Name(s):	Period:	Date:

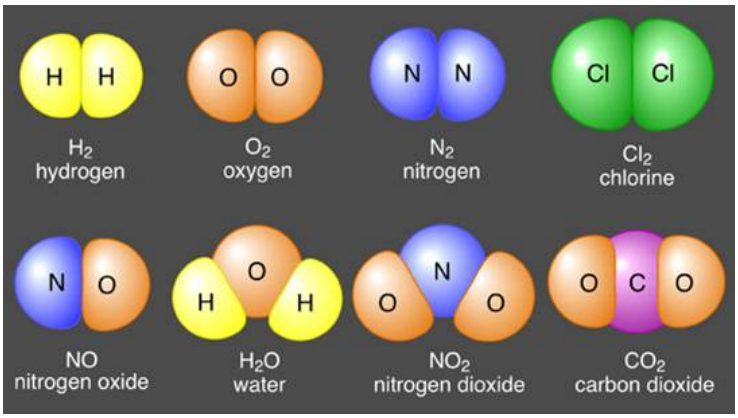
Macromolecules and Digestion

HASPI Medical Biology Lab 07a

Background/Introduction

The Elements of Life

Nearly 99% of the human body is made up of only 6 elements: oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorous. Another 0.85% of the body is made up of 5 additional elements necessary for the body to function: potassium, sulfur, sodium, chlorine, and magnesium. The remaining 0.15% is filled by dozens of trace elements. A 70 kg human is made up of nearly $7x10^{27}$ atoms. More than 60% of those are hydrogen atoms, 25% are oxygen atoms, and 10% are carbon atoms.



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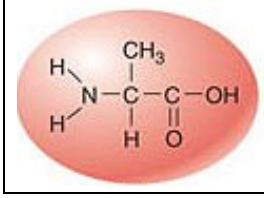
Many of these atoms are bonded together to form important molecules such as water (H_2O), carbon dioxide (CO_2), and oxygen (O_2). The remaining atoms are bonded together to form complex structures that provide energy, support shape, and perform functions within the body. These are called **macromolecules**. The four main macromolecules include proteins, carbohydrates, lipids, and nucleic acids.

Macromolecules are large **polymers**, meaning they are made up of many smaller parts. Those smaller parts are called **monomers**. Think Legos… A spaceship made from Legos would be the polymer, while each individual Lego piece used to create the spaceship would be a monomer. The atoms in each monomer are arranged differently to create a different polymer when they are bonded together.

Proteins

Proteins perform many major functions within the body, including performing chemical reactions as enzymes, communicating as hormones, and initiating movement in muscles just to name a few. The monomers of proteins are called **amino acids**. Amino acids are bonded together in long chains to create proteins, also called **polypeptides**. Proteins may be a few hundred amino acids long or hundreds of thousands of amino acids long. There are 20 different types of amino acids that can be bonded in different orders to create specific proteins. The basic structure of all amino acids is the same.

Monomer Amino Acid	**Polymer** Polypeptide	**Example** Muscle Protein
		

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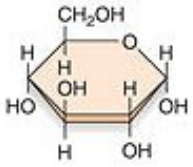
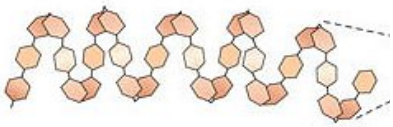
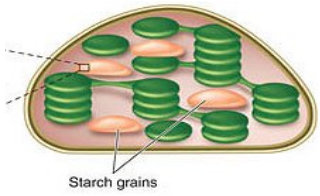
Carbohydrates

The main function of carbohydrates is to provide energy. The monomers of carbohydrates are called **monosaccharides**. Monosaccharides are simple sugars that include fructose, sucrose, and glucose to name a few. Energy is stored in the bonds that create monosaccharides, and released during cellular respiration. Monosaccharides are bonded together to form chains called **polysaccharides**. Polysaccharides are complex sugars that include starch, cellulose, and glycogen.

Monomer Monosaccharide	**Polymer** Polysaccharide	**Example** Starch in Chloroplast
		

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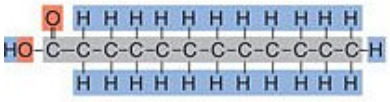
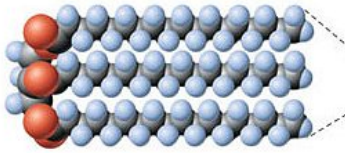
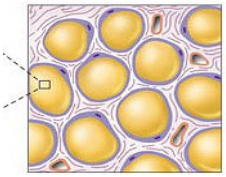
Lipids

Lipids function to form membranes in cells, as hormones and vitamins, and as energy storage. The most common monomers of lipids are called **fatty acids**. Fatty acids can be saturated, meaning they are completely covered in hydrogen atoms, or unsaturated, meaning they have some double-bonds and still have some space available for hydrogen atoms to bond. Fatty acids can be bonded to other molecules such as glycerol and phosphates to form **lipids**. Examples of lipids include triglycerides and phospholipids.

Monomer Fatty Acid	**Polymer** Triglyceride	**Example** Adipose Tissue
		

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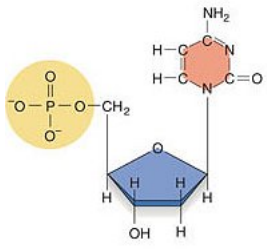
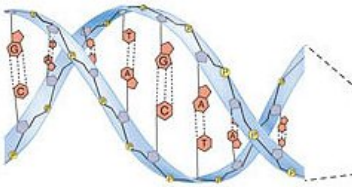
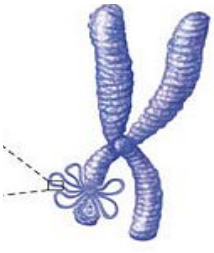
Nucleic Acids

Nucleic acids contain the instructions for creating proteins within the body, and therefore are essential molecules for life. The monomers of nucleic acids are **nucleotides**. Every nucleotide contains 3 parts: a phosphate, a sugar, and a base. There are 5 different nucleotides: cytosine, guanine, adenine, thymine, and uracil. Nucleotides are bonded together to form the two major nucleic acids, **DNA** and **RNA**. The order of nucleotides in DNA determines the order of amino acids in the protein it creates.

Monomer Nucleotide	**Polymer** DNA or RNA	**Example** Chromosome
		

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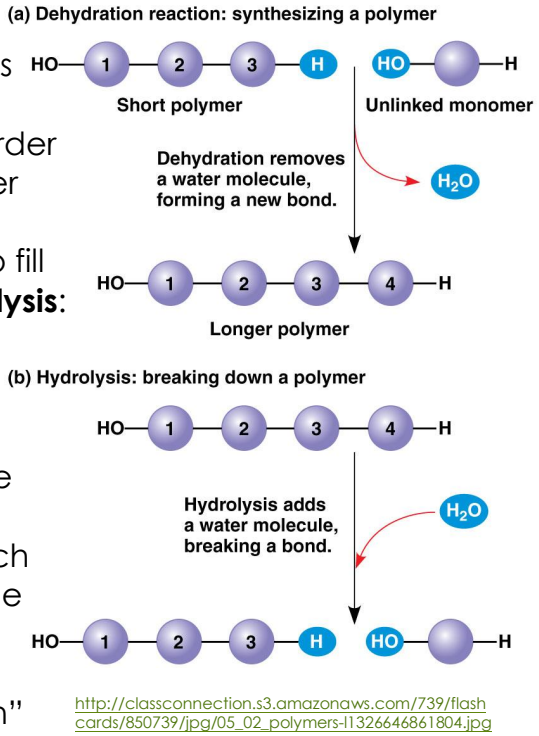
Name(s):	Period:	Date:

Dehydration Synthesis and Hydrolysis

The chemical reactions that bond together macromolecules are similar and require water. When macromolecules are consumed, they must be broken down during digestion in order to be absorbed by the body. Polymers are bonded together with covalent bonds (shared electrons between atoms). To break this bond, water (H_2O) molecules are split and used to fill the space created by the broken bond. This is called **hydrolysis**: "hydro" means water, and "lysis" means to split apart.



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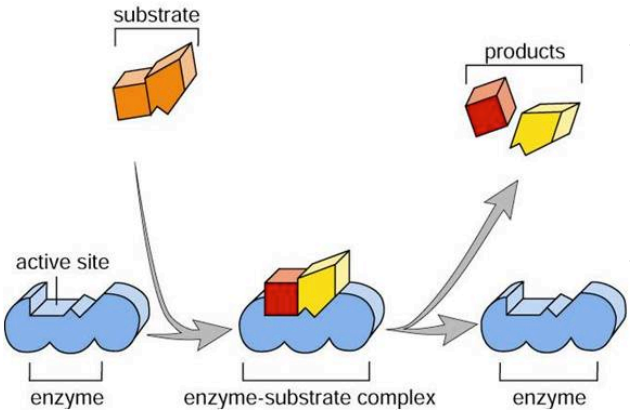
Once a polymer has been broken apart and the monomers have been absorbed, they may need to be bonded back together to form new polymers within the body. To allow the bond between monomers, a hydrogen (H) atom and a hydroxide (OH) molecule are removed from the ends of each monomer. When these are removed, it creates a spot for the two monomers to form a covalent bond with each other; thus the H and OH come together to form a water (H_2O) molecule. This is called **dehydration synthesis**: "dehydration" means losing water, and "synthesis" means to create.

Digestion: Enzymes

The digestive system consists of a group of organs that produce enzymes and substances that assist in digesting food, as well as a long tract that starts at the mouth and ends at the anus. The function of the digestive system is to break down and absorb food, which is made up primarily of macromolecules. Enzymes that break down specific macromolecules are produced in different parts of the digestive tract. An **enzyme** is a substance that speeds up chemical reactions in the body.

Proteins and Proteases

Proteases are enzymes that break down protein. There are two main types of proteases in the digestive system. **Pepsin** is produced in the stomach, and is most effective in a very acidic pH. For this reason the stomach also produces hydrochloric acid that creates a very acidic pH. **Trypsin** is another protease produced by the pancreas for protein digestion in the small intestine.



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Carbohydrates and Amylase

The enzyme that breaks down carbohydrates is called **amylase**. Amylase can be found in the saliva and is produced by the pancreas for carbohydrate digestion in the small intestine.

Lipids and Lipase

The enzyme that breaks down lipids is called **lipase**. Lipase is produced by the pancreas for lipid digestion in the small intestine. Lipids tend to stick together and are difficult for lipase to separate. **Bile** is produced by the liver to emulsify, or break apart, the lipids so lipase can work faster.

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Digestive Enzyme Deficiencies

If macromolecules are not digested correctly, it can impact an individual's health, even if he or she is eating healthy and exercising. Deficiencies in the enzymes that break down macromolecules can occur due to a variety of factors such as environmental pollution, stress, hormone imbalance, or genetic mutations (hereditary).

Protease Deficiencies

A deficiency in protease can lead to an inability of the body to digest and absorb proteins properly. Improper digestion of proteins can lead to a variety of problems, including but not limited to anxiety, arthritis, osteoporosis, bone spurs, hypothyroidism, dehydration, colitis, colon cancer, and chronic infections.

Amylase Deficiencies

A deficiency in amylase can lead to an inability of the body to digest and absorb carbohydrates properly. Improper digestion of carbohydrates can lead to a variety of problems, including but not limited to fatigue, abscesses, psoriasis, eczema, hives, dermatitis, asthma, emphysema, phosphorous deficiency, gastritis, joint stiffness, and high blood pressure.

Lipase Deficiencies

A deficiency in lipase can lead to an inability of the body to digest and absorb lipids properly. Improper digestion of lipids can lead to a variety of problems, including but not limited to high cholesterol, obesity, diabetes, heart disease, muscle spasms, spastic colon, and vertigo.

Review Questions – *answer questions on a separate sheet of paper*

1. What 6 elements make up the majority of the human body?
2. How many atoms are in a 70 kg human?
3. What element is most abundant in the human body?
4. What are macromolecules?
5. Use an example to explain the difference between a monomer and a polymer.
6. What are the monomers and polymers of protein? Give an example of a protein.
7. Looking at the amino acid diagram, what elements are found in an amino acid?
8. What are the monomers and polymers of carbohydrates? Give an example of a carbohydrate.
9. Looking at the monosaccharide diagram, what elements are found in a monosaccharide?
10. What are the monomers and polymers of lipids? Give an example of a lipid.
11. Looking at the fatty acid diagram, what elements are found in a fatty acid?
12. What are the monomers and polymers of nucleic acid? Give an example of a nucleic acid.
13. Looking at the nucleotide diagram, what elements are found in a nucleotide?
14. Compare and contrast hydrolysis and dehydration synthesis. Draw a diagram to demonstrate each process.
15. What do enzymes do?
16. What enzymes break down proteins?
17. What enzymes break down carbohydrates?
18. What enzymes break down lipids?
19. Using an example, explain how deficiencies in digestive enzymes can cause health issues.

Name(s):	Period:	Date:

Macromolecules and Digestion

HASPI Medical Biology Lab 07a

Part A: Building Macromolecules

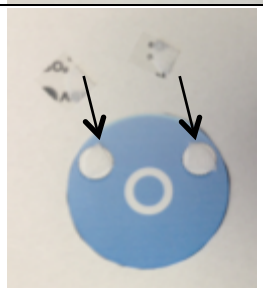
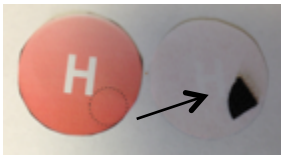
Our bodies are amazing machines capable of breaking down and building up complex molecules required for life. Since these molecules are microscopic, it is easier to understand how they are built using models. In this part of the activity, your team will be modeling dehydration synthesis and hydrolysis to obtain a better understanding of these processes before investigating digestion.

Materials

Velcro dots black (10)
Velcro dots white (10)
Macromolecule template
Scissors

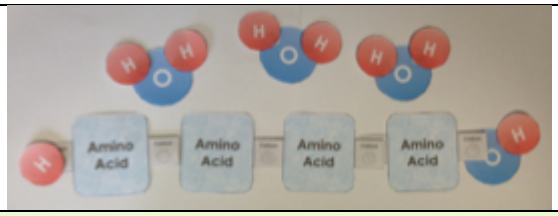
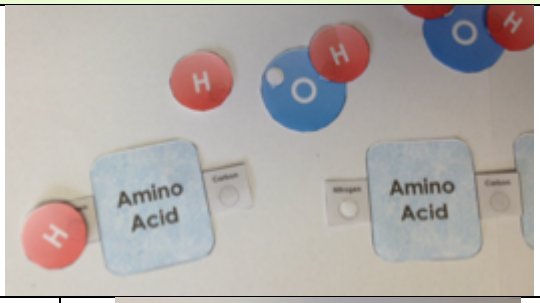
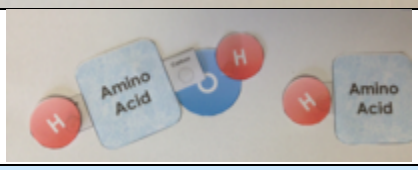
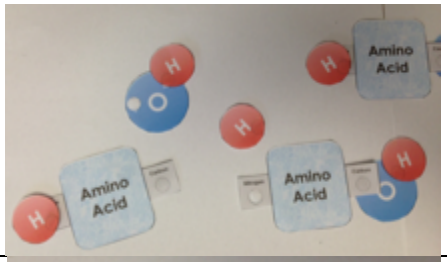
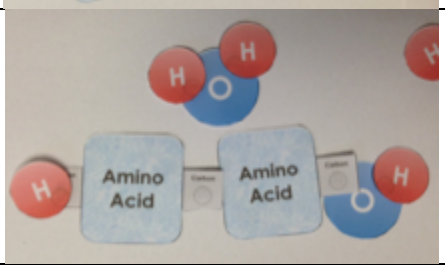
Procedure/Directions

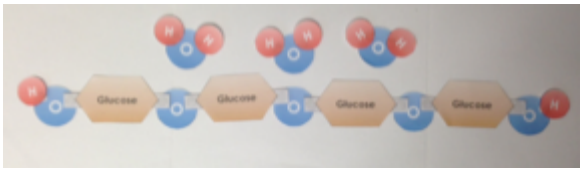
Your lab team will be given tasks, or directions, to perform on the left. Record your questions, observations, or required response to each task on the right.

Set Up		
	Task	**Response**
1	Use scissors to cut out all of the objects on the macromolecule template.	
2	Cut the black and white Velcro dots into quarters (4 sections from each dot; see image).	
3	The outlined circles on each atom or molecule identify a spot for part of a Velcro dot.	 
4	On the WHITE outlined circles, peel and stick a white Velcro section onto the FRONT of the atom/molecule.	
5	On the CLEAR outlined circles, peel and stick a black Velcro section onto the BACK of the atom/molecule.	
6	There will be extra black and white Velcro dot sections. Save these in case any dots come loose.	

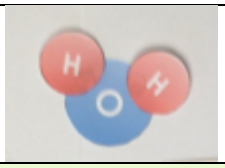
Proteins		
	Task	**Response**
1	Put the 4 amino acid molecules, 4 oxygen atoms, and 8 hydrogen atoms on the table. Push all of the other items to the side.	*a. What are the monomers of protein?*
2	Each of the black Velcro dot sections will attach to the white Velcro dot sections. The Velcro represents bonds between molecules.	*b. What does the Velcro represent?*
3	To form a polypeptide chain, attach each amino acid molecule to each other between the carbon and nitrogen atoms. There cannot be any open bonds (Velcro), so it is necessary to bond an oxygen and hydrogen to the ends of the polypeptide chain (see image).	

Name(s):	Period:	Date:

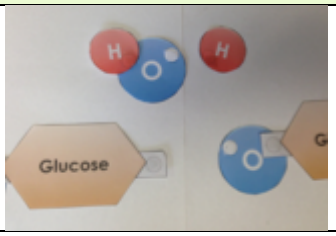
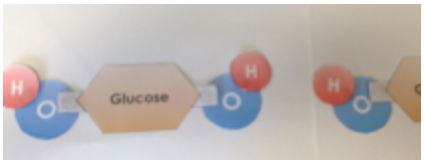
4	Water is also needed for hydrolysis, so use the remaining oxygen and hydrogen atoms to create 3 water molecules (see image).	
Hydrolysis of Proteins		
5	When the body needs to break down protein, it splits the bond between each amino acid molecule, and splits water to fill the bonds.	
6	To perform hydrolysis on your polypeptide chain, break a bond (separate the Velcro) between two of the amino acid molecules.	
7	Break the bond between one of the hydrogen atoms and oxygen on the water molecule.	
8	The hydrogen atom bonds to the nitrogen atom, and the OH bonds to the carbon atom.	
9	Repeat steps 6-8 on the remaining amino acids.	
Dehydration Synthesis of Proteins		
10	The body uses the amino acids it has broken down to build proteins needed for the body to function correctly.	
11	This is the opposite of hydrolysis. Remove the hydrogen atom from the nitrogen of one amino acid molecule, and an OH molecule from the carbon of a <u>different</u> amino acid molecule.	
12	Bond the carbon and nitrogen atoms to each other.	
13	Notice you have a hydrogen atom and an OH molecule remaining. Bond these together to form a water molecule.	
14	Repeat steps 11-13 for the remaining amino acid molecules.	

Carbohydrates		
	Task	**Response**
1	Put the 4 glucose molecules, 8 oxygen atoms, and 8 hydrogen atoms on the table. Push all of the other items to the side.	*a. List two monomers of carbohydrates.*
2	Each of the black Velcro dot sections will attach to the white Velcro dot sections. The Velcro represents bonds between molecules.	
3	To form a carbohydrate chain, connect each glucose molecule with an oxygen atom. There cannot be any open bonds (Velcro), so it is necessary to bond an oxygen and hydrogen to the ends of the carbohydrate chain (see image). Carbohydrate chains can be thousands of sugar molecules long.	

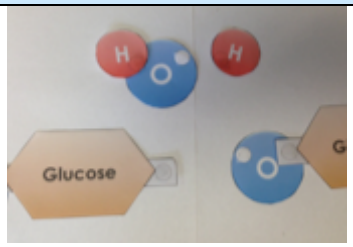
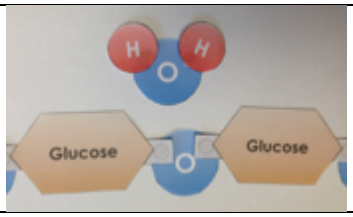
Name(s):	Period:	Date:

4	Water is also needed for hydrolysis, so using the remaining oxygen and hydrogen atoms create 3 water molecules (see image).	
5	When carbohydrates are consumed, they must be broken down into individual sugar molecules to be used to create energy in cellular respiration.	

Hydrolysis of Carbohydrates

6	When the body needs to break down carbohydrates, it splits the bond between each sugar molecule, and splits water to fill the bonds.	
7	To perform hydrolysis on your carbohydrate chain, break a bond (separate the Velcro) between two of the glucose molecules.	
8	Break the bond between one of the hydrogen atoms and oxygen on the water molecule.	
9	One of the glucose molecules should still have an oxygen atom attached. Bond the hydrogen atom that you split from the water molecule to this oxygen atom.	
10	Bond the OH molecule remaining from water to the remaining open bond on the glucose molecule (see image).	
11	Repeat steps 7-10 for the two remaining bonds on the carbohydrate chain.	

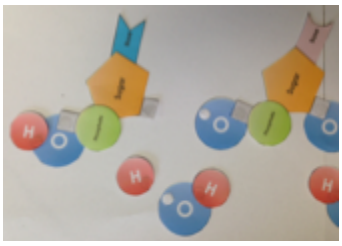
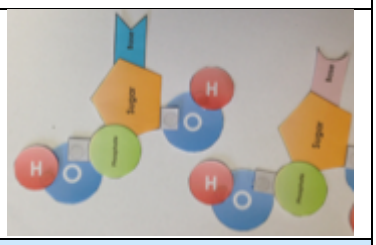
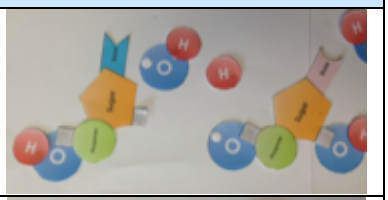
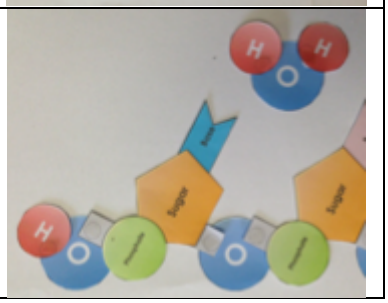
Dehydration Synthesis of Carbohydrates

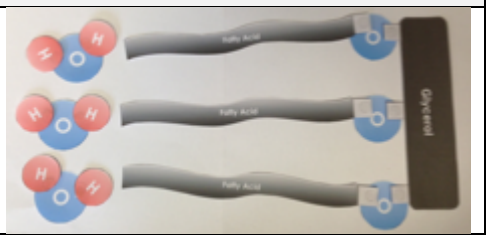
12	If the body has excess sugar, it can bond sugar together and store it for later use.	
13	This is the opposite of hydrolysis. Remove the hydrogen atom from the right side of one glucose molecule, and an OH molecule from the left side of a different glucose molecule.	
14	Bond the remaining oxygen atom that is attached to glucose to the other glucose molecule.	
15	Notice you have a hydrogen atom and an OH molecule remaining. Bond these together to form a water molecule.	
16	Repeat steps 13-15 for the two remaining glucose molecules. You should end up with a carbohydrate chain and 3 waters.	

Nucleic Acids

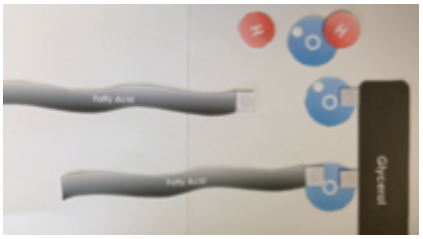
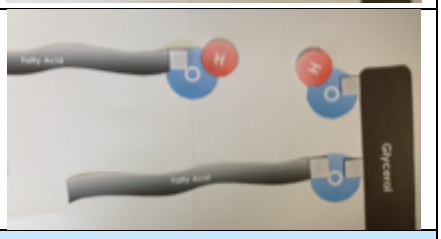
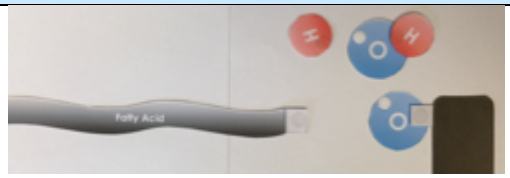
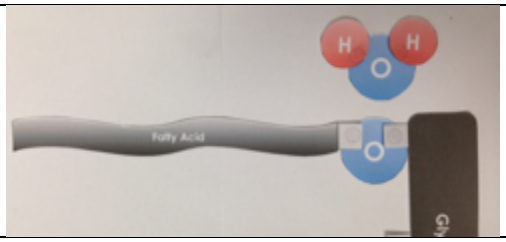
	Task	Response
1	Put the 4 nucleotides, 8 oxygen atoms, and 8 hydrogen atoms on the table. Push all of the other items to the side.	*a. What are the monomers of nucleic acids?*
2	Each of the black Velcro dot sections will attach to the white Velcro dot sections. The Velcro represents bonds between molecules.	
3	To form a nucleic acid (DNA), attach each nucleotide to one another using an oxygen atom between the sugar and phosphate (see image).	
4	There cannot be any open bonds (Velcro), so it is necessary to bond an oxygen and hydrogen to the ends of the nucleic acid (see image).	
5	Water is also needed for hydrolysis, so using the remaining oxygen and hydrogen atoms create 3 water molecules.	

Name(s):	Period:	Date:

Hydrolysis of Nucleic Acids		
6	When the body needs to break down nucleic acids, it splits the bond between each nucleotide, and splits water to fill the bonds.	
7	To perform hydrolysis on your nucleic acid, break a bond (separate the Velcro) between nucleotides. Leave the oxygen attached to one of the nucleotides.	
8	Break the bond between one of the hydrogen atoms and oxygen on the water molecule.	
9	The hydrogen atom bonds to the remaining oxygen on a nucleotide, and the OH bonds to the other nucleotide.	
10	Repeat steps 7-9 on the remaining nucleotides.	
Dehydration Synthesis of Nucleic Acids		
11	Nucleotides are bonded together to form nucleic acids, which include DNA and RNA.	
12	This is the opposite of hydrolysis. Remove an OH molecule from one nucleotide, and a hydrogen atom from a <u>different</u> nucleotide.	
13	Bond the nucleotides to each other using the oxygen atom.	
14	Notice you have a hydrogen atom and an OH molecule remaining. Bond these together to form a water molecule.	
15	Repeat steps 12-14 for the remaining nucleotide molecules.	

Lipids		
Task		**Response**
1	Put the 3 fatty acid molecules, glycerol molecule, 6 oxygen atoms, and 6 hydrogen atoms on the table. Push all of the other items to the side.	*a. What are the monomers of lipids?*
2	Each of the black Velcro dot sections will attach to the white Velcro dot sections. The Velcro represents bonds between molecules.	
3	To form a lipid, attach each fatty acid molecule to the glycerol molecule using an oxygen atom (see image).	
4	Water is also needed for hydrolysis, so using the remaining oxygen and hydrogen atoms create 3 water molecules.	

Name(s):	Period:	Date:

Hydrolysis of Lipids		
5	When the body needs to break down lipids, it splits the bond between fatty acid molecules, and splits water to fill the bonds.	
6	To perform hydrolysis on your lipid, break a bond (separate the Velcro) between a fatty acid and glycerol. Leave the oxygen attached to glycerol.	
7	Break the bond between one of the hydrogen atoms and oxygen on the water molecule.	
8	The hydrogen atom bonds to the remaining oxygen on glycerol, and the OH bonds to the fatty acid.	
9	Repeat steps 6-8 on the remaining fatty acids.	
Dehydration Synthesis of Lipids		
10	Fatty acids and glycerol are bonded together to form lipids, or fats.	
11	This is the opposite of hydrolysis. Remove the OH molecule from the fatty acid molecule, and the hydrogen atom from the glycerol.	
12	Bond the fatty acid and glycerol molecules to each other using the oxygen atom.	
13	Notice you have a hydrogen atom and an OH molecule remaining. Bond these together to form a water molecule.	
14	Repeat steps 11-13 for the remaining fatty acid molecules.	

Analysis & Interpretation

Answer the following questions using data from your lab AND internet research if needed.

Analysis Questions – *answer questions on a separate sheet of paper*

1. What is the difference between a monomer and a polymer?
2. Make a table listing the monomers and polymers of proteins, carbohydrates, lipids, and nucleic acids.
3. What is the purpose of hydrolysis?
4. What is the purpose of dehydration synthesis?
5. Explain hydrolysis using a diagram.
6. Explain dehydration synthesis using a diagram.
7. Based on what you have learned about hydrolysis and dehydration synthesis, why do you think water is so important to the body?

Name(s):	Period:	Date:

Macromolecules and Digestion

HASPI Medical Biology Lab 07b

Part B: Digestion, Macromolecules, and Enzymes

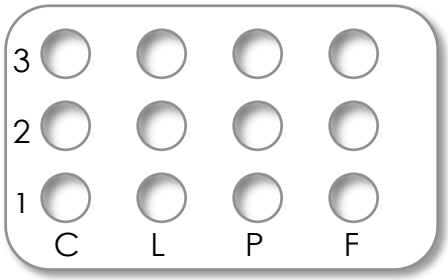
When we eat, we consume macromolecules, vitamins, and minerals needed for our body to function normally. When macromolecules are consumed, it is necessary to break them down into smaller monomers to use them. **Carbohydrates** are broken down into simple sugars, such as glucose, that are used to create energy in cellular respiration. **Proteins** are broken down into amino acids that are then rearranged during translation to make proteins important to the body, such as insulin. **Lipids** are broken down into fatty acids and glycerol. Fatty acids are used to build essential cell organelles, like the cell membrane. **Nucleic acids** are also broken down into individual nucleotides that are used for DNA replication and transcription. Breaking down these macromolecules would be EXTREMELY slow without enzymes to speed up the reaction. In this lab, your team is going to observe how enzymes can break down carbohydrates, proteins, and lipids into smaller pieces.

Materials

Spot plate
6 pH strips/indicator sheet
12 Toothpicks (stirrers)
Food sample
Protein solution
Starch solution
Lipid solution
Protease solution
Lipase solution
Amylase solution
Iodine potassium iodide
Biuret solution
1% HCl solution
Soap solution
Paper towels

Procedure/Directions

Your lab team will be given tasks, or directions, to perform on the left. Record your questions, observations, or required response to each task on the right.

Set Up		
	Task	**Response**
1	Obtain a spot plate, 12 toothpicks, 6 pH strips, a pH indicator sheet, a pencil, and paper towels. Cut or tear the pH strips in half length-wise.	**Figure A** 
2	Using a pencil, label the wells 1-3 across the side, and with a "C", "L", "P", and "F" across the bottom/top (see Figure A).	
3	The C row represents the Carbohydrates tests, the L row represents the Lipids tests, the P row represents the Proteins tests, and the F row represents Food test.	
4	All of the solutions have been placed at a central location. You will need to take your spot plate to that location to collect each solution when the task directs you to do so. Each solution may be in a dropper bottle, or there may be plastic pipettes available.	
5	*a. What is the purpose of this lab?* *b. What are monomers and polymers? Explain how you will be observing monomers and polymers in this lab investigation.*	

Name(s): **Period:** **Date:**

Part A: Carbohydrate Digestion

	Task	Response
1	Add 15 drops of **Starch solution** to wells 1 and 2 in row C.	*c. What enzymes break down carbohydrates?*
2	Add 5 drops of **Amylase** to well 2. Amylase is an enzyme that breaks down starch--a carbohydrate--into smaller sugars.	
3	Using separate stirring sticks, mix each well.	**Iodine Potassium Iodide Results**
4	Allow the wells to sit for 5 minutes.	
5	Add 1 drop of **Iodine potassium iodide** to wells 1 and 2. Potassium iodine turns blue/black in the presence of starch. If amylase has broken down the starch into smaller sugars, the potassium iodine will have a much lighter reaction.	Well 1 Results: Well 2 Results:
6	*d. What is the monomer of carbohydrates? In which well, if any, were you able to observe amylase breaking down carbohydrates?* *e. What was the purpose of well 1?* *f. Explain your results.*	

Part B: Lipid Digestion

	Task	Response
1	Add 10 drops of water to wells 1-3 in row L.	*g. What enzymes break down lipids?*
2	Add 3 drops of Lipid solution to wells 1-3 in row L.	
3	Add 5 drops of Lipase to wells 2 and 3. Lipase is an enzyme that breaks down lipids.	
4	Add 2 drops of soap to well 3. Soap is an emulsifier, which means that it does not break the bonds between lipids, but instead separates them from other lipids making it easier for lipase to break them down. In the body, bile produced by the liver acts as the emulsifier.	**Before Digestion pH** Well 1 pH: Well 2 pH: Well 3 pH:
5	Using separate toothpicks, mix each well.	**After Digestion pH**
6	Test the pH of wells 1-3 using the pH strips.	
7	Allow the wells to sit for 20 minutes.	
8	After 20 minutes, retest the pH of each well. If the lipase has been effective, the pH of the solution should decrease.	Well 1 pH: Well 2 pH: Well 3 pH:
9	*h. What is the monomer of lipids? In which well, if any, were you able to observe lipase breaking down lipids?* *i. What was the purpose of well 1?* *j. Explain your results.*	

Name(s):	Period:	Date:

Part C: Protein Digestion

	Task	Response
1	Add 5 drops of the Protein solution to wells 1-3 in row P.	*k. What enzymes break down proteins?*
2	Add 5 drops of Protease to wells 2 and 3. Protease is an enzyme that breaks down proteins. In the stomach, the protease enzyme is called pepsin.	
3	Add 5 drops of 1% HCl to well 3. Pepsin works best in an acidic environment. In the stomach, hydrochloric acid (HCl) is produced to make pepsin more effective at breaking down proteins into amino acids.	**Before Digestion pH** Well 1 pH: Well 2 pH: Well 3 pH:
4	Using separate toothpicks, mix each well.	
5	Test the pH of wells 1-3 using the pH strips.	**Biuret Results** Well 1 Results: Well 2 Results: Well 3 Results:
6	Allow the wells to sit for 5 minutes.	
7	After 5 minutes, add 2 drops of Biuret to wells 1-3. If the protein has been broken down into amino acids, the biuret will turn pink. If it has not, the biuret will remain blue/purple.	
8	*l. What is the monomer of proteins? In which well, if any, were you able to observe protease breaking down proteins?* *m. What was the purpose of well 1?* *n. Was there any difference in digestion between the well with protease and the well with protease + 1% HCl? Why do you think this happened?* *o. Explain your results.*	

Part D: Macromolecules in Food

	Task	Response
1	Choose any food item that easily mixes in water. You may need to smash the food sample in order to have it mix easily.	*p. What food item did you choose?* *q. Hypothesize which macromolecules your food item contains:*
2	In a beaker, mix a small amount of your food sample with 10 ml of water.	
3	Using a plastic pipette, add 5 drops of the food solution to wells 1-3 in row F.	
4	Dip a pH strip into one of the wells. Record the pH of your food solution.	Food pH:

Name(s): **Period:** **Date:**

TEST FOR PROTEIN		
5	Add 5 drops of protease and 5 drops of 1% HCl to well 1.	*r. Are proteins present in the food sample?*
6	Use a toothpick to stir the well.	
7	Allow well 1 to sit for 5 minutes to give the protease time to break down any proteins that are present.	
8	After 5 minutes, add 2 drops of Biuret. The solution will turn pink if protein is present.	
TEST FOR CARBOHYDRATES		
9	Add 1 drop of iodine potassium iodide to well 2.	*s. Are carbohydrates present in the food sample?*
10	Use a toothpick to stir the well.	
11	If there are carbohydrates present, well 2 will turn blue/black.	
TEST FOR LIPIDS		
12	Add 5 drops of lipase and 2 drops of soap to well 3. Mix the solution.	**pH Results** *Well 4 pH BEFORE:* *Well 4 pH AFTER:*
13	Use a toothpick to stir the well.	
14	Test the pH of the solution.	
15	Allow well 3 to sit for 20 minutes to allow the lipase and soap time to break down any lipids that are present.	
16	After 20 minutes, retest the pH of the solution. If the lipase has been effective, the pH of the food solution should decrease.	*t. Are lipids present in the food sample?*

Analysis & Interpretation

Answer the following questions using data from your lab AND internet research if needed.

Analysis Questions – *answer questions on a separate sheet of paper*

1. What are the 4 main macromolecules? What are the monomers of each of the 4 macromolecules?
2. Explain how enzymes work, and give two examples of enzymes.
3. What type of macromolecules are enzymes?
4. What does amylase do?
5. Explain how the lab was able to determine whether amylase was effective.
6. What does lipase do?
7. What is the purpose of using soap for lipid digestion?
8. Explain how the lab was able to determine whether lipase was effective.
9. What does protease do?
10. Why was 1% HCl combined with protease for protein digestion?
11. Explain how the lab was able to determine whether protease was effective.
12. What types of macromolecules were in your food sample?

Name(s):	Period:	Date:

Connections & Applications

Your instructor may assign or allow you to choose any of the following activities. As per NGSS/CCSS, these extensions allow students to explore outside activities recommended by the standards.

1. **CREATE A DIGESTIVE DISORDER POSTER OR BROCHURE:** There are a variety of disorders that can impact the breakdown and absorption of macromolecules in the digestive system. Research and create a poster or brochure that includes the following information:
   a. A disorder that affects how <u>proteins</u> are broken down or absorbed.
      i. Explanation of the disorder
      ii. Symptoms and treatment options
      iii. Prevalence (how many people suffer from this disorder)
      iv. At least one image, diagram, table, or graph supporting the information
   b. A disorder that affects how <u>carbohydrates</u> are broken down or absorbed.
      i. Explanation of the disorder
      ii. Symptoms and treatment options
      iii. Prevalence (how many people suffer from this disorder)
      iv. At least one image, diagram, table, or graph supporting the information
   c. A disorder that affects how <u>lipids</u> are broken down or absorbed.
      i. Explanation of the disorder
      ii. Symptoms and treatment options
      iii. Prevalence (how many people suffer from this disorder)
      iv. At least one image, diagram, table, or graph supporting the information
   d. NO PLAGIARISM WILL BE TOLERATED! Cite all of your sources using a bibliography.

   In any writing process, it is important to revisit your work and is often useful to have others help in the editing process. For this project, create a rough draft and ask a parent, classmate, sibling, or teacher to edit the rough draft. Have the editor write any corrections or suggestions on your rough draft. Revise and rewrite your poster/brochure using the suggested edits. Turn in <u>both</u> your rough draft and the final draft.

2. **INVESTIGATE DIET SUPPLEMENTS:** Certain diet supplements claim to be able to block the digestion of lipids and carbohydrates so they cannot be absorbed into the blood. Some of these supplements do this by actually blocking the enzymes that would normally break down lipids and carbohydrates into smaller monomers. Research the following questions and write an informational report on your findings.
   a. Explain how fat blockers and starch blockers work.
   b. Choose 1 example of a fat blocker supplement and 1 example of a starch blocker supplement. For each supplement, determine exactly how they "block" fats/starches.
   c. Determine what company creates and sells each supplement. Read the information for each supplement provided by the company that makes the supplement. Research and find an external site that has reviewed the supplement. Compare the following between the two sites:
      i. Ingredients of the supplement
      ii. Results that an individual will have taking the supplement
      iii. Negative side effects
      iv. Are there any inconsistencies between the company site and the external site?
   d. NO PLAGIARISM WILL BE TOLERATED! Cite all of your sources using a bibliography.

Name(s): **Period:** **Date:**

3. **CALCULATING DIGESTION AND ABSORPTION RATES:** The complexity, or density, of a macromolecule impacts the rate that it is digested and absorbed into the body. For example, egg protein takes less than 45 minutes to digest, while beef protein is complex and can take more than 4 hours to digest in the stomach. Once a macromolecule has been digested, the small monomers are able to diffuse through the small intestine directly into the bloodstream where they can be used. The following chart outlines the approximate digestion rate and absorption rate of common carbohydrates and proteins.

Table 1. Digestion and Absorption Rates of Carbohydrates and Proteins

Carbohydrate Absorption Rate		**Carbohydrate Digestion Rates**			
Glucose	60 g/hour	Fruit juice	0.25 hr	Carrots, beets, parsnips, turnips	0.8 hr
Protein Absorption Rates		Watermelon	0.3 hr	Corn, potatoes	1 hr
Egg protein	2.9 g/hour	Oranges, grapes	0.5 hr	Brown rice, cornmeal, oats, peas, beans	1.5 hrs
Milk protein	3.5 g/hour	Apples, peaches, cherries, pears	0.6 hr	Seeds	2 hrs
Animal protein	10 g/hour	Tomato, lettuce, celery, spinach	0.7 hr	Nuts	3 hrs
NOTE: *Fats absorb the slowest and the rate varies GREATLY based on genetics and overall health, which is why we will only be calculating protein and carbohydrate digestion and absorption rates.*		**Protein Digestion Rates**			
		Fish	0.5 hr	Turkey	2.2 hrs
		Egg	0.75 hr	Lamb	3 hrs
		Skim milk	1.5 hrs	Beef	4 hrs
		Whole milk	2 hrs	Pork	4.5 hrs
		Chicken	2.1 hrs	Cheese	5 hrs

a. An average human eats the following foods in a day. Determine the digestion rate, absorption rate, and total digestion time of each meal using the information from Table 1 (remember 1 g = 1 ml). The "Snack" has been completed for you as an example.

Breakfast 8:00 am	**Snack** 10:30 am	**Lunch** 12:00 pm	**Dinner** 6:00 pm	**Dessert** 8:30 pm
Scrambled eggs (60 grams) with cheese (20 g) Orange juice (150 ml)	Almonds (40 g) and sunflower seeds (30 g)	Chicken (100 g) & spinach salad (350 g) Apple juice (200 ml)	Beef steak (130 g) & baked potato (250 g) Skim milk (200 ml)	Peach (75 g) and oat cobbler (115 g)

Table 2. Meal Digestion, Absorption, and Elimination Rate

	Total Amount *(g)*	Digestion Rate (longest rate only)	Absorption Rate (total g / absorp. rate)	Time in Large Intestine	Total Time *(hours)*
Breakfast					
Carbohydrates				36 hrs	
Proteins					
Snack					
Carbohydrates	70 g (40g + 30g)	3 hrs (nuts)	1.17 hrs (70g / 60g)	36 hrs	39.17 hrs
Proteins	0	0	0		0

Name(s): **Period:** **Date:**

	Total Amount *(g)*	Digestion Rate (longest rate only)	Absorption Rate (total g / absorp. rate)	Time in Large Intestine	Total Time *(hours)*
Lunch					
Carbohydrates				36 hrs	
Proteins					
Dinner					
Carbohydrates				36 hrs	
Proteins					
Dessert					
Carbohydrates				36 hrs	
Proteins					

b. Which meal took the longest to digest? Why?
c. Which meal took the shortest time to digest? Why?
d. What is actually occurring to carbohydrates and proteins during digestion?
e. If the meal was eaten on Monday, what day and time would the dessert be eliminated from the body?

Resources & References

- NIH. 2008. Your Digestive System and How it Works. National Digestive Diseases Information Clearinghouse, NIH Publication No. 08-2681. www.digestive.niddk.nih.gov.

- Wyatt. 2005. Western Kentucky University, Bio 113 Nutrition, http://bioweb.wku.edu/courses/BIOL115/Wyatt/Nutrition/nutrition.asp.