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Show calculations and give units for all problems

1 In a 70 kg subject, ^{51}Cr-tagged red blood cells were used to measure the red blood cell volume and PAH was used to measure the rate of renal plasma flow with the following results:

Subject weight	70 kg
Red blood cell volume	2.5 liters
Hematocrit	0.45

a. What is the total blood volume of the subject from these data?

b. What additional data would you need to estimate interstitial fluid volume?

2. For the subject in problem #1, additional renal tests and body fluid compositional data were obtained as follows:

Glomerular filtration rate (GFR)		125 ml/min
Urinary flow rate		5 ml/min
Urine concentrations:	Na^+	45 mM/liter
	Glucose	24 mg/ml
	PAH	12 mg/ml
Plasma concentrations:	Na^+	140 mM/liter
	Glucose	4 mg/ml
	PAH	0.1 mg/ml

a. Calculate the filtered load of Na^+

b. What is the rate of Na^+ excretion?

c. If aldosterone were given to the subject, what would happen to the rate of Na^+ excretion?

d. What is the rate of glucose reabsorption?

e. If plasma glucose were to increase, what would happen to glucose reabsorption? Why?

f. What is the rate of renal plasma flow for the subject?

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3. Indicate by letter the functional activities of the following gastrointestinal cells. (Although more than one functional activity can be ascribed to some cells you only have to indicate one for each cell. Credit will be deducted for wrong answers.)

_____ Salivary acinar cell	A. stimulated by cholecystokinin (CCK)
_____ Parietal cell	B. secretes proteolytic enzymes
_____ Duodenal secretin cell	C. has Na^+-coupled amino acid transporter
_____ Chief cell	D. secretes α-amylase
_____ Gall bladder smooth muscle cell	E. most similar to cells of proximal tubule
_____ Pancreatic ductular cell	F. stimulated by histamine
_____ Somatostatin cell	G. secretes a HCO_3-rich juice
_____ Jejunal enterocyte	H. stimulated by low pH

4. Blood samples were taken before and shortly after a meal. How would they compare with respect to the following? Why?

a. pH

b. concentration of di- and tri-saccharides

c. concentration of bile salts

5. Given the following inhibitors and the membrane transporters they affect:

Inhibitor	Site of action
A. furosemide	$Na^+/K^+/2Cl^-$ cotransporter
B. amiloride	Na^+/H^+ exchange transporter
C. DIDS	Cl^-/HCO_3^- exchange transporter
D. phlorizin	Na^+-glucose coupled transporter
E. cytochalasin	Na^+-independent glucose transporter

Which inhibitor would be most effective in reducing (select one for each process)

_____ NaCl absorption in the thick ascending limb of the loop of Henle

_____ HCO_3^- absorption in the renal tubule

_____ Cholera toxin-stimulated intestinal secretion

_____ Pancreatic bicarbonate output

_____ HCl secretion by the parietal cell

_____ Glucose flux across the intestinal brush border (apical) membrane

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6. Compare the following parameters and relationships with the symbols >, <, =. (note: [ ] indicates concentration)

$[Na^+]$ in the plasma	_____	$[Na^+]$ in interstitial fluid
Interstitial [protein]	_____	Intracellular [protein]
Osmolarity of parotid saliva	_____	Osmolarity of plasma
$[Cl^-]$ of gall bladder bile	_____	$[Cl^-]$ of hepatic bile
Osmolarity of glomerular filtrate	_____	Osmolarity of proximal tubular fluid
Fluid absorbed by small intestine	_____	Fluid absorbed by large intestine
pH of salivary juice	_____	pH of gastric juice
Strength of gastric peristalsis in presence of gastrin	_____	Strength of gastric peristalsis in absence of gastrin
Rate of smooth muscle contraction at high intracellular $[Ca^{2+}]$	_____	Rate of smooth muscle contraction at low intracellular $[Ca^{2+}]$
$[Na^+]$ of pancreatic acinar juice	_____	$[Na^+]$ of pancreatic tubular fluid

7. The Na-coupled glucose transporter in the small intestine is functionally identical to that in the proximal renal tubule. Yet the following observations have been made: When the concentration of glucose entering the proximal tubule exceeds 300 mg/100 ml, then a finite amount of glucose will enter the distal tubule; however, when the concentration of glucose entering the small intestine is in excess of 300 mg/100 ml (or even greatly in excess), virtually no glucose will enter the large intestine. Provide a reasoning or speculation to account for the observed differences.

8. An individual is diagnosed to have the genetic defect of abetalipoproteinemia (i.e., a deficiency of intestinal β-lipoprotein synthesis). Describe two symptoms of nutritional deficiency that this patient is likely to have presented, and briefly describe the reason for the problems.

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Multiple choice; 2 points each. Circle the one best choice for each question. (You may fill in blanks to help yourself decide, but only the a-f selection will be graded.)

9. In contrast to skeletal muscle, gastrointestinal smooth muscle is characterized by action potentials of _____ (L, long; S, short) duration, the _____ (A, absence; P, presence) of well defined end plates, and the _____ (A, absence; P, presence) of troponin C.
   a. L,A,P c. L,P,A e. S,A,A
   b. L,A,A d. S,A,P f. S,P,A

10. The rate of gastric emptying into the duodenum is accelerated to a greater extent by _____ (G, gastrin; CCK, cholecystokinin) and is greatly slowed by _____ (H, high acidity; V, vagal stimulation; C, carbohydrates).
   a. G, V c. G, C e. CCK, H
   b. G, H d. CCK, V f. CCK, C

11. Bilateral section of the vagi will _____ the cephalic phase of gastric secretion, and _____ the gastric phase of gastric secretion. (N, not alter; PR, partially reduce; A, abolish)
   a. N, PR c. PR, A e. A, N
   b. N, A d. PR, N f. A, PR

12. In the pancreas, cholecystokinin (CCK) has a profound stimulatory effect on _____ cells, secretin will primarily stimulate _____ cells, and carbonic anhydrase inhibitors will depress secretion by _____ cells (A, acinar; D, ductular).
   a. A,D,D c. D,A,D e. A,A,D
   b. A,D,A d. D,A,A f. D,D,A

13. Acetylcholine raises intracellular _____ (cAMP, cyclic AMP; C, Ca) which primarily triggers _____ (E, enzyme secretion; F, fluid secretion) from the parotid gland and _____ (E, enzyme secretion; F, fluid secretion) from gastric chief cells.
   a. cAMP, E, E c. cAMP, F, E e. Ca, F, E
   b. cAMP, F, F d. Ca, F, F f. Ca, E, E

14. The enterohepatic circulation involves the recycling of _____ (BS, bile salts; BP, bile pigments) and includes active transport steps in the _____ (I, ileum; D, duodenum) and the _____ (H, hepatocyte; P, pancreatic acinar cell).
   a. BS,I,H c. BS,I,P e. BP,D,H
   b. BS,D,H d. BP,I,H f. BP,I,P

15. All of the following are secreted by duodenal mucosal cells EXCEPT
   a. secretin c. gastrin e. cholecystokinin
   b. gastric inhibitory peptide d. intrinsic factor f. enteropeptidase

16. The net filtration pressure for the formation of glomerular filtrate equals _____. (P_{gc}, glomerular capillary hydrostatic pressure; P_t, capsular hydrostatic pressure; π_{gc}, glomerular capillary colloid osmotic pressure)
   a. $P_{gc} + P_t - \pi_{gc}$ c. $P_{gc} - P_t + \pi_{gc}$ e. $(P_{gc}/P_t) \times \pi_{gc}$
   b. $P_{gc} - P_t + \pi_{gc}$ d. $P_{gc} - P_t - \pi_{gc}$ f. $(P_{gc}/P_t) - \pi_{gc}$

17. In order, from the lowest to the highest, the plasma clearances for the following substances would be _____. (N, Na^+; G, glucose; I, inulin; U, urea; P, para-amino hippuric acid)
   a. P,I,N,U,G c. N,I,P,U,G e. G,U,N,P,I
   b. P,U,I,N,G d. N,G,I,P,U f. G,N,U,I,P

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18. The volume distribution of Y was measured in a 100 kg subject. A total of 4800 mg of Y was given intravenously and after equilibration the plasma concentration of Y was found to be 200 mg/liter. Assuming no metabolism or excretion of Y, which of the following most closely approximates the volume distribution of Y:
    a. extracellular volume
    b. blood volume
    c. total body water
    d. intracellular water
    e. plasma volume

19. The measured single nephron glomerular filtration rate will be _____ (I, increased; D, decreased) by increased rate of solute delivery to the distal tubule; distal cells responding to this stimulus are called _____ (M, macula densa; Z, zona glomerulosa; L, lamina fenestrata).
    a. I,M
    b. I,Z
    c. I,L
    d. D,M
    e. D,Z
    f. D,L

20. The administration of phlorizin, which inhibits the glucose transport mechanism in the _____ (P, proximal; D, distal) renal tubules, would cause the renal clearance of glucose to approach _____ ml/minute.
    a. P,125
    b. P,625
    c. P,20
    d. D,125
    e. D,625
    f. D,20

21. In comparing three segments of the loop of Henle, the descending limb (DL), the thin ascending limb (Thn), and the thick ascending limb (Thck), we would expect the highest levels of active Na^+ transport to occur in the _____ , and the lowest passive permeability to Na^+ in the _____.
    a. DL, Thn
    b. DL, Thck
    c. Thn, DL
    d. Thn, Thck
    e. Thck, DL
    f. Thck, Thn

22. Given the principles of an osmotic multiplier driven by an ion pump in the loop of Henle, we would expect to find that the ion gradient in the loop is _____ by increased fluid flow rate through the loop, and is _____ by extending the length of the loop. (I, increased; D, decreased; N, not affected)
    a. I,N
    b. D,N
    c. D,I
    d. I,I
    e. N,I
    f. N,D

23. The more significant renal effect of antidiuretic hormone involves altered _____ (A, active transport, P, permeability) of epithelial cells of _____ (T, proximal tubule; C, collecting duct; L, loop of Henle).
    a. A,T
    b. A,C
    c. A,L
    d. P,T
    e. P,C
    f. P,L

24. Aldosterone is thought to exert its target renal effects by combining with_____ (M, cell membrane; I, intracellular) receptors to activate _____ (P, protein synthesis; AMP, the cyclic AMP mechanism; W, water channels).
    a. M,P
    b. M,AMP
    c. I,P
    d. I, AMP
    e. M,W
    f. I,W

25. A decreased blood volume will tend to lead to a _____ glomerular filtration rate and a _____ urinary output due to a _____ glomerular capillary pressure and _____ rate of aldosterone secretion. (D, decreased; I, increased)
    a. D,D,D,D
    b. D,I,I,I
    c. D,D,I,I
    d. D,D,D,I
    e. I,D,D,I
    f. I,I,D,D