Study Guide for the Final Lecture Exam - Cumulative Part

1. Know the normal values and units of measurement of the following physiological variables:
   - body temperature
   - arterial blood pressure (systolic/diastolic and mean)
   - plasma [glucose]
   - arterial pH
   - plasma osmolarity
   - arterial \( P_{O_2} \)
   - plasma \([Na^+]\)
   - arterial \( P_{CO_2} \)
   - plasma \([K^+]\)

2. Identify the major fluid compartments of the body and list the major solutes found in each. Which is the largest fluid compartment? What two subcompartments comprise the ECF? What processes drive fluid movement between these compartments and subcompartments?

3. Briefly outline the major biochemical pathways involved in the extraction of energy from a molecule of glucose and a fatty acid molecule. What are the major intermediate products and end products of these pathways? Contrast aerobic metabolism and anaerobic metabolism of a glucose molecule in terms of the end products and number of ATP molecules formed.

4. Summarize the following transport processes and provide an example of each:
   - simple diffusion
   - diffusion through channels
   - primary active transport
   - osmosis
   - facilitated diffusion
   - secondary active transport
   Which of these processes are protein-mediated? Which of these processes require energy?

5. Draw a diagram of the epithelium of the small intestine or kidney (PCT), distinguish between the apical and basolateral sides of the cells, and identify major structural features and specific transport proteins that are important to the cells’ function of absorption.

6. What are the major variables that affect the rate of diffusion of a substance across a membrane (from Fick’s Law). In what way does diffusion of a gas such as \( O_2 \) differ from diffusion of a dissolved solid? (Hint: think gradient.)

7. Define the terms isotonic, hypotonic, and hypertonic. Describe what happens to a cell placed in a hypotonic medium and one placed in a hypertonic medium.

8. Explain the role of \( K^+ \) and \( Na^+ \) ions in the formation of the resting membrane potential and the action potential. Which ion has the dominant effect on the resting membrane potential, and why?

9. Describe briefly how action potentials are formed by nerve cells. What specific movements of ions occur during the rising (depolarization) and falling (repolarization) phases of the action potential?

10. Contrast the properties of action potentials and graded potentials. Where does each type of potential occur in a neuron? What types of ion channels are involved in the formation of action potentials and what type of channels are involved in the formation of graded potentials?

11. Explain briefly how skeletal muscle contraction is controlled by the nervous system. What are motor units and how do they regulate muscle contraction? How are antagonistic muscles controlled? Diagram and explain a muscle spindle stretch reflex such as the “knee-jerk” reflex.

12. Summarize how muscle action potentials are coupled to contraction of the sarcomeres. Include the important cellular structures and proteins involved and explain the specific role of calcium ions.

13. Identify the neurotransmitter molecules that function at the neuromuscular junction and in the autonomic nervous system, and identify the specific types of receptors involved in each case.

14. Distinguish between the sympathetic and parasympathetic divisions of the ANS. Summarize and contrast the major actions of the sympathetic and parasympathetic divisions. What are the roles of the adrenal medulla and the vagus nerve in the two division of the ANS?
15. For each of the following hormones:
   - epinephrine
   - thyroid hormones
   - insulin
   - ADH (vasopressin)
   - glucagon
   - aldosterone
   - cortisol
   - progesterone
   
   Identify:
   a) its source - the organ and/or cells from which it is secreted;
   b) its target cells or target organs;
   c) its major effects on the target cells.

16. Summarize the anatomical and functional relationship between the hypothalamus and pituitary gland, and list the hormones secreted by the anterior pituitary and posterior pituitary gland.

17. Contrast the cellular mechanisms of hormone action between a water-soluble hormone (such as epinephrine) and a lipid-soluble steroid hormone (such as cortisol). Include the following terms in your discussion: cytosolic receptor, transcription factor, G protein-coupled receptor, G protein, amplifier enzyme, second messenger (e.g., cyclic AMP), protein kinase.

18. Understand the roles of blood pressure and osmotic pressure in the filtration and reabsorption of fluid from capillaries. What is colloid osmotic pressure and what does it result from?

19. Be able to perform the following calculations:
   a) Basic unit conversions in the metric system (e.g., cm to mm, mL to L, mL to µL, g to mg)
   b) Calculations with units of concentration, volume, and flow
   c) Dilution calculations using the equation \( C_1V_1 = C_2V_2 \)
   d) Cardiac output given heart rate and stroke volume (EDV – ESV)
   e) Mean arterial blood pressure given systolic and diastolic arterial pressure
   f) Minute volume and alveolar ventilation given respiratory rate, tidal volume and dead space volume.

20. Describe three specific physiological functions of the \( Na^+ / K^+ \) pump, for example, in a nerve cell, a renal tubule cell, and an absorptive cell of the small intestine.

21. Follow the pathway of oxygen from inhalation to delivery to an active muscle cell. Summarize the processes of (1) ventilation, (2) pulmonary gas exchange, and (3) transport of oxygen in the blood. What physiological adjustments function to increase the rate of \( O_2 \) delivery to the muscles during exercise? (Hint: consider each of the steps listed above.)

22. Discuss the physiological basis and effects of the disease diabetes mellitus. Distinguish between type 1 (insulin dependent) and type 2 (insulin independent) diabetes mellitus. Include specific effects of the disease on glucose transport, blood glucose homeostasis, cellular metabolism, acid-base balance, and renal function. (Include the following terms and concepts in your discussion: facilitated diffusion, GLUT4 protein, hyperglycemia, ketone bodies, ketoacidosis, renal plasma threshold, glycosuria, osmotic diuresis.)

23. Discuss physiological regulation of the following variables:
   - body temperature
   - arterial blood pressure
   - plasma osmolarity
   - arterial \( PCO_2 \)

Begin with a general homeostasis control diagram then “fill in the boxes” (regulated variable, sensors, integrating center, effectors, responses) with specific details for each example. Include the efferent pathways (somatic NS, autonomic NS, and/or hormones) that activate the responses.