

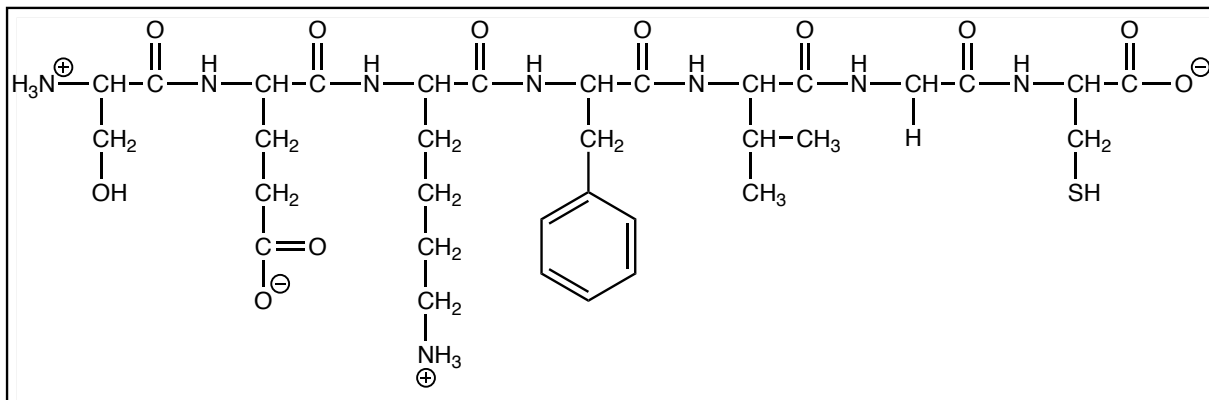
Name \_\_\_\_\_ Rec. Section \_\_\_\_\_ TA \_\_\_\_\_

**7.012 Fall 2018: Problem Set 1****Due: Mon 9/17/2018**

The solutions to these problems must be submitted electronically to your TA through the 7.012 Stellar site. All submissions must be received before 9:50 AM on September 17, 2018. Check your file to ensure it was successfully submitted. Only the material that is received prior to the deadline will be graded, no additional material will be accepted after the deadline.

**Question 1 (4.5 points)**

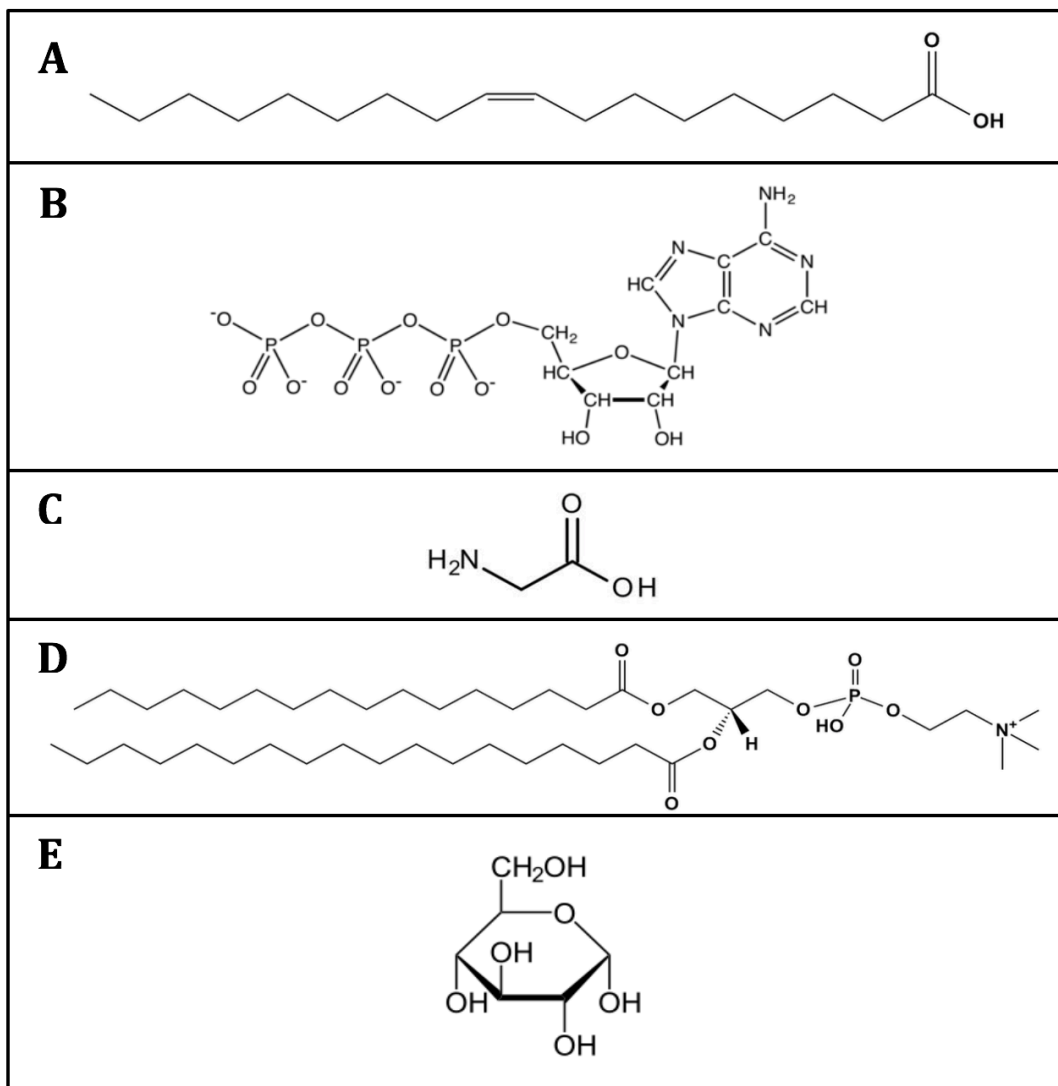
Please answer the questions (A-G) below. No explanation is required.



- A.) What kind of a macromolecule is shown above?
- B.) Name all the monomeric units starting from the amino terminus of the molecule.
- C.) Which of the monomeric units would be more likely to be found in the core of a lipid bilayer?
- D.) Which level of structure is shown for this molecule: primary, secondary, tertiary or quaternary?
- E.) Mark with an asterisk a side chain of a monomer that as drawn can participate in an electrostatic interaction.
- F.) Mark with a double arrow a side chain of a monomer that can participate in a hydrogen bond.
- G.) If the macromolecule was at pH=1, name the monomeric units whose side chains would have a different charge from the charge that is drawn (if any).

**Question 2 (2 points)**

Please answer the questions (i-vii) below. No explanation is required.



i.) Which molecule(s) from above, if any, can be added to grow the macromolecule polymer shown in question 1?

ii.) To which end of the macromolecule from question 1 would a new unit be added?

iii.) Which molecule(s) from above, if any, is generated during glycolysis?

iv.) The polymers of which macromolecule(s) shown above, if any, are stabilized by hydrogen bonds?

v.) Which molecule(s), if any, forms a cell's lipid bilayer?

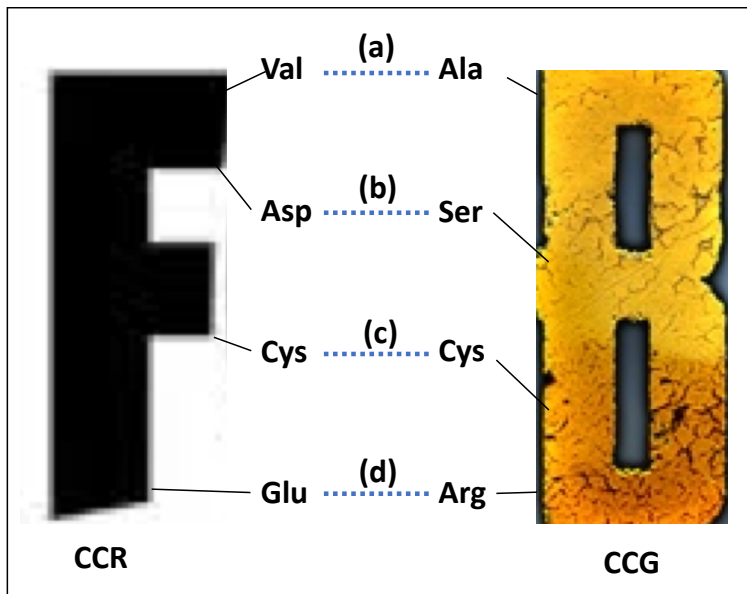
**Question 2, continued**

vi.) Which molecule(s) from above, if any, is a building block for DNA?

vii.) Which molecule(s) from above, if any, does not make a covalent bond to bring together its monomers for its biological function?

**Question 3 (4 points)**

Two bovine proteins Cortnite: Cattle Royale (CCR) and Clayerunknown's Cattlegrounds (CCG) interact at the amino acid residues shown in the diagram below. An amino acid structure chart can be found on the last page.



A.) For each interaction, indicate the strongest type of bond and/or interaction that the two residues can form in the table below and rank the interactions (a – d) according to their strength 1 being the strongest and 4 being the weakest.

Interaction	Type of interaction (hydrogen bond, covalent bond, hydrophobic, electrostatic)	Strength of interaction (1 – 4)
a		
b		
c		
d		

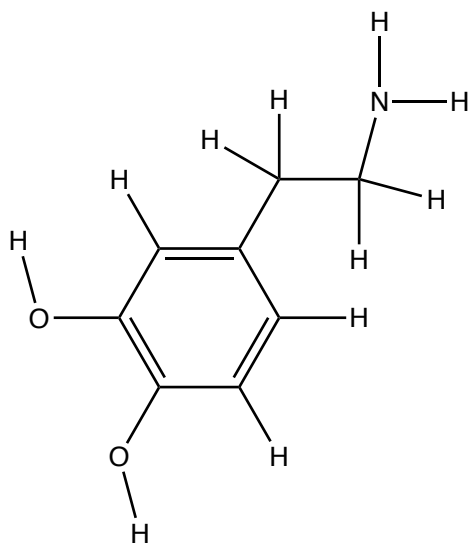
**Question 3, continued**

B.) The following mutations have been made in the CCR and CCG proteins. Predict whether the two proteins will still interact at this site, and if so, whether the change will lead to an interaction that is similar in strength, stronger or weaker.

Interaction	Mutation in CCR	Mutation in CCG	Type of interaction (hydrogen bond, covalent bond, hydrophobic interaction, electrostatic interaction, none)	Strength compared to original interaction (similar, stronger or weaker)
a	Val -> Thr	Ala -> Ser		
b	Asp -> Ile	Ser -> Ala		
c	Cys -> Met	Cys -> Met		
d	Glu ->Gln	No change		

**Question 4 (3 points)**

A.) Circle the polar bonds in the neurotransmitter dopamine below. Electronegativity values for the following atoms are: 2.20 for H, 2.55 for C, 3.04 for N, and 3.44 for O.



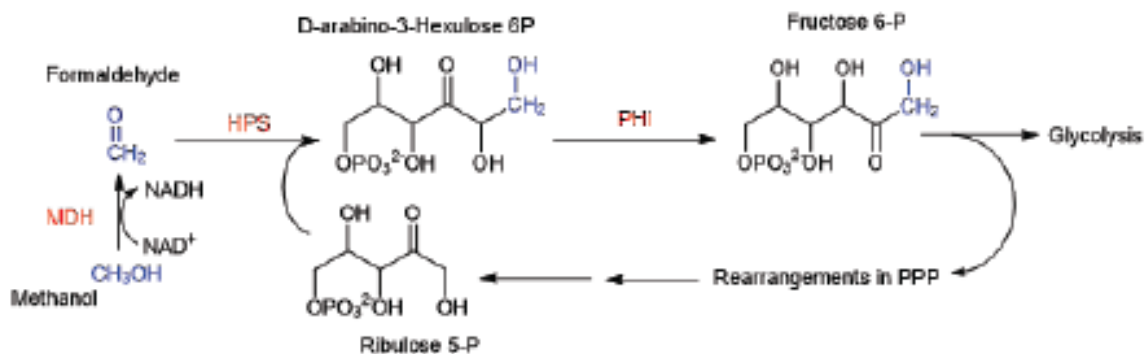
B.) The carbon–hydrogen bonds are nonpolar. Briefly explain why.

**Question 5 (3.5 points)**

Label the following statement as True or False. Briefly explain your answer.

- A.) Enzymes work by changing  $\Delta G$  for the reaction to be more favorable.
- B.) The magnitude of the activation energy barrier determines whether the reaction will be exergonic (spontaneous).
- C.) Exergonic reactions are always fast.
- D.) For an enzymatic reaction that has an equilibrium constant that is greater than one,  $\Delta G^\circ$  is always negative.
- E.) A reversible enzymatic reaction at equilibrium is still making product.
- F.) An endergonic enzymatic reaction can be driven forward by coupling it to an exergonic reaction like the hydrolysis of ATP.
- G.) The direction of a reversible enzymatic reaction can be shifted by adding product.

## Question 6 (3 points)



Three enzymes: MDH, HPS, and PHI (shown in red in the diagram above) have been engineered into an organism that you name *Methallica*, in the hopes of providing the organism with the ability to grow on methanol by the pathway shown. However, the pathway shown above does not appear to be working well as the organism does not appear to be growing well on methanol. Troubleshoot what the problem might be.

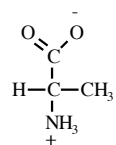
A.) Name a possible problem with step 1 (the MDH step) and a possible fix.

B.) Name a possible problem with step 2 (the HPS step) and a possible fix.

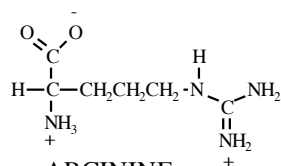
C.) You discover that adding more ribulose 5-P leads to a significant improvement in growth on methanol. This result may or may not change your thinking about the problem with your pathway design. Circle all possible problems with the designed pathway that are consistent with the ribulose 5-P finding.

- i.) There was too much flux toward glycolysis and not enough toward ribulose 5-P at the pathway branch point
- ii.) The build-up of formaldehyde, which can be toxic, was limiting cell growth
- iii.) The choice of HPS was not good; it had a low affinity for ribulose 5-P
- iv.) The pathway was subject to feedback inhibition by ribulose 5-P
- v.) The pathway design should have included an enzyme to make additional ribulose 5-P

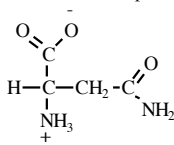
### Amino Acid Structures at pH 7



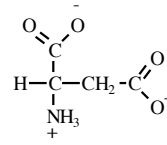
ALANINE  
(ala)



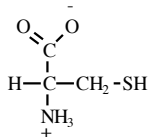
ARGININE  
(arg)



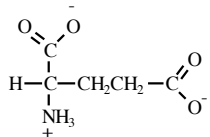
ASPARAGINE  
(asN)



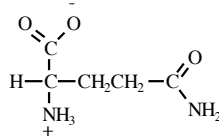
ASPARTIC ACID  
(asp)



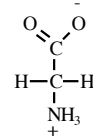
CYSTEINE  
(cys)



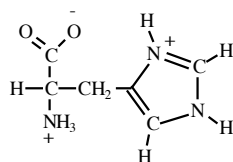
GLUTAMIC ACID  
(glu)



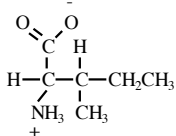
GLUTAMINE  
(gln)



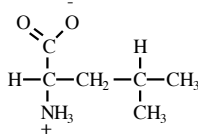
GLYCINE  
(gly)



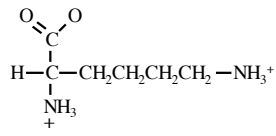
HISTIDINE  
(his)



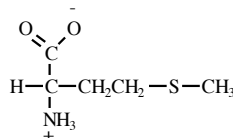
ISOLEUCINE  
(ile)



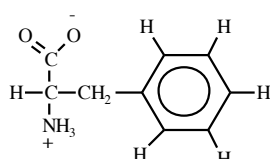
LEUCINE  
(leu)



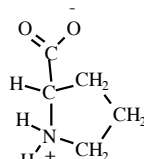
LYSINE  
(lys)



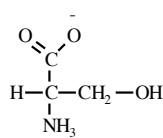
METHIONINE  
(met)



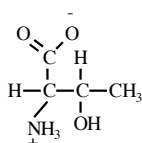
PHENYLALANINE  
(phe)



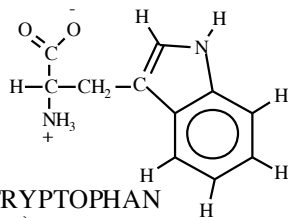
PROLINE  
(pro)



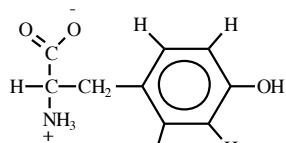
SERINE  
(ser)



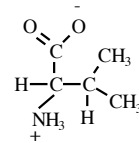
THREONINE  
(thr)



TRYPTOPHAN  
(trp)



TYROSINE  
(tyr)



VALINE  
(val)