1. Different portions of the nephron and its associated blood vessels serve different functions. Which portion(s) of the nephron and vessels is (are) primarily responsible for carrying out the following functions? Be sure to include all appropriate segments.
   a. Reabsorption of glucose and amino acids
   b. Reabsorption of more than half of the filtered water
   c. Preventing serum protein from entering the proximal tubule
   d. Generating and maintaining a concentration gradient in the renal medulla
   e. Regulating the concentration of urine produced
   f. Regulating the volume of urine produced
   g. Carrying water back to the general circulation
   h. Carrying glucose back to the general circulation
   i. Reducing the concentration of penicillin in the bloodstream

2. About 60% of the fluid filtered into the nephron is reabsorbed back into the circulation by the time the tubular fluid enters the loop of Henle.
   a. How does the osmolarity of tubular fluid in Bowman's capsule compare with the osmolarity of tubular fluid at the beginning of the descending thin limb of the loop of Henle?

   b. If inulin had been injected into the organism and time had been allowed for equilibration, how would the concentration of inulin in Bowman's capsule compare with the concentration of inulin at the beginning of the descending thin limb of the loop of Henle?

   c. Under normal conditions, how would the concentration of glucose in tubular fluid in Bowman's capsule compare with the glucose concentration in tubular fluid at the beginning of the descending thin limb of the loop of Henle?

   d. In diabetes mellitus, how would the amount of glucose per minute entering the distal tubule compare with the amount of glucose entering the descending thin limb of the loop of Henle?

3. In muscle capillaries, plasma oncotic pressure is constant all along the length of the capillary, but in the glomerulus, the plasma oncotic pressure increases along the length of the capillary. What causes the capillaries in these two tissues differ in this way?
4. If the protein content of the blood were to double, what would be the effect on glomerular filtration? Briefly explain your prediction?

5. In a clinical study, inulin is infused into the circulatory system of a person at a rate that eventually produces a constant plasma concentration of 20 mM. From the beginning of the infusion, urine is collected at 10 minute intervals. The volume of urine collected and the concentration of inulin in the urine is determined. The first 5 data points are:

<table>
<thead>
<tr>
<th>Time</th>
<th>Volume (ml)</th>
<th>Concentration (mM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>127</td>
</tr>
<tr>
<td>20</td>
<td>16</td>
<td>135</td>
</tr>
<tr>
<td>30*</td>
<td>20*</td>
<td>125*</td>
</tr>
<tr>
<td>40</td>
<td>16</td>
<td>132</td>
</tr>
</tbody>
</table>

   a. What is the glomerular filtration rate in this person?

   b. How do you explain the relatively low concentration at the first time point?

   c. Does the GFR measured in this experiment match the value that you would predict from your reading and lecture? Is this person sick?

   d. In this person, the blood glucose level is 425 mg/100 ml. Would you expect to find glucose in the urine? Why or why not?

   e. If there was glucose in the urine and you calculated the glomerular filtration rate based on the clearance of glucose (rather than on the clearance of inulin), would you expect to get a value higher than or lower than the clearance calculated for inulin?

   f. In this infusion, you also included PAH. You find that it reaches a concentration of 15 mM in the plasma after mixing is complete. In the urine that you collected between 20 and 30 minutes (starred sample above), you find that the concentration of PAH is 375 mM. Calculate the renal blood flow. Keeping in mind that normally the kidneys receive 20-25% of the entire cardiac output, and that this person is still alive, what is your cautious first diagnosis?
6. ADH is released by changes in both blood pressure and blood osmolarity.
   a. Describe the mechanism by which ADH controls the volume and osmolarity of urine produced.
   b. Describe the response of the kidney to hemorrhage and discuss, based on hypothalamic influences, how the cardiovascular system and kidney interact in response to this physiological crisis. Do the two systems act synergistically or in competition with one another?
   c. Explain in words the regulation of the volume and osmotic concentration of plasma (and hence the volume and osmotic concentration of urine) by ADH.

7. The Na⁺/K⁺/2Cl⁻ transporter in the thick ascending limb of the loop of Henle is inhibited by the drug amiloride. Amiloride also increases urine production.
   a. What effect--if any--would amiloride have on the concentration of urine produced?
   b. How can amiloride increase the volume of urine produced?
   c. What effect--if any--would amiloride have on the clearance of Na⁺ that you would measure after administering the drug?

8. In separate experiments you expand your total body fluid volume by drinking one of the following liquids. In each case, state the effect that you expect the experimental manipulation to have on the (1) volume and (2) osmolarity of urine produced during the following few hours, and describe the regulatory system that would lead to the predicted result. (You have seen this question before, in considering the shifts between fluid compartments. Now you need to consider kidney responses to the same conditions.)
   a. You drink 2 liters of pure, clear water.
   b. You drink 2 liters of Gatorade (iso-osmotic with plasma).
   c. You drink 1 liter of sea water (approximate concentration = 1 osmolar).
   d. The Friday night experiment: You drink 3 liters of your favorite beer.

9. Diuretics are drugs that increase the volume of urine excreted. Common diuretics operate by several different mechanisms. Below are listed some diuretics and, in some cases, the part of the nephron affected by that diuretic. Explain how each drug produces diuresis.
   a. Spironolactone--a steroid that competes with aldosterone for binding sites in the target cells.
   b. Mannose--is injected directly into the circulation in large quantities and is neither reabsorbed nor metabolized by renal cells.
   c. Furosemide—blocks the Na/K/2Cl co-transporter in the thick ascending limb of the loop of Henle.
   d. Ouabain--blocks the Na⁺-K⁺ ATPase on the basal membranes of proximal and distal tubule cells.