

Fueling Your Body: Biomacromolecules and Their Importance in the Cell

by

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Part I – Gym Partners

Ciara and Lucia had been exercise buddies since college. The women both got up at 5 a.m. every day and went to the gym together. Ciara preferred cardio while Lucia was a strength-training specialist. Lucia had always been very careful about what she ate, while Ciara took a more relaxed attitude to her diet.

One day while Ciara watched Lucia construct her “balanced breakfast” yet again before they left for the gym, Ciara couldn’t help herself from asking, “Why are you so concerned about food? You exercise almost every day!”

“You do realize that our bodies need all kinds of building blocks to stay healthy, right?” responded Lucia.

“You mean carbs and protein?”

“Not just carbohydrates and protein, but also lipids, vitamins, and minerals.”

“But wait, lipids are fats. I thought those were bad for us!”

“Well, too much of anything is bad for you, but you actually need all of these things to help build components of your cells. Your cells are made of four types of molecules: protein, lipids, nucleic acids like DNA and RNA, and carbohydrates. You get building blocks for all of these components from the micro- and macronutrients in your food.”

Questions

1. Fill in the chart defining the biomacromolecules of the cell, their building blocks, at least two possible functions for each, the atoms commonly found in the molecule, and a specific example of each.

<i>Macromolecule</i>	<i>Building Blocks</i>	<i>Function</i>	<i>Contains which Elements?</i>	<i>Specific Example</i>

2. How are these molecules interconnected in the cell? Which biomacromolecules are used to make or encode for which other biomacromolecules and how is this accomplished?

Part II – Where Can I Find That?

Ciara snatched the box from Lucia's health bar out of her hand flipping it over to look at the label (Figure 1).

"I see carbs, fats, and proteins. Wait a minute! This thing doesn't have any nucleic acids in it according to the label."

Patiently, Lucia took the box from Ciara's hand and said, "That's the cool part of your cells. They can take all these building blocks, called micro and macronutrients, and break them down during digestion. Your tissues and cells metabolize all of these molecules in various ways. In the process of catabolism, your body breaks down these macronutrients into smaller structures, and in the process of anabolism you can make new biomacromolecules from these building blocks. Nucleic acids and amino acids can be synthesized by breaking down other molecules you eat and reassembling them inside a cell. Nucleic acids are especially cool because, when they are assembled into DNA, the DNA sequence directs what kind of protein will be made. The order in which the amino acids of a protein biomacromolecule get assembled is dictated by the DNA through an mRNA intermediate. Proteins then do most of the "work" of the cell performing reactions, helping with structure, transporting molecules, making other biomacromolecules, and even directing communication between cells. Scientists call the process in which DNA makes mRNA which then encodes for protein, the central dogma of biology."

Nutrition Facts	
Serving size 1 bar (40g)	
Amount per serving	
Calories	190
	% Daily Value*
Total Fat 8 g	10%
Saturated Fat 2.5 g	13%
Trans Fat 0 g	
Polyunsaturated Fat 2 g	
Monounsaturated Fat 3 g	
Cholesterol 5 mg	2%
Sodium 160 mg	7%
Total Carbohydrate 23 g	8%
Dietary Fiber 3 g	11%
Total Sugars 12 g	
Includes 10 g Added Sugars	20%
Protein 10 g	20%
Vitamin D 0 mcg	0%
Calcium 30 mg	2%
Iron 1.1 mg	6%
Potassium 180 mg	4%

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Figure 1. Nutrition label.

Questions

1. Compare and contrast the molecular difference between dietary fiber and sugar on the label shown in Figure 1. Why does your body need both?
2. Specifically, what components on this label are considered lipids?
3. Based on what you answered in Question 1 of Part I, what type of biomacromolecule is likely to be involved in the breakdown and assembly of other biomacromolecules (catabolism and anabolism)? Why did you pick this molecule?
4. Describe the fate of a digestible long-chain carbohydrate after it is eaten. What products can be made from long-chain carbohydrate catabolism once the carbohydrate reaches the small intestine? What biomacromolecule is responsible for this process? What anabolic products may be made from a single ring carbohydrate once it is made and absorbed into the cell?
5. Although the single-ring sugar, glucose, may be used in anabolism of other biomacromolecules, what is the fate of the majority of this molecule once taken up by the cell? Why is this process important?
6. Predict why sodium and potassium would be important in your diet. Be sure to cite your sources.

Part III – How Is the Cell Involved Again?

Ciara thought back on their original conversation and was still a little confused. “I’ve heard about organelles and structures of the cell, but I don’t really understand how biomacromolecules are involved.”

“Well,” replied Lucia, “it turns out most structures in the cell are made up of these biomacromolecules or use these molecules in some way. The organelles in the cell wouldn’t exist if the four types of biomacromolecules weren’t present. I eat a balanced diet so my cells have the biomacromolecules they need to thrive.”

Questions

1. Compare a human skin cell and a bacterial cell with respect to their overall structure and features. How are they similar and how are they different molecularly and structurally?
2. For each organelle or cell structure indicate why the cell structure would not function if the listed biomolecule was missing.
 - a. Mitochondria missing carbohydrates:
 - b. Cell membrane missing lipids:
 - c. Cell membrane missing protein:
 - d. Nucleus missing DNA:
 - e. Ribosome missing mRNA:
 - f. Rough ER missing lipids:
 - g. Golgi missing proteins:
 - h. Cytoskeleton missing proteins:
 - i. Cell membrane missing carbohydrates:
 - j. Nucleolus missing RNA:
 - k. Lysosome without protein:
 - l. Smooth ER without lipids:
3. Draw a diagram of the central dogma. Indicate where in the cell (nucleus or cytoplasm) each step occurs in a human cell, and which biomolecules are involved in each process.

Part IV – Biomacromolecules in Life

Complete the following exercise working individually. Be sure to cite your sources.

Select a packaged food item that you consume outside of class, for example, a granola bar, a yogurt cup, a bag of chips, or a bottled drink, etc. Write a short, reflective analysis (approximately 300–500 words) that traces the journey of the biomacromolecules in that snack from the nutrition label to their specific functions within your cells.

Your analysis must address the following five components:

1. Begin by introducing your food item and summarizing its biomacromolecule content based on the nutrition label. Specifically, identify the mass (in grams) of lipids, carbohydrates, and proteins present in a single serving.
2. You will notice that one or more of the four major biomacromolecules discussed in class are not explicitly listed on standard nutrition labels. Identify the missing biomacromolecule(s) and explain why that information is not listed. Does its absence on the label mean it is absent from the food? Use the concepts of catabolism (breakdown) and anabolism (building up) to explain how your body acquires a molecule if it is not explicitly tracked on the package.
3. Choose two specific biomacromolecules found in your snack and predict their ultimate destination within a specific cellular organelle. You should apply “structure-function” logic here. For example, if your snack contains lipids, do not simply say “the cell uses them.” Instead, explain how the ER might use those lipids to synthesize steroid hormones or repair the phospholipid bilayer.
4. Examine the carbohydrate content. Does your item contain dietary fiber? If fiber is present, explain why it is listed as a carbohydrate even though humans lack the enzymes to digest it for energy. If it is absent, discuss how this might affect the absorption rate of the sugars in the snack.
5. How do the biomolecules you chose in prompt 3 above play a role in the central dogma of biology?

Please include a photograph or a screenshot of the nutrition label at the top of your document.

