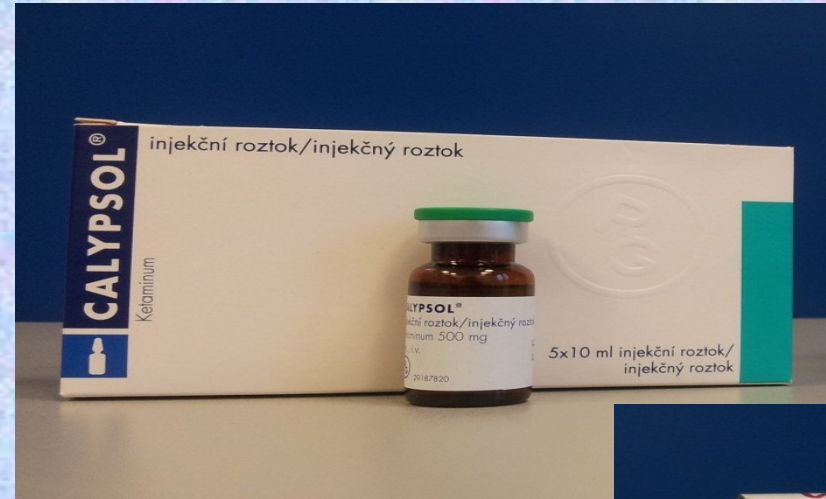
Response: increase mucus secretion, constriction of larynx and bronchus

**C-fibre receptors** (juxtacapillary=J receptors)– free nerve ending of n.vagus (unmyelinated axon) in interstitium of bronchus and alveolus;

Stimulus: Mechanical irritants (pulmonary hypertension, pulmonary oedema)+chemical

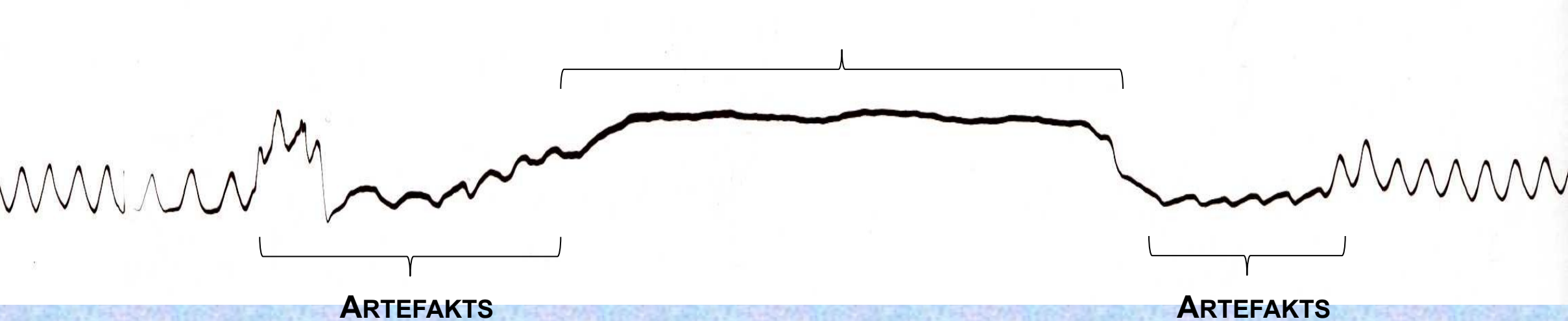
Response: hypopnoea, rapid shallow breathing, bronchoconstriction, cough

**Stretch receptors** slowly adapting (mechanoreceptors in tracheobronchial tree that detect the changes in lung volume by sensing the stretch receptors of the airway wall), inform to brain about the lung volume to optimize respiratory; its irritants triggered decrease activity of respiratory centre – **Hering-Breuer's reflexes**. (protecting the lungs from overinflation/deflation)

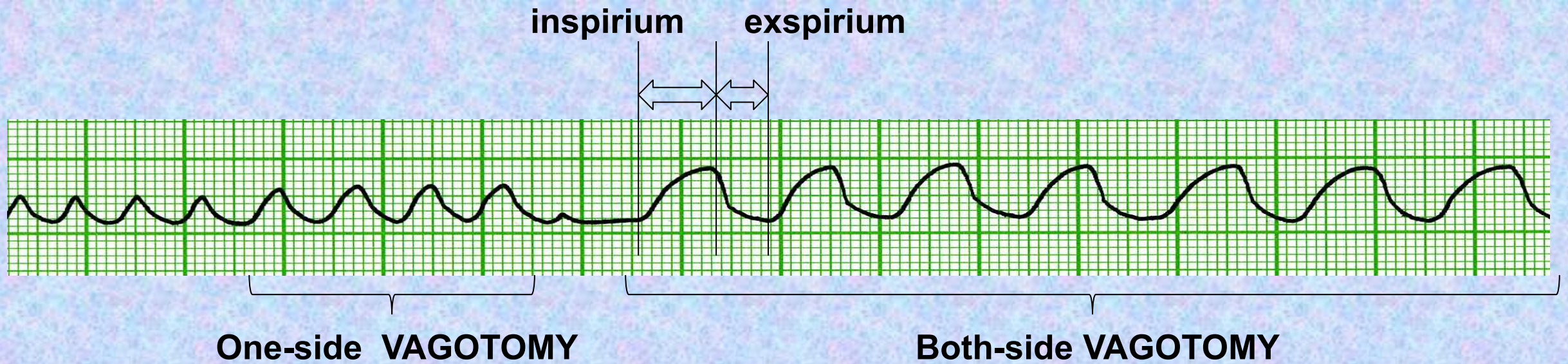


# HERING-BREUER REFLEX

## REFLEX STOP BREATHING



# VAGOTOMY



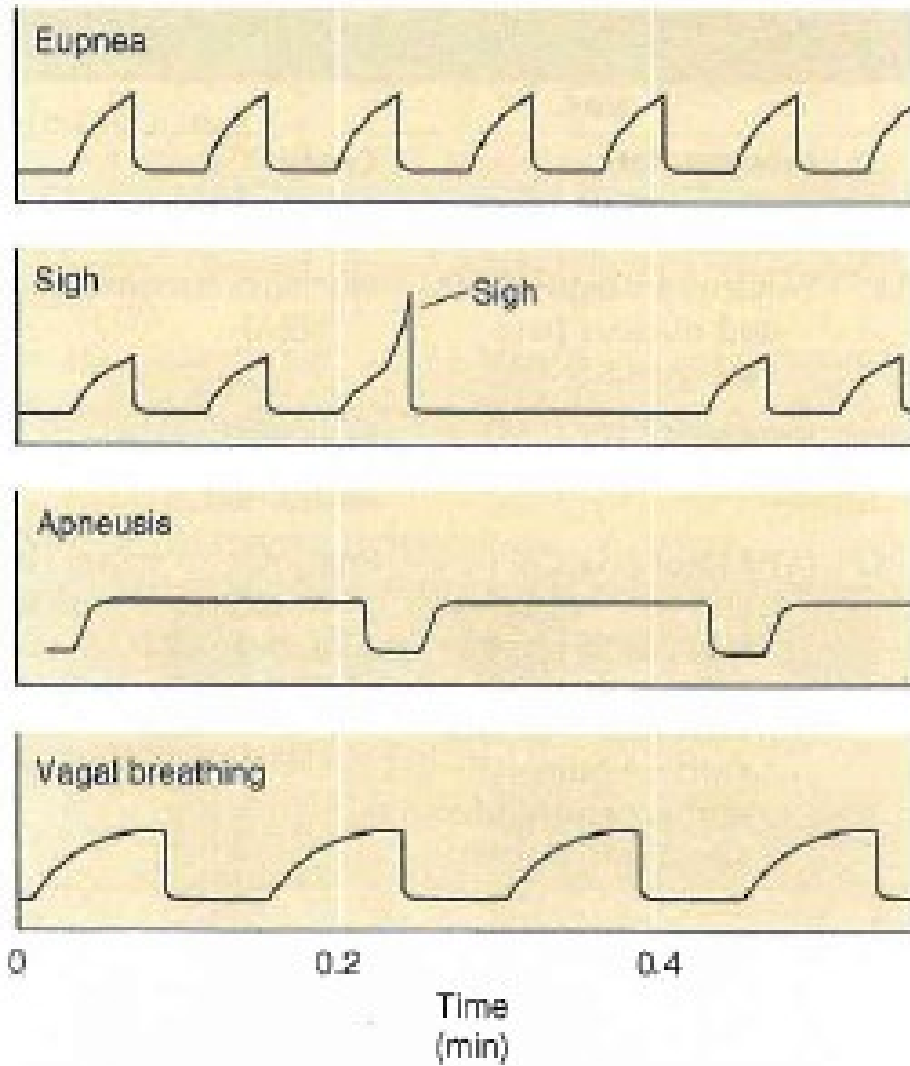


# Periodic breathing

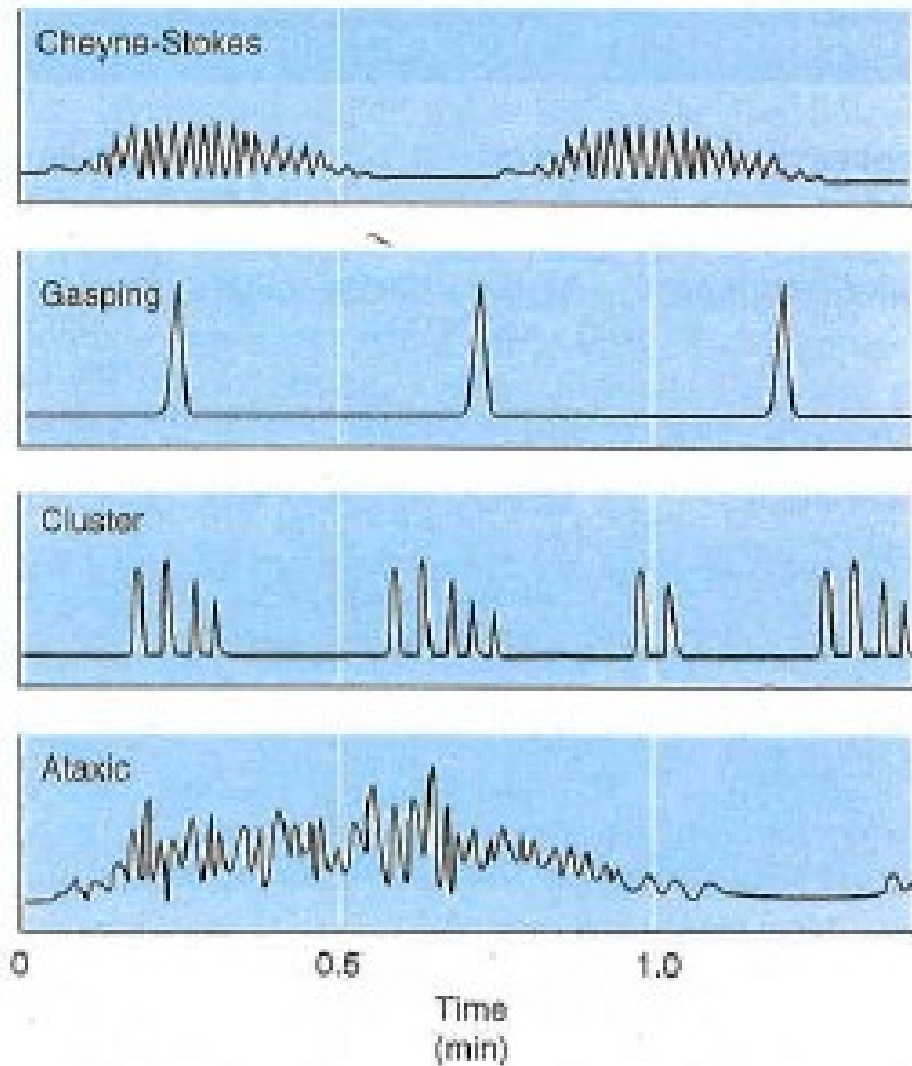
(period of apnea followed again by a few breaths)

- CHEYNE-STOKES
- BIOT'S
- „gaspig“
- KUSSMAUL

### A INTEGRATED PHRENIC NERVE ACTIVITY



### B LUNG VOLUME



The respiratory pattern can become abnormal for a variety of reasons. Several of these abnormal patterns have recognizable characteristics:

- Apnea – cessation of respiration
- Eupnea – normal breathing
- Tachypnea – an increase in respiratory rate
- Apneusis (inspiratory) – prolonged inspirations separated by brief expirations
- Ataxic breathing – highly irregular inspirations, often separated by long periods of apnea. Usually seen with medullary lesions.
- Biot breathing – first described in patients with meningitis by Biot (in 1876) - with breaths of nearly equal volume separated by periods of apnea

- Cheyne – Stokes respiration –a benign respiratory pattern. Cycles of a gradual increase in tidal volume, followed by gradual decrease of tidal volume, and than a period of apnea. Seen a bilateral cortical disease or congestive heart failure, or in healthy people during sleep at high altitude
- Cluster breathing - groups of breaths, often of differing amplitude, separated by long periods of apnea
- Gasping – maximal, brief inspiratory efforts separated by long periods of expiration. Seen in severe anoxia, as well as a terminal, agonal breathing pattern in patients with brainstem lesions

- Hyperventilation – an increase of ventilation that decreases arterial  $p\text{CO}_2$ . Seen in pregnancy, panic attacks, metabolic acidosis.
- Kussmaul breathing refers as extremely deep, rapid breathing seen with metabolic acidosis, such as in diabetic ketoacidosis
- Sighs – larger than normal breaths than occur automatically at regular intervals in normal subjects
- Vagal breathing- slow, deep inspirations caused by interruption of vagus nerve input to the brain stem
- Yawn – an exaggerated sigh

# 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<sub>2</sub> 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<sub>2</sub>)
- hypercapnia around 10 kPa - CO<sub>2</sub> narcosis - respiratory depression (preceded by headache, confusion, disorientation, a feeling of breathlessness)
- hypercapnia over 12 kPa - significant respiratory depression - coma and death.

## Cough reflex - defense mechanism

A cough reflex plays important role in ridding the tracheobronchioal tree of inhaled foreign substances

Mechanosensitive and irritants receptors in the larynx can trigger either coughing or apnea

The tickling sensation that is relieved by a cough is analogous to the cutaneous itch, and its probabaly mediated by C-fiber receptors. Thus, a cough is a respiratory scratch.

When lower airway receptors trigger a cough, it begins with a small inspiration that increases the coughing force. Than laryngeal receptors trigger the cough, inspiration is absent, minimizing the chances that offending foreign body will be forced lower into the lungs. A forced expiratory effort against a closed glottis raises intrathoracic and intraabdominal pressures to very high levels. The glottis than opens suddenly. And the pressure inside the larynx falls almost instantaneously to near-atmospheric levels



# Sneeze

Sensors in the nose detect irritants and can evoke a sneeze.

Notice: the same receptors are probably also responsible for apnea in response to water applied to the face or nose, which is part of the diving reflex that evolved in diving mammals such as the seal prevent aspiration during submersion.

A sneeze differs from a cough in that is almost always preceded by a deep inspiration.

Like as cough, a sneeze involves an initial buildup of intrathoracic pressure behind a closed glottis. Unlike a cough, sneeze involves pharyngeal constriction during the buildup phase, and an explosive forced expiration via the nose, as well as the mouth.

The effect is to dislodge foreign bodies from the nasal mucosa.

# Sleep

Or even closing ones eyes, has powerful effects on the breathing pattern and CO<sub>2</sub> responsiveness. During non-rapid eye movements sleep – there is an increase in the regularity of eupneic breathing; Also, the sensitivity of the respiratory system to CO<sub>2</sub> decreases compared with wakefulness, and The outflow to the muscles of the pharynx decreases.

During rapid eye movements sleep – there is further decrease in the sensitivity of the respiratory system to CO<sub>2</sub>, but now the pattern of breathing becomes markedly irregular, sometimes with no discernible rhythm. The results is that CO<sub>2</sub> levels often increase during NREM sleep, and usually even more so during REM sleep

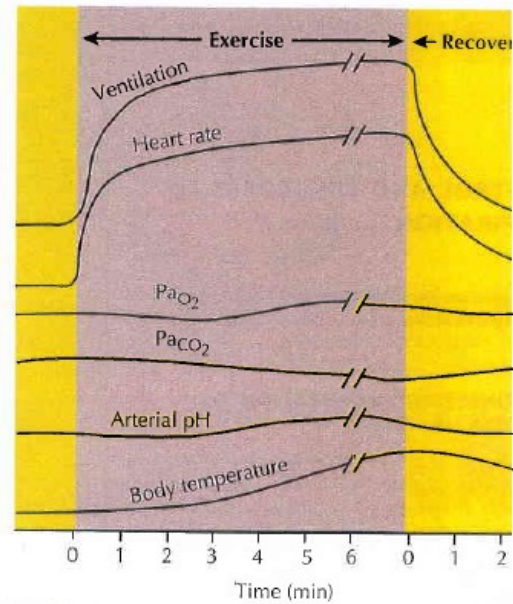
## Sleep apnea

The collection of disorders in which ventilation ceases during deeper stages of sleep, particularly during REM sleep, is known as sleep apnea.

The symptoms are **loud snoring, morning headache, fatigue, daytime sleepiness**

Some cases due to a lack of central drive – central sleep apnea. However most cases are due to collapse of the airway with sleep - obstructive sleep apnea, usually in obese people

RESPIRATORY RESPONSE TO EXERCISE

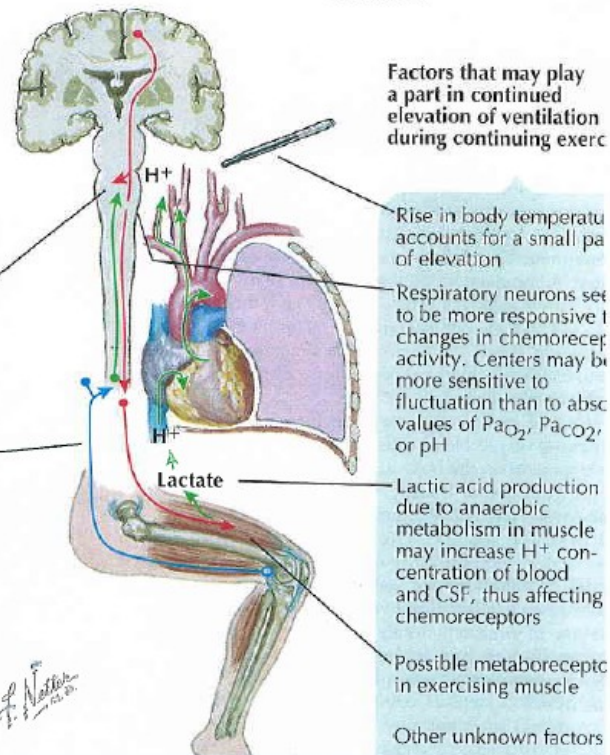


Factors that may account for initial abrupt rise and sharp terminal drop in ventilation

Collaterals to respiratory centers from motor pathways for muscle activation

Proprioceptive afferents from joint receptors to respiratory centers

Other unknown factors



Factors that may play a part in continued elevation of ventilation during continuing exercise

Rise in body temperature accounts for a small part of elevation

Respiratory neurons set to be more responsive to changes in chemoreceptor activity. Centers may be more sensitive to fluctuations than to absolute values of PaO<sub>2</sub>, PaCO<sub>2</sub>, or pH

Lactic acid production due to anaerobic metabolism in muscle may increase H<sup>+</sup> concentration of blood and CSF, thus affecting chemoreceptors

Possible metaboreceptors in exercising muscle

Other unknown factors