



## AP Summer Assignment 2019-20

### Course: AP Biology

<b>Assignment title</b>	AP Biology Summer Assignment: Video Notes & Biochemistry Worksheets
<b>Date due</b>	Part 1 – Video Notes – due 1 <sup>st</sup> day/block of class Part 2 – Biochemistry Worksheets – due 2 <sup>nd</sup> day/block of class
<b>Estimated time for completion</b>	6-7 hours
<b>Resources needed to complete assignment</b>	<input checked="" type="checkbox"/> School assigned textbook <input checked="" type="checkbox"/> Notes in packet <input checked="" type="checkbox"/> Other supplies: device(s) with internet capabilities.
<b>How the assignment will be assessed</b>	The Video Notes and the Biochemistry Worksheets will be scored using the accompanying rubric and guidelines. Both assignments will be averaged together and will be counted as a test grade 1 <sup>st</sup> quarter.
<b>Purpose of assignment</b>	<input checked="" type="checkbox"/> Review of foundational material/concepts/skills. <input checked="" type="checkbox"/> Expose students to required material/concepts/skills/texts that will not be covered during the academic year. <input checked="" type="checkbox"/> Have students read material that will be discussed or used in class at the beginning of the year.

# AP Biology Summer Assignment

Welcome to AP Biology! This course is designed to be the equivalent of a two-semester introductory biology course usually taken in the first year of college. In other words, it's a little like drinking from a fire hose. It will be a rewarding experience, but as with most things that are, it will also be challenging. Throughout the course, you will become familiar with major recurring ideas that persist throughout all topics and material.

The 4 Big Ideas of AP Biology
<b>Big Idea 1:</b> The process of evolution drives the diversity and unity of life.
<b>Big Idea 2:</b> Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
<b>Big Idea 3:</b> Living systems store, retrieve, transmit and respond to information essential to life processes.
<b>Big Idea 4:</b> Biological systems interact, and these systems and their interactions possess complex properties.

On the pages that follow, you'll find instructions for the two assignments that comprise your summer work for AP Biology. Both assignments will review biological chemistry concepts that you learned in freshman biology as well as foundational chemistry concepts you learned your sophomore year in chemistry. The first part of the assignment involves watching several assigned videos and taking video notes. The second part of your summer assignment consists of completing several sets of questions focusing on biological chemistry.

**Your video notes are due on the 1<sup>st</sup> day of AP Biology and your biochemistry worksheets will be due on the 2<sup>nd</sup> day. Both will be averaged together and counted as a project grade for 1<sup>st</sup> quarter. No late summer assignments will be accepted!**

Included in this packet are the following documents:

Document	Page(s)
Assignment #1 – Video Notes	
• Instructions and Content Video List	3
Assignment #2 – Biochemistry Notes & Worksheet Questions	
• Notes	
○ Organic Chemistry Basics-functional groups	4
○ Water	5-8
○ Carbohydrates	9-10
○ Lipids	11-13
○ Proteins	14-17
• Worksheet Questions	18-32

## Assignment #1 – Video Notes – due 1<sup>st</sup> day of AP Biology

Watch the videos listed below and take **hand-written** notes on each of them. The notes should be your **original work**. EACH note sheet will be scored 0 to 5 based on completeness and thoroughness as shown in the rubric below. Note pages **will not** be accepted late nor will they be accepted typed.

#	Video Content	Links
005	Essential Characteristics of Life	<a href="https://bit.ly/2HUpsES">https://bit.ly/2HUpsES</a>
010	Abiogenesis	<a href="https://bit.ly/2U6a7Yg">https://bit.ly/2U6a7Yg</a>
	Molecules of Life	<a href="https://bit.ly/2lwqLXK">https://bit.ly/2lwqLXK</a>
	Carbohydrates	<a href="https://bit.ly/2L7RADv">https://bit.ly/2L7RADv</a>
	Lipids	<a href="https://bit.ly/2lqVDJh">https://bit.ly/2lqVDJh</a>
	Proteins	<a href="https://bit.ly/2IJHWIS">https://bit.ly/2IJHWIS</a>
	Water – A Polar Molecule (#)	<a href="https://bit.ly/2TUfnQ">https://bit.ly/2TUfnQ</a>

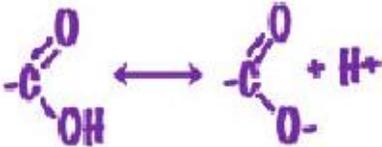
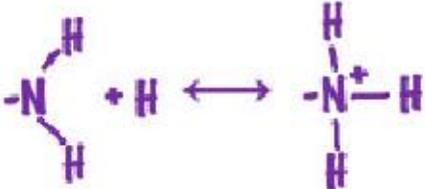
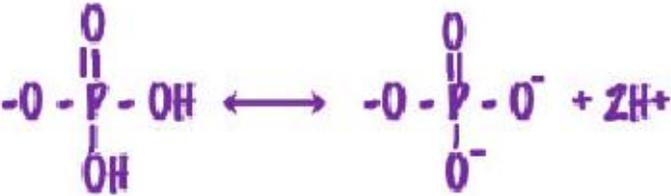
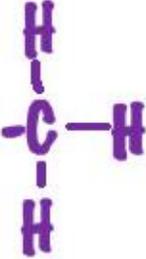
0 No Credit	2 Below expectations	3-4 Complete	5 Meets expectations
No notes <b>OR</b> copied from a peer.	Several criteria are missing from entry	All criteria are met, but there's room for improvement within criteria <b>OR</b> one criterion is missing from entry.	All criteria listed below are met <b>OR</b> have been exceeded for each entry.

### What does work that “meets expectations” have?

- ✓ Each video's notes are on a different page.
- ✓ The video's title is written as it appears in the video on the top line of the paper.
- ✓ The notes are legibly written.
- ✓ Highlighting or colors are used to emphasize key points, new vocabulary, and/or important concepts.
- ✓ Examples are documented in some way when given in the video.
- ✓ Pictures, charts, or graphs are used to display details provided in the video.
- ✓ A summary of the video content is provided at the end of the notes. Please emphasize the summary in some way (title it, star it, highlight it, etc.)

Notes are to be *original work* and are not to be copied from a peer – these serve as a log of what you have learned from the video. Copying them from a peer and not watching the video does you no good. You will receive zero credit if you are found submitting work that is too closely aligned with a classmate's work.

## ORGANIC CHEMISTRY BASICS NOTES

FUNCTIONAL GROUP	DRAWING/ FORMULA	PROPERTIES
<p style="text-align: center;"><b>Carboxyl</b></p>	<p style="text-align: center;"><b>-COOH</b></p> 	<ul style="list-style-type: none"> <li>• Polar</li> <li>• Water soluble</li> <li>• Acid</li> </ul>
<p style="text-align: center;"><b>Amino</b></p>	<p style="text-align: center;"><b>-NH<sub>2</sub></b></p> 	<ul style="list-style-type: none"> <li>• Polar</li> <li>• Water soluble</li> <li>• Weak base</li> </ul>
<p style="text-align: center;"><b>Sulfhydryl</b></p>	<p style="text-align: center;"><b>-SH</b></p>	<ul style="list-style-type: none"> <li>• Form disulfide bridges</li> <li>• Stabilize protein shape</li> </ul>
<p style="text-align: center;"><b>Phosphate</b></p>		<ul style="list-style-type: none"> <li>• Polar</li> <li>• Water soluble</li> <li>• Acid</li> <li>• Important in energy transfer</li> </ul>
<p style="text-align: center;"><b>Methyl</b></p>	<p style="text-align: center;"><b>-CH<sub>3</sub></b></p> 	<ul style="list-style-type: none"> <li>• Nonpolar</li> <li>• Not water soluble</li> </ul>

# WATER, ACIDS, BASES, BUFFERS

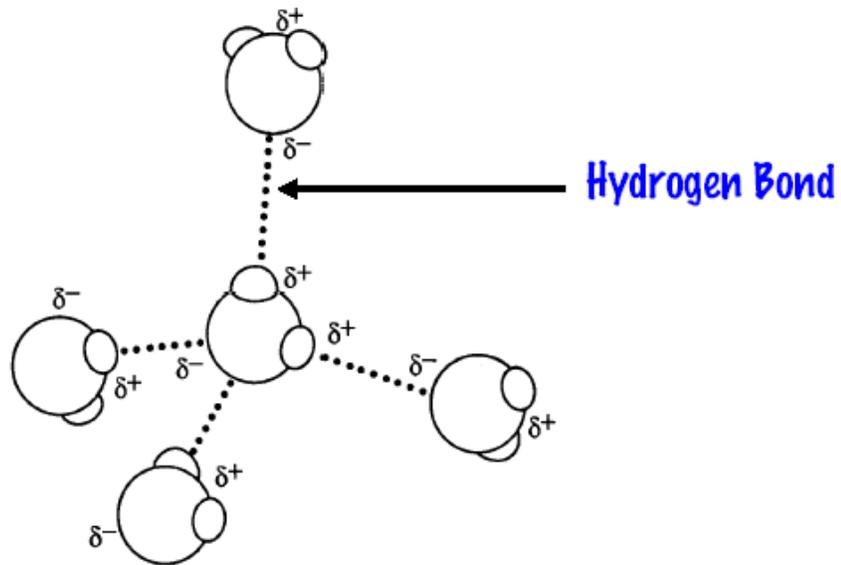
## STRUCTURE & GEOMETRY OF WATER:

Water is polar



Maximum number of H bonds = 4

Each water molecule can form a max. of 4 hydrogen bonds with 4 other water molecules



**PROPERTIES OF WATER:**

Liquid water is cohesive

Cohesion = H bonds between water molecules;  $H_2O$  molecules tend to stick tog.  
Importance = Transport  $H_2O$  against gravity in plants  
Higher surface tension

Water has a high specific heat

Takes a lot of energy to raise 1 gram of  $H_2O$  1 °C  
Why? Must break H bonds  
Liquid  $H_2O$  can absorb large amounts of heat with small changes in temperature

Water has a high heat of vaporization

Takes a lot of energy to convert liquid  $H_2O$  into vapor  
Why? Must break H bonds  
Keeps water in liquid state

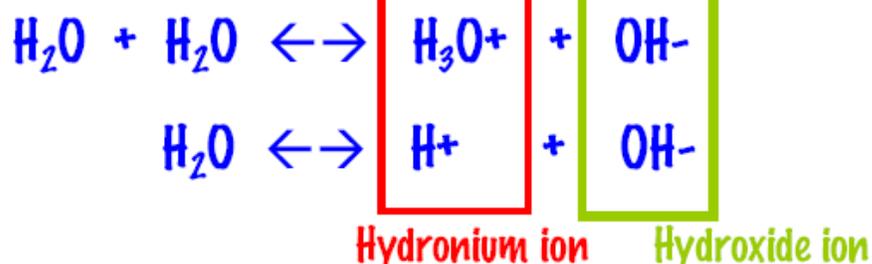
Water expands with it freezes

Solid  $H_2O$  is less dense than liquid  $H_2O$   
Why? In solid state  $H_2O$  locked into max. number of H bonds; takes up more space

Water is a versatile solvent

Will dissolve polar covalent and ionic compounds

### DISSOCIATION OF WATER:



1 out of 554,000,000 water molecules dissociates

At equilibrium in pure water at 25°C

$$[\text{H}^+] = [\text{OH}^-] = 1.0 \times 10^{-7} \text{ M}$$

If add  $[\text{H}^+]$  to pure water

Removes  $\text{OH}^-$

Equilibrium shifts left

$$[\text{H}^+] > [\text{OH}^-]$$

If add  $[\text{OH}^-]$  to pure water

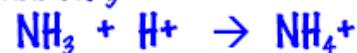
Removes  $\text{H}^+$

Equilibrium shifts left

$$[\text{OH}^-] > [\text{H}^+]$$

reduces  $\text{H}^+$  indirectly

If add  $\text{NH}_3$



Reduces  $\text{H}^+$  directly

### PH SCALE:

$$\text{pH} = -\log_{10}[\text{H}^+]$$

$$\text{if } [\text{H}^+] = 10^{-7}$$

$$\text{then pH} = 7$$

$$[\text{H}^+] \times [\text{OH}^-] = 10^{-14}$$

$$\text{If } [\text{H}^+] = 10^{-9}$$

$$\text{Then } [\text{OH}^-] = 10^{-5}$$

$$\text{pOH} = 5$$

$$\text{pH} = 9$$

<b>BUFFERS:</b>		
<b>Description</b>	<b>Function</b>	<b>Importance</b>
Weak acids or bases	Minimize changes in pH	Controls chemical reactions  Maintains homeostasis

**BICARBONATE BUFFER SYSTEM:**



HCO<sub>3</sub><sup>-</sup> = Bicarbonate (weak base)

H<sub>2</sub>CO<sub>3</sub> = Carbonic acid (weak acid)

Major buffer system in blood

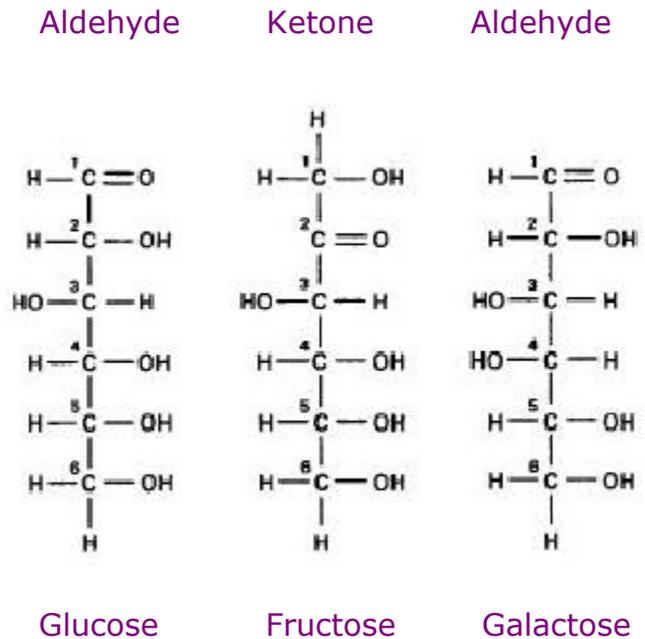
Maintains blood pH between 7.38 and 7.42

<b>Action:</b>	<b>Effect:</b>
Increase [H <sup>+</sup> ] How? Fat metabolism OD on acidic drug	Increase [H <sup>+</sup> ] Equilibrium shifts left H <sup>+</sup> + HCO <sub>3</sub> <sup>-</sup> → H <sub>2</sub> CO <sub>3</sub> → CO <sub>2</sub> + H <sub>2</sub> O Increase [CO <sub>2</sub> ] Increase rate and depth of respiration
Increase Rate & Depth of Respiration  Hyperventilate	Decrease [CO <sub>2</sub> ] Equilibrium shifts left H <sup>+</sup> + HCO <sub>3</sub> <sup>-</sup> → H <sub>2</sub> CO <sub>3</sub> → CO <sub>2</sub> + H <sub>2</sub> O Blood pH increases

# CARBOHYDRATES NOTES

## GENERAL CHARACTERISTICS:

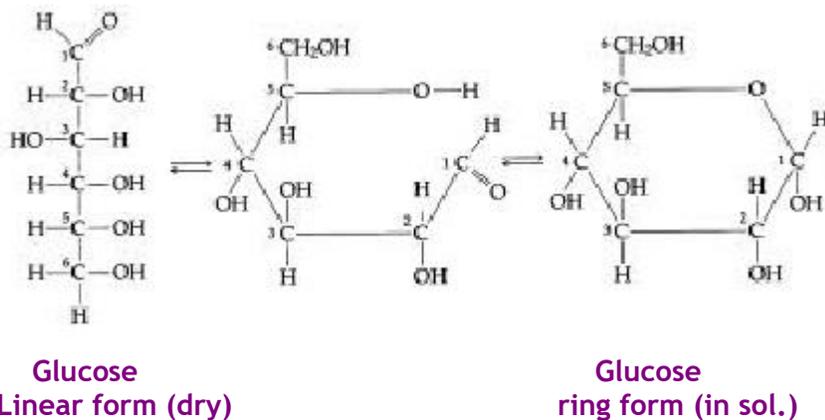
- ◆ Polymers of simple sugars
- ◆ Classified according to number of simple sugars
- ◆ Sugars
  - 3 to 7 carbons
  - -OH attached to each carbon except one
- ◆ Aldehydes or ketones



## MONOSACCHARIDES:

- ◆ Simple sugars
- ◆ Monomers of di- and polysaccharides
- ◆ Store energy in chemical bonds

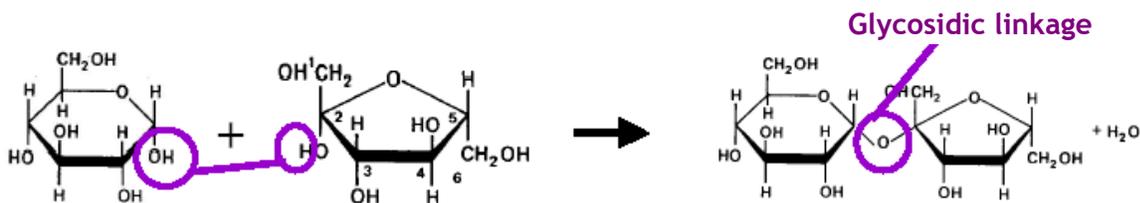
- Trioses
  - 3 carbon sugar
  - glyceraldehyde
- Pentose
  - 5 carbon sugar
  - Ribose
  - Deoxyribose
- Hexose
  - 6 carbon sugar
  - Glucose
  - Galactose
  - Fructose



## DISACCHARIDES:

Double sugars

Condensation Synthesis: removal of water molecule to form bond between monomers



## POLYSACCHARIDES:

Many monosaccharides covalently bonded together

### FUNCTIONS:

Storage

Starch: storage carbohydrate in plants

Glycogen: storage carbohydrate in animals

Structural

Cellulose: plant cell wall component

Chitin: polymer of amino sugar

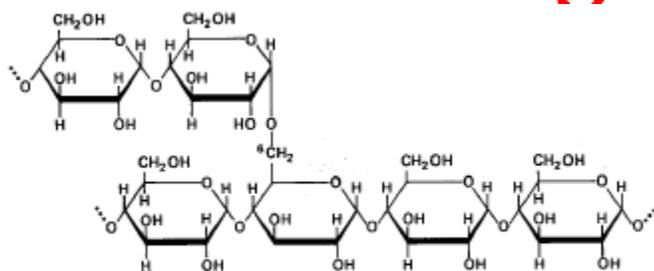
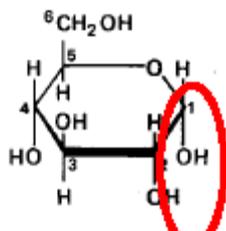
building block of exoskeletons

### STARCH VS CELLULOSE

Starch

Polymer of  $\alpha$  - glucose

Branched  $\alpha$  1-4 linkages



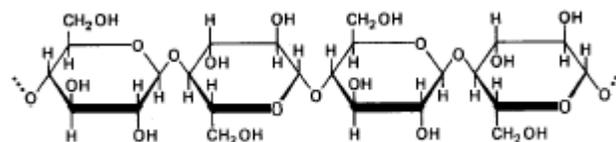
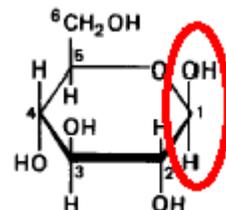
Cellulose

Polymer of  $\beta$  - glucose

Linear

Unbranched  $\beta$  1-4 linkages

Most animals lack enzyme to break  $\beta$  1-4 linkages

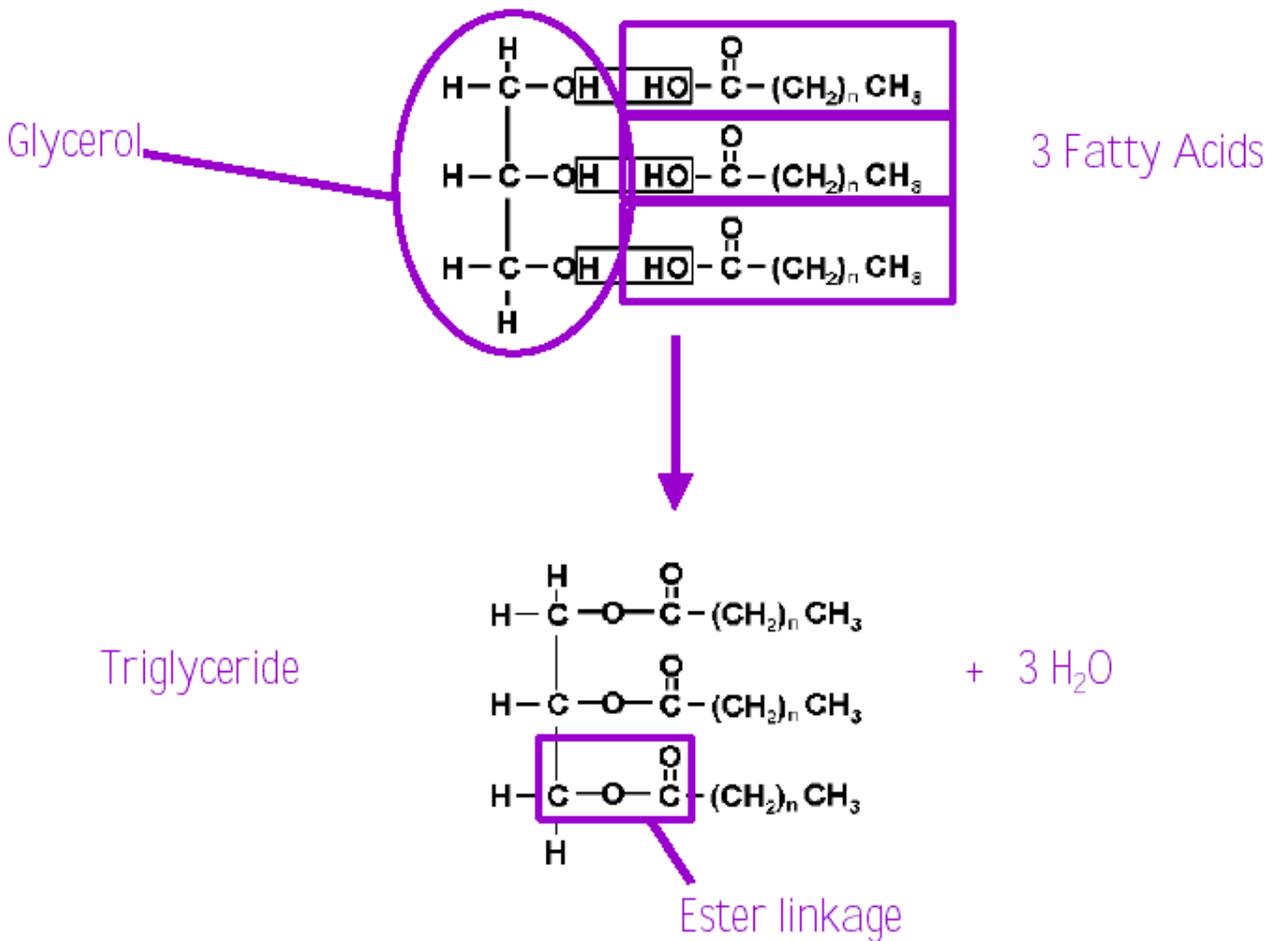


# LIPIDS NOTES

## General Characteristics:

Not soluble in water  
Mostly hydrocarbon chains  
Fats, steroids, phospholipids

## Building Blocks:



**Fats:**

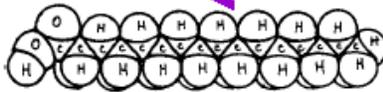
Glycerol + fatty acids  
 Triglycerides have 3 fatty acids  
 Fatty acids present may vary

Compact energy source  
 Cushions vital organs  
 Provides insulation

**Saturated:**

No double bonds between carbons  
 Straight chain

Fatty acid

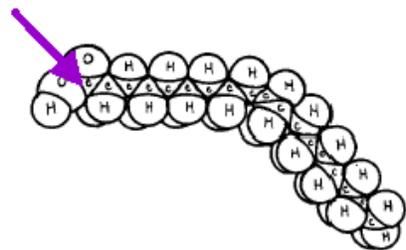


Usually solid at room temperature  
 Straight chains allow for tight packing  
 Most animal fats

**Unsaturated:**

At least 1 double bond between carbons  
 Hydrocarbon chain is bent

Fatty acid



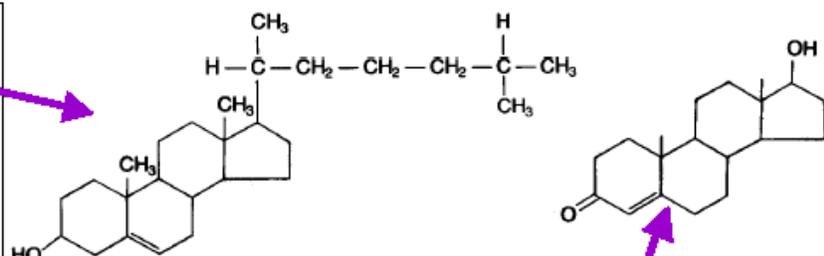
Usually liquid at room temperature  
 Bent chain prevents tight packing  
 Most plant fats

**STEROIDS:**

Consist of 4 fused carbon rings  
 Three are 6-sided  
 One is 5-sided  
 Attached functional groups vary

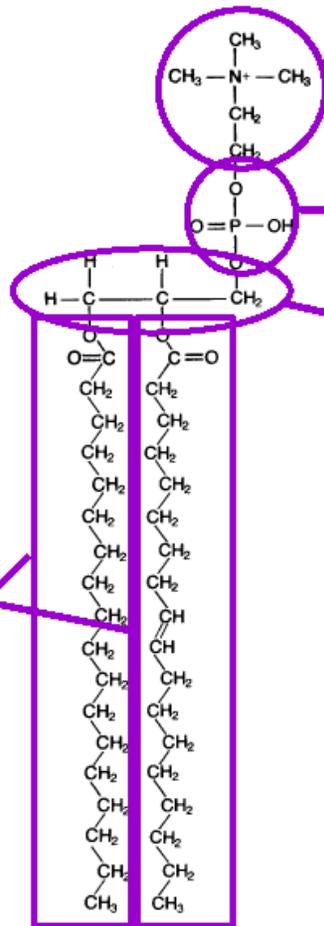
**Cholesterol**

- Precursor of other steroids
- Component of animal cell membranes
- Contributes to arteriosclerosis



Testosterone

**PHOSPHOLIPIDS:**



Functional Group

Phosphate Group

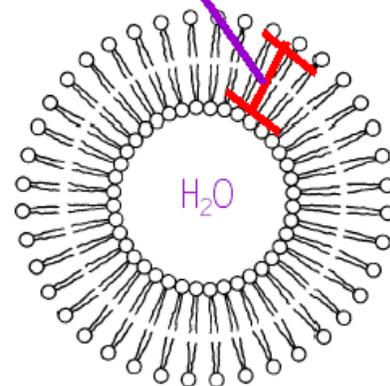
Glycerol

Head  
Hydrophilic  
Water loving  
Polar

2 Fatty acid chains

- Make up Tail of phospholipid
- Hydrophobic
- Water fearing
- Nonpolar

Nonpolar hydrophobic core



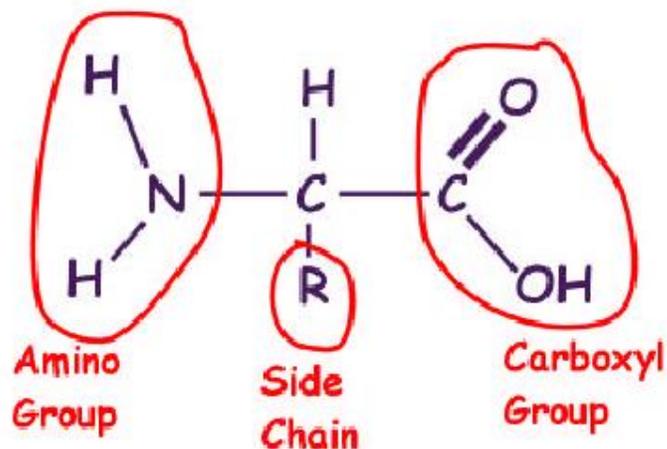
# PROTEINS NOTES

## GENERAL CHARACTERISTICS AND IMPORTANCES:

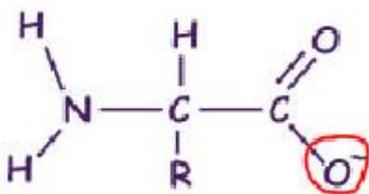
- Polymers of amino acids
- Each has unique 3-D shape
- Vary in sequence of amino acids
- Major component of cell parts
- Provide support
- Storage of amino acids
- Receptor proteins; contractile proteins; antibodies; enzymes

## BUILDING BLOCKS:

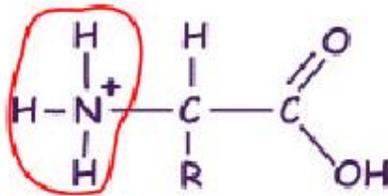
Amino acids  
20 different  
amino acids



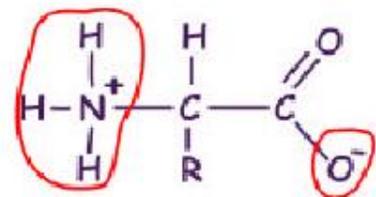
### ANION



### CATION



### DIPOLAR ION

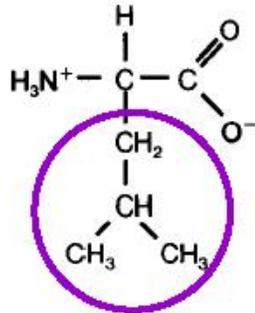
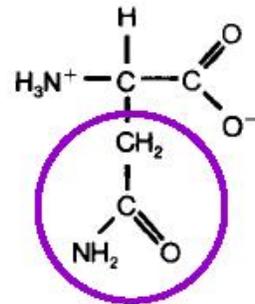
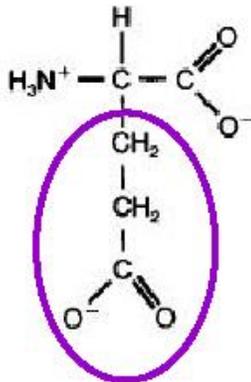
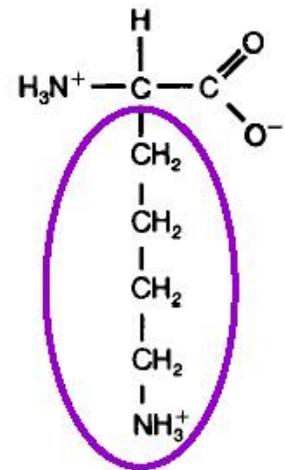
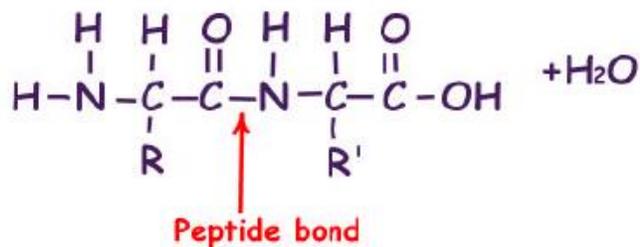
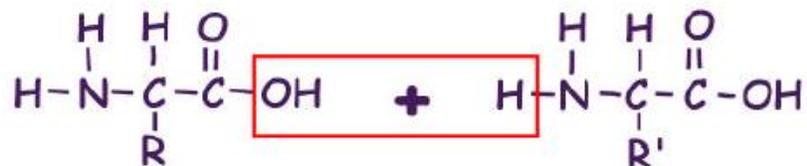


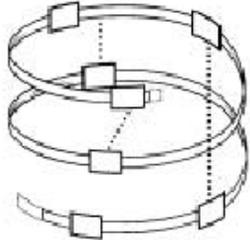
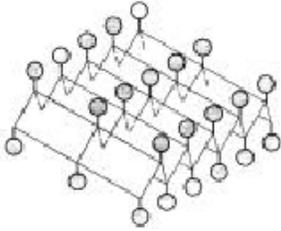
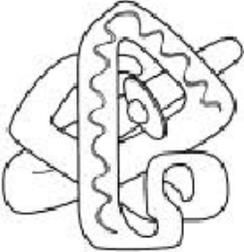
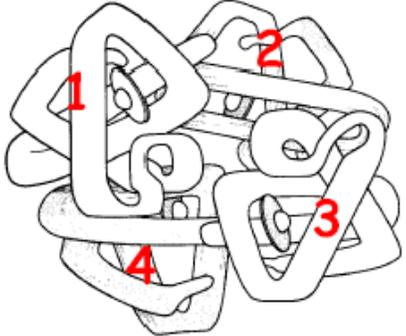
**CLASSIFICATION:**

Based on properties of side chain

**NONPOLAR:**Hydrocarbon  
Chains

No oxygen

**POLAR:**Oxygen present  
Sometimes sulfur  
No charge**POLAR CHARGED ACIDIC:**Negative  
chargeDonate H+  
to solution**POLAR CHARGED BASIC:**Positive  
chargeGain H+ from  
solution**PEPTIDE BONDS:**

<b>PROTEIN CONFORMATION:</b> <b>Unique 3-D shape</b>	
<b>PRIMARY :</b> 	<ul style="list-style-type: none"> <li>• Sequence of amino acids</li> <li>• Determined by genes (sequence of bases in DNA)</li> </ul>
<b>SECONDARY :</b> <p><b><math>\alpha</math> helix</b></p>  <p><b><math>\beta</math> pleated sheet</b></p> 	<ul style="list-style-type: none"> <li>• Regular repeated folding of peptide chain</li> <li>• Folding stabilized by hydrogen bonds</li> </ul>
<b>TERTIARY :</b> 	<ul style="list-style-type: none"> <li>• Globular proteins</li> <li>• Irregular contortion</li> <li>• Shape stabilized by H bonds, ionic bonds, hydrophobic interactions, disulfide bridges</li> <li>• Enzymes</li> </ul>
<b>QUATERNARY :</b> 	<ul style="list-style-type: none"> <li>• Interaction of several polypeptides</li> <li>• Hemoglobin</li> <li>• Collagen</li> </ul> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p>Hemoglobin 4 polypeptide chains</p> </div>

**DENATURATION:**

Changing protein's native conformation

Change shape = change in activity

How?

1. High temperature
2. Chemical agent (acid or base) change in pH
3. Organic solvent

## Summer Assignment Part #2 Biochemistry Worksheets

### I. ORGANIC CHEMISTRY QUESTIONS

*Circle and identify* the functional group(s) found in each of the following molecules.

<p><b>Molecule #1</b></p> $  \begin{array}{c}  \text{H} \quad \text{H} \quad \text{O} \\    \quad   \quad // \\  \text{H}-\text{N}-\text{C}-\text{C} \\    \quad   \quad \backslash \\  \text{H} \quad \text{R} \quad \text{O}-\text{H}  \end{array}  $	<p><b>Molecule #2</b></p> $  \begin{array}{c}  \text{HO} \quad \text{O} \quad \text{OH} \\    \quad    \quad   \\  \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\    \quad   \\  \text{H} \quad \text{H}  \end{array}  $
<p><b>Molecule #3</b></p> $  \begin{array}{c}  \text{O} \quad \text{OH} \quad \text{OH} \\  // \quad   \quad   \\  \text{C}-\text{C}-\text{C}-\text{H} \\    \quad   \quad   \\  \text{H} \quad \text{H} \quad \text{H}  \end{array}  $	<p><b>Molecule #4</b></p> $  \begin{array}{c}  \text{H} \quad \text{O} \\    \quad // \\  \text{H}_2\text{N}-\text{C}-\text{C} \\    \quad \backslash \\  \text{CH}_2 \quad \text{OH} \\    \\  \text{SH}  \end{array}  $
<p><b>Molecule #5</b></p> $  \begin{array}{c}  \text{CH}_2-\overset{+}{\text{N}}(\text{CH}_3)_2 \\    \\  \text{CH}_2 \\    \\  \text{O} \\    \\  \text{O}=\text{P}-\text{O}^- \\    \\  \text{O} \\    \\  \text{CH}_2-\text{CH}-\text{CH}_2 \\    \quad   \\  \text{O} \quad \text{O} \\    \quad   \\  \text{C}=\text{O} \quad \text{C}=\text{O} \\    \quad   \\  (\text{CH}_2)_8 \quad (\text{CH}_2)_7 \\    \quad // \\  \text{CH}_3 \quad \text{CH} \\  \quad \quad   \\  \quad \quad (\text{CH}_2)_7 \\  \quad \quad \quad   \\  \quad \quad \quad \text{CH}_3  \end{array}  $	

## II. WATER, ACIDS, BASES, & BUFFERS QUESTIONS:

1. *Fill out* the following table. *Name and explain* five of water's unique properties, and *discuss* the biological importance/significance of each of these properties.

Property of Water	Explanation of Property	Biological Importance/Significance

2. **Match** the description/definition with the correct term.

- |   |                     |
|---|---------------------|
| _____ Homogenous mixture of 2 or more substances                      | A. Aqueous solution |
| _____ Dissolving agent  | B. Hydrophilic      |
| _____ Material being dissolved  | C. Hydrophobic      |
| _____ Solution where water is solvent                                 | D. Solute           |
| _____ Water loving; molecules with an affinity for water              | E. Solution         |
| _____ Water fearing; molecules that do not have an affinity for water | F. Solvent          |

3. **Explain WHY** water is a versatile solvent. Include water's structure in your explanation.

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4. In general, what kinds of materials will not dissolve in water? \_\_\_\_\_

5. At equilibrium in pure water at 25°C:

a. How does the  $[H^+]$  compare to the  $[OH^-]$ ? \_\_\_\_\_

b. What is the  $[H^+]$ ? \_\_\_\_\_

6. Each of the following will affect the equilibrium established in pure water during the dissociation of water.

**Describe** what effect each will have on the equilibrium by completing the following chart.

Addition of:	Effects on $[H^+]$	Effect on $[OH^-]$	Direction Equilibrium Shifts
$H_2SO_4$			
KOH			
$NH_3$			

7. How does the  $[H^+]$  compare to the  $[OH^-]$  in each of the following:

a. A neutral solution: \_\_\_\_\_

b. An acidic solution: \_\_\_\_\_

c. A basic solution: \_\_\_\_\_

8. What is the pH range for most biological fluids? \_\_\_\_\_

What biological fluid is the exception to this range? \_\_\_\_\_

9. **Complete** the following chart.

[H <sup>+</sup> ]	pH	[OH <sup>-</sup> ]	pOH
10 <sup>-2</sup>			
	4		
		10 <sup>-4</sup>	
			2

10. A patient has been vomiting for a prolonged period of time.

a. What effect would this have on the [H<sup>+</sup>] in the blood? \_\_\_\_\_

b. How will the bicarbonate buffer system respond to this change?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

c. What effect will the buffer system response have on the rate of respiration?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

d. If the buffer system does not return the blood pH to within the normal range or if the vomiting continues, how will the kidneys respond?

Will the kidneys excrete or reabsorb H<sup>+</sup> ? \_\_\_\_\_

Will the kidneys excrete or reabsorb HCO<sub>3</sub><sup>-</sup> ? \_\_\_\_\_

## II. CARBOHYDRATE QUESTIONS:

1. **Match** the definition with the correct term.

- A. Condensation Synthesis      B. Hydrolysis      C. Monomer      D. Polymer      E. Polymerization

\_\_\_\_\_ Large molecule that consists of many subunits called monomers

\_\_\_\_\_ Identical or similar subunits of a polymer

\_\_\_\_\_ Process of linking monomers to form a polymer

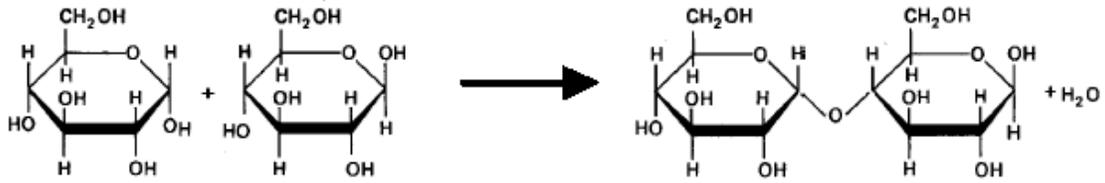
\_\_\_\_\_ Loss of a water molecule between two monomers to form a covalent bond between the monomers

\_\_\_\_\_ Breaking the covalent bond between monomers by adding a water molecule

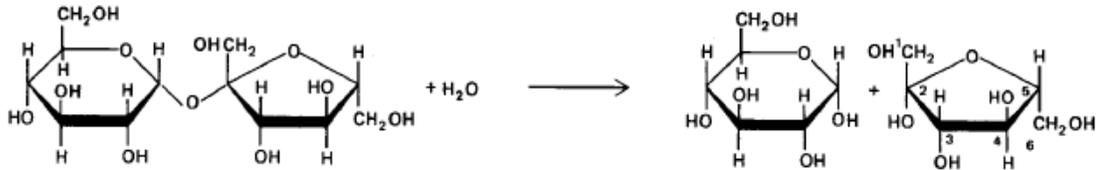
\_\_\_\_\_ A.K.A. dehydration synthesis

2. **Indicate** if each of the following is an example of condensation synthesis or hydrolysis.

Reaction #1: \_\_\_\_\_



Reaction #2: \_\_\_\_\_



Reaction #3: \_\_\_\_\_

Reactions that create proteins, carbohydrates, or lipids

Reaction #4: \_\_\_\_\_

Reactions that digest proteins, carbohydrate, or lipids

3. How can you tell if a chemical equation represents:

a. condensation synthesis? \_\_\_\_\_

b. hydrolysis? \_\_\_\_\_

4. What characteristic is used to classify/group carbohydrates? **Give an example.**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

5. **Match** the description with the correct term.

- |                  |                    |
|------------------|--------------------|
| A. Disaccharides | D. Monosaccharides |
| B. Lactose       | E. Polysaccharides |
| C. Maltose       | F. Sucrose         |

\_\_\_\_\_ Simple sugar

\_\_\_\_\_ General term used to describe a molecule that consists of 2 simple sugars covalently bonded

\_\_\_\_\_ General term used to describe a molecule that consists of 100s or 1000s of simple sugars covalently bonded

\_\_\_\_\_ Molecule that consists of 2 glucose molecules covalently bonded

\_\_\_\_\_ Molecule that consists of a glucose and a galactose covalently bonded

\_\_\_\_\_ Molecule that consists of a glucose and a fructose covalently bonded

6. **Identify** each of the following as a **M**onosaccharide, a **D**isaccharide, or a **P**olysaccharide.

\_\_\_\_\_ Sucrose

\_\_\_\_\_ Maltose

\_\_\_\_\_ Glucose

\_\_\_\_\_ Galactose

\_\_\_\_\_ Ribose

\_\_\_\_\_ Lactose

\_\_\_\_\_ Chitin

\_\_\_\_\_ Deoxyribose

\_\_\_\_\_ Starch

\_\_\_\_\_ Glyceraldehyde

\_\_\_\_\_ Glycogen

\_\_\_\_\_ Amylose

\_\_\_\_\_ Cellulose

\_\_\_\_\_ Amylopectin

\_\_\_\_\_ Fructose

7. **Draw** a glycosidic linkage between two glucose molecules.

8. Listed below are characteristics of four biologically important polysaccharides. Use the key below to indicate the polysaccharide described in each characteristic.

A. Cellulose

B. Chitin

C. Glycogen

D. Starch

\_\_\_\_\_ Polymer of  $\alpha$ -glucose

\_\_\_\_\_ Branched chain

\_\_\_\_\_ Polymer of  $\beta$ -glucose

\_\_\_\_\_ Storage polysaccharide in animals

\_\_\_\_\_ Polymer of an amino sugar

\_\_\_\_\_ Storage polysaccharide in plants

\_\_\_\_\_  $\alpha$  1-4 glycosidic linkages

\_\_\_\_\_ Component of plant cell walls

\_\_\_\_\_  $\beta$  1-4 glycosidic linkages

\_\_\_\_\_ Forms the exoskeleton in arthropods;  
building material of cell walls in some fungi

\_\_\_\_\_ Linear and unbranched

9. How is  $\alpha$ -glucose different from  $\beta$ -glucose?

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10. **Discuss** how two polysaccharides, starch and cellulose, each having the same subunit (glucose), have completely different properties. Why can we digest starch but not cellulose?

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**III. LIPID QUESTIONS:**

1. **Explain** why are lipids insoluble in water. In your explanation relate their chemical structure to their insolubility.

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2. **Discuss** three ways cholesterol is important for biological structure/function.

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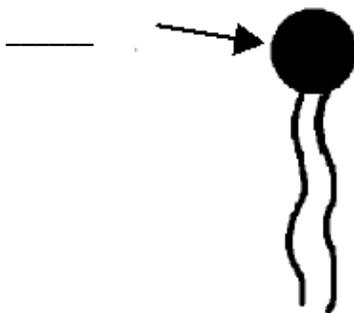
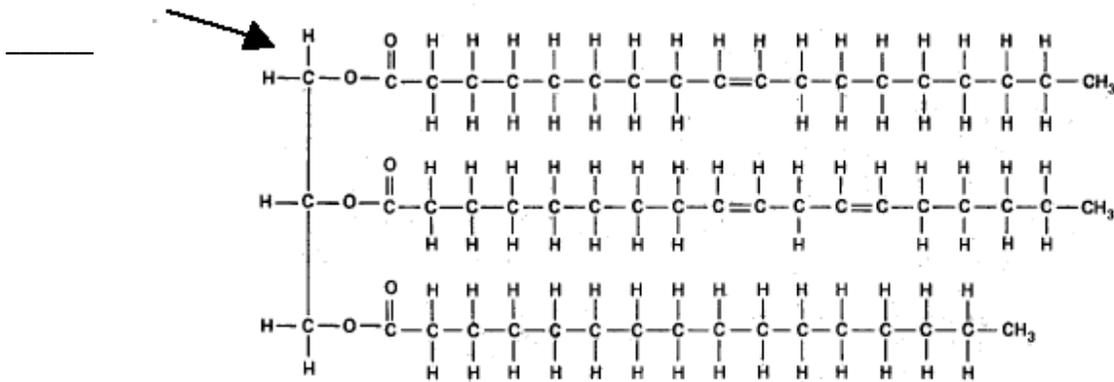
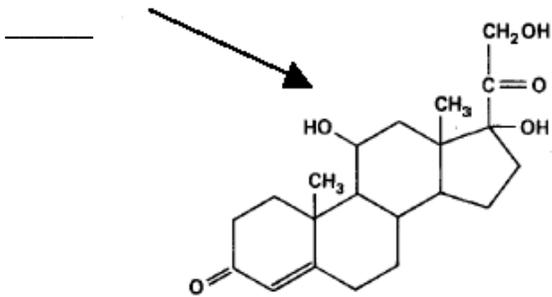
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3. **Indicate** if each of the following is true of a **F**at, a **P**hospholipid, or a **S**teroid.

- \_\_\_\_\_ Consists of glycerol and three fatty acids
- \_\_\_\_\_ Energy source
- \_\_\_\_\_ Cushions and insulates
- \_\_\_\_\_ Consists of glycerol, 2 fatty acids, and a phosphate group
- \_\_\_\_\_ Triglycerides
- \_\_\_\_\_ Part of the molecule is hydrophilic and the other part is hydrophobic
- \_\_\_\_\_ Major component of cell membranes
- \_\_\_\_\_ Consists of four fused carbon rings – three 6-sided rings and one 5-sided

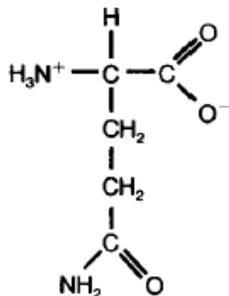




#### IV. PROTEIN QUESTIONS:

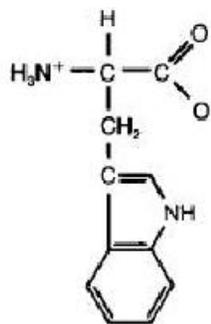
1. **Classify** each of the following amino acids as **nonpolar**, **polar uncharged**, **polar charged acidic** or **polar charged basic**. Justify your classification.

a. \_\_\_\_\_



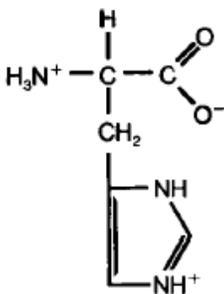
Justification:

b. \_\_\_\_\_



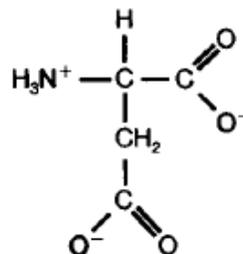
Justification:

c. \_\_\_\_\_



Justification:

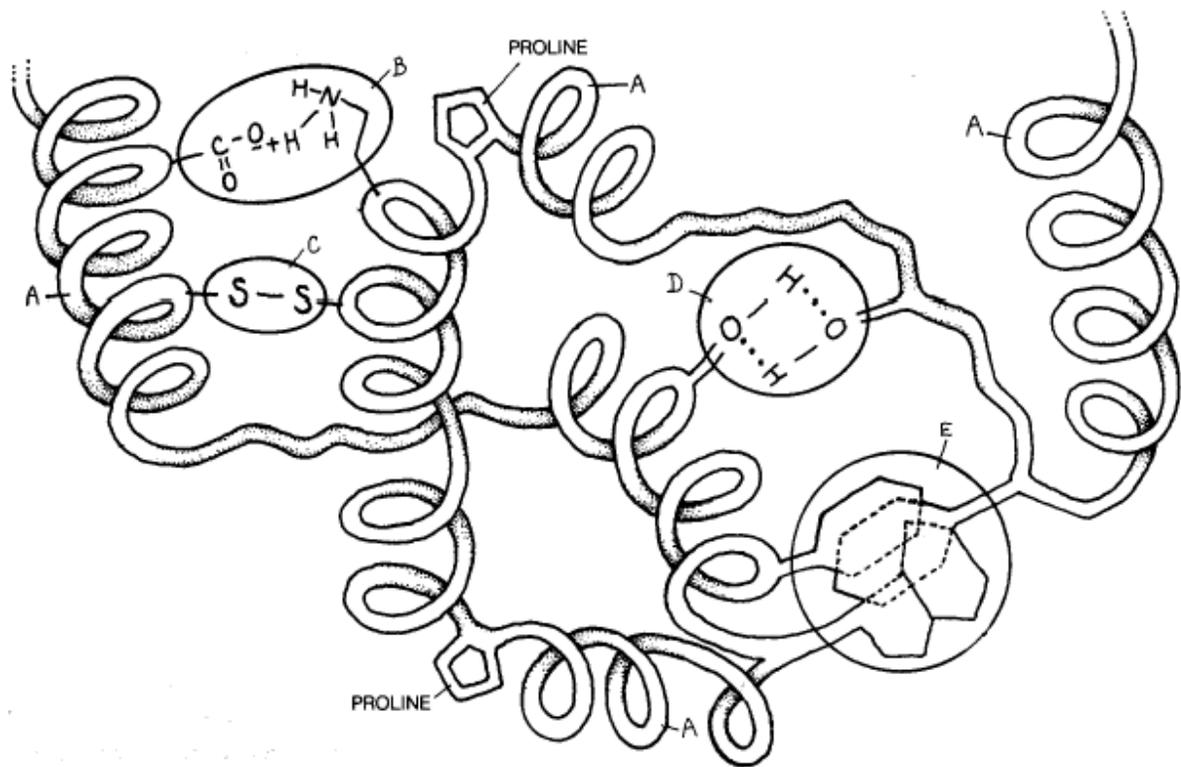
d. \_\_\_\_\_



Justification:

2. **Draw** two amino acids with a peptide bond between them.

3. Use the diagram below to answer the questions that follow.



a. What level of protein structure/organization is shown in the diagram? \_\_\_\_\_

b. **Match** the following with the correct letter from the diagram.

- |                        |                               |
|------------------------|-------------------------------|
| _____ $\alpha$ helix   | _____ Hydrophobic interaction |
| _____ Disulfide bridge | _____ Ionic bond              |
| _____ Hydrogen bonding |                               |

4. **Indicate** the level of protein structure (1, 2, 3, or 4) described in each of the following.

- |   |   |
|---|---|
| _____ $\alpha$ helix  | _____ Sequence of amino acids in a protein    |
| _____ $\beta$ pleated sheets  | _____ Most enzymes                            |
| _____ Collagen and hemoglobin   | _____ Determined by the sequence of DNA bases |
| _____ Form stabilized by hydrogen bonds   | _____ Globular proteins                       |
| _____ Interaction among several polypeptide chains  |   |
| _____ Regular, repeated folding of the peptide chain  |   |
| _____ Form stabilized by hydrogen bonds, ionic bonds, hydrophobic interactions, and disulfide bridges |   |

5. **Describe** what happens to a protein (i.e its structure) when it is **denatured**.

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6. **Explain** how denaturation affects the **function** of a protein.

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7. **Explain how/why** each of the following conditions causes a protein to denature.

Subjecting the protein to high temperatures	
Placing the protein in a strong acid	
Placing the protein in an organic solvent	

## EXPERIMENTAL RESEARCH QUESTIONS

### Introduction

After the tertiary structures of proteins were first shown to be highly specific, the question arose as to how the order of amino acids determined the three-dimensional structure. The second protein whose structure was determined was ribonuclease A, an enzyme from cows that was readily available from pancreases at slaughterhouses. Because it works in the highly acidic environment of the cow stomach, RNase A was stable compared to most proteins and easy to purify. RNase A has 124 amino acids, among which are eight cysteine residues which form four disulfide bridges. Were these covalent links between amino acids essential for the three dimensional structure? Christian Anfinsen and his colleagues set out to answer this question by first destroying these links by reducing the S-S bonds to SH and SH. With the links destroyed, they measured the three-dimensional structure of the protein (was it denatured?) as well as the effect of denaturation, the loss of enzyme activity. They then removed the mercaptoethanol and allowed the S-S bonds to reform by bubbling in oxygen gas and looked again at the structure and function of the enzyme. They found that indeed, the disulfide bonds between amino acids (primary structure) were essential for protein structure and function. Anfinsen was awarded the Nobel Prize in chemistry in 1973.

# INVESTIGATION

## HYPOTHESIS

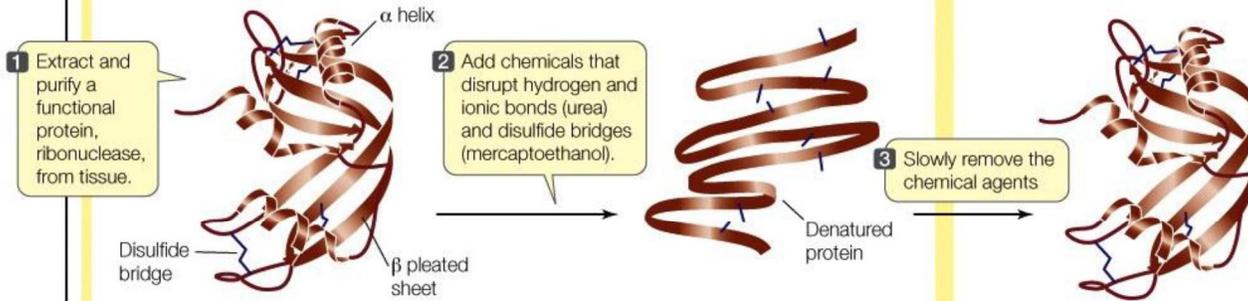
Under controlled conditions that simulate normal cellular environment in the laboratory, the primary structure of a denatured protein can reestablish the protein's three-dimensional structure.

### METHOD

Chemically denature functional ribonuclease, disrupting disulfide bridges and other intramolecular interactions that maintain the protein's shape, so that only primary structure (i.e., the amino acid sequence) remains. Once denaturation is complete, remove the disruptive chemicals.

### RESULTS

When the disruptive agents are removed, three-dimensional structure is restored and the protein once again is functional.



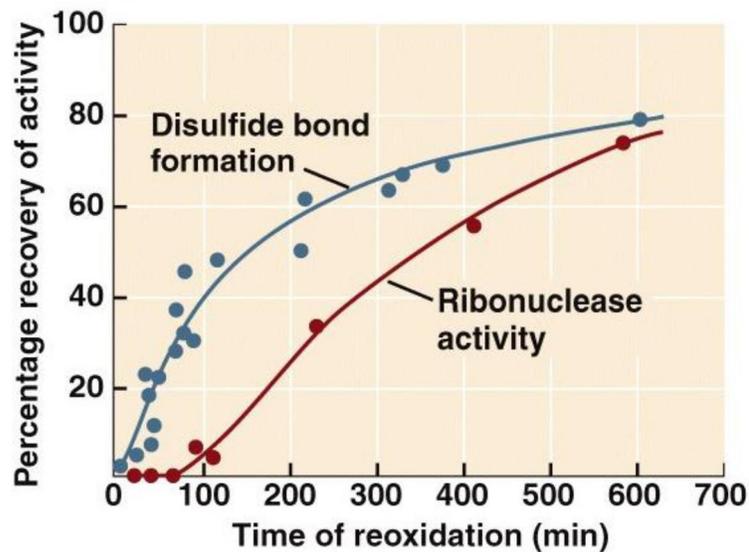
## CONCLUSION

In normal cellular conditions, the primary structure of a protein specifies how it folds into a functional, three-dimensional structure.

## Analyze the Data

### Question 1

Initially, disulfide bonds (S—S) in RNase A were eliminated because the sulfur atoms in cysteine were reduced (—SH). At time 0, reoxidation began and at various times, the amount of disulfide bond re-formation (blue circles) and the function of ribonuclease (enzyme activity; red circles) were measured by chemical methods. Here are the data:



A. At what time did disulfide bonds begin to form? \_\_\_\_\_

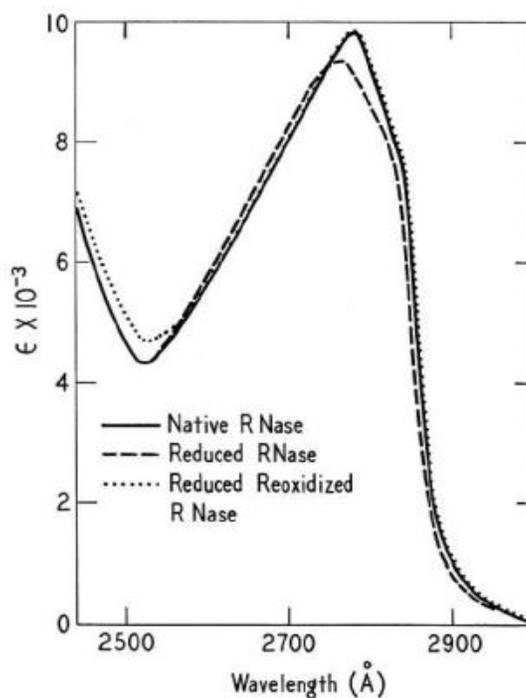
B. At what time did enzyme activity begin to appear? \_\_\_\_\_

C. **Explain** the difference between your answers for the times of (A) and (B).

### Question 2

The three-dimensional structure of RNase A was examined by ultraviolet spectroscopy. In this technique, the protein was exposed to different wavelengths of ultraviolet light (measured in Angstroms [ $1 \text{ \AA} = 10 \text{ nm}$ ]) and the amount of light absorbed by the protein at each wavelength was measured ( $E$ ). Here are the results:

A. Look carefully at the graphs. What was the difference between the peak absorbance of native and reduced (denatured) RNase A?



B. When reduced RNase A was reoxidized (renatured), what did its observed spectrum most closely match, that of native RNase A or reduced RNase A?

C. Based on the **EVIDENCE**, what can you **conclude** about the structure of RNase A in these experiments from the data?

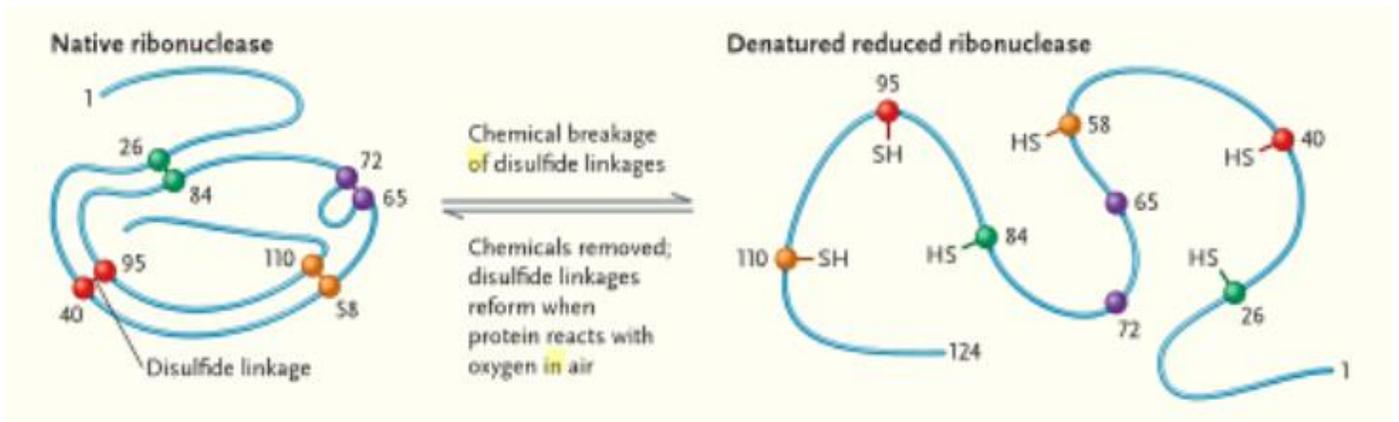
### Question 3

In a second experiment, Anfinsen and Haber investigated the following question.

**Question:** What is the relationship between the amino acid sequence of a protein and its conformation?

**Experiment:** Anfinsen and Haber studied the 124-amino acid enzyme ribonuclease in the test tube. They knew that the native (functional) enzyme has four disulfide linkages between amino acids 26 and 84, 40 and 95, 58 and 110, and 65 and 72 (see figure). They treated the active enzyme with a mixture of urea and  $\beta$ -mercaptoethanol, which breaks disulfide linkages. They then removed the two chemicals and left the enzyme solution in air.

**Results:** The chemical treatment broke the four disulfide linkages, which caused the protein to denature and lose its enzyme activity. After the chemicals had been removed and the enzyme solution exposed to air, Anfinsen made the crucial observation that the protein renatured, slowly regaining enzyme activity. Ultimately the solution showed 90% of the activity of the native enzyme.



He realized that oxygen from the air had reacted with the  $-SH$  groups of the denatured enzyme causing disulfide linkages to reform, and that the enzyme had spontaneously refolded into its native, active conformation. All physical and chemical properties of the refolded enzyme the researchers measured were the same as those of the native enzyme, confirming that the same disulfide bridges had formed as in the native enzyme.

**Conclusion:** Anfinsen concluded that the information for determining the three-dimensional shape of ribonuclease is in its amino acid sequence.

If denatured ribonuclease renatures in the presence of a high concentration of urea, the renatured enzyme has physical and chemical properties similar to those of the native enzyme indicating that refolding had occurred, but the enzyme activity is less than 1% of that of the native enzyme. **Interpret this result.**