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KARNATAKA PULMONOLOGISTS ASSOCIATION

Topic:

Pulmonary Stretch Receptors

Speaker:

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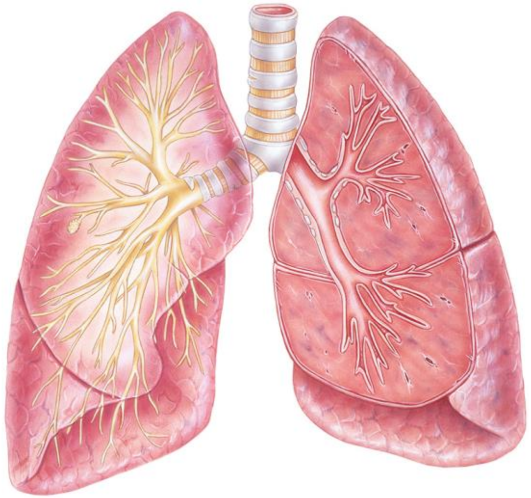
f LIVE

https://www.facebook.com/karnataka.pulmonologists.1

05th December 20
Saturday

8.30 to 9:00 pm

Pulmonary Stretch Receptors



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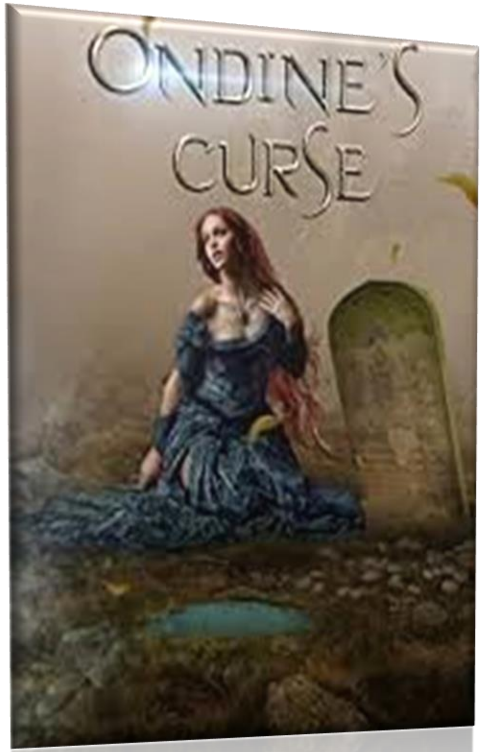


Ondine by John William Waterhouse (1849–1917)

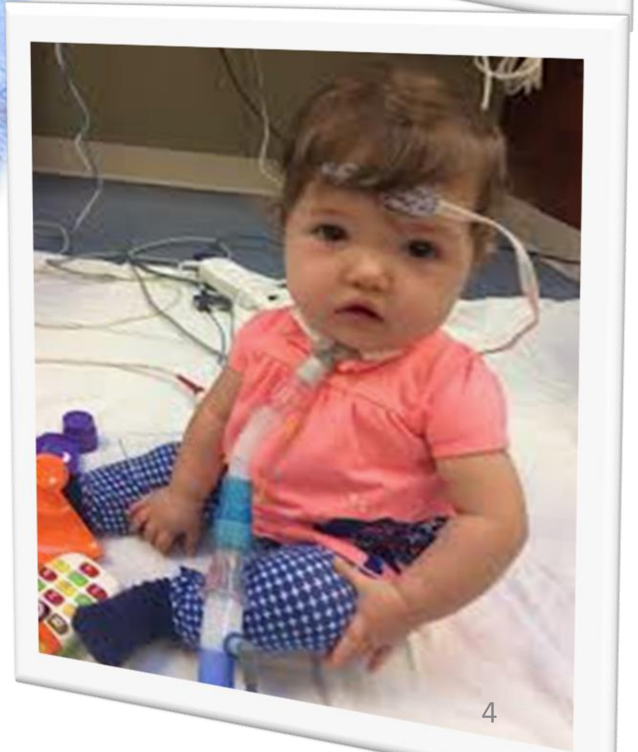
CCHS

stands for

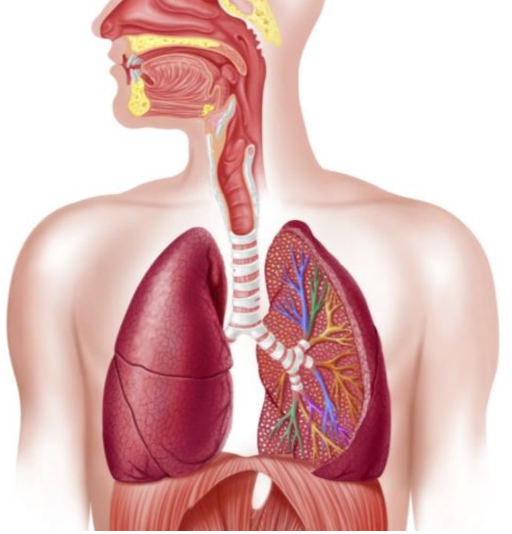
Congenital central hypoventilation syndrome

cchs NETWORK

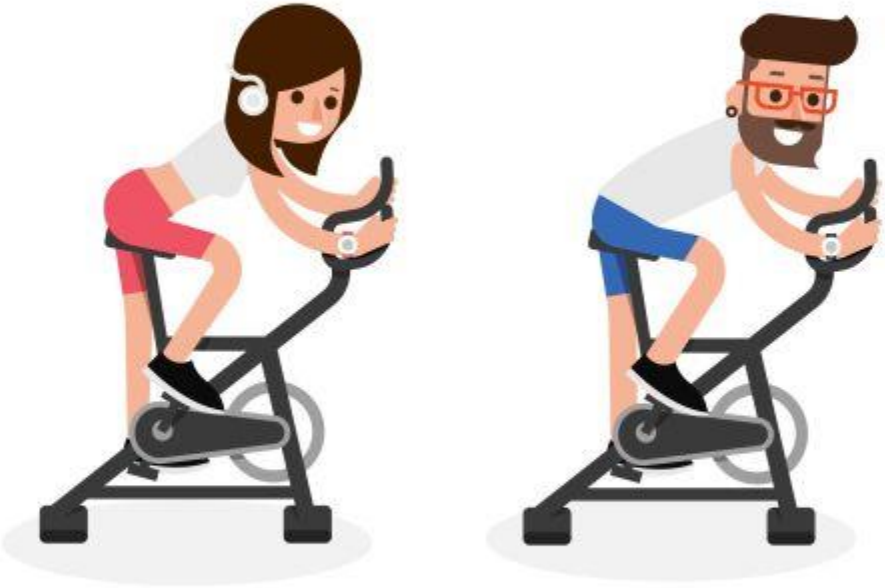
CCHS FOUNDATION



Overview

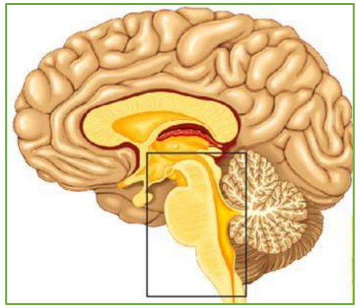


- Introduction
- Regulation of Respiration
- Respiratory Reflexes
- Pulmonary Stretch Receptors- Structure, Properties, Significance
- Hering Breuer Reflex
- Rapidly adapting Receptors
- C- fibres and J Reflex
- Summary
- References

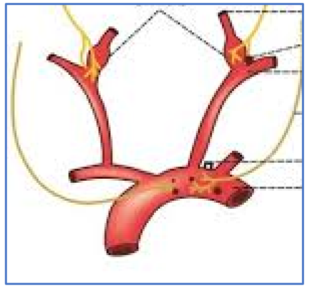


Regulation of Respiration

- I Neural Regulation
  - Cerebral Cortex
  - Pons
  - Medulla

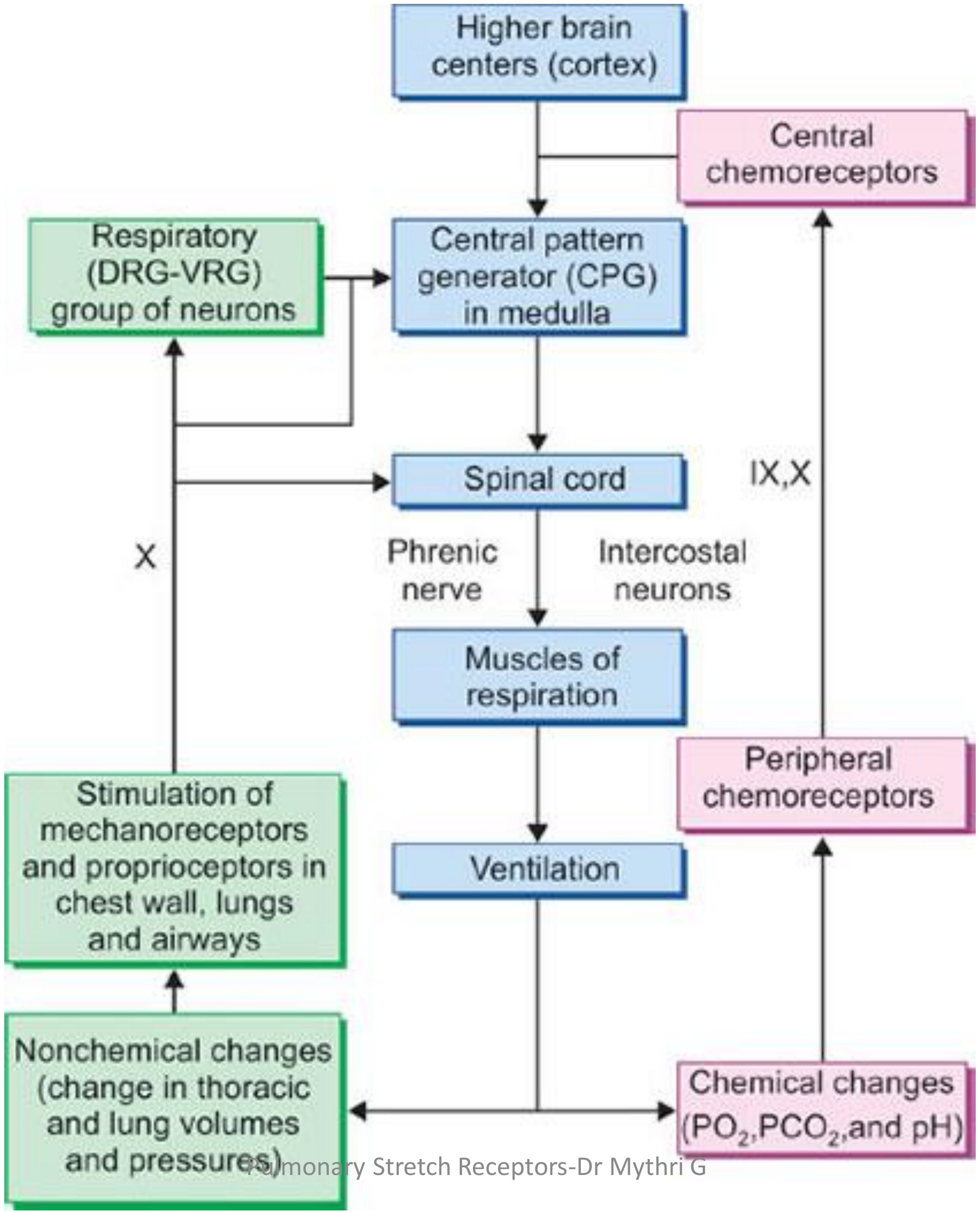


- II Chemical Regulation
  - Peripheral Chemoreceptors
  - Central Chemoreceptors

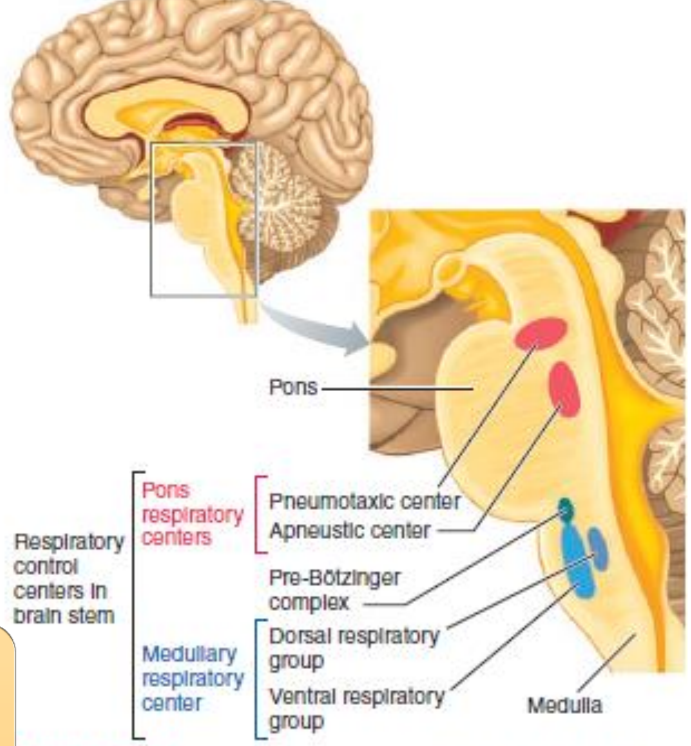


- III Non Chemical Regulation
  - Reflexes originating from lungs, airways and chest wall

Regulation of Respiration

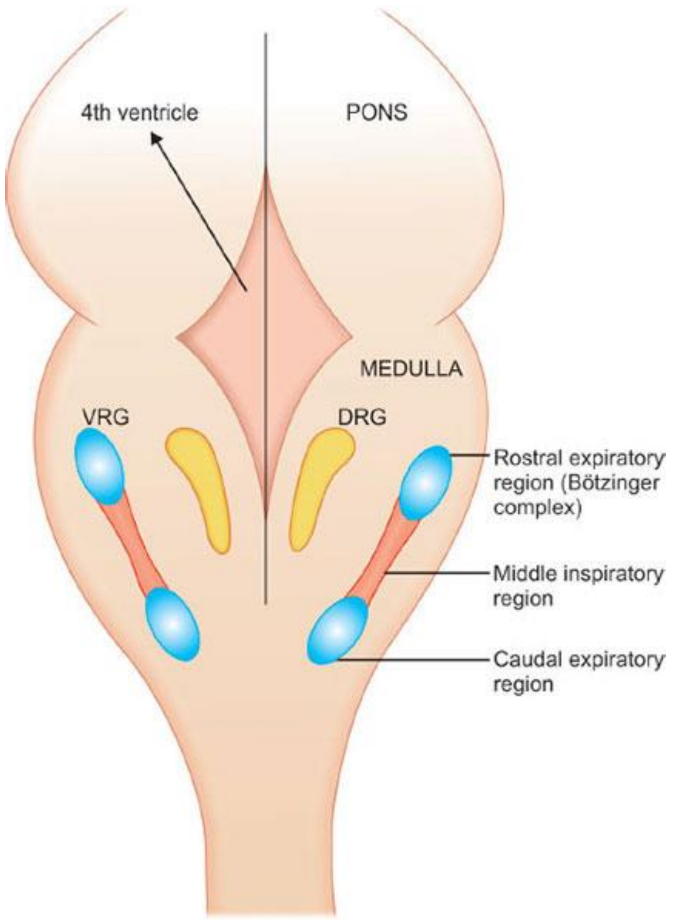


I. Neural Regulation of Respiration:

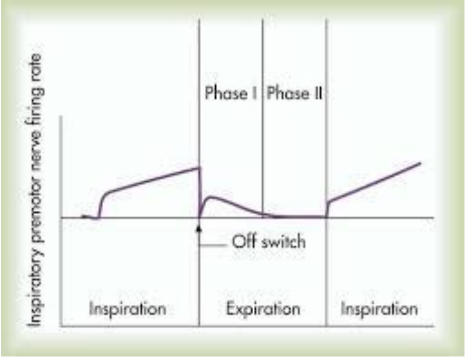


- Neural Regulation of Respiration
  - Medullary Respiratory Centres
    - Dorsal Respiratory Group
    - Ventral respiratory Group
  - Pontine Respiratory Centres
    - Pneumotaxic Centre
    - Apneustic Centre

Medullary Respiratory Centres:



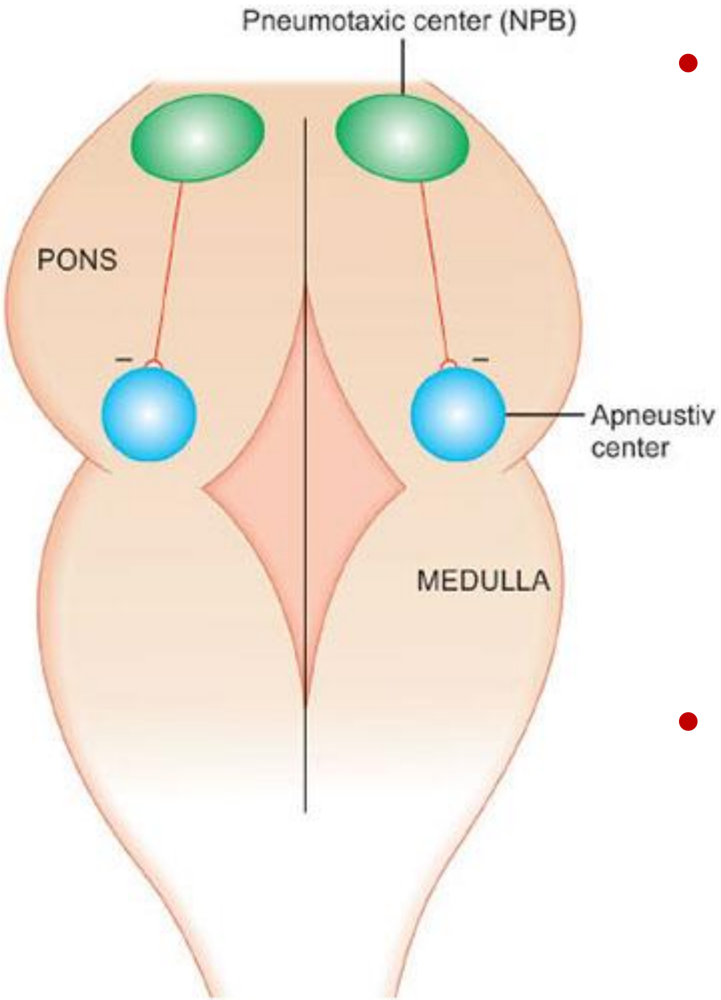
Generate basic respiratory rhythm



- **Dorsal Respiratory Group:**
  - Located bilaterally
  - Around NTS
  - Inspiratory neurons- ***Inspiratory ramp***

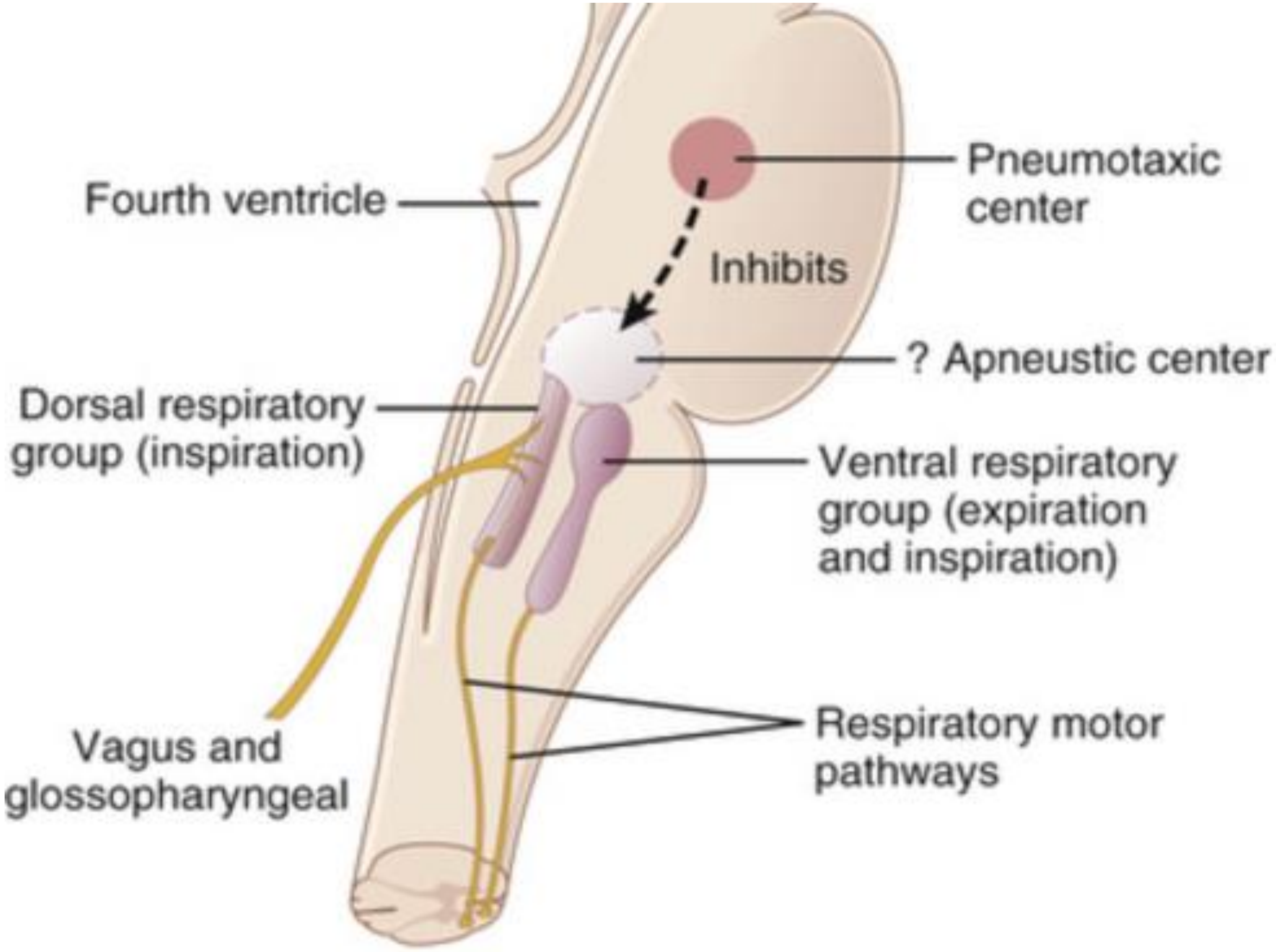
- **Ventral Respiratory Group:**
  - Located bilaterally
  - Around N. ambiguous & N. retrofacialis
  - Inspiratory and expiratory neurons
  - Remain inactive during quite breathing
  - Role during forceful respiration- exercise

Pontine Respiratory Centres:

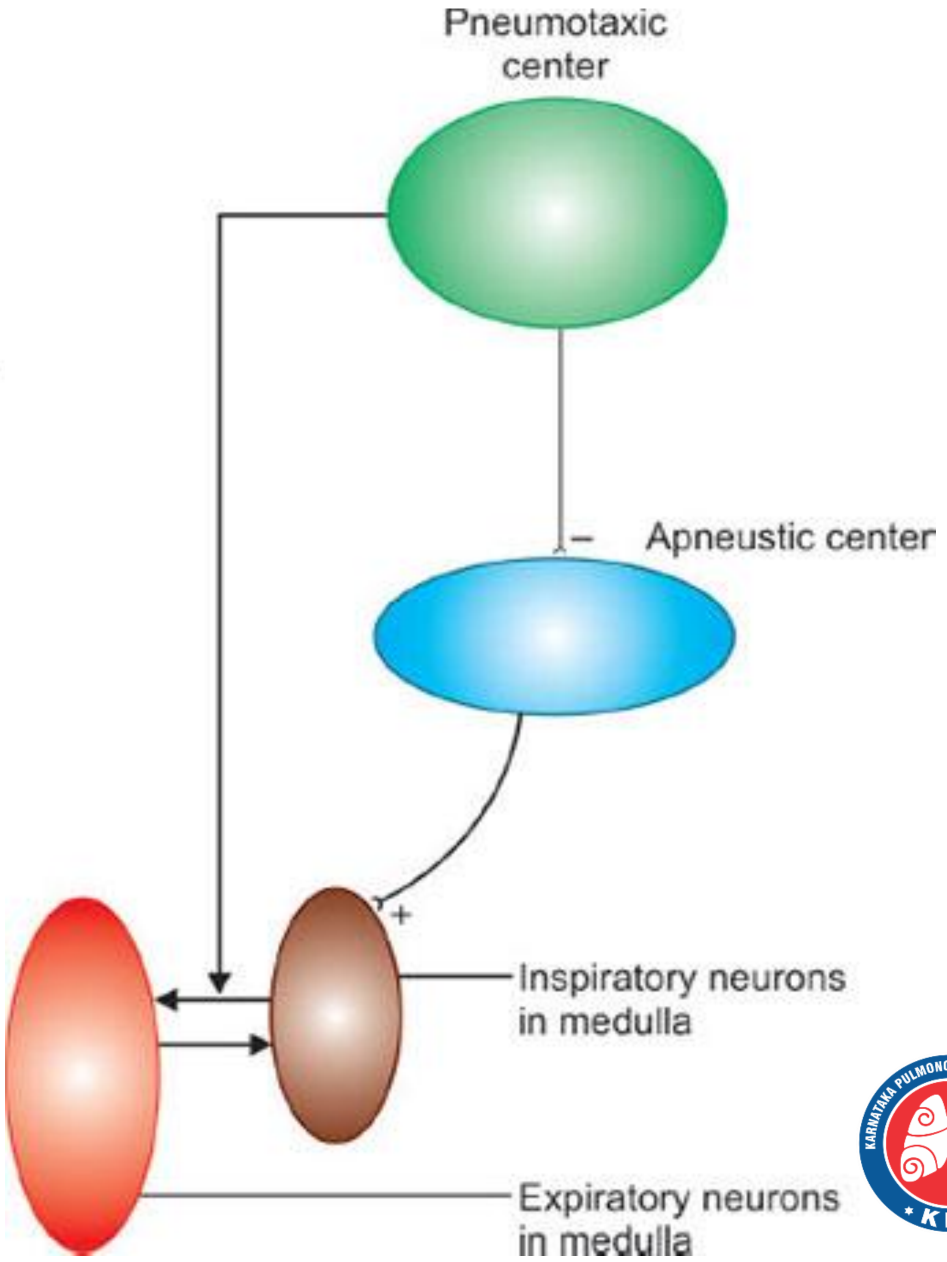


Regulate the rate and depth of respiration

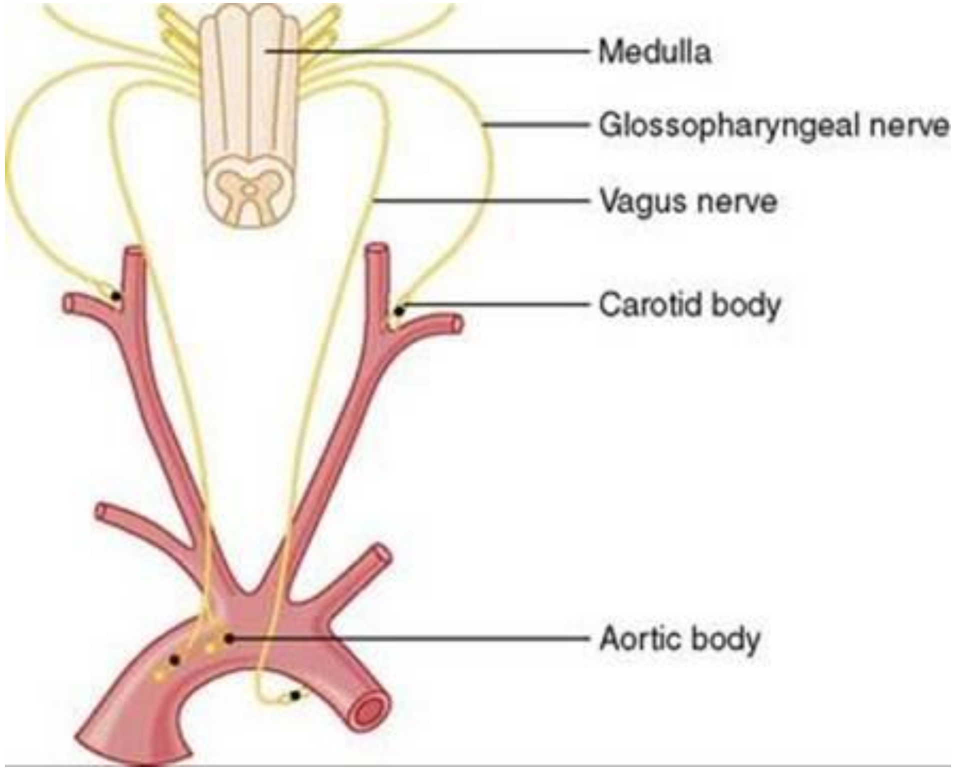
- **Apneustic Centre:**
  - Inhibitory neurons- B/L in lower pons
  - Prevents switch off of Inspiratory ramp signals
  - Increases TV and duration of inspiration
  - Stimulation -- apneusis
  - Normally, inhibited by Pneumotaxic centre and Vagus Nerves
- **Pneumotaxic Centre:**
  - Located in N. parabrachialis medialis upper pons
  - Inhibit Apneustic Centre
  - Shortens inspiration- shallow, rapid breathing



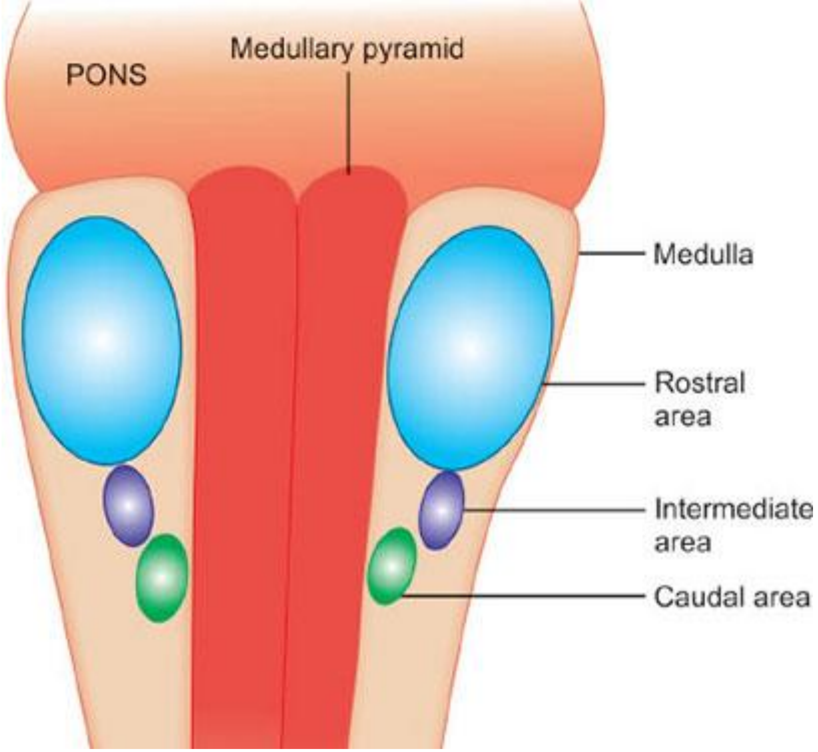
Organization of the respiratory center.



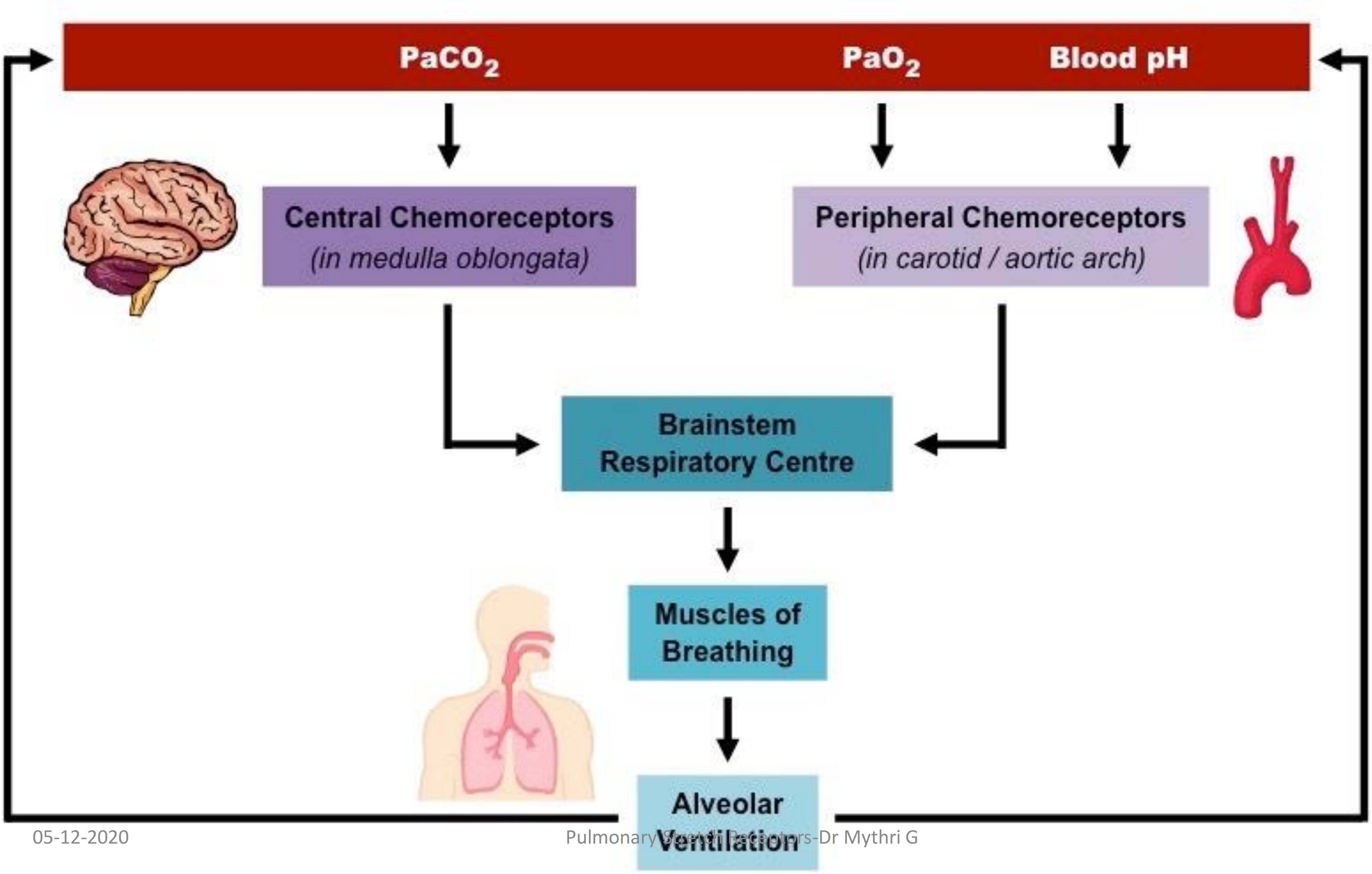
II. Chemical Regulation of Respiration:



Peripheral Chemoreceptors



Central Chemoreceptors

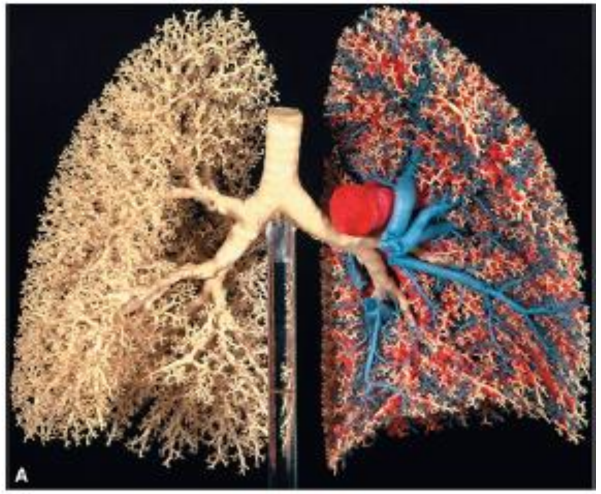

PaCO2
PaO2
Blood pH
Central Chemoreceptors
(in medulla oblongata)
Peripheral Chemoreceptors
(in carotid / aortic arch)
Brainstem
Respiratory Centre
Muscles of
Breathing
Alveolar
Ventilation

III. Respiratory Reflexes:

- Reflexes arising from the upper airways and lungs
- Provide feedback for fine tune breathing
- Protects the lungs from environmental insults

Receptors:

1. Slowly adapting receptors
2. Rapidly adapting receptors
3. C- fibre endings



Receptors for Respiratory Reflexes:

1. Slowly Adapting Receptors or Pulmonary stretch Receptor

2. Rapidly Adapting Receptors or Irritant Receptors

- Airway mucosa- Larger conducting airways
- Stimulated by – sudden maintained inflation, chemical stimuli , noxious substances
- Role in irritation , congestion and inflammation of airways

3.C- fibre Endings or J Receptors

- Airway mucosa-Alveoli and conducting airways
  - i. Pulmonary C fibres (J Receptors)- edema, congestion and embolism
  - ii. Bronchial C fibres- chemical stimuli

1. Slowly Adapting Receptors (SARs):

Also known as

" Pulmonary Stretch Receptors"

Adapt slowly to stretch imposed on them

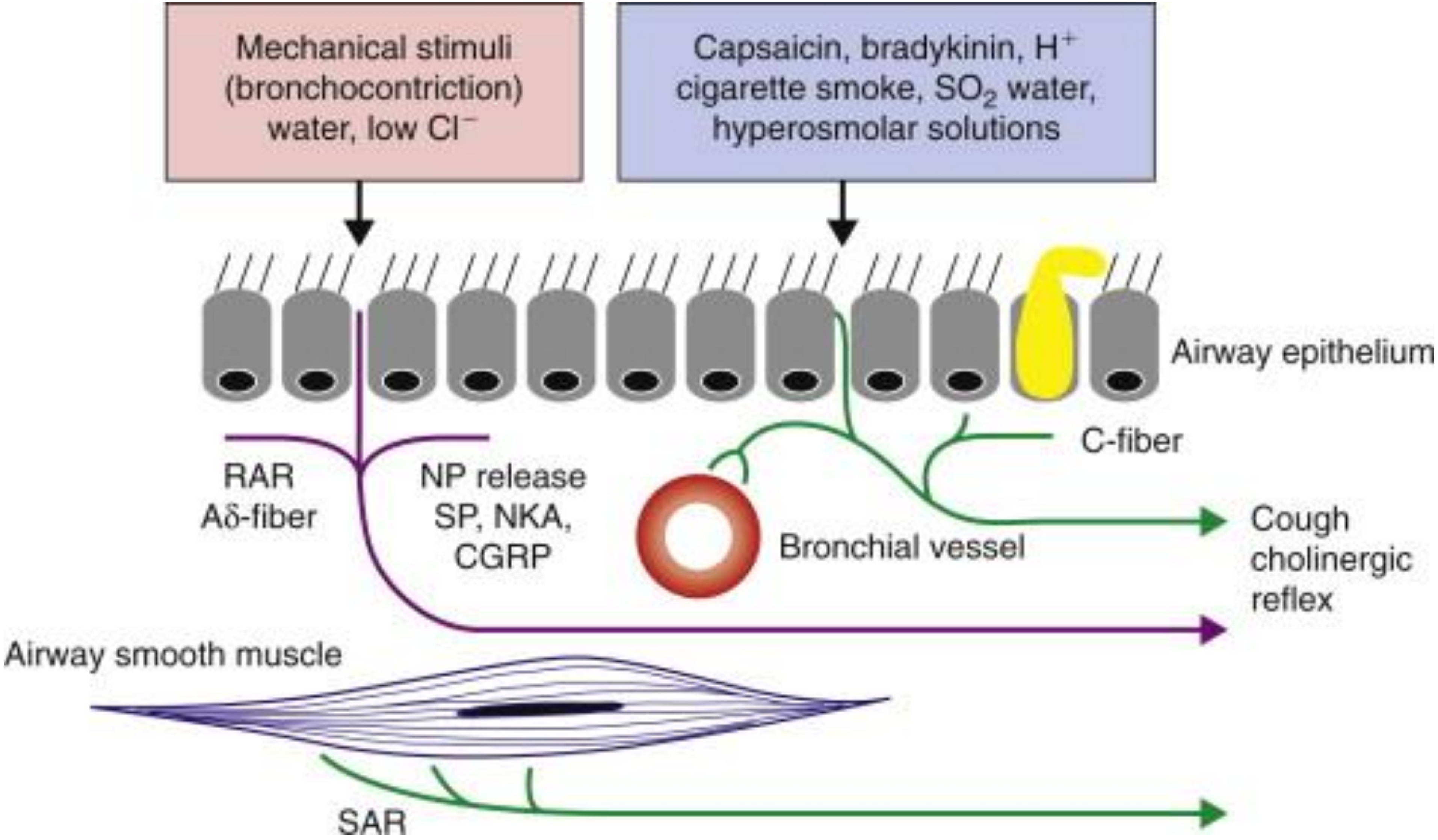
Location:

Smooth muscle of conducting airways

(trachea, bronchi, bronchioles)

Stimulus:

Stretch→ Depolarization of the SARs

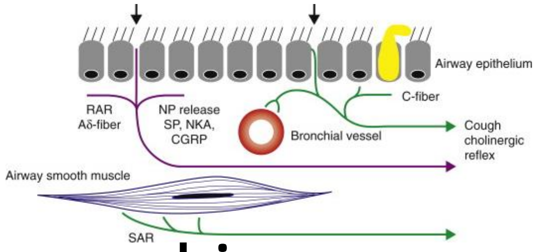


Afferent nerves in airways.

Slowly adapting receptors (SARs) are found in airway smooth muscle

Rapidly adapting myelinated (RAR) and Unmyelinated C-fibers are present in the airway mucosa.

Structure of Pulmonary Stretch Receptors:



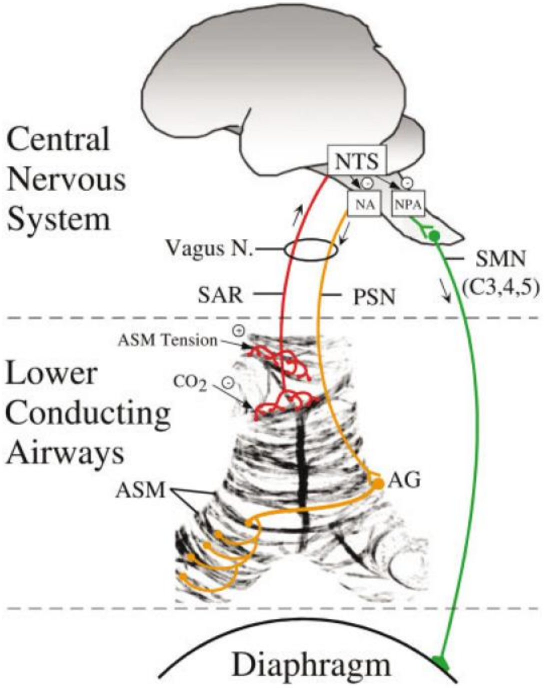
1. 100 µm in diameter
2. Sensory terminals of myelinated afferent fibres- end in plate like masses airway smooth muscle bands
3. Terminal branches of these nerves terminate between and wrap around the smooth muscle
4. Surrounded by many collagen fibres which links them to smooth muscle fibres
5. Resemble "*Muscle Spindle*" in skeletal muscle

Types of Pulmonary Stretch Receptors (SARs):

A. Based on Location in Tracheobronchial tree:

1. Intrathoracic (extrapulmonary) SARs:
   - Rhythmic pattern of discharge during eupnoeic breathing
   - Mounting pattern- inspiration
   - Declining pattern- expiration

2. Extrathoracic (intrapumonary) SARs:
   - Few receptors
   - Irregular pattern of discharge
   - Mounting discharge during expiration



Types of Pulmonary Stretch Receptors (SARs):

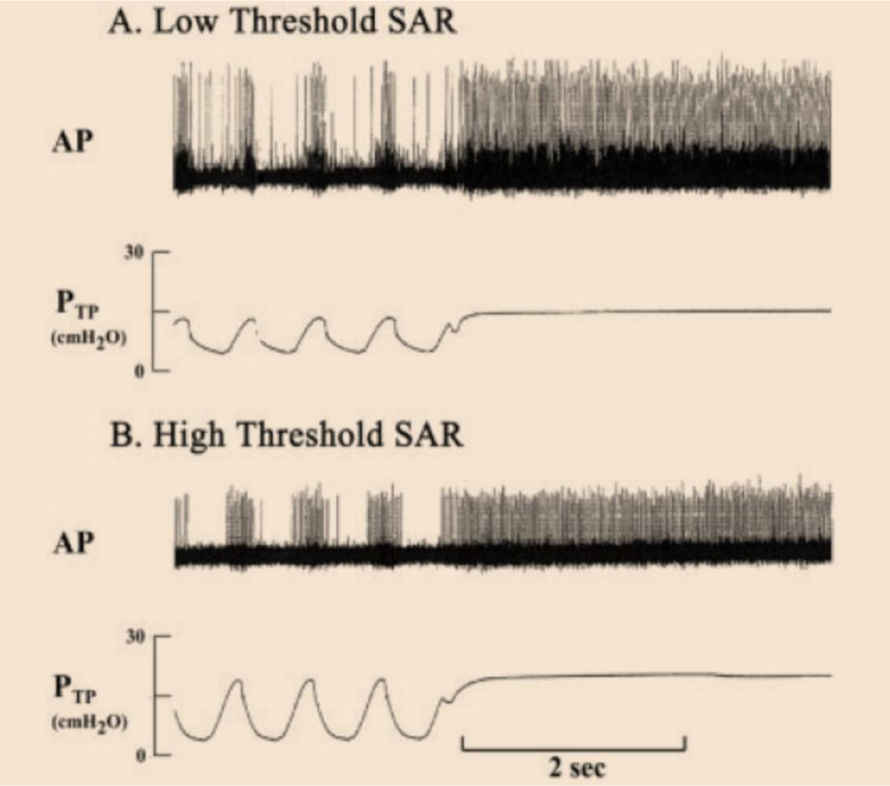
Contd………..

B. Based on discharge activity:

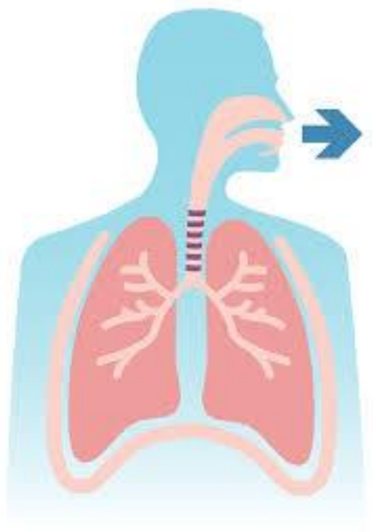
Proposed by Paintal

1. Low threshold receptors:
   - SARs with discharge activity **during expiration**
   - Located in large bronchi

2. High-threshold receptors:
   - SARs which are **silent during expiration**



Pulmonary Stretch Receptors:



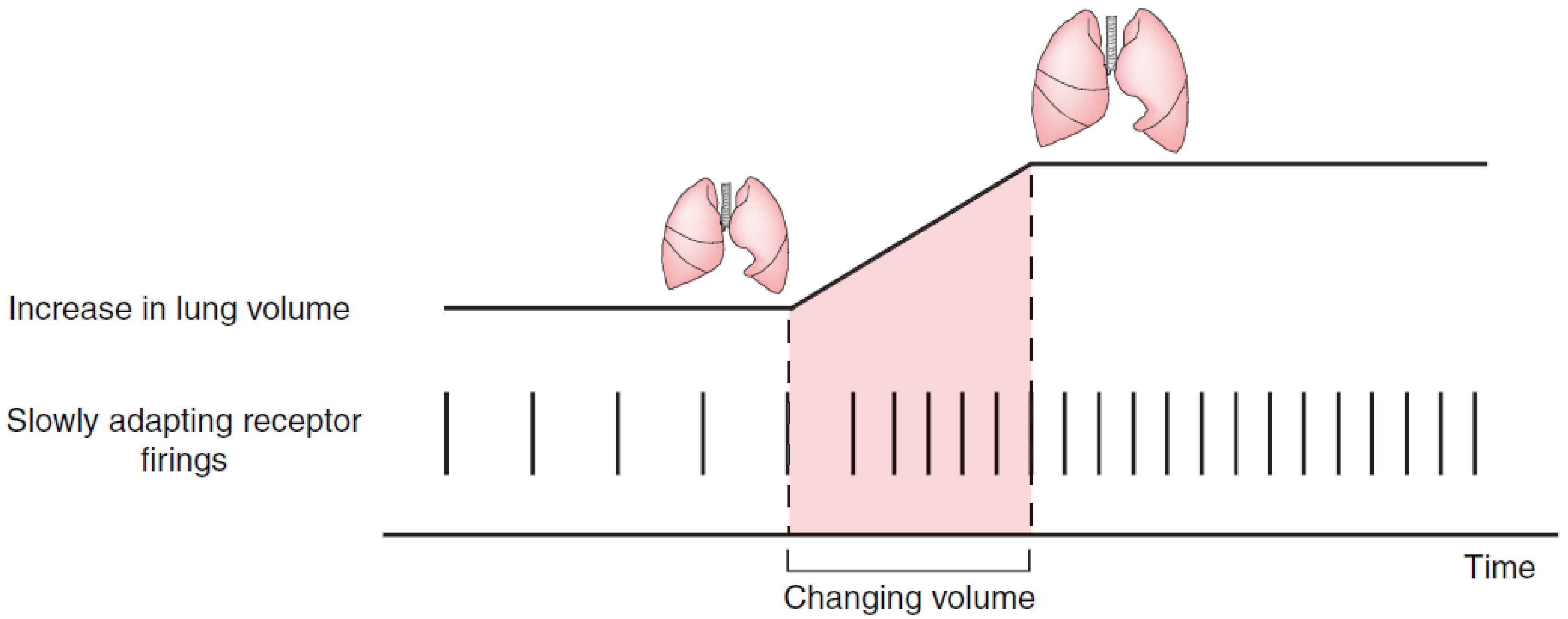
Note:

*Once a certain volume threshold is achieved → stretch receptor input → activates “**inspiratory off-switch**” →controls Tidal Volume and Inspiratory time.

* In addition, **expiratory discharge** of these receptors → determine Expiratory Time→ thus, influence breathing frequency at rest

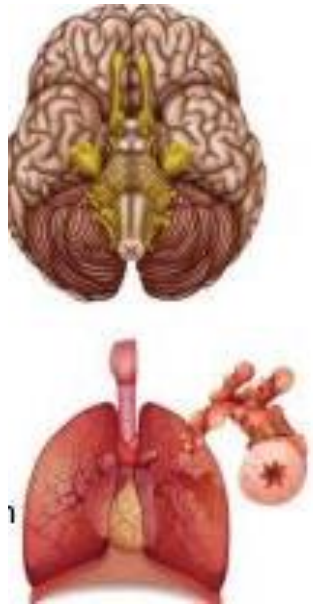
Properties of Pulmonary Stretch Receptors:

1. Slowly adapting end-organs



Properties of Pulmonary Stretch Receptors:

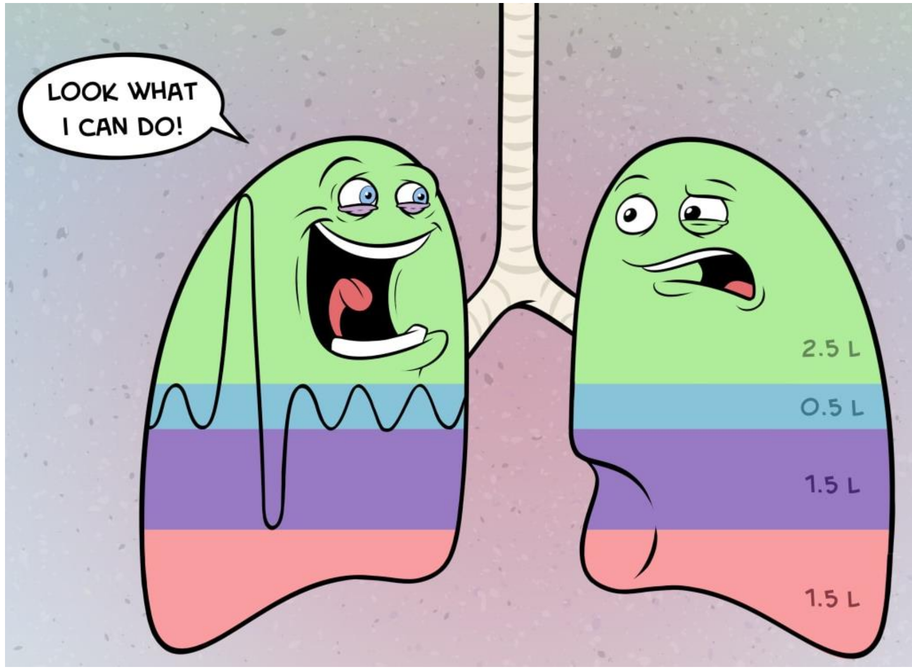
2. Large diameter myelinated afferent fibres
3. Dynamic property-
   - Rhythmic pattern of discharge during eupnoeic breathing
     - Mounting pattern- inspiration
     - Declining pattern- expiration



4. Serial discharge of impulses when stretched
5. Respond to rate of change of stretch as well as to stretch itself
6. Low threshold discharge

Properties of Pulmonary Stretch Receptors: *Contd...*

7. Some SARs are tonically active - fire at FRC
   Most SARs fire > 3 times eupnoeic TV.
8. Total range of sensitivity: Residual Volume to
   Vital Capacity
9. Mechanosensitive – respond to stretch of
   airway wall and Increase airway transmural
   pressure
10. Insensitive to chemical irritants
    (some studies- Increase pCO_2 inhibits SARs;
    pCO_2 <30mmHg- Stimulates the nerve endings)

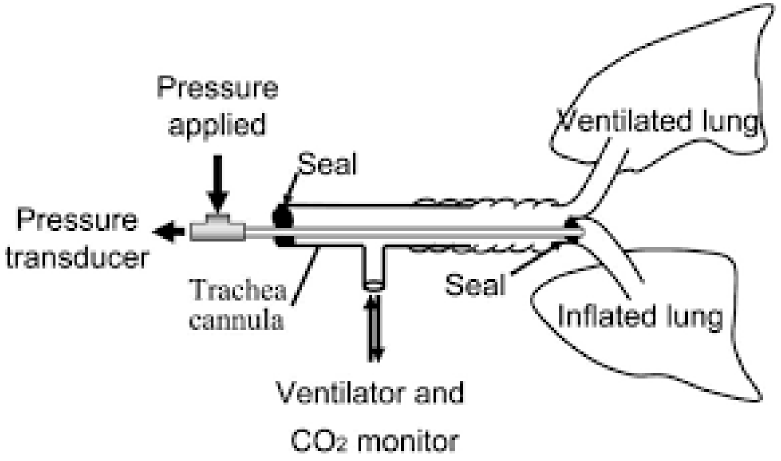


HERING –BREUER REFLEX :

Also known as – " Pulmonary Stretch Reflex"

When stimulated they inhibit Inspiration and prolong expiration.

Karl Ewald Hering



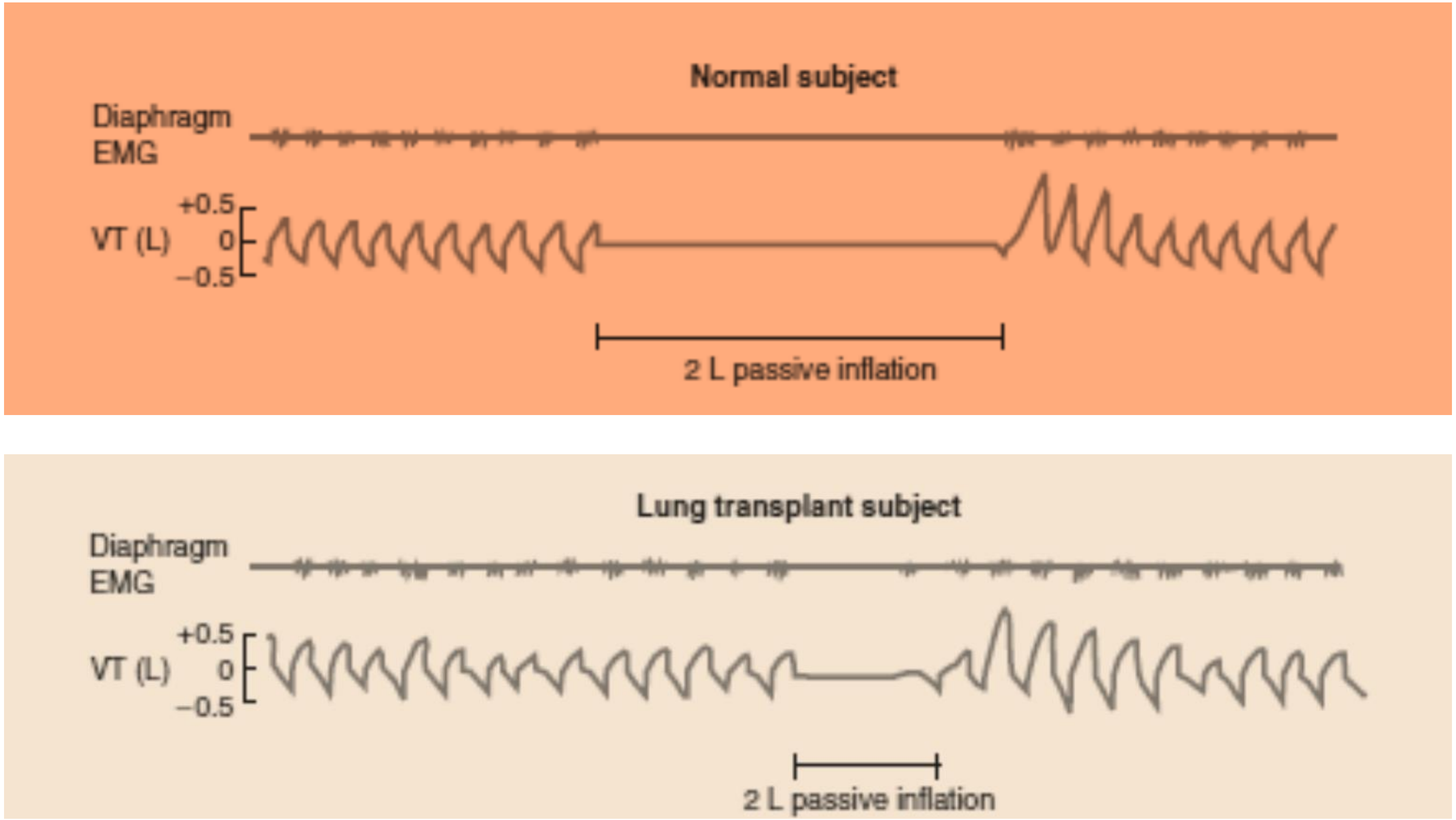
1868

Joseph Breuer

Hering Breuer Reflex:

Key points:

- Inhibitory protective reflex
- Strongest in rabbit
- Weakest in human
- ***Inactive during quite breathing***
- Does not play any regulatory role in tidal respiration
- Only tries to limit Tidal volume (when >1-1.5L) - exercise
- Bilateral vagotomy / Transient bilateral blockade of vagi by local anaesthetic abolishes this reflex



Ventilatory efforts (diaphragm EMG) and ventilation (tidal volume, VT changes) in a normal subject (upper) and a bilateral lung transplant patient (lower panel) during sleep.

After Iber et al., Am J Respir Crit Care Med 1995;152:217

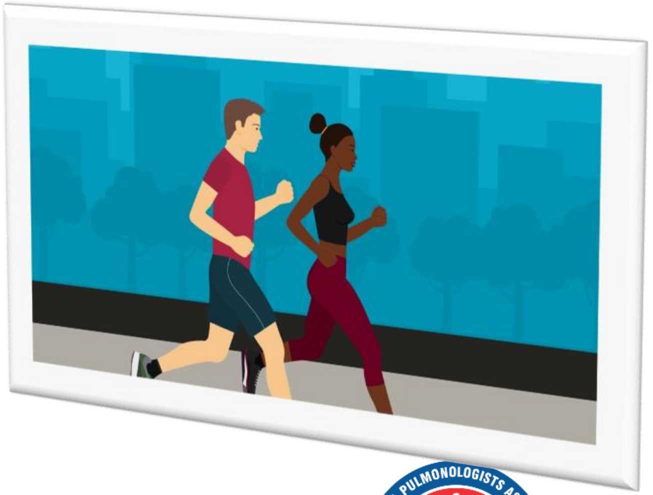
Types of Hering-Breuer Reflex

- Hering-Breuer Reflex (HBR)
  - Hering-Breuer Inflation Reflex
  - Hering-Breuer Deflation Reflex

a) Hering Breuer Inflation Reflex:

Significance of Hering Breuer:

- Protective Reflex (Negative Feedback mechanism)
- Protects the lungs from overinflation while maintaining normal alveolar ventilation



In neonates:

Stimulates and maintains rhythmic breathing pattern

In Infants:

Controls Tidal volume during eupnea

In Adults (post natal habituation of HBR):

Tidal Volume > 1 litre (>3* Normal Tidal Volume = 1.5L)

a) Hering-Breuer Inflation Reflex

Lung Inflation

> 3 times Eupnoeic TV (1.5L per breath)

Stimulate (+)

Pulmonary Stretch Receptors (SARs)

Vagus Nerve

Medullary Inspiratory Centres

Inspiratory ramp-switched off

(-)Spinal respiratory motor neurons (Phrenic Nerve; Spinal Nerves)

Inhibitory signals to Diaphragm and External Intercoastal Muscles

Abrupt termination of Inspiration

Beginning a prolonged expiration

a) Hering-Breuer Inflation Reflex:

Stimulus: Overinflation of Lungs (> 3*Eupnoeic Tidal Volume=1.5L)

Receptor: Pulmonary Stretch Receptors (SARs)

Afferents: Vagus Nerve

Integration Centre: Medullary respiratory centre (Inhibition of DRG)

Efferent: Spinal respiratory motor neurons (Phrenic N. and Spinal N.)

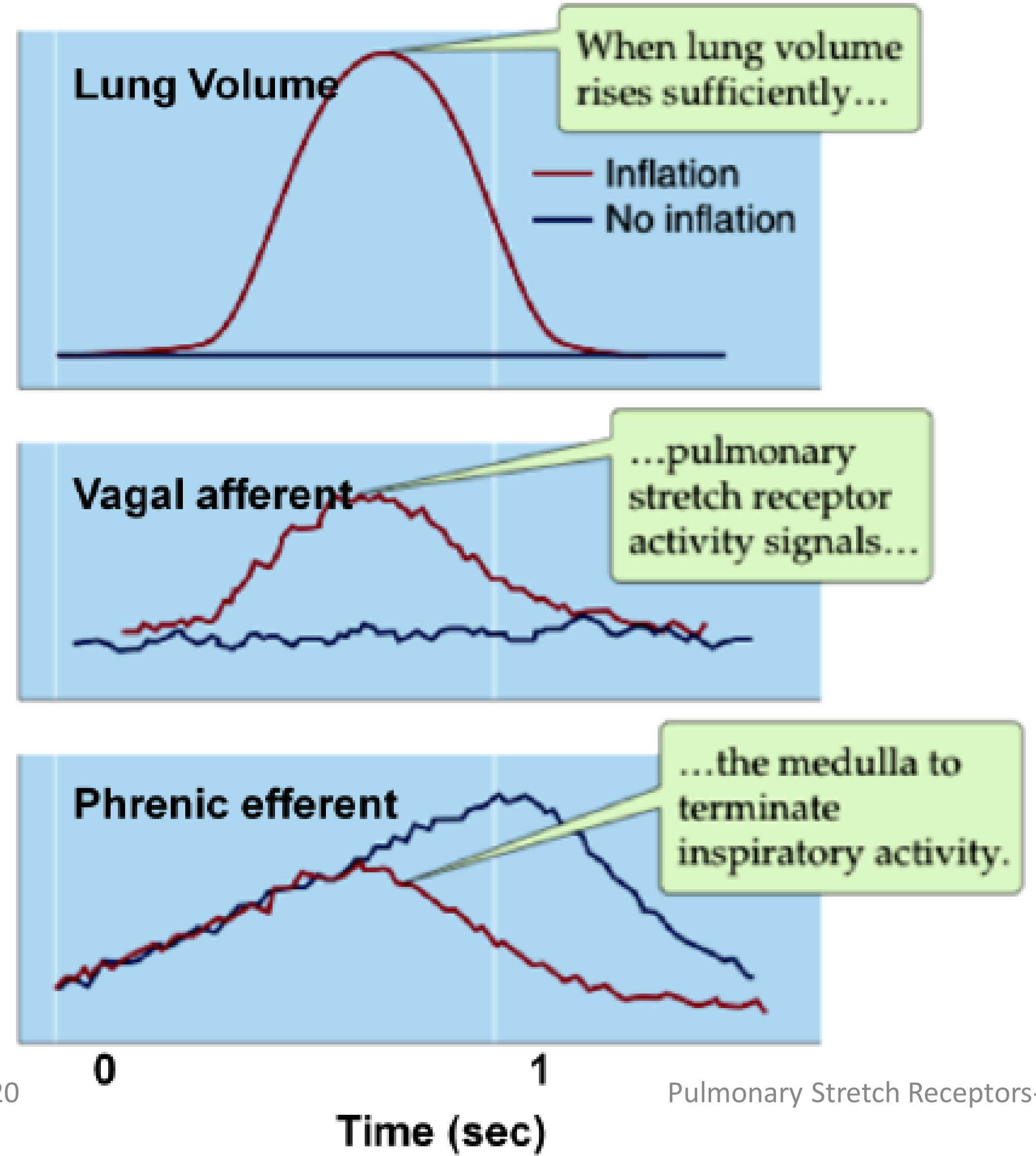
Target: Diaphragm and External Intercoastal Muscles (inhibited)

Effect: Abrupt termination of Inspiration

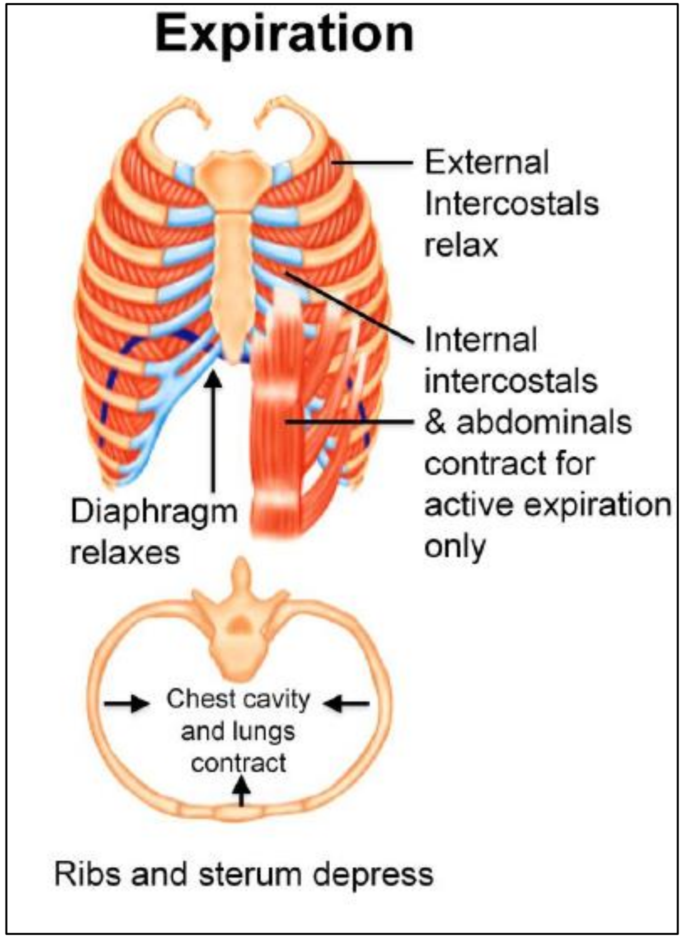
Beginning of Prolonged Expiration

Advantage: Prevents overinflation of lungs

Hering-Breuer Reflex reveals a role for stretch receptors in control of respiration



Slowly adapting pulmonary stretch receptors

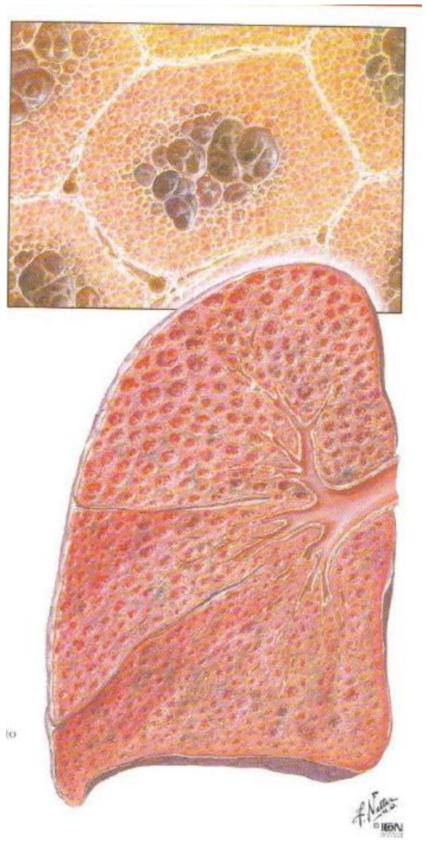


Hering Breuer Inflation Reflex:

Clinical Significance:

In obstructive pulmonary disease:

- Increased lung volume in people with obstructive pulmonary disease
- Stimulates pulmonary stretch receptors
- Delays the onset of the next inspiratory effort
- Long, slow expiratory effort
- Essential to minimize dynamic, expiratory airway compression



b) Hering-Breuer Deflation Reflex

Marked Deflation of lungs

↓

Decrease in Tidal Volume

↓

Decrease activity of **SARs**

↓

Decrease signals through vagal afferents

↓

Decrease inhibition of Inspiratory centre in medulla

↓

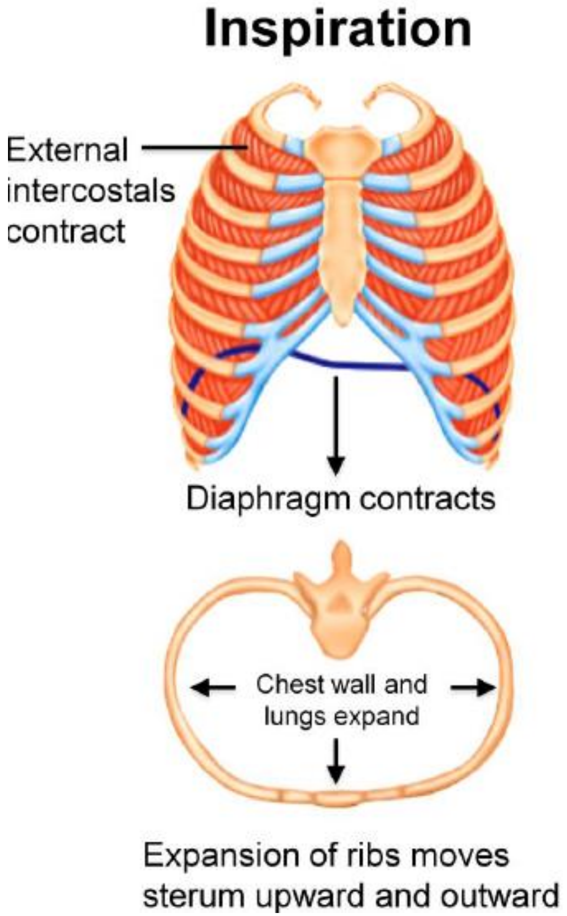
Stimulation of Inspiratory neurons

↓

Switch on – Inspiratory ramp

↓

Increase in rate of breathing



b) Hering-Breuer Deflation Reflex:

Stimulus: Marked deflation of Lungs

Receptor: Pulmonary Stretch Receptors (at times RARs)

Afferents: Vagus Nerve

Integration Centre: Medullary respiratory centre

Stimulation of DRG- Inspiratory switch - on

Efferent: Spinal respiratory motor neurons (Phrenic Nerve and Spinal Nerves)

Target: Diaphragm and External Intercoastal Muscles (stimulated)

Effect: Beginning of inspiration & Increase in Respiratory rate

Advantage: Prevents collapse of lungs

Hering-Breuer Deflation Reflex:

Physiological Significance:

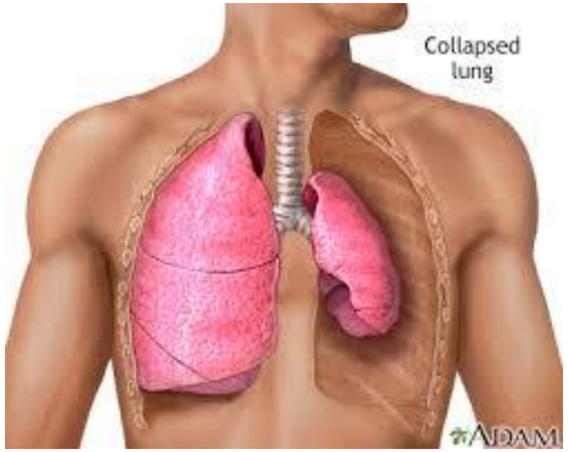
In yawning:

- Periodic Collapse of smaller alveoli
- Increase in Lung compliance
- Stimulation of RARs
- Yawning / Sighing
- Reflex opening of collapse alveoli

Hering-Breuer Deflation Reflex:

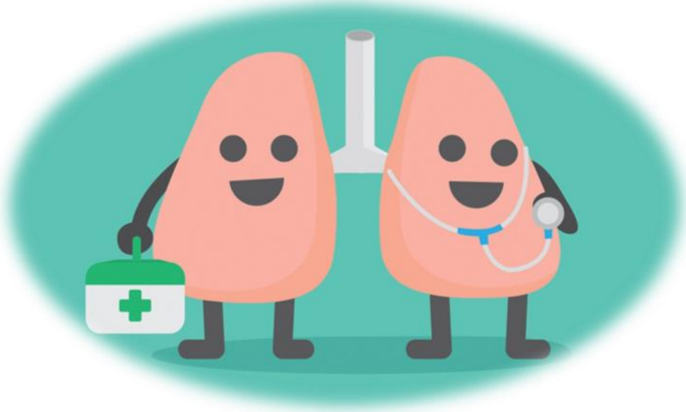
Clinical Significance:

In Pneumothorax and Lung Collapse (Atelectasis):



- Large deflation of the lungs
- Distortion of the bronchial epithelium
- Stimulation of irritant receptors (RARs) in bronchial epithelium
- Stimulates inspiration
- Prevents collapse of alveoli

Significance of Pulmonary Stretch Receptors:



1. Hering- Breuer Reflex
2. Regulation of Expiratory muscle activation, duration of expiration and Functional Residual Capacity
3. Increase parasympathetic tone (airway)→Reflex bronchodilatation → Relaxation of Airway smooth muscle
4. Optimize reciprocal relationship between dead space and airway resistance
5. Reduces systemic vascular tone
6. Increases heart rate (reflex cardio-acceleration)

Significance of Pulmonary Stretch Receptors: *Contd…*

Recent studies:

7. Controlling breathing pattern

8. Pathological conditions

    i. Asthma- Increase in sensitivity to normal stimuli due to broncho-constriction , airway obstruction

    ii. Emphysema- Alterations in breathing patterns

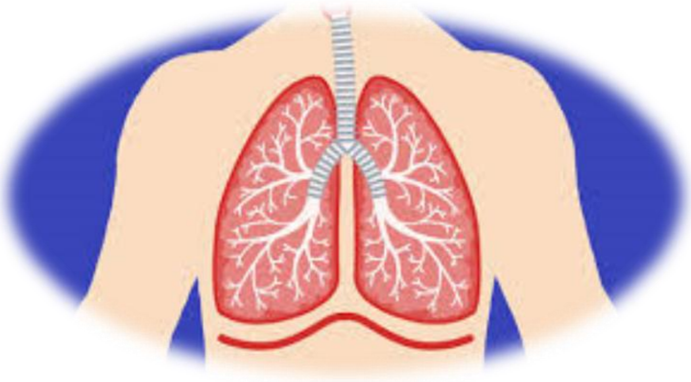
    iii. Pulmonary fibrosis-Alterations in lung compliance and rapid, shallow breathing pattern

9. Modulate sensation of air hunger and dyspnoea in lung diseases

2. Rapidly Adapting Receptors (RARs):

Frequently called as

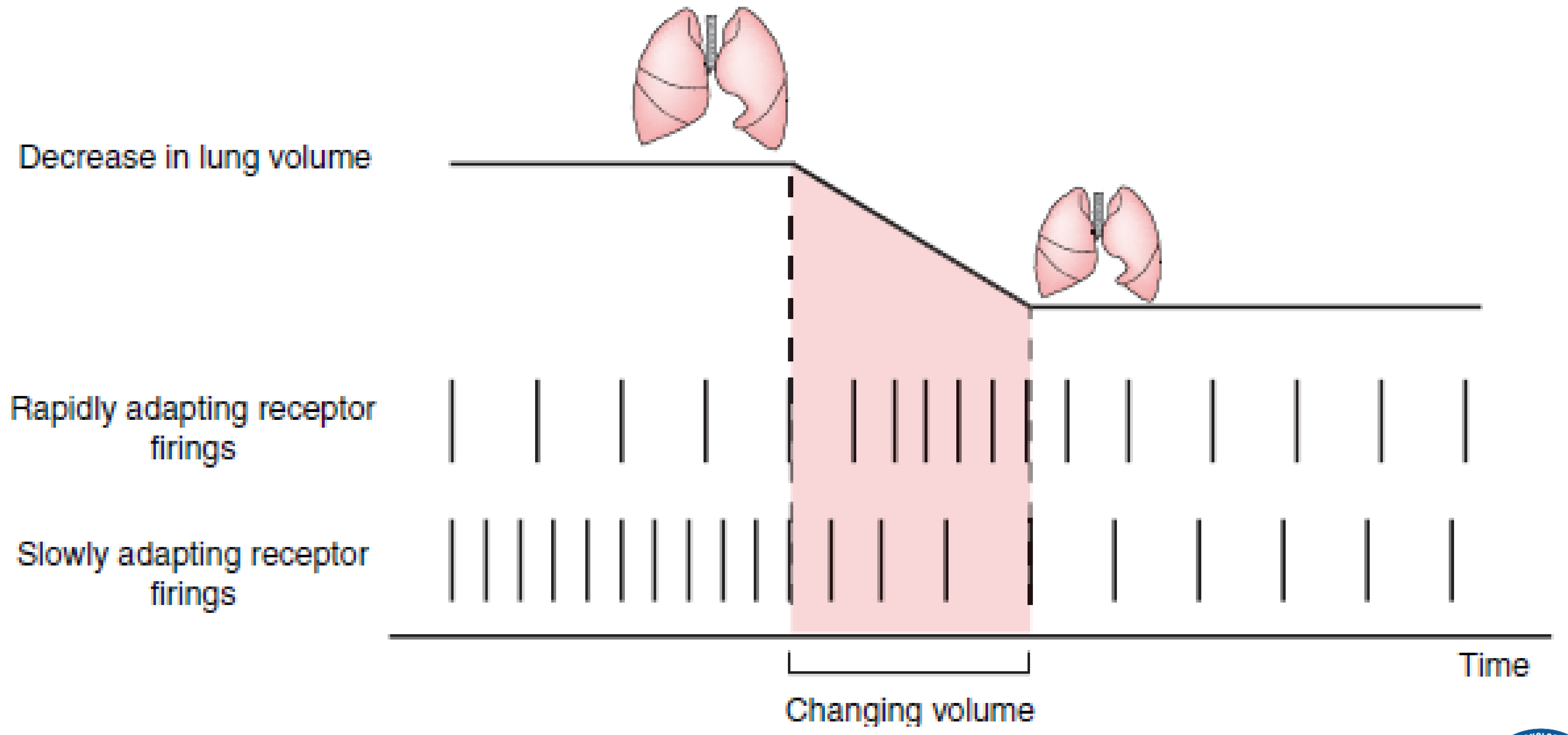
“ Irritant Receptors”



Sometimes called as

“ Rapidly adapting Pulmonary Stretch Receptors”

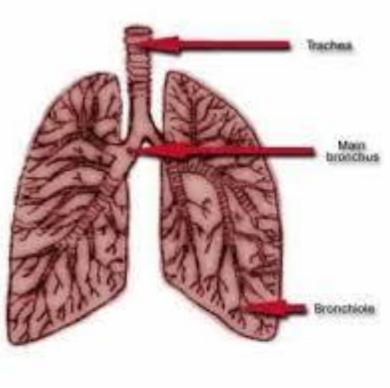
Adapt quickly to stretch imposed on them


Decrease in lung volume
Rapidly adapting receptor firings
Slowly adapting receptor firings
Time
Changing volume

Rapidly Adapting Receptors/ Irritant Receptors

Location:

Airway mucosa of larger conducting airways

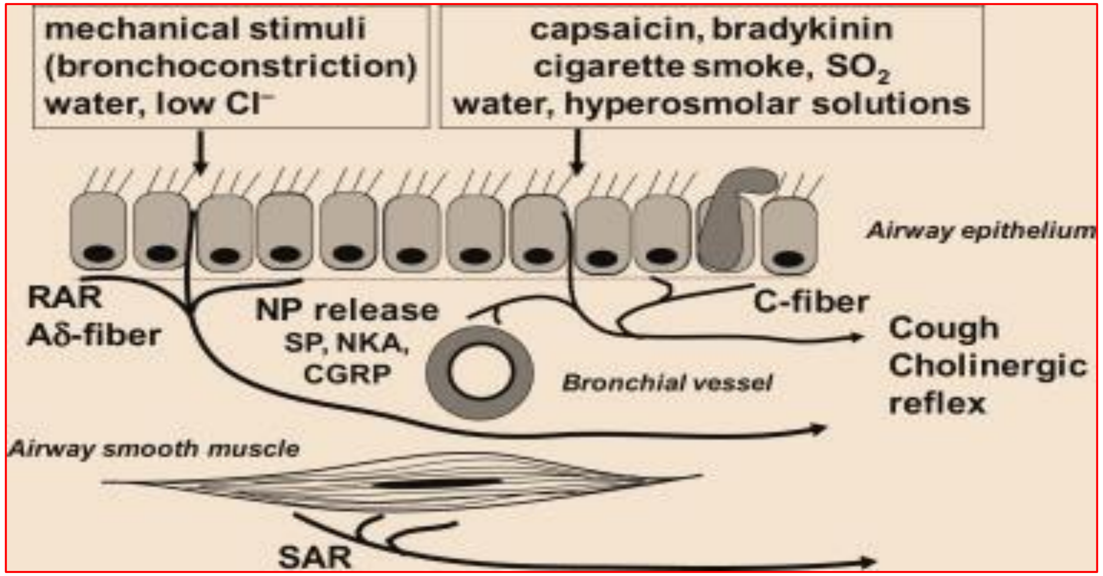


Structure:

Sensory terminals of myelinated afferent fibres

Stimulated by:

1. Sudden inflation
2. Acute congestion
3. Inflammation



Rapidly Adapting Receptors/ Irritant Receptors

Properties:

1. **Sudden** inflation- rapid **increase in firing rate**
2. Sustained volume change – firing rate rapidly decline

3. Very **sensitive** to different chemical stimuli –

   Histamine, Bradykinin, Prostaglandins

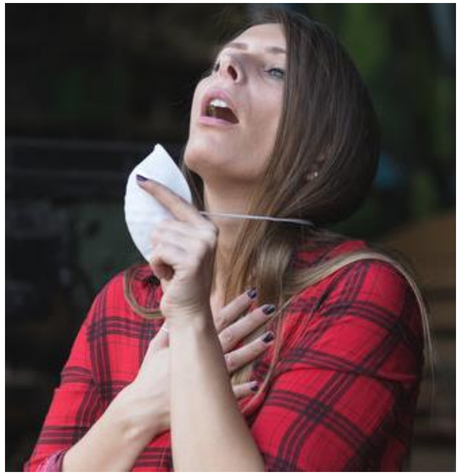
   (released locally during allergy and inflammation)

4. Respond to irritation of airways by various noxious substances- smoke, dust, ammonia

Rapidly Adapting Receptors/ Irritant Receptors

Significance:

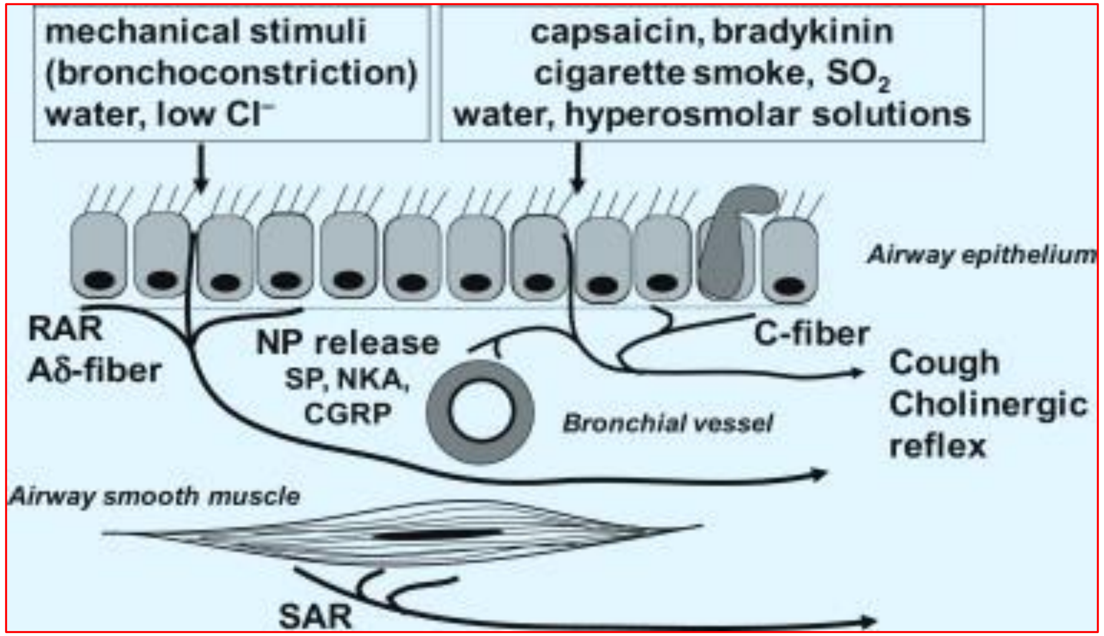
1. Role in detecting pathological processes that involve **irritation, congestion** and **inflammation** of the airways.
2. Activity of the receptors inversely proportional to **lung compliance**
3. Sensors of **compliance change** in pathological states
4. Almost inactive during quite breathing
5. Stimulation of **central RARs** result in excitatory responses-



Coughing, gasping, Increase Mucous production, Bronchospasm

Deeply located RARs- Hyperapnoea

3. C- fibre endings:



Location:

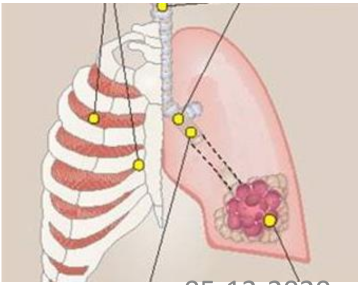
Alveoli and conducting airways

Structure:

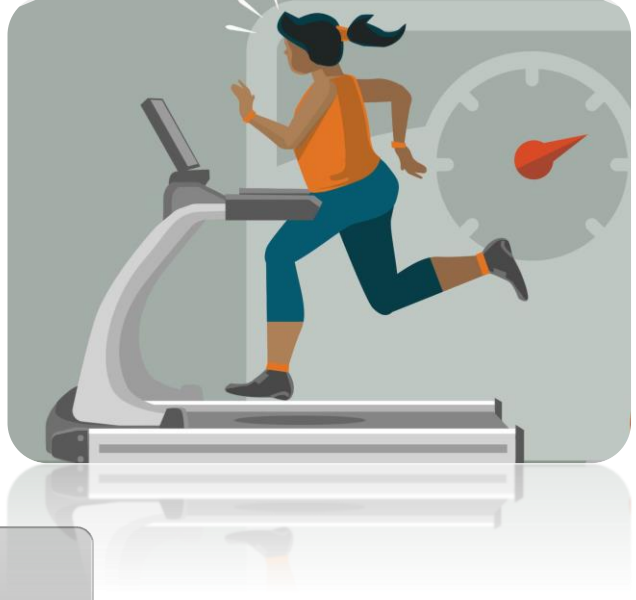
Terminals of unmyelinated nerves

Types:

1. **Pulmonary C fibres/ J-receptors**:
   - Located adjacent to alveoli
   - Accessible from pulmonary capillary circulation
2. **Bronchial C fibres** :
   - Located in airways
   - Accessible from bronchial circulation



J- Reflex



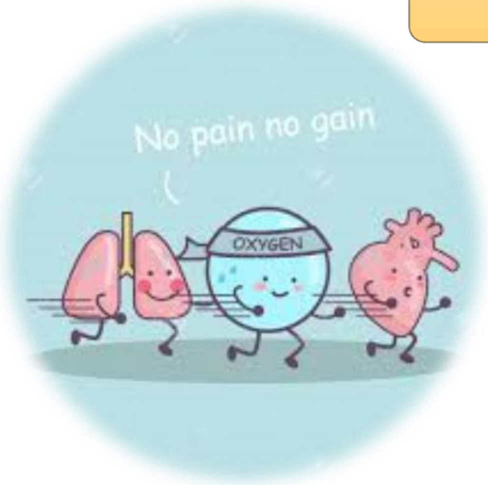
Exercise at high altitude ;
Pulmonary congestion,pulmonary oedema, pneumonia

Increase in the content of interstitial fluid between the capillary endothelium and alveolar epithelium

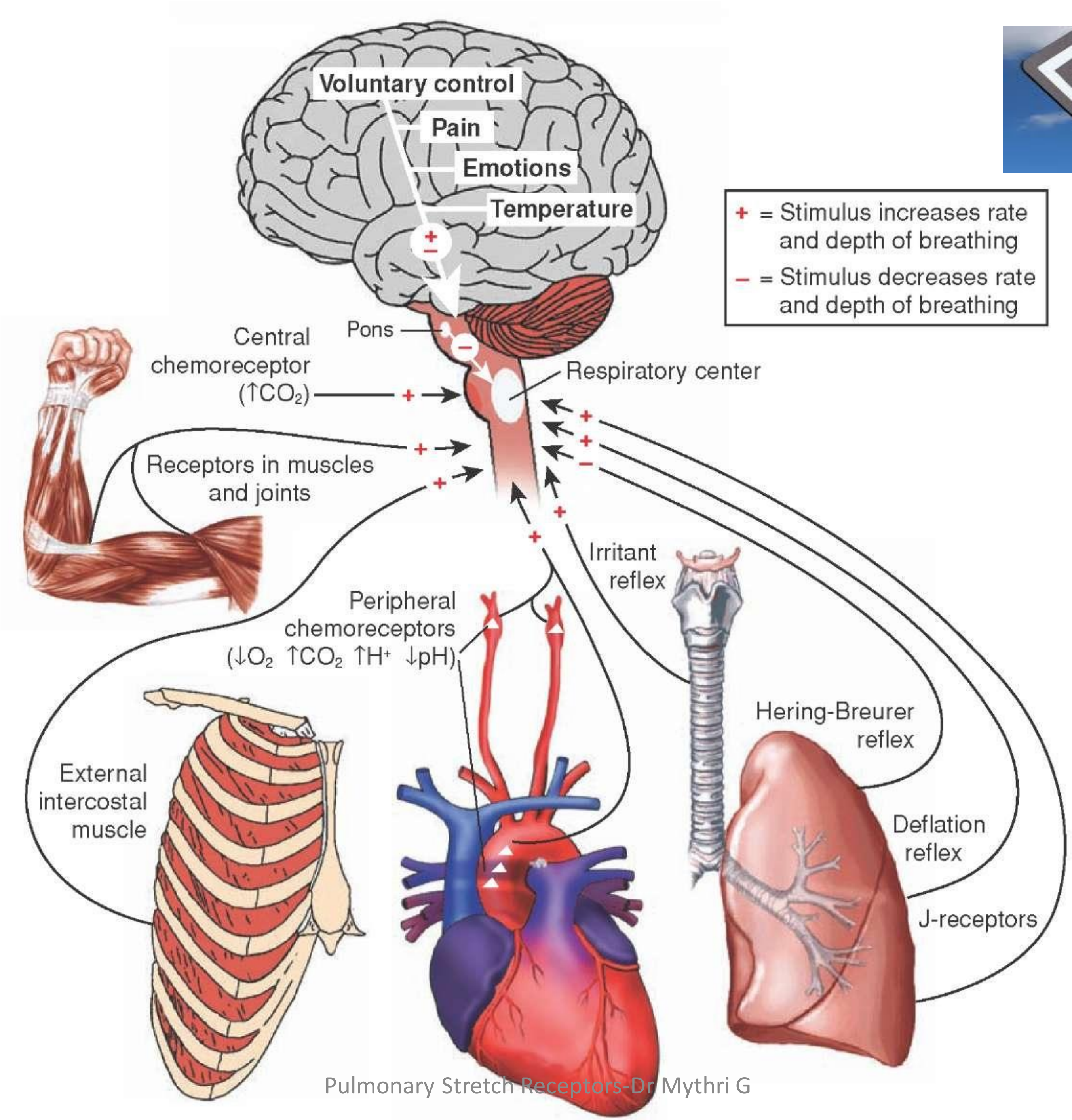
Stimulation of J receptors

Apnoea followed by hyperventilation, bradycardia, hypotension

Takes away the trigger for pulmonary congestion




Summary

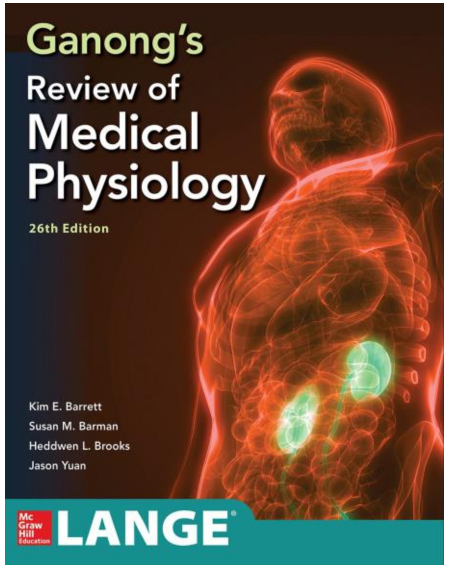

Voluntary control
Pain
Emotions
Temperature
+ = Stimulus increases rate and depth of breathing
– = Stimulus decreases rate and depth of breathing
Pons
Central chemoreceptor (↑CO_2)
Respiratory center
Receptors in muscles and joints
Irritant reflex
Peripheral chemoreceptors (↓O_2 ↑CO_2 ↑H^+ ↓pH)
Hering-Breurer reflex
External intercostal muscle
Deflation reflex
J-receptors

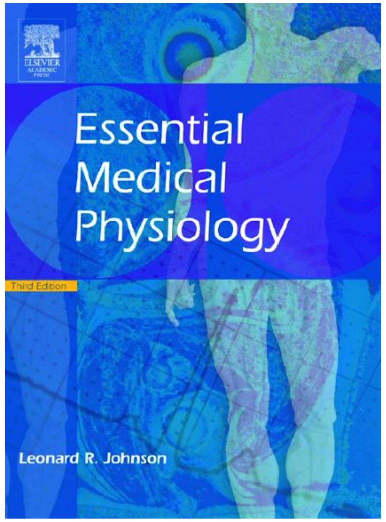
Airway and lung receptors.

Vagal Innervation	Type	Location in Interstitium	Stimulus	Response
Myelinated	Slowly adapting	Among airway smooth muscle cells (?)	Lung inflation	Inspiratory time shortening Hering-Breuer inflation and deflation reflexes Bronchodilation Tachycardia Hyperpnea
	Rapidly adapting	Among airway epithelial cells	Lung hyperinflation Exogenous and endogenous substances (eg, histamine, prostaglandins)	Cough Bronchoconstriction Mucus secretion
Unmyelinated C fibers	Pulmonary C fibers Bronchial C fibers	Close to blood vessels	Lung hyperinflation Exogenous and endogenous substances (eg, capsaicin, bradykinin, serotonin)	Apnea followed by rapid breathing Bronchoconstriction Bradycardia Hypotension Mucus secretion

Data from Berger AJ, Hornbein TF: Control of respiration. In: *Textbook of Physiology*, 21st ed. Vol 2. Patton HD, et al (editors). Saunders, 1989.

References





Functional Morphology and Physiology of Slowly Adapting Pulmonary Stretch Receptors

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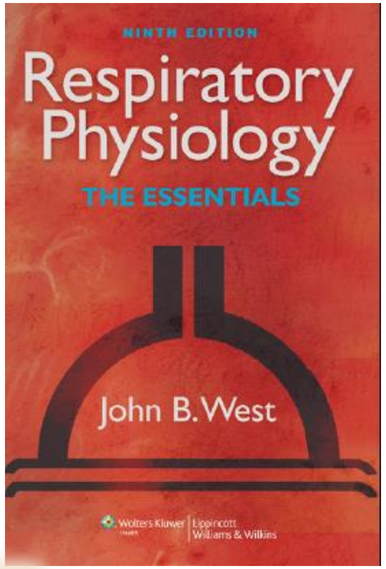

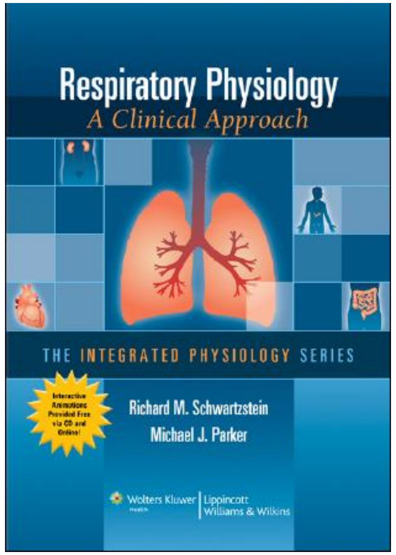

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PULMONARY AND RESPIRATORY TRACT RECEPTORS

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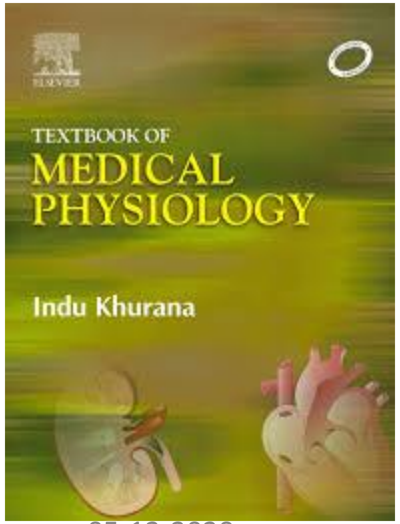

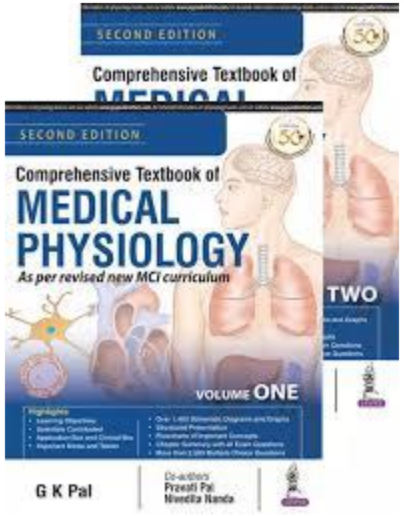

436
J. Physiol. (1961), 159, pp. 436–450
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THE ACTIVITY OF PULMONARY STRETCH RECEPTORS DURING BRONCHOCONSTRICTION, PULMONARY OEDEMA, ATELECTASIS AND BREATHING AGAINST A RESISTANCE

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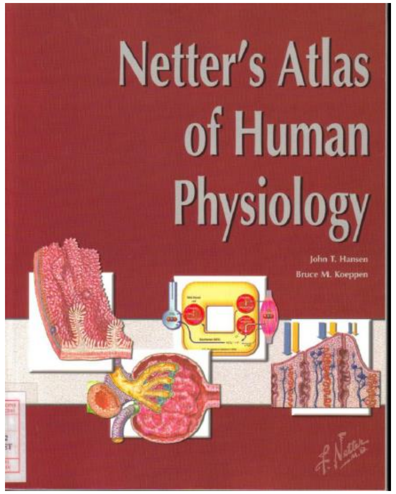

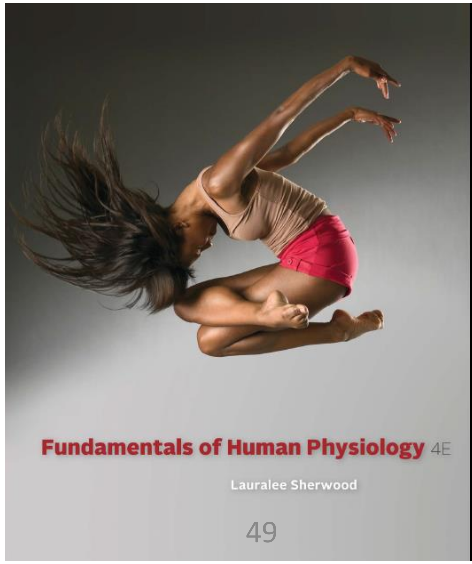


THANK YOU
FOR MAKING US A PART OF YOUR DAY
you take my breath away!
JUST BREATHE