MCB 136 SPRING 1999 Name_____

FINAL EXAM (some useful formulas are on last page)

Multiple Choice (circle the most appropriate answer) 2 pts ea

1. Ca^{2+} is required for all of the following EXCEPT
   a. release of norepinephrine from sympathetic nerve terminals
   b. conduction of action potential along the T-tubules of skeletal muscle
   c. phosphorylation of myosin light chain
   d. binding to troponin and movement of tropomyosin in skeletal muscle
   e. release of maximal amounts of Ca^{2+} from the sarcoplasmic reticulum of cardiac muscle

2. During stimulation of adenylate cyclase and production of cAMP in liver cells,
   a. regulatory subunit of PKA dissociates from the catalytic subunit, which phosphorylates multple cellular proteins.
   b. regulatory subunit of PKA is phosphorylated on serines and threonines
   c. phosphodiesterase produces cAMP
   d. cell [Ca^{2+}] decreases by being pumped into mitochondria
   e. cell [Ca^{2+}] increases because phospholamban is phosphorylated

3. Ca-ATPase, H/K-ATPase and Na/K-ATPase
   a. are all present in smooth endoplasmic reticulum of smooth muscle
   b. are plasma membrane pumps
   c. require ATP in the cytosol and phosphorylation of critical extracellular sites for operation
   d. have multiple transmembrane domains
   e. b and d are true, but not a and c

4. Which of the following would lead to systemic edema?
   a. increased venous pressure due to persistent standing in one place
   b. increased arterial pressure
   c. plasma protein deficiency (e.g., starvation)
   d. a, b and c
   e. none of the above

5. Which of the following events causes the myosin head to detach from the actin filament during skeletal muscle contraction?
   a. ATP hydrolysis
   b. when the myosin head moves, it physically separates from the actin
   c. binding of ATP
   d. the process is time-dependent
   e. phosphorylation of troponin

6. Which of the following characteristics or components is NOT shared by skeletal and cardiac muscle?
   a. Thick and thin filaments arranged in sarcomeres
   b. Troponin is a regulator
   c. Tropomyosin prevents interaction between actin and mysoin
   d. High degree of electrical coupling between cells
   e. Elevation of intracellular Ca^{2+} for excitation-contraction coupling

7. A drug blocks Ca^{2+} channels in the plasma membrane of cardiac muscle. Which of the following effects would be expected?
   a. Block the occurrence of action potentials
   b. Decrease the rate of rise of the upstroke of the action potential in ventricular musculature
   c. Reduce phase 2 of the rapid cardiac action potential
   d. Reduce phase 3 of the rapid cardiac action potential
   e. a, b and c

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8. Arterioles offer the highest resistance to flow compared to other blood vessels because they have
   a. thicker muscular walls
   b. the smallest internal diameters
   c. the smallest total cross sectional area
   d. all of the above
   e. none of the above

9. Which of the following will lead to a decrease in work of the heart?
   a. increased end diastolic length of ventricles
   b. increased peripheral resistance
   c. decreased ventricular filling
   d. constriction of the veins
   e. sympathetic stimulation

10. In the heart
   a. left atrial wall is three times thicker than the right atrial wall.
   b. systolic excitation begins in the atrio-ventricular node
   c. right atrial and ventricular musculature contract first followed by left atrial and ventricular musculature
   d. a and b are correct
   e. none of the above

11. Which of the following lung volumes or capacities CANNOT be measured by spirometry?
   a. Tidal volume
   b. Inspiratory reserve volume
   c. Expiratory reserve volume
   d. Inspiratory capacity
   e. Functional residual capacity

12. Which of the following is true during inspiration?
   a. Intrapleural pressure is positive
   b. Intrapleural pressure is more negative than it is during expiration
   c. The volume in the lungs is less than functional residual capacity
   d. Alveolar pressure equals atmospheric pressure
   e. Alveolar pressure is higher than atmospheric pressure

13. The primary defect in a patient is a thickened membrane between alveolar gas and pulmonary capillary blood. She is at rest and breathing air in the steady state. Which of the combinations of gas pressures is most consistent with that condition? (PA is alveolar gas; Pa is arterial gas)

	$PACO_2$ (mm Hg)	PAO_2 (mm Hg)	$PaCO_2$ (mm Hg)	PaO_2 (mm Hg)
a.	30	114	32	50
b.	40	104	38	45
c.	40	104	40	94
d.	40	104	60	104
e.	40	104	30	84

14. Compared with the systemic circulation, the pulmonary circulation has a significantly
   a. Higher flow
   b. Lower resistance
   c. Higher arterial pressure
   d. Higher capillary pressure
   e. Higher cardiac output

Name_____

15. Chemical combination of O_2 with Hb tends to
    a. decrease the affinity of Hb for protons
    b. decrease the affinity of any other O_2-binding sites on the same Hb molecule for O_2
    c. make the blood bluer in color
    d. make the blood more alkaline
    e. form a stronger bond than that formed by Hb and CO

16. Residing at high altitude causes all of the following EXCEPT
    a. Hyperventilation
    b. Hypoxemia
    c. Increased concentrations of 2,3-bis-phosphoglyceric acid (2,3-BPG or 2,3-DPG)
    d. Shift to the left of the hemoglobin-O_2 dissociation curve
    e. Pulmonary vasoconstriction

17. CO_2 is carried in the blood mostly
    a. as H_2CO_3 in red blood cells
    b. as dissolved CO_2
    c. as carbamino Hb
    d. as HCO_3 in the plasma
    e. as carbamino compounds with plasma proteins

18. In the transport of CO_2 from the tissues to the lungs, all of the following occur in venous blood EXCEPT
    a. Conversion of CO_2 and H_2O to H^+ and HCO_3^- in the red blood cells
    b. Buffering of H^+ by deoxyhemoglobin
    c. Shift of HCO_3^- out of red blood cells into plasma in exchange for Cl^-
    d. Binding of CO_2 to hemoglobin
    e. Alkalinization of red blood cells

19. The medullary chemoreceptors
    a. respond quickly to changes in arterial acidity at constant $PaCO_2$
    b. are primarily sensitive to changes in brain PO_2
    c. are inhibited by increases in brain extracellular fluid acidity
    d. can be physiologically stimulated quickly only through changes in $PaCO_2$
    e. are probably located deep within the medulla but have not been anatomically located as yet

20. Hypoxia influences respiration quickly mainly through its stimulatory effect
    a. directly on the respiratory centers
    b. directly on the lungs
    c. on the medullary chemoreceptors
    d. on the carotid and aortic chemoreceptors
    e. directly on the Hb-O_2 dissociation curve

21. Histamine receptors in the stomach are pharmacologically _____ (D, distinct from; S, the same as) histamine receptors in the lungs, and excessive gastric acid secretion is prevented by the hormone _____ (G, gastrin; Som, somatostatin; P, pepsin).

a. D, G	c. D, P	e. S, Som
b. D, Som	d. S, G	f. S, P

22. Bile acids are derived from (Gl, glucuronic acid; Ch, cholesterol; He, hemoglobin) and are secreted into the bile by the _____ (GB, gall bladder; L, liver).

a. Gl, GB	c. Ch, GB	e. He, GB
b. Gl, L	d. Ch, L	f. He, L

Name_____

23. With reference to gastric function:
    a. the average meal has moved on from the stomach after half an hour.
    b. contractility is augmented by sympathetic stimulation.
    c. when the quantity of ingested material increases, the intragastric pressure increases.
    d the longitudinal muscle coat has a basic electrical rhythm.
    e enterogastrone secretion inhibits the production of gastric acid.

24. All the following are transported in intestinal epithelial cells by a Na^+-dependent cotransport process EXCEPT
    a. Glucose
    b. Galactose
    c. Fructose
    d. Amino acids

25. Which of the following molecules is NOT absorbed by a specific carrier in intestinal cells
    a. Bile acids
    b. Sucrose
    c. Alanine
    d. Dipeptides
    e. Tripeptides

26. Which of the following is characteristic of saliva?
    a. Hypotonic relative to plasma
    b. Lower HCO_3^- concentration than plasma
    c. Presence of proteases
    d. Secretion rate increased by vagotomy
    e. Modification by the salivary ductal cells which reabsorb K^+ and HCO_3^-

27. Slow waves in small intestinal smooth muscle cells are
    a. Action potentials
    b. Phasic contractions
    c. Tonic contractions
    d. Oscillating resting membrane potentials

28. All of the following pairs are correct EXCEPT
    a. Myenteric plexus regulates motility of GI system
    b. Submucosal plexus regulates secretion of GI system
    c. Parasympathetic nervous system is stimulatory to GI system
    d. Sympathetic nervous system is inhibitory to salivary glands

29. Inhibition of carbonic anhydrase in the gastric parietal cell would
    a. Increase HCl secretion
    b. Decrease the antiport of HCO_3^- and Cl^-
    c. Inhibit the Na^+/K^+ pump
    d. Increase amount of Cl^- moving into the cell
    e. Increase production of H^+

30. Which of the following will NOT be found in micelles in the small intestine?
    a. vitamin C
    b. lecithin
    c. lipase
    d. bile salts
    e. a and c

Name_____

31. If the pancreatic duct cell lumen contains 125 mM HCO_3 and 20 mM Cl, while the cell contains 25 mM HCO_3, what is the maximum concentration of Cl that can be present in the cell to allow the continued secretion of HCO_3 by the cells?
    a. 145 mM
    b. 105 mM
    c. 25 mM
    d. 20 mM
    e. 4 mM

32. Which of the following will tend to increase fluid in the small intestine?
    a. Presence of non-reabsorbable solutes in the lumen
    b. Genetic lack of amylase
    c. cholera toxin
    d. aldosterone
    e. a, b and c

33. Use the values below to determine the magnitude (value) of glomerular capillary oncotic pressure that would just prevent filtration
    Glomerular capillary hydrostatic pressure = 47 mmHg
    Bowman's space hydrostatic pressure = 10 mmHg
    Bowman's space oncotic pressure = 0 mmHg
    a. 57 mmHg
    b. 47 mmHg
    c. 37 mmHg
    d. 10 mmHg
    e. 0 mmHg

34. Which of the following would cause an increase in both GFR and RPF?
    a. Dilation of the afferent arteriole
    b. Increase in proteins in the blood
    c. A stone in the urethra
    d. Dilation of the efferent arteriole
    e. Constriction of the efferent arteriole

35. Which is the site of greatest Na^+ reabsorption?
    a. Glomerular capillaries
    b. Proximal tubule
    c. Loop of Henle
    d. Distal tubule
    e. Collecting Duct

36. With respect to plasma clearance and renal function all of the following are true EXCEPT:
    a. the clearance of a substance can exceed the subject's glomerular filtration rate (GFR) only if the substance is secreted into the tubular fluid
    b. a substance which is filtered at the glomerulus, but is neither secreted nor reabsorbed in the tubules will have a clearance value equal to the volume of plasma that flows through the renal circulation in one mmute.
    c. the renal clearance for glucose in a normal subject is usually less than 1 ml/min.
    d. if the plasma glucose concentration rises to three times normal (as a result, for instance of glucose injected intravenously), the glucose clearance will rise.
    e. if the plasma bicarbonate concentration doubles the renal clearance of bicarbonate will rise.

Name_____

37. In the kidney about _____ (90%; 50%, 20%) of the plasma flowing to the glomerular capillaries is filtered into the tubules, and the counter current mechanism results in the tubular fluid, when it leaves the loop of Henle, having a _____ (H, higher; L, lower) osmolarity than plasma.
a. 90%, H c. 50%, H e. 20%, H
b. 90%, L d. 50%, L f. 20%, L

38. The renal tubular absorption of bicarbonate is dependent upon tubular H+ _____ (A, absorption; S, secretion) and will be _____ (I, increased; D, decreased; 0, not changed) by increasing plasma PCO_2.
a. A, I c. A, 0 e. S, D
b. A, D d. S, I f. S, 0

39. A patient has complete pyloric obstruction for a day or two and has been vomiting all his gastric secretions including HCl and pepsin. As a result of this, his arterial plasma would probably show
a. abnormally high PCO_2 and low or normal pH
b. abnormally low PCO_2 and high pH
c. normal or high PCO_2 and high pH
d. abnormally high PCO_2 and low HCO_3 concentration

40. A patient who has been suffering from diarrhea is found to have an arterial pH of 7.25 and an arterial PCO_2 of 33 mm Hg. One would classify his condition as a primary
a. respiratory acidosis
b. respiratory alkalosis
c. metabolic acidosis
d. metabolic alkalosis
e. normal acid-base status

True-False (indicate by T or F)

1. A membrane that is permeable to water and Cl^- but not to Na^+ or glucose has solution #1 (2 M NaCl + 0.5 M glucose) on one side and solution #2 (1 M NaCl + 1 M glucose) on the other. Are the following statements true or false?

_____ Water will flow from side #1 to side #2 by osmosis.

_____ The membrane voltage will be negative on side #2.

_____ After 1 hr has passed, [Cl] on side #1 will be 1.5 M.

_____ If the membrane contained a glucose transporter like that present in the basolateral membrane of intestinal cells, glucose would move from side #1 to side #2.

2. With respect to intestinal absorption

_____ The large intestine absorbs more salt and water than the small intestine due to its larger absorbing surface area than the small intestine.

_____ Glucose, but not galactose, is absorbed across the microvillar membranes of small intestinal cells by Na-dependent secondary active transport.

_____ Water is absorbed from the intestinal tract because the osmolarity of the luminal fluid is half that of the blood, so water is rapidly transported across the epithelial cell surface by osmosis.

_____ Vagotomy would reduce Na^+ and Cl^- absorption by the small intestine by more than a actor of two.

_____ During NaCl secretion by the intestine, Cl^- is secreted across the cells while Na^+ moves across the tight junctions.

Name_____

3. Concerning gastro-intestinal secretions:
_____ gastro-intestinal hormones are steroids.

_____ secretin results in a flow of pancreatic secretion with a high concentration of precursor enzymes.
_____ the maximal flow of pancreatic juice in response to cholecystokinin and secretin given together is greater than the maximum produced by either hormone alone.

_____ the gall bladder epithelium secretes more than one liter of juice per day.

4. Concerning pancreatic secretion:
_____ the pancreatic juice secreted in response to vagal stimulation is rich in enzymes.
_____ atropine blocks the secretogogue effects of vagal stimulation.
_____ atropine blocks the secretogogue effects of secretin.
_____ secretin stimulates ductal cells via an elevation of cAMP.
_____ secretin can produce a greater flow of pancreatic juice than the maximal flow in response to vagal stimulation.

5. If an excessive amount of water is drunk:
_____ only a small fraction of it is absorbed from the gastro-intestinal tract.
_____ the osmolality of interstitial fluid decreases.
_____ receptors in the right atrium may be stimulated.
_____ receptors in the carotid body may be stimulated.
_____ an increase in glomerular filtration rate is the main means of disposing of the extra water.

6. With reference to water in the body:
_____ the total accounts for approximately 60% of body weight in a lean adult man.
_____ approximately two-thirds of the total volume is intracellular.
_____ the total volume may be estimated using radioactively labelled plasma albumin.
_____ there is inevitably a continuous loss of water via the lungs.

7. At the renal glomeruli, in normal physiological conditions
_____ blood in the efferent arterioles is more viscous than blood in the afferent arterioles.
_____ the hydrostatic pressure in the capillaries varies as the arterial blood pressure varies.
_____ the hydrostatic pressure in the capillaries is normally much higher than in capillaries elsewhere.
_____ the glucose concentration in the efferent arteriole is virtually the same as that in the afferent arteriole.

8. With reference to the control of extracellular fluid volume and osmolarity:
_____ aldosterone acts in the kidney by increasing the permeability of the distal tubules to water.
_____ renin is secreted by cells situated close to the afferent glomerular arterioles.
_____ antidiuretic hormone is released in response to decreased plasma osmolarity.
_____ an increase in right atrial pressure leads to an increase in atrial natriuretic peptide secretion.
_____ an excessive secretion of aldosterone results in increased loss of sodium in the urine.

Name_____

9. With regard to the countercurrent mechanism of concentration of urine:
_____ the urine entering the descending limb of the loop of Henle is approximately isotonic with arterial plasma.
_____ the descending limb of the loop of Henle is freely permeable to electrolytes.
_____ tubular fluid in the thin segment of the ascending limb is approximately isotonic with arterial plasma.
_____ the thick portion of the ascending limb pumps electrolytes into the tubular fluid from the extracellular fluid.
_____ the concentration of urea in the extracellular fluid of the renal medulla is greater than that of the renal cortex.

10. Concerning acid-base balance and body fluids:
_____ the amount of undissociated carbonic acid in an aqueous solution is inversely proportional to the amount of dissolved carbon dioxide.
_____ the amount of undissociated carbonic acid is approximately equal to the amount of dissolved carbon dioxide at a PCO_2 of 40 mmHg.
_____ the renal compensation for a respiratory acidosis includes an increase in amount of bicarbonate added to the blood by the renal tubules.
_____ as a chemical buffer in a closed system, the bicarbonate buffer system is more effficient at a pH of 7.1 than at a pH of 7.4.

Matching and Comparisons

A. Match the letters of the functions and descriptions on the right to the structures on the left. Each letter may be used one, or multiple times, or not at all. 1 pt ea

_____ tight junctions
_____ adhering junctions
_____ desmosomes
_____ gap junctions

a. attach (directly or indirectly) to cytoskeleton
b. attach to the extracellular matrix
c. attach to intermediate filaments
d. prevent free diffusion of macromolecules from apical to basolateral side
e. found in both epithelia and cardiac muscle
f. contain occludin and claudin
g. contain connexin
h. require Ca for function

B. Match the letters of the second messengers and/or functions on the right to the numbered hormones, neurotransmitters and other extracellular mediators on the left. Each number may be matched to none, one or several correct letters. Each letter may be used one or multiple times or not at all. 1 pt ea.

_____ nitric oxide
_____ epinephrine
_____ lactic acid
_____ acetylcholine

a. causes increases in cytosolic [IP_3] in pancreatic acinar cells
b. causes increases in phosphorylation of phospholamban in cardiac muscle cells
c. causes relaxation of arteriolar smooth muscle
d. produced in endothelial cells of arterioles
e. causes depolarization of postsynaptic cell bodies in sympathetic ganglia
f. binds to adrenergic receptor
g. is a gas

Name_____

C. Describe the changes (increase, decrease or no change) in the following physiological parameters that would occur during the response to hemorrhage: 1 pt each

a. Frequency of afferent action potentials from the baroreceptors to the central cardiovascular center

b. glomerular filtration rate

c. [ADH] in the plasma

d. breathing rate

e. frequency of efferent action potentials from the cardiovascular center to venous smooth muscle

Short Answer and Calculations

1. Explain why K^+ channels in the basolateral membranes of intestinal cells are important for the absorption of Na^+ and glucose across the apical membranes of small intestine and renal proximal tubule cells? 4 pts

2. Diagram a small intestinal villus showing the positions of the sucrase-maltase, tight junctions, capillaries, and lymph vessels. 4 pts

Name_____

3. Discuss how an H^+ pump or exchanger, Cl^- channels and anion exchange can give rise to acid secretion by the parietal cell of the stomach and of HCO_3^- secretion by the pancreatic duct cell. 4 pts

4. Discuss the effects of hemorrhage and exercise on peripheral resistance and arterial blood pressure. State the direction of changes that occur and the physiological mechanisms that control the changes. 4 pts

5. The following measurements were made on a subject:

plasma glucose concentration	18.0 mmol/l
urinary excretion of glucose	0.18 mmol/min
glomerular filtration rate	125 ml/min
urine flow	2 ml/min

Calculate (3 pts each):

a. the concentration of glucose in the urine.

b. the renal clearance of glucose

c. the Tm (transport maximum) for glucose

d. Can we conclude that diuresis was occurring? Why?

Name_____

6. Below is a list of arterial blood acid-base measurements:

	pH	PCO_2 (mm Hg)	HCO_3 (mEq/liter)	PO_2 (mm Hg)
Normal	7.40	40	24	100
a.	7.50	42	32	99
b.	7.26	60	26	50
c.	7.35	45	24	90
d.	7.21	40	15	100
e.	7.46	35	24	105

7. Indicate (by letter) which of the blood samples was taken from the following individuals (2 pts each):

_____ a nervous candidate immediately before the final exam

_____ a patient arriving at the hospital in coma from an overdose of respiratory depressant (e.g., barbiturates)

_____ an individual addicted to TUMS (Antacid tablets)

_____ a patient in diabetic coma with high blood levels of acetoacetic acid and β-hydroxybutyric acid

_____ a normal person after 60 seconds of breath holding

9. We inject 4 mg of inulin into a 70 kg subject. After a suitable equilibration time the bladder was voided and total amount of inulin in the voided urine was 0.4 mg of inulin. The plasma concentration of inulin was measured to be 0.22 mg/1000 ml. We then begin a 10 min urinary collection period and clearance measurement. During that time the urinary flow rate was 1 ml/min and concentration of inulin was 25 mg/1000 ml.

a. For this subject, calculate the volume of the extracellular fluid.

b. Calculate the glomerular filtration rate for the subject.

Some Useful Formulas:

$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$

$Flow = \Delta P/R$

$Q = k_f [(P_C + \pi_i) - (P_i + \pi_C)]$

$C_X = [U]_X V / [P]_X$

$T_X = F_X - E_X = (GFR \times P_X) - (U_X \times V)$

$V_D = V_T \times [(PA_{CO_2} - PE_{CO_2})/PA_{CO_2}]$

$Q = \Delta P \times \pi r^4/8\eta l$

$C = dV/dP$

$V_A = (V_T - V_D) \times f$

$Min\ vol = V_T \times f$

$V_{gas} = dm/dt = D'A\ (P_1 - P_2) / T$

$pH = pK + \log[HCO_3^-]/[H_2CO_3]$

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Useful formulae

Flow = Q = $\Delta P \times \pi r^4/8\eta l$, where r = tube radius and l = length in cm

Cardiac output = C.O. (ml/min) = H.R. (beats/min) X S.V. (ml/beat)

C.O. = arterial blood pressure/peripheral resistance

C.O. = O_2 utilization/$(AO_2 - \bar{V}O_2)$

If $Q_1 = Q_2$ (flow in two regions are equal), then
$v_1A_1 = v_2A_2$ and $v_1/v_2 = A_2/A_1$
where v is in cm/sec and A is in cm^2.

vascular compliance = Δvolume/ Δpressure

Law of Laplace
$\Delta P = T (1/r_1 + 1/r_2)$, where r_1 and r_2 are the principal radii of curvature.
For a sperical bubble (soap bubble), $r_1 = r_2$, and $P = T \times 2/r$
For a cylinder, one axis has an infinite radius, i.e., $1/r_2 = 0$, therefore $\Delta P = T/r$
Note: pressure conversion is 1 mm Hg = 1,330 dynes/cm^2

Fluid flow across capillary walls
Q_f = Jv = flow = k [(forces out of cap.) - (forces into cap.)]
$Q_f = k [(P_c + \pi_i) - (P_i + \pi_c)]$

Flow = $\Delta P/R$

Flow = Q = $\Delta P \times \pi r^4/8\eta l$

Q (across cap.) = $k_f [(P_c + \pi_i) - (P_i + \pi_c)]$

Min vol = $\dot{V} = V_T \times$ freq

$\dot{V}_A = (V_T - V_D) \times$ freq

$V_D = V_T \times [(PA_{CO_2} - PE_{CO_2})/PA_{CO_2}]$

C = dV/dP

R_{aw} = $(P_{alv} - P_{atm})$/Flow

$P_{gas} = P_{tot} \times f_{gas}$

$\dot{V}_{gas} = dm/dt = D'A (P_1 - P_2) / T$

$D_L = \dot{V}_{CO}/PA_{CO}$

PA_{CO_2} = factor x $\dot{V}_{CO}/\dot{V}_A$

$H.Hb + O_2 \leftrightarrow HbO_2 + H^+$

$Hb.DPG + O_2 \leftrightarrow HbO_2 + DPG$

$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$

$pH = pK + \log[HCO_3^-]/[H_2CO_3]$