BME 444
HW 6 - Due Mar 28, 2023

1. Regulation of extracellular fluid osmolarity. The regulation of extracellular fluid (ECF) osmolarity is vested in the so-called osmoreceptor-antidiuretic hormone system. A high ECF osmolarity causes the hypothalamus to send increased nerve impulses to the neurohypophysis (posterior pituitary gland), which causes secretion of antidiuretic hormone (ADH). ADH promotes increased water reabsorption from the distal tubules and collecting ducts. This, in turn, results in a reduced ECF osmolarity.

   Special ganglion cells, known as osmoreceptors, are located in the anterior hypothalamus and respond to changes in ECF osmolarity. These cells supposedly contain large fluid chambers which are filled with ECF and each of which continually emits nerve impulses. When the ECF osmolarity becomes very low, osmosis of the water into the fluid chambers of the osmoreceptors causes them to swell, which decreases their rate of impulse discharge. The impulses are transmitted through the pituitary stalk into the neurohypophysis where they cause the release of ADH.

   Sketch a control system for this physiological system.

2. In class we discussed how the equilibrium of a physiological system is equal to the intersection point of two curves. The specific curves we looked at were alveolar ventilation $\dot{V}_A$ and arterial carbon dioxide partial pressureP_{aCO_2}. Assume that you have performed experiments and that you have determined the relationship between $\dot{V}_A$ and P_{aCO_2}.

   When $\dot{V}_A$is the independent variable and P_{aCO_2} is the dependent variable the equation is

   $$P_{aCO_2} = \frac{4.15}{\dot{V}_A}$$

   When P_{aCO_2} is the independent variable and $\dot{V}_A$ is the dependent variable the equation is

   $$\dot{V}_A = 2.41P_{aCO_2} - 3.82$$

   Find the equilibrium values for $\dot{V}_A$ and P_{aCO_2}.

3. Using the simulink model for respiratory control that we covered in class, create a model for the following scenario. Assume a person climbs a mountain and the lower oxygen concentration at the summit is $P_{IO_2} = 107$ mmHg (15% O2). Assume $P_{ICO_2} = 0$ mmHg.

Sink all three variable outputs to workspace. Add an IC block for $\dot{V}_C$ and set it to 2. Use the ODE solver ode15s and a simulation time of 10 seconds. Run the Simulink model and determine the equilibrium values for P_{aO_2}, P_{aCO_2}, and $\dot{V}_C$.