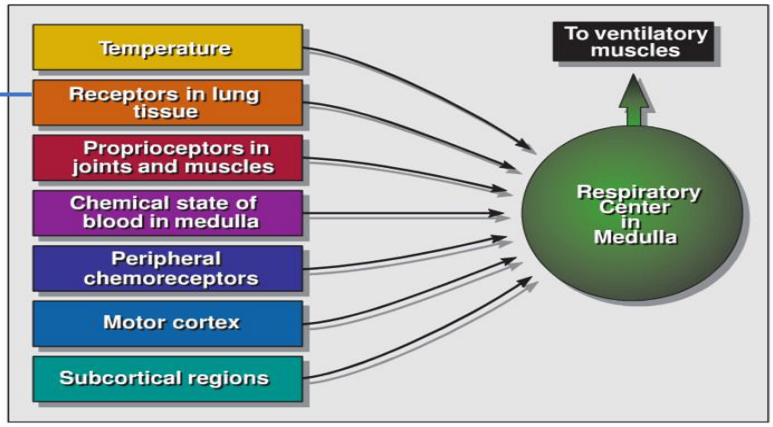
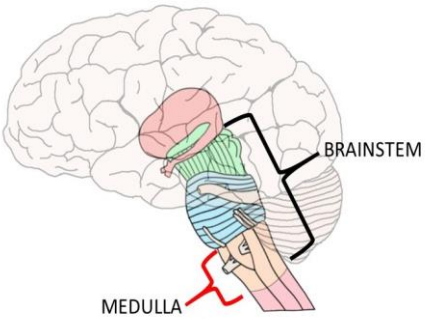
Exercise Physiology

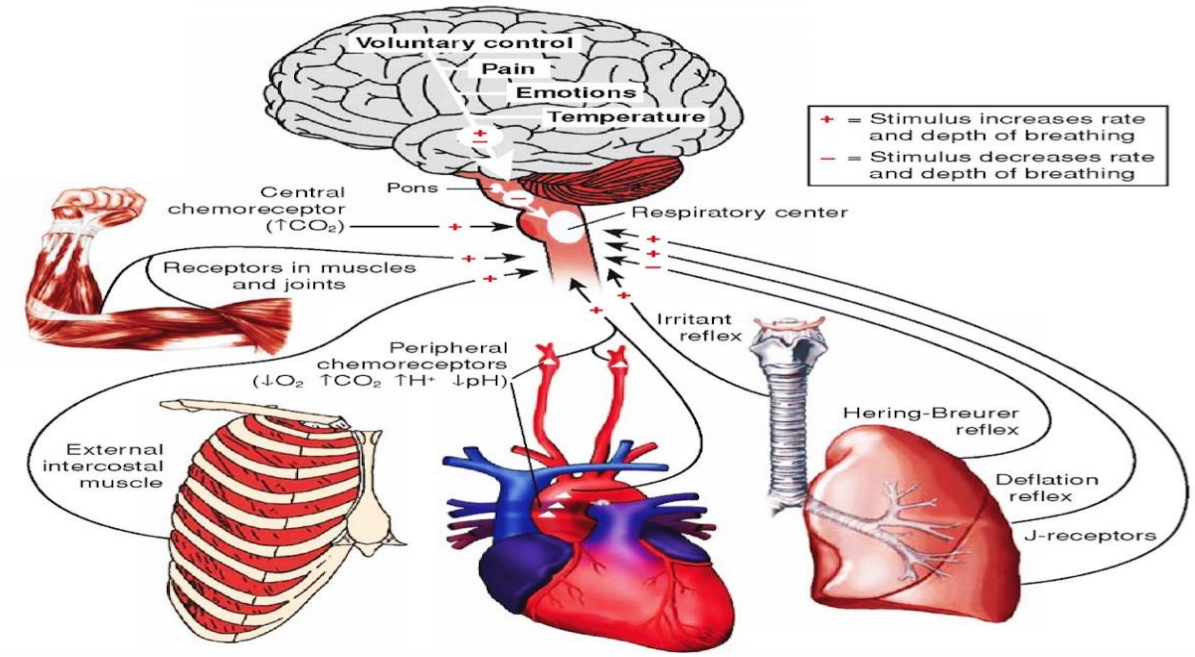
2.1.5 Describe the nervous and chemical control of ventilation during exercise

- Ventilation _____ in response to increasing intensity of exercise
  - The main objective is to _____ resting oxygen and carbon dioxide levels in blood
  - This is achieved by increasing breathing _____ and depth of breathing
  - **Regulation of breathing is quite _____ and no single factor is responsible.**
  - Carbon _____ levels in the blood is commonly thought to be the main driving factor.



- Inspiration is activated via the respiratory center in the _____ of the brain
  - The lungs inflate because motor _____ activate the diaphragm and the external intercostal muscles.
  - _____ of the lung tissue stimulates **stretch receptors** in the bronchioles that inhibit _____ and stimulate expiration. (don't want to stretch too much)
  - Expiration begins with a _____ of the stretched lung tissue and the inspiratory muscles are stimulated to relax. The internal _____ muscles will be stimulated while inspiratory muscle activation is inhibited.





Chemical state of blood in medulla

- The _____ state of blood regulates pulmonary ventilation at rest and exercise.
- **Variations in PO_2, O_2, CO_2 acidity and temperature activate sensors in the brain (medulla) and arterial system to adjust ventilation and maintain blood chemistry within narrow limits.**

Peripheral chemoreceptors

PO_2 = _____ pressure of oxygen.

- It is the individual **pressure** exerted independently by a particular gas within a mixture of gasses.

- When we exercise, we _____ an increase in depth and rate of respiration to meet the increased oxygen _____.
  - The increase in respiration often precedes the actual _____ oxygen requirement!!! What?!?!
  - There are at least 2 components to this _____ in respiration that precedes the increased oxygen requirement.

1) The first component is "_____ of exercise" and may involve activation of the sympathetic nervous system in order to prepare the body for activity

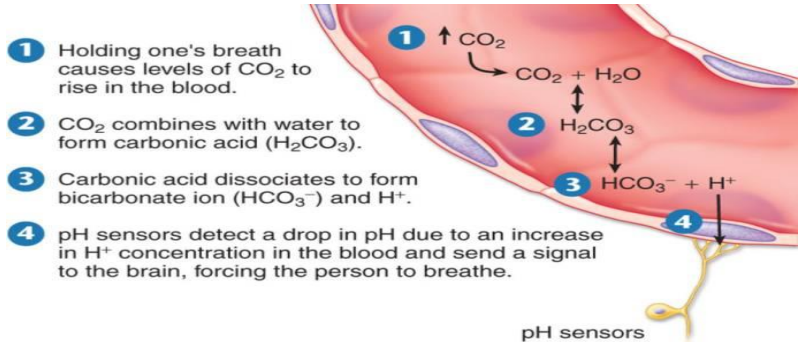
2) The second component involves _____ of stretch _____ (proprioceptors) in **skeletal muscle and joints**.

  - Increased activity of stretch receptors is _____ by the medulla and results in increased rate and depth of respiration.
  - The _____ is very rapid and shows the value of stretching/warming up before exercise (ie. in addition to heating up muscles and connective tissues and reducing stretch-related injuries).
  - This allows the body to properly prepare for _____ and helps control breathing, heart rate, temperature, etc.

- Carbon dioxide (CO_2) _____ through the alveolar walls much more easily than _____
- CO_2 is produced by muscles then sent into _____. CO_2 reacts with **carbonic anhydrase & H2O** (enzyme to speed up reactions) in red _____ cells (RBC's) and forms **carbonic acid**
  - After being further reduced, it is now **bicarbonate** (HCO_3-) which dissolves in **blood plasma** (discussed in a few slides).
  - _____ pH drops and sensors force us to breathe.
    - This is necessary to _____ CO_2 out of the body because we don't want gases in the bloodstream
    - All of these reactions are reversed in the lungs so we can transfer and exhale CO_2 from our bodies

$$CO_2 + H_2O \xrightleftharpoons{\text{Carbonic Anhydrase}} H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \rightleftharpoons CO_3^{2-} + 2H^+$$

Carbon dioxide | Carbonic acid | Bicarbonate | Carbonate

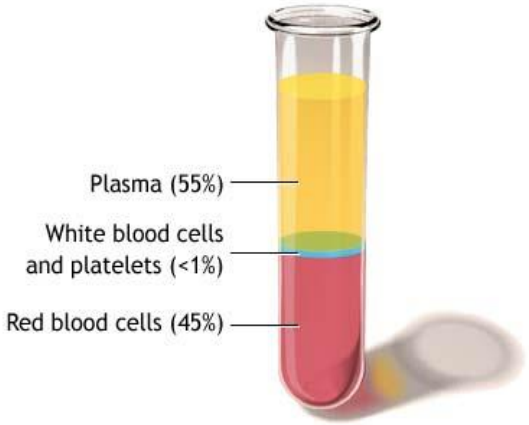


- As it is, carbon dioxide _____ is far more easily hindered than is oxygen absorption.

- **Thus breathing is governed not by oxygen, but the carbon dioxide content of the blood.**

- **HYPERVENTIALTION**
  - An increase in _____ above what is required
  - Exhale too much CO2 and inhale too much O2
  - Leads to an increased blood pH
  - Typically caused by a state of _____, dizziness, tingling in the lips, hands or feet, headache, weakness, fainting and seizures are common

2.1.6 Outline the role of hemoglobin in oxygen transportation



- _____ is the iron containing oxygen transport protein in the red blood cells.
- It transports oxygen from the _____ to the rest of the body, such as the muscles, where it releases its oxygen.
- Each molecule of hemoglobin can carry _ oxygen molecules
- It can also carry CO_2 as carboaminohemoglobin (a compound of hemoglobin and carbon dioxide, and is one of the forms in which carbon dioxide exists in the blood) back to the lungs for diffusion and expiration.

- Oxygen at the lungs is _____ mostly by red blood cells (~95%) where they combine with hemoglobin to form oxy-hemoglobin (O_2 saturated hemoglobin) and the rest (~5%) diffuses into blood plasma (O_2 has low solubility)
- This oxygen dissolved in the _____ determines the movement of oxygen from cells into the blood (_____ gradient)
- Plasma PO_2 determines the loading of _____ at the lungs and the unloading of oxygen at the cells
- When there is low PO_2, hemoglobin gives up its oxygen to the plasma (it now becomes part of the blood) which increases the PO_2 of the blood in relation to surrounding cells. Oxygen moves from the blood to the cells.
- At rest only 25% of the _____ content of blood is used with rest remaining in circulation.

Diffusion - The passive movement of molecules or particles along a concentration gradient, or from regions of higher to regions of lower concentration in relation to surface area – Ficks Law (kind of, see below)

Gas concentration - Reflects the amount of gas in a given volume, (determined by the gas' partial pressure and solubility)

Partial pressure = percentage concentration x total pressure of gas mixture i.e. $PC0_2$ and PO_2

Gas pressure - represents the force exerted by the gas molecules against the surfaces they encounter i.e. breathing

2.1.7 Explain the process of gaseous exchange at the alveoli

<u>Fick's Law</u>

Fick's law is used to measure the rate of diffusion.

It states that: The larger the area and difference in _____ and the thinner the surface, the quicker the rate.

- So, for example, in the _____ the surface area is made very large by the presence of many alveoli.
- The difference in _____ is maintained by breathing, which brings in air with a high oxygen concentration and removes the air with a high carbon dioxide concentration and by a good blood supply.
- The capillaries surrounding the alveoli take away the _____ blood and replace it with blood with a high carbon dioxide concentration.
- The walls of the _____ are only one cell thick, so the surface across which diffusion occurs is thin and the rate is high.