

Respiratory control

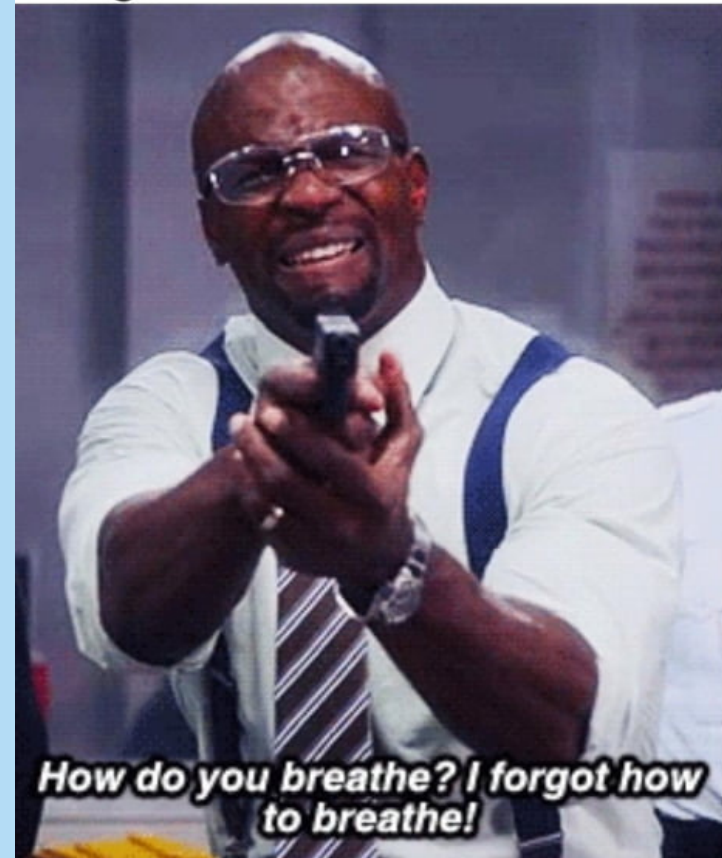
By Alexandra K Vedeler

MD 6/6

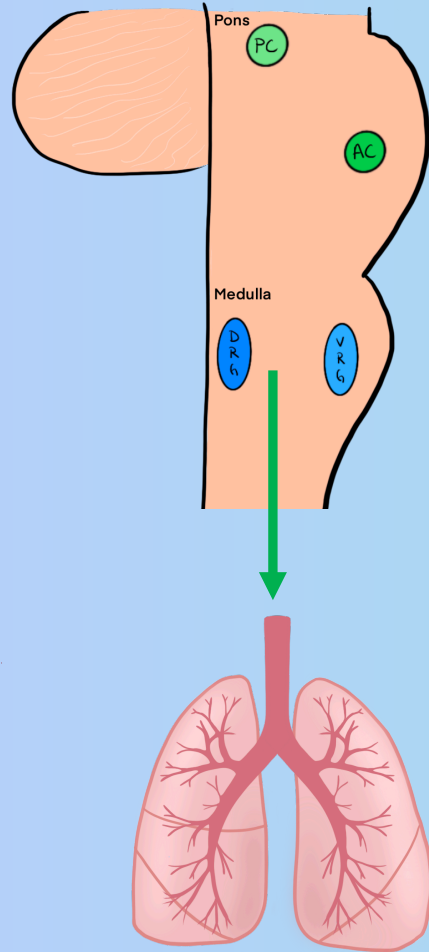
Let's get control of that breathing

- **Involuntary breathing**
 - Active inspiration and passive expiration
 - The respiratory control center
 - Central chemoreceptors
 - Peripheral chemoreceptors
- **Voluntary breathing**
 - Active inspiration and expiration
- **Exercise**
 - Ventilation and perfusion
 - Changes due to exercise

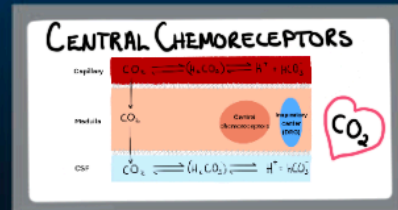
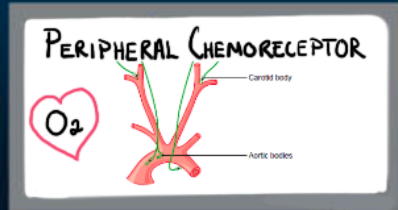
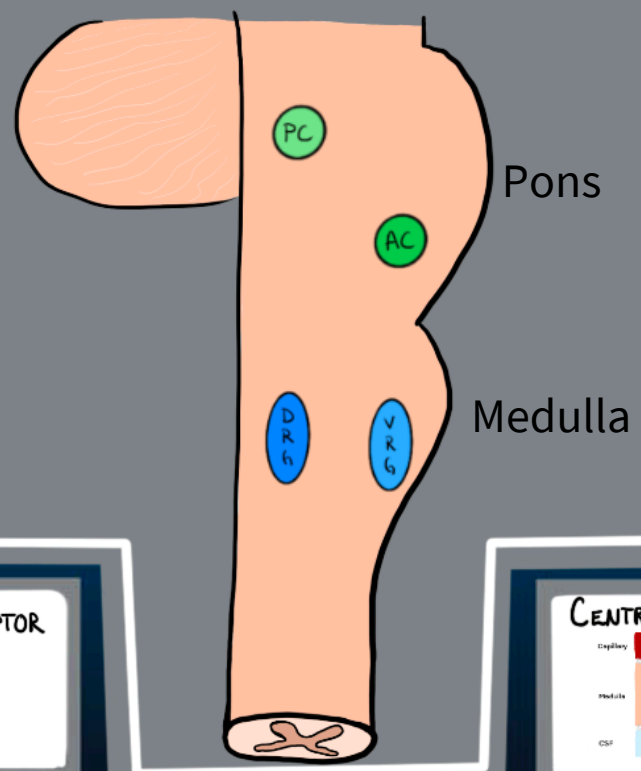
Lungs: *breathing normally*
Brain: *thinks about breathing*
Lungs:



Involuntary breathing = unconscious breathing



THE RESPIRATORY CONTROL CENTER



Medullary center

Inspiratory Center (DRG)
Expiratory Center (VRG)

Pontine center

Pneumotaxic Center (PC)
Apneustic Center (AC)

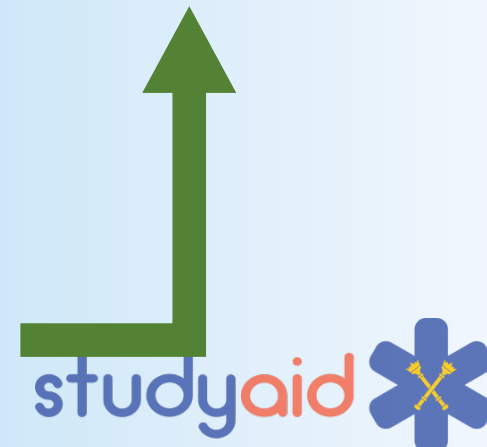
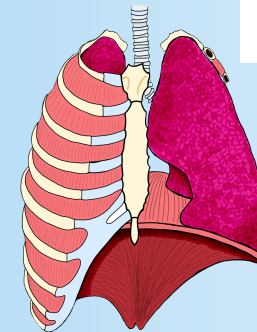
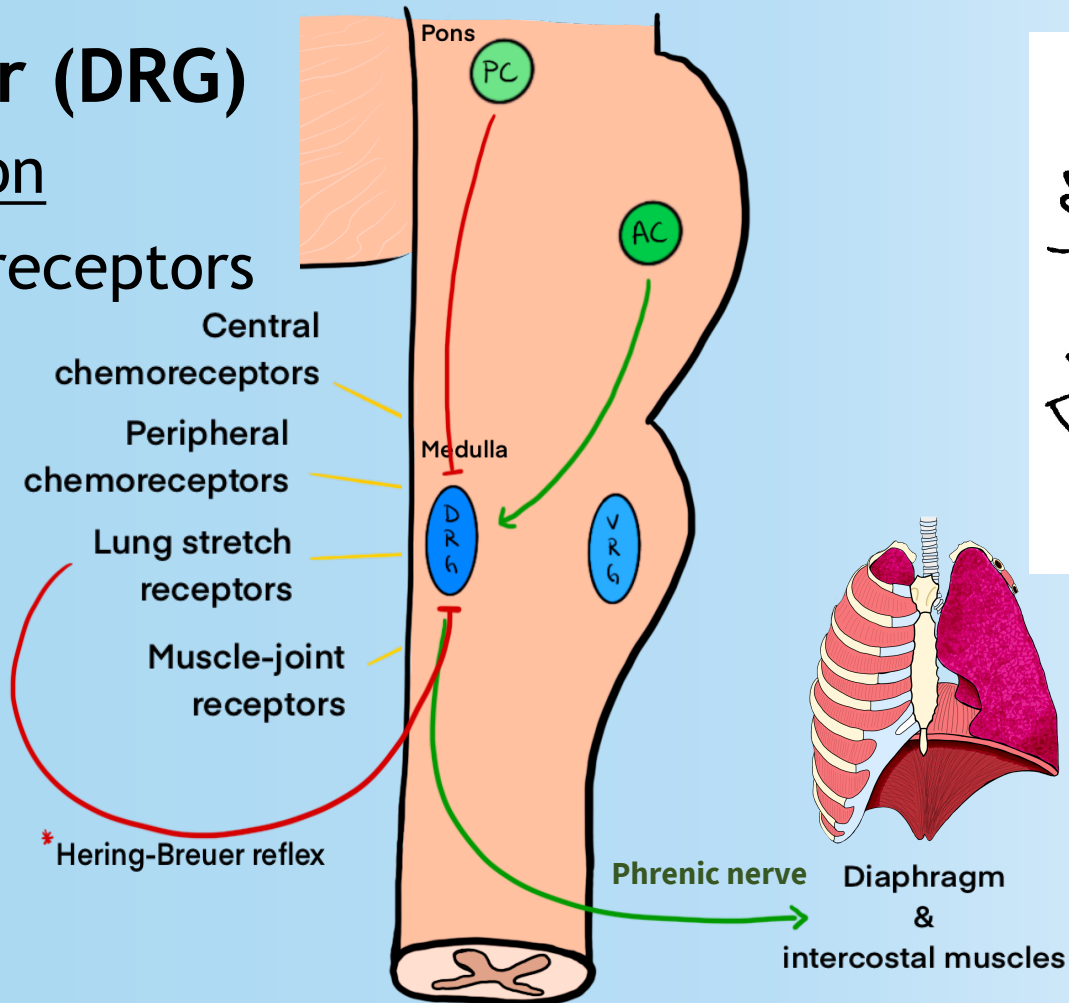
DRG = Dorsal Respiratory Group
VRG = Ventral Respiratory Group

The Medullary Centers

Responsible for the periodic nature, and the generation of the basic rhythm of breathing.

The Inspiratory Center (DRG)

- Responsible for inspiration
- Input: peripheral chemoreceptors and mechanoreceptors
- Output: phrenic nerve
- **Inhibited by:**
 - The Hering-Breuer reflex
 - The pneumotaxic center

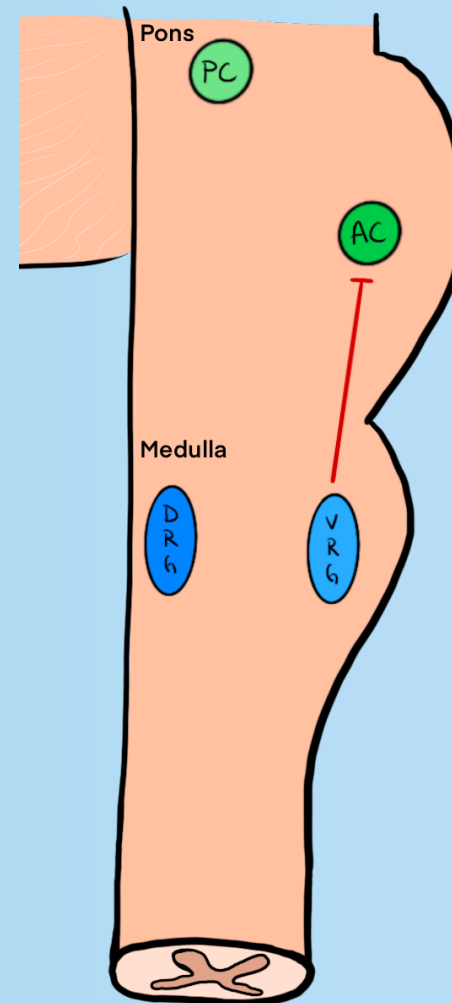


The Medullary Centers

Responsible for the periodic nature, and the generation of the basic rhythm of breathing.

The Expiratory Center (VRG)

- Responsible for expiration
- Expiration is passive during normal, quiet breathing = VRG in gear 1
- During forceful expiration, like exercise = VRG in gear 5
- **Inhibits:**
 - The apneustic center

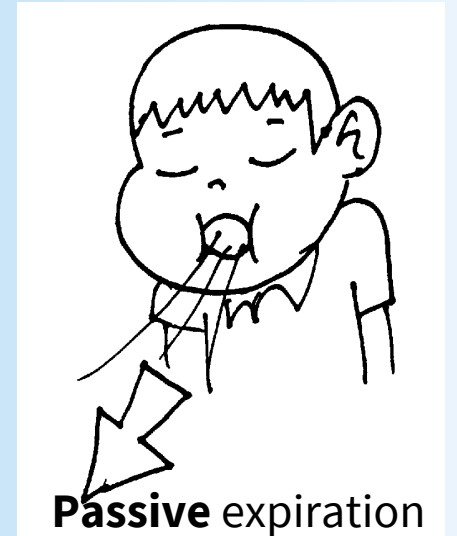
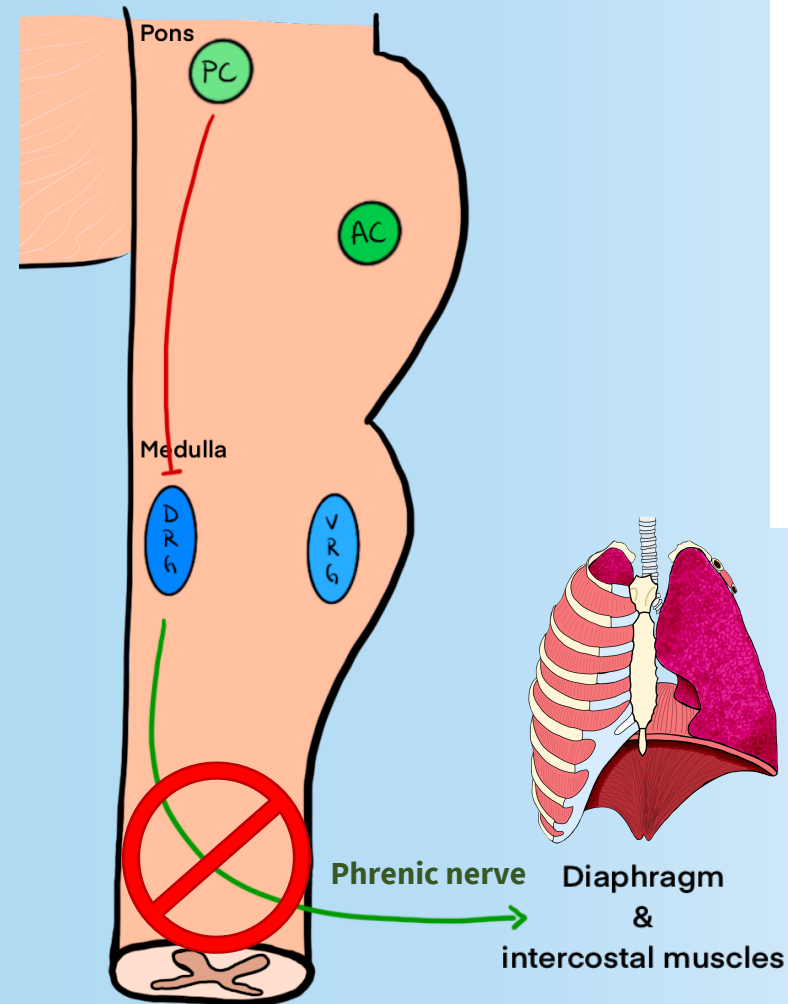


The Pontine Centers

Modifies the activities of the medullary center

The Pneumotaxic Center

- Regulation of respiratory rate and pattern of breathing by limiting or delaying inspiration
- **Inhibits:**
 - Apneustic center
 - Inspiratory center (DRG)

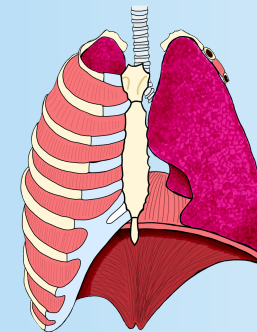
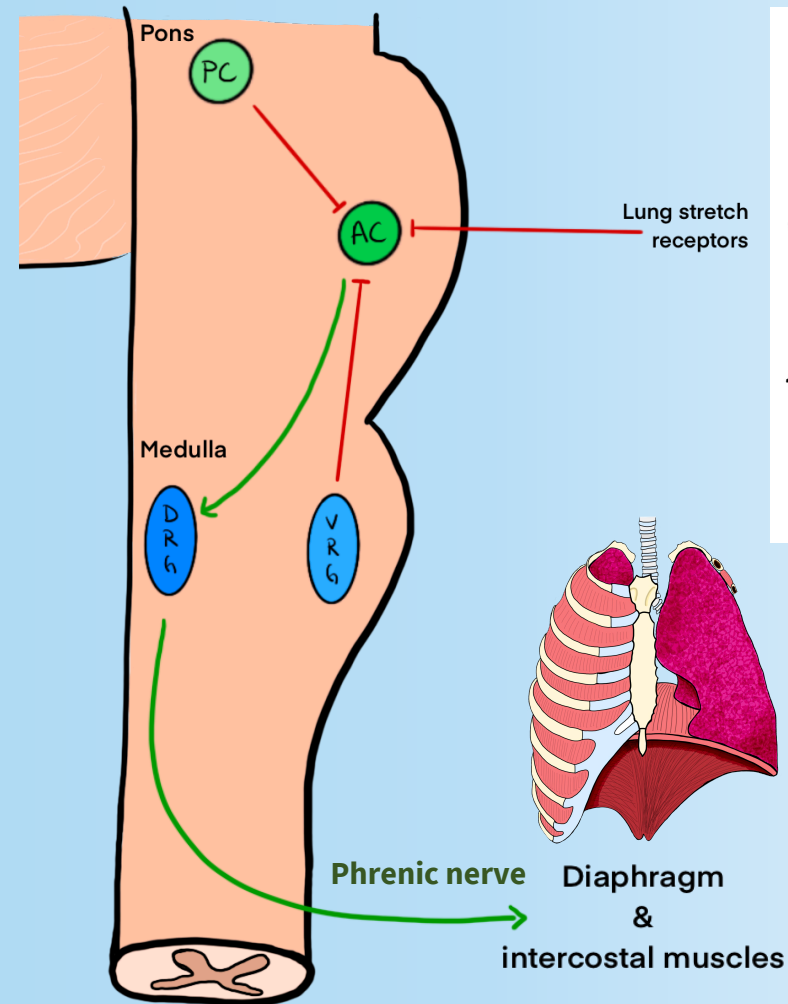


The Pontine Centers

Modifies the activities of the medullary center

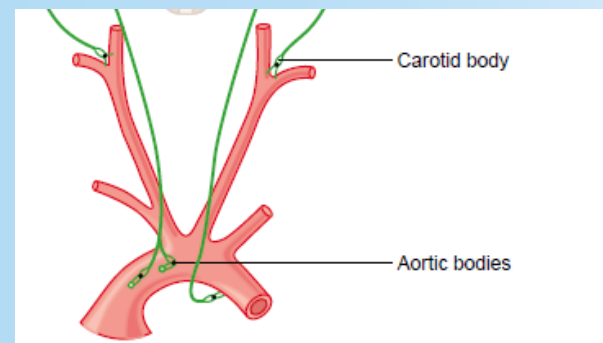
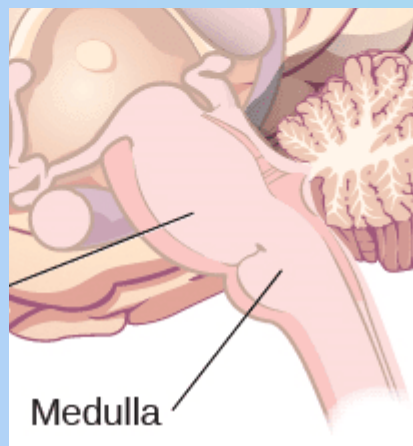
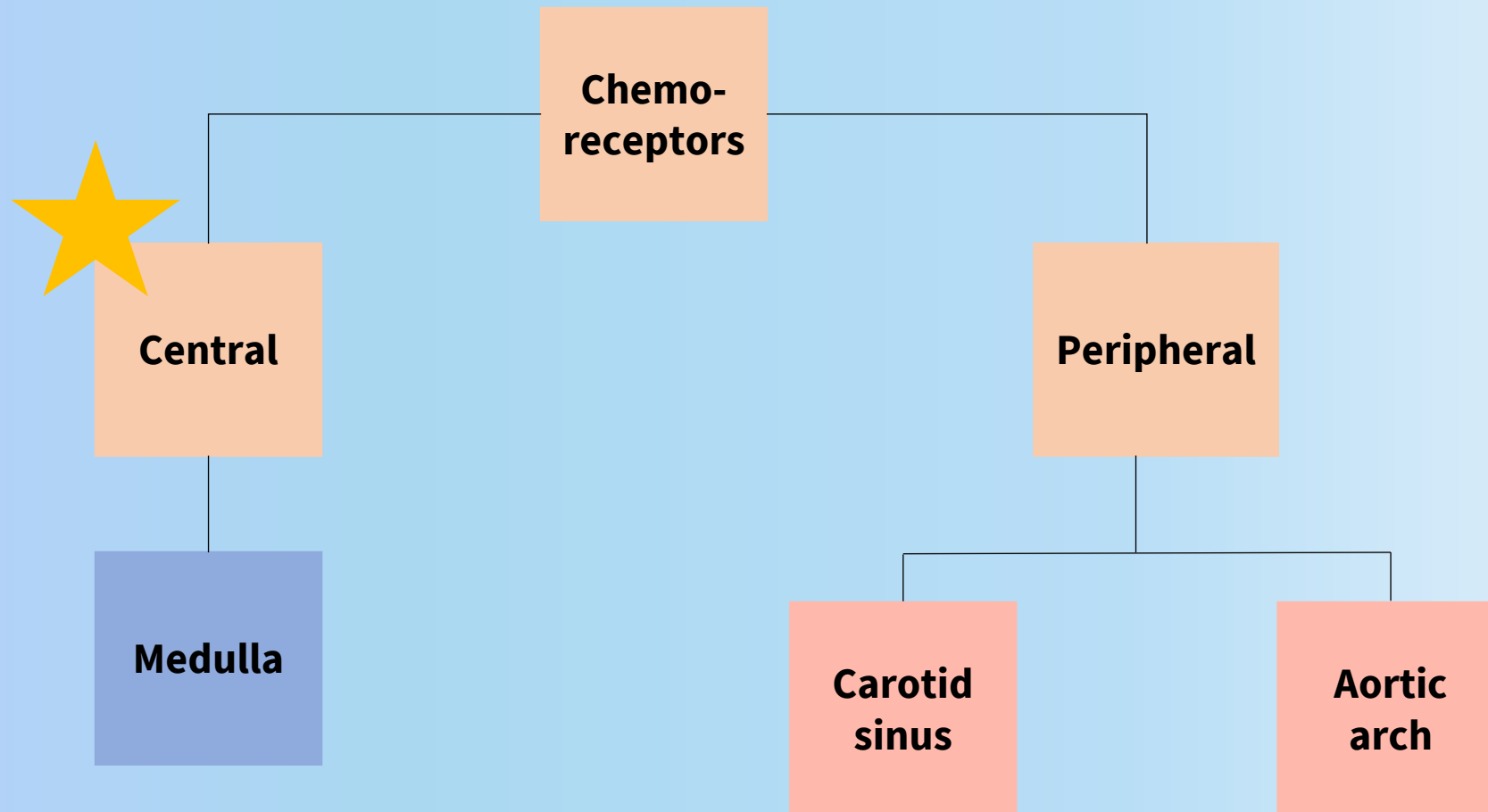
The Apneustic Center

- Promotes deep, prolonged inspiration (apneusis)
- **Activates** DRG
- **Inhibited by:**
 - Penumotaxic center
 - Expiratory center (VRG)
 - Lung stretch receptors

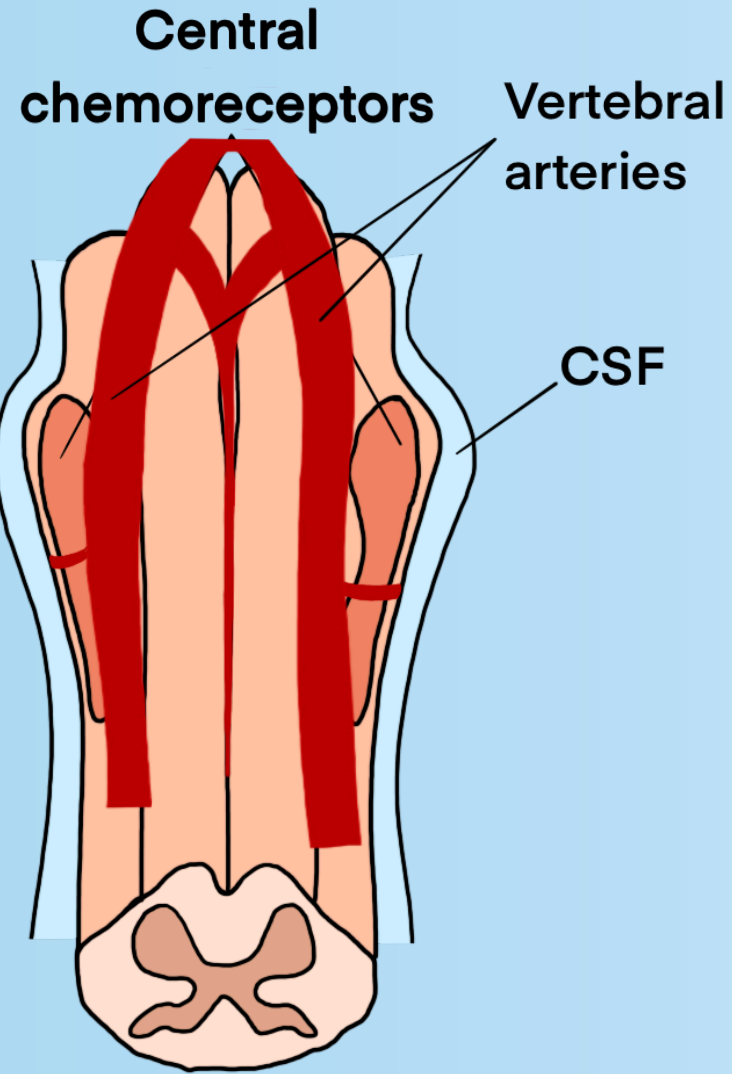
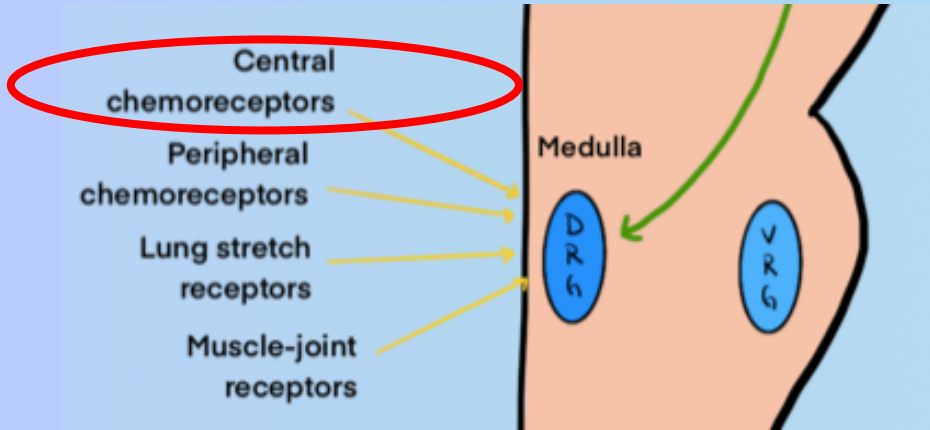


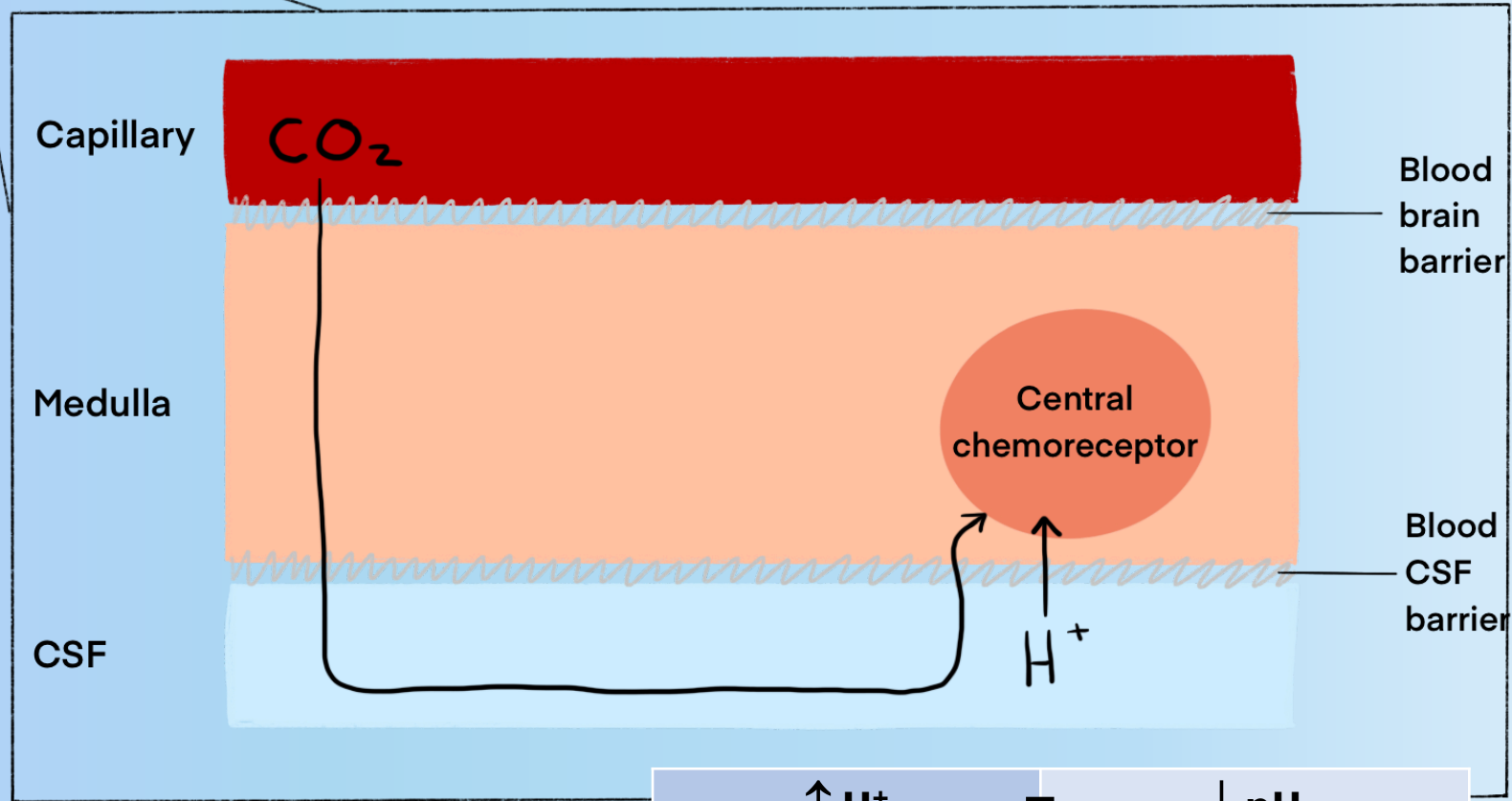
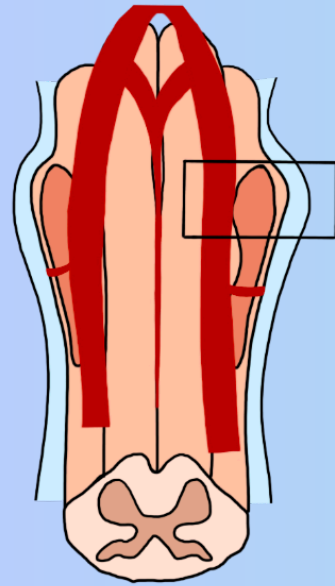
Let's review

| | Brain stem center | Inspiration | Expiration | Main action |
|---------|--|-------------|---------------------|--|
| pons | Pneumotaxic center | | X <i>passive</i> | Control of respiratory rate and pattern |
| | Apneustic center | X | | Triggers prolonged inspiration |
| medulla | Inspiratory center = Dorsal respiratory group | X | | Generation of the basic rhythm of breathing |
| | Expiratory center = Ventral respiratory group | | X <i>active</i> | Generation of the basic rhythm of breathing <i>Active during exercise</i> |

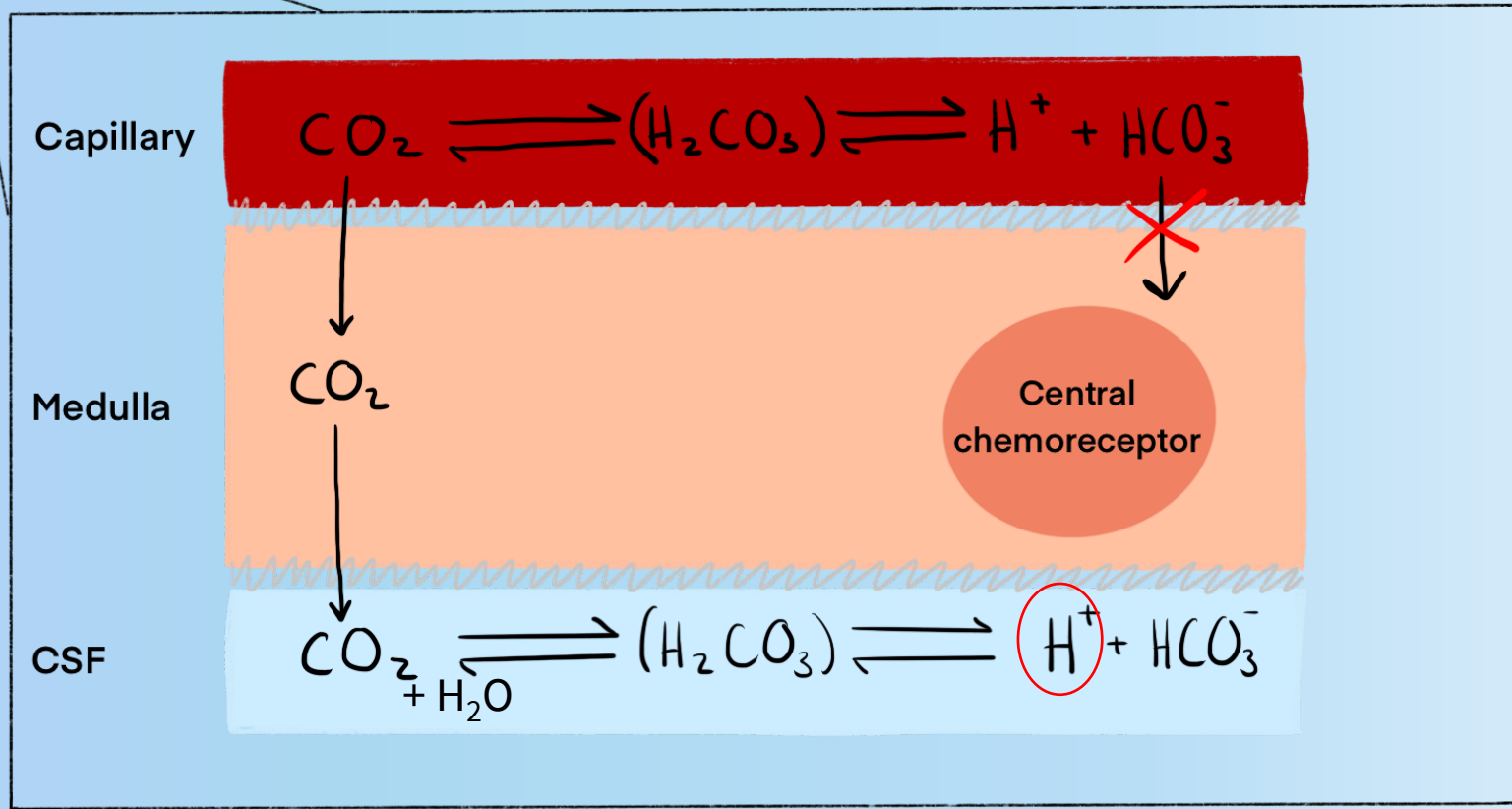
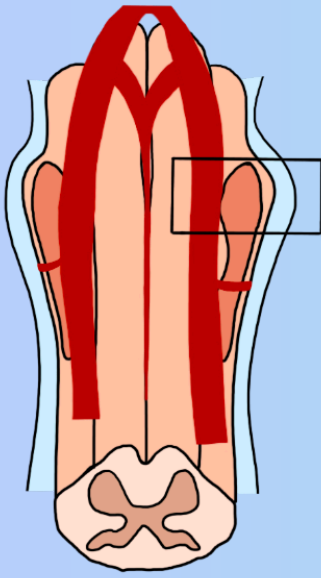


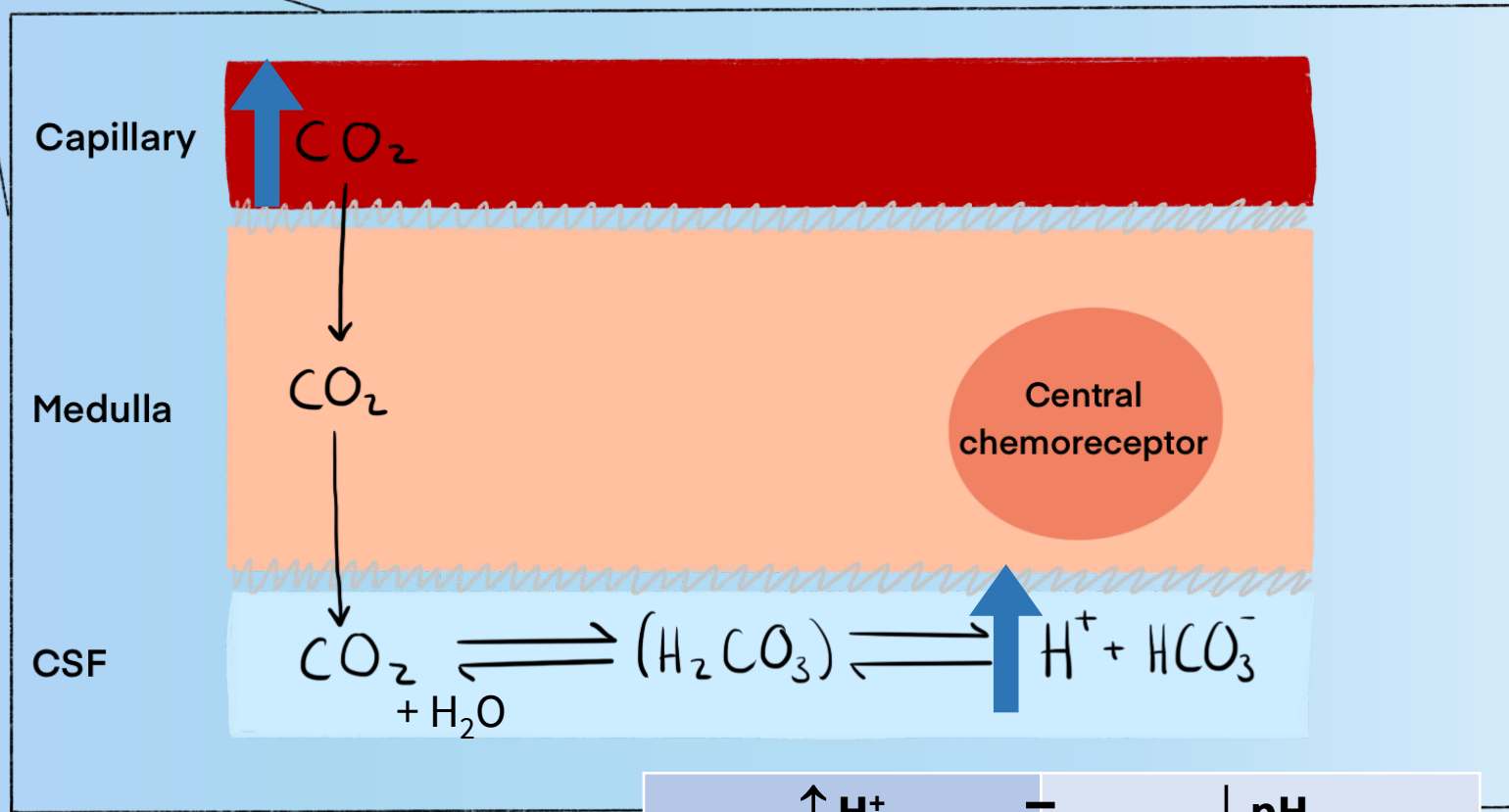
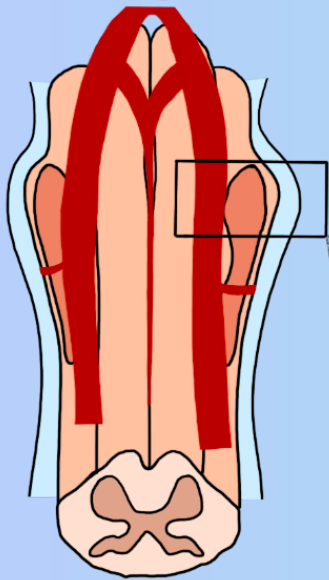
**Central
chemo-
receptors**



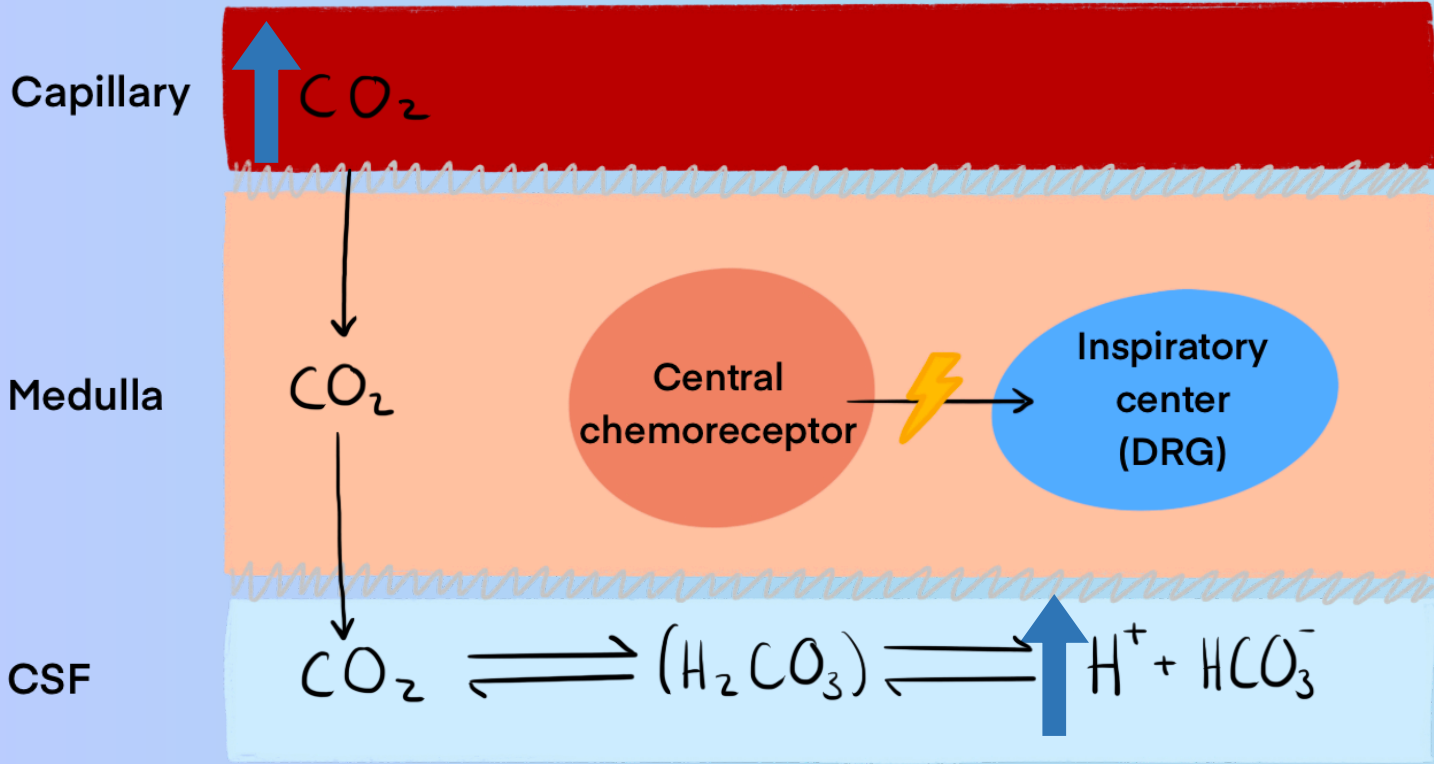


| | | |
|-------------------------|---|------------------------|
| $\uparrow \text{H}^+$ | = | $\downarrow \text{pH}$ |
| $\downarrow \text{H}^+$ | = | $\uparrow \text{pH}$ |



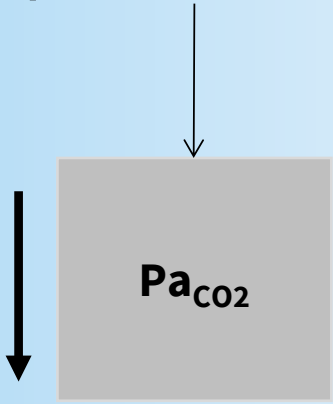


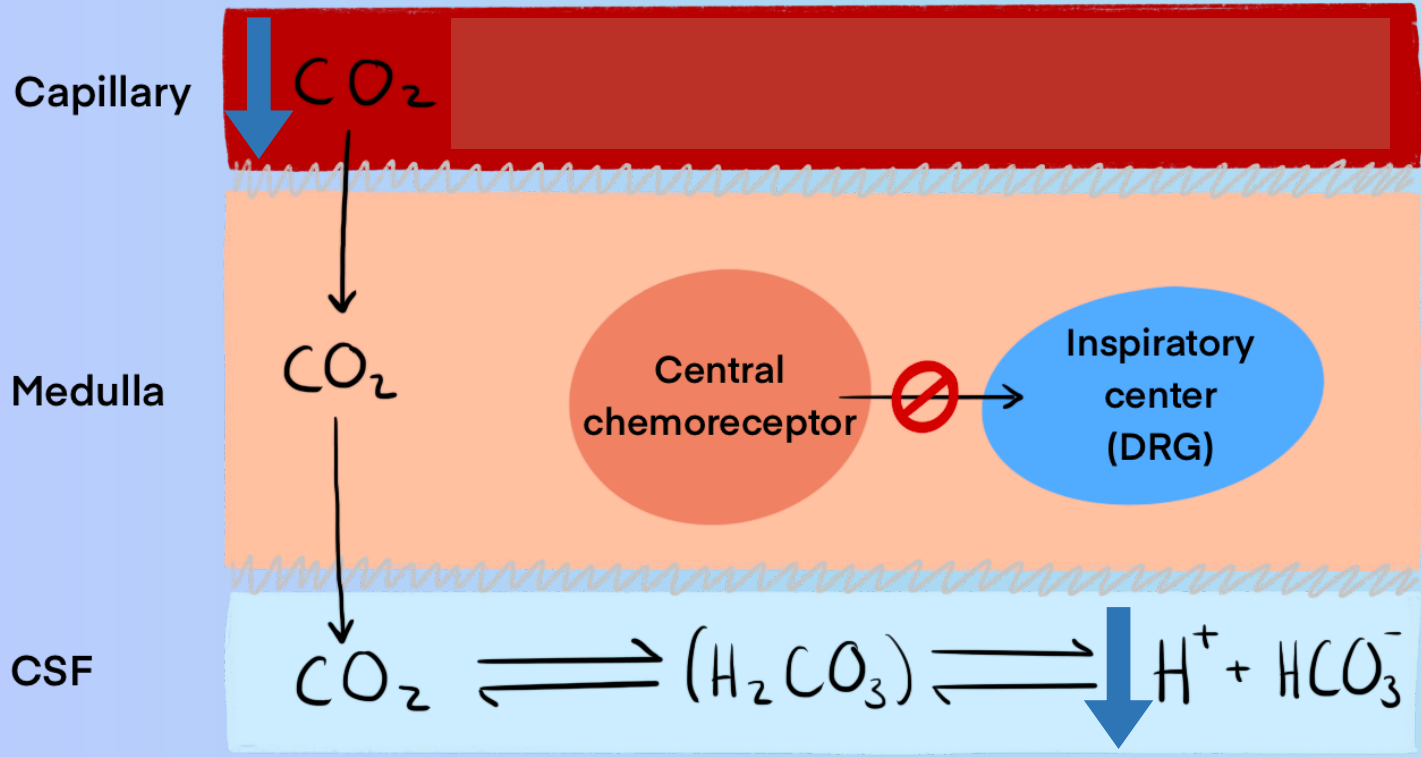
| | | |
|------------------|---|-----------------|
| $\uparrow H^+$ | = | $\downarrow pH$ |
| $\downarrow H^+$ | = | $\uparrow pH$ |



$\uparrow H^+ = \downarrow pH \rightarrow \uparrow \text{Breathing rate}$

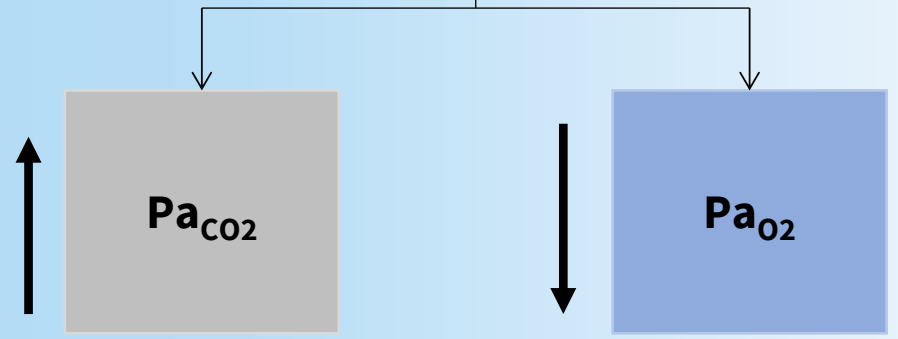
May lead to
Hyperventilation



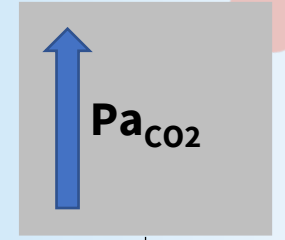
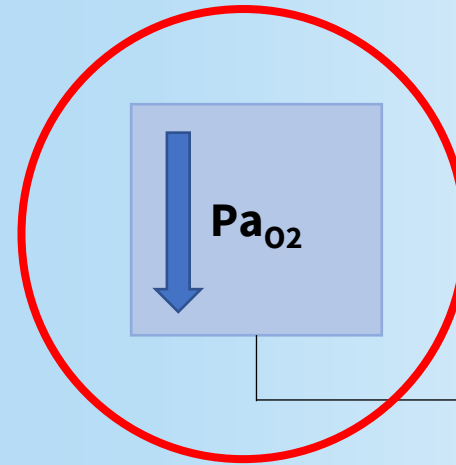
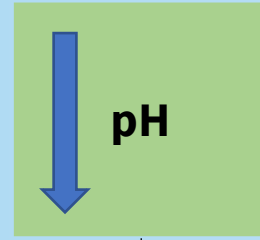
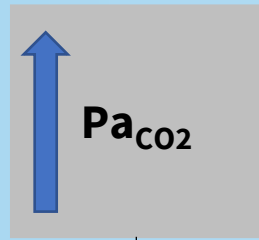
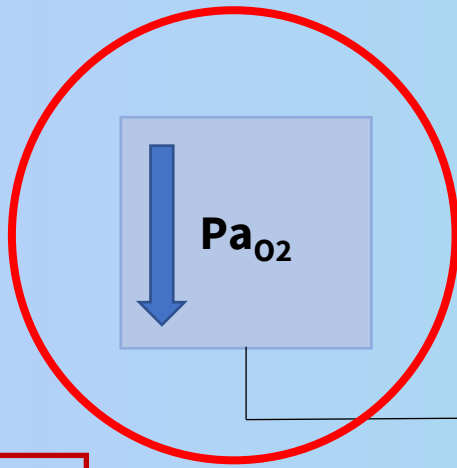


$\downarrow H^+ = \uparrow pH \rightarrow \downarrow$ Breathing rate

May lead to
Hypoventilation



Peripheral chemo-receptors



PaO₂ has to drop below 60 mmHg !

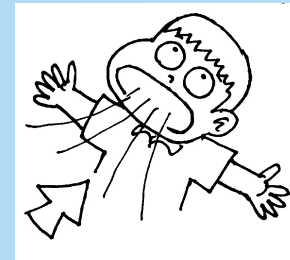
Carotid bodies

Aortic bodies

Inspiratory center (DRG)

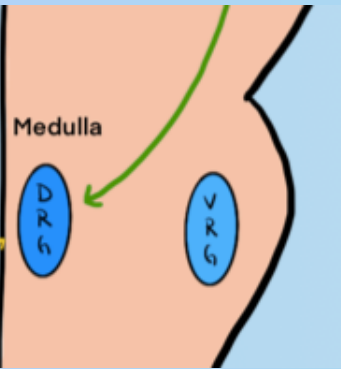
CN IX

CN X



Increased respiratory rate

Central chemoreceptors
Peripheral chemoreceptors
Lung stretch receptors
Muscle-joint receptors



Overview of other receptors

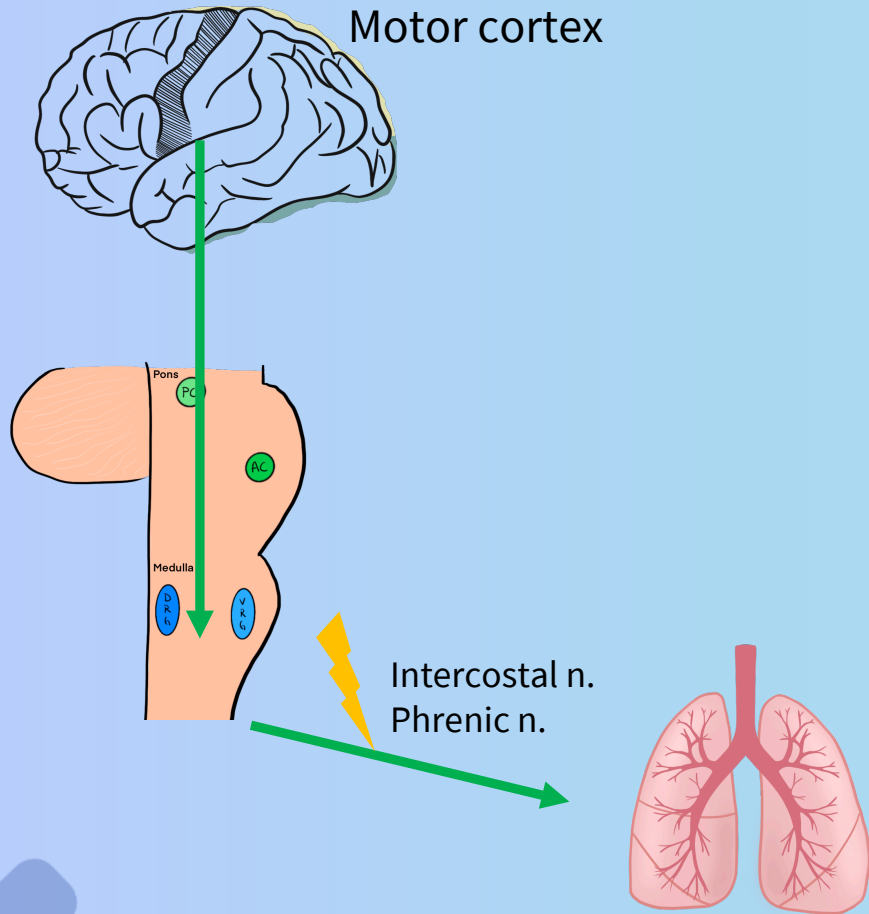
| | Lung stretch receptors | Muscle-joint receptors | Irritant receptors | Juxtacapillary receptors |
|----------------------------|-------------------------|--|---------------------------------|---|
| Type | Mechanoreceptor | Mechanoreceptor | Rapidly adapting receptors | Sensory nerve endings |
| Location | Airway smooth muscle | Joints and muscles | Between airway epithelial cells | Alveolar walls |
| Stimulation | Distension of the lungs | Movement of limbs during exercise | Noxious chemicals and particles | ↑ blood volume ↑ interstitial fluid volume |
| Effect on respiratory rate | ↓ | ↑ | ↑ | ↑ |
| Reflexes | Hering-Breuer reflex* | | Coughing reflex | |

Let' take a deep breath

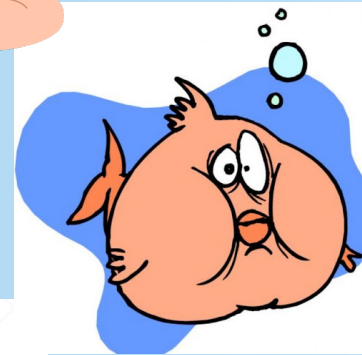


Voluntary breathing

= breathing under conscious control



- Hypoventilation



- Breath holding



- Hyperventilation

Clinical correlation

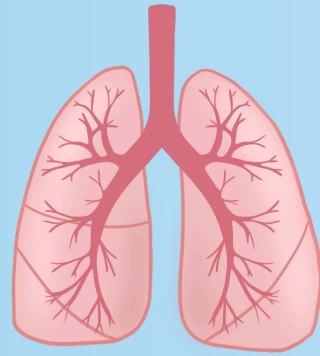
Mr. Stress is been under a lot of pressure at work lately. One late evening, 1 hour before the deadline of handing in the annual work report he starts sweating, his heart is racing and his breathing rate increases.

He is hyperventilating and he starts to feel dizzy. His co-worker, Ms. Namaste, hands him a paper bag and tells him to breathe into it.

He slowly starts to feel better.

Why does the paper bag help Mr. Stress?





Hyperventilation

