

Macromolecular math

Learning objectives:

Through this worksheet, students should be able to...

- Understand and describe the basic makeup of different types of biological macromolecules
- Review the chemical bonds that are important in macromolecular structure

In this activity, you will use a nutrition label to answer questions about the types and quantities of macromolecules found in your food. Note that these are simplified values so that you do not get overwhelmed by calculations using huge numbers. In reality, there are hundreds to thousands of monomers in every polymer, and there may be millions of monomers in a “serving size”. You may want to draw out the polymers showing how the monomers make up the polymer, in order to better visualize the calculations you will make.

Nutrition Facts			
Serving Size 2/3 cup (55g)			
Servings Per Container About 8			
Amount Per Serving			
Calories 230		Calories from Fat 40	
		% Daily Value*	
Total Fat	8g	12%	
Saturated Fat	1g	5%	
Trans Fat	0g		
Cholesterol	0mg	0%	
Sodium	160mg	7%	
Total Carbohydrate	37g	12%	
Dietary Fiber	4g	16%	
Sugars	1g		
Protein	3g		
Vitamin A		10%	
Vitamin C		8%	
Calcium		20%	
Iron		45%	
* Percent Daily Values are based on a 2,000 calorie diet. Your daily value may be higher or lower depending on your calorie needs.			
	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

NOTE: The calculations on the next several pages are an exercise in being able to read the question correctly. The math examples are not accurate representations of the macromolecules within the product.

Fatty acids

1. Calculations – assume that all fats found in this food are triglycerides. How many **fatty acids** are there in one serving size of this food if there are 10 triglycerides per gram? (*In reality, there may be more than 10^{20} triglycerides per gram of material.*)

2. Questions about lipids

a.	What is the general structure of a triglyceride?	
b.	What is the name of the covalent bond holding the parts of a triglyceride together?	
c.	How can a fatty acid vary within a triglyceride?	
d.	What is the difference between a saturated and unsaturated fatty acid?	

e.	What is the general structure of a phospholipid?	
f.	How can the structure of a phospholipid vary?	
g.	Where would you most expect to find a phospholipid in a cell?	
h.	Molecules like phospholipids have both hydrophilic and hydrophobic structures. What is the general name for a molecule with both hydrophilic and hydrophobic structures?	
i.	What part of a phospholipid is hydrophilic and what part is hydrophobic?	
j.	What are two roles of lipids in cells?	
k.	On the nutrition label, there are 8 g of total fat. What other compound(s) listed is(are) a lipid(s)?	

Amino acids

3. Calculations - How many **amino acids** are found in one serving size of this food if every individual protein contains 100 amino acids and there are 20 individual proteins for every gram of "protein"?

4. Questions about amino acids, polypeptides and proteins

a.	What is the general structure of an amino acid (draw)?	
b.	How many amino acids are found naturally in polypeptides? How are amino acids different from one another?	
c.	What is the name of the covalent bond that holds amino acids together in a linear chain?	
d.	What does the primary structure of a polypeptide refer to?	
e.	What are the ends of the linear chain of amino acids called and what are the functional groups at each end?	
f.	What are two examples of non-covalent bonds in macromolecules? <i>These may be found in other types of macromolecules as well.</i>	
g.	What type(s) of bonds hold together the secondary structure of a polypeptide?	
h.	What are the two (2) examples of polypeptide secondary structures?	

i.	What parts of an amino acid interact in the secondary structure?	
j.	What type(s) of non-covalent bonds hold together the tertiary structure of a polypeptide?	
k.	In general, what amino acid functional groups are interacting with non-covalent bonds of the tertiary structure?	
l.	What covalent bond may be found between amino acids (not the one found in the primary structure) and between what specific amino acid(s)? <i>2 parts</i>	
m.	How are the tertiary and quaternary structures different in polypeptides?	
n.	What is the difference between a polypeptide and a protein?	
o.	What does denaturation of a protein refer to?	
p.	What are some conditions that could lead to protein denaturation?	
q.	What are some general functions of proteins?	

Carbohydrates

5. Calculations – Assume “dietary fiber” consists of only cellulose. If cellulose fibers are polymers containing 50 dimers apiece and there are 20 cellulose fibers in every gram of “dietary fiber”, how many **monosaccharides** from “dietary fiber” are there in one serving size of this food?

6. Questions:

a.	Cellulose polymers are made up of what monosaccharide?	
b.	What is the name of the covalent bond that links two monomers in cellulose?	
c.	What are two (2) additional polymers that are made up of the monomer found in cellulose (see part 6a above)?	
d.	What is a disaccharide found in milk?	
e.	For the disaccharide described in part 6d above, what are the two monosaccharides that make up this disaccharide?	
f.	Sucrose, common table sugar, is a disaccharide made of what two monosaccharides?	
g.	The monomer sugars that make up sucrose and the sugar found in part 6d have the same chemical makeup. These are called _____	
h.	What are two distinct roles of carbohydrates in cells?	
i.	What are the pentose sugars that are found in nucleic acids (see more in question 8 below)?	

Nucleic acids

7. Calculations – Nucleic acids are not included in normal nutrition labels (they are present), but let's say that we know there is 1 gram of nucleic acids per serving in this food. If every gram is made up of 100 strands of DNA and each strand contains 100 base pairs, how many total **nucleotides** are found in one serving size of this food?

8. Questions

a.	What are the three parts of a nucleotide?	
b.	What are the monomeric units of a DNA strand called?	
c.	What is the name of the covalent bond that holds monomers of a DNA strand together?	
d.	Draw a generic monomer of the DNA strand. Label the carbons of the sugar correctly.	
e.	What are the monomeric units of an RNA strand called?	
f.	What are two (2) differences between an RNA and a DNA?	
g.	What are two significant structural differences between DNA and RNA molecules in a eukaryotic cell (do not include the differences between the monomeric structures)?	
h.	One molecule used in cells for energy that we will talk a lot about later is ATP. What type of molecule is ATP? Note: GTP is used for energy in some processes)	

Small molecules

9. Questions

a.	What are three small ions listed on the nutrition facts label? Are these cations or anions?	
b.	What is one significant role for each of these ions in cell function?	
c.	What is vitamin A?	
d.	What is vitamin C?	