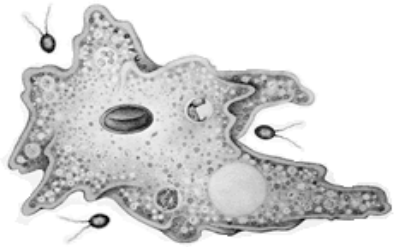
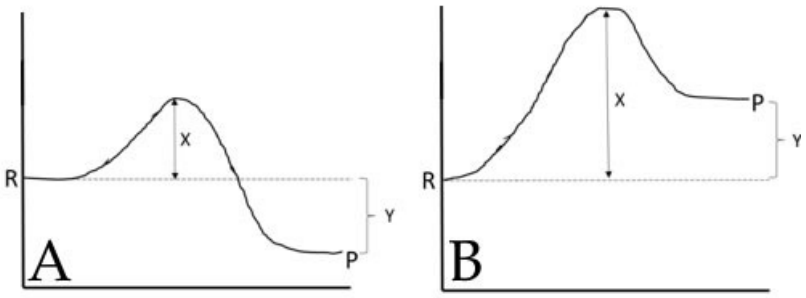
MCDB 1150-003 Biofundamentals **Answer KEY**
Midterm 2 - Fall 2015



Directions: There are 20 questions, each worth 5 points. Remember, you can check "no idea" and you will receive 1 point (no reasoning is required).

As before, in some cases you are asked to select the wrong answer, otherwise pick the correct answer. **READ CAREFULLY** to determine what the question wants you to do next**!**

Q1: Consider two chemical reactions, described by the reaction coordinate graphs A and B.



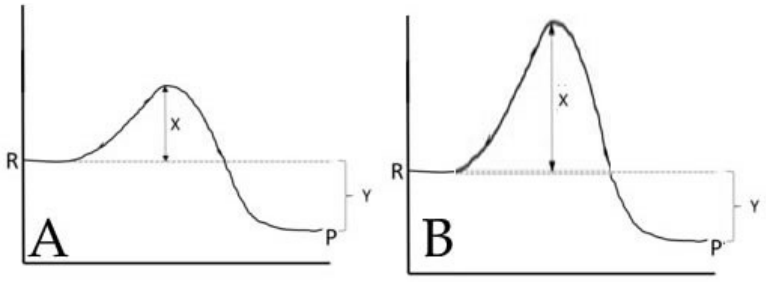
These reactions involve reactants (R) and products (P). Which reaction is thermodynamically favorable?

■ **A** □ B □ C - impossible to tell □ no idea

Explain the logic behind your answer:

In the graphs Y = ΔG (the free energy difference between the reactants and product). Reaction A has a -ΔG and so is thermodynamically favorable, in reaction B ΔG is positive, so the reaction is unfavorable.

Q2: Now consider these two chemical reactions. Given the same physical conditions (e.g. temperature) which reaction is more likely to proceed faster toward equilibrium?



■ A □ B

□ C - not possible to tell □ no idea

Explain the logic behind your answer AND predict what will happen to the values of X and Y if a catalyst is added to the reactions.

The activation energy (X, the difference between the reactants and the higher energy intermediate in the reaction) is smaller in reaction A versus reaction B; reaction A will occur faster.

A catalyst reduces the activation energy of the reaction, so that it proceeds faster (at a given temperature).

Q3: If the electronegativities of H and O were equal to one another, what would happen to the boiling point of water?

☐ A. it would increase ■ B. it would decrease

☐ C. it would remain unchanged ☐ no idea

Explain the logic behind your answer:

Without the difference in electronegativity, the water molecules would interact only through London Dispersion Forces (van der Waals interactions); such interactions are significantly weaker than H-bonding interactions. Less energy (lower temperature) is needed to knock them apart. Boiling point would be lower.

Q4: Two neutral molecules of similar size will begin to repel each other when …

☐ A. They are dissolved in a polar solvent, like water

■ B. They are closer that the sum of the van der Waals radii

☐ C. They are close enough to make H-bonds with one another ☐ no idea

Explain the logic behind your answer:

The van der Waals radius of a molecule is the distance at which attraction and repulsion are balanced. As the molecules move closer than the sum of their van der Waals radii, the positive charges of the nuclei (as well as the negative charges of the electrons) begin to repel one another.

Q5: Bonds between atoms with significantly different electronegativities are polar because:

☐ A. The electrons associated with the bond are shared equally

■ B. The electrons associated with the bond spend more time in the vicinity of the more electronegative atom.

☐ C. The electrons associated with the bond spend more time in the vicinity of the less electronegative atom

☐ D. The distribution of electrons is not involved in bond polarity ☐ no idea

Explain, what makes all of the wrong answers wrong.

Because the atoms are of different electronegativities, the electrons are not shared equally - they will tend to spend time around the more electronegative atom.

All of the wrong answers ignore and misinterpret electron distribution with respect to differential electronegativity.

Q6: Consider the following set of reactions. A+B ⇆ C+D is thermodynamically unfavorable, while C+E ⇆ F is highly thermodynamically favorable.

Both reactions rapidly reach equilibrium. We compare two reaction systems.
At the start of the experiment flask 1 contains [A] = 1M , [B] = 1M, and [C] = 0.5 M,
while flask 2 contains [A] = 1M, [B] = 1M, and E = [0.5 M]
After the two reaction systems reach equilibrium which is the expected result.

■ A. There is more D in flask 2 □ B. There is more D in flask 1

□ C. There is the same amount of D in the two flasks □ no idea

Explain the logic behind your answer.

In flask 2, the thermodynamically favorable reaction will generated E, which can then react with C. This will lead reaction to move toward the products, producing more D.

Q7: PICK THE <u>WRONG</u> ANSWER: Compared to H-bonding interactions, van der Waals interactions …

□ A. are non-directional □ no idea

■ B. occur only when molecules contain atoms with different electronegativities

□ C. occur between all molecules, regardless of their atomic composition

Explain why the incorrect answer is wrong.

van der Waals interactions (due to London Dispersion Forces) occur between all atoms (and molecules), because there is a separation between positive and negative charges in atoms. There is no necessity for the formation of polarized bonds.

Q8: A cell generates ATP using a plasma membrane-associated H+ gradient. ATP hydrolysis is coupled to the movement of Na+ out of the cell and K+ into the cell. Other channels permit Na+ and K+ to leak slowly through the membrane. What will happen to intracellular [Na+] and [K+] when a drug is added that allows H+ to pass freely through the plasma membrane?

□ A. Nothing, the process depends on ATP, Na+ and K+

■ B. cytoplasmic [Na+] will increase while cytoplasmic [K+] will decrease

□ C. cytoplasmic [Na+] changes while cytoplasmic [K+] remains constant

□ D. impossible to predict □ no idea

Explain the logic of your choice.

van der Waals interactions (due to London Dispersion Forces) occur between all atoms (and molecules), because there is a separation between positive and negative charges in atoms. There is no necessity for the formation of polarized bonds.

Q9: A channel in a membrane is like a catalyst in that it …

■ A. decreases the free energy needed to pass through the membrane ☐ no idea

☐ B. changes the structure of the molecule passing through the membrane

☐ C. increases the speed at which molecules collide with the membrane

☐ D. increases the size of the gradient between inside and outside of the cell

Explain the logic behind your answer:

Both reduce the free energy required for the associated reaction. In the case of a channel protein, that reaction is to move from one side of the membrane to the other.

Q10: PICK THE <u>WRONG</u> ANSWER: The plasma membrane of a cell …

☐ A. Provides a barrier between the cytoplasm of the cell and its environment ☐ no idea

☐ B. Helps cells maintain a non-equilibrium state

☐ C. Is likely to be homologous to the membrane present in the first living organism on earth.

■ D. Likely evolved multiple times independently

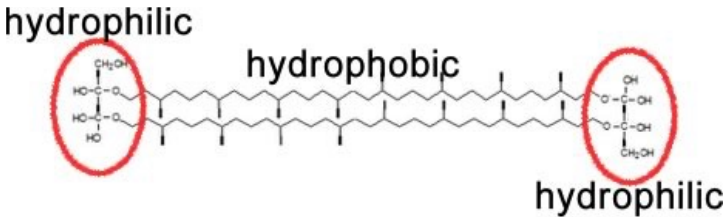
Explain, what makes the WRONG answer wrong.

Because of the similarities in membrane (and lipid structures) it is likely to have been inherited from a common ancestor. If so, it evolved once.

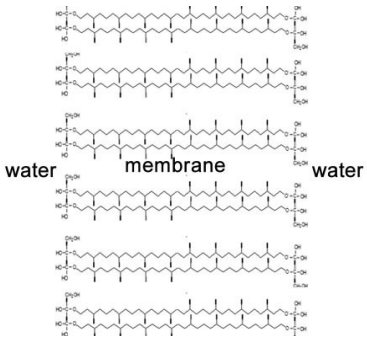
Q11: Here is a type of lipid, somewhat different from the typical lipid.

Part A (2 POINTS) Explain why it could reasonably classified as a lipid.

☐ no idea



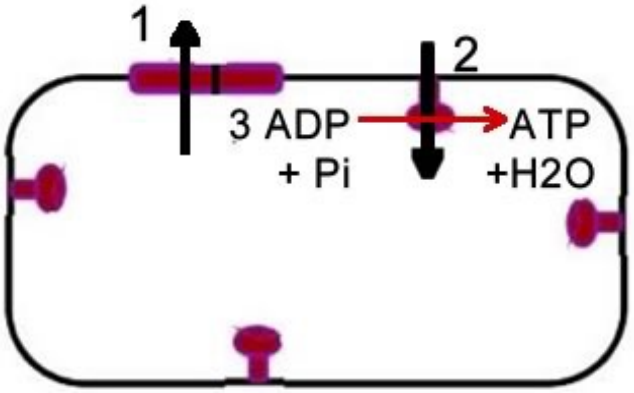
Part B (3 points): You disperse these molecules in water; draw a stable structure they might form and explain the logic behind your prediction. Use a simple schematic to represent the molecule.



Q12: Here is a diagram of the photosynthetic prokaryote *Halobium;*

1) indicate the direction in which H+ ions move in response to light
2) indicate the direction in which H+ ions move when ATP is synthesized
3) indicate where ATP synthesis occurs

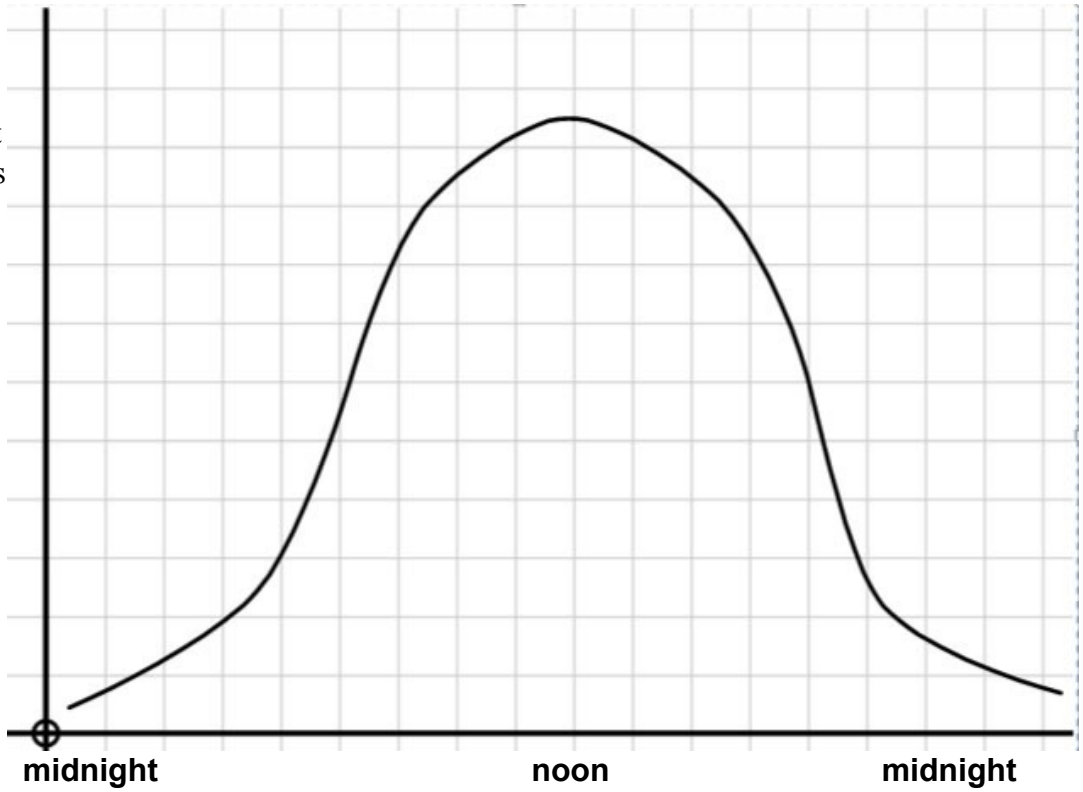
☐ no idea



Q13: You measure the rate of ATP synthesis in Halobium: you start taking measurements beginning at midnight and continue through an entire day (until midnight of the next day).

Draw the graph of the **rate of ATP synthesis** as a function of time.

☐ no idea



Explain how your graph will change if, at noon, you add a drug that makes the membrane of the cells freely permeable to H+.

The rate of ATP synthesis would drop to zero after the addition of the drug because ATP synthesis is driven by the H+ gradient. Addition of the drug leads to the rapid loss of the H+ gradient.

Q14. **If genetic information were encoded in the living structure of cells, rather than in the nucleotide sequences within DNA molecules, Griffith's studies on the transformation in bacteria ..**

☐ A. would have produced exactly the same result

■ B. would not have worked at all

☐ C. would have identified proteins as the genetic material ☐ no idea

Explain (below) why the <u>correct</u> answer is correct

The fact that information persisted after death (in a molecular form) is essential for the experimental results observed. In what molecular form that information was in was not addressed. (It was addressed later through the use of enzyme that differentially digested nucleic acids, proteins, or other molecules).

Q15. **In his studies, Griffith found that S-strain (smooth + virulent) bacteria grown in culture very occasionally gave rise to R-strain (rough + avirulent) bacteria (a change from S → R).**
Can you predict the relative frequency of a R → S mutation rate?

☐ A. The same as the S → R rate ☐ B. Much higher than the S → R rate

■ C. Much lower than the S → R rate ☐ D. impossible to say ☐ no idea

Explain the logic of your answer

If we think about genes, their products, and the effects of mutations, there are many ways to break (inactivate) a gene product through mutation (S to R) , but a very much smaller number of ways in which a mutation can lead to the reversal of that process (R to S).

Q16: A mutation occurs that leads to higher mutation rates in actively dividing cells, but which has no obvious effect on DNA in non-dividing cells. You would be justified in assuming that the original mutation inactivated ...

☐ A. DNA-dependent DNA polymerase

■ B. DNA polymerase's proof-reading activity

☐ C. DNA-dependent, RNA polymerase (primase)

☐ D. the repair of mutations due to the demethylation of C's ☐ no idea

Explain the logic behind your answer:

B and D would both increase the mutation rate, the effect of a mutation in the mutation repair system would be found in all cells, whether or not they were replicating their DNA. The effects of a mutation in the proof-reading activity would be restricted to cells that are actively replicating their DNA.

Q17: PICK THE WRONG ANSWER: Which of the following statements is correct about DNA replication?

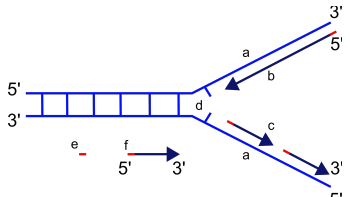
☐ A. DNA synthesis of the daughter strand always proceeds from 5' to 3' ☐ no idea

■ B. DNA synthesis of the daughter strand always proceeds from 3' to 5'

☐ C. DNA synthesis can occur in either direction depending on which strand is to be replicated

Explain the logic behind your answer (Hint: Draw a picture with labels and arrows indicating synthesis directionality for full credit) ...

And that is just the way it goes!



Q18: The YUM gene is normally expressed only in the skin cells of an organism. In your studies, you discover a mutant allele that leads to the expression of the normal YUM gene product in all cells of the organism. Which is the most plausible explanation?

■ A. the mutation is in the regulatory region of the YUM gene ☐ no idea

☐ B. the mutation is within the coding region of the YUM gene

☐ C. the mutation alters DNA synthesis, leading to defect in primer synthesis

Explain the logic behind your answer

The sequence of the gene's regulatory region (together with which transcription factors) are expressed will determine where and when a gene is expressed. In this case, you might predict a negative regulatory protein normally blocks YUM expression outside of skin cells.

Q19: As the percentage of GC in a double-stranded DNA molecule increases, what would you be completely and totally confident will occur?

☐ A. The rate of DNA synthesis will increase ☐ no idea

☐ B. The mutation rate will increase

☐ C. The separation of two strands of the DNA molecule, due to thermal motion, will increase

■ D. The percentage of A in the DNA would decrease

Explain the logic behind your answer

Because the total percentage of nucleotides is 100%. If G increases C will increase (due to base pairing), leading to an increase in GC relative to AT, so percentage of A will decrease.

Q20: A mutation occurs that leads to very high numbers of single stranded breaks in the replicated strands of a double-stranded DNA molecule, but with no obvious effects on the parental strands. A plausible model for this effect would be to assume that the mutation inactivated ...

☐ A. the proof-reading activity associated with DNA polymerase

■ B. the DNA ligase

☐ C. DNA-dependent, DNA polymerase

☐ D. topoisomerase I ☐ no idea

Explain the logic behind your answer:

In the absence of ligase activity, the primer initiated strands will be not joined together, the results will be lots of single strand breaks in the replicated DNA strand.