

Chapter 4 Reading Guide

1. How many covalent bonds does carbon (C) form?
2. What is the chemical formula for glucose?
3. List the major dietary monosaccharides and disaccharides. What are the components of each disaccharide? What are some natural sources of each?
4. Which two of the above monosaccharides form hexose (six-sided) rings? Which one forms a pentose (five-sided) ring?
5. What suffix is used to indicate a simple sugar? Which classes of carbohydrates are considered simple sugars?
6. Plants make sucrose. What 2 monosaccharides do plants attach to make it? What is the name of the reaction that attaches the 2 monosaccharides together; and, is water consumed or produced in this reaction?
7. We digest sucrose. What is the name of the reaction that splits a disaccharide into two monosaccharides; and, is water consumed or produced in this reaction?
8. Name the 3 major classes of polysaccharides and talk about their respective roles, paying attention to whether each is made by plants or animals.
9. List and describe the roles of the different fibers. Why can't we digest fibers?
10. Which of the fibers are soluble? Insoluble? Describe the difference, noting also differences in their effects on our digestive functioning.
11. Explain some health benefits of fiber in general.
12. Where are two places that starch is enzymatically digested?
13. Why does enzymatic digestion of starch cease in the stomach? What is the product of starch hydrolysis?
14. Name the 3 enzymes that hydrolyze disaccharides. What are the products of each? Where are these enzymes located?
15. Where are fructose and galactose converted to glucose, once they are absorbed? (There's another important role!!)
16. What enzyme is lacking in people who are lactose intolerant? What causes the symptoms?
17. What is the preferred fuel source of neurons?

18. Where are the 2 places that MOST glycogen is stored? Which of them stores glycogen for the purpose of maintaining blood levels of glucose during fasting? Which of them stores glucose for its own uses?
19. Can fatty acids be converted to glucose? Can glucose be converted to fatty acids?
20. What is the process of converting amino acids (the book states "proteins," but it is really amino acids) to glucose called?
21. From what nutrient are ketone bodies derived?
22. What happens to excess glucose, when the liver has all the glycogen it can store?
23. Why is it important the blood glucose is adequately and constantly maintained? Be specific: talk about cell activity and cell types, not a general statement about whole body health.
24. Where are insulin and glucagon produced?
25. When would insulin be secreted, and what effect does it have on cells of the body?
26. When would glucagon be secreted, and what effect does it have on liver cells?
27. Besides glucagon, what is another hormone that causes liver cells to release glucose into the blood?
28. Explain the difference between type I and type II diabetes, in terms of age of onset and why excess glucose is present in the blood.
29. Describe a slow glycemic response vs. a fast glycemic response. Which is more desirable?
30. Explain how the glycemic index ranks food types in terms of the glycemic responses they induce.
31. What are two dietary substances that help slow absorption by causing the stomach to release chyme more slowly?
32. What are some problems with using the glycemic index to guide food choices?
33. Explain "nutrient-dense food" again, comparing why a 100-kcal apple is more nutritious than a 100-kcal serving of honey.
34. How are dental caries formed?
35. List and explain several benefits of dietary fiber. Explain one drawback of having a diet extremely high in fiber.

36. Which has more fiber: brown rice or white? Whole wheat pasta or regular pasta? Whole grain bread or white bread?
37. Explain how to ensure that you are getting a good source of whole grains when you buy a loaf of “multi-grain” or “wheat” bread.
38. Very briefly compare the different alternative sweeteners, paying closest attention to how long they have been on the market, how well each has been studied, and how safe each may be. Keep in mind that the shorter the time on the market, the less information we have about long-term effects of the product. I won't ask anything about chemical properties of the different artificial sweeteners.
39. Explain the anatomy of a grain. What is the different between whole grain flour and refined grain flour? If a bread lists “wheat flour” as an ingredient, does it mean “whole wheat?”
40. Does enriching refined grain products, such as white bread, make the product as nutritious as an unrefined, unenriched whole-grain product? Explain and provide examples.
41. Why are whole fruits generally more nutritious than fruit juices?

Supplemental Reading

- I. **Why glucose is so critical-** it doesn't seem like glucose should be such a critical nutrient, considering that we can use fatty acids for energy in addition to using glucose. In fact, fats offer a much more efficient way to store energy: they are much less dense, and store over twice as much energy per gram as glucose does. That's a good thing for animals, because we have to move around! Glycogen, the storage form of glucose, is much heavier (but stores less energy) than triglycerides, the storage form of fatty acids.

So, why is it that we need to have a constant supply of glucose in our blood? Why do liver cells work so hard to store glucose when it is plentiful, so that they can release it during a fast and keep blood levels steady? Why do muscle cells hoard glucose and store it as glycogen? Two reasons:

- a) Neurons don't use fatty acids for energy. Your brain is the culprit here. The neurons of the brain use glucose almost exclusively, and that's the biggest reason that blood levels of glucose need to be maintained. Most of the rest of the cells in your body are perfectly happy to use fatty acids; but not neurons! The only other thing that most neurons will use is ketone bodies... this turns out to be a nice adaptation to starvation and low-carb diets, but I'll discuss that in another supplemental note!
- b) Muscle cells have the capacity to use fatty acids, and in fact, during rest they use fatty acids almost exclusively! Yes, **the more muscle mass you have, the more fat you burn just sitting there.** BUT, when a muscle cell begins to become active, it must use glucose. Why? Extracting energy from glucose is MUCH faster than extracting it from fats. When a muscle cell becomes active, its energy requirements change ABRUPTLY! It suddenly needs a ton of energy, and the only way it can get that much energy for the first couple of minutes is to split glucose. Now, fatty acids will start to be processed, and after a couple of minutes muscle cells can rely more and more on fats. In fact, after about 20 minutes of constant exercise, the active muscle groups are relying almost entirely on fats. But again, to get started they need glucose.

II. How cells use nutrients for energy:

When a cell uses a nutrient for energy, it breaks the bonds in that nutrient. For example, when glucose is used for energy, its bonds are split up and rearranged into 6 molecules each of CO₂ and H₂O. That splitting of bonds releases energy. There are only a specific few nutrients that cells can use for energy, and they are all derived from glucose or fatty acids. For example, when proteins are used for energy, it is actually each amino acid that is used. The amino acid must first be converted to glucose, a glucose derivative, or a fatty acid derivative. So, when it comes to what cells can use for energy, it ultimately comes down to glucose or fatty acids.

- III. Random note:** Glucose can be converted to fatty acids; for example, if you take in excess glucose it will be converted to fat and stored. However, fatty acids cannot be converted to glucose.
- IV. The formation and significance of ketone bodies:** Any time fatty acids are used for energy by cells, some ketone bodies are formed. Ketone bodies are formed because when lots of fats' bonds are being split, often times there is a "back up" in the cell's machinery; it can't handle all the pieces that have been split from the fats at once. All of those pieces have energy in them. So, each cell can share those pieces with the rest of the body: it converts those pieces to ketone bodies. Ketone bodies are basically excess pieces that have been split off from fatty acids when the fatty acids were being used for energy. Ketone bodies can travel through the blood, and other cells can take them in and split them for the energy they store. **IN FACT**, even most neurons can use ketone bodies for energy. So, this is an important adaptation during times of fasting/starvation: as most of the cells of the body switch to using the fats that have been stored, they share some of that energy in the form of ketone bodies. Glycogen stores are depleted within about 8 hours after the last meal, so as a fast continues ketone bodies become a more and more important source of energy for the brain. If brain cells could not do this, your body would have to convert lots of amino acids to glucose to keep your brain fed. If that were your only choice, you would quickly digest the proteins in your organs to feed your brain. We'll talk more about ketone bodies (they are not always good!) in the fats chapter.
- V. The effect of insulin on cells' use of glucose-** Insulin causes cells to build glucose channels into their membranes. Remember that any time a cell wants to allow a water-soluble substance in, it has to build channels for that substance. Most cells of the body will **ONLY** build significant numbers of glucose channels when they are

“told” to do so by insulin. This occurs, of course, shortly after a meal when plenty of glucose is available for all cells to use. When glucose levels start to decline, less insulin is released by the pancreas, and cells of the body start to remove these glucose channels from their membranes. So, they stop using glucose for energy. This allows what little glucose is left to be used almost exclusively by neurons. As cells remove their glucose channels, they switch naturally to fatty acids (these are fat soluble and do not require channels to enter cells).

VI. A note on fiber and why we can't digest it- the interesting thing about fibers is that most of them are made of monosaccharides, including glucose. What that means is that technically fibers have loads of energy (kcal)! But, we don't get much of that energy. The only reason we don't get any energy out of fibers is because of the way that the monosaccharides are linked together. Remember that enzymes are 3-dimensional structures, and they fit perfectly with their substrates. So to hydrolyze starch, amylase fits perfectly over it, and rips it up. Fibers are shaped a little bit differently, and we simply don't make any enzymes that can rip them up.

Why is that? Well, actually, all the instructions for all of the enzymes that your body makes are stored in your DNA. We simply don't have any genes that have the instructions for making those enzymes. Who does have the genes for making enzymes to hydrolyze fibers? Certain bacteria. Herbivores (cows and so forth) don't have those genes either, but they have specialized compartments in their digestive tract that provide homes to the fiber-digesting bacteria. The herbivore provides a home to the bacteria, and the bacteria share some of their monosaccharides with the herbivore! We house some of these bacteria, too, but we do not rely solely on vegetable matter as much as true herbivores, so our relationship is not as extensive. Still, our resident bacteria are good for us in a variety of ways,

and they do share a little bit of the energy from our fiber. Eat your fiber and keep your “good” bacteria happy!

VII. Identifying when grain products really are whole: If you are trying to purchase whole-grain products, you need to be aware of how to make sure that the product really is made from WHOLE grains. The biggest issue here is with bread, or other products made from wheat flour. When bread is white, that means it was probably made with refined (not whole) wheat flour that has been bleached or is light in color because of the refining process. In general, bread flour is wheat flour. Often, you will see in the ingredients list on a slice of brown-looking bread, “wheat flour.” This is NOT whole wheat! It’s refined wheat, and the bread appears brown because of the addition of molasses or other colorant. The ONLY way you know the product is whole grain is if the ingredients say so: “whole wheat,” “whole stone-ground wheat,” etc.

Sometimes you’ll see breads that have a mixture of the two; and this may or may not yield a more nutritious bread than white. It depends on the ratio of whole to refined wheat/grains. The best way to determine what that ratio is is to look at the fiber content. If the fiber is approximately 15% or more of the total carbohydrates, then there is probably a reasonable amount of whole grain in the “mixed” bread.

Finally, the most common type of wheat used is a “red” wheat. There is another variety being used more and more, a “white” wheat. It is a little lighter in texture, but offers similar nutritional value as red wheat when it is whole. So, if you see “whole white wheat,” that is not marketing trickery! They’re just telling you it’s the whole grain of the white variety of wheats.

Please refer back to figure 2-7, page 52, for a refresher on this.