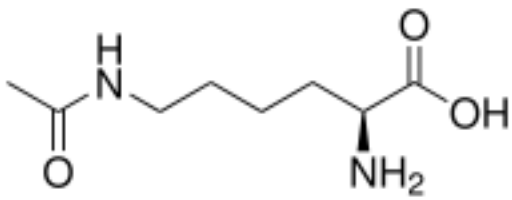
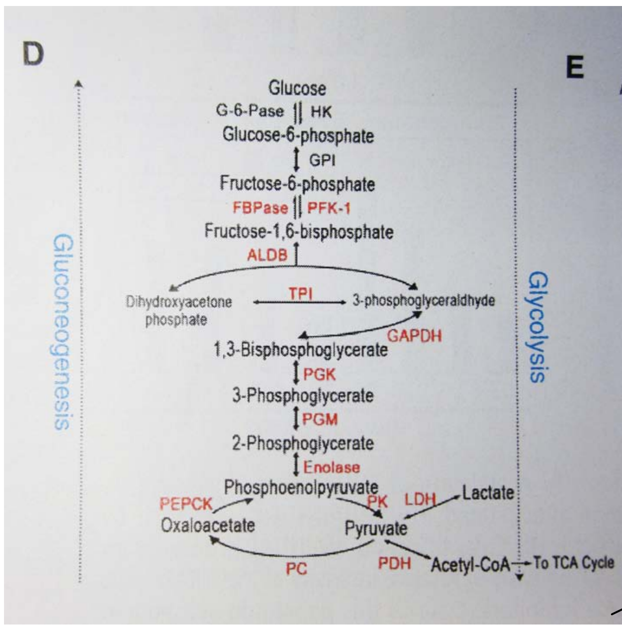
# LAST LECTURE

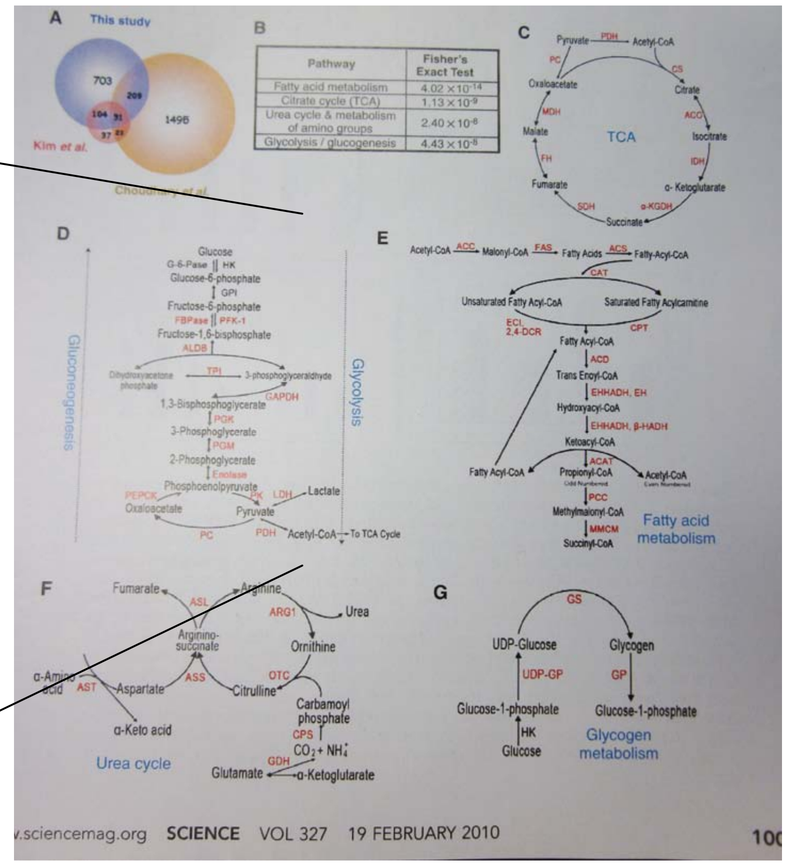
1. Things the course missed
2. Things you might be tested on

Things I didn't tell you that might make more sense now that you have had BIS105

From "Regulation of Cellular Metabolism by Protein Lysine Acetylation"






(Science VOL 327 19 February 2010)

From "Diet Drives Convergence in Gut Microbiome Functions Across Mammalian Phylogeny and Within Humans"

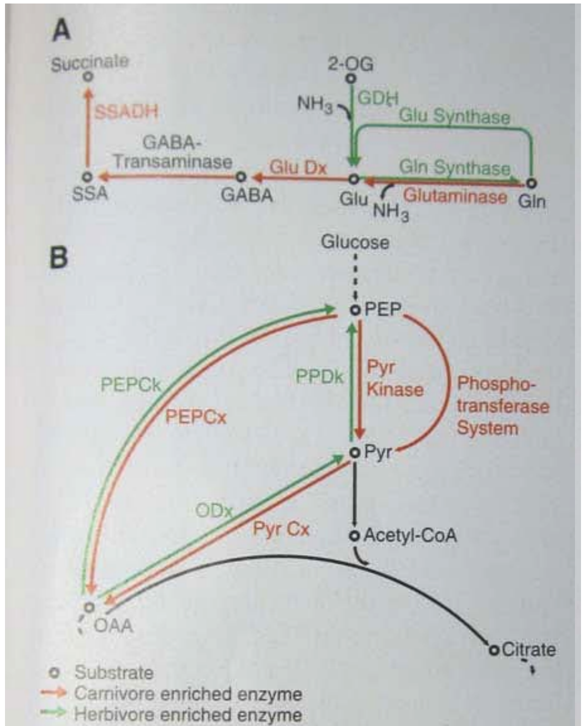


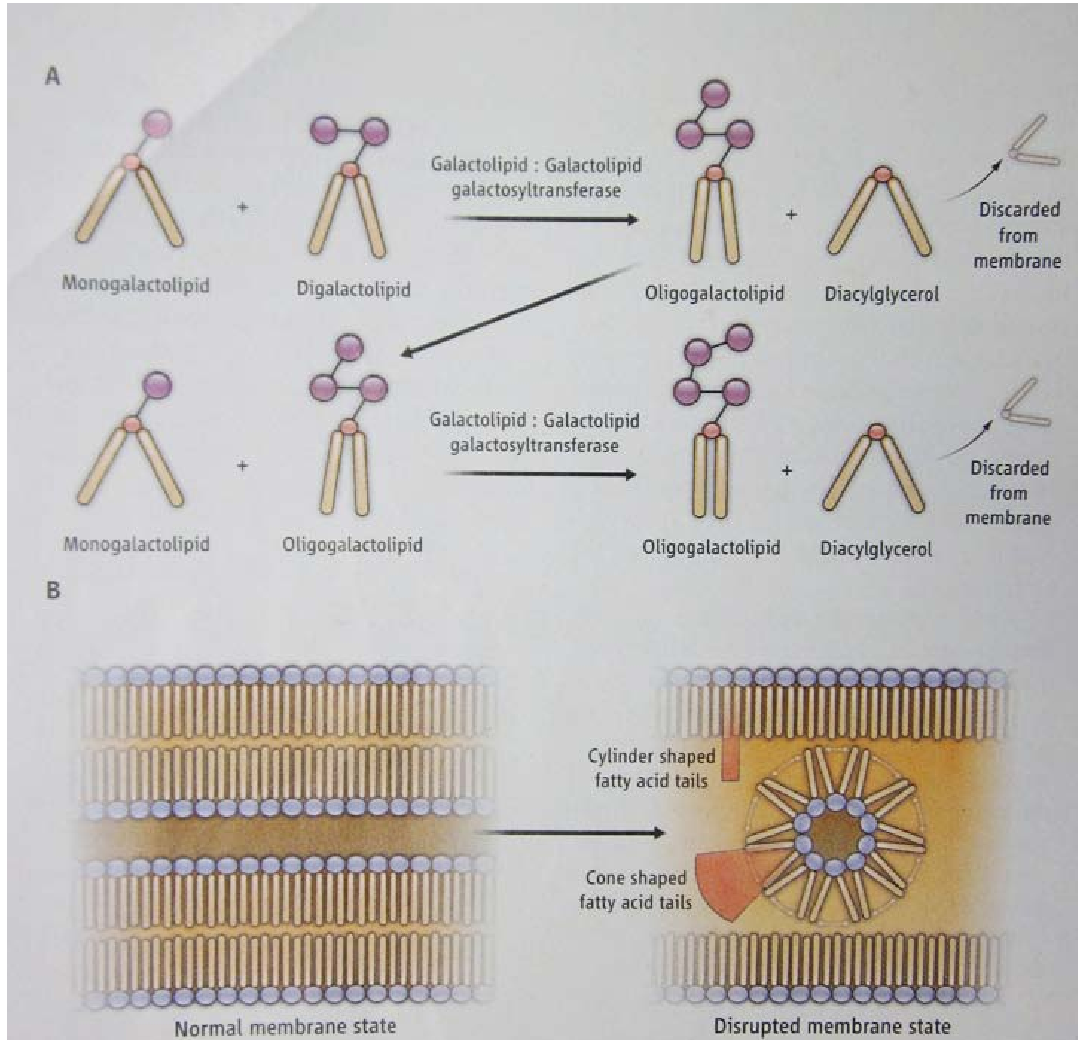

**Fig. 3.** Differences in metabolic features encoded in fecal microbiomes among herbivores versus carnivores. **(A)** Carnivorous and herbivorous microbiomes indicate opposing directionality for amino acid metabolism. Colored arrows denote enzyme functions whose representation is significantly ($P <$ 0.001) greater in the fecal microbiomes of herbivores (green) or carnivores (red). **(B)** Carnivorous and herbivorous microbiomes suggest opposing directionality at the central PEP-pyruvate-OAA node. The coloring scheme is as in (A). Abbreviations: 2-OG, alpha-ketoglutarate; Ck, carboxykinase; Cx, carboxylase; DH, dehydrogenase; Dx, decarboxylase; GABA, γ-aminobutyrate; GDH, Glu DH; ODx, OAA Dx; PPDk, Pyr-phosphate dikinase; Pyr, pyruvate; SSA, succinate-semialdehyde.

(red: carnivores;
green: herbivores)

Science VOL 332 20 May 2011

From “Saving the Bilayer” (Science VOL 330 8 October 2010)

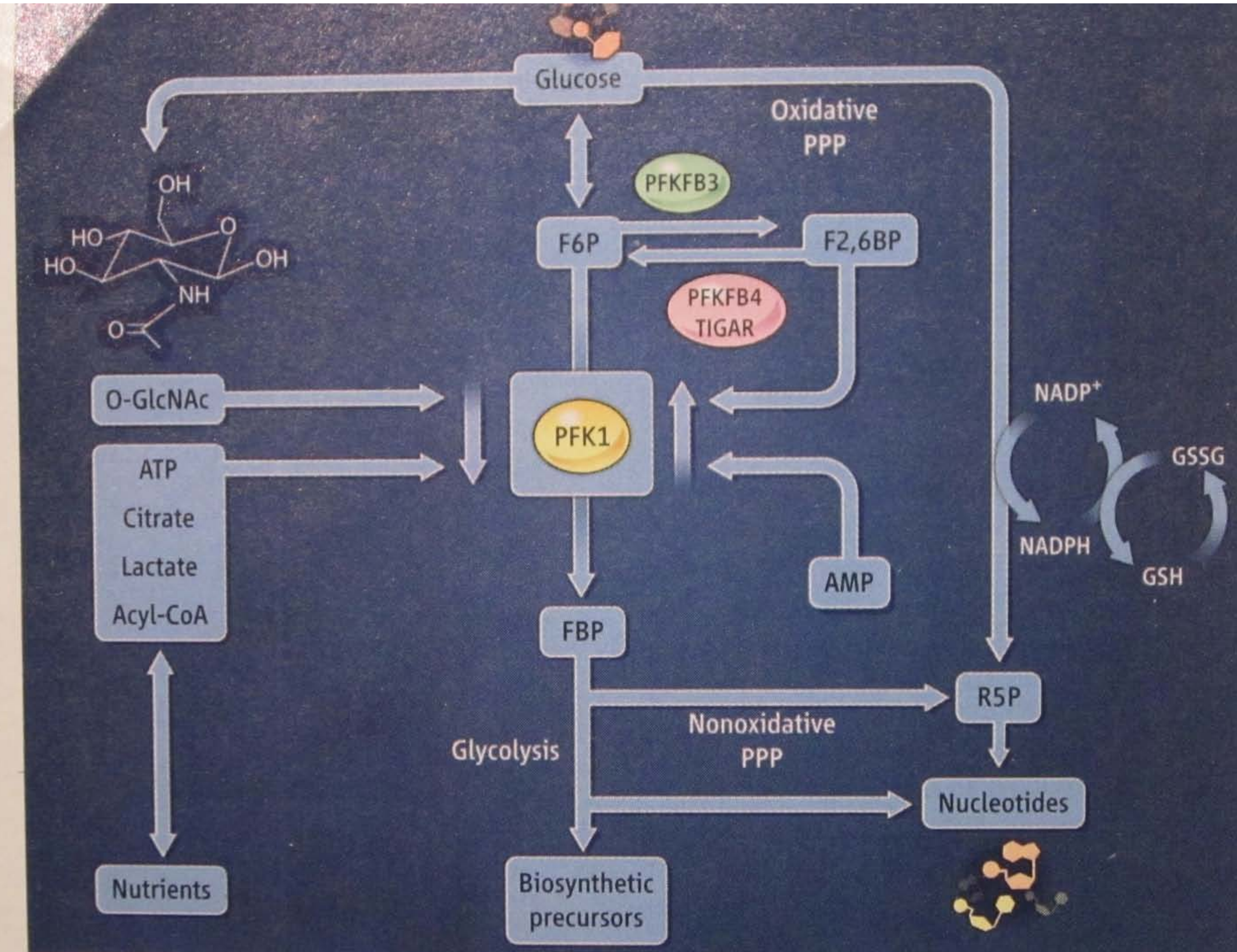
“Membrane lipids must be metabolized to protect plants from frost”




**Lipid conversion.** (**A**) In the plant chloroplast outer membrane, the galactolipid:galactolipid galactosyltransferase (GGGT) encoded by *SFR2* converts cone-shaped monogalactolipids to cylindrical oligogalactolipids and diacylglycerol (which is removed from the bilayer). (**B**) A series of nonbilayer $H_{II}$ structures can form from adjacent leaflets of closely appressed bilayers. It is proposed that GGGT prevents this by removing the $H_{II}$-forming monogalactolipids.

From “Glycosylation to Adapt to Stress” (Science VOL 337 24 August 2012)

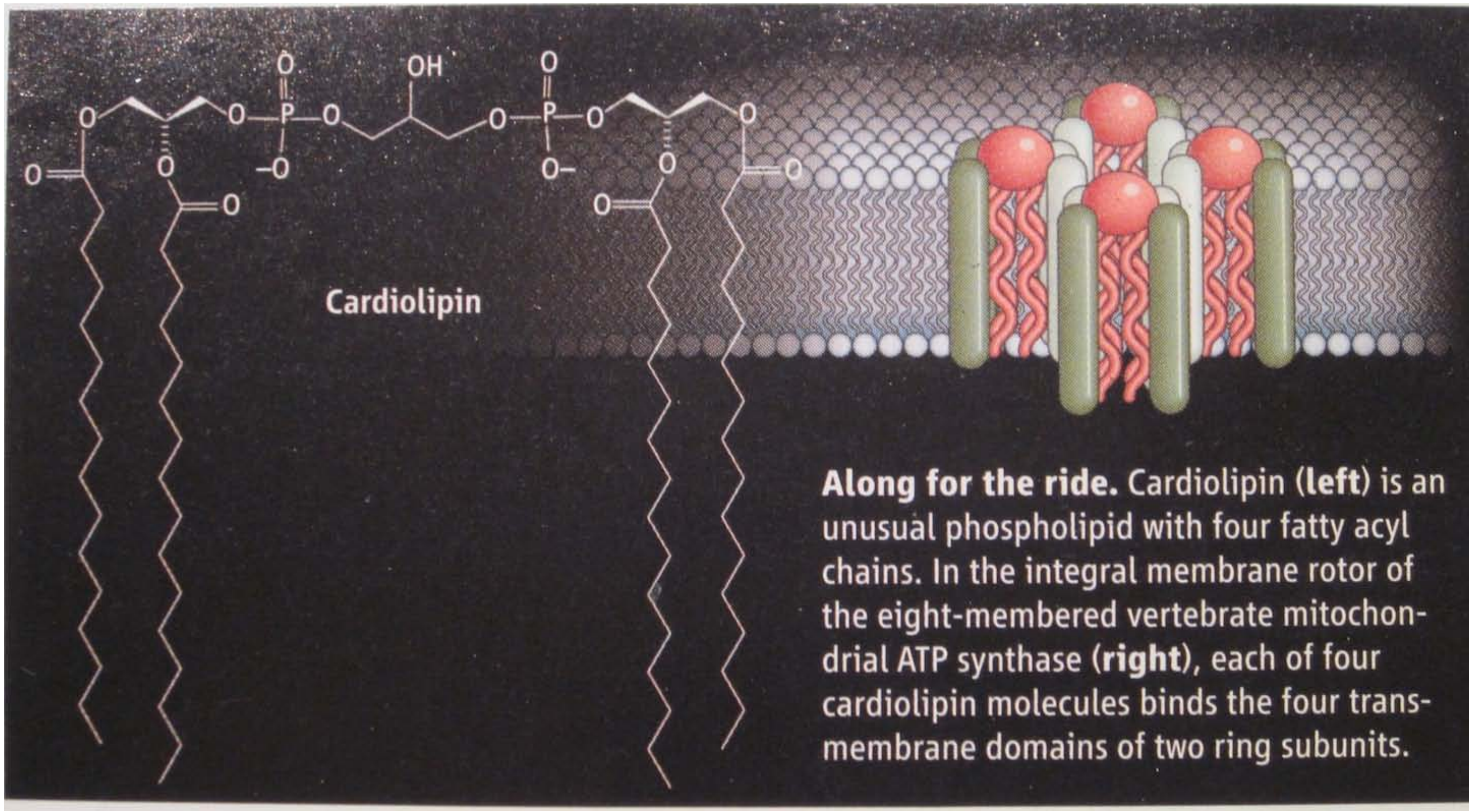
O-GlcNacsylation (addition of N-acetylglucoseamine) to a serine of PFK1 decreases its activity, diverts C to the oxidative PPP, and increases NADPH, which reduces glutathione and protects against reactive oxygen ($O_2^-$, $H_2O_2$).




**Converging on PFK1.** PFK1 catalyzes the formation of FBP from F6P in glycolysis. Decreased PFK1 activity diverts glucose carbon from glycolysis and downstream biosynthetic pathways to the oxidative pentose phosphate pathway (PPP). This allows production of NADPH to maintain reduced glutathione pools (GSH) and allow cells to counteract oxidative stress. R5P, ribose-5-phosphate; GSH/GSSG, reduced/oxidized glutathione.

From “Up Close with Membrane Lipid-Protein Complexes”

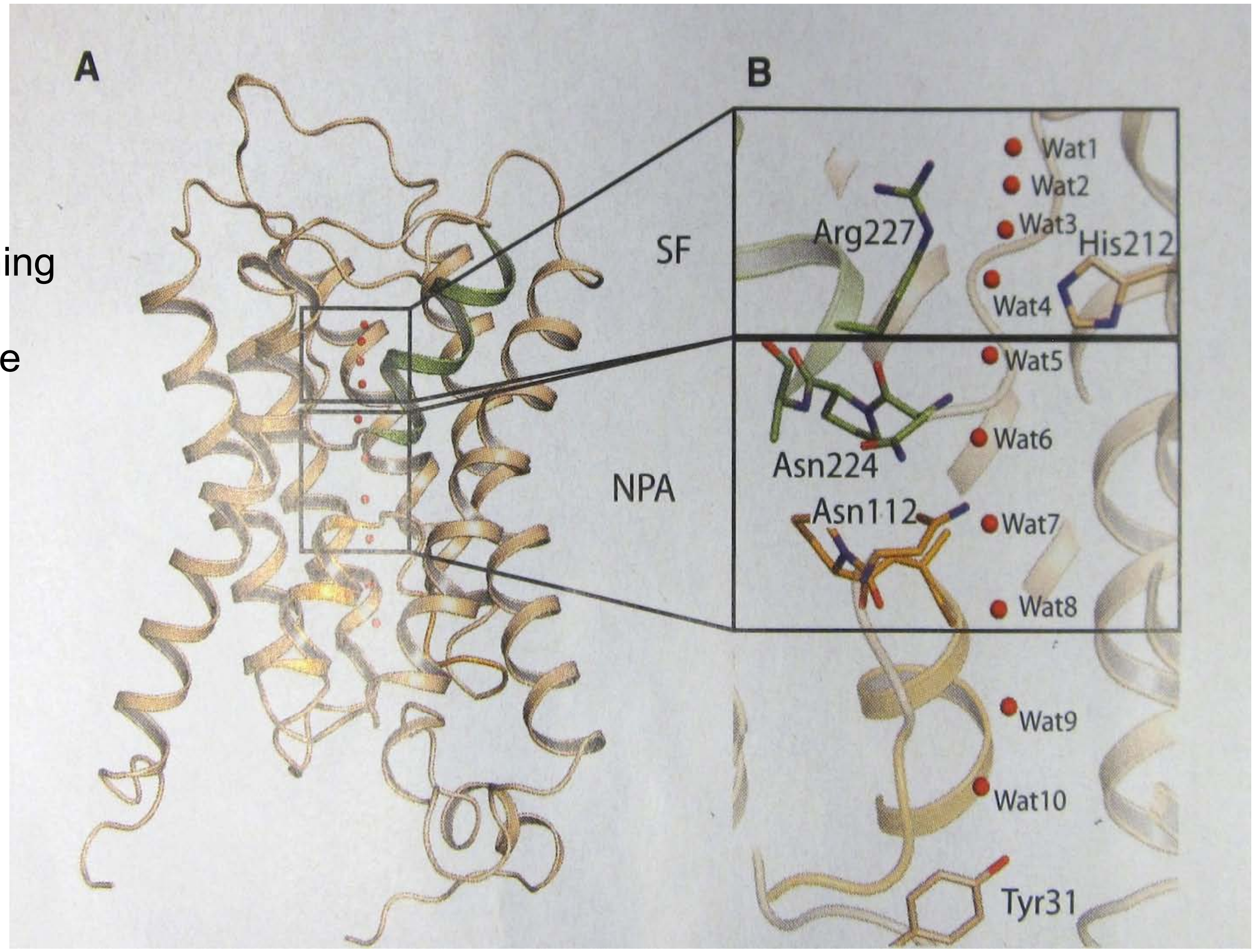
(Science VOL 334 21 October 2011)




**Along for the ride.** Cardiolipin (**left**) is an unusual phospholipid with four fatty acyl chains. In the integral membrane rotor of the eight-membered vertebrate mitochondrial ATP synthase (**right**), each of four cardiolipin molecules binds the four transmembrane domains of two ring subunits.

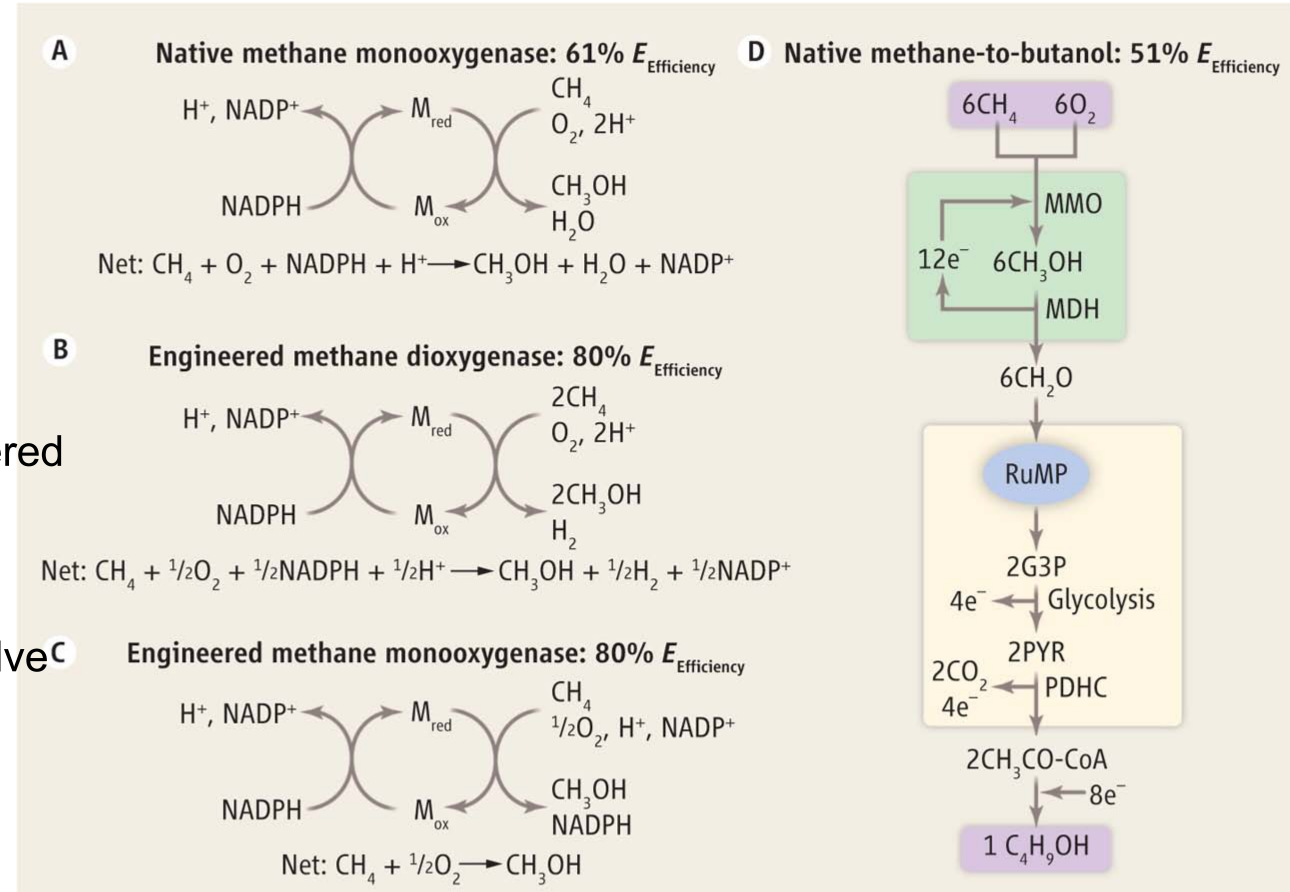
From “Sub-angstrom Resolution X-Ray Structure Details Aquaporin-Water interactions” (Science VOL 340 14 June 2013)

Six membrane-spanning $\alpha$-helices and two pseudohelices provide selectivity for $H_2O$, excluding $OH^-$ and $H_3O^+$.



From “Envisioning the bioconversion of methane to liquid fuels”
(Science VOL 343 7 February 2014)

Bacterial enzymes can convert methane to liquid fuels--methanol and ethanol--but the process is inefficient. Re-engineered enzymes and pathways may be more efficient. (Enzyme C--not yet available--would not involve a net use of NADPH.)



What should you expect on the final exam?

Part I: the last third of the course

- PDH, TCA cycle
- ETS and oxidative phosphorylation
- ATP synthesis
- Photosynthesis
- Gluconeogenesis, PPP
- Fatty acid catabolism
- Fatty acid synthesis
- Nitrogen metabolism

8-10 questions, 100 points
“essay”/problem solving

Part II: the whole course

25-30 questions
multiple-choice, identifications

The following are some parts of the final…

From the front page:

The following formulas and constants might be helpful:

$V = V_{max}\,[S]/([S]+K_m)$

$V = \dfrac{(V_{max}/(1 + [I]/K_i))[S]}{([S] + K_m)}$

$V = \dfrac{V_{max}[S]}{([S] + K_m(1 + [I]/K_i))}$.

$\Delta G' = RT \ln ([product]/[reactant]) + z\,\mathcal{F}\,\Delta E_o'$

$\Delta G = -2.3\ RT\ \Delta pH + z\,\mathcal{F}\,\Delta E_o'$

$\Delta G = \Delta G^o + RT \ln ([Y]/[X])$

$pH = -\log([H+])$

$\Delta G^o = -RT \ln K_{eq}$

$\Delta G^{o'} = z\,\mathcal{F}\,\Delta E_o'$

$\Delta E' = \Delta E_o' + (RT/n\mathcal{F})\ln([ox]/[red])$

$A = -\log (I/I_o)$

$R = 8.31\ J/^oK\text{-mol}$

$\mathcal{F} = 96485\ J/\text{volt-mol}$

$pH = pKa + \log([A-]/[HA])$

Some questions from the first part of previous years' finals:

1. Describe the reaction catalyzed by isocitrate dehydrogenase, showing the structures of the principal substrates and products but just naming the cofactors.

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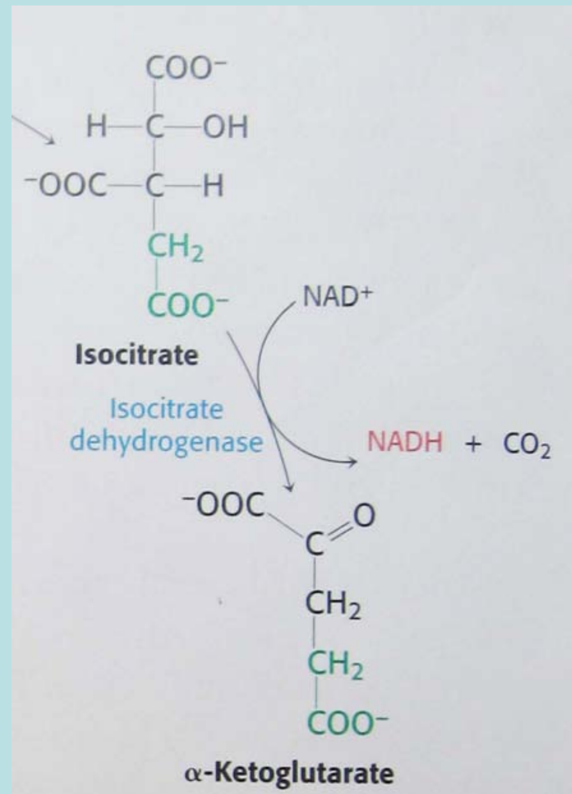

2. (12) When respiration is occurring normally, the typical difference in pH between the inter-membrane space and the matrix of the mitochondrion is about 1 unit; the typical difference in voltage, $\Delta\Psi$ ($\Delta E_o$'), is about 0.18 volt. What is the free energy ($\Delta G$') associated with the movement of <u>one</u> mole of $H^+$ back across the membrane (i.e. free energy available for the synthesis of ATP)? Calculate the total value and point out the amounts that are available in response to the $\Delta$pH and the $\Delta\Psi$ ($\Delta E_o$'), respectively.

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$$\Delta G' = -2.3\ RT\ \Delta pH + z\ \mathcal{F}\ \Delta E_o'$$

$$= -(2.3)(8.3)(298)(1) + (1)(93500)(-0.18)$$

(both contributions have the same sign)

$$= -5695 - 17367 = -23{,}062\ \text{J/mol}$$

6. a) (4) Below are the names of enzymes that catalyze four steps in ß-oxidation, producing one acetyl-CoA. Each enzyme acts on an acyl-CoA molecule as one substrate. For each enzyme, give the other substrate or cofactor, using these choices: $H_2O$, $FADH_2$, CoA-SH, $CO_2$, FAD, $NAD^+$, NADH, $FAD^+$, NADPH, $NADP^+$.

i. thiolase ________

ii. acyl-CoA dehydrogenase ________

iii. ß-hydroxyacyl-CoA dehydrogenase ________

iv. enoyl-CoA hydratase ________

b.) (8) How much ATP will be formed from the total metabolism of one molecule of palmitoyl(16C)-S-CoA? Assume 2.5 ATP/NADH and 1.5 ATP/$FADH_2$. Show your work.

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i. thiolase _CoA-SH_

ii. acyl-CoA dehydrogenase _FAD_

iii. ß-hydroxyacyl-CoA dehydrogenase _NAD+__

iv. enoyl-CoA hydratase __$H_2O$__

b.) (8) How much ATP will be formed from the total metabolism of one molecule of palmitoyl(16C)-S-CoA? Assume 2.5 ATP/NADH and 1.5 ATP/$FADH_2$. Show your work.

| | |
|---|---|
| 7 NADH + $H^+$ | 17.5 ATP |
| 7 $FADH_2$ | 10.5 ATP |
| 8 acetyl-CoA | 80 ATP |
| less activation | -2 ATP |
| | 106 ATP |

The distribution of questions follows the list of lectures:

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Spring 10 | PDH; ATP per NADH, FAD | deltaG: delta pH, delta Psi | Redox equation | PS pathway | Gluconeogen-esis enzymes | ß-oxidation coenzymes; ATP/fatty acid | Malonyl-CoA synthesis | GOGAT | Reaction locations | |
| Spring 11 | PDH components: location, stoichiometry | deltaG: delta pH | Redox equation | Urea cycle | PPP products | Gluconeogen-esis enzymes | ß-oxidation coenzymes; ATP/fatty acid | Malonyl-CoA synthesis | GOGAT | |
| Spring 12 | Isocitrate DH reaction | ATP/H+, NADH; charge/ATP | PS light reaction components; hv/O2 | Glycerol metabolism | Gluconeogen-esis stoichiometry | FA oxidation intermediate | FA synthesis requirements | CAP synthesis function | Reaction locations | |
| Spring 13 | Citrate synthase reaction | ATP/H+, NADH | Charge/ATP | PS e- flow; hv/O2 | Energy state; glucose synthesis | FA oxidation intermediate | FA synthesis requirements | Urea structure, origin; ATP requirement | FA water production | |
| Fall 13 | CO2 release in mitochondria | NADH synthesis in mitochondria | ATP/NADH | Redox equation vs ATP synthesis | CP GAP DH reaction | FA oxidation stoichiometry | FA synthesis intermediate | Reaction locations | GOGAT | Glycogen synthesis: enzyme, energy |

Some questions from the second part of previous year's finals:

2. The formula for the velocity of an enzyme reaction with Michaelis-Menten kinetics in the presence of a non-competitive inhibitor is...

a. $V = V_{max}\,[S]/([S]+K_m)$

b. $V = \dfrac{(V_{max}/(1 + [I]/K_i))[S]}{([S] + K_m)}$

c. $V = V_{max}[S]/([S] + K_m\,(1 + [I]/K_I))$

d. $V = \dfrac{(V_{max}/(1 + [I]/K_i))[S]}{(K_m/(1 + [I]/K_i) + [S])}$

e. $1/V = (K_m/V_{max})(1/[S]) + 1/\,V_{max}$

4. In a 0.1 M solution of acetic acid, adjusted with NaOH to pH 4.76, the concentration of acetate ion ($CH_3COO^-$)...

a. is 0.1 M.  b. is 0.05 M.  c. is 0.2 M.

d. depends on the concentration of NaOH used.

e. depends on the final concentration of $Na^+$ ion.

5. The number of hydrogen bonds stabilizing an alpha-helix is generally...

a. one per turn of the helix.

b. two per turn of the helix.

c. three per turn of the helix.

d. four per amino acid in the helix.

e. one per amino acid in the helix, less four for the amino acids at the ends.

10. The lecture on enzyme mechanisms described in detail the hydrolysis of a protein by the enzyme chymotrypsin. Which of the statements below best describes a principle of enzyme catalysis illustrated by the chymotrypsin reaction that is <u>different</u> from the principles guiding uncatalyzed or most inorganically catalyzed reactions?

a. The reaction proceeds forward only if the $\Delta G$ of the reaction is negative.
b. The reactants must acquire a certain amount of potential energy (activation energy) before they can form products.
c. The reactants may form covalent bonds to the catalyst.
d. The reaction is temperature sensitive.
e. The reaction is not temperature sensitive.

15. $N_2 + 16\ ATP + 10\ H^+ + 8\ e^- \text{-->} 2\ NH_4^+ + H_2 + 16\ ADP + 16\ Pi$

The equation above describes...

a. nitrogen fixation

b. nitrate assimilation

c. ammonium excretion

d. abiotic denitrification

e. the urea cycle

20. The formula for photosynthesis is often written,

$$6\ CO_2 + 12\ H_2O \text{-->} C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O.$$

The source of the $O_2$ on the right-hand side of the equation is...

a. $CO_2$. b. $H_2O$. c. both $CO_2$ and $H_2O$.

d. $C_6H_{12}O_6$ e. air.

Thank you for your attention to

me (Terry Murphy),

the TA (Ralph McNeilage),

and the course.

Review here 12-2 on Friday

I hope you have successful finals and a great summer.