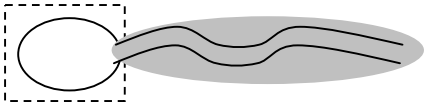
Solutions for 7.012 Quiz I

Class Ave = 83
Standard Dev = 12

Approximate grade	Range	%
A	90 - 100	34%
B	78 - 89	38%
C	60 - 77	23%
D	48 – 59	3%
F	0 – 47	2%

Question 1 (29 points)

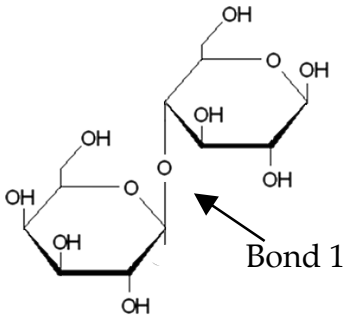
a) To the right is an iconic view of a phospholipid molecule. 

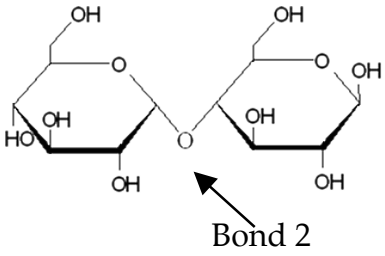
- List the atoms that are found in the shaded region of this molecule. Describe the properties associated with this region.
  C and H. These two atoms form non-polar covalent bonds and this region is very hydrophobic.

- List two atoms that are found in the boxed region BUT NOT in the shaded region of this molecule. Describe the properties associated with this region.
  O, P or N. These atoms form polar covalent bonds and this region is hydrophilic..

- Phospholipids can arrange in the form of a lipid bilayer, which is the basis of the cell membrane. The membrane has many embedded proteins. List **three** amino acids whose side chains could be exposed to the part of the membrane formed by the shaded regions of the phospholipids. *Note that a chart of the amino acids is found on the final page of this exam.*
  Ala, gly, ile, leu, met, phe, pro, trp, or val

b) Below are two molecules that have the same chemical formula: C12H22O11.





i) Each of these molecules could be described as… (circle all that apply):

a monosaccharide an amino acid a nucleotide [a disaccharide]

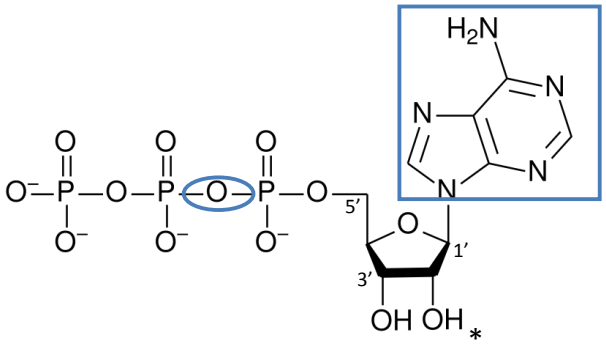
ii) Prototrophs can use these molecules as the only carbon source in minimal media. The prototrophs use these molecules as… (circle all that apply):

[a source for generating ATP through glycolysis] a monomer (building block) of DNA

[a source for carbon atoms in macromolecules] a monomer (building block) of protein

c) These two molecules have the same chemical formula and a 1-4 glycosidic linkage. Enzyme X can cleave bond 1 but not bond 2. Explain why enzyme X specifically cleaves bond 1 but not bond 2.
The stereochemistry of these two molecules is different, which means that they have different shape. Each enzyme has a binding pocket that is exquisitely specific for its substrate, thus the binding pocket of enzyme 1 will not accommodate the molecule on the left.

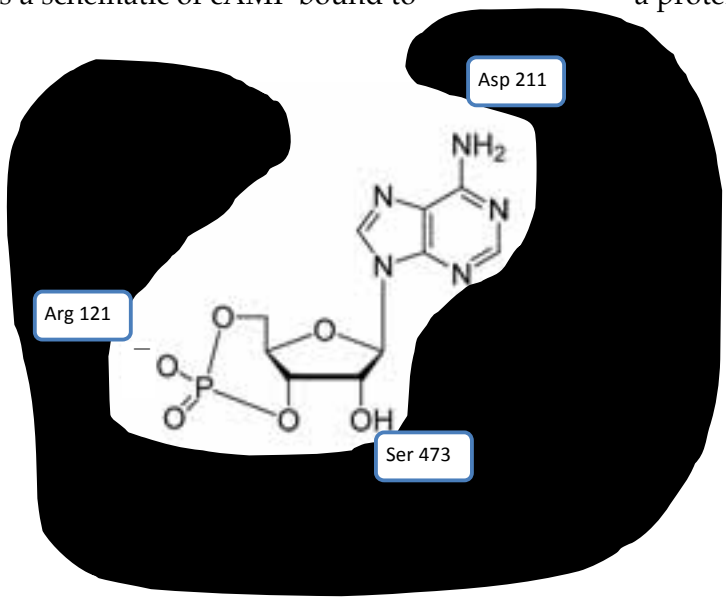
Question 1, continued
Below is the structure of ATP.



d) On your drawing above…

- **label** the 1′, the 3′ and the 5′ carbons.
- **circle** the bond that is broken when this monomer is added to a growing RNA polymer.
- **Star** the part of this molecule that distinguishes it as a building block of RNA and not DNA.
- **Box** the part of this molecule that can form hydrogen bonds with the complementary base, which is *Uracil* .

In some cells, ATP is converted to 3′-5′ cyclic adenosine monophosphate (cAMP) which is used as a signaling molecule. Below is a schematic of cAMP bound to a protein.

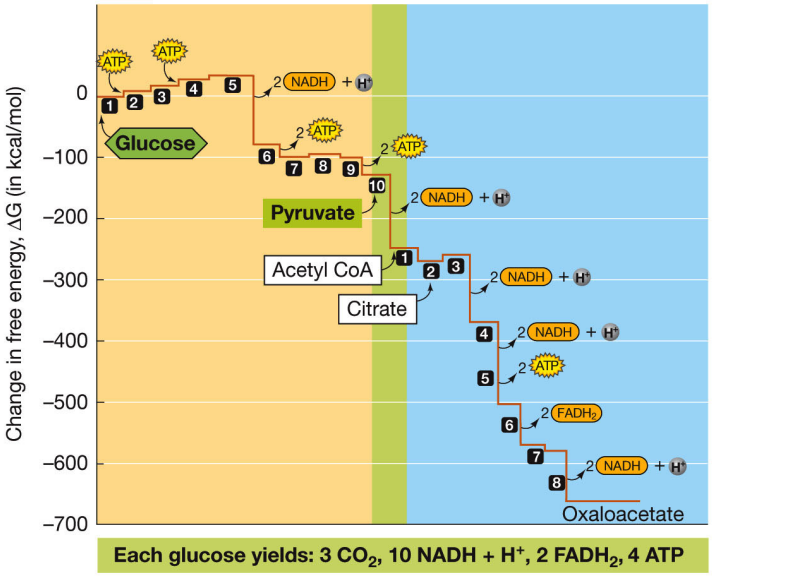


e) What is the strongest possible interaction between the side chains of the amino acids listed below and cAMP? Choose from covalent bonds, van der Waals forces, ionic bonds, and hydrogen bonds.
Note that a chart of the amino acids is found on the final page of this exam.

Position	strongest interaction
Arg 121	*Ionic bond*
Ser 473	*hydrogen bond*
Asp 211	*hydrogen bond*

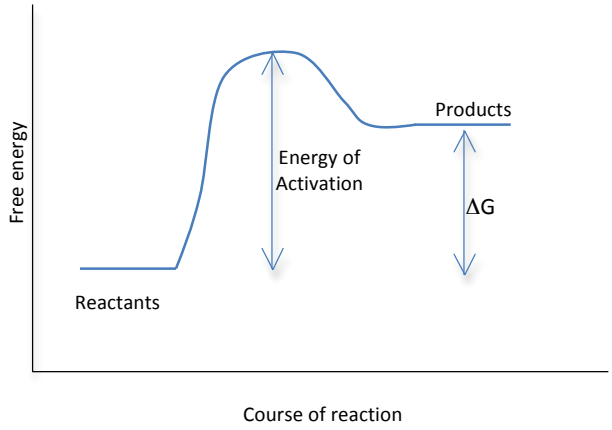
Question 2 (20 points)

Below is a representation of the energy profile for all the steps in glycolysis and the Citric acid cycle.



LIFE 8e, Figure 7.7

a) Draw an energy profile for the reaction **in glycolysis** that converts intermediate 4 to intermediate 5 on the axes below. Label the axes and indicate the products, the reactants, ΔG and the energy of activation.



b) The diagram indicates that glycolysis and the citric acid cycle produce:

3 CO_2, 10 NADH (+ H^+), 2 $FADH_2$, and 4 ATP.

You learned that respiring cells produce about 36 ATP per glucose molecule, not 4.

- What is the name of the process that occurs after glycolysis and the citric acid cycle and generates the additional ATP?
  Oxidative phoshorylation

- A net of 4 ATPs per glucose molecule provides sufficient energy for the survival of the cell. Explain why a cell that cannot complete the process given above will not survive.
  Glycolysis and the citric acid cycle require NAD^+ as an electron carrier. The NAD^+ is regenerated from the NADH (+ H^+) produced in glycolysis and the citric acid cycle when NADH donates an electron to the first protein in the electron transport chain.

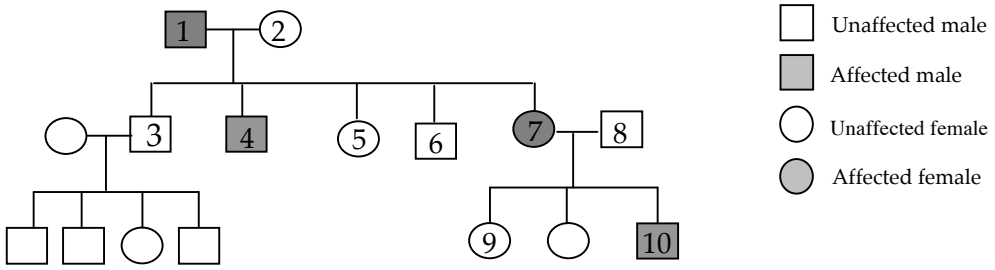
Question 2, continued

c) An enzyme may alter some or all of the following parameters. For each choose whether the enzyme would "increase" or "decrease" that parameter. If the enzyme does not affect that parameter, write "no change".

Parameter	Effect of enzyme
Free energy of the products	*no change*
Rate of forward reaction	*increase*
Rate of reverse reaction	*increase*
Energy of activation	*decrease*
Overall free energy change	*no change*

Question 3 (21 points)

You are studying a genetically inherited disease. The pedigree for a family with this disease is shown below. This disease occurs at a high frequency in the population, and shows complete penetrance.



a) Circle all **mode or modes** of inheritance that could be possible.

Autosomal dominant Autosomal recesive X-linked dominant

X-linked recessive Y-linked

b) Now assume that individual 2 does **not** carry any alleles associated with the disease.

- Does your answer to (a) above change? If so, how?
  Yes, if individual 2 does not carry an allele associated with the disease, the only mode of inheritance possible is autosomal dominant.

- If individual 2 does **not** carry any alleles associated with the disease, give all possible genotypes for the individuals below. Use the *symbols* X^A, X^a, *Y, A or a* where appropriate. In each case, use the upper case letter to indicate the allele associated with the dominant phenotype.

  What are all the possible genotypes for individual 3? *aa*

  What are all the possible genotypes for individual 4? *Aa*

  What are all the possible genotypes for individual 5? *aa*

Question 4 (30 points)

There are many traits in Laborador retriever dogs whose mode of inheritance is well understood.

- Assume the coat color can be black, brown or cream, and the color is determined by three alleles of the C gene, C^{black}, C^{brown}, and C^{cream}
- Assume the head shape can be broad or narrow, and the head shape is determined by two alleles of the H gene, H or h.

You have three true-breeding lines of dogs:

PI: black color with broad head
PII: brown color with narrow head
PIII: cream color with narrow head

Experiment 1: You cross a PI dog to a PII dog. All of the F1 dogs are black and with narrow heads.

Experiment 2: You cross a PI dog to a PIII dog. All of the F1 dogs are black with narrow heads.

a) Give the genotype of the three parental dogs in these crosses.**Note use the notation given above. Use **H** to indicate the allele associated with the dominate head trait and **h** to indicate the allele associated with the recessive head trait.*

PI dog: $C^{black}\ C^{black}\ hh$ PII dog: $C^{brown}\ C^{brown}\ HH$ PIII dog: $C^{cream}\ C^{cream}\ HH$

b) You cross a female F1 dog from experiment 1 and male F1 dog from experiment 2.
In the Punnett square started below, give the genotypes for the gametes produced by the F1 female and the F1 male dog assuming classic Mendelian inheritance. You do not need to fill in the shaded boxes, but may do so as an aid for part (c).

Gametes from female F1 from exp. 1→ Gametes from male F1 from exp. 2 ↓	$C^{black}\ H$	$C^{black}\ h$	$C^{brown}\ H$	$C^{brown}\ h$
$C^{black}\ H$				
$C^{black}\ h$				
$C^{crean}\ H$				
$C^{crean}\ h$				

c) If the ratio of phenotypes seen in the offspring from this cross were as follows:

9 black with narrow heads	3 black with broad heads	3 brown with narrow heads	1 brown with a broad head

You could conclude that…

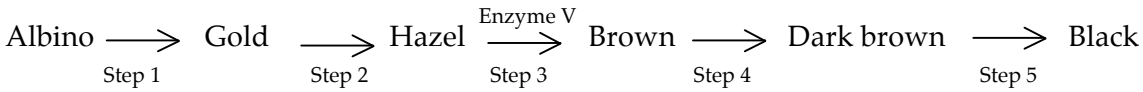
Black is *Dominant* to brown (choose from dominant, recessive, not enough information)

Black is *Dominant* to cream (choose from dominant, recessive, not enough information)

Cream is *Recessive* to brown (choose from dominant, recessive, not enough information)

Question 4, continued

In hypothetical further studies, you discover the pathway for eye color in dogs is as follows:



There are five enzymes involved in this pathway, enzymes V-Z, where enzyme V is encoded by gene V enzyme W is encoded by gene W, *etc*. Each arrow represents the action of a unique enzyme, and the step catalyzed by enzyme V is step 3.

d) Below are the genotypes and phenotypes of some **double** mutant dogs. (V^- indicates a mutation in the gene encoding enzyme V. X^- indicates a mutation in the gene encoding enzyme X.)

Genotype of dog	Phenotype
$V^-V^-X^-X^-$	Hazel
$W^-W^-X^-X^-$	Gold

- Which step or steps could be catalyzed by enzyme X? *Steps 4 or 5.*
- Which step or steps could be catalyzed by enzyme W? *Step 2*

e) You also examine the inheritance of webbed feet and big ears. You do the following cross:
a dog with webbed feet and big ears (FFee) X a dog with normal feet and small ears (ffEE).
The F1 dog has webbed feet and small ears. You do a test cross with an F1 dog and find the F and E genes are linked.

i) Fill in genotype for the other parent in the test cross:

FfEe X *ffee*

ii) Only part of the data is given below. Complete the table by giving the four genotypes and the associated phenotypes you could have seen in the 100 progeny.

Genotype	Phenotype	Number of each type
Ffee	*Webbed feet big ears*	46
ffEe	*normal feet small ears*	46
FfEe	*Webbed feet small ears*	4
ffee	*normal feet big ears*	4

iii) What is the recombination frequency between the foot gene and the ear size gene?

8/100 = 8%