First Test Review

Chapter 1: Themes in the study of biology.

I'll try to hit each of the themes and give you at least a one-liner for the main point:'

1. Emergent properties. New properties emerge as we add levels of organization. Example: a long string of amino acids can fold into complex three-dimensional shape so that the protein carries out a chemical reaction. New interactions lead to new properties. The only complaint I have with this is that ALL properties arise from interaction. So…emergent properties are really just properties I didn't know enough to predict.
2. Organisms interact with other organisms and the environment. Example: neutrophil chasing the bacterial cell. We have looked at many many cases and will see more and more. The key question of "how do they do that," for now has the answer "There's a protein for that" (or protein***s***). We will deal with many more cases.
3. Energy transformation: Again, more to come. But, for now know that living systems are **open**, which means they take in energy and material. They convert that material to lower-energy products and use the "Free Energy" to do the work of keeping themselves alive. Free Energy is not called that because it is "free" of cost. Energy is never destroyed. But, as we convert concentrations of high-potential energy molecules to low potential energy products, the energy gets to distribute more randomly, mostly in the form of heat we put out. We capture some of that to do work. It's kind of like using water flowing downhill to turn a mill and do work for you.
4. Structure and function are correlated at all levels of biology. You get the idea I like this topic? We have seen many examples at the level of macromolecules. Think of the seemingly subtle difference between the structure of cellulose and starch, and how that changes the larger structure and function dramatically. We've looked at how you can build a rigid rod out of a string of magnetic beads…or how you can build a complex protein out of a string of amino acids.
   If you see construction workers installing a steel beam in a building, you don't have to think too hard to realize it must have the function of providing support for something heavy. When we look at different cell types, you will see that the pattern repeats. "Form Follows Function."
5. Continuity of life depends on heritable information. This is DNA, in almost every case. This seems a little trite, but consider this: a **single** dragonfly (adult form) lives a couple of weeks; **dragonflies** have lived for about 250,000,000 years.
6. Feedback mechanism. We will address this far more soon. Basically, think again of the neutrophil chasing the bacterial cell. It has to be able to "ask," am I still going the right way? We'll do much more of this later.
7. Evolution: core theme. This is what it is all about. Without the theory of evolution, biology is just categorizing things.
   I've tried to put in some fun examples of the connectedness of life through evolution. This comes from a few points places. But, the "form follows function" argument (that, when you see a particular form, you can be pretty sure it has a specific

function). The next question is "What specifies that form?" We know the answer is the sequence of DNA which is read out as a code to specify the structure of proteins (in a process we have only touched on so far). And that molecule, DNA, is the basis of the continuity of life (see #5). Also, that molecule can change…mistakes made when making a copy of it, such as incorrect base pairs, which you now know can happen…
Put that all together and we see that life is both "constant" in appearance over the course of several lifetimes and yet ever changing over "deep time."
This will come up over and over.

8. Observation, propose hypothesis, test hypothesis, refine hypothesis…repeat. I will be coaching you all year in doing this better. We've had some practice already.

Chapter 2-4, Chemistry of life.

The blogs do a decent job on pH and a decent job on properties of water. I won't rewrite those things here. We also looked at how carbon compounds come together (always four bonds around carbon, for example).
For the most part, review the "bonding basics" screencast and you should be fine. Ionic bonds are not that common. Covalent bonds almost always involve carbon, hydrogen, nitrogen and oxygen (After that, Phosphorous as phosphate and then a huge drop in prevalence to things like sulfur etc.).
Isotopes are really not that important **except** when we use them to trace certain chemicals. They are useful as tools. So, ^{14}C (pronounced "carbon-fourteen") contains 6 protons (as all carbon does) and 8 neutrons, instead of the 6 found in the usual version of carbon. Frankly, I don't care if you remember that. However, since carbon 14 is radioactive, it can be traced in a living cell. So…all you need to know is that isotopes of various elements differ in the number of neutrons, not protons or electrons. Thus, they are chemically the same and will form the same bonds. But the differences can be used in experiments we will examine later to measure things.
Also later in the year, we may look at particular ions and the charge they carry. For now, just know that an ion has the same number of protons and neutrons as its parent atom, but has gained or lost electrons.
Know the important roles of the various functional groups.
Especially in this context, weak interactions (including hydrogen bonds) are critical for life.
Hydrophobicity. The idea that hydrophilic and hydrophobic structures will sort out away from each other and spontaneously arrange based on these associations is key (think, lipid bilayer).
Somewhat new was the observation that interactions can be "tweaked" so that one can favor one state over another with small changes. Think about how the detergent affected the adhesion of the water to the waxy paper etc. This might come up in a longer question about how proteins affect each other, for example.
pH I think you have had some experience with this. Remember it is a **log** scale. Concentration of H^+ of 0.01 is pH 2. $[H^+]$= 0.1 is pH 1. What would pH of a solution of $[H^+]$= 0.05 be? It would be between that of 0.01 and 0.1, so somewhere between pH 1 and 2. Log_{10} of 0.05 is -1.3, so it would be pH 1.3

Carbon and the molecular diversity of life: chapter 4.

A key point is that carbon always has 4 bonds with a characteristic geometry. So, four different bonds leads to tetrahedral angles (109.5^0). But, a double bond and two single bonds also adds up to 4. The angles there are closer to 120^0. I'm less concerned with you memorizing that then realizing that this gives rise to building blocks with particular geometries…this can be used to build things with specific angles. An example of this would be the cis and trans double bonds in long carbon chains, such as those in fatty acids.

It has been suggested that all life, anywhere it exists in the universe, must be based on carbon. I don't know if that's true. But, like many others, I've never been able to come up with a plausible chemistry that would provide all the structural components to build a living thing based on any other element. Certainly, carbon's unusual properties seem woven into life as we know it (Fan's of the old Star-Trek series may remember a creature that was based on silicon (right below Carbon on the periodic table with some similar chemistry). Cool idea. I could never make it work out, though, since the oxides of Si are solids not soluble in water (or, indeed, much of anything).

Chirality: I don't need you to be able to identify chiral carbons in a structure. **But**, the fact that "enantiomers" or "mirror images" or "handed" structures exist has an important implication because all interactions in the cell are based on structures fitting together. Two chemically identical molecules can be very different biologically if to different enantiomers don't fit in the protein the same way. We also have a maddeningly large number of words to refer to these isomers. In addition to chiral, handed, mirror images, and enantiomer, there is also "stereoisomer" and "optical isomer." You probably won't hear those last too very often.

Chapter 5

This will probably make up most of the questions on the test. Please read the blogs and study the figure on page 90 of your book.

I really think that the blogs are good enough review. I'll just list some things for you to make sure you read about in the blogs

1. Carbohydrates:
    - 1.1. n-ose versus n-saccharide. A triose or hexose is a sugar with three or six carbons (Glucose is a hexose). A trisaccharide is three monomers linked together via a glycosidic link.
    - 1.2. Polymers formed via dehydration synthesis and broken via hydrolysis
    - 1.3. Storage forms include Starch (amylose, not branched) and Pectins (amylopectin… some branches via 1-6 links) in plants or glycogen (highly branched) in animals. These are all "alpha" at the carbon 1 position and form few inter and intra-strand hydrogen bonds.
    - 1.4. Structural forms. Beta linked. Lots of inter- and intra-strand hydrogen bonds make them more rigid. Cellulose in plants and Chiton (not really glucose, but a similar molecule) in animals.
2. Lipids: stuff in the cell that is hydrophobic and soluble in non-polar solvents, not water.
    - 2.1. Sterol: all based on that 4-ring structure. Important in regulating cell membrane in animals (cholesterol) and also forms the basis of a lot of hormones.

2.2. Fatty acid (FA) based: FAs are Long hydrophobic carbon chains (usually 17 or so) with an acid (carboxyl) group on one end.
   2.2.1. Linked to glycerol…a three-carbon molecule with three OH groups (one on each carbon). Link via dehydration synthesis from the acid to the OH (remove water) to form an ester. Again, hydrolysis breaks the bond.
   2.2.2. Can be saturated (no double bonds) or unsaturated (at least one double bond). Normal FA's that are unsaturated have **cis** double bonds.
   2.2.3. Mono, di or tri-acyglycerol tells you how many FA (or FE, I guess) are linked to the glycerol. A **fat** is always 3.
   2.2.4. Special form: **Phospholipid.** These have two FE's linked to glycerol with last linked to a phosphate, and then in turn to something charged. These form membranes in your cells. The phospholipid bilayer.

3. Protein: arguably most versatile. Perform almost all of the work in the cell and provide much of the structure.
   3.1. Made of amino acids linked in a long chain via a peptide bond (remove water). These are now amino-acid residues. Again, hydrolyzed by adding water across the bond.
   3.2. Has "chemical polarity" or directionality: an amino-end and carboxyl end
   3.3. Can be small (15 or 20 residue hormones), medium a few hundred amino acids residues or up to thousands. The sequence of the amino acids is the **primary structure or 1^0 structure.**
   3.4. Fold into **secondary structures, or 2^0 structure** (often alpha-helices or beta sheets) based on **hydrogen bonds along the backbone** (an amine as a donor and a carbonyl as the acceptor). R-side chains (what makes each of the 20 AA's different) have different chemical properties.
   3.5. R-side chains mediate the folding into **Tertiary structure (3^0).** This results in a complex 3-D structure with some function.
   3.6. Multiple polypetptides can come together in a single protein via "**quaternary"** structure (also via R-side chains.
   3.7. For the most part, proteins fold fine on their own. Some need "chaperone" proteins to assist them to fold correctly.
   3.8. By folding these long strands into complex shapes positioning chemically important functional groups in the right spot to carry out some chemistry in the body, or provide structure to the cell. Virtually all the chemistry in living things is mediated by proteins.
   3.9. The 20 amino acids come with side-chains off the "alpha carbon" that provide the unique chemistry. They may be polar, non-polar, charged (acidic or basic) or have other special functions. In this way, a seemingly infinite array of proteins with different structures and functions can be evolved.

4. Nucleic acid: usually storage and retrieval of information: the "genes" that encode the proteins are in DNA. RNA carries out a few very important jobs in the cell, instead of protein. Polymerized via dehydration reactions, broke via hydrolysis.
   4.1. DNA: The ribose in the backbone missing an oxygen at carbon 2'. Know polarity of strands and how to recognize them (5' end and 3' end). Recognize the base pairs using the rules I gave you. Know strands are anti-parallel. and that one strand can tell you what the other strand is (base-pairing rules).
   Recognize sugar-phosphate backbone and bases.
   4.2. RNA: Same synthesis and polarity applies. Has the extra oxygen at position 2'.
      4.2.1. know the relative roles of mRNA, rRNA and tRNA.