

### **Midterm Exam 3**

The exam is not cumulative: therefore, you only need to cover the ventilation, rat heart and enzyme material. I am always available for quick questions via e-mail.

#### **Possibly useful websites:**

Leif - <http://stripe.colorado.edu/~saul/physiology/>  
Mike - <http://ucsu.colorado.edu/~pascoe/physiology/index.html>  
IPHY - <http://www.colorado.edu/intphys/iphy3435/index.html>

#### **Prioritize in this order:**

1. Read the manual and notes: understand all the expected outcomes from the experiments and re-read closely to pick up some of the obscure information for tricky questions.
2. Be prepared to use Chart and Scope to replicate parts of the lab sessions.
3. Cover all the questions we had on the quizzes and homeworks.
4. Ask questions if you don't understand something.

### **Ventilation**

Big picture: Ventilation and gas exchange work together to supply tissue with oxygen and eliminate carbon dioxide. Partial pressure of O<sub>2</sub> and the oxyhemoglobin dissociation curve underlie the offloading of oxygen to tissues but ventilation itself is primarily determined by partial pressure of CO<sub>2</sub>.

- Control of ventilation: chemical conditions of blood; central/peripheral chemoreceptors; brain [pg. 68 in manual].
- Partial pressure of O<sub>2</sub>/CO<sub>2</sub> throughout the body (lungs - arteries - capillaries - veins - lungs: O<sub>2</sub> cascade) + the role in diffusing O<sub>2</sub> into tissues, removing CO<sub>2</sub>.
- Calculation of partial pressures (atmospheric pressure multiplied by fractional concentration of gas, **not** percentage i.e. 0.2093, not 20.93%) + alveolar ventilation (tidal volume - anatomical dead space, multiplied by breathing frequency).
- Anatomical dead space: inspired air not participating in gas exchange, primarily found in bronchi and trachea; volume in mL is ~ equal to weight in lbs.
- Muscles involved in ventilation.
- Effect of altitude on fractional concentration of gases in air [none] and their partial pressures [decrease as total atmospheric pressure decreases]. Physiology of altitude illness. We simulate the effect of altitude (where pressure is lower) by lowering the fractional concentration of the gas (which does not change in reality) - resulting in the same partial pressures.
- Oxyhemoglobin dissociation curve: physiological significance of its shape, role of Hb; causes and effect of left and right shifts in the curve (Bohr effect).
- Use of Chart for interpreting any of the data we recorded in class.
  - o Tidal volume, breathing frequency, ventilation, alveolar ventilation

### **Rat Heart**

Big Picture: The heart is myogenic i.e. can generate its own action potentials independent of neural input, but its rate and contractile force can be modulated by the parasympathetic and sympathetic branches of the autonomic nervous system.

- Review anatomy of heart, including cardiac tissue anatomy
- Electrical conduction system of the heart: SA node → AV node → Bundle of His (right and left bundle branches) → Purkinje Fibers
- Autonomic nervous system.
- Dissection procedures - what we cut, what we don't cut. The order of procedures, e.g. cannulate trachea before cutting diaphragm.
- Experimental procedures - heart to force transducer, use of several drugs (Ach, Epi + what they do), use of conditions (hypoxia, vagus nerve stimulation/excision).

- Mechanisms by which treatments have their effect (e.g. changing membrane permeability to ions).
- Use of Chart for obtaining any of the data we recorded in class (tension, HR).
- The inherent rate of cardiac autorhythmicity is set by the *sino-atrial (SA) node*, which is located in the right atrium. The cells of the SA node have the fastest rate of depolarization in the heart and, in healthy hearts, cardiac action potentials are generated at the SA node.
- The specialized muscle cells of the SA node are also called pacemaker cells and the action potentials generated within these cells are called pacemaker potentials. Pacemaker cells have 'leaky'  $\text{Na}^+$  channels which allow  $\text{Na}^+$  ions into the cell, causing the membrane potential to slowly approach threshold. Unlike neurons, there is not a steady resting potential.
- Cardiac cells have specializations for enhanced conductance. Resistance to ion flow is greatly reduced at intercalated discs (gap junctions), allowing electrical signals to spread rapidly from one cell to another at these areas - this allows for synchronized contraction.
- *Parasympathetic Nervous System Modulation*: Parasympathetic neural input decreases rate of SA depolarization, HR, excitability of AV node and atrial contractility. The vagus nerve supplies parasympathetic innervation to heart, neurotransmitter = acetylcholine (ACh), ACh binds receptors on cardiac cells. Increases permeability to  $\text{K}^+$ , results in greater hyperpolarization and increased time to threshold for SA node APs.
- *Sympathetic Nervous System Modulation*: Sympathetic neural input increases rate of SA node depolarization, excitability of AV node, HR, and contractile force in ventricles. Also leads to an increase in venous return and increase in strength of contraction (via Frank Starling mechanism). Sympathetic cardiac nerves supply sympathetic innervations to heart, neurotransmitter = norepinephrine (NE), NE binds adrenergic receptors on cardiac cells. Sympathetic nervous activation of the adrenal medulla causes the release of epinephrine (a hormone NOT a neurotransmitter). Once released, Epi circulates through the blood and binds to adrenergic receptors in the heart, again resulting in increased HR and contractile force. Decreases  $\text{K}^+$  conductance and increases  $\text{Na}^+$  conductance.
- *Hypoxia*: Technically we look at breath-holding. This stimulates the carotid bodies and lowers HR, cardiac output and oxygen consumption. This masks an underlying drive to increase HR because of the  $\text{O}_2$  deprivation, which will manifest when breathing resumes.
- KCl results in a high extracellular concentration of  $\text{K}^+$  ions, disrupting the normal ion gradient and preventing repolarization.

### **Enzymes**

**Big Picture**: The predominant metabolic pathways of a given tissue can be determined by measuring the activity of the marker enzymes, MDH and LDH which are involved in aerobic and anaerobic metabolic pathways, respectively.

- List the general characteristics of enzymes in general + their effect on activation energy.
- Know factors that affect enzyme activity (temp, pH, etc)
- Write out the chemical reactions we studied and explain how they fit into the context of metabolic pathways. Substrates and products: pyruvate/lactate, oxaloacetate/malate,  $\text{NADH}/\text{NAD}^+$
- List the three types of skeletal muscle fiber, and compare their characteristics.
- Explain the expected MDH and LDH activities, and the expected MDH/LDH ratio, for each tissue we studied.
- Explain the significance of the lactate shuttle and the Cori cycle.
- The reactions involved the oxidation of  $\text{NADH}$  to  $\text{NAD}^+$ . Since  $\text{NADH}$  absorbs light at 540nm but  $\text{NAD}^+$  does not, we measured the disappearance of  $\text{NADH}$  to quantify enzyme activity.
- What was the total protein reagent?
- What was in the supernatant?
- What were the variables used to construct the standard curve + what did you use it for?

- Understand the significance of:  $\Delta\text{ABS}/\Delta t$ , activity/mL supernatant vs. activity/mg protein.
- Be able to perform a simple regression in SPSS and know how to use the regression equation.
- Be able to determine the enzyme activity for an example trace in Chart.