Chapter 5 Reading Guide
Note: please read my supplemental lecture (part I) before going through these questions.

1. Which has more oxygen atoms (O), carbohydrates or lipids?
2. What 2 chemical groups are found at each end of a fatty acid? What is in-between? (Ie, describe the structure of a fatty acid)
3. Do fatty acids store more or less kcalories per gram than carbohydrates?
4. What is the most common range of carbon-chain length of fatty acids in meats and vegetable oils? Are dairy fats usually shorter or longer?
5. Explain the difference between saturated and unsaturated fatty acids: -which has more H? –Which has at least one double bond? –Which is usually bent in its natural form?
6. Explain the difference between mono- and poly- unsaturated fatty acids.
7. When a fatty acid (or any organic compound) is abbreviated, what do you assume is at each corner? How do you know how many "unseen" H are attached?
8. How many C (carbon) does stearic acid have? Oleic acid? Linolenic acid? Linoleic acid? What is the difference between the above fatty acids?
9. When fatty acids are stored in fat cells, they are stored as part of a triglyceride. Describe and draw a triglyceride.
10. Describe the difference between saturated, monounsaturated and polyunsaturated in terms of solidity/liquidity at room temperature and vulnerability to oxidation.
11. What is the process of hydrogenation? Why is it done? If you start with a *cis*-unsaturated fat and partially hydrogenate it, which two types of fats do you end up with?
12. Describe the difference between *cis*- and *trans*- fatty acids in terms of: which is more common in nature, which is straight and which is bent, which has negative health effects.
13. Are the three fatty acids attached to glycerol in a triglyceride necessarily the same or can they be mixed (ie, if one is oleic acid, are they all oleic, or could one be stearic and one be butyric, for example)?

14. Describe and draw the phospholipids bilayer of a cell membrane (my powerpoint for this chapter will provide more pictures)
15. To what does the term "invisible fat" refer? Explain and provide some examples.
16. Is it necessary for you to eat phospholipids; that is, are they essential? Why or why not?
17. What does the term "emulsify" mean?
18. Does peanut oil contain cholesterol? Why or why not?
19. What are some functions of sterols in the body?
20. Where in the body is cholesterol manufactured? Where does most of your blood cholesterol come from: self-manufactured or diet?
21. Of the lipid classes, which is composed of a multiple-ring structure?
22. Are lipids hydrophobic or hydrophilic?
23. Why is lipid digestion and absorption particularly challenging?
24. What are the breakdown products of fat digestion by lipase?
25. Where are three places that lipases are secreted?
26. Explain again the difference between bile and lipase (be sure to explain emulsification)
27. Why can soluble fibers such as pectins help to reduce blood cholesterol? (this also refers back to chapter 4)
28. What is a micelle as it relates to fat absorption?
29. What is the largest, least dense lipoprotein, and the only one NOT made by the liver? Where IS it made?
30. What type of lipid is primarily delivered by VLDLs? LDLs?
31. What is the role of HDLs?
32. Between LDL and HDL, which is called "good?" Why? Is there any difference between the cholesterol inside them?
33. What are some ways you can increase blood HDL and decrease blood LDL?
34. What are the essential fatty acids, and what does "essential" mean? To what class (omega-3 or omega-6) does each of the above belong?
35. What is the major omega-6 that is made from linoleic acid? What are the major omega-3s that are made from linolenic acid?

36. What type of cells are specialized for storing fat?
37. Explain how a triglyceride is transferred from a chylomicron or VLDL to an adipose cell.
38. Which raises blood cholesterol more: dietary cholesterol or dietary saturated and trans fat?
39. What are some benefits of replacing some saturated and trans fats with unsaturated fats?
40. Besides fish, name 2 other ANIMAL sources of omega-3 fatty acids.
41. Follow the fate of a triglyceride in the small intestine, describing how it is digested and absorbed. Be sure to follow through and mention how/when it gets to the blood.
42. Explain some health risks associated with high saturated fat and trans fat intake.
43. What are some foods that have lots of saturated fats? Trans fats?
44. What percent of your total kcalories is recommended to come from fat?
45. Of your total fat intake, what percent is recommended to come from saturated fat?
46. Explain some general choices you can make at the grocery store or in your kitchen to a)keep fat intake within reasonable limits, b)choose "heart-healthy" fats.
47. Do you think there would be any drawback in eating a diet in which only 15% of kcalories came from fat, and what might those drawbacks be? There is no right answer here necessarily, this is just to get you thinking about the roles of fat and different types of fats.
48. What are some ways that Harvard's advice on fat intake differs from the USDA's?

Supplemental Reading

I. **Lipids: general information-** Lipids are, by definition, organic compounds that do not associate with water. They are hydrophobic (water fearing). The lipids that we're concerned with can be considered in 3 general categories:
   a. Fatty acids and lipids CONTAINING fatty acids

i. Fatty acids are used directly by cells for energy. Cells split the bonds in fatty acids, and use the energy released to make ATP.
ii. Triglycerides- this is how plants and animals STORE fatty acids
iii. Phospholipids- a unique type of lipid that has two fatty acids attached to a glycerol, and a water-soluble component attached to the other side of the glycerol. All cells are covered with a bilayer of phospholipids, kind of like the thin membrane of a soap bubble. The bilayer makes an excellent covering because the inside of cells is watery and the outside of cells is watery. The phospholipid bilayer creates a fatty barrier that prevents free passage of water and water-soluble substances. This allows cells to control what enters and exits, for example by building the tunnels we've been talking about.

b. Eicosanoids- your cells make these from the essential fatty acids (omega-6 and omega-3) but eicosanoids do not retain fatty acids in their original form. Used by cells to communicate locally, and important for blood clotting and clot clean-up.

c. Sterols- These have a unique multiple-ring structure. Sterols can NOT be used for energy by cells; for example, cholesterol has no kcalories. Sterols are used for structure and function. Some examples: cholesterol helps to insulate the electrical activity of neurons, and is embedded into the phospholipids bilayer of cells. As such, it helps cell membranes retain the appropriate level of fluidity at different temperature extremes. Other important sterols include estrogen, testosterone, cortisol, and vitamin D (calcitriol).

II. **Some common dietary fatty acids and their sources: know which of these is saturated, monounsaturated, and polyunsaturated.**

a. Stearic acid- common in meats, has surprisingly gotten some good press lately
b. Oleic- the most common fatty acid in olive oil
c. Linoleic- an essential omega-6. It is very common in plant oils.
d. Linolenic- an essential omega-3. Only a few sources provide significant amounts: flax, walnuts, soy. (Fish, high-omega eggs and grass-fed grazing mammal meats provide some linolenic, but mostly other omega-3s, DHA and EPA which are just as good!)

III. **Practical application of phospholipids**- phospholipids can be used to make creamy, coherent sauces when watery and oily ingredients are mixed. Lecithin occurs naturally in egg yolks, milk and a few other foods (ex, ground mustard). When you make hollandaise sauce, you mix butter, lemon juice and water, ingredients that don't normally mix. But, when you add egg yolks the lecithin molecules emulsify the fats and allow the fatty and watery ingredients to make a smooth (delicious) sauce. Now that you are reading ingredients on food labels, you will notice lecithin from time to time! By the way, Alton Brown has a great episode of Good Eats on Food Network all about making mayonnaise, the ultimate emulsion!

IV. **More on the digestion and absorption of fats**-

a. When you eat fat, you are eating triglycerides. In the small intestine, bile salts isolate small blobs of triglycerides, making it easier for lipases to reach all of the triglycerides. Fat digestion by lipase involves ripping two of the fatty acids off of the glycerol. One fatty acid stays on the glycerol. So, the products of fat digestion are 2 free fatty acids and one MONOglyceride (one fatty acid attached to a glycerol).

b. Now, the free fatty acids and the monoglycerides will be surrounded by bile salts again. This compound: digested fats surrounded by bile salts, is called a MICELLE.
c. When the micelle bumps into a microvillus of a small intestinal cell, the fatty acids and monoglycerides will leave the micelle and diffuse into the cell. No channels are needed because the fatty acids and monoglycerides are hydrophobic and have no problem associating with the fatty cell membrane.
d. Once inside the cell, the 2 fatty acids are reattached to the monoglyceride, forming (you guessed it) a triglyceride again! All that work just to make another triglyceride right away! Anyway, the small intestinal cell will package the newly absorbed triglycerides into a sphere called a CHYLOMICRON. The outer wall of the chylomicron consists of phospholipids with some embedded proteins. The water-soluble portion of the phospholipids faces out, so that the outside of the chylomicron is water soluble and floats with no problem through watery lymph and blood. Triglycerides aren't the only lipids carried by chylomicrons. Most dietary lipids, including cholesterol and fat-soluble vitamins, are also trapped inside the chylomicrons.
e. The chylomicron will now leave the cell and enter the lacteal of the villus (remember that the intestinal cell is part of the lining of a villus). The lacteal is NOT a blood vessel, it is a lymph vessel. Lymph vessels carry fluid (not blood) and merge with blood vessels at the shoulder. Fluid from the lymph vessels (with chylomicrons) enter the blood at the shoulder.
f. Now the chylomicrons are in the blood. Cells of the body can access those lipids. For example, as chylomicrons pass through adipose tissue, adipose cells will remove some triglycerides from the chylomicrons to store them. Once chylomicrons reach the liver, they have been depleted of many of their lipids. Liver cells will break the chylomicrons down and repackage the lipids into another type of lipoprotein: VLDL or LDL.

V. ***Trans* vs. Saturated fats-**

Both get a lot of bad press these days. Of the two, trans fats have the most severe negative heath effects. Shortening and margarine are the two basic sources of trans fats. Both ingredients (especially shortening) are used heavily in baked goods: crackers, cookies, croissants, pie crusts and other pastries.

It turns out that you're actually better off using butter rather than margarine that's made with hydrogenated oils; IF you are going to have one or the other.

Some of the butter substitutes out there these days do not use hydrogenated oils and are PROBABLY a better choice than either butter or traditional margarine.

VI. **A little more on omega-3s and a pitch for grass-fed beef:**

Omega-3 fatty acids are found in small amounts in plants and algae. It's difficult for us to get enough from plants alone; save a few notable sources such as walnuts.

Grazing animals accumulate omega-3 fatty acids, because they eat huge amounts of one of the plants that produce them: grasses. Fish accumulate omega-3s by grazing on algae and eating other omega-3 rich fish.

Most of today's beef cattle are fed an unnatural diet: grains. Grains do not contain as many omega-3 fatty acids, and grain-fed beef offer fewer omega-3s than grass-fed beef. We are lucky that we live in an area with several local farms that produce grass-fed beef. In addition to having a healthier fat profile, grass-fed ("pasture-raised") beef are also leaner, so they have less total fat AND the fat they do have is better for you!

Finally, the cattle themselves are healthier when pasture-raised. They have very specific digestive tracts that do not

deal well with grains (actually, they are very dependent on their intestinal flora, and it's the bacterial populations that get sick on grains); the cattle are more prone to sickness when fed a grain-fed diet. The only way to give cattle grass is to let them graze, so cattle are healthier (and leaner) because they are less cramped and move around more. This translates to less need to pump cattle full of antibiotics. We will see why this is important when we get to antibiotic resistance toward the end of the quarter.