NAME: For GradeScope, please write your FIRST and LAST name in CAPITAL letters WITHIN the box:

Exam IV
April 17, 2024
Biochemistry II
BI/CH 422

I.	________	/45
II.	________	/18
III.	________	/37
TOTAL	________	/100

I. <u>MULTIPLE CHOICE</u>. (45 points; 3 points each answer)
Choose the BEST answer to the question by WRITING the appropriate letter in the BOX to the left of each question.

1. The glycogen-branching enzyme catalyzes:

   A. glycogen degradation in tree branches.
   B. formation of (□1□ 6) linkages during glycogen synthesis.
   C. formation of (□1□ 4) linkages in glycogen.
   D. removal of unneeded glucose residues at the ends of branches.

2. The Cori cycle is:

   A. the interconversion between glycogen and glucose-1-phosphate.
   B. the synthesis of alanine from pyruvate in skeletal muscle and the synthesis of pyruvate from alanine in liver.
   C. the synthesis of urea in liver and degradation of urea to carbon dioxide and ammonia by bacteria in the gut.
   D. the production of lactate from glucose in peripheral tissues with the resynthesis of glucose from lactate in liver.
   E. none of the above.

3. Which of the following is true of glycogen synthase?

   A. It catalyzes addition of glucose residues to the nonreducing end of a glycogen chain through (□1□ 4) bonds.
   B. The conversion of an active to an inactive form of the enzyme is controlled by the concentration of cAMP.
   C. Activation of the enzyme involves a phosphorylation.
   D. The enzyme has measurable activity only in liver.

4. Transketolase requires the coenzyme:

   A. pyridoxal phosphate.
   B. thiamine pyrophosphate.
   C. cobalamin (vitamin B_{12}).
   D. tetrahydrofolic acid.

5. Which of these chloroplast enzymes is <u>**not**</u> regulated by light (directly or indirectly)?

   A. rubisco
   B. fructose-1,6-bisphosphatase
   C. ribulose-5-phosphate kinase
   D. glyceraldehyde-phosphate dehydrogenase
   E. transketolase

6. The decision to metabolize pyruvate through the TCA cycle or to the cytosol for gluconeogenesis is accomplished by:

   A. phosphorylation/dephosphorylation of pyruvate dehydrogenase (PDH) and pyruvate decarboxylase by protein kinase A/phosphoprotein phosphatase, respectively
   B. Reciprocal phosphorylation/dephosphorylation of pyruvate dehydrogenase and pyruvate carboxylase by PDH-kinase A/PDH-phosphatase, respectively
   C. Reciprocal allosteric inhibition/activation of pyruvate dehydrogenase and pyruvate carboxylase by acetyl-CoA, respectively
   D. Reciprocal allosteric activation/inhibition of pyruvate dehydrogenase and pyruvate carboxylase by acetyl-CoA, respectively

7. Glucagon (in liver) and epinephrine (in muscle):

   A. activate glycogen phosphorylase and inactivate glycogen synthase.
   B. inhibit glycogen synthesis and activate glycogenolysis.
   C. act by raising the concentration of cyclic AMP (cAMP).
   D. act through a protein kinase
   E. do all of the above.

8. Which of the following substrates *cannot* contribute to net gluconeogenesis in mammalian liver?

   A. alanine
   B. palmitate
   C. □-ketoglutarate
   D. glutamate
   E. pyruvate

9. In the light-independent ("dark") reactions of photosynthesis, the biosynthesis of 1 mole of hexose from 6 moles of carbon dioxide requires:

   A. 18 moles of NADPH and 18 moles of ATP.
   B. 18 moles of NADPH and 12 moles of ATP.
   C. 12 moles of NADPH and 18 moles of ATP.
   D. 12 moles of NADPH and 12 moles of ATP.
   E. no NADPH and 12 moles of ATP.

10. Isolated spinach chloroplasts evolve O_2 when illuminated in the presence of potassium ferricyanide (a Hill reagent), according to the equation

$$2H_2O + 4Fe^{+3} \rightarrow O_2 + 4H^{+} + 4Fe^{+2}$$

where Fe^{+3} represents ferricyanide and Fe^{+2}, ferrocyanide. Does this process produce NADPH?

   A. Yes, NADPH forms because the cytochrome *bcf* complex has a much higher affinity for electrons than ferricyanide.
   B. No, ferricyanide removes electrons from the photosynthetic system, leaving none available for $NADP^+$ reduction.
   C. Yes, ferricyanide shuttles electrons directly to photosystem I for the reduction of $NADP^+$.
   D. No, ferricyanide reduces NAD^+ and produces NADH instead of NADPH.
   E. Yes, the Hill reagent was a marker for reduction and does not participate in the chloroplasts

11. In an organism growing on acetate (such as *E. coli*) that has both the citric acid cycle and the glyoxylate cycle, what determines which of these pathways isocitrate will enter?

   A. The enzyme metabolizing isocitrate in each pathway is under reciprocal allosteric regulation.
   B. A high [ATP]/[ADP] ratio favors the citric acid cycle.
   C. The accumulation of glycolytic intermediates favors the glyoxylate cycle.
   D. The pathway depends solely on the location of isocitrate in the cell.

12. Why is it important that gluconeogenesis is not the exact reversal of glycolysis?

   A. Gluconeogenesis would be highly endergonic, and it would be impossible to regulate the two processes separately.
   B. Gluconeogenesis would be highly exergonic, and it would be impossible to regulate the two processes separately.
   C. The continuous reversible conversion of glucose to pyruvate and back would deplete the brain’s energy supply.
   D. Alanine stimulation would inhibit pyruvate production.

13. Malic enzyme, found in the bundle sheath cells of C4 plants and in liver cytosol, and 6-phosphogluconate dehydrogenase, as part of the pentose-phosphate pathway, carry out a reaction that has a counterpart in the citric acid cycle. What is the analogous reaction in the citric acid cycle?

A. the isocitrate dehydrogenase reaction
B. the succinate dehydrogenase reaction
C. the malate dehydrogenase reaction
D. the citrate synthase reaction
E. the fumarase reaction

14. What impact would depletion of carbon dioxide have on photosynthesis?

A. The photosystems would lose the ability to synthesize ATP and NADPH needed to synthesize carbohydrates.
B. Water molecules would lose the ability to donate electrons to photosystem II, preventing the harvest of solar energy.
C. Failure to regenerate ribulose 1,5-bisphosphate would prevent the regeneration stage of the Calvin cycle.
D. Failure to synthesize 3-phosphoglycerate would prevent the carbon fixation stage of the Calvin cycle.

15. The coenzyme $NADP^+$ is the terminal electron acceptor in chloroplasts, according to the reaction

$$2\,H_2O + 2\,NADP^+ \longrightarrow 2\,NADPH + 2\,H^+ + O_2$$

The equilibrium constant, K'_{eq}, for this reaction at 25 °C is 1.35×10^{-77}

How can the chloroplast overcome this unfavorable equilibrium?

A. Chloroplasts decrease the rate of CO_2 assimilation via the Calvin cycle to overcome this barrier.
B. The absorption of photons provides the energy needed for the chloroplasts to overcome this barrier.
C. Chloroplasts decrease the E_o' of water to make water a strong electron donor and overcome this barrier.
D. Phosphorylation of the P680 special pair in photosystem II allows the chloroplasts to overcome this barrier.

II. SHORT ANSWER/FILL IN. (18 points)

Give a brief answer or fill in the boxes as directed to each problem or question below. Put your answers WITHIN the boxes provided.

16. Some glucose produced by gluconeogenesis is stored in the body as glycogen. What is the correct order the steps of glycogen synthesis. (3 pts)

A. UDP-glucose pyrophosphorylase catalyzes the reaction of glucose-1-phosphate and UTP to UDP-glucose and PP_i
B. Pyrophosphatase converts PP_i and water into two P_i
C. Glycogen synthase adds a glucose unit from UDP-glucose to glycogen, producing a larger glycogen molecule and UDP

—> —>

17. In muscle tissue, the rate of conversion of glycogen to glucose 6 phosphate is determined by the ratio of phosphorylase a (active) to phosphorylase b (less active). Determine what happens to the rate of glycogen breakdown, and place the correct choice in the adjacent box, if a muscle preparation containing glycogen phosphorylase is treated with: (6 pts)

(a) phosphorylase kinase and ATP

(b) PP1

(c) epinephrine.

Choices:
A. Increases glycogen breakdown
B. Decreases glycogen breakdown

18. The light-absorbing pigments in the thylakoid membranes of chloroplasts are organized into two photosystems: photosytem II (PSII) and photosytem I (PSI).

Using a spectrophotometer, researchers can sometimes directly observe the extent of oxidation or reduction of an electron carrier during photosynthetic electron transfer. Illuminating chloroplasts with 700 nm light oxidizes cytochrome *f*, plastocyanin, and plastoquinone. Illuminating chloroplasts with 680 nm light, however, reduces these electron carriers.

Complete the passage explaining this observation. (5 pts)

Choices:
a. PSI, but not PSII
b. PSII, but not PSI
c. PSI and PSII
d. PSI
e. PSII
f. P680
g. P700

Illuminating chloroplasts with 700 nm light excites [ ] The [ ] reaction center donates electrons to $NADP^+$, but no electrons flow from [ ] to replace them.

Illuminating chloroplasts with 680 nm light excites [ ] Electrons tend to flow to [ ] but the electron carriers between the two photosystems quickly become completely reduced.

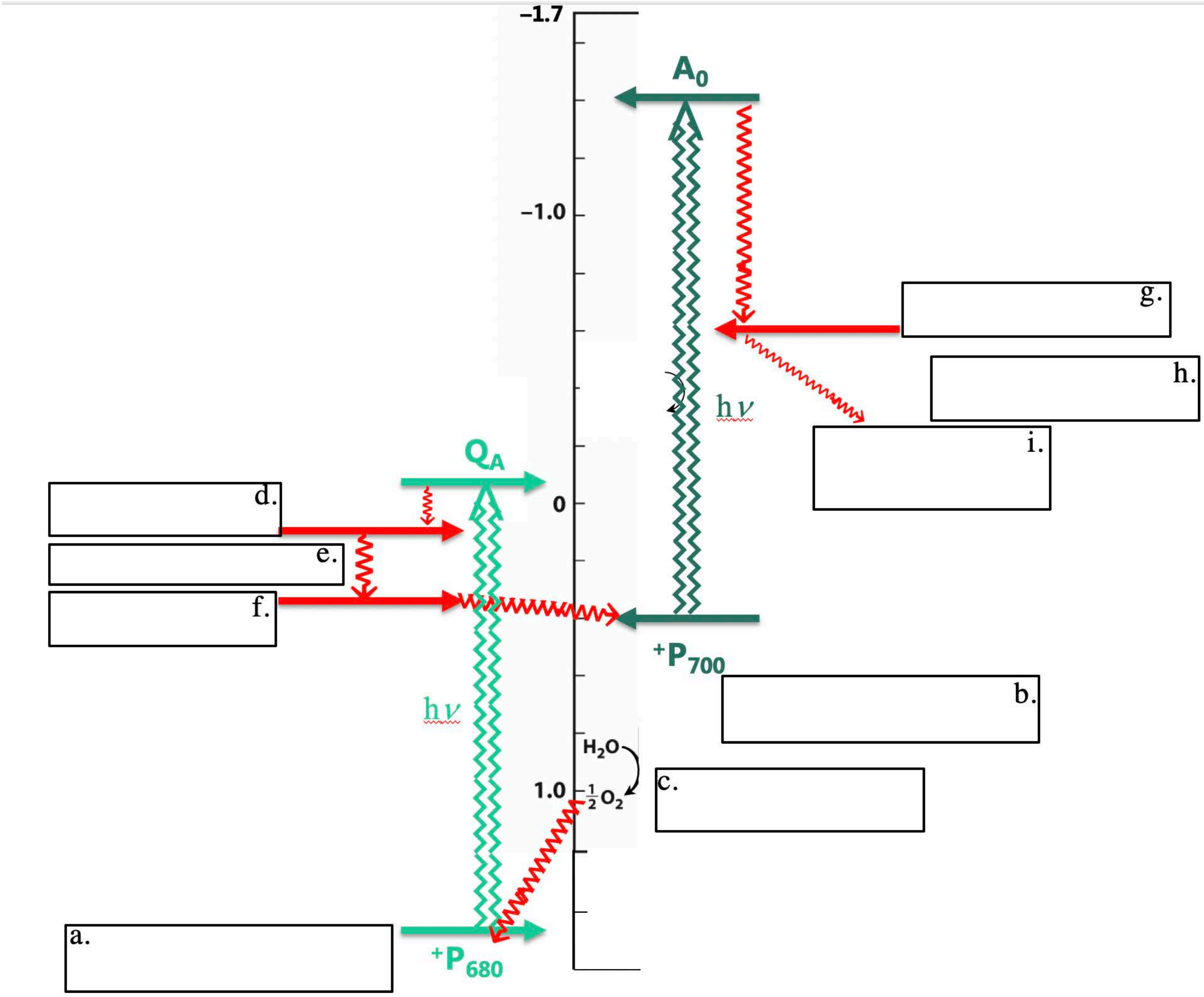
19. The pentose phosphate pathway provides [ ] for reducing oxidized glutathione (GSSG) biosynthesis and [ ] for nucleotide synthesis. (4 pts)

III. FILL-IN/PATHWAYS/MECHANISM (37 points)

20. The mechanism for moving acetyl-CoA produced in the mitochondrial matrix into the cytosol for fatty acid synthesis starts with Acetyl-CoA in the mitochondrial matrix, which condenses with [a.] to form [b.] in a reaction catalyzed by [c.]. [b.] moves out of the matrix via the tricarboxylate transporter. [b.] in the cytosol is cleaved by [d.], yielding acetyl-CoA and [a.]. To complete the cycle, [a.] in the cytosol is reduced to [e.], which is converted to pyruvate by [f.] (thus creating [g.] for the fatty-acid synthase reactions). Then pyruvate moves into the mitochondrial matrix through its own transporter, and is converted to [a.] in the matrix by the enzyme [h.].

(8 pt)

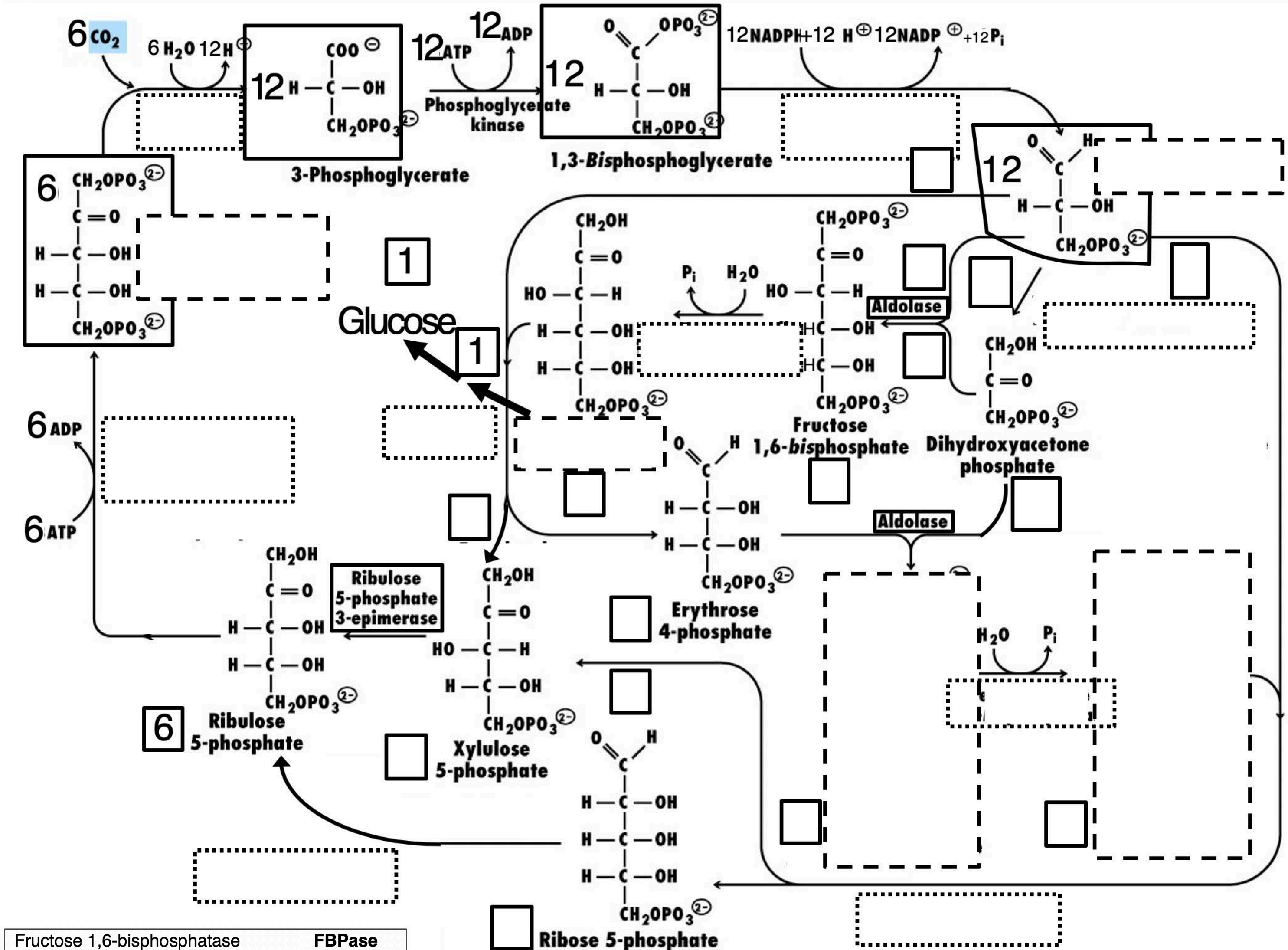
21. The energetics of photosynthesis is diagrammed below. Name each of the entities a.-i. in the boxes provided (abbreviations OK). Entities a. and b. are photosystems. Entities next to arrows are redox players, whereas entities e. and h. are enzymes/complexes. Entity c. is a cofactor. (5 pts)



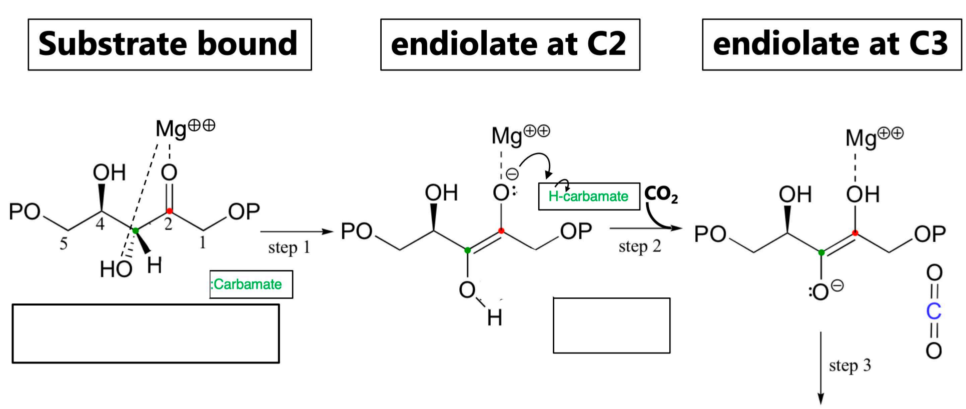
22. Fatty acid synthesis and fatty acid breakdown occur by similar pathways. The synthetic and breakdown pathways differ in six ways. Note these differences with 1-2 words or abbreviations in the boxes below. (6 pt)

Fatty acid Oxidation		Fatty Acid Synthesis
	Location	
	Cofactor used for Reaction at □-carbonyl	
	Stereochemistry of alcohol	
	Cofactor used for Reaction at alkene	
	Group Carrier	
	C-2 unit	

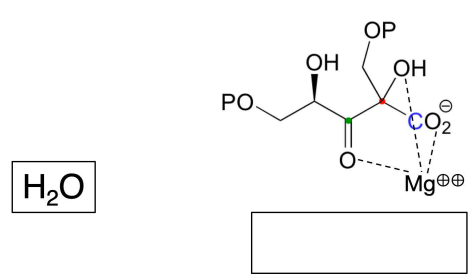
23. In the diagram of the Calvin Cycle below (with a stoichiometry of 6 CO_2 molecules fixed to make 1 molecule of glucose), fill in the missing boxes using abbreviations from the table below. For those 9 boxes in dotted lines provide the names of an enzyme. For those 5 boxes in dashed lines provide the name of the sugar intermediates. For those 15 empty boxes with solid lines provide numbers pertaining to the correct stoichiometry. (11 pts)



Fructose 1,6-bisphosphatase	FBPase
Fructose 6-phosphate	F6P
Glyceraldehyde-3-phosphate	GA3P
Glyceraldehyde-3-phosphate Dehydrogenase	GAPDH
Phosphoribose isomerase	PRI
Phosphoribulose kinase	RPK
Ribulose 1,5 bisphosphate	RBP
Ribulose 1,5 bisphosphate Carboxylase/Oxidase	RUBISCO
Sedoheptulose 1,7 bisphosphatase	SBPase
Sedoheptulose 1,7 bisphosphate	SBP
Sedoheptulose 7-phosphate	S7P
Transketolase	TK
Triosephosphate isomerase	TPI



24. **RUBISCO Mechanism** (7 points)
First, fill-in the missing arrows for electron movements for steps 1, 2, and 3. Second, Fill-in the names of the substrate, catalytic base, and catalytic intermediate in the 3 boxes (P=phosphoryl). Third, draw and arrow from the water molecule to the carbon atom in the last intermediate that is attacked in the next step leading to the cleavage of 3-phosphoglycerate.



No. on Test	Correct Answer
1	B
2	D
3	A
4	B
5	E
6	C
7	E
8	B
9	C
10	B
11	A
12	A
13	A
14	D
15	B

16

Some glucose produced by gluconeogenesis is stored in the body as glycogen. What is the correct order the steps of glycogen synthesis. (3 pts)

A. UDP-glucose pyrophosphorylase catalyzes the reaction of glucose-1-phosphate and UTP to UDP-glucose and PP_i

B. Pyrophosphatase converts PP_i and water into two P_i

C. Glycogen synthase adds a glucose unit from UDP-glucose to glycogen, producing a larger glycogen molecule and UDP

A —> B —> C

17

In muscle tissue, the rate of conversion of glycogen to glucose 6 phosphate is determined by the ratio of phosphorylase a (active) to phosphorylase b (less active). Determine what happens to the rate of glycogen breakdown, and place the correct choice in the adjacent box, if a muscle preparation containing glycogen phosphorylase is treated with: (6 pts)

(a) phosphorylase kinase and ATP **A**

(b) PP1 **B**

(c) epinephrine. **A**

Choices:
A. Increases glycogen breakdown
B. Decreases glycogen breakdown

18

Illuminating chloroplasts with 700 nm light excites [a.] The [g.] reaction center donates electrons to $NADP^+$, but no electrons flow from [f.] to replace them.

Illuminating chloroplasts with 680 nm light excites [b.] Electrons tend to flow to [d.] but the electron carriers between the two photosystems quickly become completely reduced.

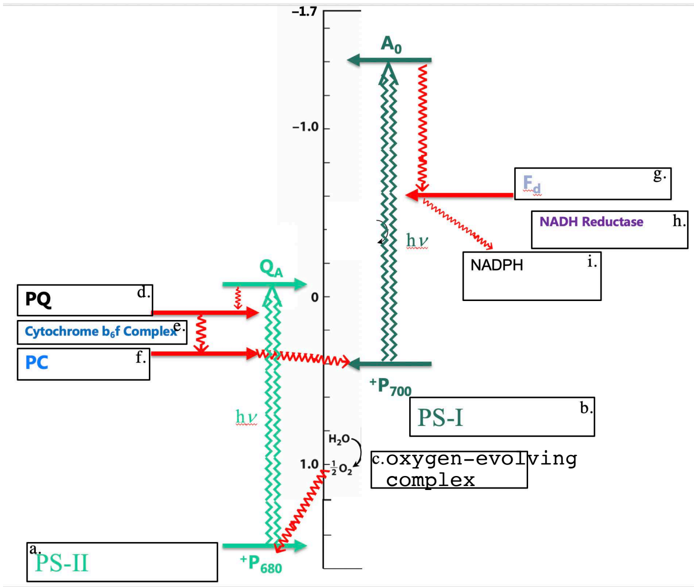
19 **NADPH; ribose 5-phosphate**

20

The mechanism for moving acetyl-CoA produced in the mitochondrial matrix into the cytosol for fatty acid synthesis starts with Acetyl-CoA in the mitochondrial matrix, which condenses with **oxaloacetate** to form **citrate** in a reaction catalyzed by **citrate synthase**. **Citrate** moves out of the matrix via the tricarboxylate transporter. **Citrate** in the cytosol is cleaved by **citrate lyase**, yielding acetyl-CoA and **oxaloacetate**. To complete the cycle, **oxaloacetate** in the cytosol is reduced to **malate**, which is converted to pyruvate by **malic enzyme** (thus creating **NADPH** for the fatty-acid synthase reactions). Then pyruvate moves into the mitochondrial matrix through its own transporter, and is converted to **oxaloacetate** in the matrix by the enzyme **pyruvate carboxylase**.

No. on Test	Correct Answer

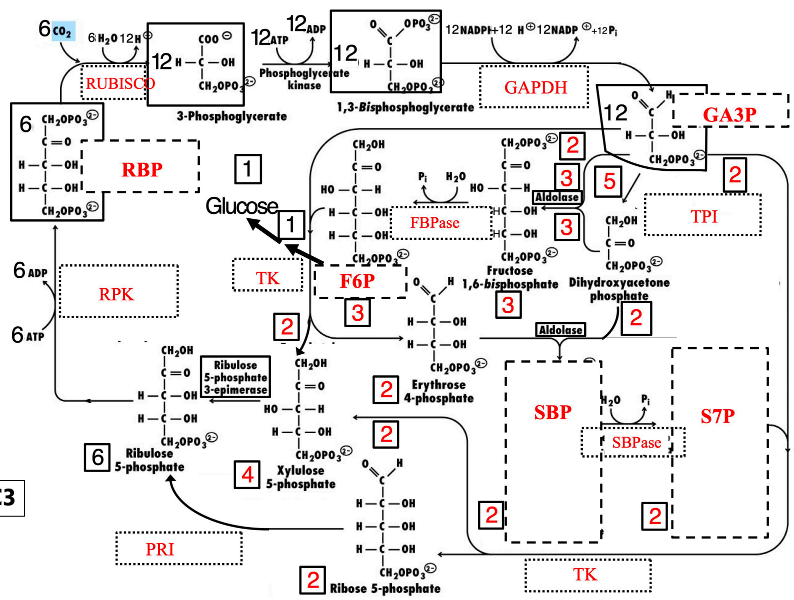
21



22

Fatty acid Oxidation		Fatty Acid Synthesis
Mitochondria	Location	**Cytosol**
NADH	Reaction at □-carbonyl	**NADPH**
3-**L**-hydroxyacyl	Stereochemistry of alcohol	3-**D**-hydroxyacyl
FADH$_2$	Reaction at alkene	**NADPH**
Coenzyme A	Group Carrier	**ACP**
acetyl-CoA	C-2 unit	**malonyl-CoA**

23



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