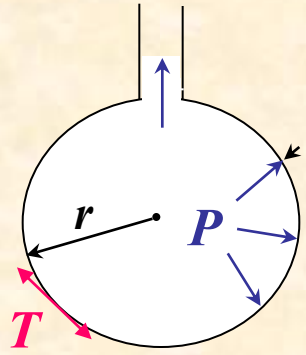
RESPIRATORY SYSTEM

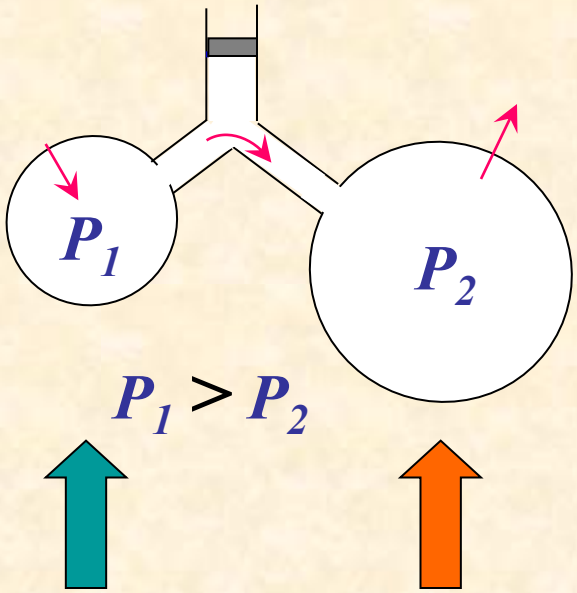
RESPIRATORY FUNCTIONS
MECHANICS OF RESPIRATORY SYSTEM
GAS TRANSPORT

LAW OF LAPLACE

spherical structures



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



P pressure

r radius

T surface tension

PATHOLOGY

- COLLAPSE OF ALVEOLI - ATELECTASIS
- EXPANSION OF ALVEOLI

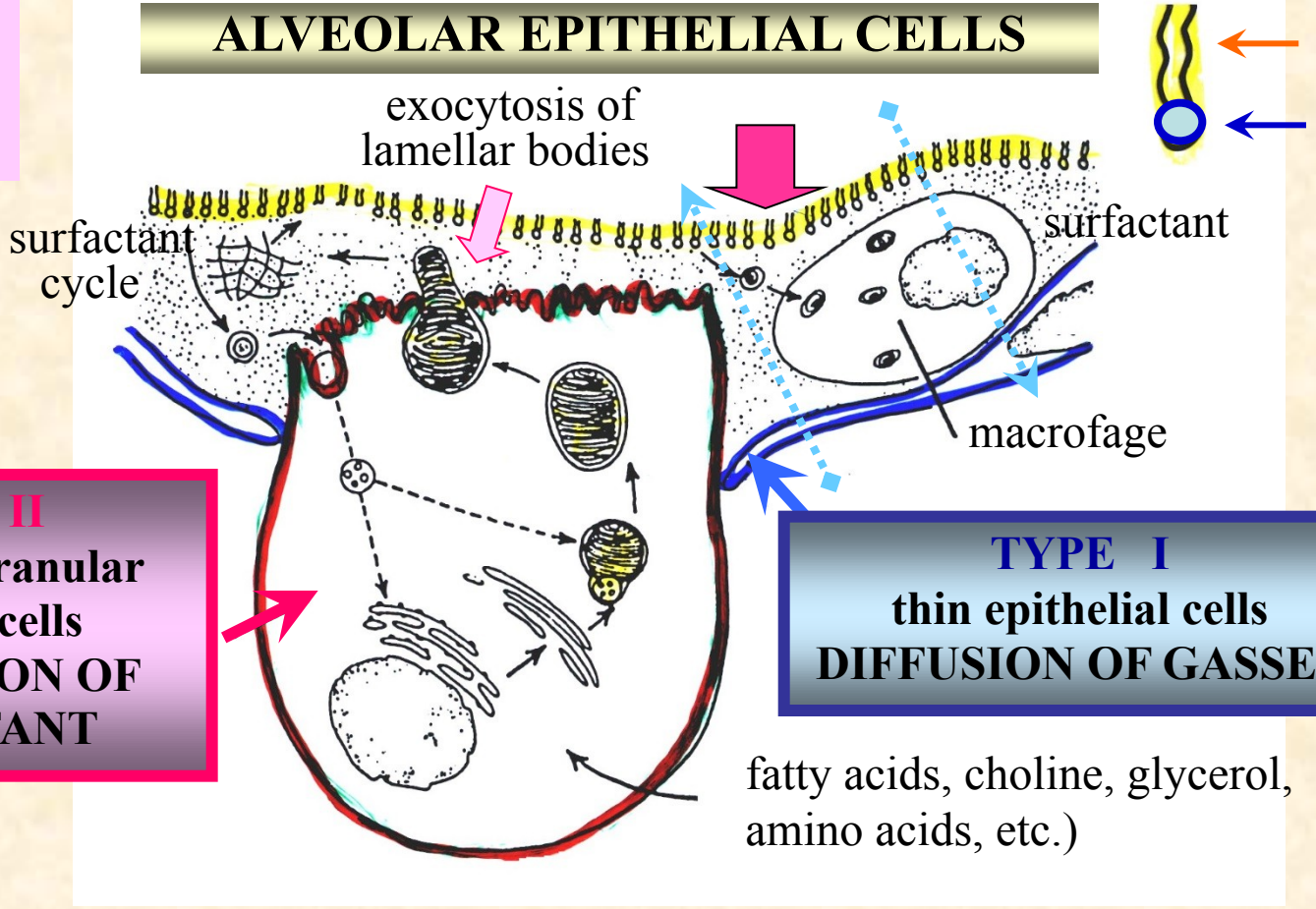
SURFACTANT

SURFACE TENSION LOWERING AGENT

EFFECT MAINLY IN THE EXPIRED POSITION

PHOSPHOLIPID
dipalmitoyl
fosfatidyl cholin

ALVEOLAR EPITHELIAL CELLS



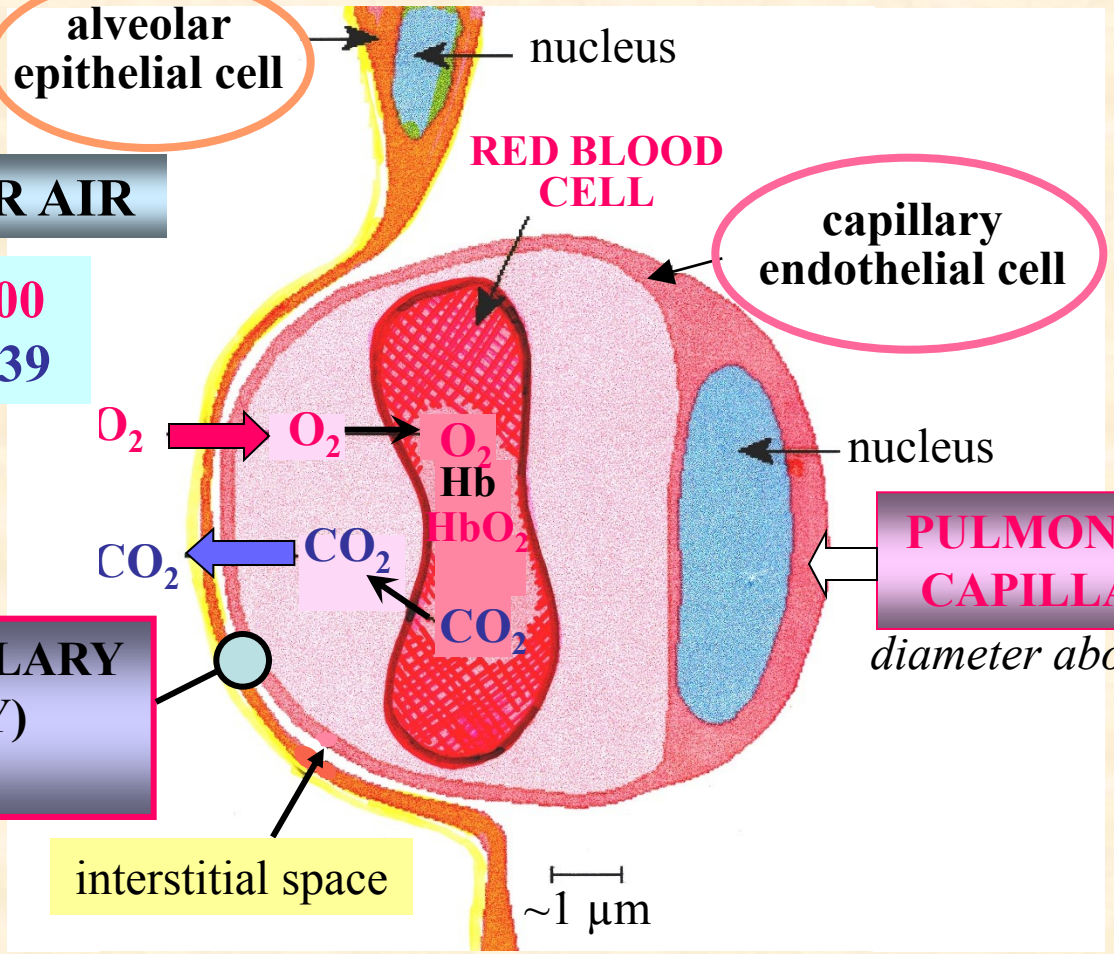
TYPE II
specialized granular epithelial cells
PRODUCTION OF SURFACTANT

TYPE I
thin epithelial cells
DIFFUSION OF GASSES

fatty acids, choline, glycerol,
amino acids, etc.)

ALVEOLAR-CAPILLARY (RESPIRATORY) MEMBRANE

DIFFUSION OF GASES



0.75 s

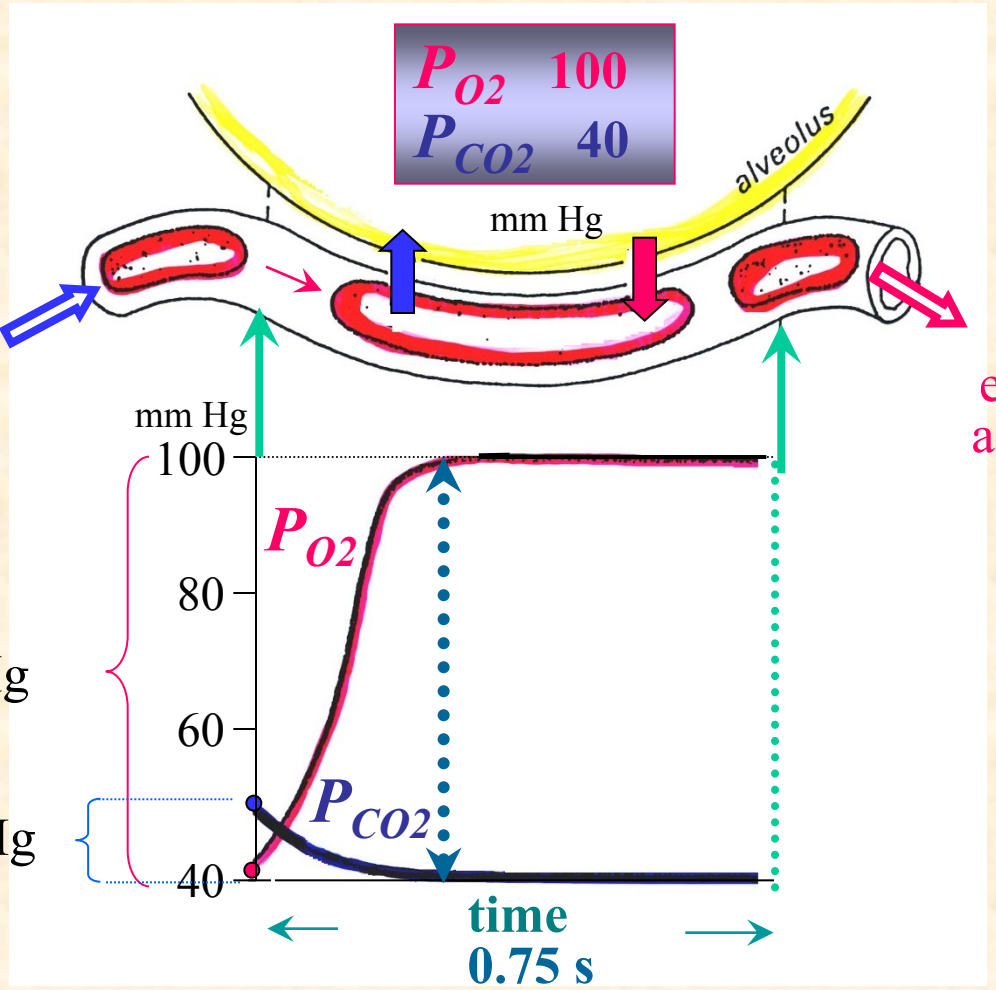
time interval of erythrocyte contact with respiratory membrane at rest

TIME COURSE OF CAPILLARY P_{O2} AND P_{CO2} DURING GRADUAL EQUILIBRATION WITH ALVEOLAR AIR

venous blood

P_{O2} 40
P_{CO2} 46

mm Hg



P_{O2} 100
P_{CO2} 40

mm Hg

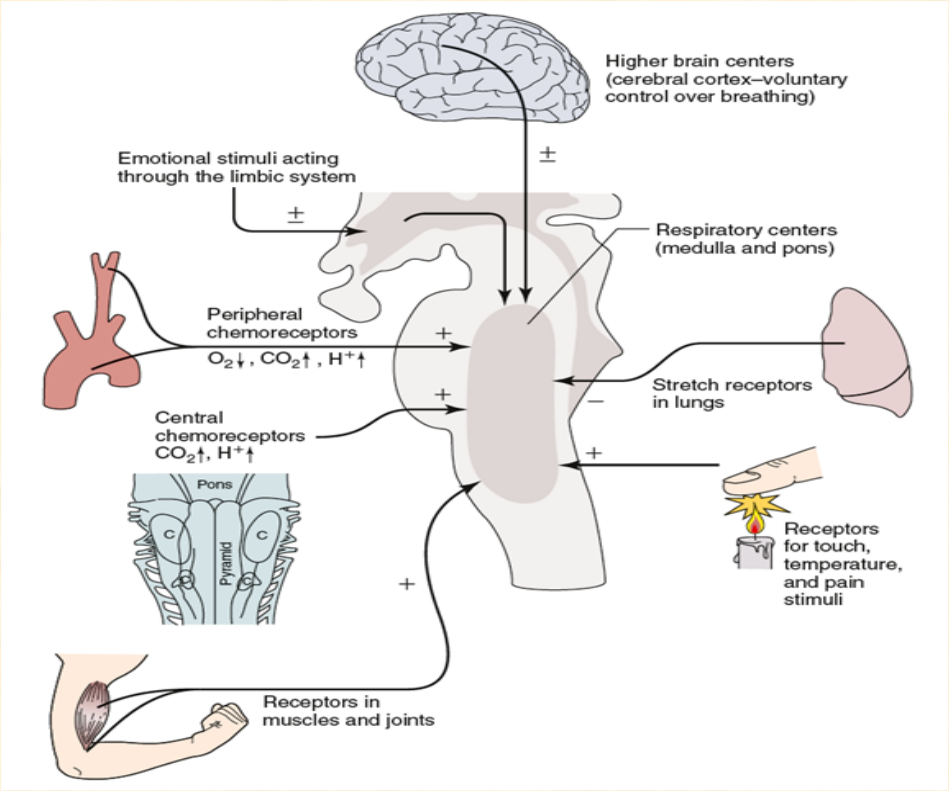
equalization with alveolar pressures

$\Delta P_{O2} \cong 60$ mm Hg

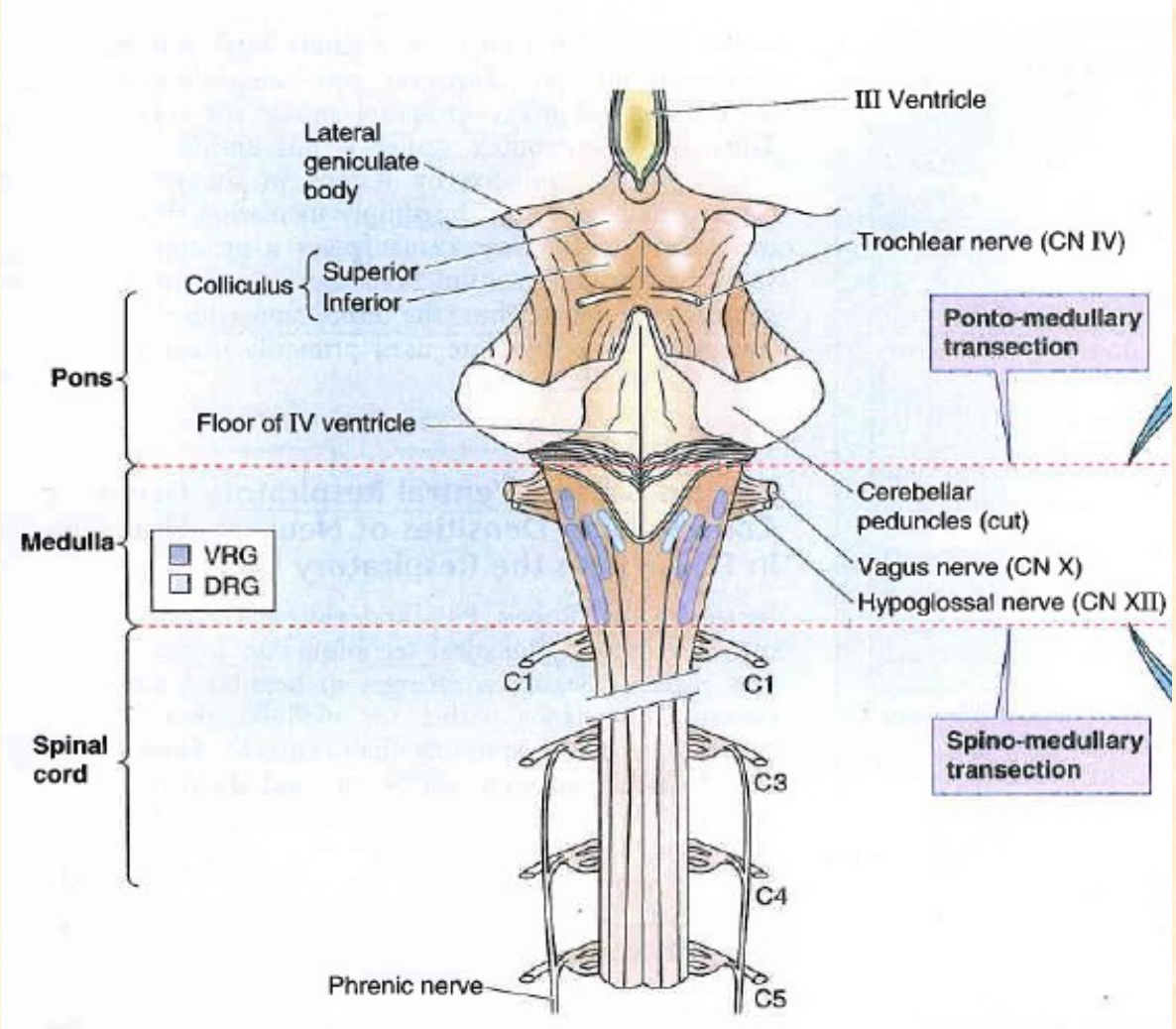
$\Delta P_{CO2} \cong 6$ mm Hg

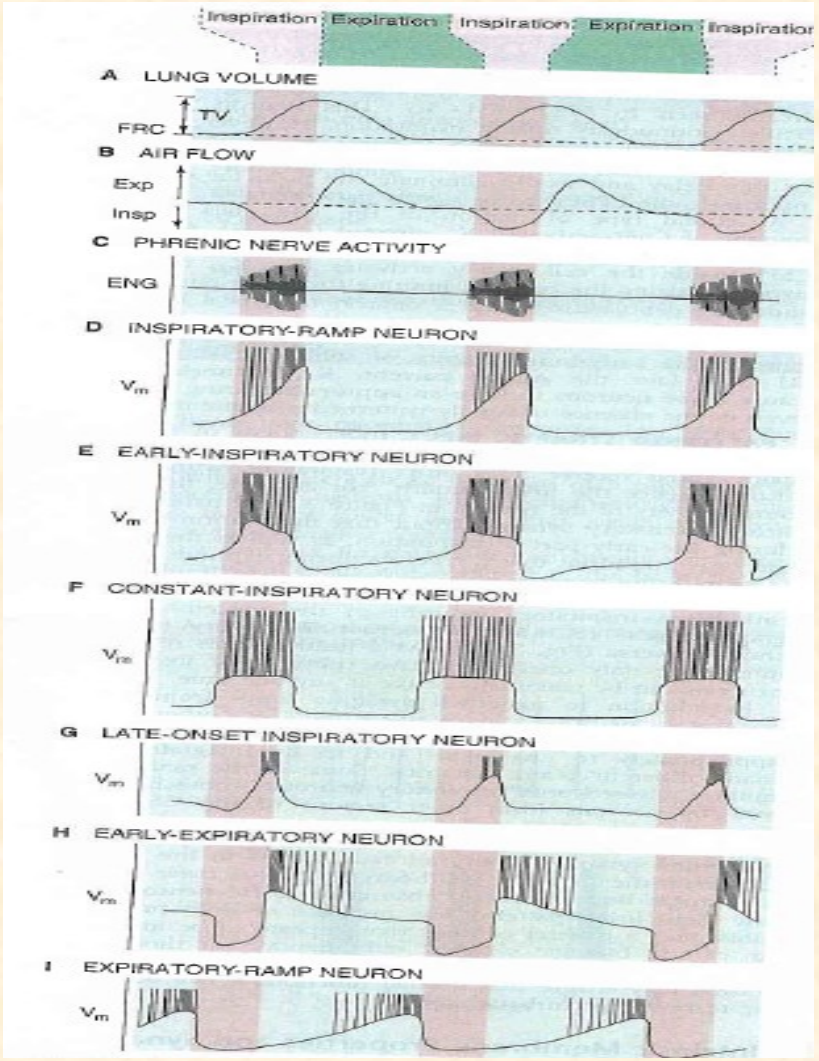
time interval of contact of erythrocyte with respiratory membrane at rest

Control of ventilation



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


III Ventricle
Lateral geniculate body
Trochlear nerve (CN IV)
Colliculus
Superior
Inferior
Ponto-medullary transection
Pons
Floor of IV ventricle
Cerebellar peduncles (cut)
Medulla
VRG
DRG
Vagus nerve (CN X)
Hypoglossal nerve (CN XII)
C1
C1
Spino-medullary transection
Spinal cord
C3
C4
Phrenic nerve
C5


Inspiration
Expiration
Inspiration
Expiration
Inspiration
A LUNG VOLUME
TV
FRC
B AIR FLOW
Exp
Insp
C PHRENIC NERVE ACTIVITY
ENG
D INSPIRATORY-RAMP NEURON
V_m
E EARLY-INSPIRATORY NEURON
V_m
F CONSTANT-INSPIRATORY NEURON
V_m
G LATE-ONSET INSPIRATORY NEURON
V_m
H EARLY-EXPIRATORY NEURON
V_m
I EXPIRATORY-RAMP NEURON
V_m

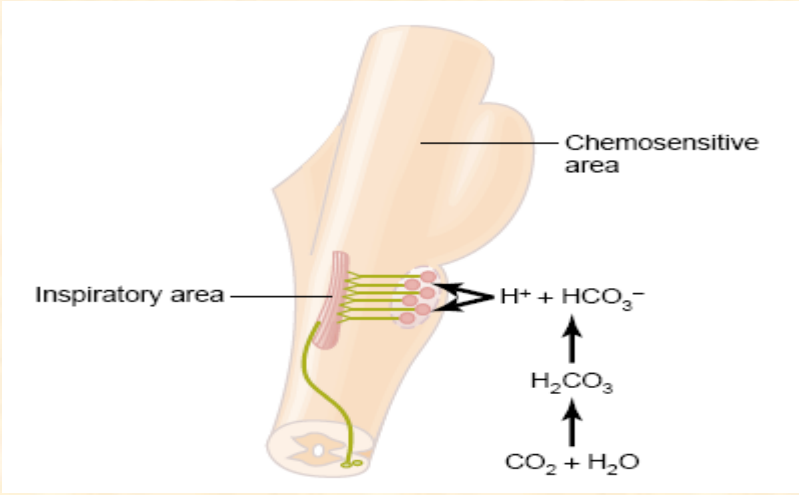
- **Breathing is an automatic process that takes place unconsciously. Automaticity of breathing comes from regular (rhythmic) activity of groups of neurons anatomically localized in the medulla and its vicinity.**

- 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

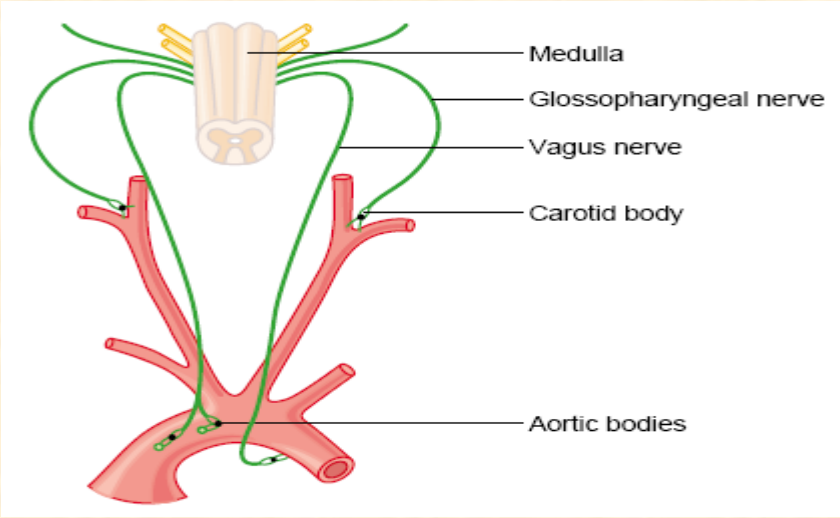
Chemical factors affecting the respiratory center:

Central chemoreceptors

- on the front side of the medulla
- sensitive only to increase of arterial pCO_2 (by increasing H^+)



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

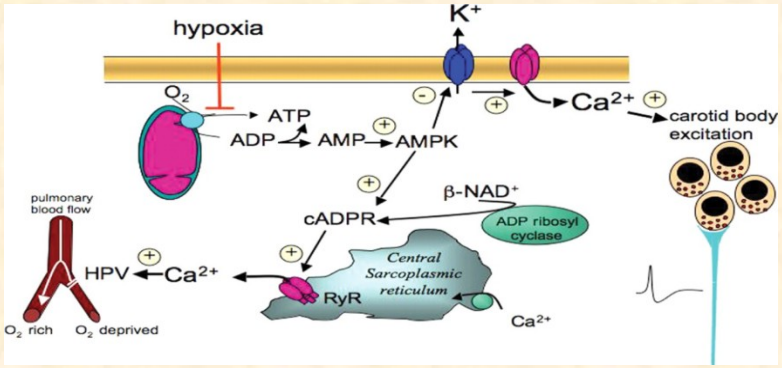


Peripheral chemoreceptors

– located in the aortic and carotid bodies

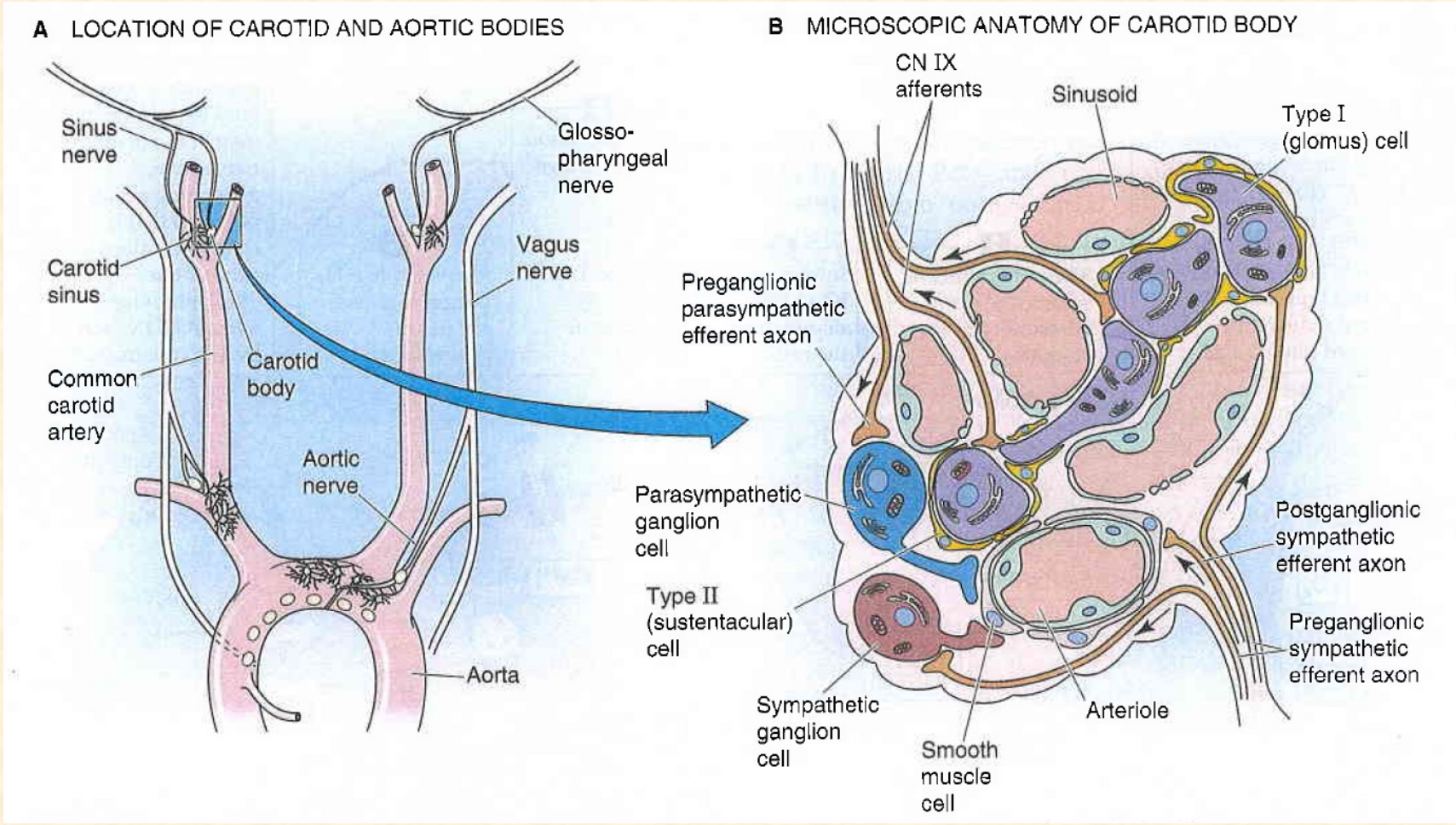
-primarily sensitive to decrease in arterial pO_2, particularly to decrease of O_2 under 10-13 kPa in the arterial blood.

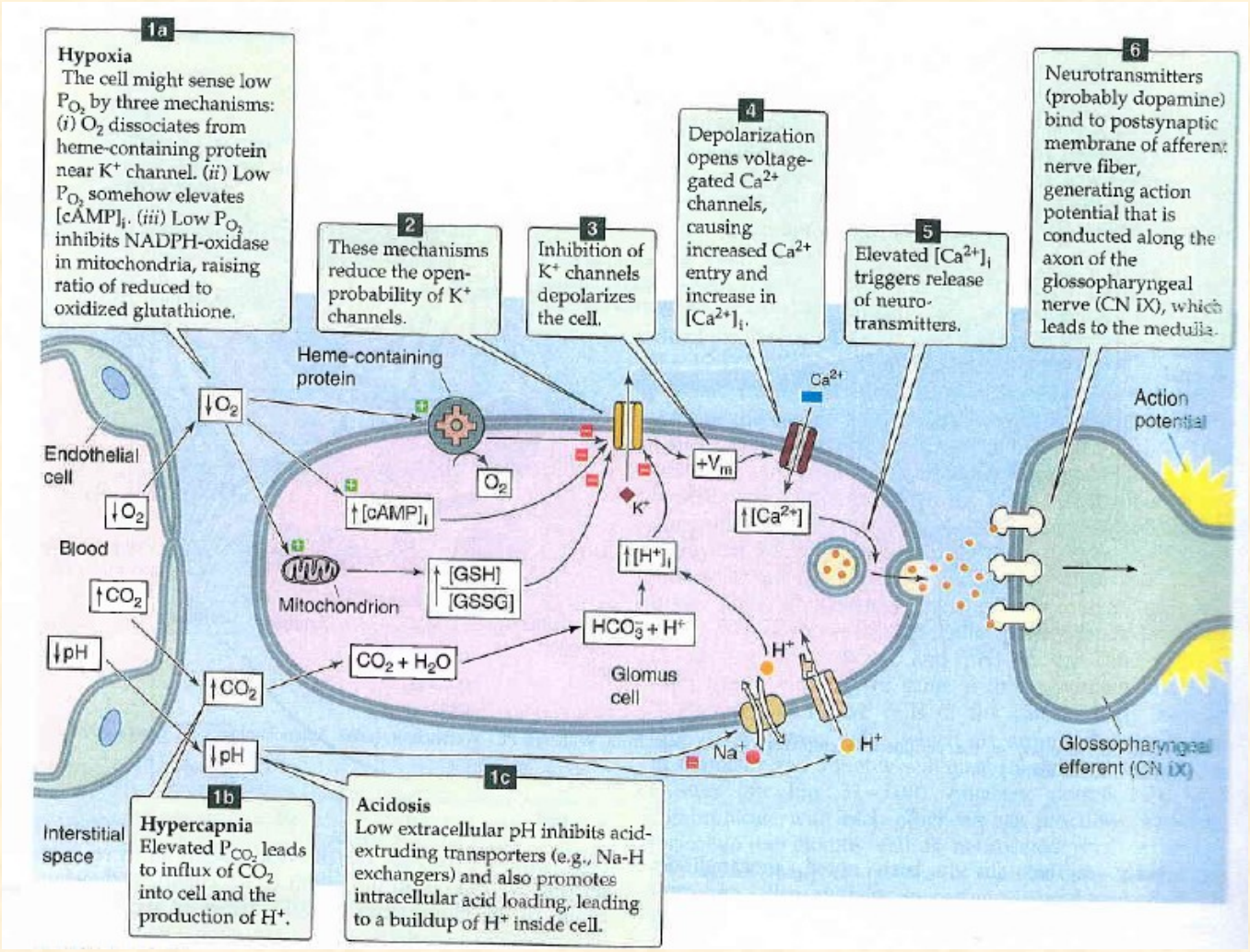
They convey their sensory information to the medulla via the vagus nerve and glossopharyngeal nerve.



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

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


A LOCATION OF CAROTID AND AORTIC BODIES
Sinus nerve
Glosso-pharyngeal nerve
Vagus nerve
Carotid sinus
Carotid body
Common carotid artery
Aortic nerve
Aorta
B MICROSCOPIC ANATOMY OF CAROTID BODY
CN IX afferents
Sinusoid
Type I (glomus) cell
Preganglionic parasympathetic efferent axon
Parasympathetic ganglion cell
Type II (sustentacular) cell
Postganglionic sympathetic efferent axon
Preganglionic sympathetic efferent axon
Sympathetic ganglion cell
Smooth muscle cell
Arteriole


1a
Hypoxia
The cell might sense low P_{O_2} by three mechanisms: (*i*) O_2 dissociates from heme-containing protein near K^+ channel. (*ii*) Low P_{O_2} somehow elevates $[cAMP]_i$. (*iii*) Low P_{O_2} inhibits NADPH-oxidase in mitochondria, raising ratio of reduced to oxidized glutathione.
2
These mechanisms reduce the open-probability of K^+ channels.
3
Inhibition of K^+ channels depolarizes the cell.
4
Depolarization opens voltage-gated Ca^{2+} channels, causing increased Ca^{2+} entry and increase in $[Ca^{2+}]_i$.
5
Elevated $[Ca^{2+}]_i$ triggers release of neuro-transmitters.
6
Neurotransmitters (probably dopamine) bind to postsynaptic membrane of afferent nerve fiber, generating action potential that is conducted along the axon of the glossopharyngeal nerve (CN IX), which leads to the medulla.
Heme-containing protein
Endothelial cell
↓O_2
Blood
↑CO_2
↓pH
Interstitial space
↑CO_2
↓pH
↓O_2
O_2
↑$[cAMP]_i$
Mitochondrion
↑[GSH]/[GSSG]
$CO_2 + H_2O$
$HCO_3^- + H^+$
↑$[H^+]_i$
K^+
+V_m
Ca^{2+}
↑$[Ca^{2+}]$
Glomus cell
H^+
Na^+
H^+
Action potential
Glossopharyngeal efferent (CN IX)
1b
Hypercapnia
Elevated P_{CO_2} leads to influx of CO_2 into cell and the production of H^+.
1c
Acidosis
Low extracellular pH inhibits acid-extruding transporters (e.g., Na-H exchangers) and also promotes intracellular acid loading, leading to a buildup of H^+ inside cell.

Modulation of respiratory output

Major parameters for feedback control – classical gases:pO2, pCO2, pH

In additin 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 agentsreceptors in respiratory system
2. Higher CNS centers that modulate respiratory activity for the sake of nonrespiratory activities

Irritants receptors on mucose of respiratory system – rapidly adapting
Stimulus: agens - chemical substances (histamin, serotonin, prostaglandins, ammonia, cigarette smoke).
Respons: increase mucus secretion, constriction of larynx and brochus

C-fibre receptors (juxtacapillary=J receptors)– free nerve ending of n.vagus (unmyelinated axon) in intersticium of bronchus and alveolus;
Stimulus: Mechanical irritans (pulmonary hypertension, pulmonary oedema)+chemical
Response: hypopnoe, rapid shallow breathing, bronchoconstriction, cough

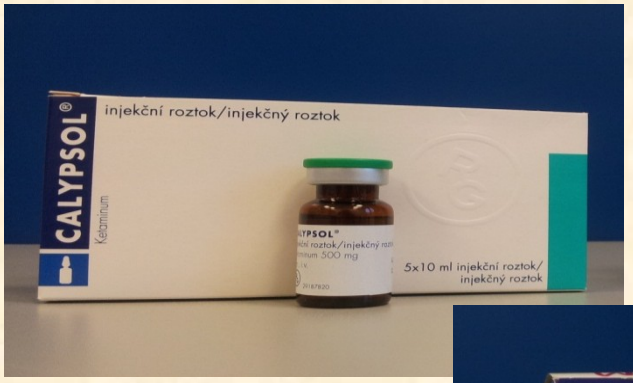
Stretch receptors, slowly adapting (mechanoreceptors in tracheobronchial tree that

Baroreceptors – suppresses activity of respiratory centre

Irritants of **proprioreceptors of muscles, tendons** during active and pasive 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

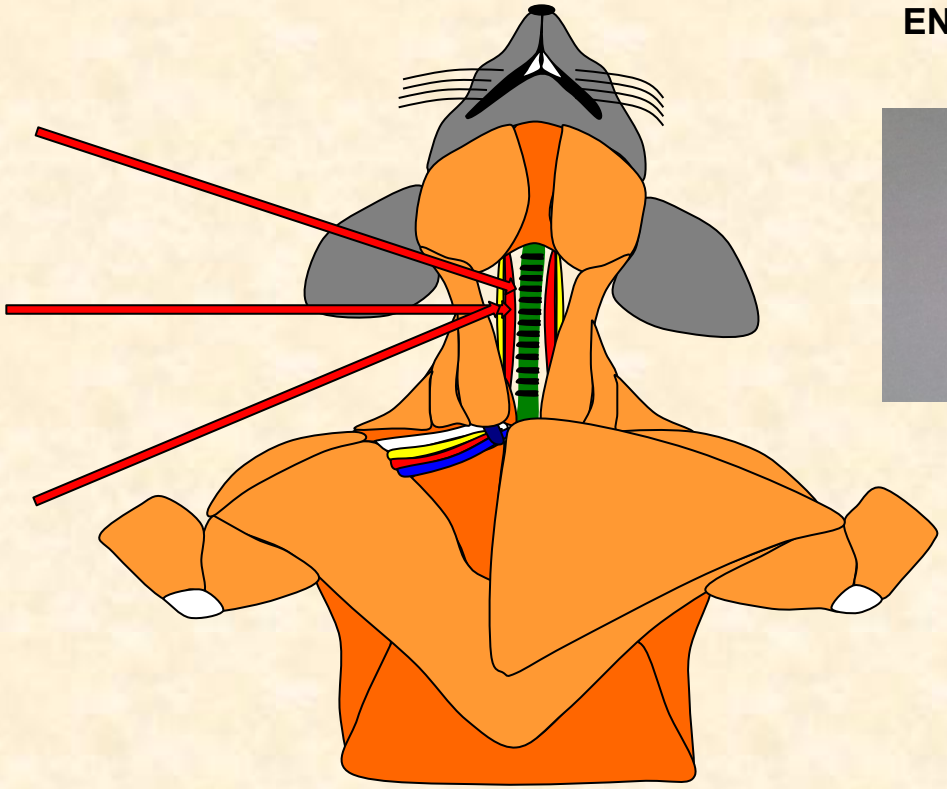

CALYPSOL®
injekční roztok/injekčný roztok
Ketaminum
5x10 ml injekční roztok/
injekčný roztok


Rometar 2%
JEN PRO ZVÍŘATA!
Analgetikum
50 ml
SPOFA
Rometar 2%
JEN PRO ZVÍŘATA!
SPOFA

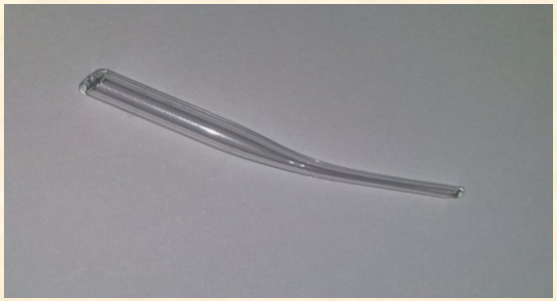
TRACHEA

A. CAROTIS

N. VAGUS

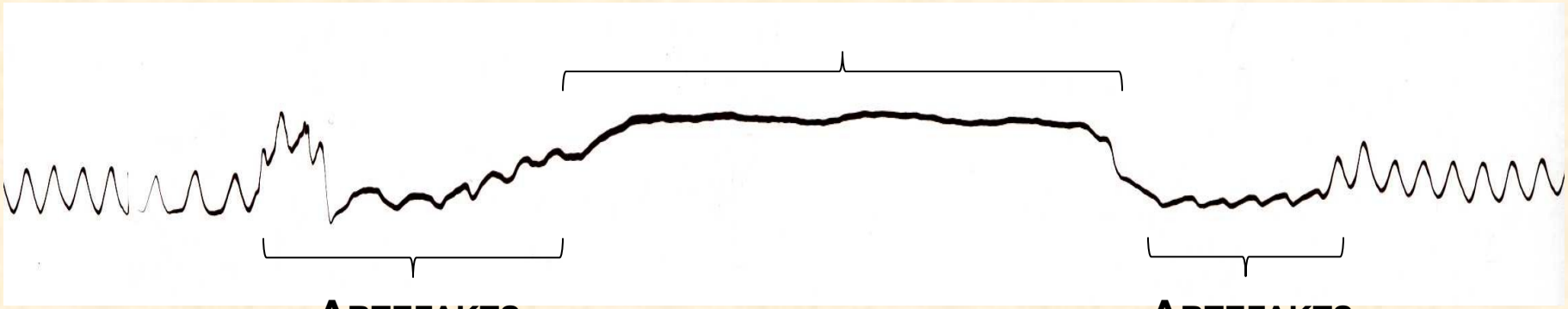


ENDOTRACHEAL CANNULA



HERING-BREUER REFLEX

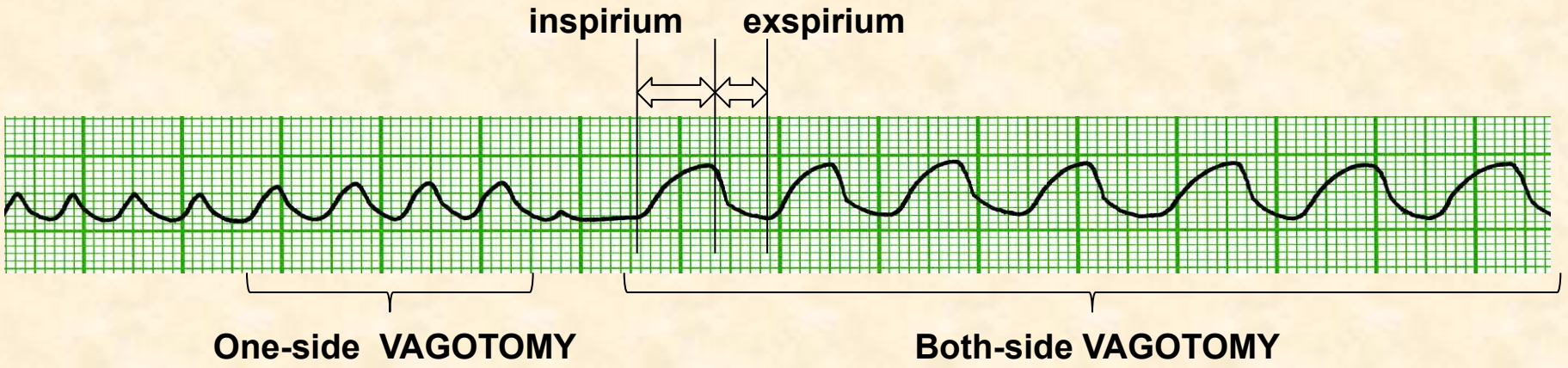
REFLEX STOP BREATHING



ARTEFAKTS

ARTEFAKTS

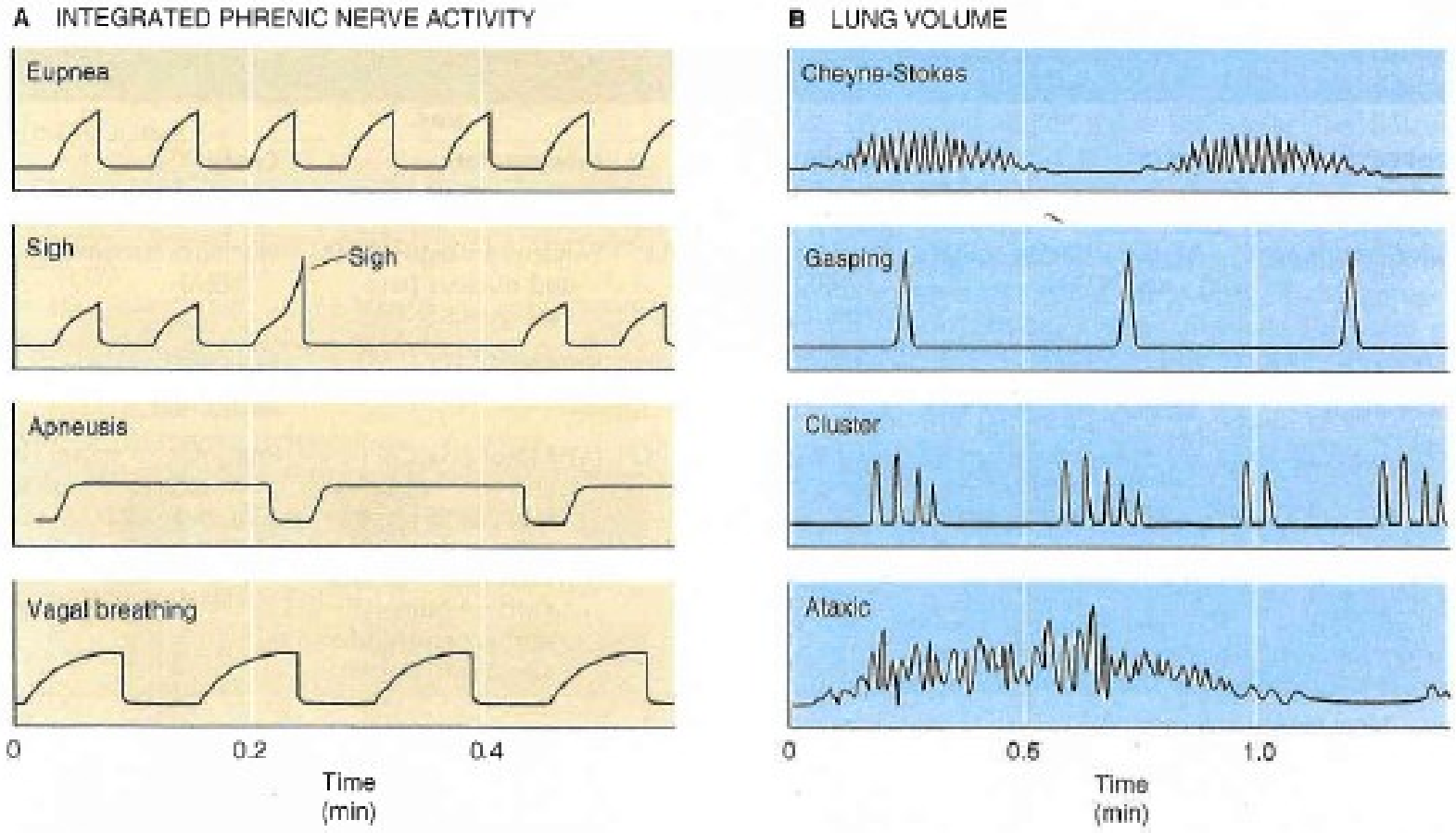
VAGOTOMY



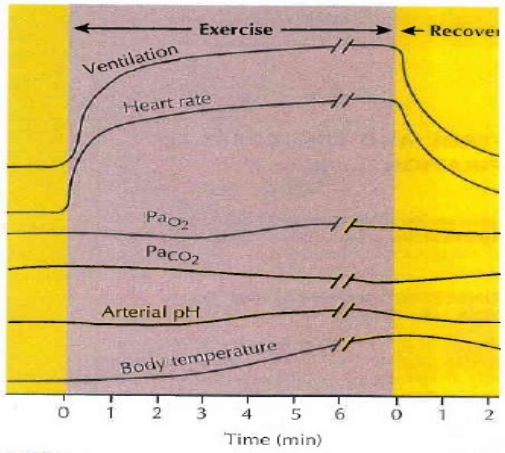
Periodic breathing

- It is not regular, rhythmic, but respiration occurs in periods ("a moment to breathe, take a moment to not breathe„)

- **CHEYNE-STOKES**
- **BIOT‘S**
- „gasping“
- KUSSMAUL


A INTEGRATED PHRENIC NERVE ACTIVITY
Eupnea
Sigh
Sigh
Apneusis
Vagal breathing
0
0.2
0.4
Time
(min)
B LUNG VOLUME
Cheyne-Stokes
Gasping
Cluster
Ataxic
0
0.5
1.0
Time
(min)

Respiratory Response to Exercise

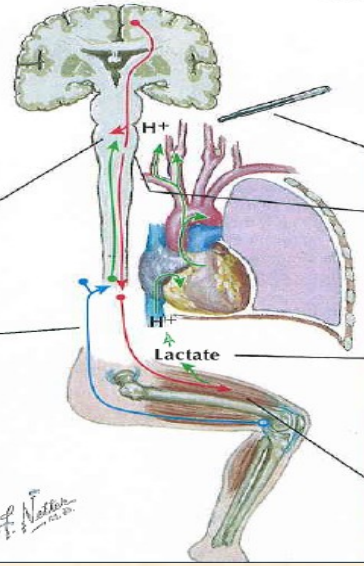


Factors that may account for initial abrupt rise and sharp terminal drop in ventilation

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 exerc

Rise in body temperatu accounts for a small pa of elevation

Respiratory neurons see to be more responsive t changes in chemorecep activity. Centers may b more sensitive to fluctuation than to absc values of Pa_{O_2}, Pa_{CO_2}, or pH

Lactic acid production due to anaerobic metabolism in muscle may increase H^+ con-centration of blood and CSF, thus affecting chemoreceptors

Possible metaboreceptc in exercising muscle

Other unknown factors

THANK YOU FOR YOUR ATTENTION

Merry Christmas and Happy New Year