Alveolar Ventilation

Adequate O$_2$ and CO$_2$ diffusion between the alveoli and pulmonary capillary is dependent on the partial pressures within the alveoli. The partial pressures of O$_2$ and CO$_2$ in the alveoli are dependent on adequate exchange of atmospheric gases.

The amount of air that enters the lung is dependent on respiratory rate and tidal volume. Normal respiratory rate is ~ 12, and tidal volume for a 70 kg person is 500 ml. Therefore each minute (minute ventilation) a 70 kg person would bring 6 liters of air into their lungs.

However, not all air gets into the alveoli and is available for gas exchange. This volume is referred to as *dead space*. Alveolar ventilation is then defined to be equal to

\[(\text{Tidal Volume} - \text{dead space}) \times \text{respiratory rate}.\]

There are two types of dead space:

1) Anatomical dead space. This is the upper airways, trachea, bronchioles, in which there is no gas exchange.

2) Physiological dead space. This is an area of the lung that can have ventilation, but no blood flow. Therefore there will be no diffusion of gas from the alveoli to the blood. Examples of physiological dead space include upper portions of the lungs, or areas with pulmonary embolism.

The following exercise will demonstrate the effect of altering alveolar ventilation on O$_2$, CO$_2$ and H+ levels, while maintaining minute ventilation.

The Alveolar Ventilation Protocol

Run the simulation for 10 minutes and then record the control data. Note the tidal volume, respiratory rate, dead space, minute and alveolar ventilation.

Next, place the person on a ventilator to maintain the same minute and alveolar ventilation. In the ventilator controls, adjust the rate and volume to match the normal volume and rate, and then turn the ventilator on. Run the simulation for 30 minutes and make sure the systemic values are normal.

Then decrease alveolar ventilation while keeping minute ventilation constant. To do this, adjust the artificial ventilator by doubling the respiratory rate and cutting the tidal volume in half. Run the simulation for 30 minutes and note the changes in O$_2$, CO$_2$, and pH.

*Question: Why does this action decrease alveolar ventilation?*

Now increase alveolar ventilation while keeping minute ventilation constant. For this, adjust the artificial ventilator by cutting the respiratory rate to half normal
and increasing the tidal volume to twice normal. Run the simulation for 30 minutes and note the changes in O₂, CO₂, and pH.

NOTE: Minute ventilation should not change!

Question: Why do changes in alveolar ventilation directly changes arterial PO₂, PCO₂, and pH levels?
Question: If a patient produces a new pulmonary embolism, what should happen to arterial O₂, CO₂, and pH?