Regulation of Respiration

6- Nervous Control Of Respiration

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Control of Respiration

1) Automatic mechanism:

- Its centers are present in the **pons** and **medulla**
- It allows subconscious**(spontaneous)** rhythmic respiration.

2) Voluntary mechanism:

- Its center is present in the **motor cerebral cortex** and control the anterior horn cells of the respiratory muscles via the **cortico-spinal** tract.
- It allows voluntary control of respiration e.g. **voluntary hyper-ventilation** and **apnea** but cannot be maintained for long time.

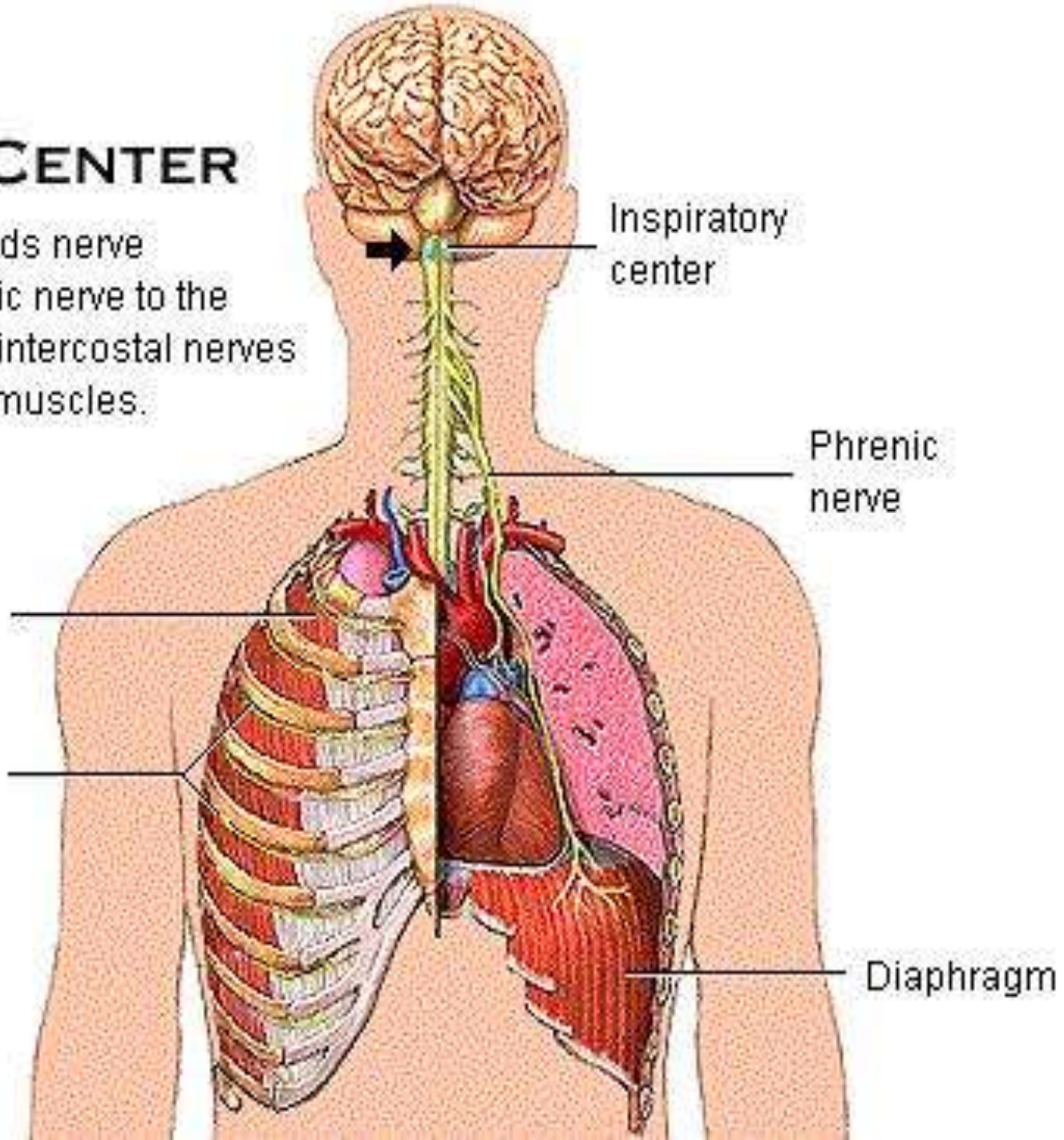
- **Inspiratory muscles**, diaphragm and external intercostal, composed of skeletal muscle and must be stimulated to contract

- **Two phrenic nerves** responsible for diaphragm originate at the **3rd, 4th, and 5th cervical** spinal nerves

- **11 pairs** of intercostal nerves originate 1- 11th thoracic spinal nerves

Inspiratory Center

The inspiratory center sends nerve impulses along the phrenic nerve to the diaphragm and along the intercostal nerves to the external intercostal muscles.



INSPIRATORY CENTER

The inspiratory ramp signal

The normal resting breathing rate is between 12 - 15 breaths per minute.

Inspiratory Center Sends Nerve Impulses (2 seconds)

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Diaphragm and External Intercostal Muscles Contract

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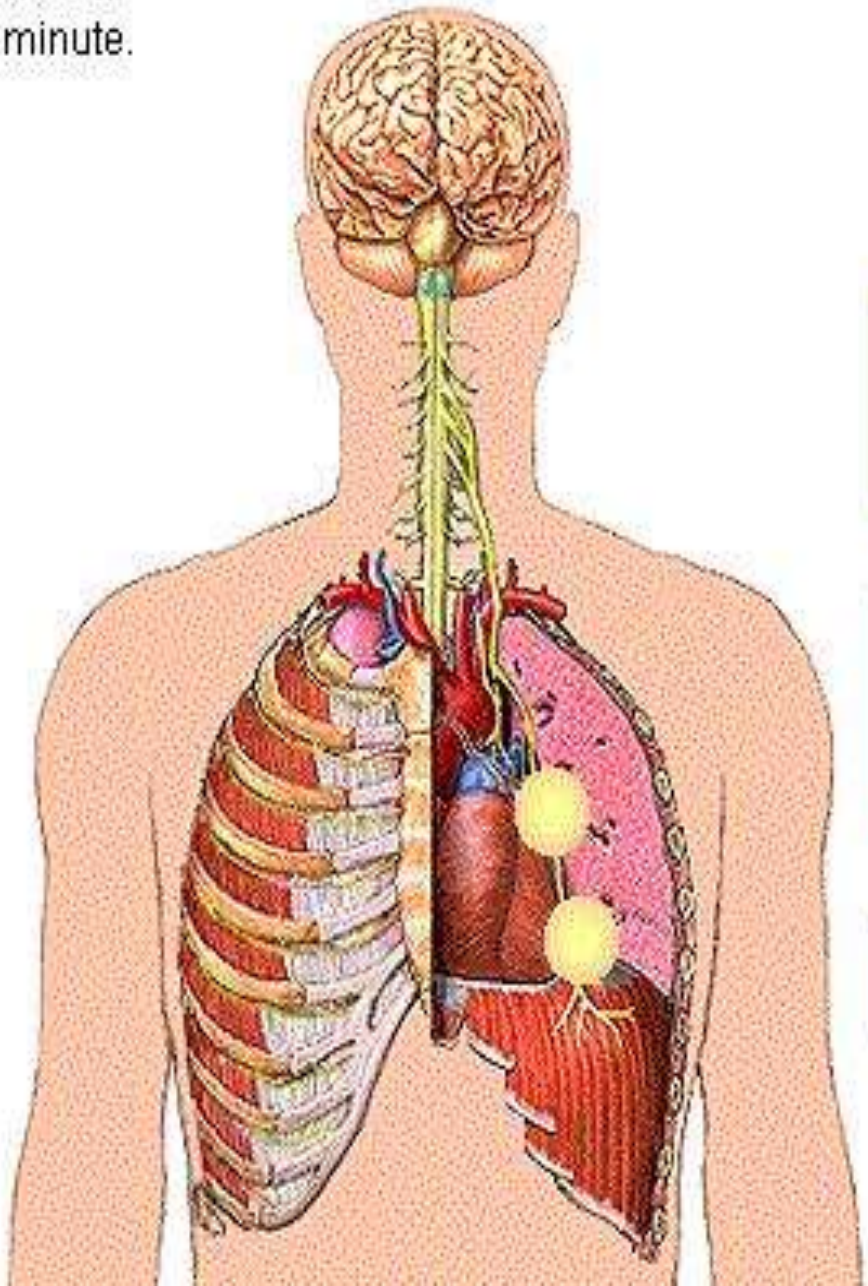
Inspiration



Inspiratory Center Stops Impulses (3 seconds)

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Diaphragm and External Intercostal Muscles Relax

↓

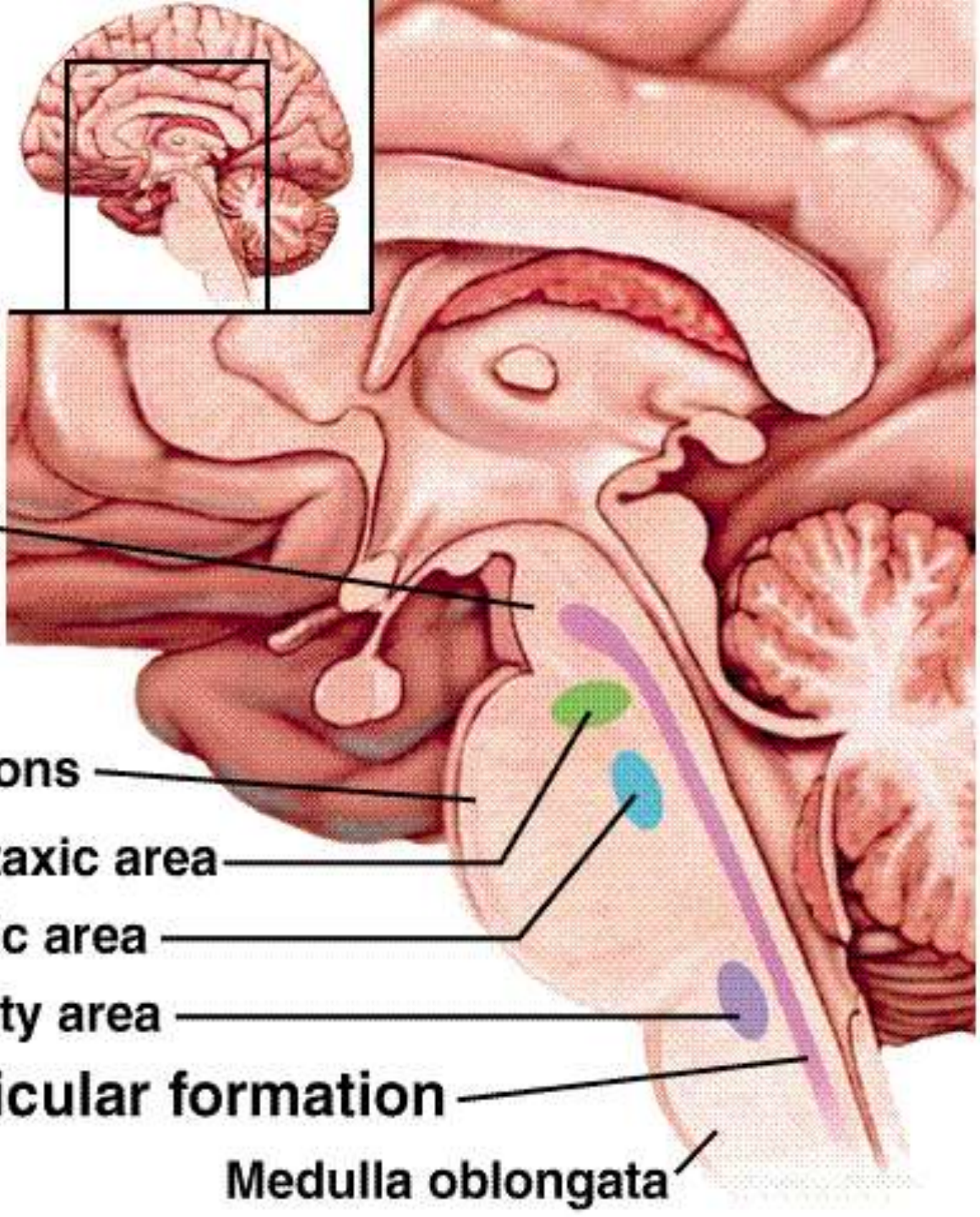
Expiration

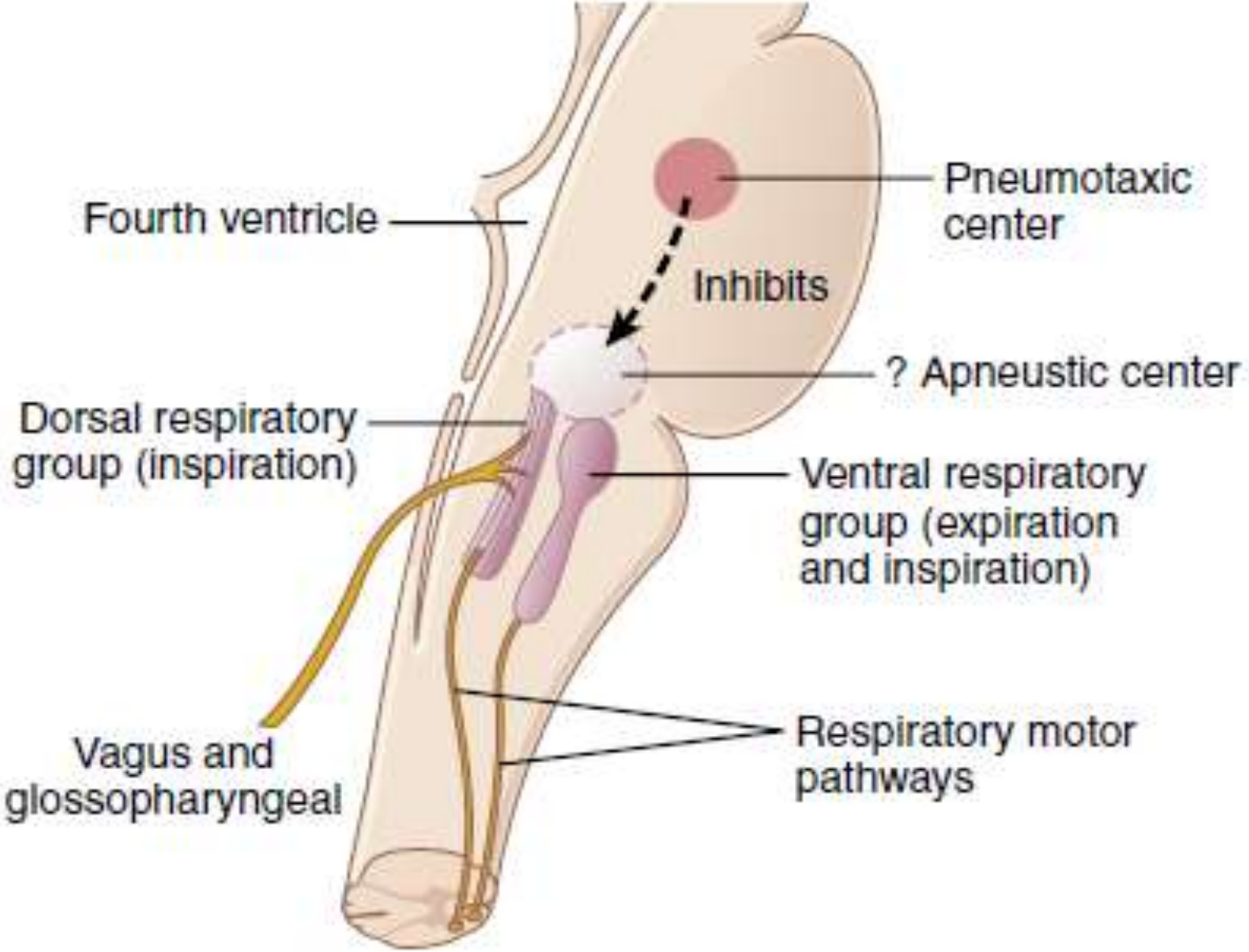
Respiratory Areas in Brainstem

- Theses centers responsible for **automatic basic rhythm** of respiration, located bilaterally in the brain stem composed of two groups of neurons (inspiratory, expiratory)

- **Medullary respiratory centers**
  - **Dorsal respiratory group** (insp. center)
  - stimulate inspiratory muscles
  - **Ventral respiratory group** (exp. center)
  - stimulate expiratory muscles as the internal intercostal and abdominal muscles
- **Pontine respiratory centers**
  - Involved with switching between inspiration and expiration
  - **Pneumotaxic** and **apneustic** centers

Brain Stem Respiratory Control Centers




Fourth ventricle
Pneumotaxic center
Inhibits
? Apneustic center
Dorsal respiratory group (inspiration)
Ventral respiratory group (expiration and inspiration)
Vagus and glossopharyngeal
Respiratory motor pathways

A. Medulla Respiratory Centers

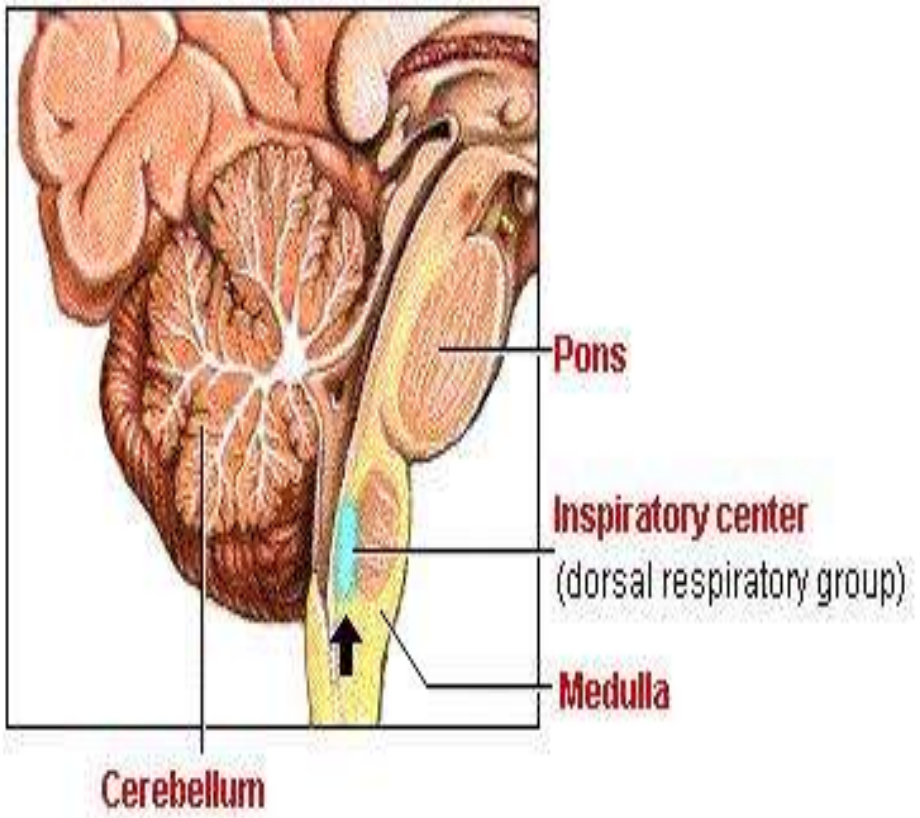
- Regulate the rate and pattern of breathing
- Accelerate or slows down breathing rate

1-Inspiratory Center or Dorsal Resp. Group (DRG)

- **Basic rhythmic breathing**

Phrenic nerve ----> Intercostal nerves ---> Diaphragm + external intercostal muscles

- **Containing Insp. neurons**



The basic rhythm of breathing is controlled by respiratory centers located in the medulla and pons of the brainstem.

The inspiratory center (dorsal respiratory group) sets this rhythm by automatically initiating inspiration.

A. Medulla Respiratory Centers

2- Expiratory Center or Ventral Resp. Group (VRG)

Forced expiration ---->

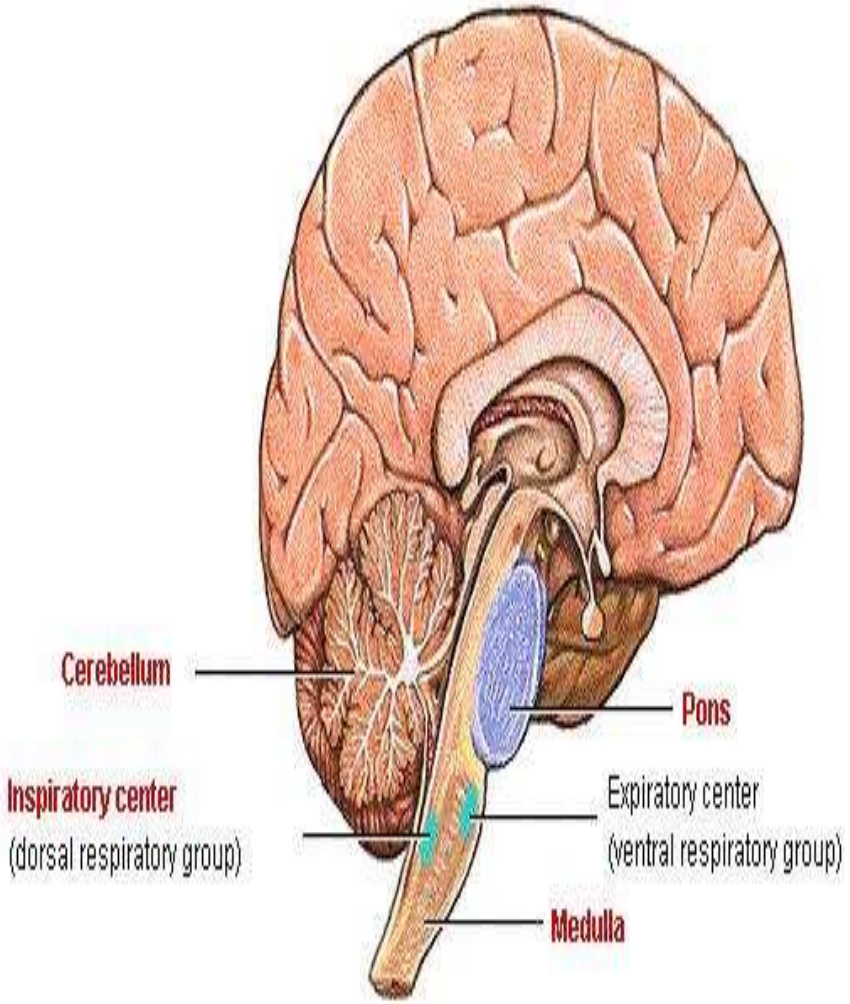
Intercostal nerves ----Internal intercostal + anterior abdominal wall muscles (expiration)

- **Containing exp. neurons mainly**

OTHER RESPIRATORY CONTROL CENTERS

The **expiratory** center in the medulla appears to function during forced expiration, stimulating the internal intercostal and abdominal muscles.

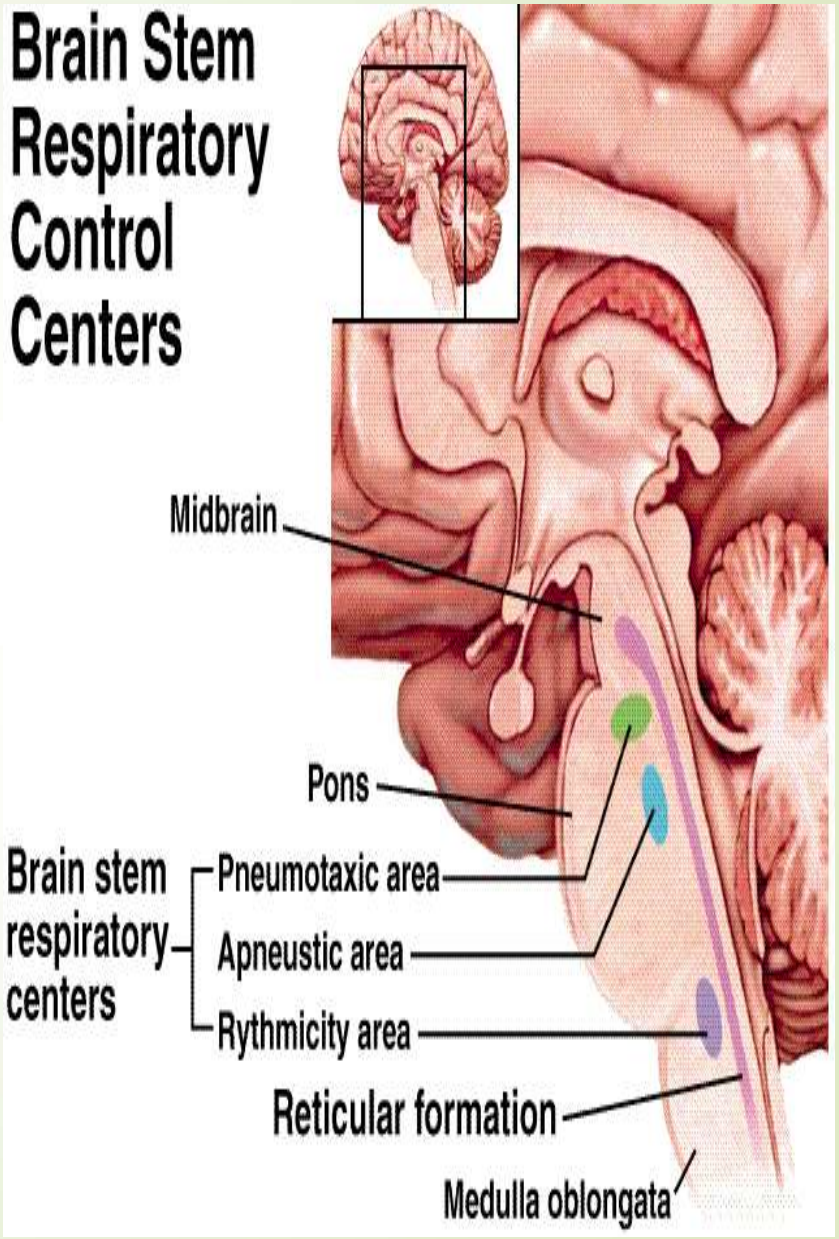
Other respiratory centers in the pons modify inspiration and allow for smooth transitions between inspiration and expiration. Their precise roles are not fully understood.



B. Pons Respiratory Centers

Pneumotaxic center

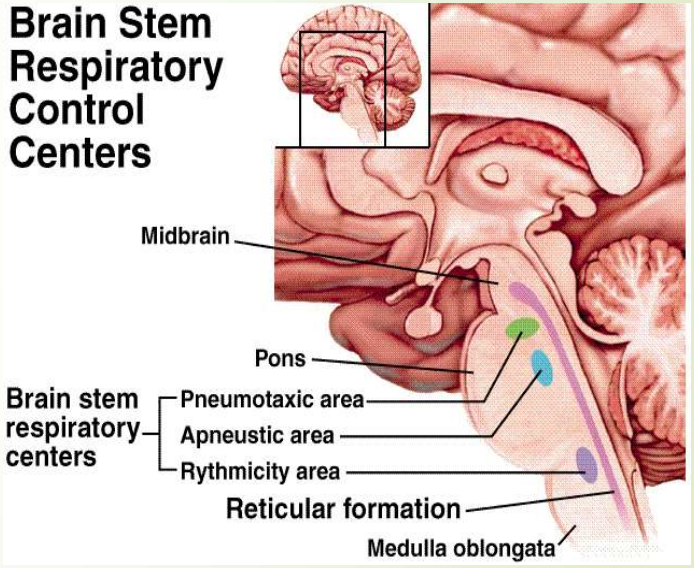
- Located in upper part of the pons
- **Slightly inhibits medulla, causes shorter, shallower, quicker breaths**
- Inhibitory effect on inspiration
- Its function is to modulate the activity by **apneustic center** on and off to create the normal rhythm of respiration
- when activity of inspiration center stops, inhibitory impulses cease from **pneumotaxic center** and inspiratory impulses initiated



B. Pons Respiratory Centers

- **Apneustic center**
  - Located in lower portion of pons
  - **Stimulates the medulla, causes longer, deeper, slower breaths (prevent switch off)**
  - Stimulatory effect on Insp. center
  - Its activity is modulated on and off by pneumotaxic center
  - It is intermittently **inhibited by**

Afferent vagal discharge (Herring-Breuer inflation Reflex) arise from slowly adapting stretch receptors in the lung thus the inspiratory process stops & expiration starts



Genesis of normal rhythmic respiration

1)The **apneustic center** stimulates the **inspiratory center** so inspiration is **switch on.**

2)The inspiratory center send gradual stimulatory signals to inspiratory muscles → gradual inspiration (inspiratory ramp signal).

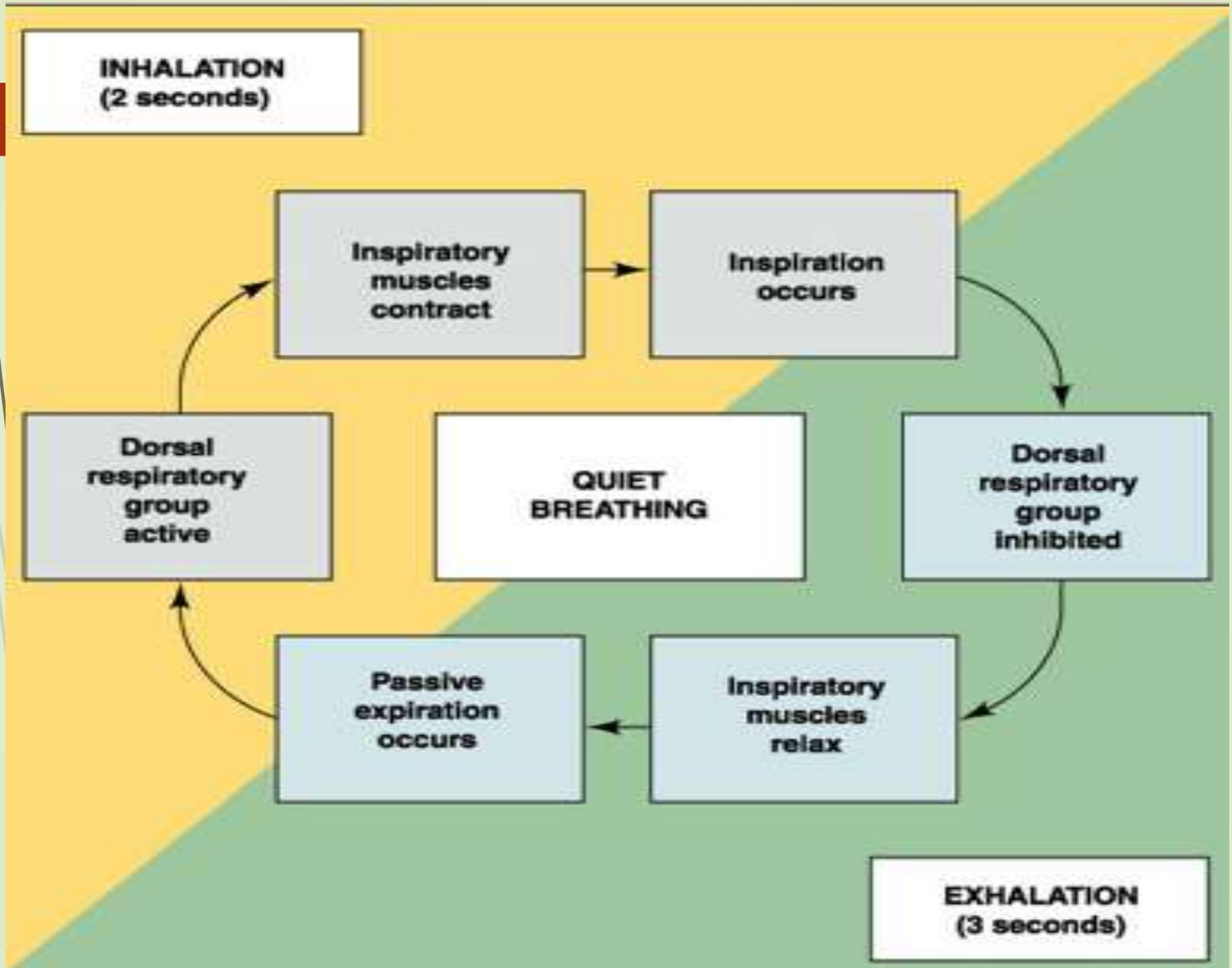
3) This inspiratory signal is **switch off** by:

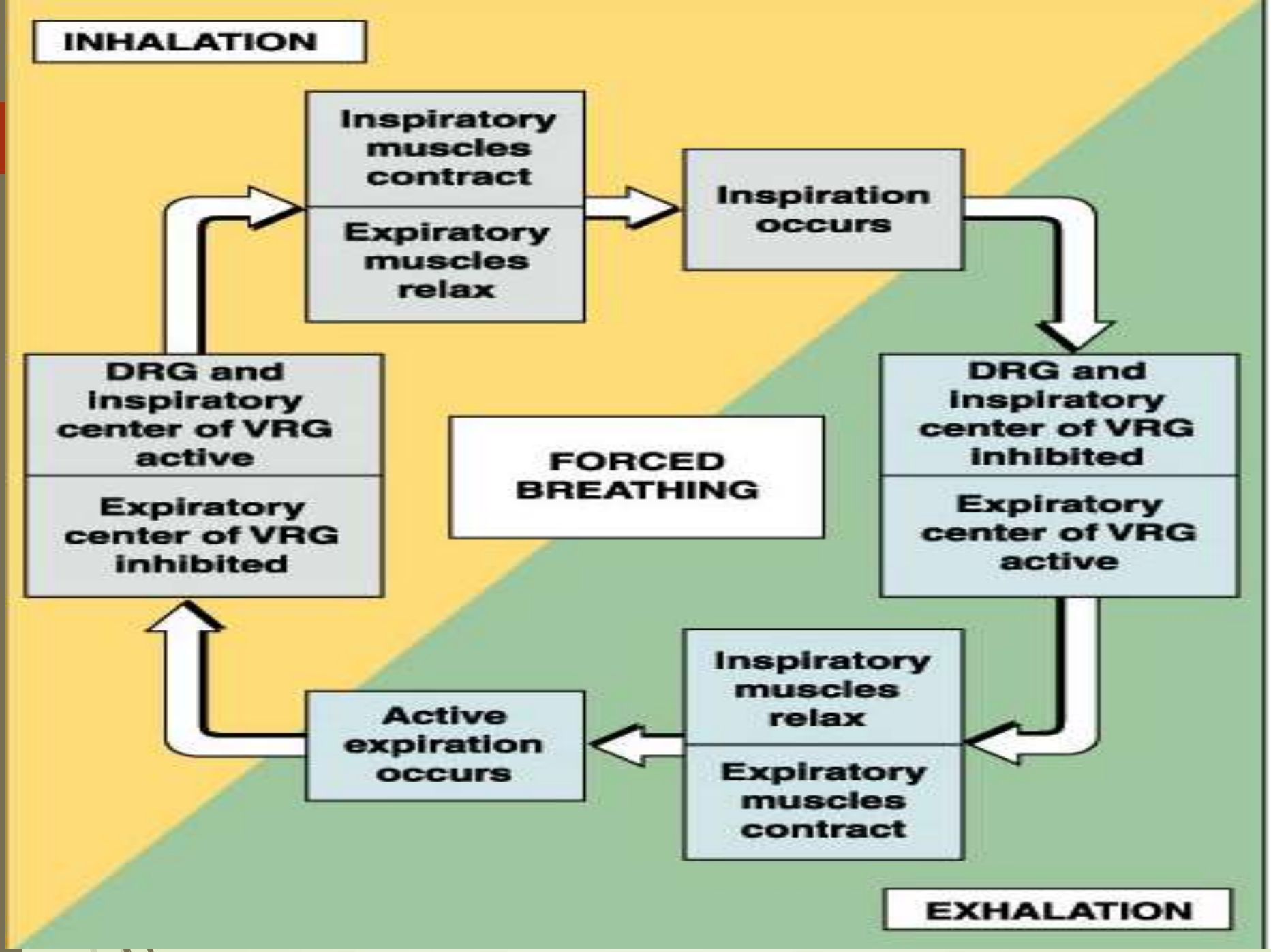
(a) Vagi: as a result of stimulation of stretch receptors in smooth muscle of bronchioles (Herring Breuer inflation reflex).

(b) Pneumotaxic center: but slow in action than vagal inhibition both (a)&(b) inhibition of **apneustic** and **inspiratory center.**

4)Once inspiration is inhibited expiration follows passively **expiratory Centre** is active in **forced expiration only** .

N.B Pre-Bottzinger complex: It is the ***pace maker*** neurons present bilaterally in medulla oblongata and give ***rhythmic discharge*** to phrenic nerve.


INHALATION
(2 seconds)
Inspiratory muscles contract
Inspiration occurs
Dorsal respiratory group inhibited
Inspiratory muscles relax
Passive expiration occurs
Dorsal respiratory group active
QUIET BREATHING
EXHALATION
(3 seconds)


INHALATION
Inspiratory muscles contract
Expiratory muscles relax
Inspiration occurs
DRG and inspiratory center of VRG inhibited
Expiratory center of VRG active
Inspiratory muscles relax
Expiratory muscles contract
Active expiration occurs
DRG and inspiratory center of VRG active
Expiratory center of VRG inhibited
FORCED BREATHING
EXHALATION

Vagal (inflation) reflex (Herring- Breuer reflex)

- Stretch or inflation of lungs, stimulates endings of **Vagus nerve (X)** in bronchi, bronchioles, lungs
- Discharges inhibitory impulses to **brain stem**

causing inspiration to stop

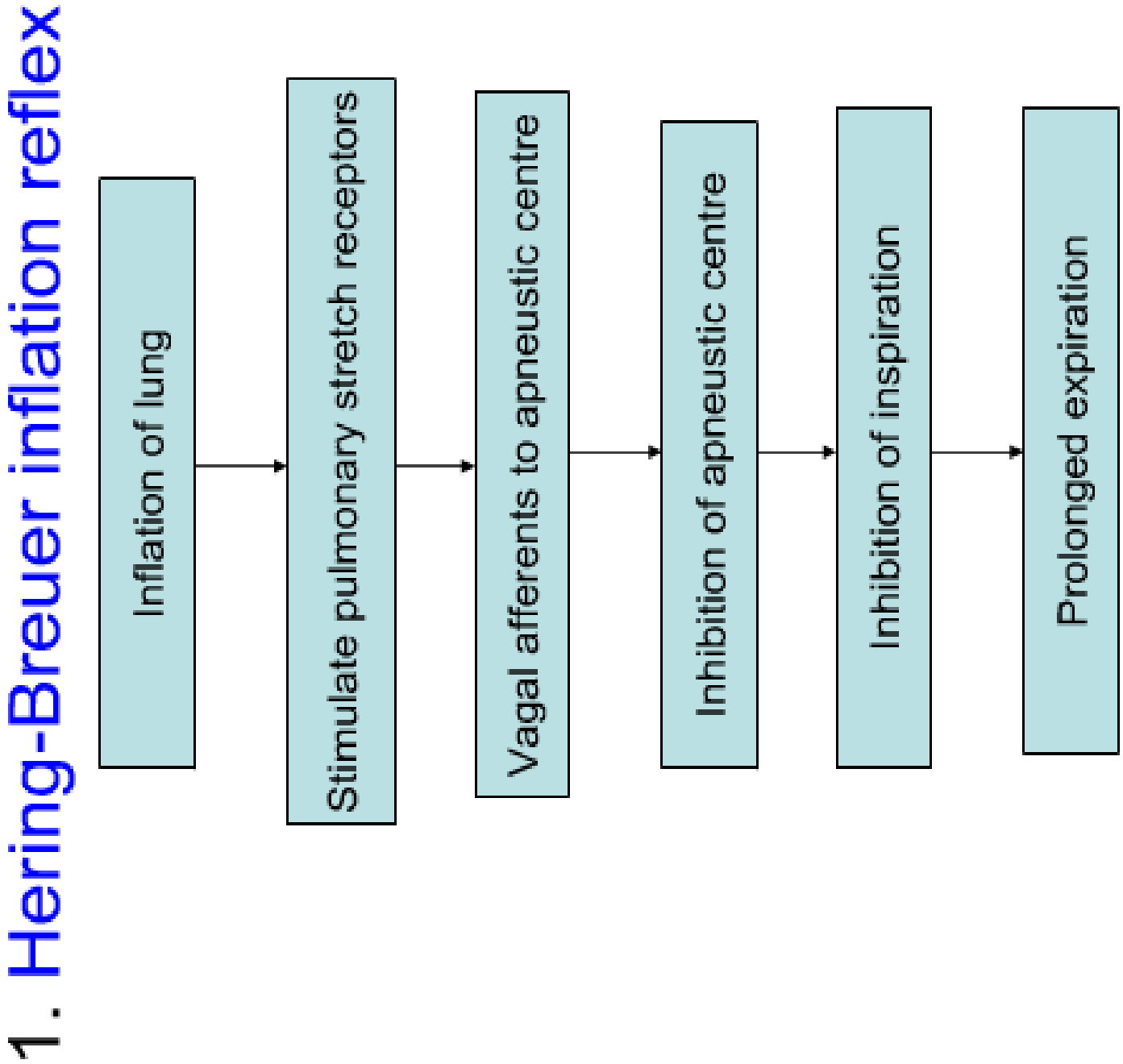
- Expiration occurs, lungs deflate and stretch receptors are no longer stimulated

- **Limits inspiration and prevents over inflation specially during sleep & anesthesia**

Significance

In human Hering-Breuer reflex is not activated until the lung volume > 1.5 liters

So, this reflex appears to be a protective mechanism to prevent excessive lung inflation.



Experimental evidence of respiratory centers

Complete section of brain stem above pons	normal **A**utomatic respiration **without** voluntary control
Section at lower medulla or upper cervical	death (as in Hanging)
Section of lower cervical	diaphragmatic respiration
Bilateral vagotomy	deep & slow respiration
Bilateral vagotomy **+ Damage of pneumotaxic center**	**A**pneusis (inspiratory spasm interrupted by short expiration by fatigue of muscles).

THANK YOU.