Study Guide Chapter 2: Life Chemistry and Energy

Study hint: While working through this study guide, make a list of key terms in the right margin. Usually, these terms are boldfaced in the study guides or they appear in the referenced figures. Consult one of the glossaries if you are not sure of definitions.
Answer the “Do you understand concept 2.3, 2.4 and 2.5”.

0. Application

1. Heroin is a substance not synthesized by the human body. When injected, snorted, or smoked, it causes a feeling of well-being and diminishes the sensation of pain. Why can heroin cause an effect in our cells?

2. What causes atherosclerosis? Remember that you should be able to define bold-faced terms.

Note: usually it is not enough to write down the answers to the following questions. You also need to understand and commit them to your long-term memory.

I. The big picture

3. What is life? Chapter 1 gave us one biological definition, based on the tasks a living entity has to perform. Chapters 2-3 will introduce us to the molecules that make up living entities and the chemical reactions that lead to the emergent properties of, for example, order, communication, and reproduction. We will see that natural selection has favored certain elements, molecules and environments over others, because they are uniquely suited to sustain life. How many of the 94 naturally occurring elements make up 98% of the mass of every living organism? Which are they (mnemonic: CHNOPS)?

4. What do these elements have in common? (Think of why none of the essential elements is found in group 18).

As Chemistry 101A is a prerequisite for Biology 100A, I assume that you are familiar with the following terms. If not, please review:

<table>
<thead>
<tr>
<th>Matter</th>
<th>Element</th>
<th>Atom</th>
<th>Ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proton</td>
<td>Electron</td>
<td>Atomic nucleus</td>
<td>Atomic number</td>
</tr>
<tr>
<td>Energy level</td>
<td>Electron shell</td>
<td>Equilibrium</td>
<td>Valence electron</td>
</tr>
<tr>
<td>Valence shell</td>
<td>Cation</td>
<td>Anion</td>
<td>Molecule</td>
</tr>
<tr>
<td>Structural formula</td>
<td>Molecular formula</td>
<td>Electronegativity</td>
<td>Polar covalent</td>
</tr>
</tbody>
</table>
II. Atoms interact and form molecules

5. Organisms are composed of matter. Atoms need to be held together in molecules and compounds to create the order necessary to make life possible (remember, order was one of the properties defining life). Chemical interactions are important on every level of biological organization (remember energy processing, reproduction, and regulation). Whether atoms and molecules interact with each other and to which effect depends on their location, concentration, and specific structure (key concept 4). Illustrate this concept with examples from any level of biological organization (Fig. 1.6).

6. Some of the bonds that hold molecules together need to be strong, others need to be weak. Why? Give examples.

7. Why do chemical species react at all? (Two reasons, see Fig. 2.1)

8. Compare and contrast the chemical bonds most important for life using the table below (Table 2.1, Fig. 2.2-2.5). Remember that life happens in an aqueous environment (this is a review from chemistry).

<table>
<thead>
<tr>
<th>(Polar) Covalent</th>
<th>Ionic</th>
<th>Hydrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition, basis of interaction</td>
<td>Mutual attraction to shared electrons</td>
<td></td>
</tr>
<tr>
<td>Strength under physiological conditions</td>
<td>Weak in water</td>
<td>Strong in _____</td>
</tr>
<tr>
<td>Atoms likely to form these bonds, know why</td>
<td></td>
<td>Hydrogen involved in polar covalent bond $\text{H}^{+}$ with very electronegative partner, in biology often O$^{2-}$</td>
</tr>
</tbody>
</table>

Not quite clear? Use the Animated Tutorial on BioPortal.

9. The “Frontiers” box on page 20 states that the activities of biological molecules depend largely on their shapes. Give an example that illustrates this statement (Application 1). Review: What role do concentration and location play in this example?

10. With the use of a diagram or diagrams, explain why water molecules are:

   a. **Polar** (Figure 2.5)
   b. **Capable of hydrogen bonding** with four neighboring water molecules

11. Review what makes water such a great supporting material for life, use heat capacity, cohesion, and universal solvent, ice is less dense than liquid water (chapter 29).

12. For each of the four characteristics give an example that illustrate its importance for life.
13. **Macromolecules** can be seen as variations of hydrocarbons. What makes carbon such a useful ubiquitous molecules of life?

14. How do the **functional groups** common to life add “function” to a hydrocarbon? Why are hydrocarbons not prevalent in living organisms?

15. Fill in the following table (Figure 2.7). Note that the first seven functional groups increase solubility in water. I have added an important seventh functional group, methyl, not mentioned in this context in your book.

<table>
<thead>
<tr>
<th>Functional group</th>
<th>Structure</th>
<th>Functional Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroxyl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aldehyde</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keto</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carboxyl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amino</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfhydryl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methyl</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

16. How would exchanging an amino group for a carboxyl group change the properties of the molecule?

17. Distinguish between the four major classes of organic compounds found in cells, their **monomers**, their main functions, and the elements they are composed of. Give an example for each (see also chapter 3). Note that you will encounter our CHNOPS elements again.

<table>
<thead>
<tr>
<th>Class</th>
<th>Monomer</th>
<th>Example</th>
<th>Main functions</th>
<th>Elements present in all molecules of this class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td></td>
<td></td>
<td></td>
<td>C, H, O</td>
</tr>
<tr>
<td>Lipids</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

18. Draw diagrams to illustrate **condensation** and **hydrolysis** reactions (Figure 2.8). Which of these reactions is usually exergonic, which is usually endergonic? What role do **enzymes** play in these reactions?

19. How can the huge variety of **polymers** (more than a million antibody proteins) in cells be built from a small set of monomers?
III. Carbohydrates consist of sugar molecules
   20. Describe glucose as precisely as you can (Fig. 2.9).
   21. Compare and contrast starch, glycogen, and cellulose (structure, function, occurrence). Explain why the differences are biologically important (Fig. 2.10).

IV. Lipids are hydrophobic molecules
   22. Describe the building-block molecules, structure, characteristics, and biological importance of triglycerides and phospholipids (Fig. 2.11 and 2.13).
   23. Explain the structural differences between fats and oils that lead to their different fluidity at room temperature.
   24. Distinguish between saturated, monounsaturated, polyunsaturated, hydrogenated, cis and trans fatty acids (Fig. 2.12).

V. Biochemical changes involve energy
   25. When do chemical reactions happen?
   26. Relate the following terms to each other: kinetic energy, potential energy, endergonic, exergonic, anabolic, catabolic, free energy, entropy (Fig. 2.14).
   27. State the first and second laws of thermodynamics and briefly discuss their relevance for life (Fig. 2.15).

Essay question

Compare and contrast hydrogen, ionic, and covalent bonds. Include a definition of each bond, explain between which kinds of atoms each bond forms, and compare the strength of the different bonds. Give examples where applicable, highlighting the significance of these different bonds for life.

**Note:** You might find parts of essay questions on the next exam. Don’t skip them!
Study guide chapter 3: Nucleic Acids, Proteins, and Enzymes

The big picture

In this chapter we will encounter two more “complex molecules that reflect the complexity of tasks necessary to sustain life” (KS 6), we will see once again how “homeostasis is efficiently maintained by feedback regulation” (KS 5) and reflect upon the necessity for reactions to be fast and specific, and how location, concentration and structure achieve this task in the cellular environment of random, heat-driven molecular movement (KS 4).

0. Application

1. Why do kids suffering from protein malnutrition suffer from a swollen abdomen, weight and hair loss?
2. Explain function and mechanism of action of aspirin.

I. Nucleic Acids

1. List the major components of a nucleotide (Fig. 3.1), and describe how these monomers are linked to form a nucleic acid (Figure 3.2).
2. Explain the principle of complimentary base pairing (Figure p. 36).
3. Explain the sentence: “nucleic acids grow in the 5’ to 3’ direction”.
4. Compare and contrast DNA and RNA (structure and function, Fig. 3.3 and 3.4).
5. What are differences between DNA replication and transcription?

II. Proteins

6. List some of the major function of proteins, know an example for each.
7. Distinguish between a protein and a polypeptide.
8. List and describe the four major components of an amino acid.
9. Explain how amino acids may be grouped according to the physical and chemical properties of the R group (Table 3.2). Note: you do not need to learn amino acids by heart, but you should be able to recognize their main chemical property from their depiction.
10. What are essential amino acids (refer to Application question)?
11. Give an example of food items with complimentary essential amino acids.
12. Define primary structure. Which parts of amino acids and which bonds are involved?
13. The secondary protein structure consists of only few, very regular forms while the tertiary level leads to a huge variety of forms. Why is that (again, consider parts of amino acids and bonds involved)?
14. Define quaternary protein structure and distinguish between globular and fibrous proteins. Know examples for each.
15. What is the advantage of having the huge variety of protein shapes?
16. What happens when a protein denatures (Figure 3.10). List four conditions under which proteins may be denatured.
III. Enzymes

Compare a newspaper left on a windowsill to one burned. You cannot predict how fast something will happen by knowing its delta G; what you can predict is in which way the reaction will proceed, and how much energy will be released or consumed.

Rates are limited by Activation Energy

Reacting molecules must have enough energy to overcome barrier of activation energy (protection for complex molecules from spontaneously decomposing).

17. Describe form and function of a typical enzyme. Differentiate between the "lock and key" and the "induced fit" model of enzymes. (Fig. 3.14).
18. Describe the enzyme action cycle (Fig. 3.13).
19. List three ways enzymes can cause their substrates to enter the transition state (pp. 48-49). Important!
20. How do concentration, location, and specificity (enzyme-substrate affinity) influence the rate of the catalytic cycle of an enzyme? Other cellular factors influencing enzyme activity are cofactors, prosthetic groups and coenzymes, pH and temperature. Explain, using specific examples, how these factors exert their influence on enzymes.
21. What does the rate of a reaction depend upon (Fig. 3.15)? Include saturation and turnover number in your discussion.
22. What is the life challenge that necessitates enzymes? Which key strategy is exemplified by enzymes?

IV. Regulation of metabolism

23. Why is enzyme regulation necessary? How can enzymes be regulated?
24. Distinguish between reversible and irreversible, competitive and noncompetitive inhibition (Fig. 3.16 and 3.17). Give examples for each.
25. How does allosteric regulation work (Fig. 3.18)?
26. Distinguish between regulation of an individual enzyme (on-off) and regulation of the overall rate of a reaction in a cell (volume).
27. Describe the role of feedback inhibition in a simple metabolic pathway (Fig. 3.19).
28. How would you a) design a heat-stable and b) a pH-neutral enzyme?
29. Answer the apply the concept questions on page 53.

Essay question

Describe enzyme action and regulation. Include: how do enzymes work; factors that influence enzyme activity; why is regulation of enzyme activity crucial; mechanisms that cells use to regulate enzyme activity.
Introduction, Scientific Method, Protocol Writing

A. Objectives
The purpose of this introductory lab is threefold:
1. Become familiar with your laboratory partners, the laboratory setting, laboratory safety procedures, the process of keeping a legal scientific notebook, and with how Bio 100A labs are organized.
2. Gain an understanding of the nature of science and recognize the stages of the scientific method as they apply to everyday experiences.
3. Start applying the scientific method to biological questions;
4. Practice writing a protocol for a laboratory exercise.

B. Before coming to lab
2. Do the BioPortal pre-quiz. If you do not have access to BioPortal yet, answer the questions in part F of this exercise. If you don’t have a notebook yet, you can glue your answers into the notebook later.

C. During lab
1. Your instructor will introduce you to
   • the laboratory website,
   • lab exams,
   • the laboratory setting,
   • laboratory safety procedures,
   • and how and why to keep a laboratory notebook.
   Please listen carefully and take good notes.
2. In a group of four, complete the exercises in Part G and H, paying special attention to the part on protocols.
3. Summarize your proposed investigation and present it to the whole lab section.
4. Once all groups have presented their proposed investigation, vote on which of the investigations you would like to carry out in the next lab section. You might want to use the following criteria:
   • Which of the questions investigated do you find the most interesting?
   • Which investigation can be carried out in 30-40 minutes?
   • Which investigation can be carried out without an extensive set-up?

D. After lab (before coming to the next lab)
5. Review the information in this handout and your notes from your instructor’s presentation.
6. Review laboratory safety procedures (http://fog.ccsf.cc.ca.us/~cpogge/Lab/Labsafety.html).
7. Review how to keep a laboratory notebook (http://fog.ccsf.cc.ca.us/~cpogge/Lab/Notebooks.html).
8. Buy an appropriate laboratory notebook.
E. Background

Note 1: Your laboratory binder
The laboratory exercises are available for you to copy or to print from the internet (http://fog.ccsf.edu/~cpogge/Lab). Most laboratory exercises follow the format outlined in Table 1.

Table 1: Laboratory exercise format and student preparation

<table>
<thead>
<tr>
<th>Parts of lab exercise</th>
<th>Student preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Objectives</td>
<td>Before the practical, read through all the objectives and make sure you master them.</td>
</tr>
<tr>
<td>B. Before coming to lab</td>
<td>Read the background. Sometimes you are asked to prepare a protocol (see note 2. below). The protocol needs to be in your notebook at the beginning of class, because otherwise your lab partners have to wait for you. In addition, you’ll lose points. Other times, you will have to do a graded pre-lab assignment (see schedule) or just answer a few questions on BioPortal.</td>
</tr>
<tr>
<td>C. During lab</td>
<td>This part briefly outlines what you need to do during lab. It is also an indication of what you need to report in your notebook during lab. Do not forget to sign and date your notebook and to get your instructor’s signature before you leave. As soon as you have questions, approach your instructor. Do not wait for your instructor to read your mind!</td>
</tr>
<tr>
<td>D. After lab</td>
<td>You should always review the lab shortly after you are done. What was the purpose of the lab? Why did you use certain procedures and materials? Fill out the review worksheet and identify questions you cannot answer. Discuss these questions promptly with your lab partners, the mentors, or your instructor. Do not wait for the questions to pile up into an overwhelming heap. Make sure you do the assignments as outlined in this section. You might have to turn in a report (see Appendix C) or write a short paragraph in your notebook.</td>
</tr>
<tr>
<td>E. Background Note 1 Note 2…</td>
<td>This section gives you theoretical background on the exercise of the day. It might also point you to optional resources. One of the notes outlines the procedure to follow – this is the section you usually have to condense into a numbered protocol.</td>
</tr>
<tr>
<td>F. Review questions</td>
<td>Often, you’ll have waiting periods during labs – use these times to fill out worksheets with your partners. Take advantage of your instructor being there to discuss your answers. Note that many questions on the lab exam will come directly from these review questions.</td>
</tr>
</tbody>
</table>

Note 2. Protocols
For most laboratory investigations, you are expected to write a protocol of the experiment to come. The laboratory write-up often contains an explanation of the basic methods used in your laboratory investigation. But it is up to you to write-up each experiment in a condensed form that will allow you to perform the experiment without
consulting the on-line notes. This means that you need to include all the materials used, times, techniques, etc. Think of it as something like a cooking recipe. As for such a recipe, it is important to list the steps in the most time-efficient order, e.g., you might prepare a solution for a step further down the line while waiting for something else to incubate. The write-up does not have to be very formal, best would be to simply draw numbered steps (see Figure 1); but you must include the salient information as outlined before.

For each experiment you perform, you should

1. give a **short description of the question** we try to address in the experiment. The write-up of the purpose and procedures serves as a preparation to the investigation. You can thus clarify what you will be doing in the lab to come and identify questions that you might want to discuss with your lab partners or your instructor before you begin. **Note: THIS IS DIFFERENT FROM WHAT YOU ARE USED TO FROM CHEMISTRY!**

2. Methods: How will you set up your experiment? How many experimental groups will you have? How will you measure the effect you wish to study? How long will the experiment last?

3. Controls: Identify the relevant control variables and what treatment your control group receives.

Your instructor will check the completion of the protocol before you are allowed to begin your investigation. As you proceed through the experiment, **note any steps which you performed differently from the outline** (either accidentally or intentionally) and note the appearance of reactions, pellets, supernatants, etc. All this information will be important in interpretation of results and in trouble-shooting failed experiments.

**Figure 1:** Sample Protocol

| QUESTION: What is the effect of chewing gum on face recognition. |
| Methods: |
| 1. Divide class in two groups. |
| 2. First groups does face recognition test three times [http://faculty.washington.edu/chudler/java/facemem.html](http://faculty.washington.edu/chudler/java/facemem.html) while chewing gum; second group without chewing gum. |
| 3. Record performances. |
| 4. Then let second group chew gum, while first group does not while doing three face recognition tests |
| 5. Record performances. |
| 6. Compare results. |
| Controls: Independent: chews gum, dependent; performance on face recognition test; control variable: same room, same gum, same time: |
| Date | Your signature | Instructor's signature |
| 20.1.2011 | Jenny Finn | Crima Pogge |
Note 3: The nature of scientific inquiry
Note that the linear representation of scientist’s approach to science in Hillis (Fig. 1.8) is simplified and that “real” science is much more dynamic. The following flowchart (Figure 2) from UC Berkeley gives a more realistic depiction of the process of science (http://undsci.berkeley.edu/article/0_0_0/howscienceworks_02).

Figure 2.: How science works
F. Reading guide for Hillis et al., concept 1.5 (alternative to BioPortal assignment)
1. List three important differences between Figure 1.8 in Hillis and Figure 2 above.
2. Define inductive reasoning, give an example.
3. Define deductive reasoning, give an example.
4. Distinguish between controlled and comparative experiments.
5. List the first four steps of the scientific methodology and write down how each step was applied in the investigation described in Hillis et al., Fig. 1.9.
6. Identify the experimental and control groups in this case study. How do they differ?
7. Define null hypothesis.
8. Which two important qualities must scientific questions have?

G. Review questions (answer in your lab notebook after your instructor’s lecture)
9. Which of the following are valid scientific questions? Explain.
   a. Does cigarette smoke cause lung cancer?
   b. In 2001, a Texas woman drowned her five kids claiming that God had told her to do so. Did she really hear the voice of God?
   c. Is the Texas woman competent to stand trial?
   d. Why are leaves green?
   e. Are vitamins good for you?
10. Does science contradict the existence of God? Name three things that science does not do (http://undsci.berkeley.edu/article/0_0_0/whatisscience_12).
11. Give an example for the subjectivity of observation from your own life.
12. Give an example for how social context influences scientific research.
13. Define hypothesis.
14. Why is it desirable to formulate multiple hypotheses?
15. Give several examples of factors that might contribute to bias. What measures are taken to avoid bias?
16. Give examples for two other important contributing factors in important discoveries.
17. Define control group, controlled experiment, independent variable, dependent variable and control variable.
18. In Dr. Tyrone Hayes’ study, identify independent variable, dependent variable and control variable(s).

H. Writing protocols
19. Use a single sheet of paper. Still in your group of four, write a protocol for an investigation of the effect of _______ on heart rate of _________. You should be able to carry out the experiment next week, involving the whole class. Try to come up with a question about heart rate that really interests you. For example, it is rather obvious that exercise will increase heart rate, but does it do so equally for female and male students? For trained and non-trained students? What else but exercise can influence heart rate?
20. Imagine you are a research team excited about an investigation. Prepare a brief presentation of your project that might convince your peers to vote to carry it out next week. Think of why this investigation is important or innovative.
Model Cell I

(adapted with permission from R. Griffin, City College of San Francisco)

A. Objectives
   Become familiar with
   1. Certain properties of non-living membranes which are shared with the membranes of living organisms;
   2. The actual practice in strong inference and in deductive reasoning.

B. Before coming to lab
   3. Read this exercise;
   4. Formulate the question this investigation is trying to answer (this is the title of this lab in your lab notebook).
   5. Draw a protocol for the initial experiment with the model cell (including how to make the model cell). Refer to Figure 1 in the introductory lab exercise for a sample protocol.

C. Procedure during lab
   6. Work in groups of two. Construct the model cell (see Note 1) and place it in a clean beaker. Add just enough water to cover the cell completely. Then add 10 drops of Lugol's iodine solution and swirl gently to mix. Observe for 20 minutes, recording all visible changes.
   7. Formulate multiple working hypotheses for the possible cause or causes of the color change observed (we do not have time to investigate other changes you might have observed). Number your hypotheses and write them in your notebook. Be exhaustive in formulating hypotheses so that you identify every possible cause. Remember, though, that a hypothesis is worthless if it can't be tested by experiment.
   8. For each hypothesis, design a simple experiment that will test it, using the strong inference criterion (the hypothesis must provide the possibility of disproving it). Construct a table in your laboratory notebook like the one in Note 2 to record your tests, predictions, and results.
   9. Perform your experiments, record the observed results and conclusions.
  10. Clean-up and waste disposal. Clean up your glassware; that means that you need to remove all labels, rinse out all solutions, remove all solid materials, brush out all residues stuck to the glass. Empty the cell's content in the container provided. Throw membrane and strings in the wastebasket.
D. Materials available for testing

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dialysis tubing, string 0.3% starch suspension 10% glucose solution</td>
<td>To build the model cell.</td>
</tr>
<tr>
<td>Lugol's iodine a solution of 5% I₂ in 20% KI. Corrosive. Remove stains</td>
<td>Elemental I is only very slightly soluble in water, but it</td>
</tr>
<tr>
<td></td>
<td>dissolves readily in KI by formation of the tri-iodide ion, I₃⁻. Your</td>
</tr>
<tr>
<td></td>
<td>initial observations of this experiment should lead you to a hypothesis</td>
</tr>
<tr>
<td></td>
<td>of what Lugol's reacts with.</td>
</tr>
<tr>
<td>Sodium tri-iodide, Sodium iodide, I₂ Potassium iodide, Sodium chloride,</td>
<td>To isolate components of Lugol's iodine solution</td>
</tr>
<tr>
<td>Potassium chloride</td>
<td></td>
</tr>
<tr>
<td>Funnels, 70 mL, Test tubes w/ racks Graduate cylinders, 10 mL</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Constructing the model cell
Obtain a piece of cellophane dialysis tubing about 12 cm long and tie one end. Fill it with 5 mL of 0.3% (w:v) starch suspension and 2 mL of 10% (w:v) glucose solution. The measurements don't need to be precise - one good dropperful approximates 0.5 mL. Now tie the second end of the tube securely shut, and rinse your model cell before placing it in the beaker.

Note 2: Constructing your hypotheses table
Use the following format for your tests of hypotheses for the causes of the color change

<table>
<thead>
<tr>
<th>Hypothesis #</th>
<th>Test</th>
<th>Prediction</th>
<th>Result</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note that the conclusions will consist of a single word: either "supported", "rejected" or "inconclusive". If the conclusion for any test is inconclusive, then you must devise a new test. Also note that the prediction has to be congruous with the hypothesis.

E. After lab
After class discussion, discuss your experimental design with your team mates. How could you have streamlined your experiments? Saved time or materials? Which controls would have been useful – what would they have told you? Which variables had you overlooked? Write a one paragraph summary of your discussion in your notebook.
Model Cell 2

(adapted with permission from R. Griffin, City College of San Francisco)

Note: You need to bring goggles to this lab

A. Objectives
Become familiar with
1. Certain properties of non-living membranes which are shared with the membranes of living organisms;
2. The actual practices of strong inference and deductive reasoning;
3. Tests for detecting ions and molecules;
4. The importance of positive and negative controls;
5. Find out how dialysis tubing discriminates between particles. Compare this to the discrimination of living cell membranes.

B. Before coming to lab
From last laboratory’s investigation, you can deduce that at least one substance passed through the membrane while at least one other could not pass through the membrane. In today's investigation, we want to
a) determine which of the substances (including the constituents of Lugol's Iodine) present can actually pass through the membrane; and
b) hypothesize which property of the substance its (dis)ability to pass through the membrane is based upon.

To prepare for this lab,
1. Read this exercise. Pay special attention to the materials available and the safety notes that accompany them.

C. Procedures during lab
1. Carry out the experiments to test each hypothesis according to your protocol.
2. Fill in the blank cells in your hypothesis table.
3. Clean-up and waste disposal. Dispose of all solutions containing iodine, cobaltintitrite, Benedicts, or silver nitrate in the containers provided. Starch, glucose, sodium, potassium, and chloride ions can be flushed down the sink. For glassware clean-up see above.
## Materials available

<table>
<thead>
<tr>
<th>Materials</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All materials from Lab 1</strong></td>
<td></td>
</tr>
<tr>
<td>Benedict’s (B.’s) reagent (a solution of cupric sulfate, sodium carbonate and sodium or potassium citrate)</td>
<td>A test for reducing sugars, such as glucose. Place 1 or 2 mL of the solution to be tested in a test tube with an approximately equal volume of B.’s and place the test tube in a water bath*. After 3-5 minutes, B.’s will react with any reducing sugar present to form a yellowish/orange precipitate of cuprous oxide. If very little sugar is present, the precipitate will not be visible as a solid precipitate, but the tiny particles will be numerous enough to absorb and scatter light to cause the solution to change from blue to green.</td>
</tr>
<tr>
<td>*Tripods, bunsen burners, igniters, boiling chips, wire gauze</td>
<td>Benedict's test has to be performed in a boiling water bath. Leave the boiling chips in the beaker -- they protect the glassware from breaking (and you from burns). When lighting the bunsen burner, remember to close the air intake first. The igniters work only if you make the spark about two inches above the mouth of the bunsen burner</td>
</tr>
<tr>
<td>Silver nitrate (AgNO₃)</td>
<td>A test for monooiodide ion (I⁻¹). If I⁻¹ is present in a solution, adding a few drops of silver nitrate solution will produce a white precipitate of silver iodide. We do not have a test for I₃⁻¹ alone. Tri-iodide ions form only in the presence of an excess of monooiodide. Think about how you can reach conclusions about I₃⁻¹.</td>
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<tr>
<td>Sodium Cobaltinitrite Contains glacial acetic acid. Highly corrosive - wear goggles**</td>
<td>A test for potassium ion. Place 2 mL of the solution to be tested in a test tube and add 15 drops of sodium cobaltinitrite test solution. If potassium ions are present, a yellow precipitate of potassium cobaltinitrite will form in 3 to 5 minutes. Warming the test tube in your hand will speed up the reaction a little bit.</td>
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</table>

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**A Note on Safety . . .

** If you get anything in your eyes in spite of the safety goggles

1. Immediately tell your classmates around you and get them to guide you to the nearest faucet or the eyewash spray.
2. Hold your eyelids open while someone else runs water into your eyes.
3. Rinse your eyes continuously for several minutes after your feel relief.
4. Clean up all spills immediately. Do not put acid-contaminated towels in the wastebasket. Neutralize them first.
E. After lab
Read the file on how to write lab reports
(http://fog.ccsf.cc.ca.us/~cpogge/Lab/Reports.html) and write a title for a report on
today’s lab (just a title, not a report) in your notebook.

F. Lab review
1. What caused the color change? Justify your answer.

2. Where are starch, glucose, tri-iodide -, monoiodide- and potassium ions located after
diffusion has been allowed to proceed for 20 minutes?

3. State the evidence on which your inferences are based.

4. What further inferences can you make about the artificial membrane? Why do you
think some molecules or ions can pass through the membrane while others cannot?

5. What are the principal ingredients of Lugol's iodine?

6. Explain what is meant when the concentration of a solution is expressed as a certain
percent (w:v) (see Appendix D).

7. Which positive and which negative controls (if any) did you use in your tests?

8. Which further tests do you suggest to increase confidence in your results?

9. Identify independent, dependent and control variables for your experiments.

10. Last semester, only two out of 12 teams had positive results when testing the
permeability of the artificial membrane for potassium ions. Suggest explanations
assuming a) that \( K^+ \) cannot, and b) that \( K^+ \) can permeate the membrane.

11. By testing the permeability of the model membrane to certain substances, we hope
to find out general rules about what \textbf{kinds} of molecules can or cannot pass. Is this
an example of \textbf{inductive} or of \textbf{deductive} reasoning?
A. Objectives
1. Practice carrying out a controlled biological experiment
2. Practice organizing the data collected from the controlled experiment
3. Practice visualizing the data collected
4. Practice making biological sense of biological data.

B. Before coming to lab
6. Read the file on how to write lab reports for this class at http://fog.ccsf.cc.ca.us/~cpogge/Lab/Reports.html.
7. For the investigation your lab section agreed upon, formulate (a) the research question as precisely as you can and (b) a null hypothesis, and (c) an alternative hypothesis. Justify your alternative hypothesis by stating your assumptions (why do you think the treatment would make a difference). Example: (The question in this case is from the first lab Figure 1)
   Question: What is the effect of chewing gum on face recognition?
   Null hypothesis: There is no difference between face recognition while chewing gum or not chewing gum.
   Alternative hypothesis: Chewing gum increases face recognition.
   Assumptions: (1) Chewing gum is not a distraction from recognizing faces, and (2) Research shows that studying biology while moving (taking notes, chewing gum) enhances content retention. Since face recognition is a cognitive task similar to studying biology, chewing gum will enhance this task too.

C. During lab
8. In this exercise, you will be asked to participate as a subject in a biological investigation. The investigation involves an activity and its effect on your heart rate. Please let your instructor know if you cannot or do not want to participate in the activity part of this exercise.
9. Watch your instructor's demonstration of how to properly take someone's heart rate.
10. You will work with a partner and carry out the controlled experiment your lab section agreed upon. Agree upon an appropriate format for reporting the data you collect. Report results in your notebook.
11. After class data have been pooled, you will use an appropriate type of graph to visualize both your results and the class results. Do not forget to label the axes and to give your graph a descriptive title. Both of you should have both graphs in your respective notebooks.
12. In a group of four students, answer the questions in part E. of this exercise.
13. Listen to your instructor's explanation on how to write lab reports for this class.
D. After lab (before coming to the next lab)
   14. If you could not finish answering the questions in part E. during lab, please finish
       answering them after lab.
   15. Write a laboratory report on this investigation, using the instructions at
       http://fog.ccsf.cc.ca.us/~cpogge/Lab/Reports.html.

E. Questions about your investigation
   1. Formulate the research question as precisely as possible.
   2. Identify the different groups.
   3. Identify dependent, independent and control variables.
   4. Are the variables that you collected **quantitative (discrete or continuous) or
      categorical**?
   5. Are there outliers in the class results? Can you explain why these students got
      results different from the majority?
   6. Do the results support or contradict your alternative hypothesis?
   7. In light of the results, refine or change your hypothesis.
   8. (How) Do you need to revise your assumptions based on the results?
   9. Review the research question now in light of your results. What conclusions can
      you draw from the results?
  10. How could you gain more confidence in your conclusions?
  11. What future research can you propose that would shed more light on your
      original research question?
# Grade tracker Bio 100A – Fall 2012

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