

First Examination (a)  
Friday, February 14, 2006  
10:20-11:40 A.M.

408 \_\_\_\_\_ 512 \_\_\_\_\_

Row \_\_\_\_\_ Seat \_\_\_\_\_

Please place your name on each page.

PART I - 50 points (Place the correct choice here; each question has only one correct answer):

- |                 |                  |                  |
|-----------------|------------------|------------------|
| 1. <u>  a  </u> | 10. <u>  d  </u> | 19. <u>  d  </u> |
| 2. <u>  c  </u> | 11. <u>  d  </u> | 20. <u>  e  </u> |
| 3. <u>  c  </u> | 12. <u>  c  </u> | 21. <u>  a  </u> |
| 4. <u>  e  </u> | 13. <u>  c  </u> | 22. <u>  c  </u> |
| 5. <u>  a  </u> | 14. <u>  b  </u> | 23. <u>  d  </u> |
| 6. <u>  c  </u> | 15. <u>  d  </u> | 24. <u>  d  </u> |
| 7. <u>  b  </u> | 16. <u>  e  </u> | 25. <u>  a  </u> |
| 8. <u>  b  </u> | 17. <u>  d  </u> |                  |
| 9. <u>  c  </u> | 18. <u>  c  </u> |                  |

Total \_\_\_\_\_

PART II - 50 points

II-1. \_\_\_\_\_

II-2. \_\_\_\_\_

II-3. \_\_\_\_\_

II-4. \_\_\_\_\_

II-5. \_\_\_\_\_

Total \_\_\_\_\_

GRADE \_\_\_\_\_

## First examination

1. The specificity of the potassium channel for  $K^+$  over other cations arises mainly from:
  - (a) Specific interactions with the pore selectivity filter;
  - (b) Repulsive forces generated by the pore selectivity filter;
  - (c) Hydrophobic interactions with bilayer lipid;
  - (d) The presence of cholesterol esters in the channel;
  - (e) A molecule that binds to the channel permitting the selective passage of potassium ions.
2. Which of the following statements about the mechanism of water movement by aquaporins is correct?
  - (a) Repulsive forces generated by the pore selectivity filter move water out of the cell;
  - (b) It is responsible for the selective water permeability of lens cells;
  - (c) A special  $H_2O$  orientation forces the hydrogens to face hydrophobic residues, resulting in a break of proton transit, while permitting  $H_2O$  flow to proceed;
  - (d) It accounts for the single file passage of glycerol molecules through the aquaporin channel;
  - (e) None of the above.
3. Which of the following statements about the mechanism of transport by the *E. coli* lactose permease is incorrect?
  - (a) Substrate permeation arises from a cycle of conformational changes in which wide aqueous cavities alternate in exposure to the two sides of the membrane;
  - (b) The flow of electrons through the respiratory chain generates a  $H^+$  gradient that drives lactose transport;
  - (c) It is energized by a lactose/ $H^+$  antiport mechanism;
  - (d) Large polypeptide backbone rearrangements are involved in the alternate exposure of the wide aqueous cavities to the two sides of the membrane;
  - (e) The lactose- and proton-binding sites are located in separate domains.
4. Which of the following statements about gap junctions is not true?
  - (a) They mediate the passive flow of small molecules and ions to provide metabolic and electrical coupling;
  - (b) Their pore function is mediated by  $Ca^{2+}$ -dependent closure;
  - (c) They mediate intracellular transfer of important second messengers like cAMP;
  - (d) They consist of two hexameric arrays of connexin molecules;
  - (e) They mediate the mechanism of  $Ca^{2+}$  transport into the sarcoplasmic reticulum during skeletal muscle relaxation.
5. In the light reactions of photosynthesis:
  - (a) The excitation of a chlorophyll *a* molecule in the PSII reaction center ultimately results in the passage of an electron to the cytochrome *b<sub>6</sub>f* complex;
  - (b) Exciton transfer to neighboring chlorophyll molecules ultimately results in a charge separation in the LHCII complex;
  - (c) Passage of excited electrons to the electron transfer chain involves the transfer of excitations from chlorophyll *b* to carotenoids;
  - (d) Replacement of the electron in the oxidized reaction center chlorophyll requires the accumulation of reducing equivalents in LHCI;
  - (e) None of the above is correct.
6. In the production an  $O_2$  molecule by the photolysis of water, catalyzed by the oxygen-evolving complex, how many photons of light at a wavelength of 680 nm are required?
  - (a) 1
  - (b) 2
  - (c) 4
  - (d) 6
  - (e) 8

## First examination

7. Which of the complexes of the thylakoid membrane generates the protons that accumulate in the thylakoid lumen and drive photophosphorylation?
- The LHCII and LHCI complexes;
  - The cytochrome *b<sub>6</sub>f* and oxygen evolving complexes;
  - The PSI and CF<sub>1</sub>F<sub>0</sub> complexes;
  - The cytochrome *bc<sub>1</sub>* and cytochrome *aa<sub>3</sub>* complexes;
  - Ferredoxin-NADPH reductase and Complex I.
8. Cyclic electron flow in chloroplasts produces:
- ATP and O<sub>2</sub>, but not NADPH;
  - ATP, but not NADPH or O<sub>2</sub>;
  - NADPH and ATP, but not O<sub>2</sub>;
  - NADPH, but not ATP or O<sub>2</sub>;
  - O<sub>2</sub>, but not NADPH or ATP.
9. Which of the following statements about the oxygen-evolving complex (OEC) is incorrect?
- One e<sup>-</sup> is removed photochemically at each light flash, moving the OEC through four oxidation states
  - Electrons released by the OEC are transferred to the redox-active Tyr<sub>Z</sub> of the D1 reaction center protein, the immediate reductant of P680<sup>+</sup>
  - The OEC associates with PSI during oxygen evolution;
  - O<sub>2</sub> evolution peaks after four photons of light at a wavelength of 680 nm are transferred to PSII;
  - O<sub>2</sub> evolution requires accumulation of four oxidizing equivalents in PSII;
10. Which of the following enzymes does not participate in fatty acid oxidation in the mitochondrial matrix?
- L-β-hydroxyacyl-CoA dehydrogenase;
  - Acyl-CoA dehydrogenase;
  - Thiolase;
  - Acyl-CoA synthetase;
  - Enoyl-CoA hydratase.
11. The role of hormone-sensitive triacylglycerol lipase is to:
- Hydrolyze membrane phospholipids in hormone-producing cells;
  - Facilitate the interaction between colipase and mixed fatty acid-bile salt micelles;
  - Synthesize hepatic triacylglycerol;
  - Hydrolyze triacylglycerols in adipose tissue;
  - Alternate between a closed-active and open-inactive conformation upon activation by insulin.
12. Transport of fatty acids from the cytoplasm to the mitochondrial matrix requires:
- ADP, acyl carrier protein and malate dehydrogenase
  - NADP, FAD and citrate lyase;
  - ATP, carnitine and coenzyme A;
  - The tricarboxylate carrier protein, NADP and CO<sub>2</sub>;
  - Glucose-6-phosphate and acetyl-CoA
13. The hormone leptin regulates body weight by:
- Sending signals to adipose tissue that inhibit cholesterol biosynthesis;
  - Stimulating neuropeptide Y release and suppressing melanocyte-stimulating hormone (MSH) in the hypothalamus;
  - Suppressing neuropeptide Y and stimulating MSH to interact with its receptor in the hypothalamus;
  - Blocking transport across the blood-brain barrier;
  - Stimulating fatty acid accumulation in skeletal muscle.

## First examination

14. Which of the following is not true of the reaction producing malonyl-CoA during fatty acid biosynthesis?
- It is stimulated by citrate;
  - It requires acyl carrier protein (ACP);
  - It requires CO<sub>2</sub> (or bicarbonate);
  - One ATP is converted to ADP + P<sub>i</sub> for each malonyl-CoA synthesized;
  - Biotin acts as the cofactor.
15. Which one of the following receptor-mediated hormonal signals that regulate fatty acid metabolism does not require direct G-protein interaction?
- Melanocyte-stimulating hormonal activities;
  - Glucagon-stimulated triacylglycerol lipase activation;
  - Glucagon-stimulated acyl-CoA carboxylase inhibition;
  - Insulin-stimulated cAMP phosphodiesterase activity;
  - Epinephrine-stimulated triacylglycerol lipase activation.
16. All of the following represent strategies used in the biosynthesis of membrane phospholipids except?
- Activation of the headgroup by attachment of CDP which is displaced as CMP by the free hydroxyl group of diacylglycerol;
  - Activation of phosphatidic acid by attachment of CDP which is displaced as CMP by a headgroup free hydroxyl group;
  - Headgroup phosphorylation;
  - Exchange of an ethanolamine headgroup for a serine headgroup;
  - Decarboxylation of phosphatidylethanolamine to form phosphatidylserine.
17. The sorting pathway for proteins processed in the endoplasmic reticulum involves:
- Binding of the signal recognition particle (SRP) to the signal peptide which accelerates synthesis of the nascent polypeptide chain;
  - Cleavage of the signal sequence by a cytoplasmic signal peptidase;
  - Location of the signal peptide at the C-terminus for recognition by the SRP;
  - Binding of the SRP to the signal sequence of the nascent polypeptide chain soon after it emerges from the ribosome to temporarily arrest translation;
  - Addition of the signal sequence to the polypeptide in a posttranslational modification reaction.
18. The pathway of mitochondrial import of proteins synthesized on cytosolic ribosomes includes the following steps:
- The chaperone matrix Hsc70, together with its ATPase activity, acts as an import motor for the nascent polypeptide.
  - The chaperone cytosolic Hsc70 binds to the nascent polypeptide.
  - Cleavage of the targeting sequence.
  - Binding to an import receptor.
  - Transfer to the translocase of inner membrane (Tim23/17)
  - Transfer to the general import pore (translocase of outer membrane, Tom40)
- What is the correct sequence in which they occur?
- 2, 6, 4, 5, 3, 1
  - 1, 6, 4, 5, 3, 2
  - 2, 4, 6, 5, 1, 3
  - 1, 2, 3, 4, 5, 6
  - None of these sequences is correct.

## First examination

19. Which of the following is not associated with lysosomal proteolysis?
- (a) Fusion of primary lysosomes with autophagic vesicles engulfing organelles to generate secondary lysosomes;
  - (b) Fusion of primary lysosomes with phagocytic vacuoles engulfing external material to generate secondary lysosomes;
  - (c) Rupture of lysosomes within the cytoplasm, resulting in autolysis;
  - (d) The recycling of ubiquitin for further proteosomal proteolysis;
  - (e) LDL receptor-mediated endocytosis of the LDL receptor, in which endosomes containing free LDL fuse with primary lysosomes to degrade apoprotein B100.
20. All of the following are factors that are involved in ubiquitin-mediated proteolysis except:
- (a) The ubiquitin activating enzyme;
  - (b) Specific ATP-dependent proteases located in the inner surface of the  $\beta$ -subunits of the 20S proteasomal core;
  - (c) Multi-ubiquitin chain promoting factors ( $E_4$ );
  - (d) A proteasomal proofreading isopeptidase which cleaves the isopeptide bonds of inappropriately ubiquitinated proteins;
  - (e) The cathepsins, which serve as acid proteases.
21. Protein kinase A is a (an):
- (a) cAMP-activated soluble enzyme consisting of two catalytic subunits and two regulatory subunits that dissociate upon binding cAMP to the regulatory subunits;
  - (b)  $Ca^{2+}$ -activated membrane bound enzyme containing domains that interacts with phospholipids headgroups, diacylglycerol and a pseudosubstrate domain;
  - (c) Allosteric enzyme that transmits extracellular signals to the cell interior by oligomeric association, permitting interaction of the cytoplasmic domain that results in activation;
  - (d) Enzyme that releases the second messengers inositol-1,4,5-triphosphate and diacylglycerol from phosphatidylinositol-4,5-bisphosphate;
  - (e) Pseudosubstrate for protein kinase C.
22. Calmodulin serves as a:
- (a) cAMP-dependent protein kinase;
  - (b) Calcium-dependent inhibitor of target enzymes;
  - (c) Regulatory subunit of calcium-dependent enzymes;
  - (d) Plasma membrane calcium channel;
  - (e) Calciosome membrane calcium channel.
23. The following are second messengers arising from G-protein-coupled signal transduction pathways, except:
- (a) cAMP;
  - (b) Diacylglycerol;
  - (c)  $Ca^{2+}$ ;
  - (d) Phosphatidylserine
  - (e) Inositol-1,4,5-triphosphate.
24. All of the following are mechanisms for removal or termination of the effects of second messengers in signal-transduction pathways, except
- (a) Dephosphorylation of phosphorylated target proteins;
  - (b) cAMP degradation;
  - (c)  $Ca^{2+}$  re-sequestration;
  - (d) Ubiquitin-mediated receptor degradation in endoplasmic reticulum;
  - (e) G protein self-inactivation (hydrolysis of bound GTP to GDP and  $P_i$ ).
25. The routes for transitory increases in cytoplasmic  $Ca^{2+}$  concentrations include:
- (a) Inositol-1,4,5-triphosphate-stimulated release from calciosomes and endoplasmic reticulum;
  - (b) cAMP-stimulated release from the endoplasmic reticulum;
  - (c) cAMP-stimulated release from calciosomes;
  - (d) Inositol-1,4,5-triphosphate-stimulated release from the nucleus;
  - (e) None of the above.

## First examination

1. Contrast the directionality of cation movement by the  $\text{Ca}^{2+}$ -ATPase of skeletal muscle with that of the  $\text{Na}^+, \text{K}^+$ -ATPase of the mammalian plasma membrane. What are their stoichiometries with regard to the number of ions moved vs. the number of ATPs hydrolyzed? Which one of these systems is electrogenic and why?

$\text{Ca}^{2+}$ -ATPase = 2  $\text{Ca}^{2+}$  moved into sarcoplasmic reticulum/ATP hydrolyzed (4 pts)

$\text{Na}^+, \text{K}^+$ -ATPase = 3  $\text{Na}^+$  moved out of the cell, 2  $\text{K}^+$  moved into cell/ATP hydrolyzed (4 pts)

$\text{Na}^+, \text{K}^+$ -ATPase = electrogenic system -- uncompensated net movement of  $\text{Na}^+$  (3  $\text{Na}^+$  out, 2  $\text{K}^+$  in) (2pts)  
(also full credit for  $\text{Ca}^{2+}$ -ATPase, since movement of 2  $\text{Ca}^{2+}$  is also uncompensated).

2. Discuss the similarities and difference in the electron carriers involved in the charge separations of the PSI and PSII reaction centers and their immediate reductants. Which of these photosystems contains redox active iron sulfur centers and how are they designated?

PSII (4 pts)

PSI (4 pts)

(Either type of designation = full credit)

Chlorophyll pair ( $\text{P}_{\text{D1}}/\text{P}_{\text{D2}}$ )

Chlorophyll pair (eC-A1/eC-B1)

Adjacent monomeric Chlorophyll ( $\text{Chl}_{\text{D1}}$ )

Adjacent monomeric Chlorophyll(eC-B2)(eC-A2)

Pheophytin ( $\text{Pheo}_{\text{D1}}$ )

Monomeric chlorophyll ( $\text{A}_0$ )(eC-A3)(eC-B3)

Plastoquinone ( $\text{Q}_\text{A}$ )

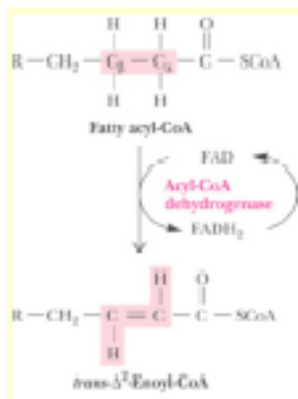
Phylloquinone( $\text{A}_1$ )( $\text{Q}_{\text{K}-\text{A}}/\text{Q}_{\text{K}-\text{B}}$ )

Immediate reductant: PSII:  $\text{Try}_\text{Z}$  ( $\text{Y}_\text{Z}$ )(Tyr 161 of D1 polypeptide) PSI: plastocyanin (cytochrome  $c_6$ )  
(1 pt)

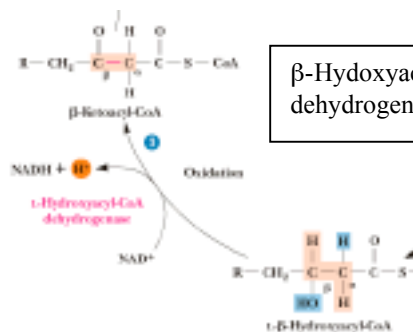
PSI contains redox active iron sulfur centers:  $\text{FeS}_\text{X}$ ,  $\text{FeS}_\text{A}$ ,  $\text{FeS}_\text{B}$  ( $\text{F}_\text{X}$ ,  $\text{F}_\text{A}$ ,  $\text{F}_\text{B}$ )(1 pt)

3. Show how the following cofactors are used in the reactions of ketogenesis, the first cycles of fatty acid oxidation and biosynthesis, and in the first stage of cholesterol biosynthesis (need not list enzyme) (1.7 pts. Each)

Flavin adenine dinucleotide (FAD);  
(Acyl-CoA dehydrogenase)

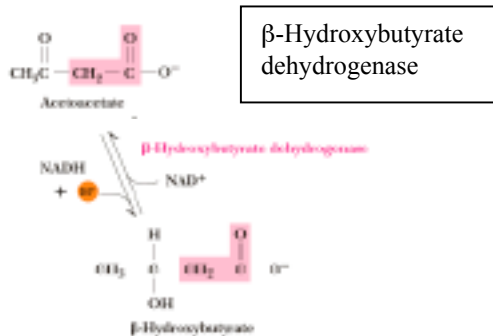


Nicotinamide adenine dinucleotide (NAD);



$\beta$ -Hydroxyacyl-CoA dehydrogenase

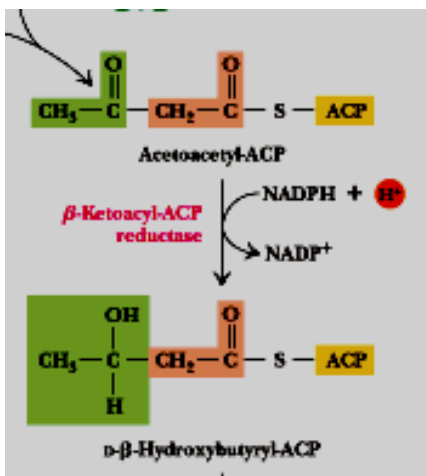
NADH



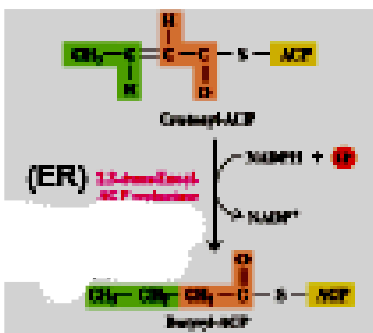
$\beta$ -Hydroxybutyrate dehydrogenase

NADPH.

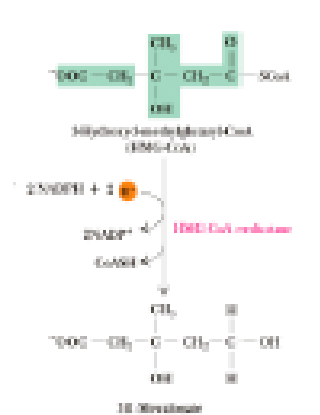
$\beta$ -ketoacyl-ACP reductase



2,3-trans-Enoyl-ACP reductase



HMG-CoA reductase



## First examination

4. Following release of secretory proteins from the trans-Golgi network, they follow either the constitutive or regulated pathway of protein secretion. How are these two pathways distinguished?

a. In constitutive secretion, soluble proteins within transport vesicles, arising from the Golgi apparatus, fuse with plasma membrane at cell surface and are secreted. They are secreted without any special intercellular signals controlling their release, aside from those involved in their synthesis in the ER and subsequent vesicle movement. (5 pts)

b. In regulated secretion, specific soluble proteins are stored in secretory vesicles from pancreatic and neuronal cells – release requires hormonal or neural signals. (5 pts)

5. Show how the ubiquitin-protein ligase ( $E_3$ ) functions in the tagging of proteins for degradation (10 pts)

