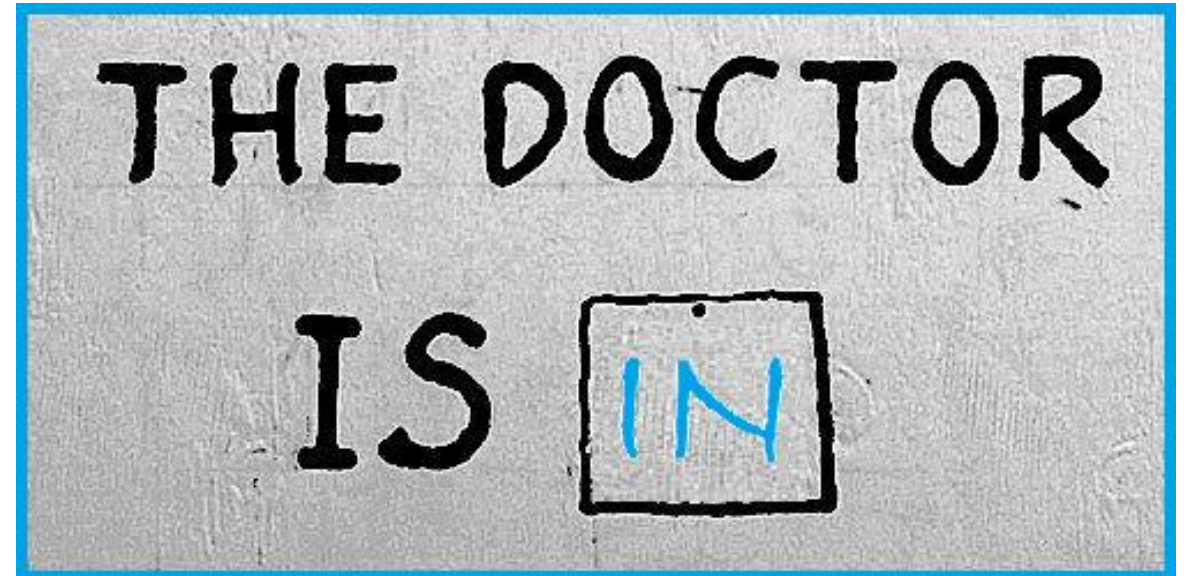


Next Step Office Hours: Biochemistry Review

- Welcome to Office Hours!
- Introduction
- What Do I Need for this Session?
- Biochem Content Review
- What Next?



Introduction to Office Hours

- Thanks for coming to Next Step Office Hours!
- If you haven't been here before, here's how it works...
- These sessions are meant to be:

Interactive

Problem-focused

Specific to your needs (so ask questions!)

- Today's focus: Review of Biochem
- Future sessions: content review, FL review
- This is NOT a lecture! You can benefit most by:

Raising your hand and speaking

Commenting in the chat box

Responding to poll questions

Before Getting Started

1. If you have a microphone, make sure it is turned on and easily available.
2. Locate the hand-raise button on the toolbar on your screen.
3. Locate the chat box on the toolbar.
4. Let me know if you're having any technical issues!

Think of your question after Office Hours are over?

- **Post on the forums!**
forum.nextstepmcat.com

Biochem Content Review

- **Overall study strategies**

 - Active learning*

 - Big-picture perspective*

 - Test-like thinking*

- **High-yield topics**

 - Enzymes & enzyme kinetics*

 - Amino acids*

 - Glycolysis*

 - Citric acid cycle*

 - Electron transport chain*

Biochem Study Strategies

Recurring theme for biochem:

Don't miss the forest for the trees!

When studying, ask yourself ...

- *Why does this matter physiologically?*
 - *Biomolecules: how does chemical structure connect to biological function?*
 - *Pathways: what does a pathway DO?*
- *What are the inputs & outputs of a pathway?*
- *How is a pathway regulated (big-picture?)*
- *Does a pathway have any especially important steps?*



Biochem Study Strategies

A big-picture approach to biochem:

How is biochem tested on the MCAT? How do you get the most bang for your buck in terms of studying?

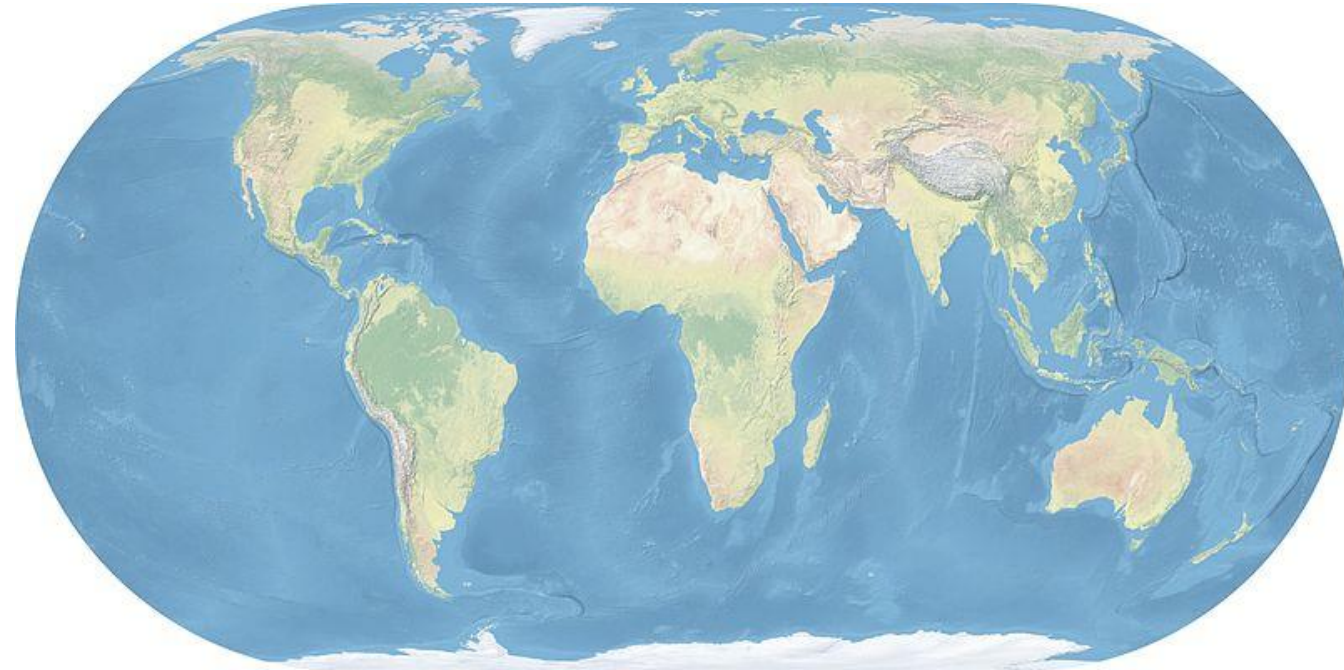
Focus on:

- *Principles*
- *Physiological function*
- *Interconnections with other subject matter*

Amino acids & acid-base chemistry

Carbohydrates & stereochemistry

Metabolism & physiology



**What have your biochem experiences been like?
What strategies work for you?**

Enzymes and Enzyme Kinetics

What do enzymes do?

- Enzymes are **biological catalysts**.
- Enzymes reduce activation energy of rxn.
- Reduced activation energy → faster rate
- What do enzymes NOT do?
- Major types of enzymes:

Oxidoreductases

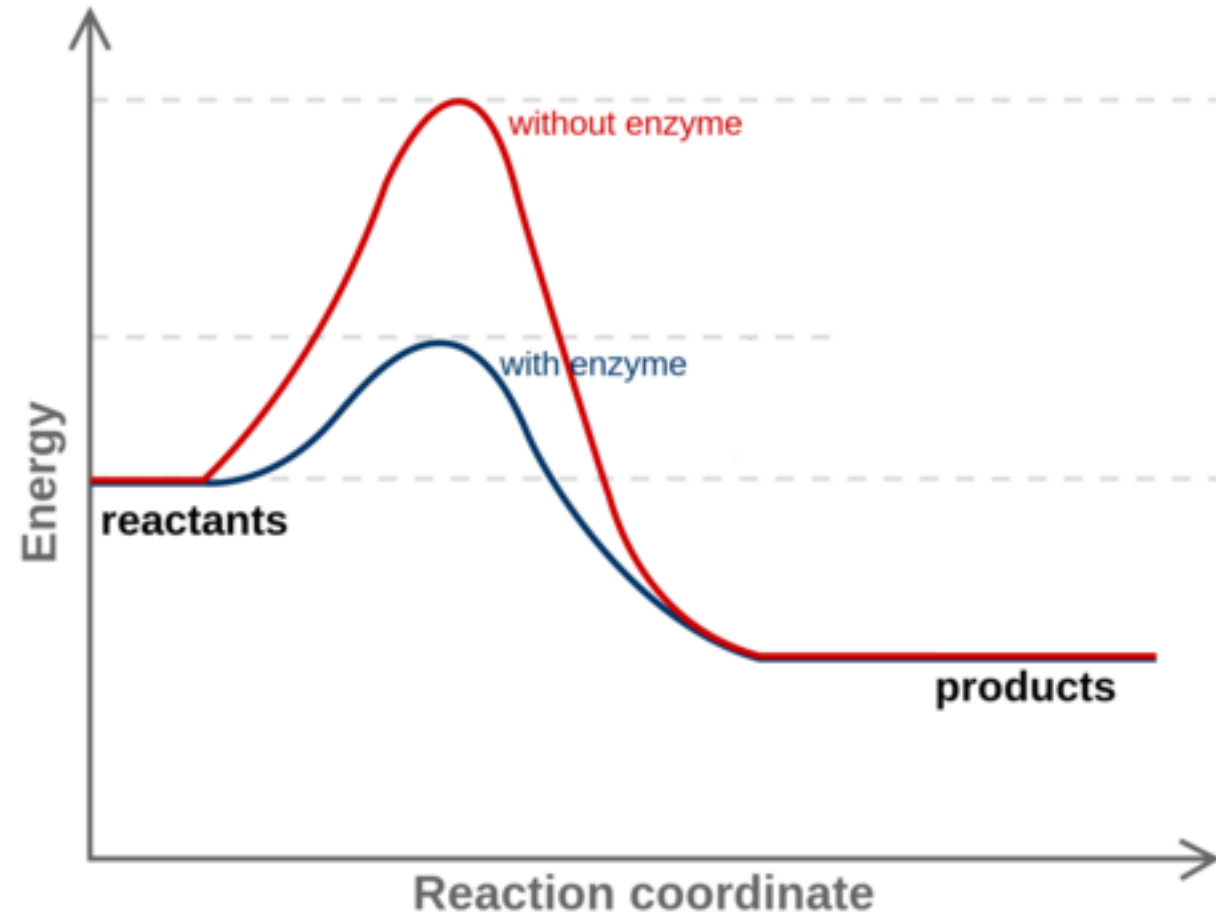
Lyases

Transferases

Isomerases

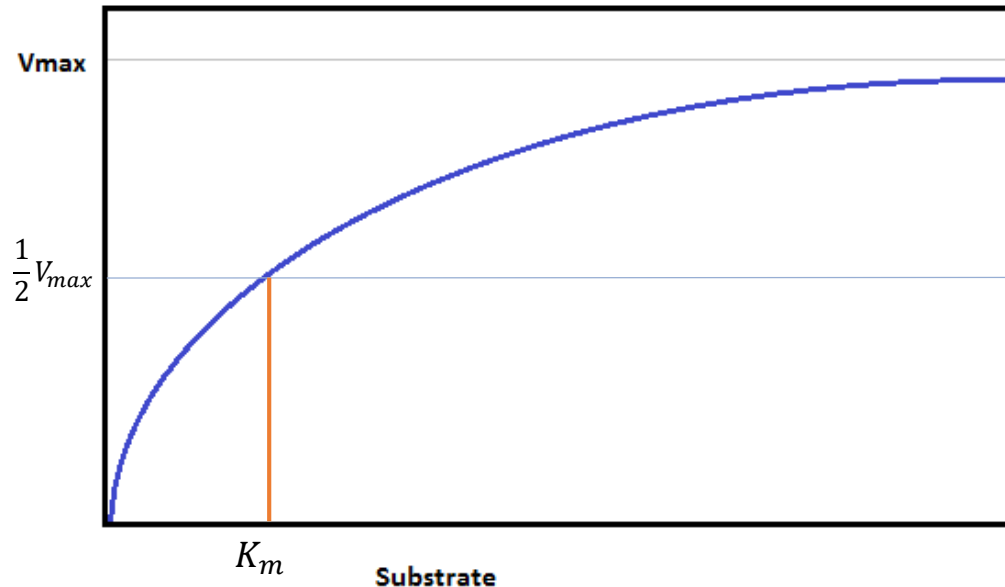
Hydrolases

Ligases



Enzymes and Enzyme Kinetics

Michaelis-Menten saturation curve



V_{max} : *the maximum rate of the reaction*

K_m : *the amount of substrate needed for the enzyme to work half as fast as it can*

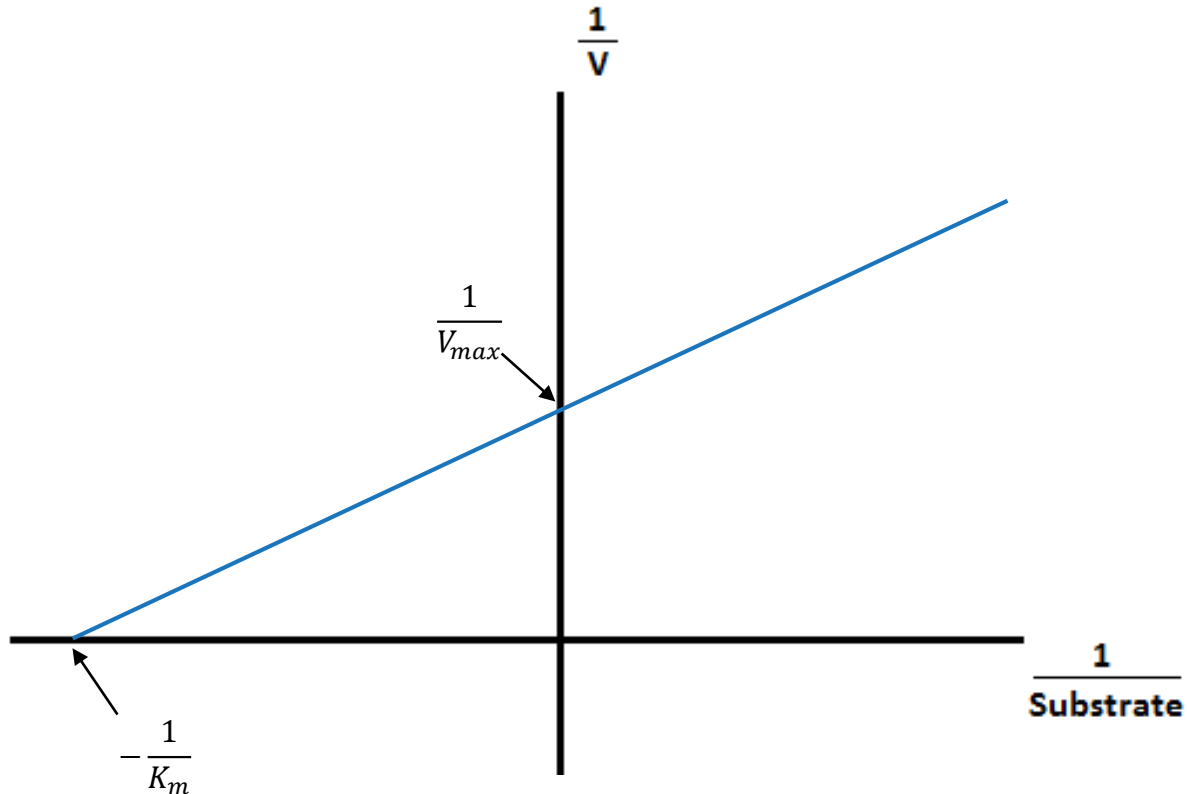
Why is K_m a useful thing to measure?

What are units for K_m ? What about K_{eq} and rate constant k ?

What other assumptions do MM curves make? (Hint: [enzyme])

Enzymes and Enzyme Kinetics

Lineweaver-Burk plot



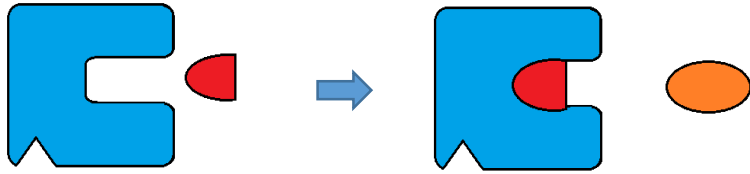
Why use LB plots?

- V_{max} and K_m can be more precisely determined.
- Types of inhibition can be visualized more clearly.

Remember, info about [substrate] is still on x-axis, and info about rate is still on y-axis.

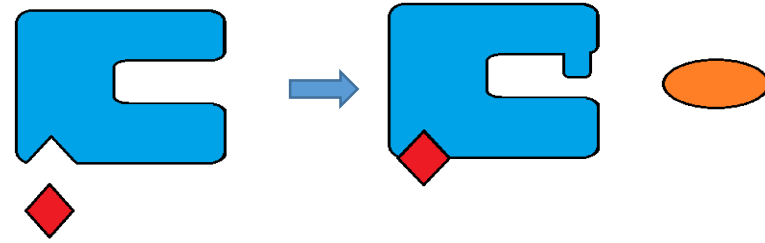
Enzymes and Enzyme Kinetics

Types of inhibition: understand first, memorize K_m and V_{max} effects second!



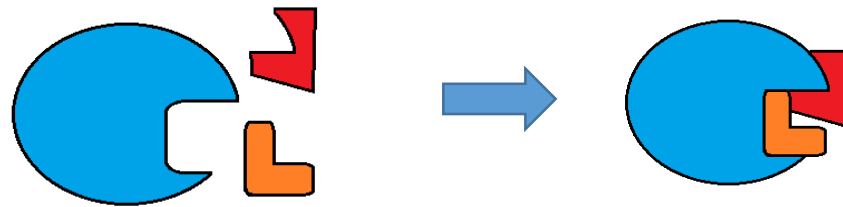
Competitive inhibition: inhibitor binds at active site

V_{max} unchanged & K_m increased: why?



Noncompetitive inhibition: inhibitor binds at allosteric site

V_{max} reduced & K_m unchanged: why?

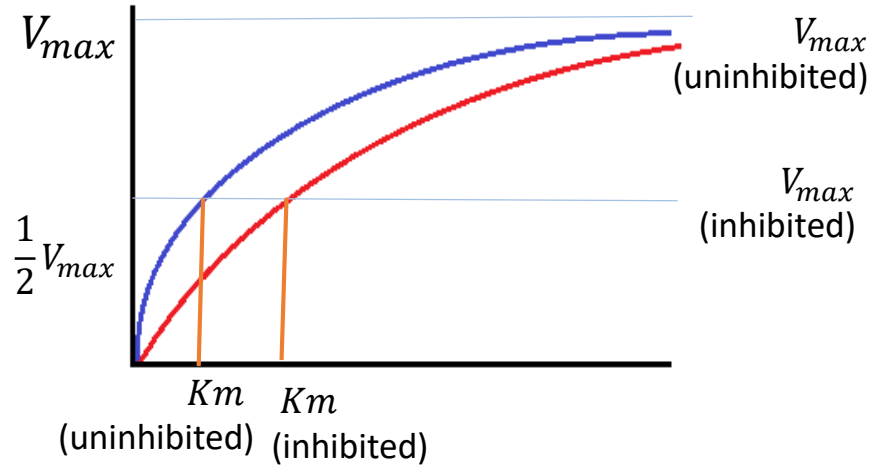


Uncompetitive inhibition: inhibitor binds E-S complex

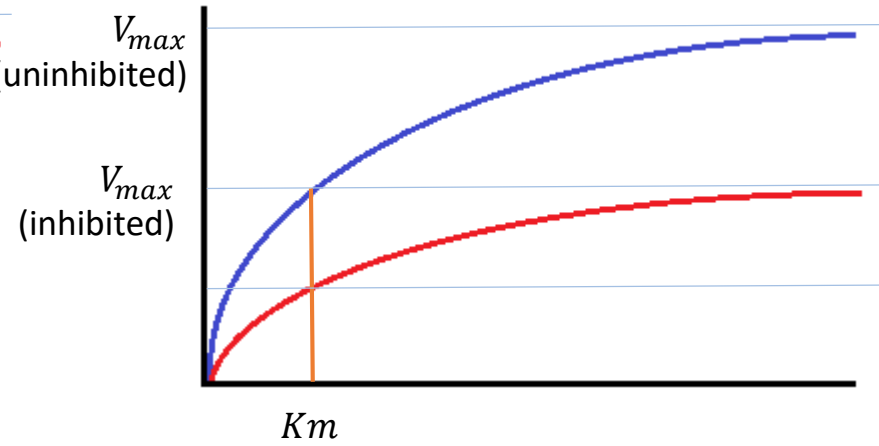
V_{max} reduced & K_m reduced: why?

Enzymes and Enzyme Kinetics

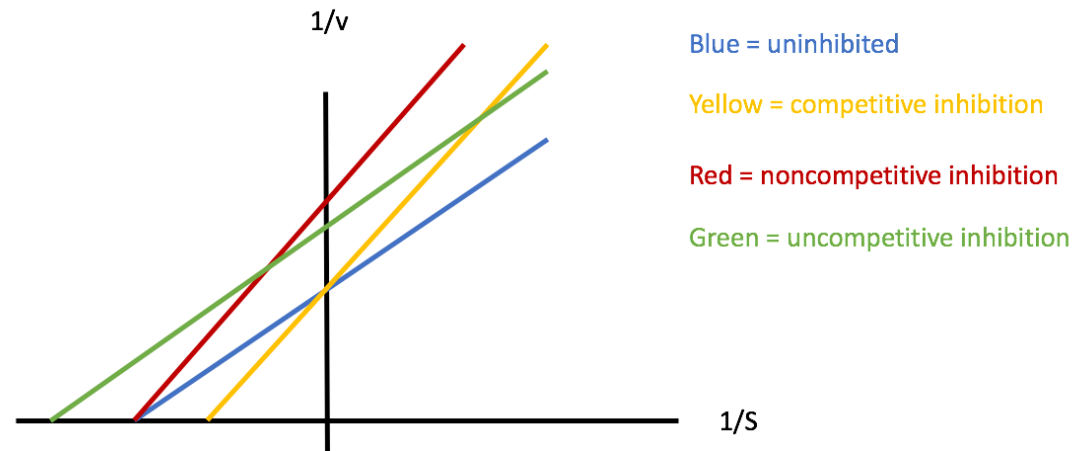
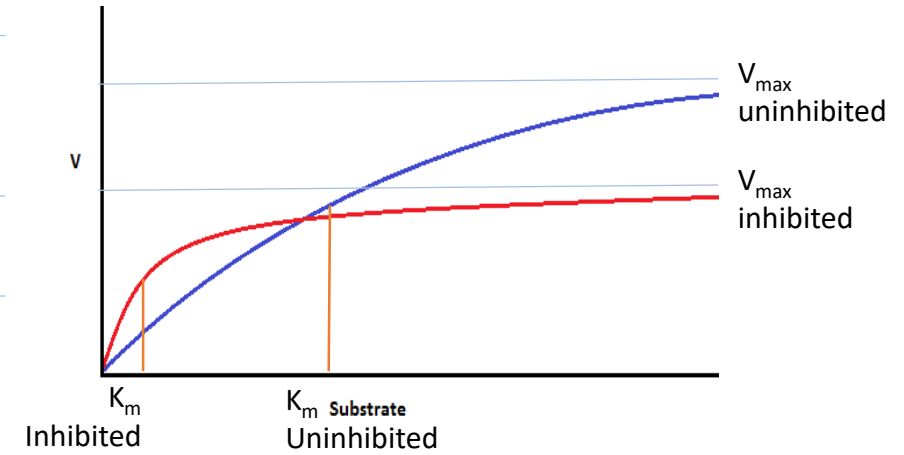
Competitive



Noncompetitive



Uncompetitive



Enzymes and Enzyme Kinetics

1. A biochemist is investigating a reaction featured in human metabolism. He notes that all necessary reactants are present in his test tube and that the process should proceed spontaneously given the conditions, but observes that no products are being made. The most likely explanation is:

- A) the rate of the uncatalyzed reaction is extremely slow.
- B) a particular enzyme within live cells changes the mechanism of the reaction.
- C) catalysts within human cells increase the amount of free energy released during the course of the reaction.
- D) A and B only.

2. Catalase is an enzyme found in especially high concentrations in the liver. This molecule catalyzes the conversion of the reactive oxidative species hydrogen peroxide into water and oxygen. In the presence of this enzyme:

- A) the conversion of hydrogen peroxide to water and oxygen gas is made spontaneous.
- B) the rate of conversion of hydrogen peroxide to water and oxygen gas is increased.
- C) the rate of conversion of water and oxygen gas to hydrogen peroxide is increased.
- D) more than one of the above.

Enzymes and Enzyme Kinetics

3. Priya is investigating the function of Enzyme D, which has a K_m value of 0.175 mM. She adds a large quantity of competitive inhibitor (Compound G) into her test tube. Which of the following is the apparent K_m value that she subsequently observes?

- A) 0.09 mM
- B) 0.10 mM
- C) 0.175 mM
- D) 0.500 mM

4. Which of the following changes may impact the V_{max} , or maximal reaction rate?

- A) Altering the amount of enzyme
- B) Altering the amount of a noncompetitive inhibitor
- C) Altering the amount of a mixed inhibitor
- D) All of the above

Difficult Passage

The artificial sweetener aspartame is the methyl ester of the dipeptide of L-phenylalanine and L-aspartic acid (Figure 1). There are two general approaches to prepare aspartame. The chemical approach involves reacting the methyl ester of phenylalanine with an N-protected anhydride of aspartic acid. The protecting group, either a benzyl or formyl group is then removed by mild acid hydrolysis. In addition to the desired product, a beta structural isomer is also formed due to formation of a peptide bond with the wrong carboxylate group, which must be removed since it produces a bitter taste. A second enzymatic synthesis has been developed in which proteases catalyze the selective peptide bond formation and avoids the formation of the beta isomer.

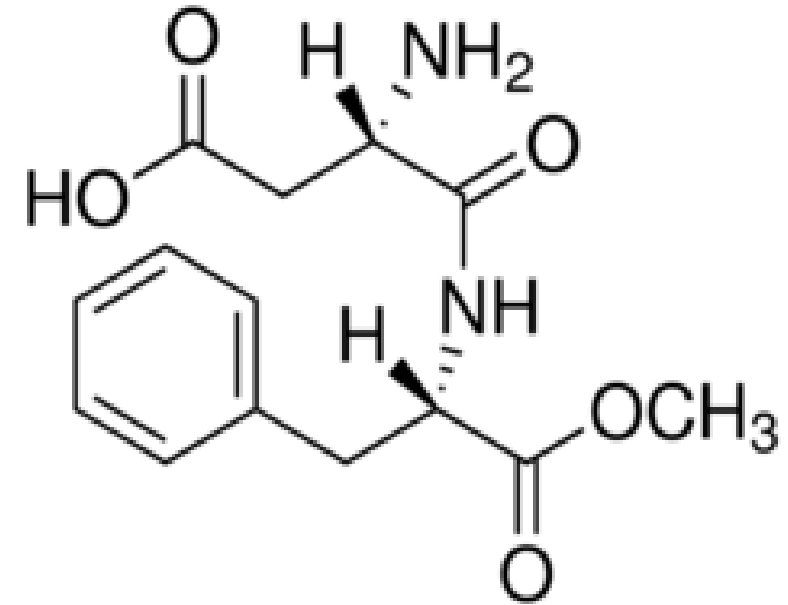


Figure 1 Structure of N-(L- α -Aspartyl)-L-phenylalanine, 1-methyl ester (Note: $pK_{a1} = 3.2$ and $pK_{a2} = 7.7$)

Difficult Passage

Upon ingestion, aspartame is broken down in the duodenum into its components, aspartic acid, phenylalanine and methanol, with the subsequent formation of metabolites such as formaldehyde and formic acid. Some research has raised concerns that aspartame may lead to the formation of certain cancers as a result of the formation of some of these potentially toxic compounds. A new drug, known as protein AT7 (MW = 5×10^4 amu), has been developed to counter this possibility.

Difficult Passage

25. According to the passage, the pI of aspartame is most nearly:

- A. 3.2
- B. 5.5
- C. 7.0
- D. 7.7

26. How many stereocenters are in aspartame?

- A. 1
- B. 2
- C. 3
- D. 4

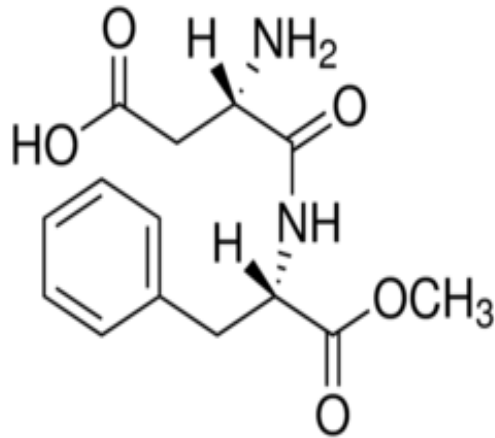


Figure 1 Structure of N-(L- α -Aspartyl)-L-phenylalanine, 1-methyl ester (Note: $pK_{a1} = 3.2$ and $pK_{a2} = 7.7$)

Difficult Passage

27. The two amino acids that form the basis for the dipeptide structure of aspartame, aspartic acid and phenylalanine, are most accurately be classified as:

- A. hydrophilic and hydrophilic, respectively.
- B. hydrophobic and hydrophilic, respectively.
- C. hydrophilic and hydrophobic, respectively.
- D. hydrophobic and hydrophobic, respectively.

28. Prior to its digestion in the small intestine, aspartame must pass through the stomach. What is net charge on aspartame while in the stomach?

- A. -1
- B. 0
- C. +1
- D. +2

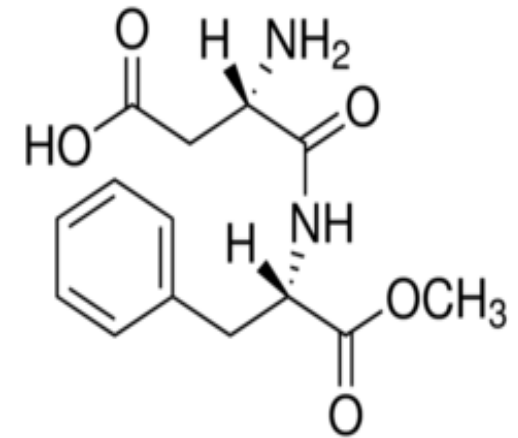


Figure 1 Structure of N-(L- α -Aspartyl)-L-phenylalanine, 1-methyl ester (Note: $pK_{a1} = 3.2$ and $pK_{a2} = 7.7$)

Difficult Passage

29. How many amino acid residues are in AT7?

- A. 2
- B. 50
- C. 450
- D. 900

“A new drug, known as protein AT7 (MW = 5×10^4 amu), has been developed to counter this possibility.”

30. Peptides are stable in water because:

- A) peptide bonds cannot be cleaved by hydrolysis.
- B) electron sharing between the carbonyl and amino group contributes resonance stabilization across the amide bond.
- C) the breakdown of peptides into individual amino acids is entropically unfavorable.
- D) peptides hydrogen bond with free-floating proline residues to promote stabilization.

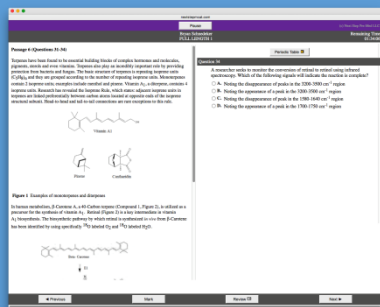
Any Questions?

- *Any questions about the content we've reviewed?*
- *Thoughts about approaches to studying biochem in future? (Study sheets, etc.)*

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Self-Study

MCAT Class



MCAT Study Schedule: Week 3

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1	Bio Lesson 1 Chem Lesson 2 Quiz on p. 19 Start Verbal Chapter 3	Class Morning	Tutoring Session with Bryan	Class All Day	Physics 2 Quiz on p. 51 Verbal Timed Section 4	Timed Physical Sciences Quiz Complete VR Exercises	Day Off
Week 2		Class Morning	Tutoring Session with Bryan	Class All Day			Day Off

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First, tell me how long you have to study.

When do you want your study plan to start?

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When are you planning to take the MCAT?

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05/05/2018



03	04	05	06	07	08	09
Lesson 1	Complete 2 passages from the 108 CARS book	Read Gen Chem and Organic Chem Ch 1	Complete 2 passages from the 108 CARS book	Read Verbal, Quant, and Research Ch 2	Complete 2 passages from the 108 CARS book	Complete 2 passages from the 108 CARS book
Read Verbal, Quant, and Research Ch 1	Math Skills 2 CR Video	Complete 2 passages from the 108 CARS book	Complete Passages 1-5 from AAMC CARS QPack 1	Complete 2 passages from the 108 CARS book		
Complete 2 passages from the 108 CARS book		Scientific Method and Data Interpretation CR Video				
Math Skills 1 CR Video						
10	11	12	13	14	15	16

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- Anthony: MD/PhD; 12 years MCAT experience
- Clara: 526 MCAT, 5 years experience
- Phil: 5 years experience; 98% score
- Andrew: U Chicago PhD, 523 MCAT



Bryan



Anthony



Clara



Phil



Andrew



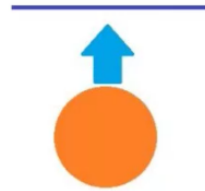
Welcome to Office Hours



Buoyancy

Whenever an object is submerged in a fluid, it provides a lifting force.

$$F_{\text{Buoyancy}} = \rho g V_{\text{sub}}$$



Common Trap!

ρ = Density of the fluid!

$$g = 9.8 \frac{\text{m}}{\text{s}^2}$$

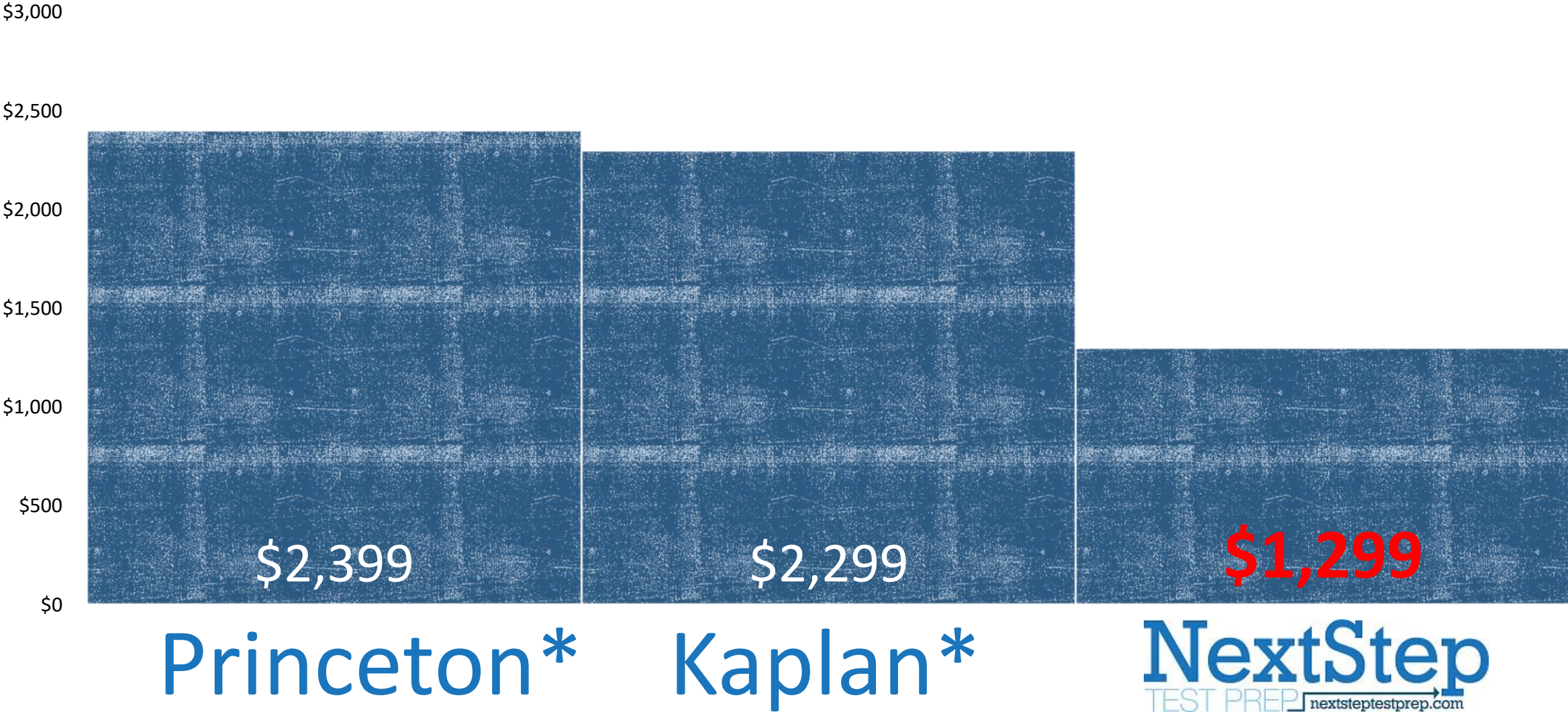
V_{sub} = part of the object below the surface of the fluid



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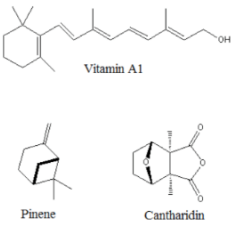
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Pause Remaining Time 01:34:06

Bryan Schnedeker FULL LENGTH 1

Passage 6 (Questions 31-34)

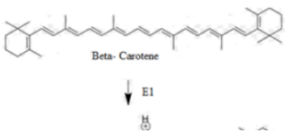
Terpenes have been found to be essential building blocks of complex hormones and molecules, pigments, sterols and even vitamins. Terpenes also play an incredibly important role by providing protection from bacteria and fungus. The basic structure of terpenes is repeating isoprene units (C_5H_8)_n and they are grouped according to the number of repeating isoprene units. Monoterpenes contain 2 isoprene units; examples include menthol and pinene. Vitamin A₁, a diterpene, contains 4 isoprene units. Research has revealed the Isoprene Rule, which states: adjacent isoprene units in terpenes are linked preferentially between carbon atoms located at opposite ends of the isoprene structural subunit. Head-to-head and tail-to-tail connections are rare exceptions to this rule.



Vitamin A₁
Pinene
Cantharidin

Figure 1 Examples of monoterpenes and diterpenes

In human metabolism, β -Carotene A, a 40-Carbon terpene (Compound 1, Figure 2), is utilized as a precursor for the synthesis of vitamin A₁. Retinal (Figure 2) is a key intermediate in vitamin A₁ biosynthesis. The biosynthetic pathway by which retinal is synthesized *in vivo* from β -Carotene has been identified by using specifically ^{18}O labeled O_2 and ^{18}O labeled H_2O .



Beta-Carotene

Periodic Table

Question 34

A researcher seeks to monitor the conversion of retinal to retinol using infrared spectroscopy. Which of the following signals will indicate the reaction is complete?

A. Noting the disappearance of peaks in the 3200-3500 cm^{-1} region

B. Noting the appearance of a peak in the 3200-3500 cm^{-1} region

C. Noting the disappearance of peak in the 1580-1640 cm^{-1} region

D. Noting the appearance of a peak in the 1700-1750 cm^{-1} region

Previous Mark Review Next

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Close and Return Remaining Time 01:34:06

Bryan Schnedeker FULL LENGTH 1

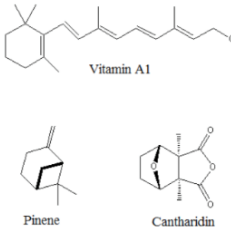
Passage 6 (Questions 31-34)

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Key terms: terpenes, isoprene unit formula, mono/di terpene, isoprene rule

Contrast: the favored isoprene links are head-to-tail, though exceptions do occur

Cause and effect: repeated isoprene units can combine to form several biologically important molecules



Vitamin A₁
Pinene
Cantharidin

Figure 1 Examples of monoterpenes and diterpenes

Figure 1 shows us that the various terpene molecules made up of repeating isoprene units

In human metabolism, β -Carotene A, a 40-Carbon terpene (Compound 1, Figure 2), is utilized as a precursor for the synthesis of vitamin A₁. Retinal (Figure 2) is a key intermediate in vitamin A₁ biosynthesis. The biosynthetic pathway by which retinal is synthesized *in vivo* from β -Carotene has been identified by using specifically ^{18}O labeled O_2 and ^{18}O labeled H_2O .

Periodic Table

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A. Noting the disappearance of peaks in the 3200-3500 cm^{-1} region

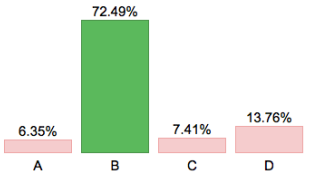
B. Noting the appearance of a peak in the 3200-3500 cm^{-1} region

C. Noting the disappearance of peak in the 1580-1640 cm^{-1} region

D. Noting the appearance of a peak in the 1700-1750 cm^{-1} region

72.49% of students answered this question correctly.

Your answer was incorrect



Answer Explanation:

- Difficulty: 2 Medium
- Reasoning Skill: 2 Scientific Reasoning and Problem Solving
- Concept Category: 4D Light and Sound

B is correct. Retinol differs from retinal in that it contains -OH groups, but does not contain a carboxyl group (C=O). The carbonyl stretching frequency falls in the region 1700-1750 cm^{-1} , whereas the O-H stretching frequency is expected to fall in the region 3200-3500 cm^{-1} .

A: This would indicate a lack of OH groups, which is a characteristic of retinal, not retinol.

C: This peak is indicative of C=C groups, which both molecules have and cannot be used to determine when retinal has been converted.

Previous Passage Previous Next Section Next Next Passage

Comprehensive Reporting and Analytics

Scaled Scores

Section	Scaled Score	Percentile
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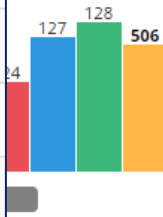
Chemical and Systems		
Critical Analy		
Biological and Systems		
Psychological Behavior		
Total		

Results by Reasoning Skills

Concept Category	Total Correct	Correct Percentage
1 Knowledge of Scientific Concepts and Principles	49	71.01% (49/69)
2 Scientific Reasoning and Problem Solving	39	68.42% (39/57)
3 Reasoning About the Design and Execution of Research	23	69.7% (23/33)
4 Data-based and Statistical Reasoning	10	55.56% (10/18)
5 Foundations of Comprehension	12	75% (12/16)
6 Reasoning within the Text	14	60.87% (14/23)
7 Reasoning Beyond the Text	9	64.29% (9/14)

Results by Section

Chemical	Correct:
Critical Ar	Correct:
Biological	Correct:
Psycholog	Correct:



Results by Concept Category

Concept Category	Total Correct	Correct Percentage
1A Amino Acids and Proteins	4	57.14% (4/7)
1B Molecular Genetics	9	81.82% (9/11)
1C Classical Genetics	9	69.23% (9/13)
1D Metabolism	3	37.5% (3/8)
2A Cell Biology	1	100% (1/1)
2B Microbiology	4	80% (4/5)
2C Reproduction	3	60% (3/5)
3A Nerve and Endocrine	4	50% (4/8)
3B Organ Systems	1	100% (1/1)
4A Kinematics and Force	5	50% (5/10)

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