



# ***Regulation of Respiration***

## **7- Nervous Control Of Respiration**


***By***

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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.

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- ➔ **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 **3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> cervical** spinal nerves
  - ➔ **11 pairs** of intercostal nerves originate 1- 11<sup>th</sup> 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.

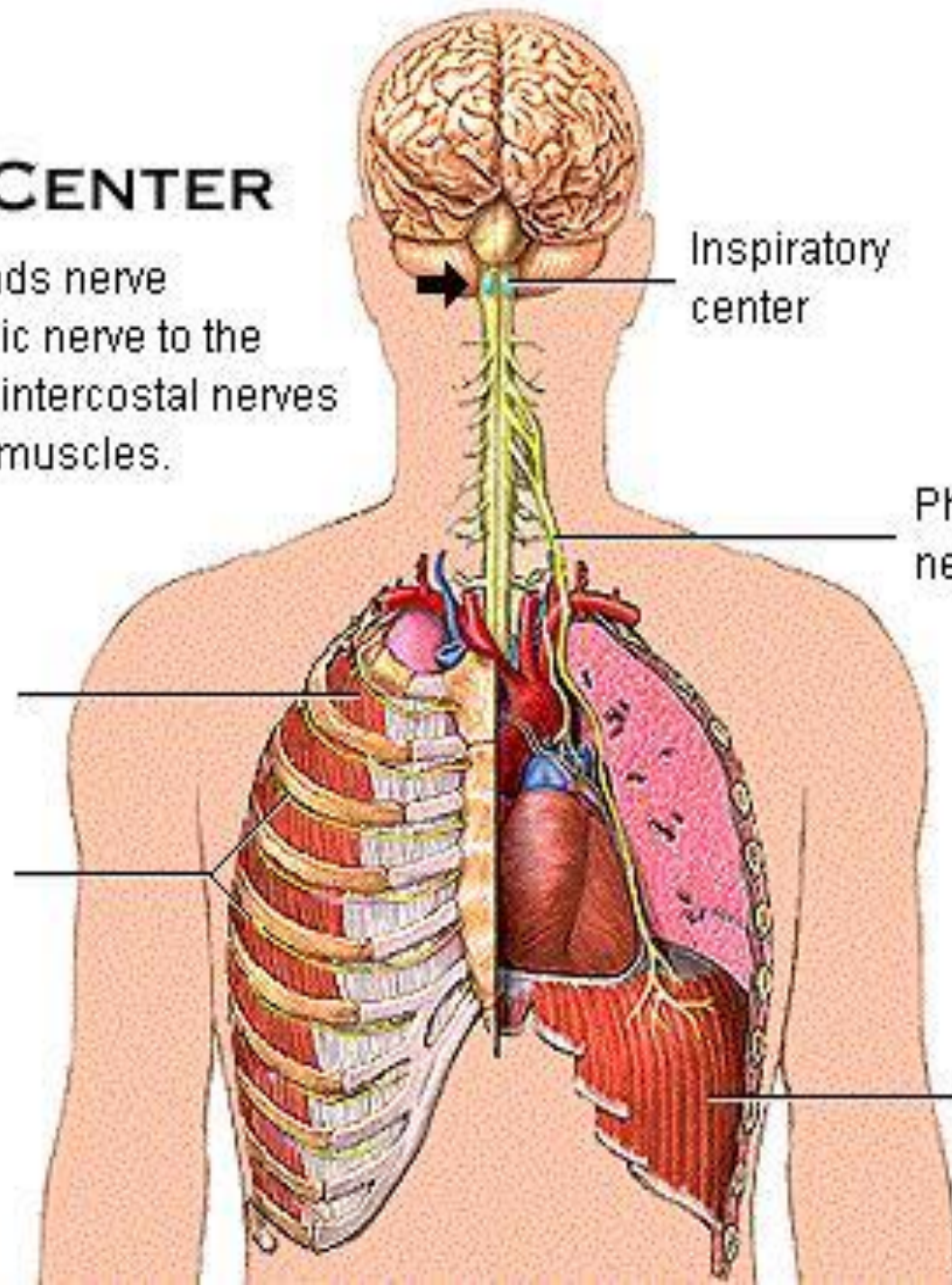
External  
intercostal  
muscles

Intercostal  
nerves

Inspiratory  
center

Phrenic  
nerve

Diaphragm

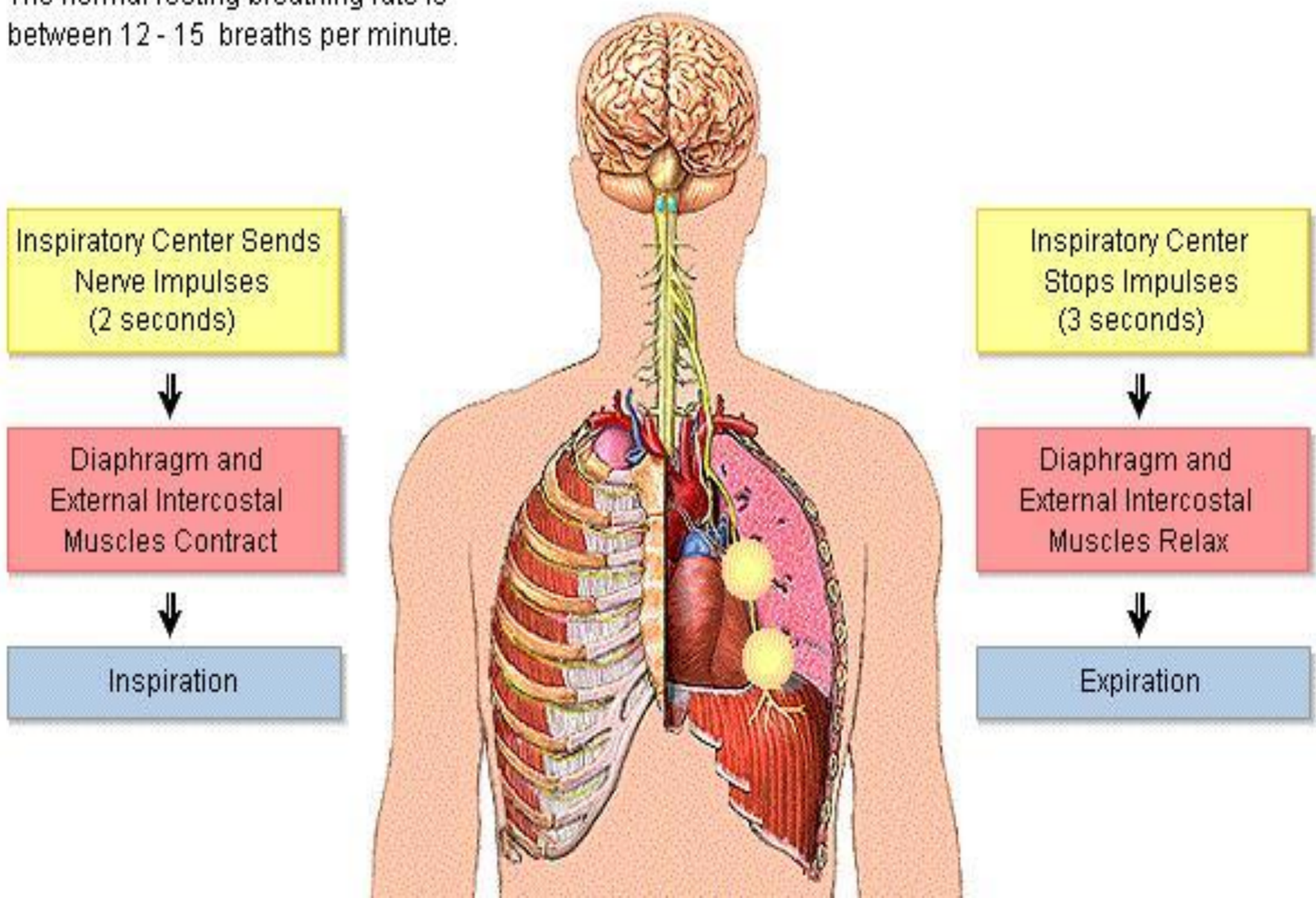




# INSPIRATORY CENTER

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

## The inspiratory ramp signal



# Respiratory Areas in Brainstem

➤ These 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

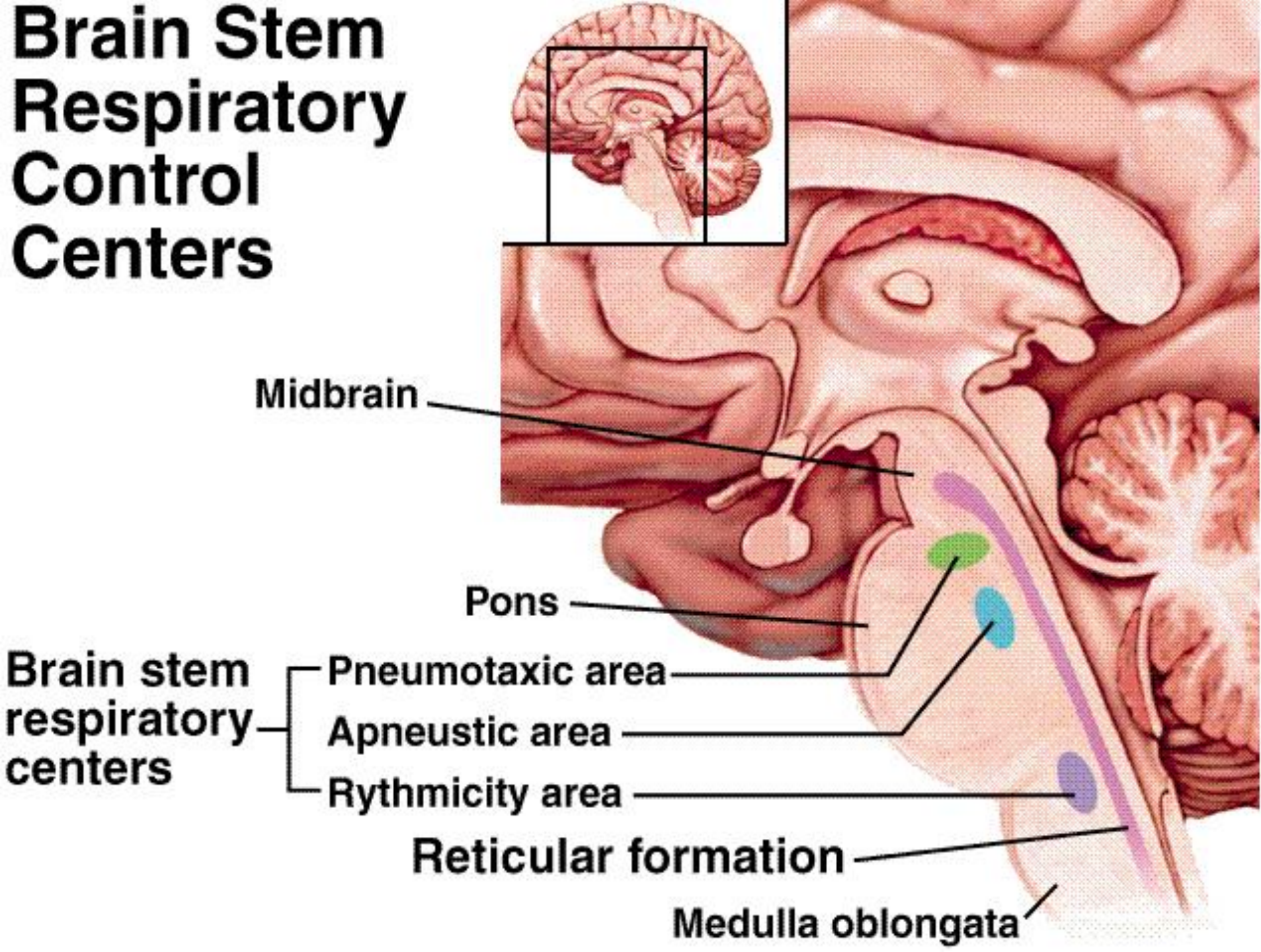
## ➤ **Pontine respiratory centers**

Involved with switching between inspiration and expiration

**Pneumotaxic** and **apneustic** centers



# Brain Stem Respiratory Control Centers



# A. Medulla Respiratory Centers

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

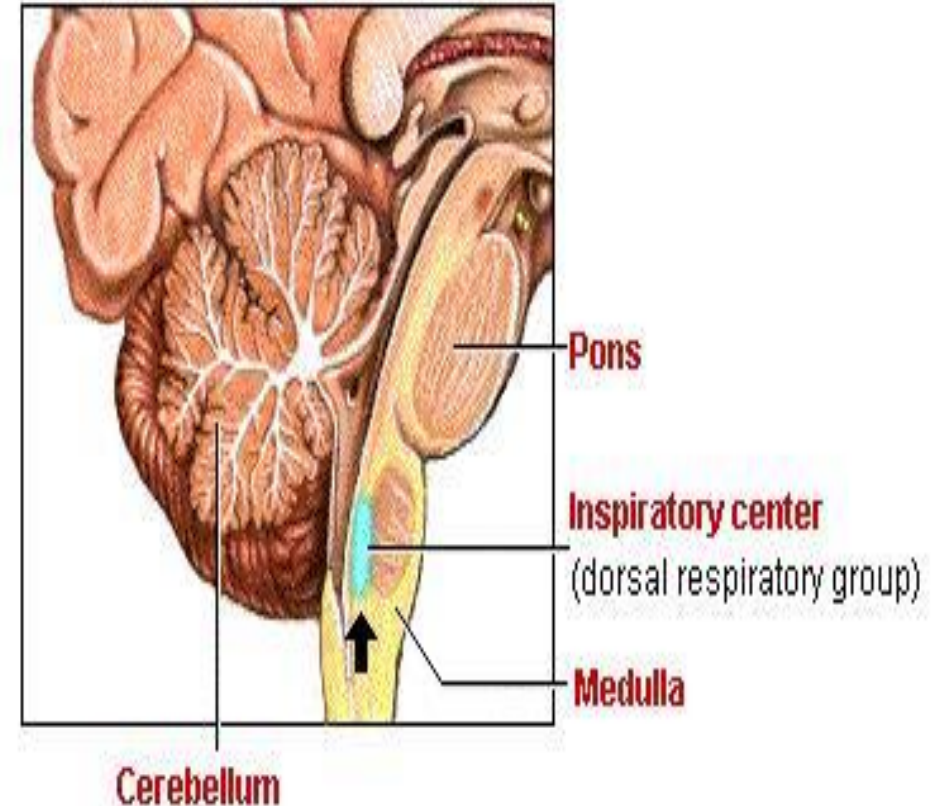
## 1-Inspiratory Center or Dorsal Resp. Group (DRG)

### ➤ **Basic rhythmic breathing**

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

- **Containing Insp. neurons**

## INSPIRATORY CENTER



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** ---->

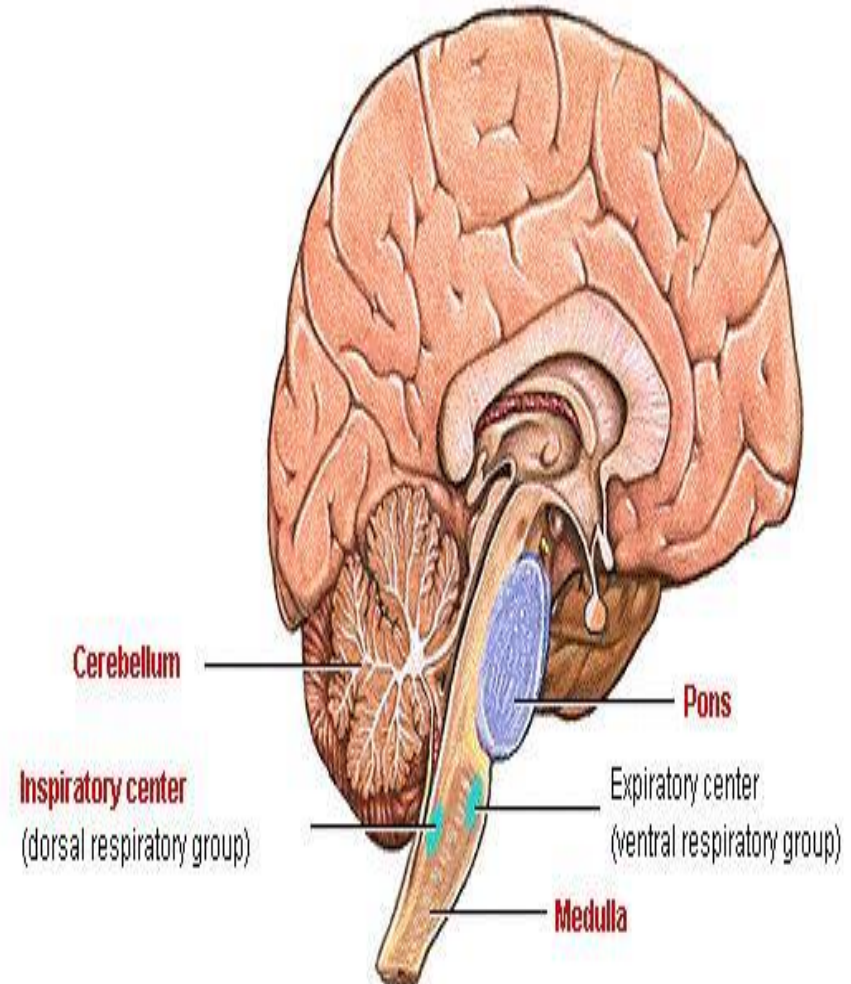
Intercostal nerves ----Internal intercostal + anterior abdominal wall muscles (expiration)

➔ **Containing exp. neurons mainly & some Insp. neurons**

## 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.



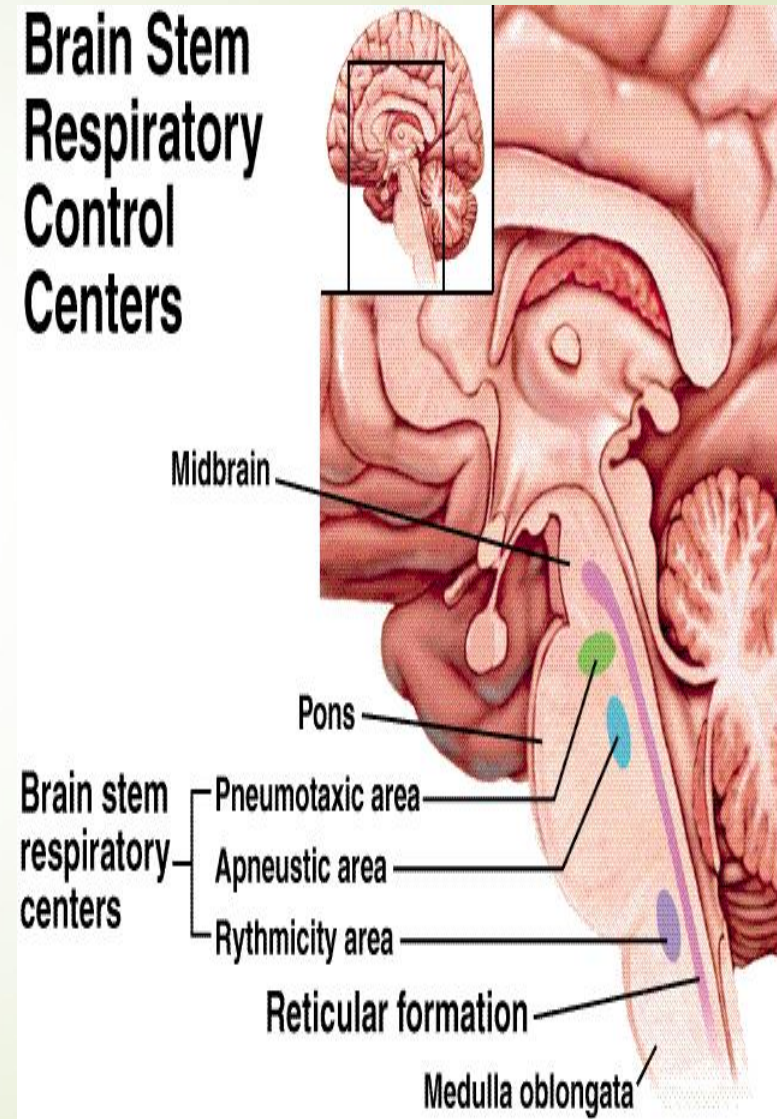
# B. Pons Respiratory Centers

## Apneustic center

- Located in lower portion of pons
- Stimulates the medulla(DRG), 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** (Hering-Breuer inflation Reflex) arise from slowly adapting stretch receptors in the lung thus the inspiratory process stops & expiration starts

## Brain Stem Respiratory Control Centers



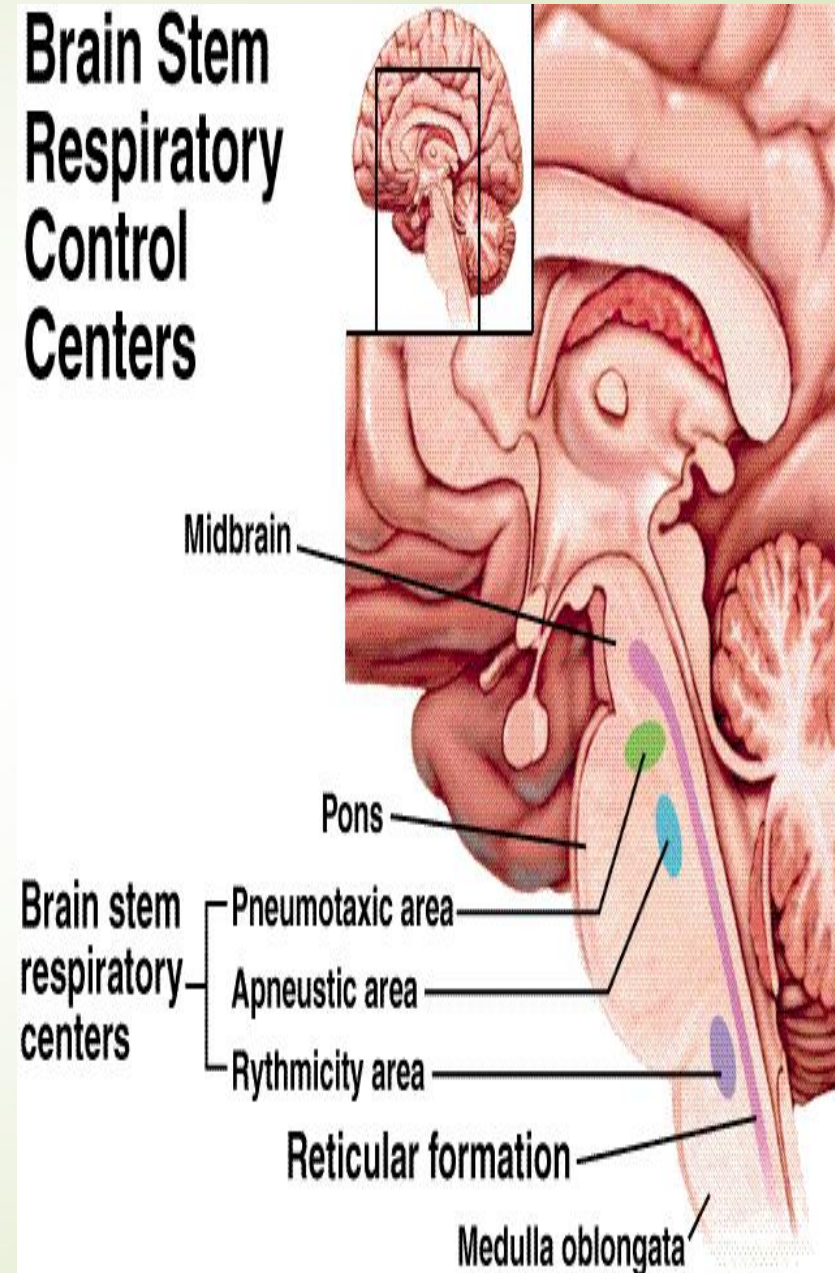


# B. Pons Respiratory Centers

## Pneumotaxic center

- Located in upper part of the pons
- The function of the **pneumotaxic center** is primarily to limit inspiration (Inhibitory effect on inspiration)
- **causes shorter, shallower, quicker breaths**
- Its function is to modulate the activity of **apneustic center** “**switch-off**” to create the normal rhythm of respiration
- when activity of inspiration center stops, inhibitory impulses cease from **pneumotaxic center** and inspiratory impulses initiated again

## Brain Stem Respiratory Control Centers

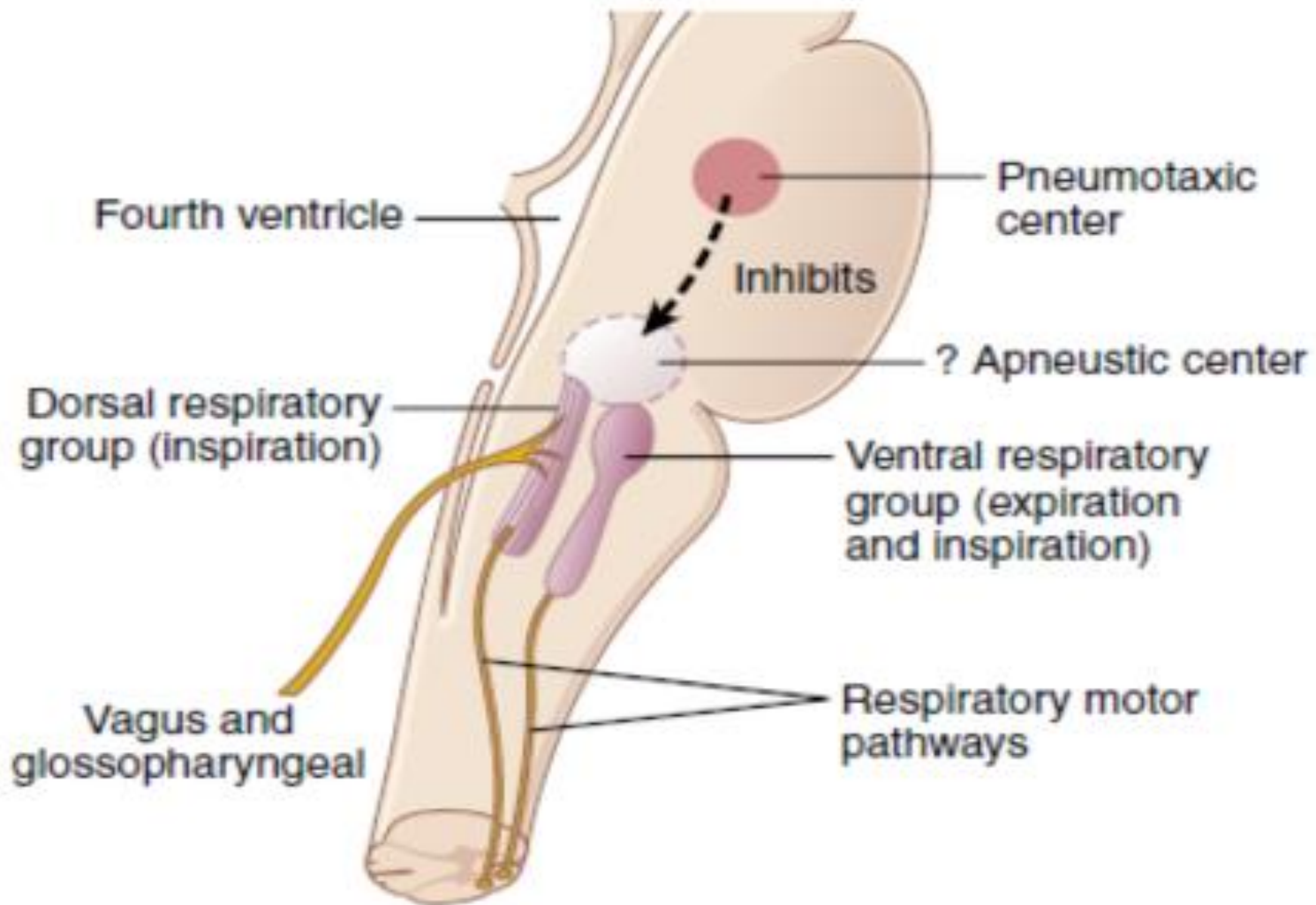




# Genesis of normal rhythmic respiration

- 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 bronchi & bronchioles (Hering 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  
active**

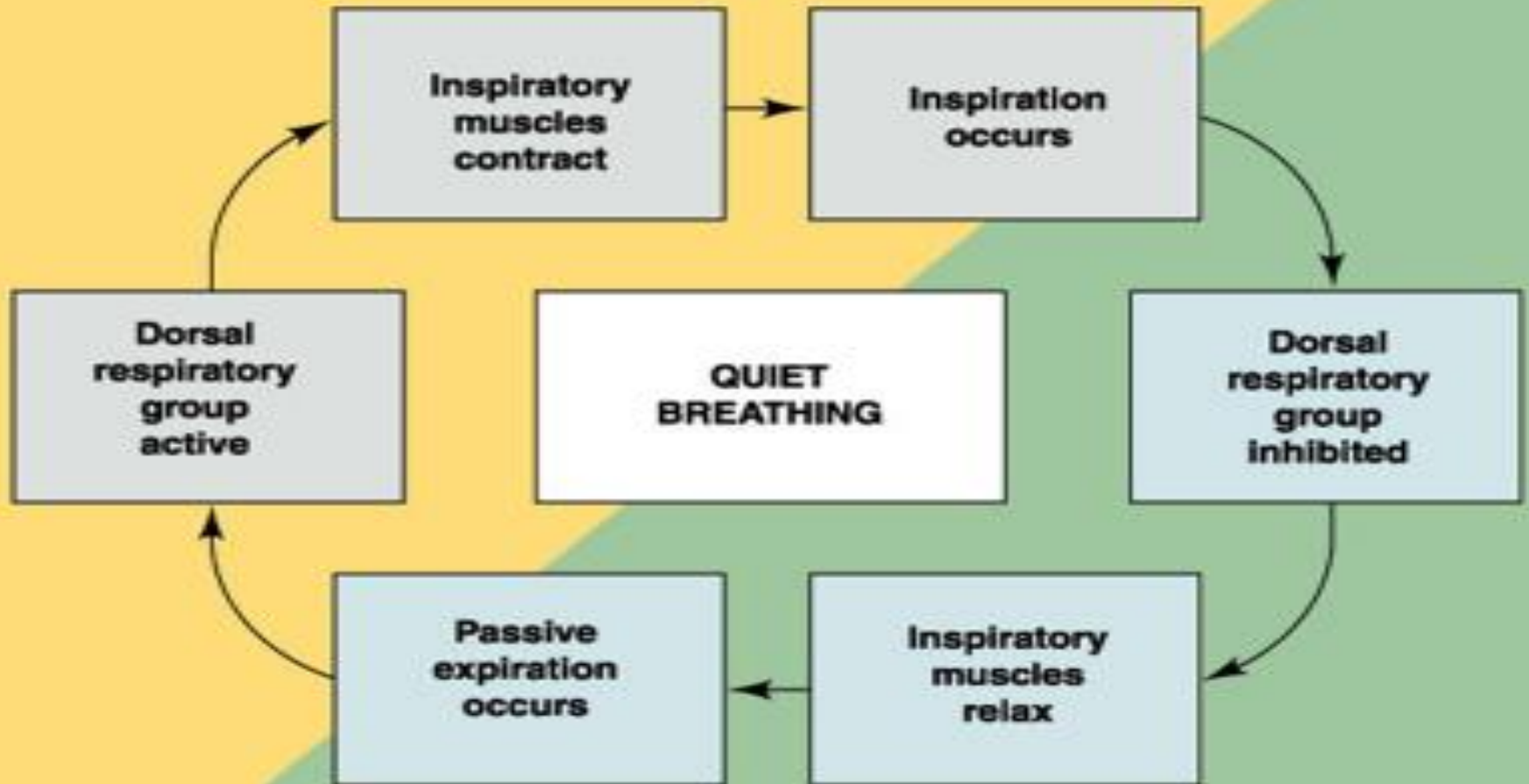
**QUIET  
BREATHING**

**Dorsal  
respiratory  
group  
inhibited**

**Passive  
expiration  
occurs**

**Inspiratory  
muscles  
relax**

**EXHALATION  
(3 seconds)**





# INHALATION

Inspiratory muscles contract

Expiratory muscles relax

Inspiration occurs

DRG and inspiratory center of VRG active

Expiratory center of VRG inhibited

## FORCED BREATHING

DRG and inspiratory center of VRG inhibited

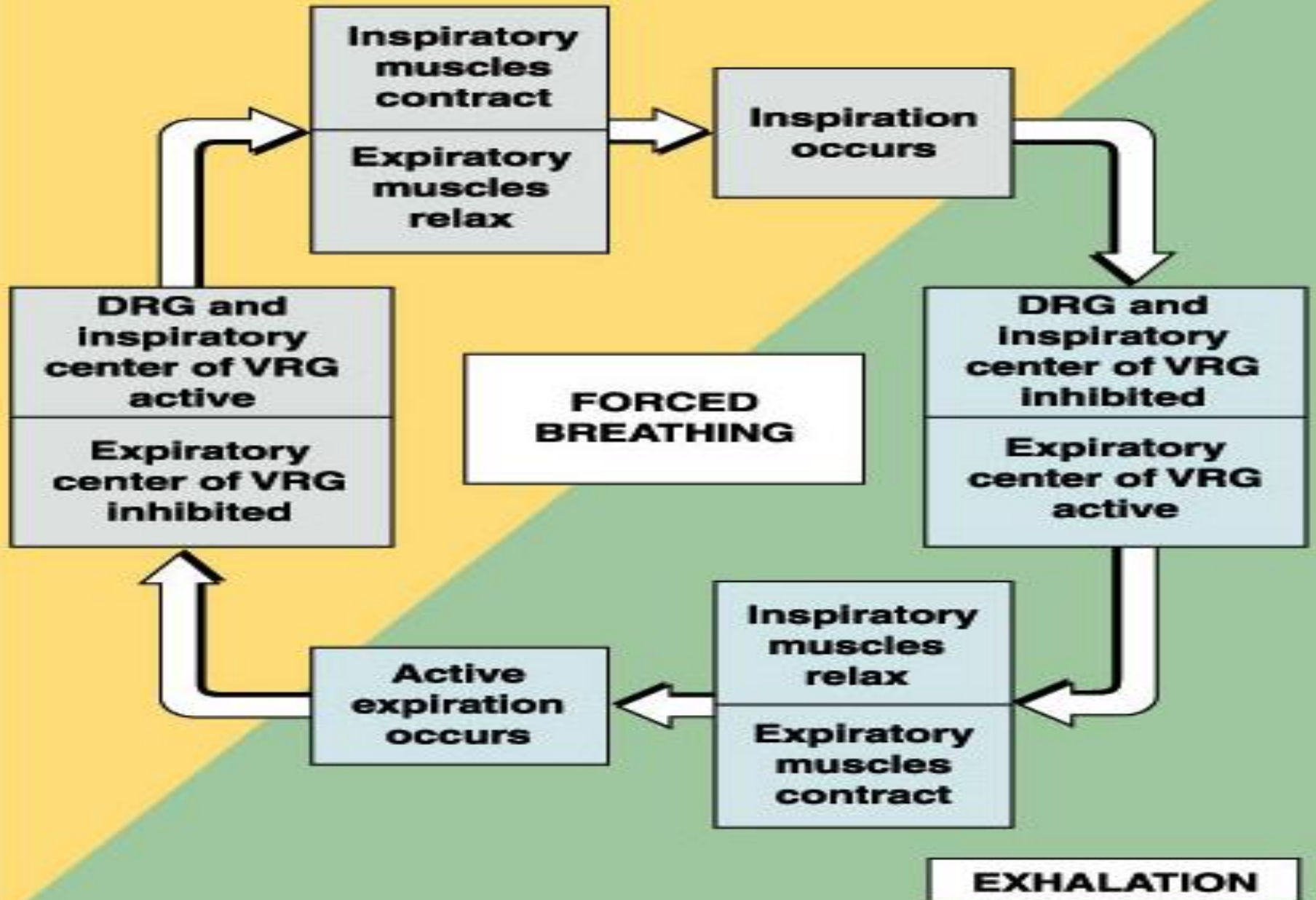
Expiratory center of VRG active

Inspiratory muscles relax

Expiratory muscles contract

Active expiration occurs

# EXHALATION



# Vagal (inflation) reflex (Hering- Breuer reflex)

- ➔ Stretch or inflation of lungs, stimulates endings of **Vagus nerve (X)** in bronchi & bronchioles of 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**

# Experimental evidence of respiratory centers

Complete section of brain stem above pons	normal <u>A</u> utomatic respiration without voluntary control
Section at lower medulla or upper cervical	<u>d</u> eath (as in Hanging)
Section of lower cervical	<u>d</u> iaphragmatic respiration
Bilateral vagotomy	<u>d</u> eep & slow respiration
Bilateral vagotomy + Damage of pneumotaxic center	<u>A</u> pneusis (inspiratory spasm interrupted by short expiration by fatigue of muscles).



**THANK YOU.**

