

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

Departments of Electrical Engineering, Mechanical Engineering, and the Harvard-MIT Division  
of Health Sciences and Technology

6.022J/2.792J/BEH.371J/HST542J: Quantitative Physiology: Organ Transport Systems

**PROBLEM SET 10**

**Assigned:** April 29, 2004

**Due:** May 6, 2004

### Problem 1

Inulin and para-amino hippuric acid are infused into the blood stream of a 40 kg ape. The following measurements were made during the course of the infusion, and were noted to be constant throughout the experiment: arterial plasma concentration of inulin 0.15 mg/ml, of para-amino hippuric acid 0.2 mg/ml; renal venous plasma concentration of para-amino hippuric acid 0.0015 mg/ml; urine flow 2 ml/min; urinary concentration of inulin 9.0 mg/ml, of para-amino hippuric acid 5 mg/ml.

- A. What is the glomerular filtration rate?
- B. What is  $T_m$  (transport maximum) for PAH secretion?
- C. What is the renal plasma flow?
- D. Calculate the renal venous concentration of inulin.

## Problem 2

In a particular experiment designed to determine rate of renal excretion of vitamin C, a human subject, after large doses of vitamin C, showed plasma concentration of the vitamin of 40 mg/liter. The vitamin C clearance was determined to be 60 ml/min. The inulin clearance which was measured simultaneously was 130 ml/min.

- A. Calculate the excretion rate of the vitamin.
- B. Calculate the reabsorption rate of the vitamin in the tubules.
- C. It is known that vitamin C exhibits a transport maximum ( $T_m$ ); i.e., the tubules cannot reabsorb a larger amount of the vitamin than  $T_m$ . What is the value of  $T_m$  for vitamin C? Find also the blood concentration of the vitamin for which excretion of the vitamin will approach zero.

### Problem 3

From electron-microscopic studies it was estimated that the wall thickness of the glomerular capillaries through which filtration occurs is about  $500\text{\AA}$ . The individual pore diameter is  $80\text{\AA}$ . Using the values for glomerular filtration rate (GFR), viscosity of the fluid,  $\mu$ , and the filtration pressure,  $\Delta p$ , of:  $\text{GFR} = 125\text{ ml/min}$ ,  $\mu = 0.01\text{ g/cm-sec}$ , and  $\Delta p = 30\text{ mmHg}$ , estimate the total number of pores and the cross-sectional area of a single pore which would provide an equivalent resistance. (Assume laminar viscous flow.)

**Problem 4**

A 70 kg patient in the hospital was found to have a plasma  $\text{Na}^+$  concentration of 112 mEq/liter. (Normal is 140 mEq/l.) It is decided that this abnormality must be corrected rapidly because of altered mental status. If it is desired to raise the plasma  $\text{Na}^+$  concentration to 132 mEq/liter, how much 5% NaCl solution must be administered? (The molecular weight of NaCl is 58.)

### **Problem 5**

An elderly patient who weighed 50 kg when in good health became ill and stopped eating and drinking. Several days later the patient was taken to the hospital where serum electrolytes were measured. The serum sodium concentration was 160 mEq/liter. (Normal = 140 mEq/L). Estimate the approximate volume of water which must be administered to the patient to restore normal osmolarity. (Use the approximate “20–40–60” percent rule. Assume the patient had lost pure water.)