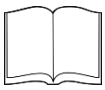
Subject Code	Biology 1	Fundamentals of Biology 1
Learning Guide Code	2.0	Nutrition and Digestion
Lesson Code	2.3	Digestive Enzymes and Substances
Time Frame		30 minutes (1 session)



MATERIALS NEEDED

To complete this learning guide, you need the following:

1. Pen
2. Biology: A global Approach by Campbell et al. (2015).
3. Laptop Computer/Internet-ready gadgets
4. Stable internet connection
5. Moodle account

TARGET

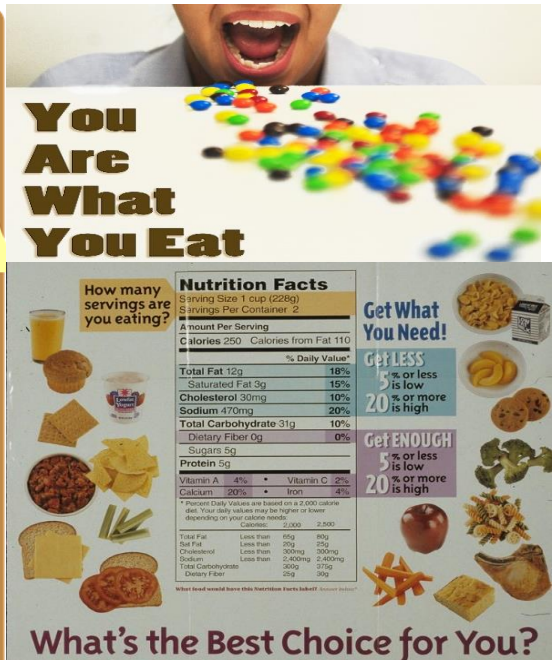
After completing this learning guide, you are expected to:

- list the principal digestive enzymes, where they are produced, and the type of food they act upon.
- state the end products of the digestion of the different biomolecules

HOOK

3 minutes

What consisted your meal before you started reading this module? Write it here



Now, have you ever wondered how they might affect your brain? **Watch this and find out!**

https://www.youtube.com/watch?v=xyQY8a-ng6g

Note: You are not required to access the site.

IGNITE

21 minutes

In the previous learning guides, we have discussed how food is processed by different organisms. We focused on the different mechanisms various organisms adapt to perform the major stages in food processing. Recall that all organisms need to break down food to obtain energy that will serve as fuel in maintaining cellular processes and making molecules essential for homeostasis and so for staying alive. Today, we are going to talk about food and how our body acts on it.

In the video you watched, it was mentioned that, "when it comes to what you bite, chew, and swallow, your choices have a direct and long-lasting effect on the most powerful organ in your body." This is also true to other organs in your body. That is why, choosing a healthy meal requires you to have knowledge about what is in your food.

Broadly classifying, the food we eat can be categorized into four biomolecules: carbohydrate, lipids, proteins, and nucleic acids. Of these, three are considered as macromolecules because they contain polymers. A **polymer** is defined in Chemistry as a natural or synthetic macromolecule (macro- meaning big) composed of repeating units of a

smaller molecule, called **monomer**. Take the train and the train cars as an analogy. The train cars are the monomers. When we attach them such that they appear like the train we are familiar with, we make a polymer. Polymers are broken to monomers through a reaction called **hydrolysis**. It is termed as such because during the process, a water molecule is added to the existing bonds that connect one monomer to another. On the other hand, polymers are created through a **dehydration** reaction. In this process, water molecules are removed from the chains of monomers. Just remember this, when we dehydrate, we make; when we hydrolyze, we break. To visually present to you how this process occurs, watch this video. **Note: You are not required to access the site.**

Hydrolysis and Dehydration Synthesis: https://www.youtube.com/watch?v=ZMTeqZLXBSo

FIGURE 1. Carbohydrates. Wuzefe (n.d.). Retrieved from: https://www.needpix.com/photo/download/291120/bread-health-carbohydrates-cake-free-pictures-free-photos-free-images-royalty-free-free-illustrations. This image is under Public Domain.

Carbohydrates

The usable energy in food is measured in units called **calories**. Some food labels may also opt to use kilocalories. According to health.gov., the total number of calories a person needs each day depends on many factors such as the person's age, sex, height, weight, and level of physical activity. No matter how varied our required calorie intake may be, it is estimated that about two-thirds of that are used by the body in "keeping body temperature constant, repairing internal organs and skin, keeping the heart beating and lungs breathing, and ensuring the proper chemical balance inside and outside the body's cells" (National Academy of Sciences, 1992).

Carbohydrates are the most important and least expensive source of food energy. They are also among the most abundant in supply. They are a family of compounds made of carbon, hydrogen and oxygen. These elements are arranged into rings and these rings may be strung together to form chains depending if they are simple or complex carbohydrates. Simple carbohydrates are those sugars with one or two rings only. Specifically and respectively, they are called **monosaccharides** and disaccharides. Glucose, for example, is a simple sugar and a monosaccharide. On the contrary, Sucrose is a simple sugar and a disaccharide because it contains one ring of glucose molecules bonded to another ring of fructose. Sucrose is commonly known as table sugar. Meanwhile, complex carbohydrates are those sugars with three or more rings bonded together. These are the oligosaccharides and **polysaccharides**. Additionally, complex carbohydrates can be digestible (starch) or indigestible (fiber) depending on the configuration of linkages between monomers that compose them. **Let us try if you can now relate this to the concept of polymer versus monomer. If I have a starch as the polymer, what would be its monomer?**

Carbohydrates are needed by our body. Your brain needs them to think and your muscles need them during contraction. All cells need them to make ATPs, the energy currency of cells, to operate cellular processes.

FIGURE 2. Proteins. Unknown (March 1989). Retrieved from:https://upload.wikimedia.org/wikipedia/commons/b/b8/Protein_%281%29.jpg. This image is in the public domain and can be freely used.

Proteins

Proteins are the body's building blocks. They are composed of monomers called **amino acids** which are made up of carbon, hydrogen, oxygen, nitrogen and sometimes sulfur. Meat is a rich protein source. When we eat meat, the proteins in it are first digested in our stomach and further digested into its monomers, the amino acids, in our small intestine. These amino acids are the ones which get absorbed usually via active transport in the epithelial cells lining our small intestine. Most **enzymes** are proteins. They act as catalysts that hasten chemical reactions. These enzymes, together with other molecules, make the materials or so called the "building blocks" needed by cells to create another needed molecule. Proteins can also be found in plant sources like beans and nuts. They are needed for muscle maintenance. We also rely on them in manufacturing almost everything in our body - from something as small as our antibodies to our hair and nails.

Nucleic acids

Nucleic acids are the genetic material. We consume almost everything that has nucleus and DNA or RNA in it- plant cells and animal cells. DNA and RNA are broken down to its monomers called **nucleotides**. Nucleotides have carbon, hydrogen, oxygen, and phosphorus.

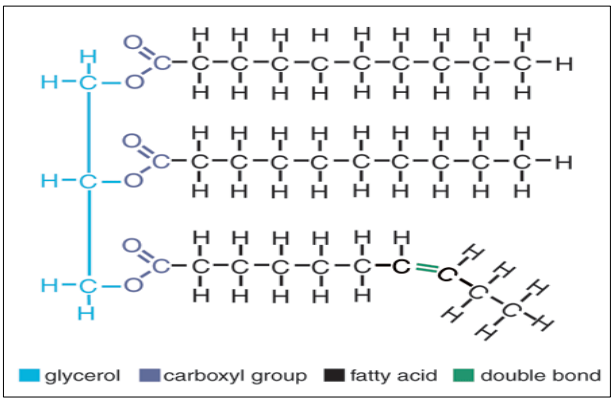
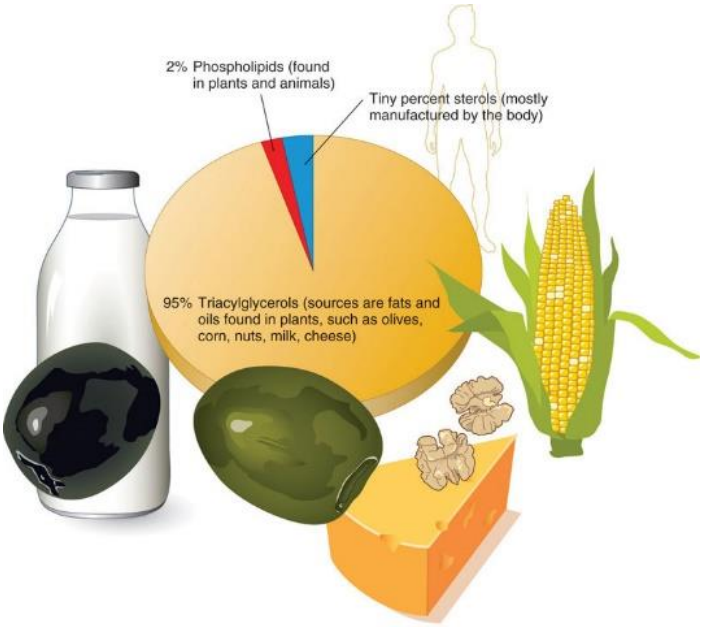


FIGURE 3. A fat molecule showing its component parts: the glycerol, carboxyl group, and fatty acids. Harrigan, G., Maguire, G., and Boros, L. (2008). Retrieved from: https://www.visionlearning.com/es/library/Biologia/2/Lipids/207

Lipids

Lipids are hydrophobic molecules that contain carbon and hydrogen. They include fats, oils, waxes, certain vitamins, and hormones. Fats are the second energy source next to carbohydrates. The major fat found in food is triglyceride, a molecule of glycerol linked to three fatty acids. They can be saturated or unsaturated. Saturated fatty acids are termed as such because their structure is made up of carbons that are bonded to hydrogens with single bonds. There are no double bonds formed, that is why they are saturated with hydrogen. They are solid at room temperature. Unsaturated fatty acids form double bonds and contain less hydrogen molecules. They are usually liquid at room temperature. Among the four biomolecules mentioned earlier in this learning guide, lipids are not considered as a macromolecule. For one thing, their size is not large enough to be considered as a macromolecule. For another thing, they don't have true monomers. However, they can still be broken down into component parts.



Fats are integral to maintaining the structure of our cell membranes. They are also precursor molecules in making hormones. It is also an energy storage. It stores twice as much energy as carbohydrates do. They can be found both in plant and animal sources.

To summarize the key points in our discussion above, refer to FIGURE 5 below. A parallel table can be found on **page 140 of Campbell 10th edition.**

Now that you are already familiar with the major classes of molecules that make up your food and their corresponding monomers, let us now direct our attention to the sites where these molecules are broken down and what specific enzymes function to do such.

FIGURE 4. Types of Lipids. 2012books.lardbucket.org. (n.d.). Retrieved from: https://2012books.lardbucket.org/books/an-introduction-to-nutrition/s09-01-what-are-lipids.html. This file is licensed under Creative Commons.

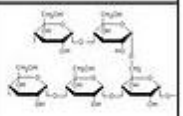
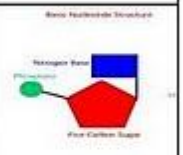
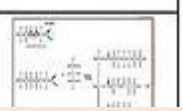
Biomolecule	Elements/Chemical Formula	Function	Monomer/Polymer	Examples	Other
Carbohydrates -end in -ose	Carbon, Hydrogen, Oxygen $C_6H_{12}O_6$ = glucose	Main source of energy	Monomer = sugar or monosaccharide Polymer = starch or polysaccharide	Glucose, fructose, galactose Sugar, starch (potatoes, pasta, etc.)	
Proteins *one of the most important Biomolecules ***Nitrogen** makes it different	Carbon, Hydrogen, Oxygen and Nitrogen	*control rate of chemical reactions through ENZYMES *Bones and muscles *transport things in and out of cells	Monomer = amino acids Polymer = protein/polypeptide chain	Meat, poultry, eggs, beans, soy, nuts, peanut butter, enzymes	
Nucleic Acids ***phosphorus** makes it different	Carbon, Hydrogen, Oxygen, Nitrogen and Phosphorus	*stores and transmits genetic information	Monomer = nucleotide Polymer = nucleic acid (DNA)	DNA = deoxyribonucleic acid RNA = ribonucleic acid	
Lipids *no true	Primarily Carbon and Hydrogen	*stores energy and make up biological membranes and	Made up of 3 Fatty Acids and 1 glycercol	Fats, oils, waxes, membranes	

FIGURE 5. Biomolecules Chart. Pinterest.ph (2019, May 22). Retrieved from: https://www.pinterest.ph/pin/362328732515331073/.

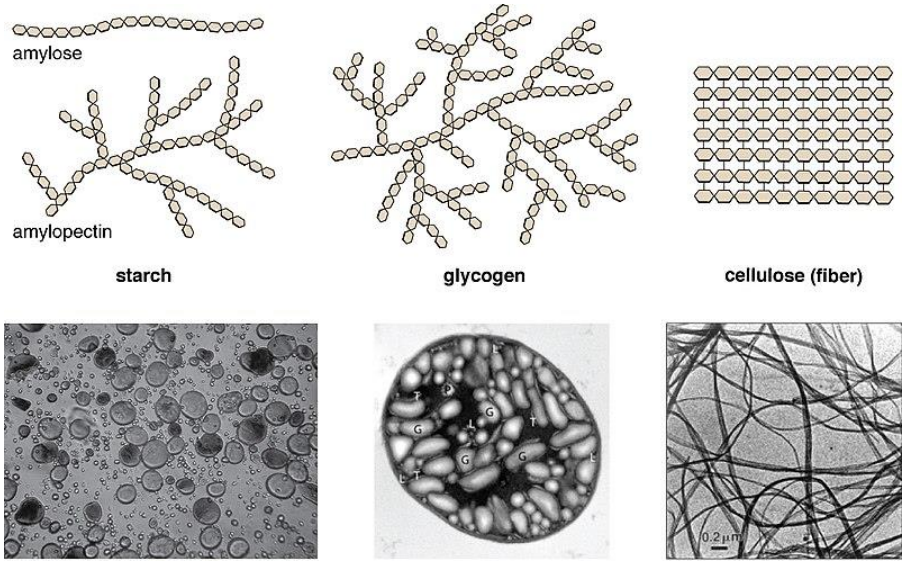


FIGURE 6. The three most abundant polysaccharides – starch, glycogen, and cellulose. Cnx.org (2016, November 11). Retrieved from: https://commons.wikimedia.org/wiki/File:OSC_Microbio_07_02_polysacch.jpg. This file is licensed under the Creative Commons Attribution 4.0 International license.

Chemical Digestion of Carbohydrates

We already noted that carbohydrates can be simple or complex, digestible or not. We will focus with digestible carbohydrates, those that our body can process. Plants synthesize carbohydrates and store them in the form of starch which primarily come in two forms: amylose and amylopectin. Amylose is an unbranched form of starch, while amylopectin is a branched form of starch (see FIGURE 6). Both are composed of glucose monomers. Most of the digestible carbohydrates (starch) included in our diet are in the form of **amylose**. Animals, on the other hand, store a polysaccharide called **glycogen**. It resembles amylopectin in structure but it is more highly branched.

When we take in carbohydrate-rich food, or more specifically starch-rich food, enzymes present in our oral cavity begin digesting them. Our saliva contains **salivary amylase or ptyalin**, the enzyme responsible for breaking down the amylose into **smaller polypeptides** and **maltose**, a disaccharide consisting of two glucose molecules linked together. In the **small intestine**, these disaccharides are further digested into monosaccharides by **pancreatic amylase**, amylase enzymes secreted by the pancreas. Other carbohydrates are digested by **enzymes secreted by the small intestine**. For example, sucrose is digested by the enzyme sucrase to yield glucose and fructose. Lactose is digested by lactase to generate glucose and galactose. These all happen in the intestines. When they are in their simplest form, they move inside the epithelial cells lining the small intestine and finally transported in the capillaries for processing in the liver. Some people cannot produce sufficient lactase to digest lactose that is why some of us are lactose intolerant.

DID YOU KNOW THAT?

"Many East Asians and Native Americans, up to 90 percent in some ethnic groups, become lactose-intolerant after the early childhood years as their genes direct a slowdown in the production of lactase. A nearly opposite ratio of lactase nonpersistence exists in people of northern European descent, who can digest dairy throughout adulthood. Why the difference?"

Find out more on: https://charactermedia.com/why-most-east-asians-are-lactose-intolerant/#:~:text=Many%20East%20Asians%20and%20Native,in%20the%20production%20of%20lactase.

Chemical Digestion of Proteins

Proteins have polypeptides as their polymers and these must be broken down to the monomers, amino acids, before being absorbed by the epithelial cells of the small intestine. As discussed in the previous learning guide and as mentioned earlier, protein digestion begins in the **stomach.** The enzyme **pepsin**, which is activated by the action of hydrochloric acid, breaks down polypeptides into **smaller polypeptides**. This occurs in the stomach. After chyme is secreted in the duodenum of the small intestine, **pancreatic trypsin and chymotrypsin** further break down the small polypeptides into even smaller ones. Unlike pepsin which works efficiently in acidic environments, trypsin and

chymotrypsin require a basic environment to be able to perform their function. Further, through the action of **pancreatic carboxypeptidase**, smaller polypeptides are further broken down. **Dipeptidases, carboxypeptidases, and aminopeptidases** cleave one amino acid at a time from a dipeptide or a polypeptide. These all occur in the **small intestine.**

Chemical Digestion of Nucleic Acid

Nucleic acids are digested into **nucleotides** by **pancreatic nucleases** produced by pancreas and secreted in the small intestine. Nucleotides are further broken down into **nucleosides** by **nucleotidases** produced by intestinal epithelium. These nucleosides are further acted upon by **nucleosidases and phosphatases** to yield **nitrogenous bases, phosphates, and sugars.**

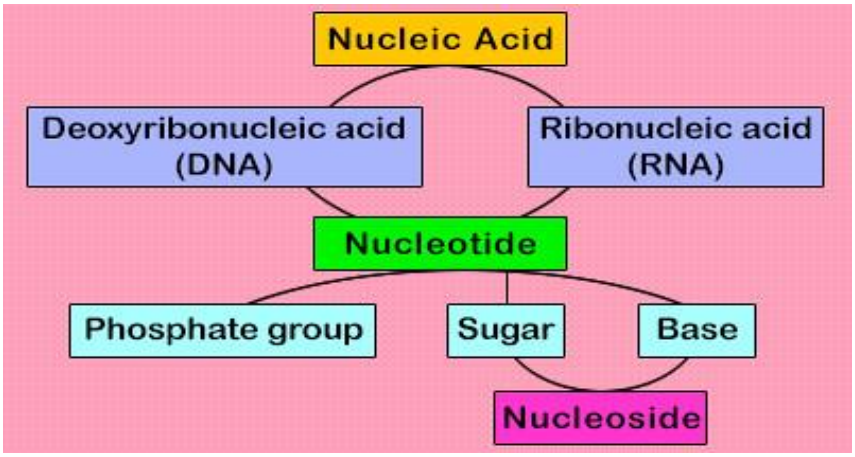
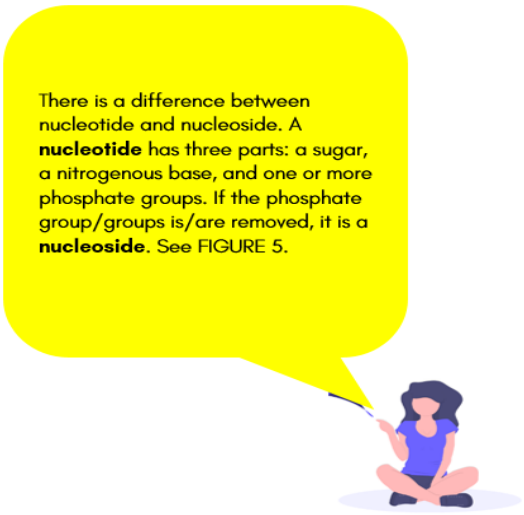


FIGURE 7. Nucleic acid. Flickr.com. (2014, December 24). Retrieved from: https://www.flickr.com/photos/102642344@N02/15907824517.



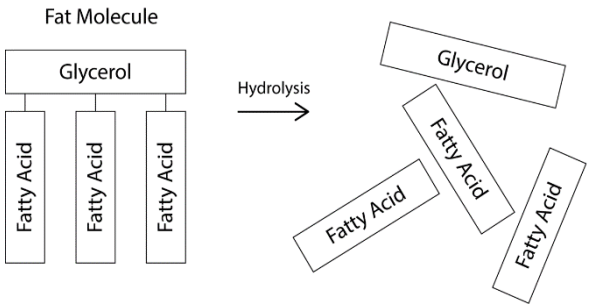


FIGURE 8. A very basic diagram of what happens to a triglyceride in a hydrolysis reaction.
Greenwood, Sarah. (2018, August 15). Retrieved from: https://upload.wikimedia.org/wikipedia/commons/8/87/Simple_Triglyceride_Hydrolysis.png. This file is under the Creative Commons Attribution-Share Alike 4.0 International license.

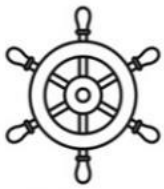
Chemical Digestion of Lipids

Digestion of lipids begins in the oral cavity when salivary enzymes, **lipase**, break down short-chain lipids into **molecules made up of two fatty acids**. A little digestion occurs in the **stomach** but the rest is done in the **small intestines** where **pancreatic lipases** break down lipids into its component molecules: **glycerol, fatty acids, and monoglycerides.** Digestion of fat is assisted by **bile salts** produced in the liver and secreted by the gallbladder in the small intestines. Review the mechanism of fat digestion through emulsification as discussed in the previous learning guide.

The table below gives us a summary of the discussion above.

Digestive Enzyme	Organ, Glands That Secretes It	Compound It Digests
Amylase	Salivary Glands, Pancreas	Amylose (Polysaccharide)
Sucrase	Small Intestine	Sucrose (Disaccharide)
Lactase	Small Intestine	Lactose (Disaccharide)
Lipase	Salivary Glands, Pancreas	Lipid
Pepsin	Stomach	Protein
Trypsin	Pancreas	Protein
Chymotrypsin	Pancreas	Protein
Deoxyribonuclease	Pancreas	DNA
Ribonuclease	Pancreas	RNA
Nuclease	Small Intestine	Small Nucleic Acids

FIGURE 9. Digestive enzymes. Wakim, Suzzane and Grewal, Mandeep. (2020, August 10). Retrieved from: https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/18%3A_Digestive_System/18.3%3A_Digestion_and_Absorption. LibreTexts content is licensed by CC BY-NC-SA 3.0

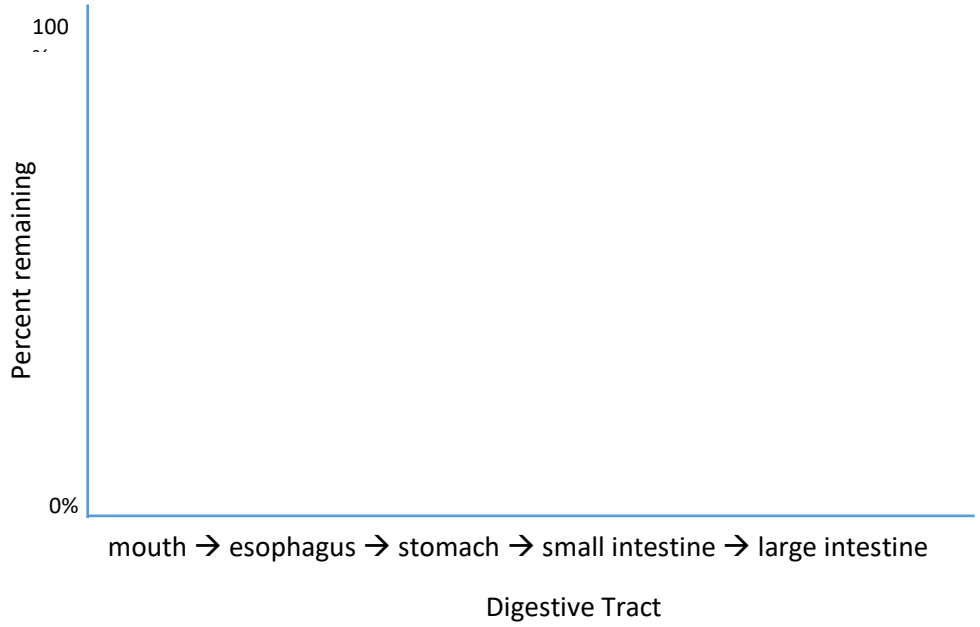


NAVIGATE

5 minutes

Note: This is a graded formative assessment.

Choose one food from among the list you generated under the HOOK part of this learning guide. After that, complete the graph below to indicate the relative percentages of carbohydrate, fat, protein and nucleic acid that remain in the ingested food as it progresses from your mouth through your digestive tract. Then explain your reasoning behind the graphing. You will be graded using the rubrics below. Submit your output (via moodle) in pdf format.

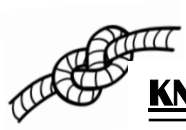


RUBRICS

TOTAL NUMBER OF POINTS: 5 POINTS

CRITERIA	POINTING SYSTEM		
Content	**3 points**	**2 point**	**1 point**
	Ideas are well-explained with very strong and clear support; transitions are used appropriately contributing to the logical ordering of thoughts; all enzyme-secreting parts and their specific functions were given; and, there are no grammar errors	Ideas are a bit vague but an attempt to explain them is evident; thoughts are slightly disorganized; almost all enzyme-secreting parts and their specific functions were given; and, there at most 5 grammar errors.	Ideas seem to be irrelevant and unclear. T most three enzyme-secreting parts and their specific functions were given; and, there is a grammar error in almost every line.
Graph	**1 point**		**0 point**
	The graph is correct.		The graph is not correct.
Submission/Compliance	**1 point**	**0.5 point**	**0 point**

	The student submitted the output on or before the deadline.	The student submitted the output beyond the given deadline.	The student did not submit any output.



KNOT **1 minute**

Different biomolecules make up our food. They come in large sizes upon entering our oral cavity. The digestive system breaks them down into smaller pieces, those enough to be transported in the cells lining our small intestines. This way nutrients can be readily absorbed and distributed to every cell in our body. Enzymes, which are mostly proteins, play the principal part in speeding up chemical reactions for faster nutrient absorption and molecule formation, among its many functions.

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Book

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Online Resources

18.3: Digestion and absorption. (2020, June 6). Biology LibreTexts. https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/18%3A_Digestive_System/18.3%3A_Digestion_and_Absorption

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Videos

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Images

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Biomolecules chart | Macromolecules, sight word worksheets, molecules. (2019, May 22). Pinterest. https://www.pinterest.ph/pin/362328732515331073/A fat molecule showing its component parts: the glycerol, carboxyl group, and fatty acids. (2008). Retrieved from: https://www.visionlearning.com/es/library/Biologia/2/Lipids/207

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