

7.012 Practice Quiz 1

Actual Quiz 1 (closed book) will be given **Monday 10/4** at 10:00 am
No Sections on Monday or Tuesday 10/4-10/5 (No Kidding.)

Quiz Review Session

Thursday, 9/30

7:00 - 9:00 pm

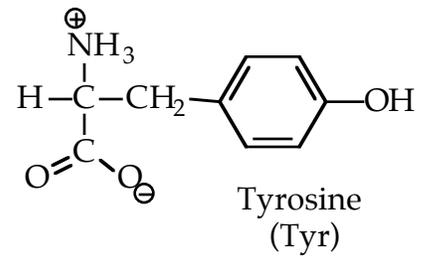
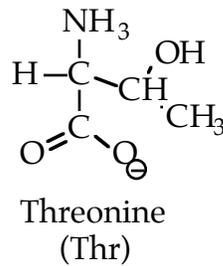
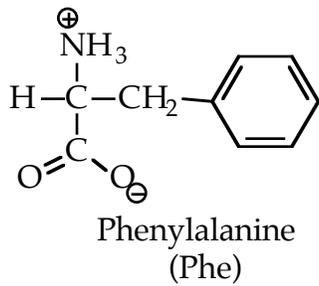
Tutoring Session

Friday, 10/1

4:00 - 6:00 pm

Question 1

Shown below are the structures of three amino acids.



Using the blanks below, rank these three in order of the hydrophobicity of their side chains.

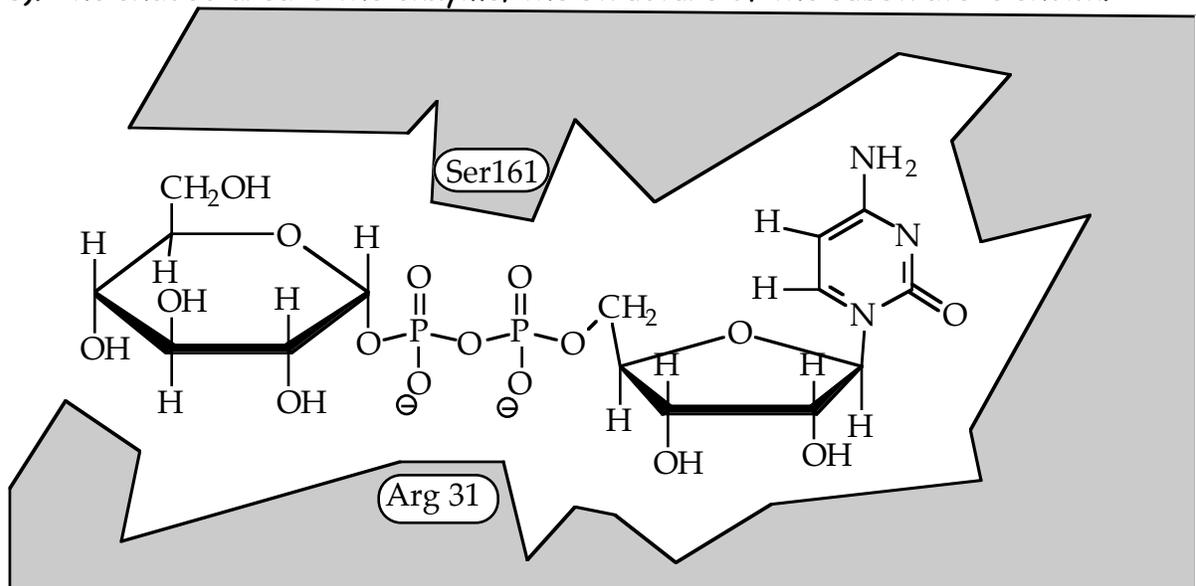
- a) **Most Hydrophobic** _____
- b) **Intermediate** _____
- c) **Least Hydrophobic** _____

d) Explain why (a) is more hydrophobic than (b).

e) Explain why (b) is more hydrophobic than (c).

Question 2

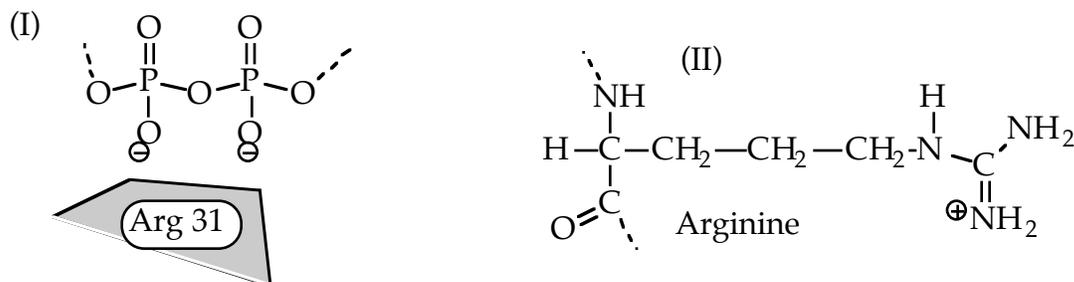
Shown below is a close up of a substrate (UDP-Glucose) bound to the active site of an enzyme (UTase). The shaded area is the enzyme; the structure of the substrate is shown.



Two amino acids of the enzyme are highlighted: Arg 31 and Ser 161.

Question 2, continued

a) Part (I) of the figure below shows the relative positions of Arg 31 and the portion of the substrate with which it interacts; part (II) shows the structure of arginine.



The side chain of Arg 31 interacts with the portion of the substrate shown previously. What type of interaction(s) is/are possible between the side chain of Arg 31 and this portion of the substrate? (circle all that apply)

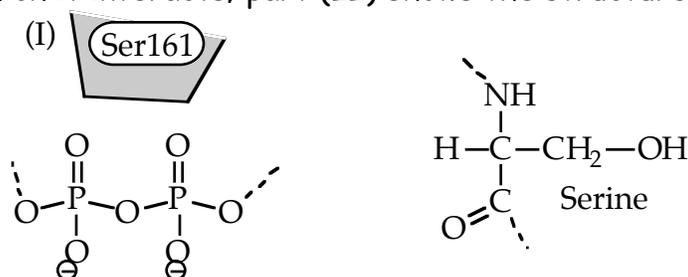
hydrophobic
interaction

Hydrogen
bond

ionic
bond

van der Waals
interaction

b) Part (I) of the figure below shows the relative positions of Ser 161 and the portion of the substrate with which it interacts; part (II) shows the structure of serine.



i) The side chain of Ser 161 interacts with the portion of the substrate shown above. What type of interaction(s) is/are possible between the side chain of Ser 161 and this portion of the substrate? (circle all that apply)

hydrophobic
interaction

Hydrogen
bond

ionic
bond

van der Waals
interaction

ii) The side chain of Ser 161 interacts with the region of the substrate shown above. Draw the structure of Ser 161 and the relevant portion of the substrate as they would interact with each other. Be sure to indicate:

(1) the interaction (use a dotted line)

(2) the places where Ser 161 connects with the backbone of the protein

Question 2, continued

c) Suppose that you are studying the interactions between the substrate and the enzyme. It is possible to make variant enzymes that differ from the one above by a single amino acid substitution. (For example, Asp 78 could be replaced with tryptophan). You could use this technique to investigate the roles of each amino acid shown above.

i) If you change Arg 31 to a lysine, would you predict that the substrate still binds, or that the substrate now fails to bind to the altered enzyme? Explain.

ii) Choose an amino acid substitution for Ser 161.

iii) Explain the possible outcome of this change.

Note: There are many possible full-credit answers for (ii) and (iii). A table of amino acid structures can be found at the end of this exam.

Question 3

a) Briefly define the following:

Dominant:

Recessive:

Phenotype:

Genotype:

Alleles:

Homozygous:

Heterozygous:

Mendel's First Law:

Mendel's Second Law:

Haploid:

Diploid:

b) A yeast cell has the genotype AaBb, where the A and the B loci are on different chromosomes. Sketch the chromosome arrangement of this cell in meiosis I, when $2n = 4$.

Question 4

You have started a UROP in the behavioral genetics department at the University of Monterrey in Mexico. For your first assignment, your advisor asks you to figure out the genetics of a particular species of honeybee that has just been discovered- a red killer bee!

To begin your studies, you cross this true breeding red killer bee with the local true breeding blue gentle bee. The F1 progeny show the following phenotype:

54 red "feisty" bees

You have characterized the disposition as such:

gentle: will ignore humans and simply gather pollen

killer: will attack and sting without provocation

feisty: will approach humans threateningly, but will not sting

a) Write the genotypes of the F₀ parental types and the F1 progeny.

(Be sure to indicate which particular phenotype corresponds to each parental genotype.)

Use "H" and "h" as your symbols for the alleles of the gene conveying color or hue and "D" and "d" as your symbols for alleles of the gene for disposition.

F₀

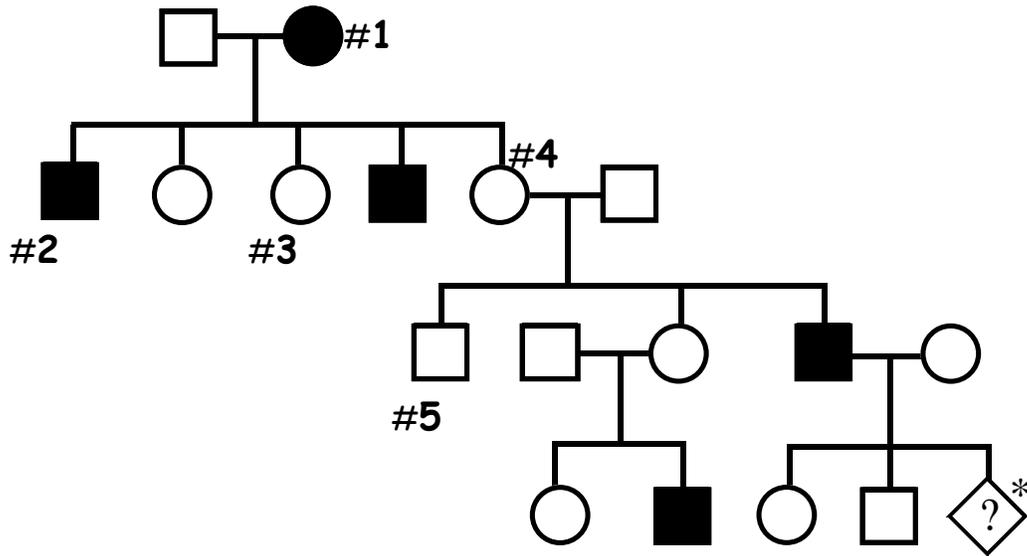
F₁

b) You want to determine if the gene for hue is linked to the gene involved in disposition. You decide to set up a test cross for the F1. Indicate the genotypes of the strains you choose for the cross:

c) Using your chosen strains indicate the ratio of genotypes and phenotypes of the progeny if the traits are NOT linked.

Question 5

In the following pedigree, assume no outsiders marrying in carry a disease allele.



a) What is the mode of inheritance of this disease? Circle one.

Autosomal dominant
Y-linked

Autosomal recessive
mitochondrial inheritance

X-linked dominant
X-linked recessive

b) Explain your choice in a). (Give two lines of reasoning.)

c) Write the genotypes of the following individuals.

(If more than one genotype is possible, write down **all** the possibilities.)

#1_____ #2_____ #3_____ #4_____ # 5_____

d) Name a disease that follows this pattern of inheritance.

e) What is the probability that the asterisked individual will be affected with the disease

if male?_____

if female?_____

Question 6

A long time ago, in a galaxy far, far away, you are a scientist. You have just joined a lab that recently published a paper in *Galactic Scientific* reporting a new microorganism named *Metachlorianus forcus*, called metachlorians. These microorganisms colonize the brains of most humanoids. However, in those who are part of the religious sect known as the Jedi, they are found in very high concentrations. In Jedi, these microorganisms secrete a protein known as Saberin. Saberin is encoded by the gene *saberin*. Saberin, when released in the brain, makes the Jedi emanate a sword known to many as a light saber. Blue is the most common light saber color amongst the Jedi.

You would like to understand this phenomenon. First, you study the metachlorians. Like present day yeast cells, the metachlorians can live in both a diploid and haploid state. Knowing this, you can now study the genetics of the light saber phenomenon.

The assay:

You mutagenize haploid metachlorians and isolate mutants altered in the light saber phenomenon. The way you are going to look for mutants is by injecting mutagenized strains into the brain of a willing Jedi, Jacensolo, who has been depleted of his own metachlorians. Because the strains you will inject are growth impaired, they stay around only long enough for Jacensolo to make one light saber. This allows you to follow the protocol shown:

- Inject mutant strain of metachlorians into the brain of Jacensolo
- Allow Jacensolo to make a light saber
- Check light saber color for non-blue colors
- Let the injected metachlorians die off
- Inject a new mutant strain

In this procedure, you isolate 10 mutants: m1, m2, m3, m4, m5, m6, m7, m8, m9 and m10. All of these mutants cause Jacensolo to create light sabers that are **not** blue.

The first thing you do is to find out how many complementation groups exist. So, you make diploid combinations between each of the mutants. You then inject these diploids into Jacensolo and see if he produces a blue (WT) light saber. The results are shown below:

	(+)= Blue light saber						(-)= non-blue light saber				
	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	wt
m1	-	-	+	+	+	+	-	+	+	-	+
m2		-	+	+	+	+	-	+	+	-	+
m3			-	+	+	-	+	-	+	-	+
m4				-	-	+	+	+	-	-	+
m5					-	+	+	+	-	-	+
m6						-	+	-	+	-	+
m7							-	+	+	-	+
m8								-	+	-	+
m9									-	-	+
m10										-	-

a) How many complementation groups exist in your collection of mutants? _____

b) How many genes have you found involved with this phenomenon? _____

c) Designate your complementation groups A, B, C, D, E, F,... and so on. (Put m1 into Group A). Which mutants are in each of your complementation groups?

Now you want to find out the order in which these genes' products are acting. You do this by constructing **haploid** metachlorians with 2 mutations. The results of this analysis are shown.

Double mutant	Sword color														
m1 m2	Red	m2 m3	Yellow	m3 m4	Yellow	m4 m5	Green	m5 m6	Yellow	m6 m7	Yellow	m7 m8	Yellow	m8 m9	Yellow
m1 m3	Yellow	m2 m4	Red	m3 m5	Yellow	m4 m6	Yellow	m5 m7	Red	m6 m8	Yellow	m7 m9	Red		
m1 m4	Red	m2 m5	Red	m3 m6	Yellow	m4 m7	Red	m5 m8	Yellow	m6 m9	Yellow				
m1 m5	Red	m2 m6	Yellow	m3 m7	Yellow	m4 m8	Yellow	m5 m9	Green						
m1 m6	Yellow	m2 m7	Red	m3 m8	Yellow	m4 m9	Green								
m1 m7	Red	m2 m8	Yellow	m3 m9	Yellow										
m1 m8	Yellow	m2 m9	Red												
m1 m9	Red														

d) What do you call this kind of analysis? _____

e) Draw the light saber color pathway below:

Example:

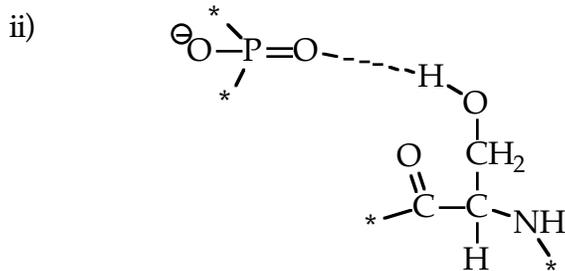


h) Luke Skywalker made a green light saber. Explain this observation in terms of the metachlorians in his body.

Solutions to Practice Quiz 1

- 1) a) most hydrophobic: phenylalanine
b) intermediate tyrosine
c) least hydrophobic threonine
- d) Phe is more hydrophobic than tyr because tyr has a hydrophilic -OH group that phe lacks (-OH can form H-bonds).
- e) tyr is more hydrophobic than thr because, although both have -OH's, tyr has more non-polar CH's than thr.
- 2) a) hydrogen and ionic bonds (vdw OK but not required).

b) i) hydrogen bond (vdw OK but not required).



(* indicates the connections to the backbone)

c) i) It should still bind because the lys is also (+) charged and can therefore still make an ionic with the (-) of the phosphate.

ii) and iii) Determine if your substitution changes the ability of the enzyme and substrate to form a hydrogen bond. If it does, is that interaction now stronger or weaker? For example, if Ser 161 was changed to Ala, the ability to form a hydrogen bond would be lost. Therefore the interaction is weaker, and you may predict that the substrate no longer binds.

3)

Dominant: Phenotype 1 is dominant over phenotype 2 if the F1 heterozygote of the two alleles shows phenotype 1.

Recessive: Phenotype 2 in the above example above is recessive. In other words, a recessive phenotype is only visible when the recessive alleles are homozygous.

Phenotype: An *observed characteristic* of an individual that develops under the influence of one or more genes and the environment. Any trait that can be measured is a phenotype.

Genotype: The description of a genetic makeup of an individual, in terms of what alleles it has for one or more genes.

Alleles: Alternative forms of a gene.

Homozygous: In a diploid organism, homozygous implies that the same allele of a given gene is carried by each of the homologous chromosomes.

Heterozygous: Different alleles of the same gene are carried by the pair of homologous chromosomes. Homozygosity and heterozygosity refers to the genotype of a given gene. An organism may be homozygous for one gene, and heterozygous for another.

Mendel's First Law: There are discrete units of inheritance that are separable in the gametes. This is also called the law of segregation.

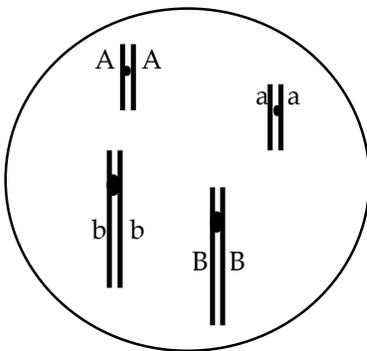
Mendel's Second Law: The law of independent assortment says that unlinked genes will segregate independently of one another.

Sex linked means that the gene is located on the X or Y chromosome. Because of this, there are distinctive patterns of inheritance.

Haploid: A cell with a chromosome complement consisting of one copy of each chromosome. Gametes are haploid.

Diploid: A cell with a chromosome complement consisting of two copies of each chromosome.

b)



4 a) Write the genotypes of the F_0 parental types and the F_1 progeny.

F_0 HHDD (red killer) X hhdd (blue gentle)

F_1 HhDd (red feisty)

b) HhDd X hhdd (the red feisty F_1 against a pure breeding blue gentle bee)

c) Using your chosen strains indicate the ratio of genotypes and phenotypes of the progeny if the traits are NOT linked.

1 red feisty (HhDd) : 1 red gentle (Hhdd) : 1 blue feisty (hhDd) : 1 blue gentle (hhdd)

Question 5

a) What is the mode of inheritance of this disease? Circle one.

Autosomal dominant

Autosomal recessive

X-linked dominant

Y-linked

mitochondrial inheritance

X-linked recessive

b) Explain your choice in a). (Give two lines of reasoning.)

all sons of affected mother are affected, but none of her daughters

many more males affected than females

disease never transmitted by father to his children

c) Write the genotypes of the following individuals.

#1 $X^d X^d$

#2 $X^d Y$

#3 $X^D X^d$

#4 $X^D X^d$

#5 $X^D Y$

d) Name a disease that follows this pattern of inheritance.

Duchenne's Muscular or Dystrophyhemophilia

e) What is the probability that the asterisked individual will be affected with the disease

if male? _____ if female? _____

*0% chance * is affected*

Question 6

(m10 has a **dominant** mutation and cannot be included in this analysis. It could in a completely different pathway. It is impossible to determine at this point.)

a) How many complementation groups exist in your collection of mutants? 3

b) How many genes have you found involved with this phenomenon? 3

c) Designate your complementation groups A, B, C, D, E, F,... and so on.

(Put m1 into Group A). Which mutants are in each of your complementation groups?

A- m1, m2, m7

B- m3, m6, m8

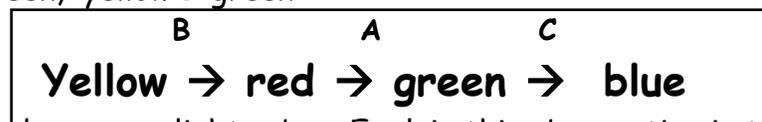
C- m4, m5, m9

epistasis

d) What do you call this kind of analysis? _____

e) Draw the light saber color pathway below: A-red, B-yellow, C-green

yellow → red, red → green, yellow → green



h) Luke Skywalker made a green light saber. Explain this observation in terms of the metachlorians in his body.

C is mutated.