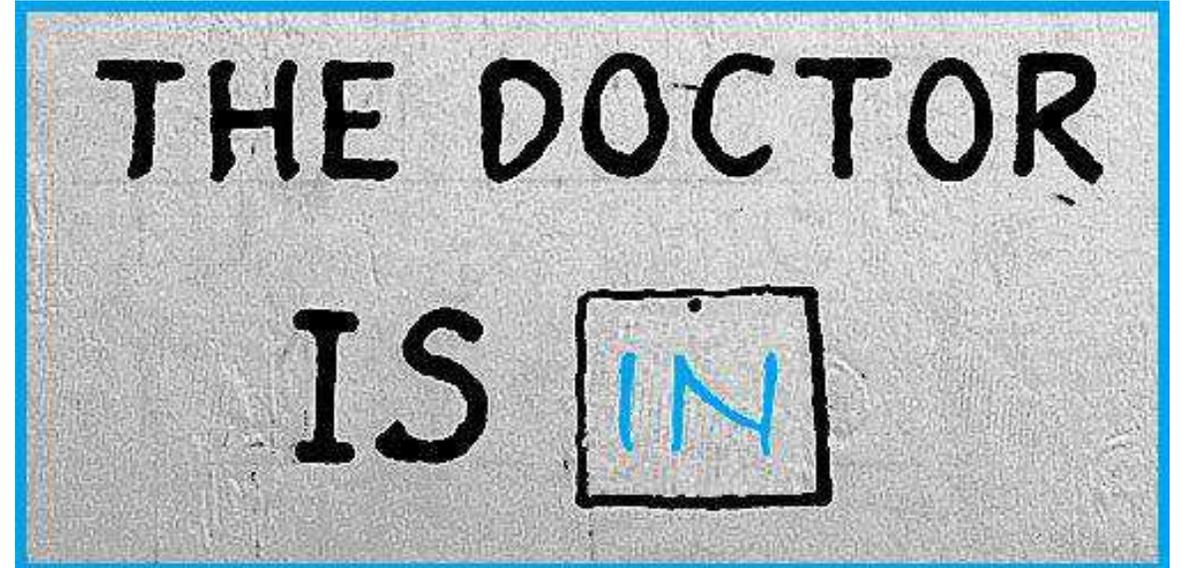


Next Step Office Hours: Biochemistry Review

- 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

Congrats on making progress through our MCAT course! Today let's focus on biochem:

- **Overall study strategies**

 - Active learning*

 - Big-picture perspective*

 - Test-like thinking*

- **High-yield topics**

 - Enzymes & enzyme kinetics*

 - Amino acids*

 - Glycolysis*

 - Krebs 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?

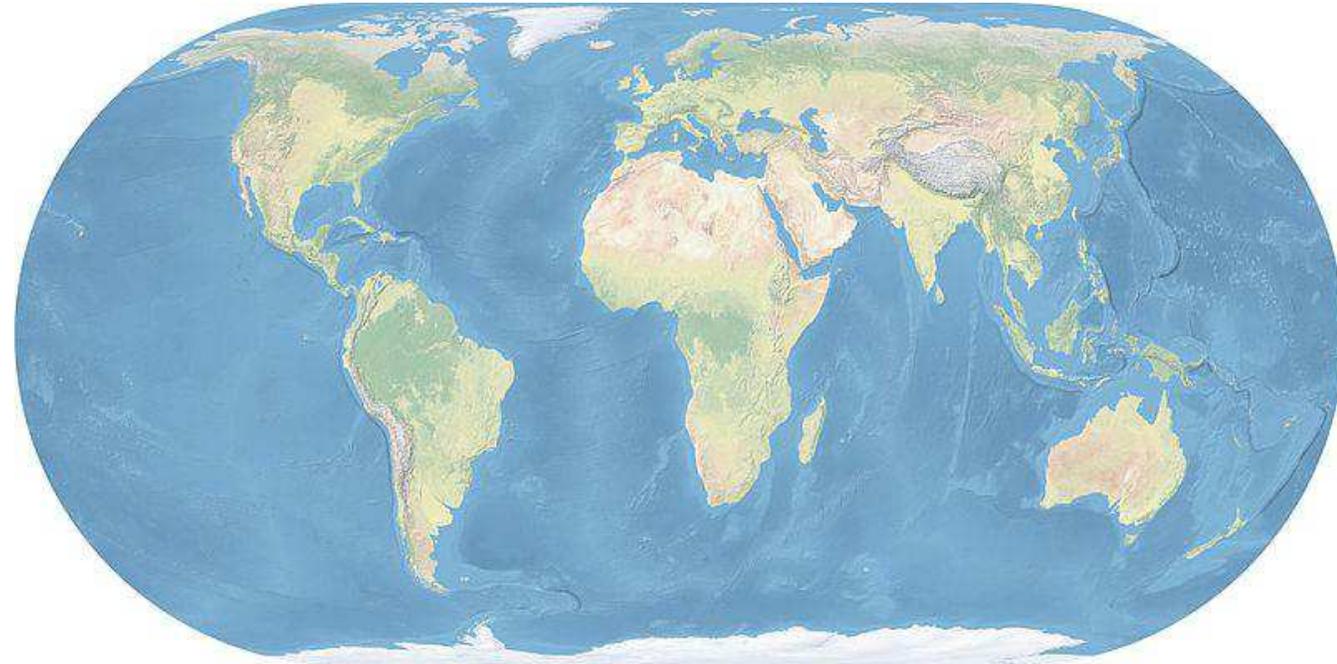
Focus on:

- *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

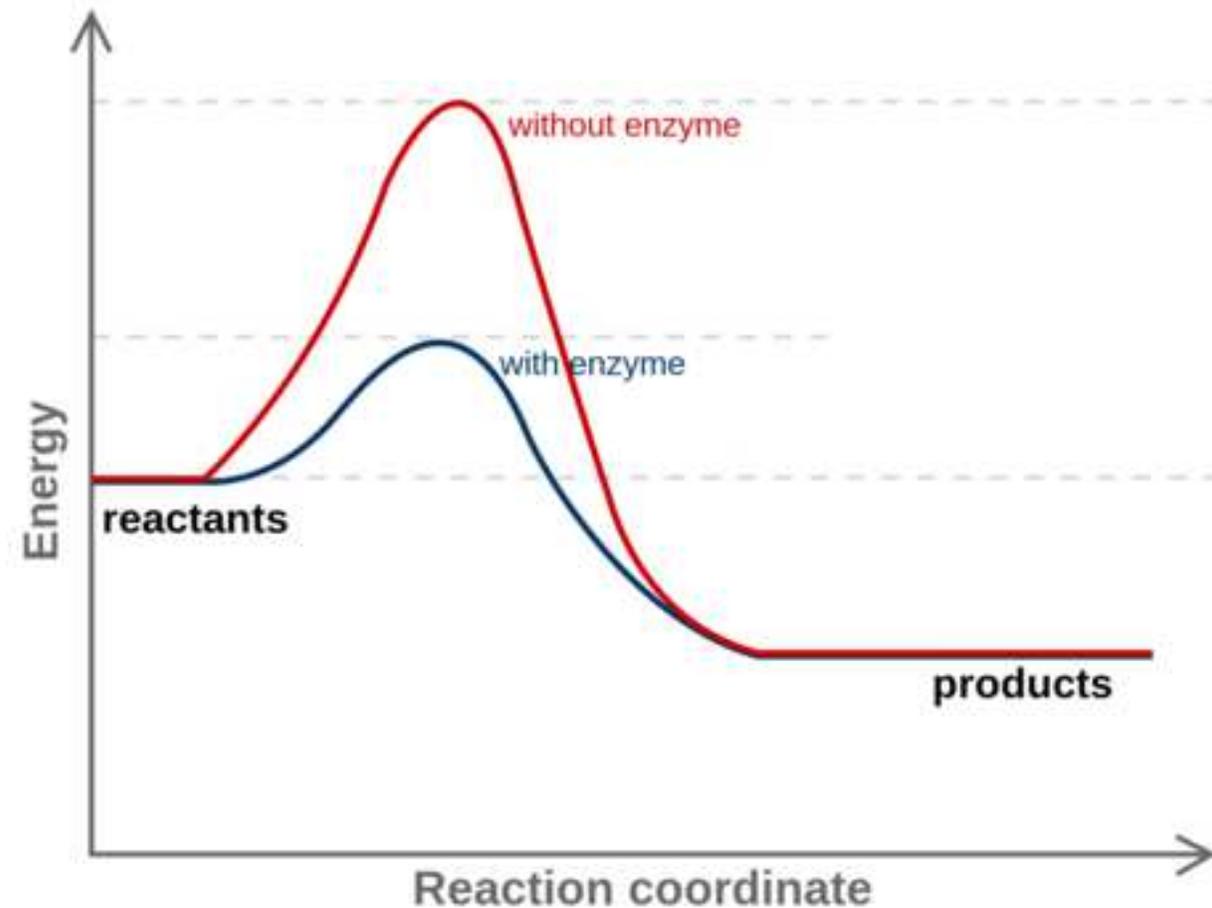
Lyases

Transferases

Isomerases

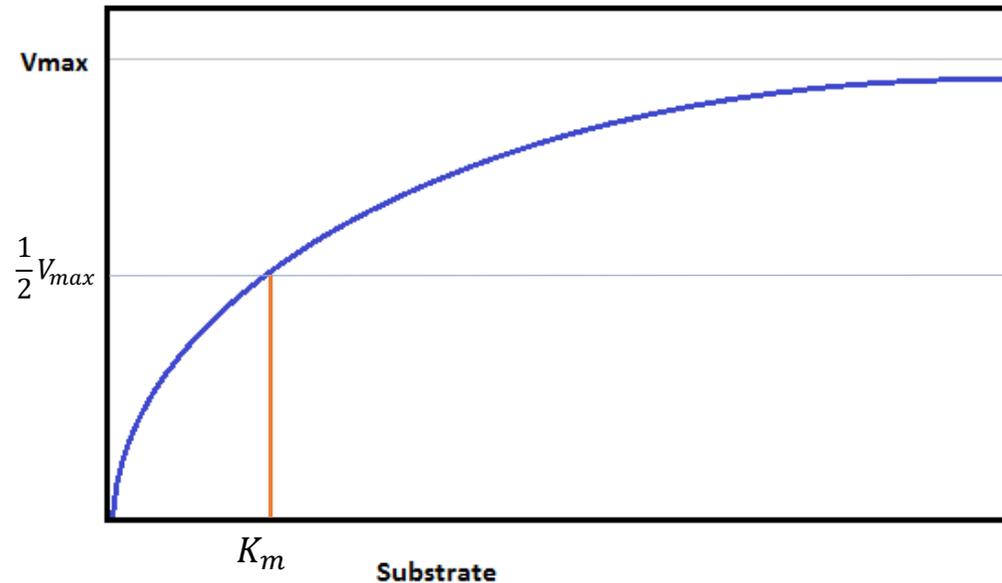
Hydrolases

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*

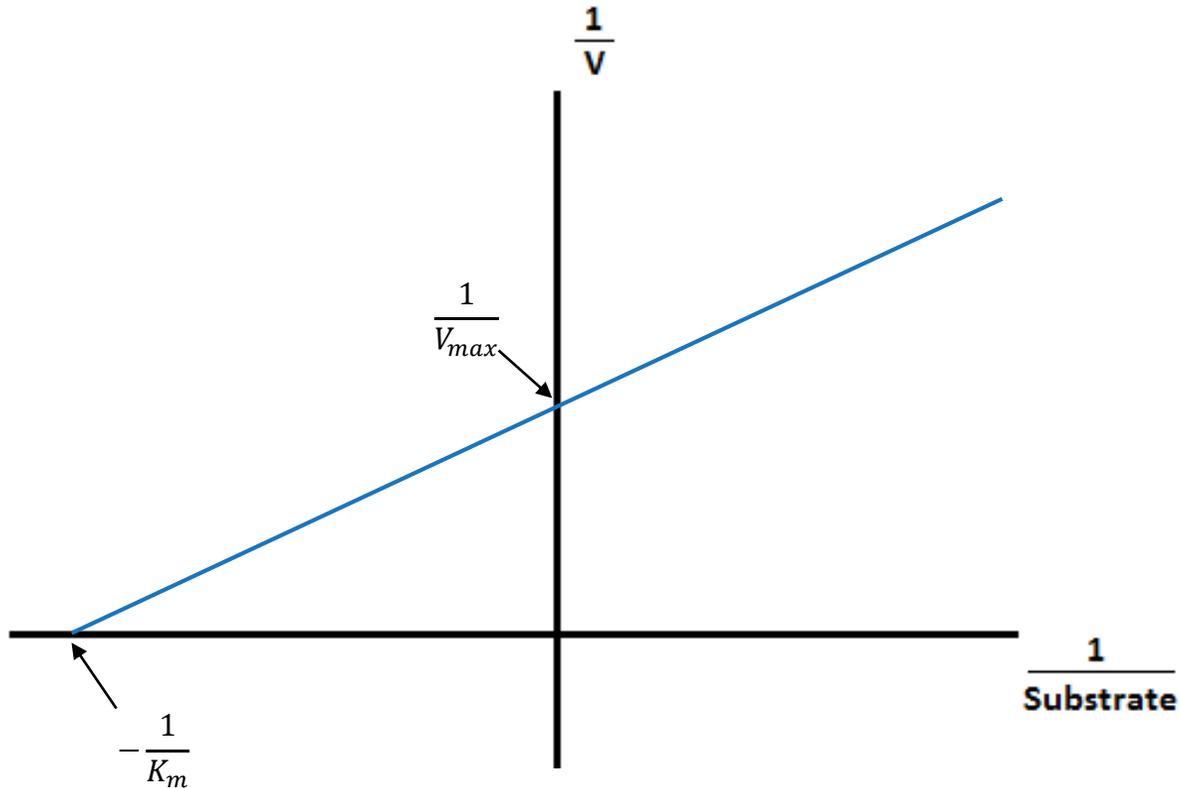
Why is K_m a useful thing to measure?

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



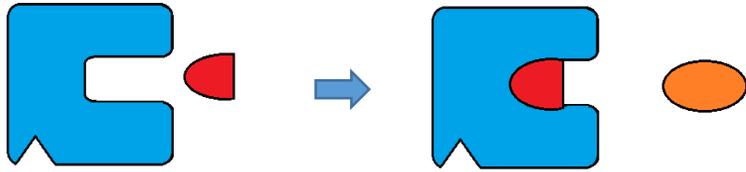
Why use LB plots?

- 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.

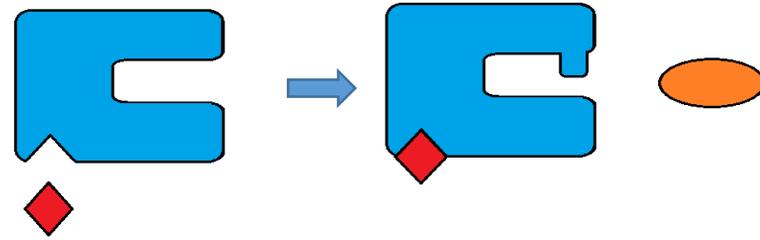
Enzymes and Enzyme Kinetics

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



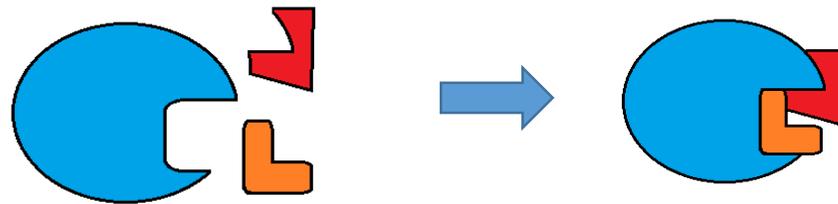
Competitive inhibition: inhibitor binds at active site

V_{max} unchanged & K_m increased: why?



Noncompetitive inhibition: inhibitor binds at allosteric site

V_{max} reduced & K_m unchanged: why?

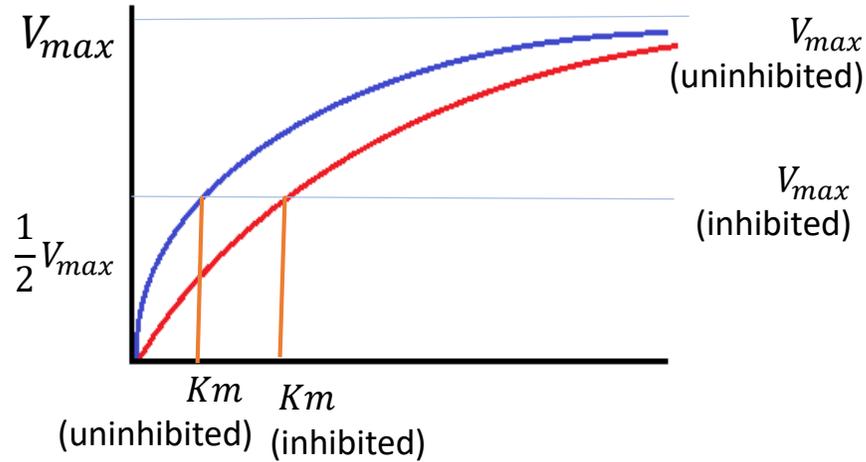


Uncompetitive inhibition: inhibitor binds E-S complex

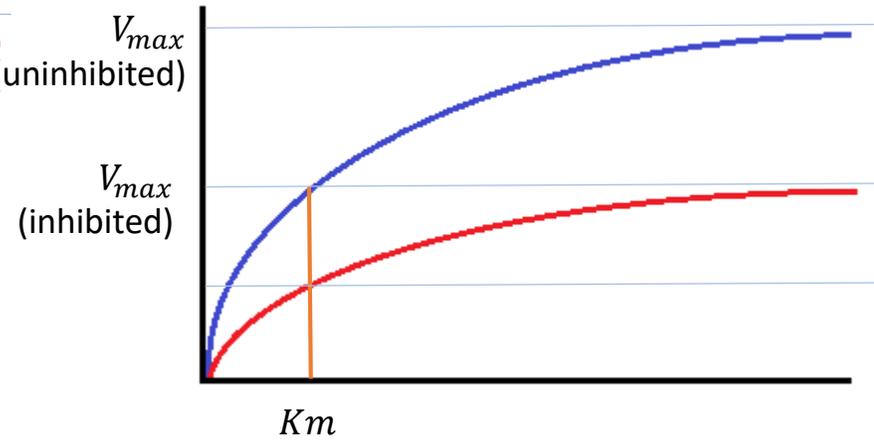
V_{max} reduced & K_m reduced: why?

Enzymes and Enzyme Kinetics

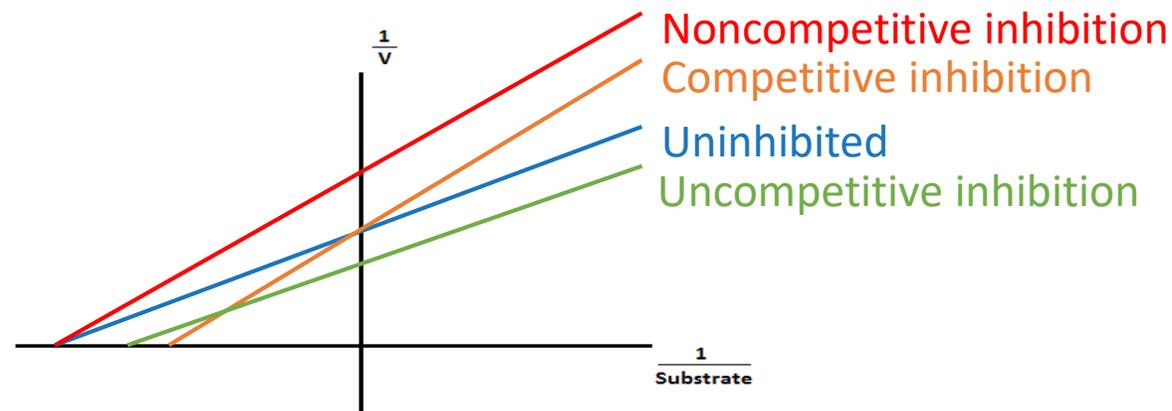
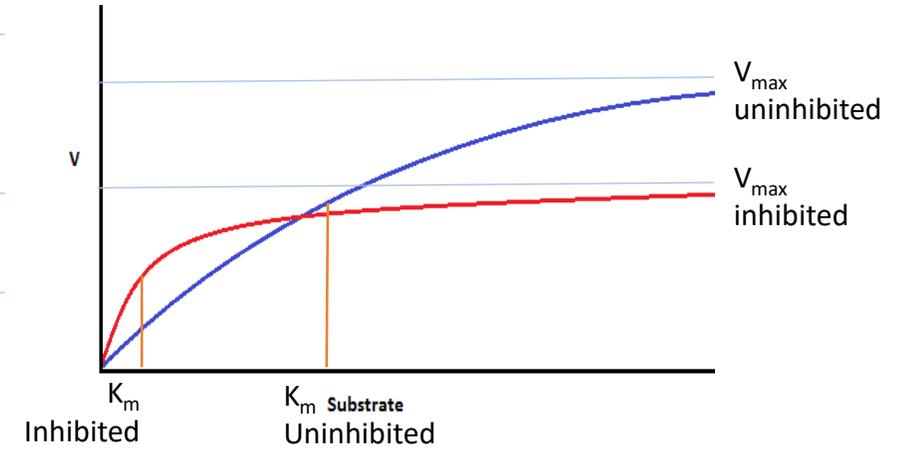
Competitive



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

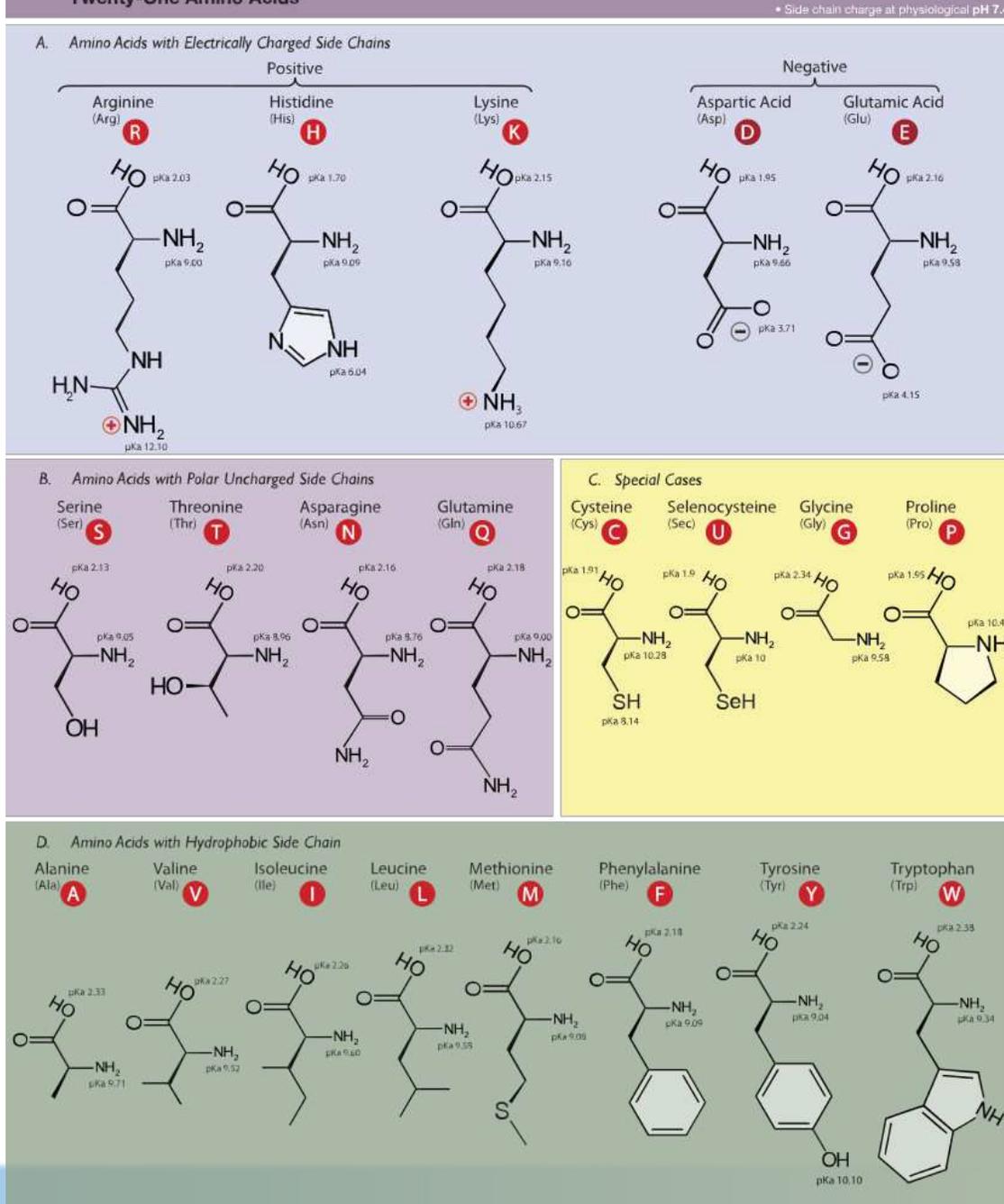
Amino acids

MCAT musts for amino acids

- Understand chemical structure (peptide bond, etc.)
- Which amino acids have which properties?
- 3-letter abbreviations
- Specific structures and 1-letter abbreviations
- pK_a acid-base properties
- How are amino acid properties & protein properties connected? Which residues would you expect in the transmembrane domain of a protein?

Special amino acids (why?)

- Cysteine
- Proline
- Glycine

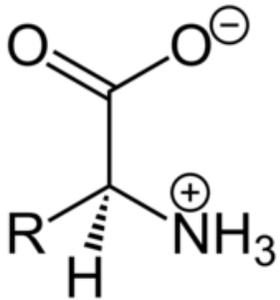


Amino acids

Acidic vs. basic functional groups

- *Acidic: -COOH (Asp, Glu); weakly acidic = -OH (Tyr), -SH (Cys)*
- *Basic: amines, guanidium, imidazole (Arg, Lys, His)*

Zwitterion: form where some groups are charged but overall charge of molecule is 0

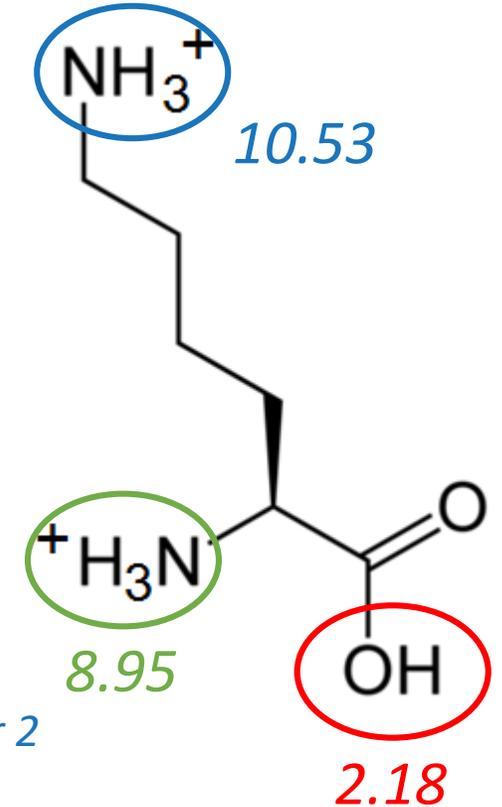


*Glycine (and many others)
at physiological pH*

pI = pH where entire molecule has net charge of 0

- *If AA has 2 pK_a values → average them!*
- *If AA has 3 pK_a values, average most relevant (2 acidic or 2 basic)*

pK_a = pH for a given functional group where half of all molecules are protonated



Amino acids

5. Which type of chromatography would most effectively separate alanine from other compounds with dissimilar properties in a sample at pH 1.0?

- A) Cation-exchange chromatography
- B) Anion-exchange chromatography
- C) Size-exchange chromatography
- D) Nickel affinity chromatography

6. Of the following amino acids, the one most likely to be a neutral zwitterion is:

- A) alanine at pH 5.
- B) tyrosine at pH 12.
- C) lysine at pH 4.
- D) glycine at pH 1.

Amino acids

7. Hair is composed of proteins known as keratins. In chemical hair-straightening treatments, curly hair is semi-permanently relaxed into straight hair. During these treatments, alkalis are used to reduce the disulfide bonds formed between residues in the keratin. Which amino acid is found in keratin, and how is it affected by the alkali treatment?

A) Threonine; the alkalis reduce, and thus form, new disulfide bonds between threonine residues.

B) Serine; the alkalis reduce, and thus form, new disulfide bonds between serine residues.

C) Cysteine; the alkalis reduce, and thus break, existing disulfide bonds between cysteine residues.

D) Methionine; the alkalis reduce, and thus break, existing disulfide bonds between methionine residues.

8. A professor attempts to purify glycine from a solution using anion-exchange chromatography. At which pH would he observe the largest amount of glycine adhering to the column?

A) 1.5

B) 6.5

C) 8.0

D) 10.0

Amino acids

9. Due to the planar properties of the peptide bond, proteins can easily assume various organized structures (for example, beta sheets). All of the following are characteristics of the peptide bond EXCEPT:

- A) its rotation is restricted.
- B) it has multiple resonance forms.
- C) it frequently breaks and reforms to allow structural fluidity.
- D) it exhibits partial double bond character.

10. Ion-exchange chromatography with a positively-charged stationary phase is used to separate two polypeptides, A and B. Which of the below amino acids is LEAST likely to abound in the polypeptide that elutes first?

- A) A
- B) H
- C) P
- D) D

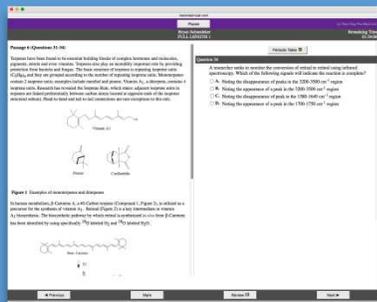
Any Questions?

- *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 Org. Chem 1 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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1 Select your start date

08/10/2016

2 Select your exam date

10/31/2016

3 How will you be preparing for the MCAT?

On the side (5-20 hrs/week) Part-Time (20-40 hrs/week) Full-Time (40+ hrs/week)

4 Select the MCAT science subject about which you are most worried

Biology Biochem General Chemistry Organic Chemistry Physics Psy/Soc

YOUR CUSTOM STUDY PLAN

Jump to a month: Aug Sep Oct

August 2016

SUN	MON	TUE	WED	THU	FRI	SAT
			10 DAY 1 REQUIRED • Watch Orientation Video • Take Science Content Diagnostic OPTIONAL	11 DAY 2 REQUIRED • Take Diagnostic Test OPTIONAL • Complete 2 CARS passages • Watch 3 Bio/Biochem Content Review Videos • Office Hours	12 Catch Up Day	13 DAY 3 REQUIRED • Lesson 1 OPTIONAL • Complete 30 questions from Biology Qbank
14 DAY 4 REQUIRED • Read CARS SP Chapters 1-3 • Complete practice passages for CARS SP Chapters 1-3 OPTIONAL • Complete 2 CARS passages • Watch 2 Bio/Biochem Content Review Videos • Office Hours	15 Catch Up Day	16 DAY 5 REQUIRED • Lesson 2 OPTIONAL • Complete 30 questions from Biology Qbank • Watch 2 Psych/Soc Content Review Videos • Office Hours	17 DAY 6 REQUIRED • Read CARS SP Chapter 4 • Read Physics/Math CR Section 1 • Complete Math Assessment from Physics/Math CR Section 5 OPTIONAL • Complete 2 CARS passages • Complete 20 questions from Biochem Qbank	18 Catch Up Day	19 DAY 7 REQUIRED • Read Chem/Orgo CR Sections 1 and 2 • Read Chem/Phys SP Ch 1 and 2 OPTIONAL • Complete 2 CARS passages • Watch 2 Physics Content Review Videos	20 DAY 8 REQUIRED • Lesson 3 OPTIONAL • Complete 2 CARS passages • Complete 30 questions from Chemistry Qbank

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- Bryan: 15 years MCAT teaching experience
- 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!

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

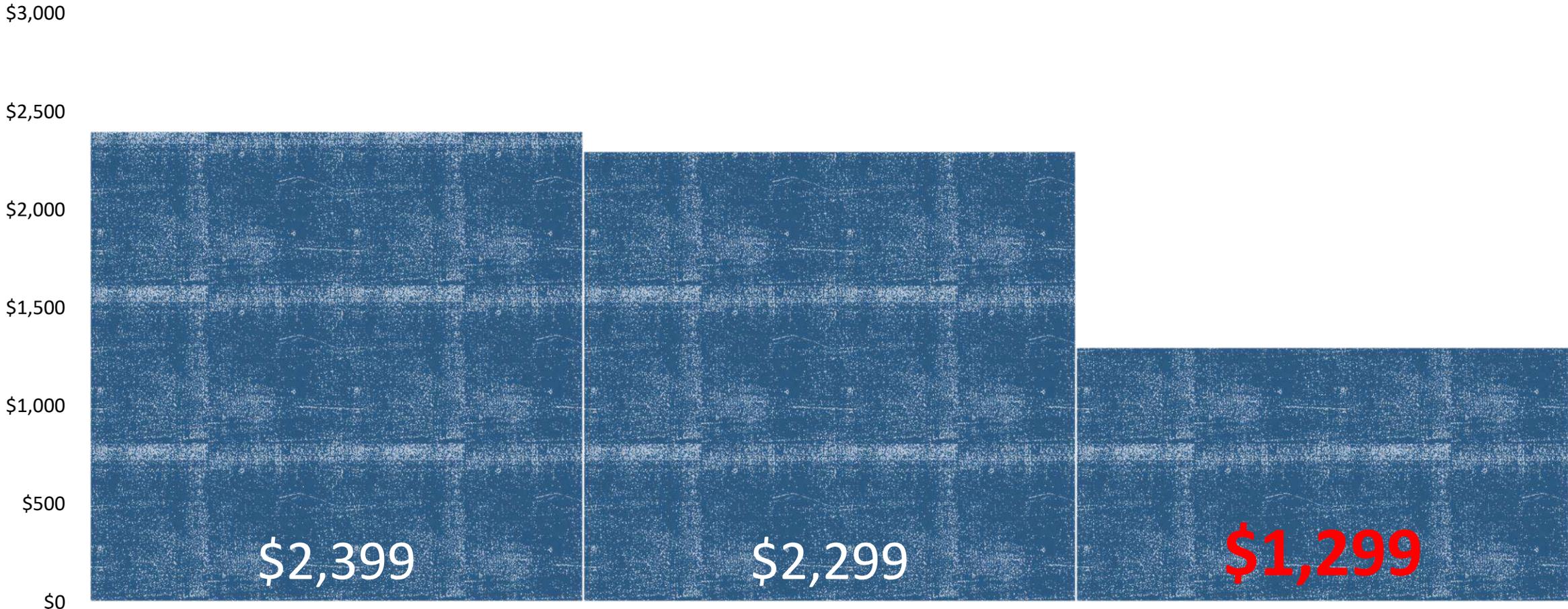
V_{sub} = part of the object below the surface of the fluid



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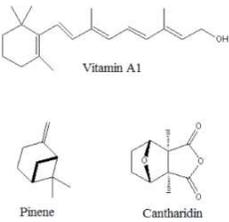
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Pause Remaining Time 01:34:06
Bryan Schnedeker FULL LENGTH 1

Passage 6 (Questions 31-34) Periodic Table

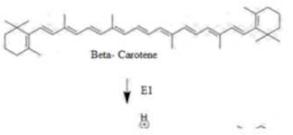
Terpenes have been found to be essential building blocks of complex hormones and molecules, pigments, sterols and even vitamins. Terpenes also play an incredibly important role by providing protection from bacteria and fungus. The basic structure of terpenes is repeating isoprene units (C_5H_8)_n and 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

Previous Mark Review Next

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

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Close and Return Remaining Time 01:34:06
Bryan Schnedeker FULL LENGTH 1

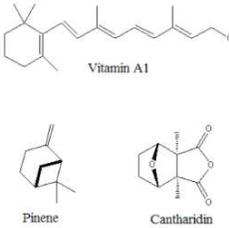
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Key terms: terpenes, isoprene unit formula, mono/di terpene, isoprene rule

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 .

Question 34

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- 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
---------	--------------	------------

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

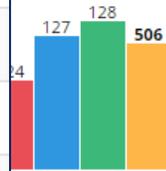
Correct:

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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Next Step Office Hours

Office hours are **IN SESSION**

We've had to step away for a minute but...



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AND
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