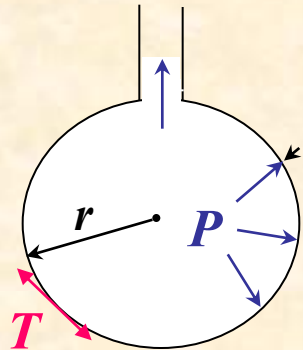


# **RESPIRATORY SYSTEM**

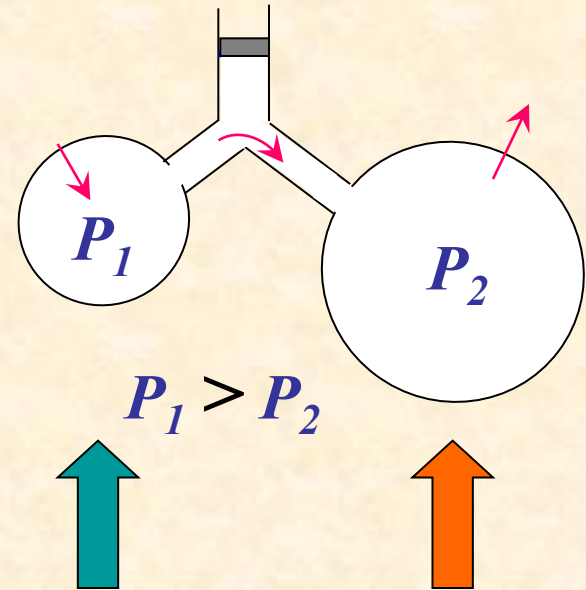
**RESPIRATORY FUNCTIONS  
MECHANICS OF RESPIRATORY SYSTEM  
GAS TRANSPORT**

# LAW OF LAPLACE

## spherical structures



$$P = \frac{2T}{r}$$



$P$  pressure

$r$  radius

$T$  surface tension

### PATHOLOGY

- COLLAPSE OF ALVEOLI - ATELECTASIS
- EXPANSION OF ALVEOLI

# SURFACTANT

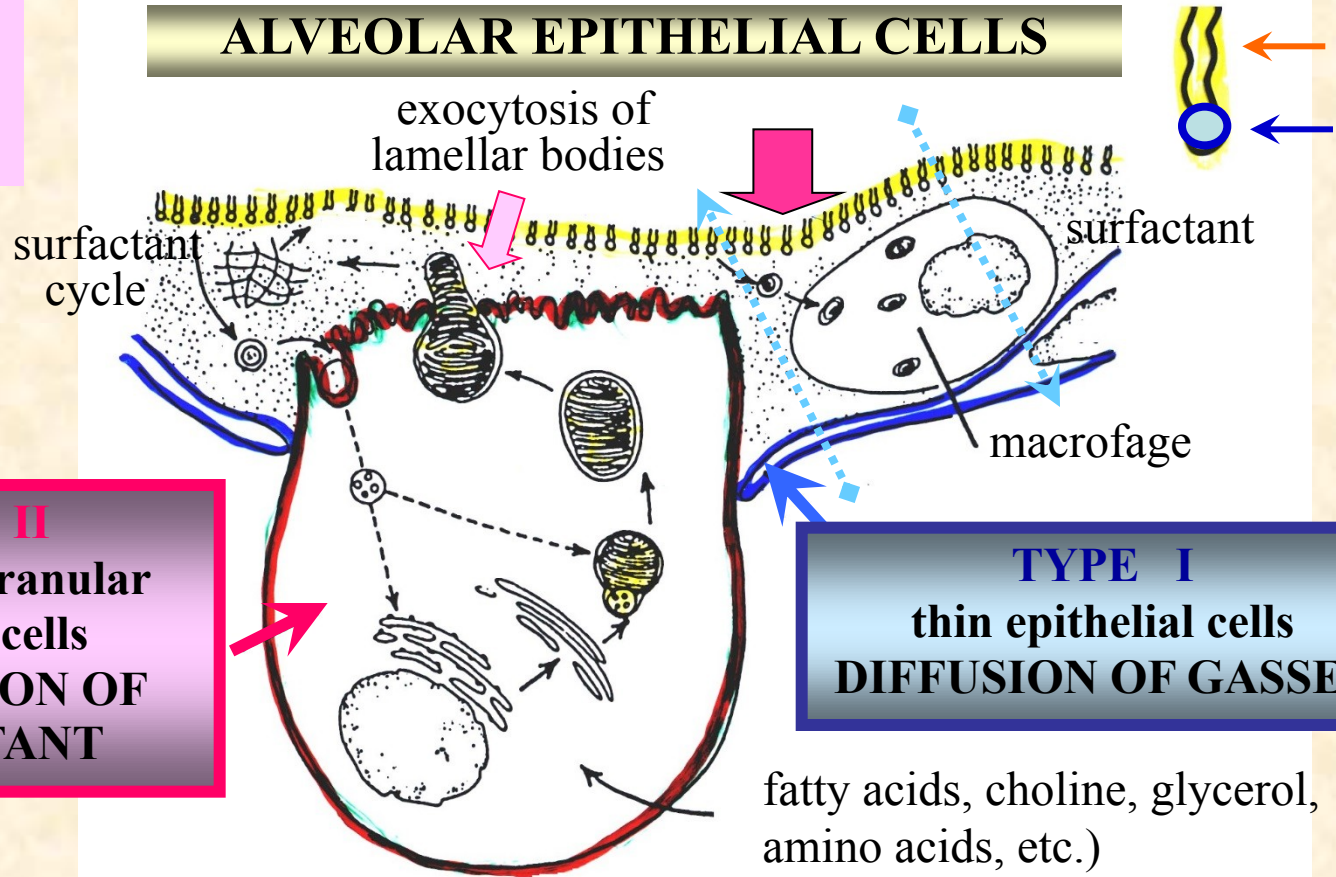
# SURFACE TENSION LOWERING AGENT

## EFFECT MAINLY IN THE EXPIRED POSITION

### PHOSPHOLIPID

dipalmitoyl  
fosfatidyl cholin

### ALVEOLAR EPITHELIAL CELLS



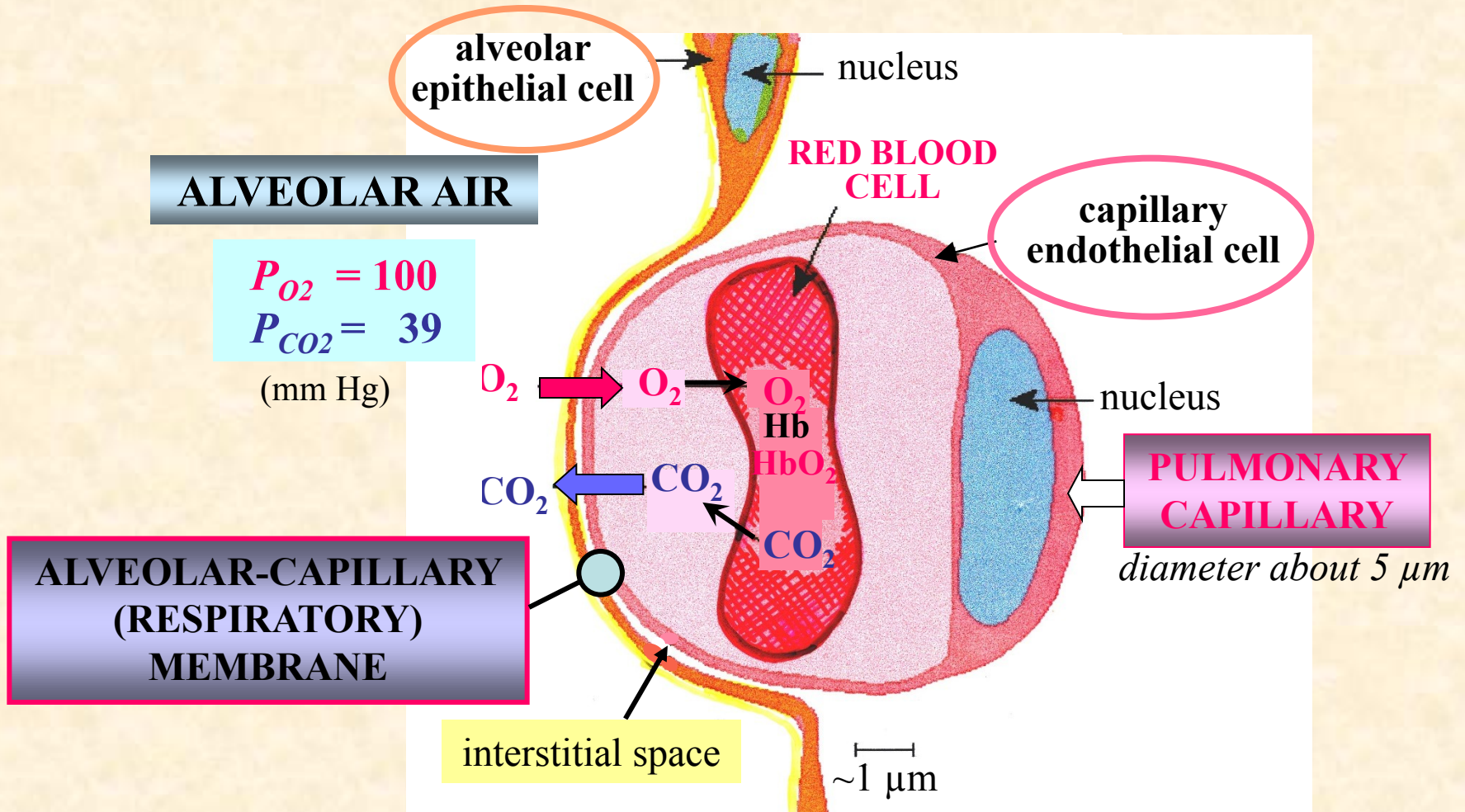
**TYPE II**  
specialized granular  
epithelial cells  
**PRODUCTION OF  
SURFACTANT**

**TYPE I**  
thin epithelial cells  
**DIFFUSION OF GASSES**



# ALVEOLAR-CAPILLARY (RESPIRATORY) MEMBRANE

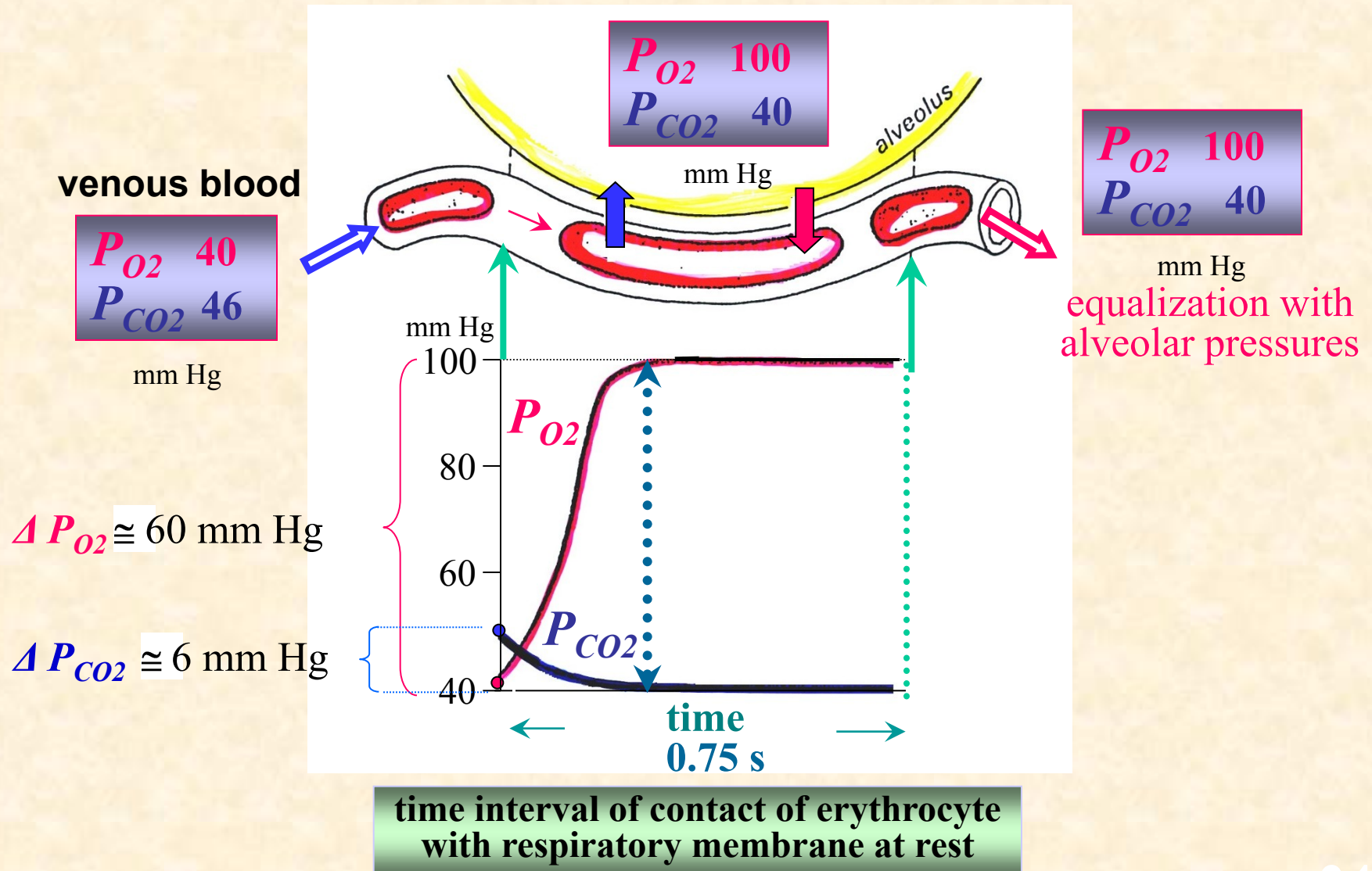
## DIFFUSION OF GASES



**0.75 s**

*time interval of erythrocyte contact with respiratory membrane at rest*

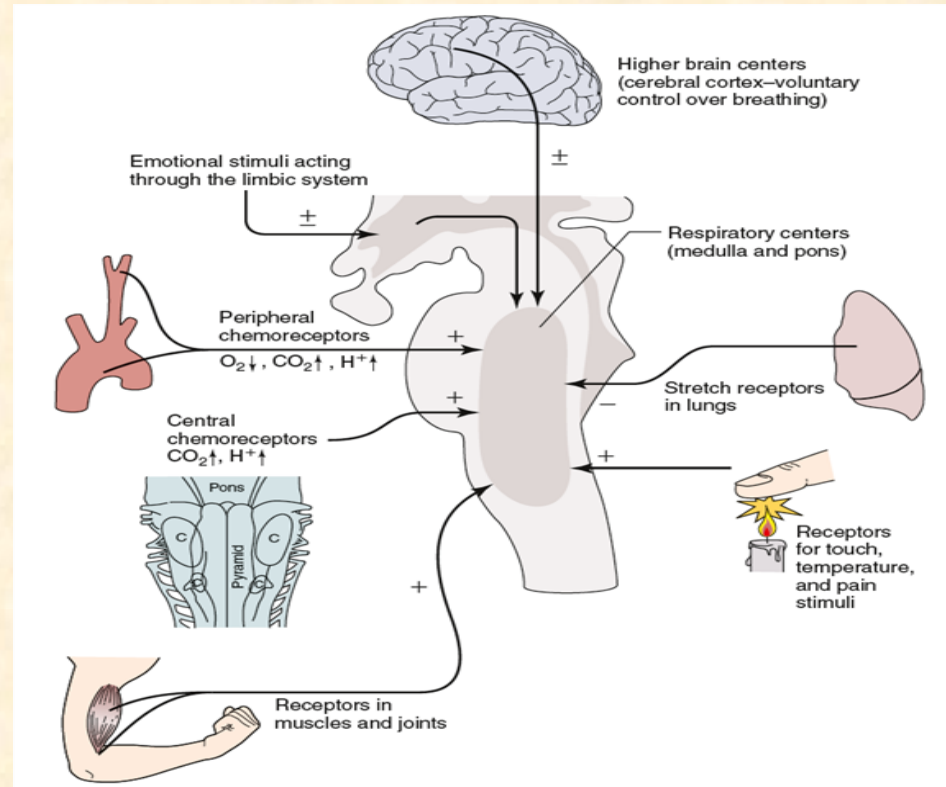
# TIME COURSE OF CAPILLARY $P_{O_2}$ AND $P_{CO_2}$ DURING GRADUAL EQUILIBRATION WITH ALVEOLAR AIR



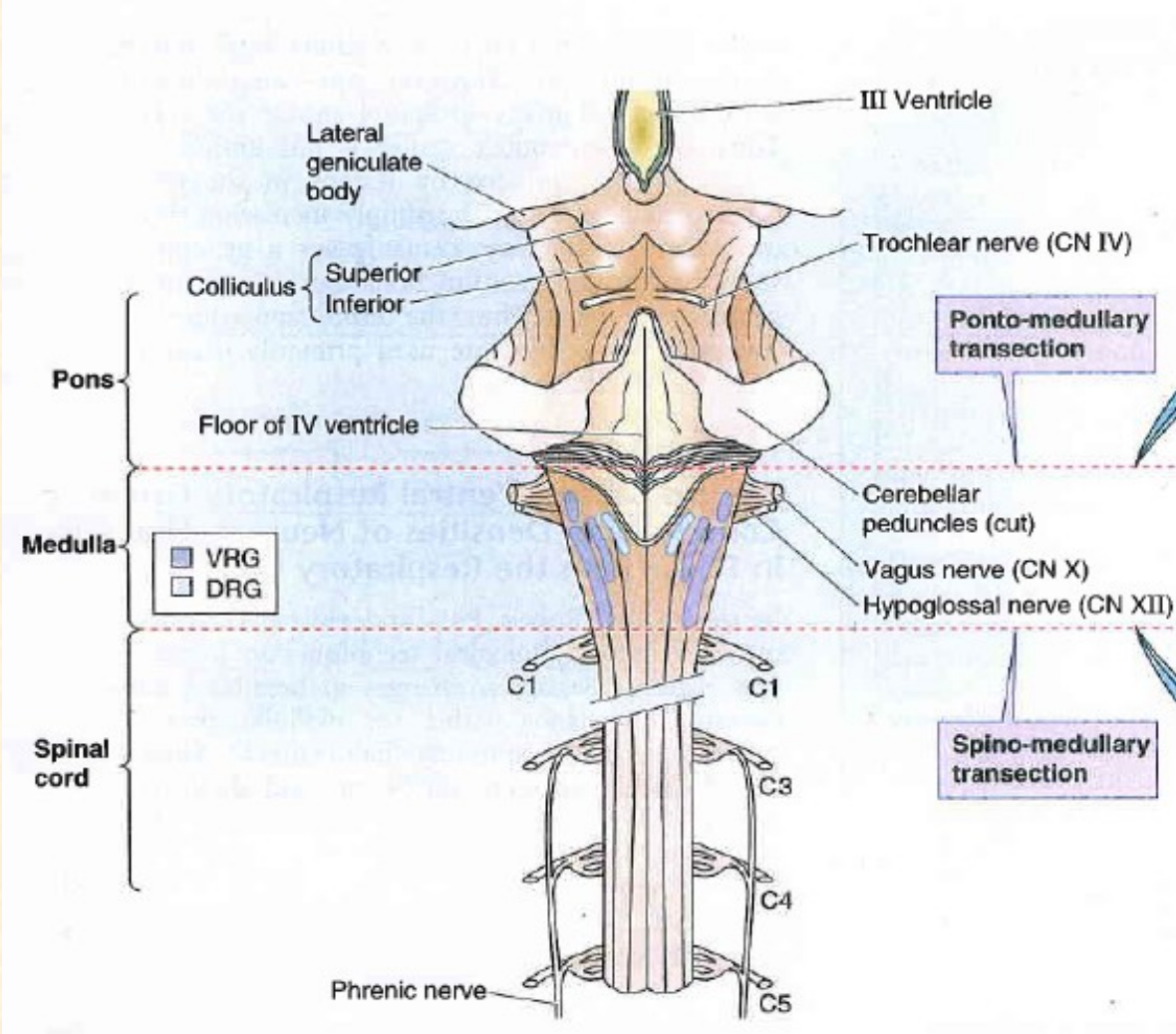


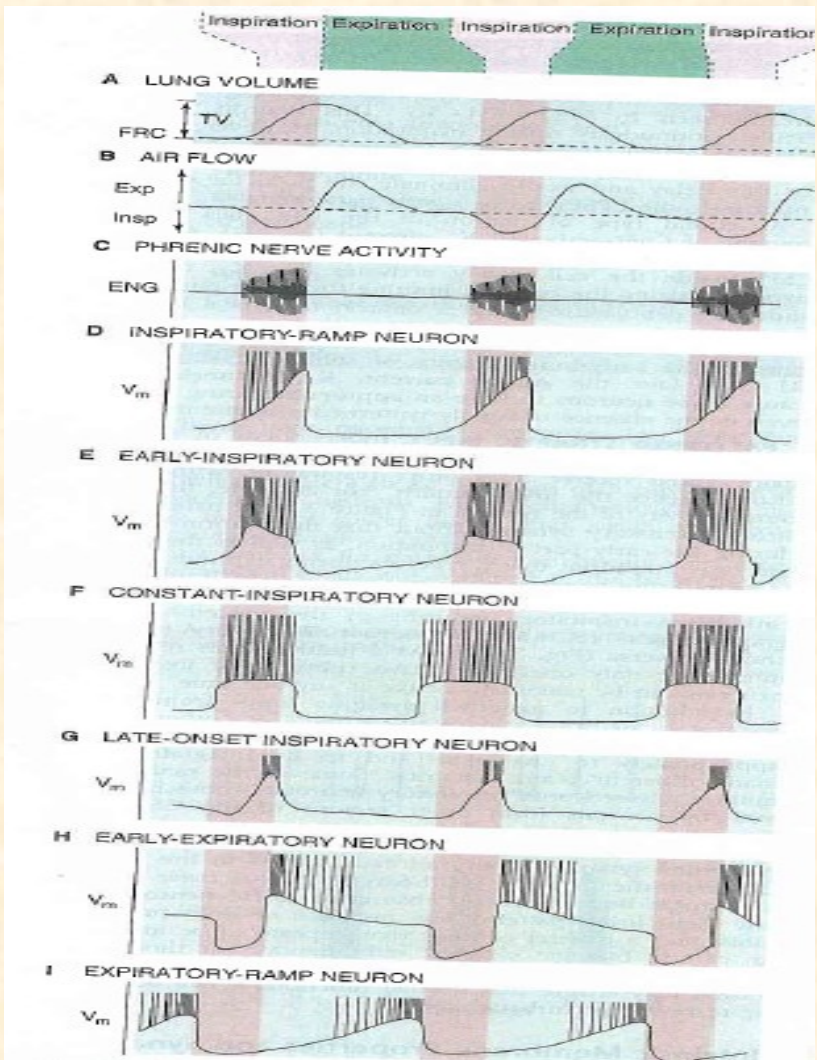


# Control of ventilation









- **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.

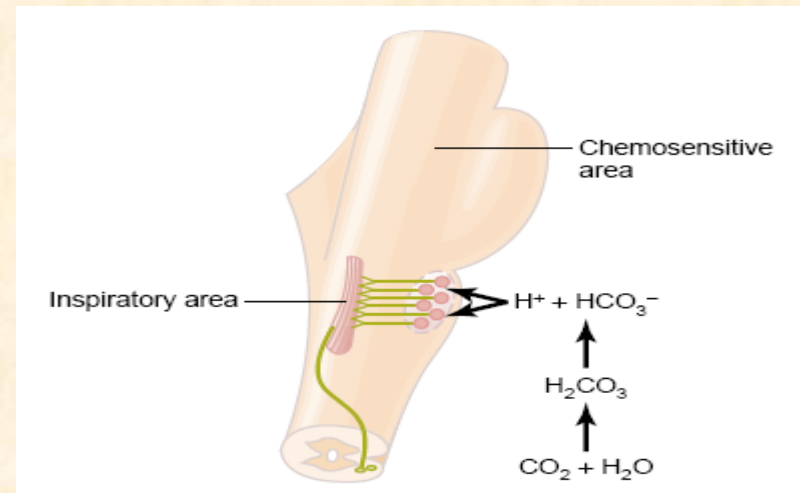
# Chemical factors affecting the respiratory center:

## Central chemoreceptors

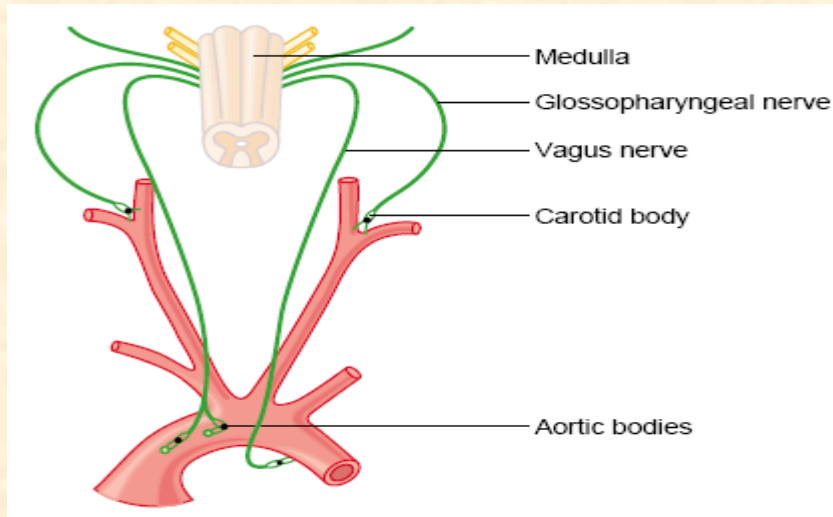
- on the front side of the medulla
- sensitive only to increase of arterial  $p\text{CO}_2$  (by increasing  $\text{H}^+$  )

- Notice:

- central chemoreceptor are stimulated by other types of acidosis (lactate acidosis, ketoacidosis)





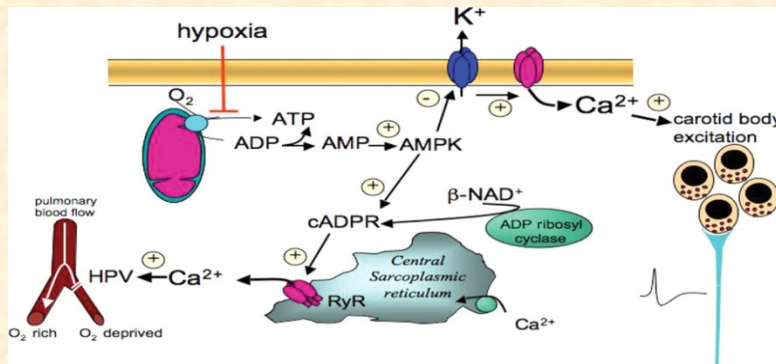


## Peripheral chemoreceptors

– 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.

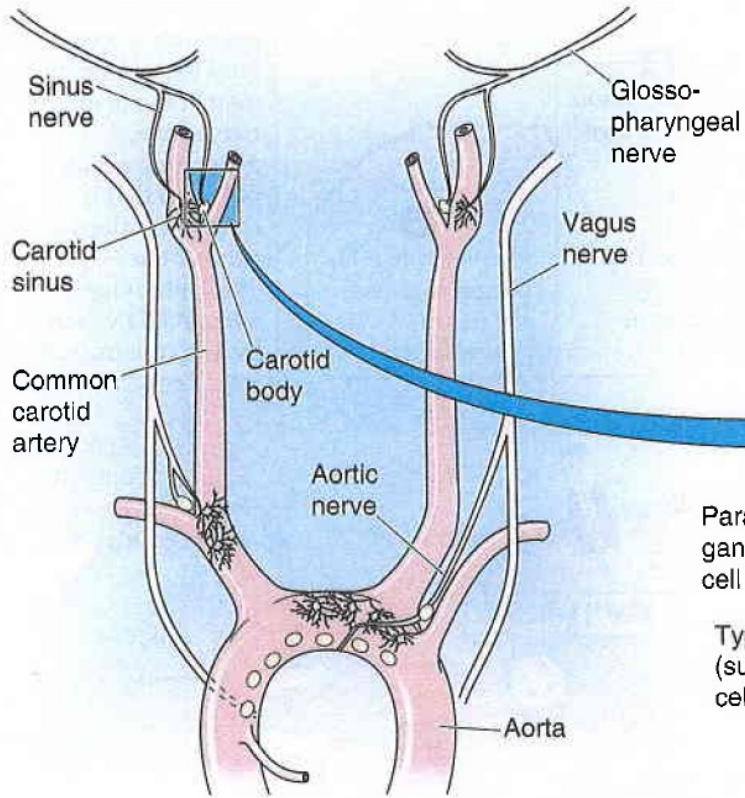
They convey their sensory information to the medulla via the vagus nerve and glossopharyngeal nerve.



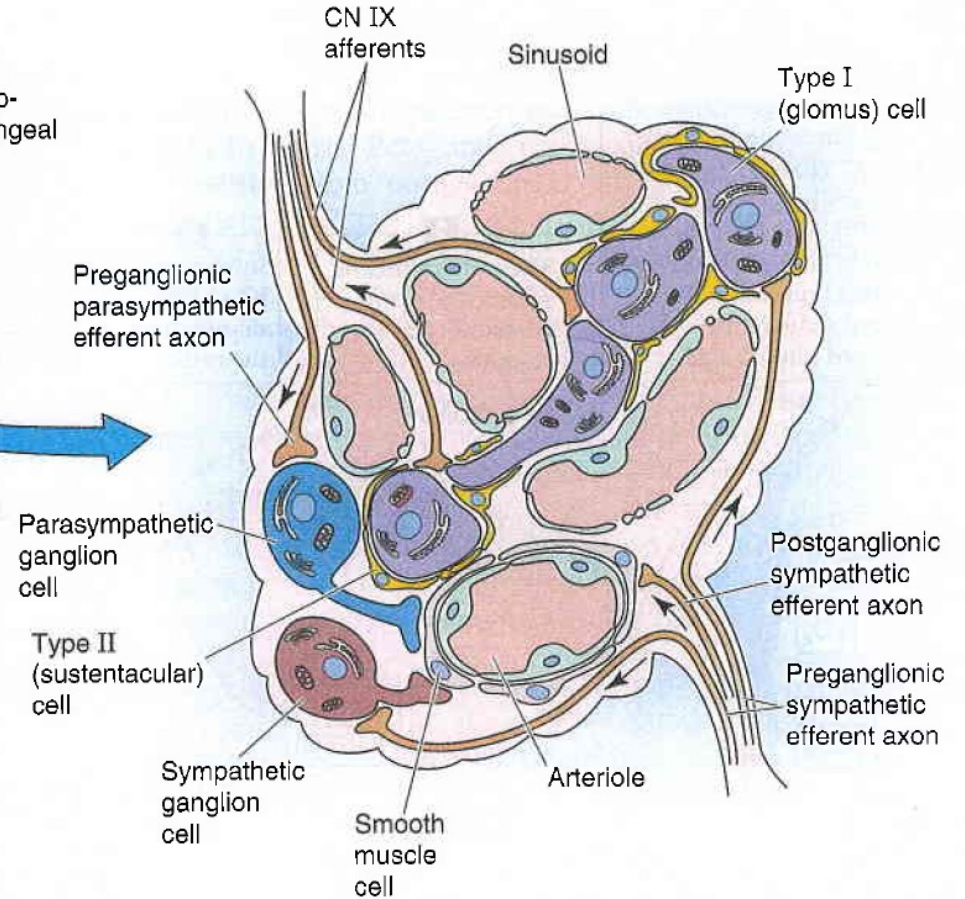
Mechanism of action: Decreased ATP production in mitochondria leads to depolarization of receptors membrane and to excitation of chemoreceptor

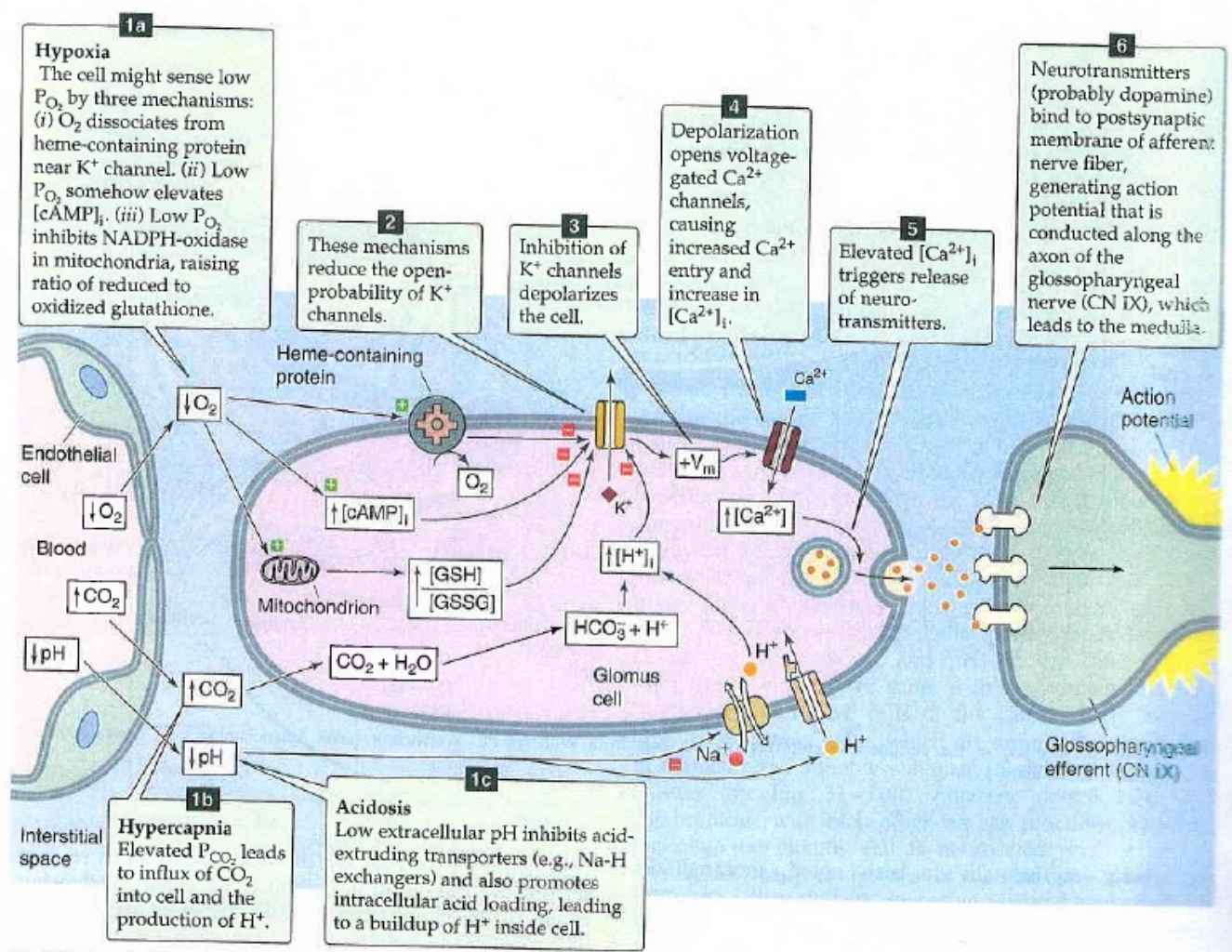


**A LOCATION OF CAROTID AND AORTIC BODIES**



**B MICROSCOPIC ANATOMY OF CAROTID BODY**







# 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)

**Baroreceptors** – suppresses activity of respiratory centre

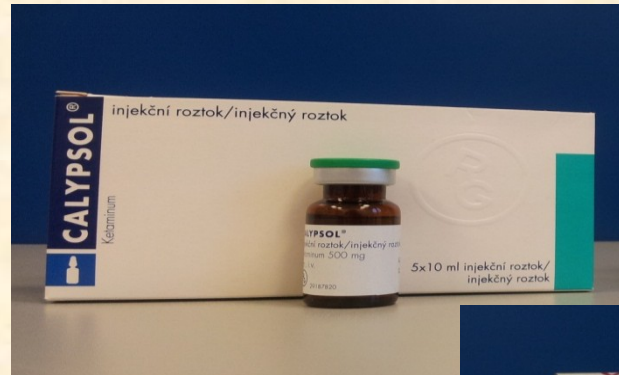
Irritants of **proprioceptors of muscles, tendons** during active and passive movements of limbs

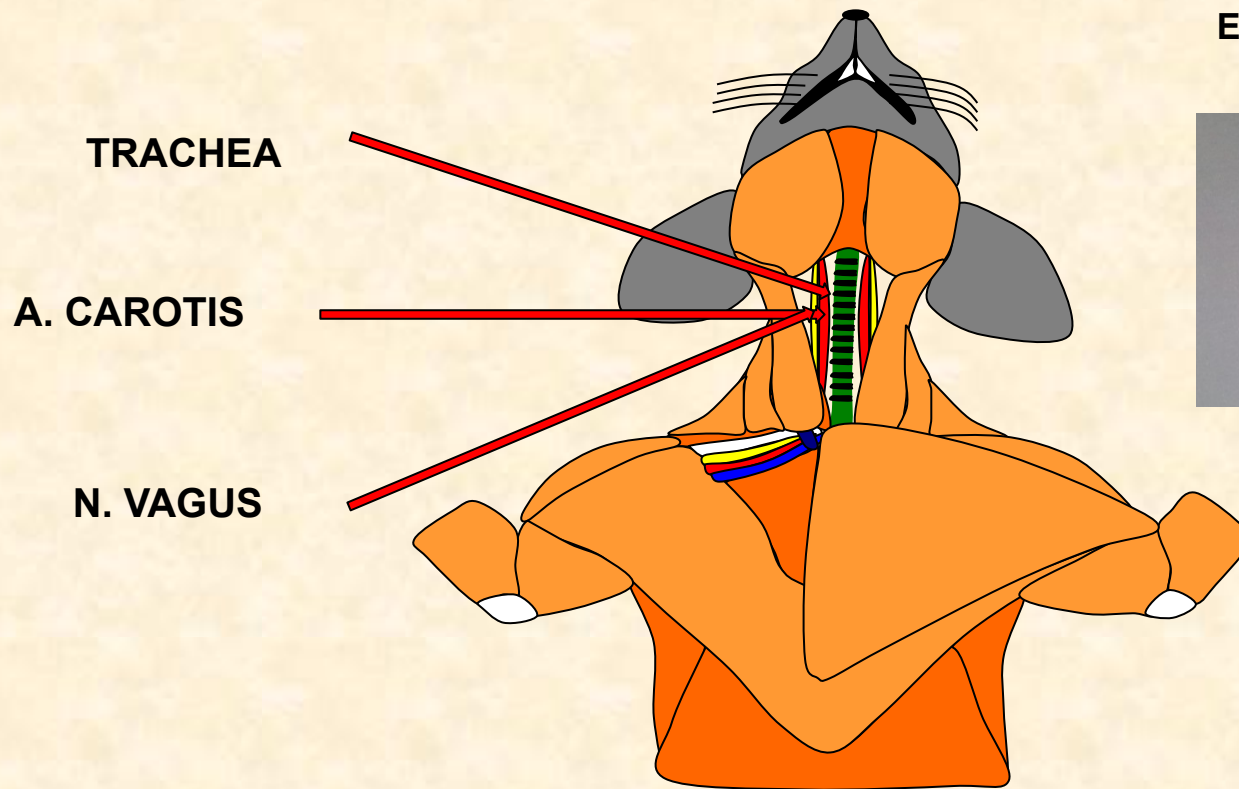
Influenced activity of respiratory neurons (increase minute ventilation during work load)

**Limbic system, hypothalamus** – strong pain, emotion

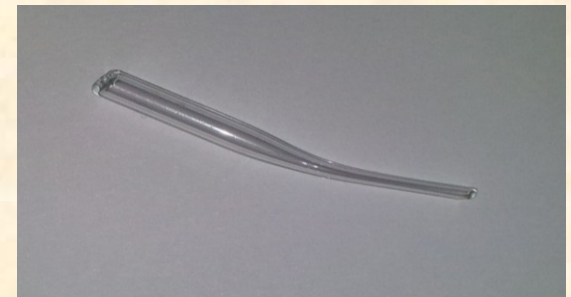
Tractus corticospinalis = cortex – activated RC during work load

**temperature**





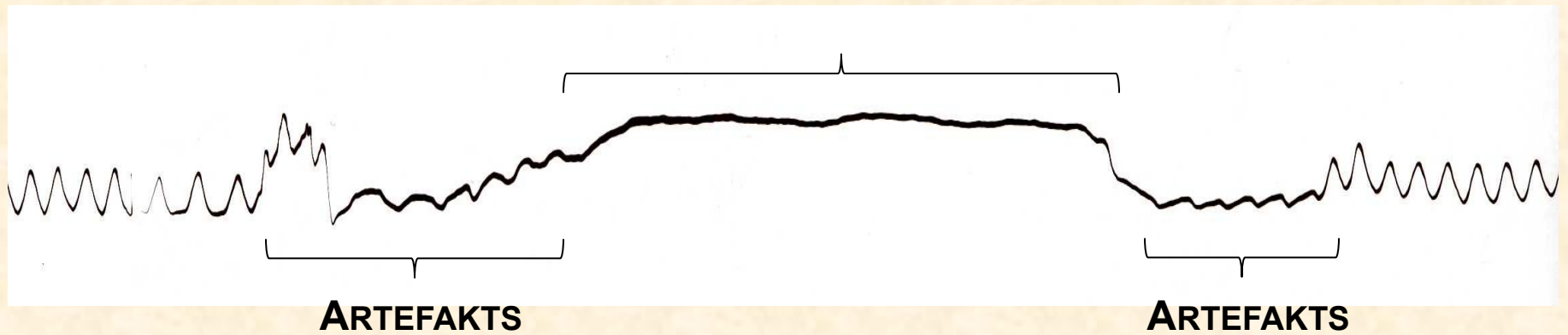
## ENDOTRACHEAL CANNULA



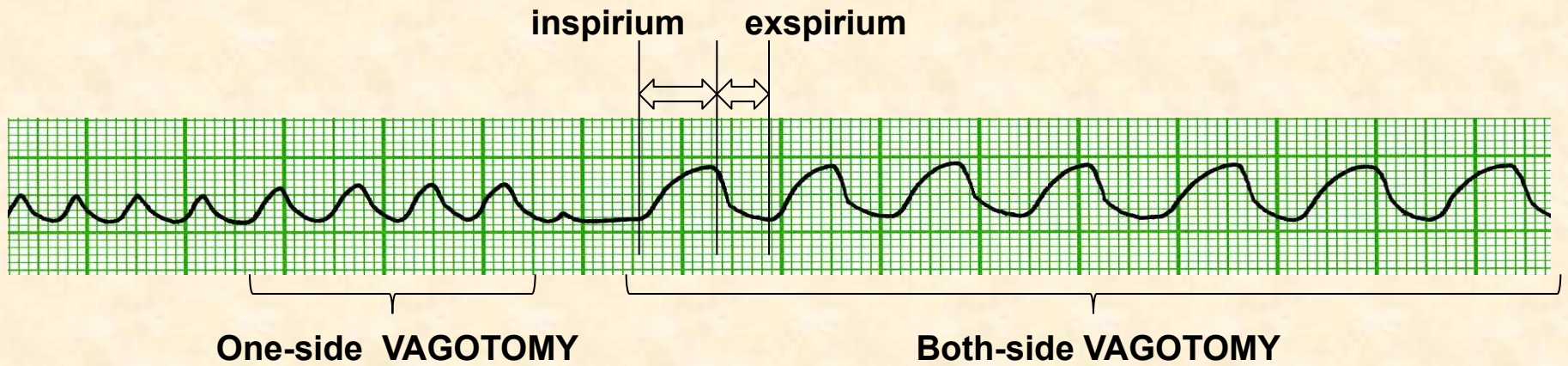


# HERING-BREUER REFLEX

## REFLEX STOP BREATHING



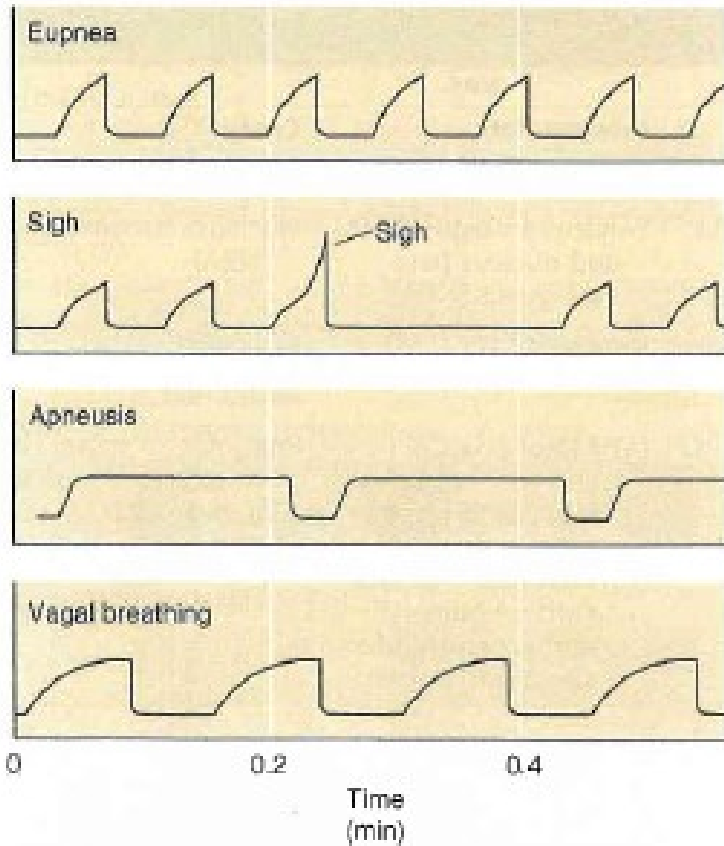
# VAGOTOMY



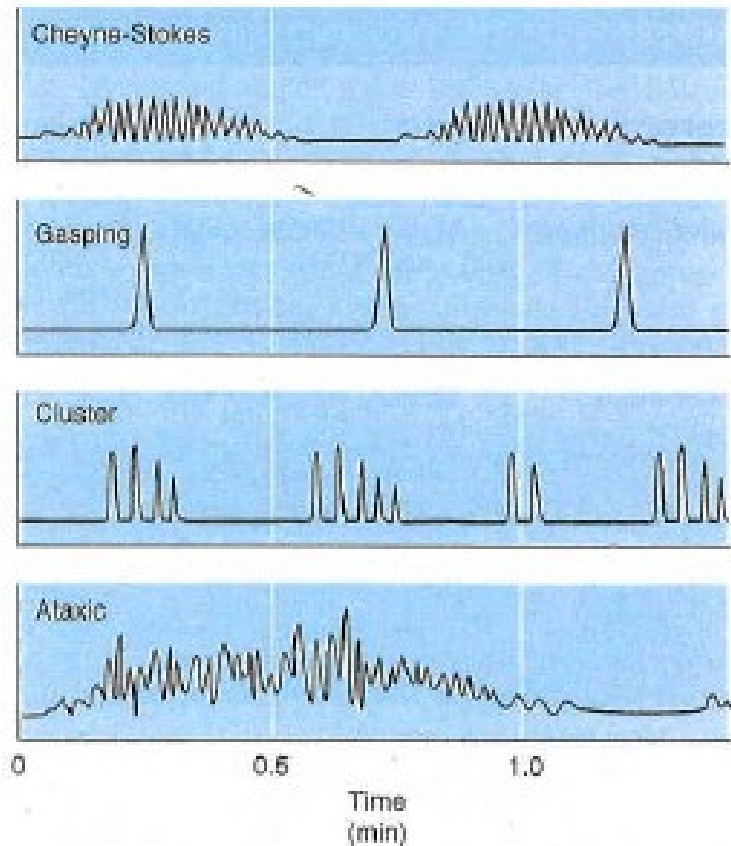
# Periodic breathing

- It is not regular, rhythmic, but respiration occurs in periods ("a moment to breathe, take a moment to not breathe,,")
- **CHEYNE-STOKES**
- **BIOT'S**
- „gaspig“
- **KUSSMAUL**

**A INTEGRATED PHRENIC NERVE ACTIVITY**

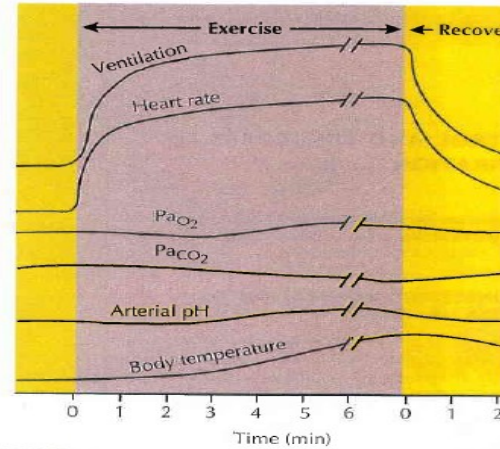


**B LUNG VOLUME**





RESPIRATORY RESPONSE TO EXERCISE

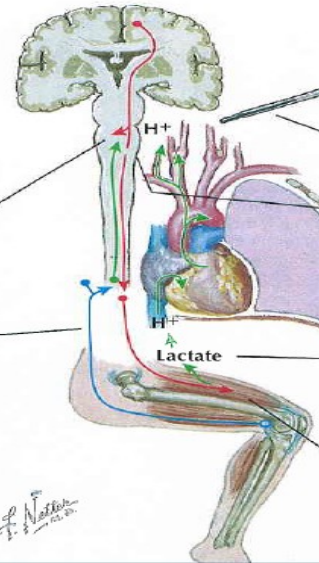


Factors that may account for initial abrupt rise and sharp terminal drop in ventilation

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 seem to be more responsive to changes in chemoreceptor activity. Centers may be more sensitive 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



**THANK YOU FOR YOUR**  
**ATTENTION**

**Merry Christmas and Happy New Year**

