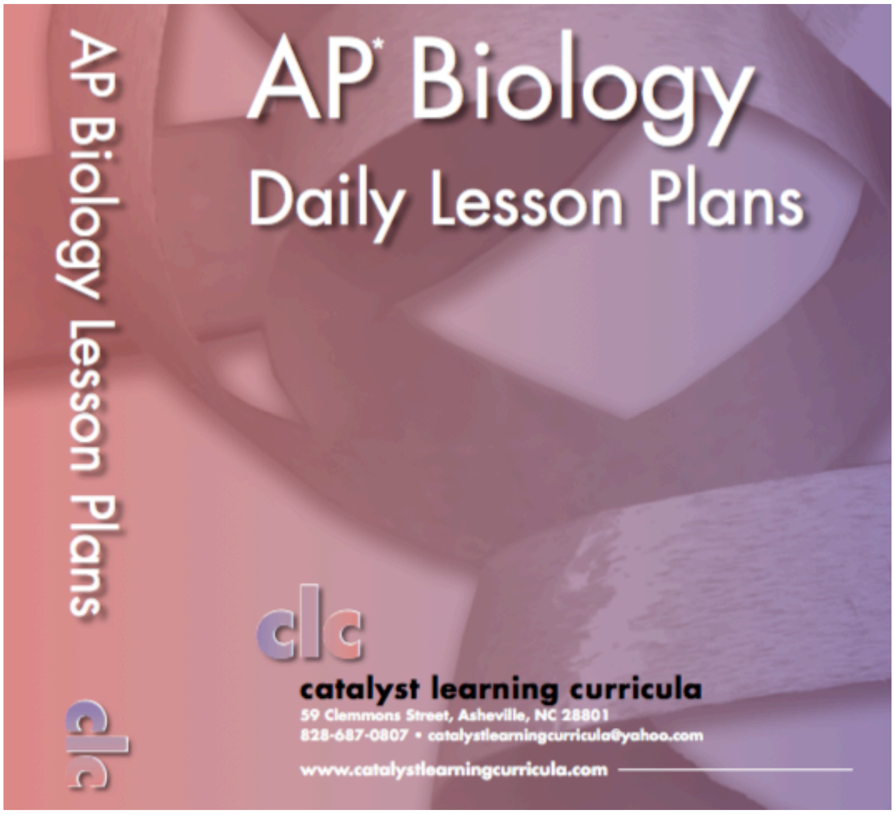


AP® Biology
Daily Lesson Plans
(Sample Week of Lesson Plans)

This full-year curriculum includes:

- 142 sequential lesson plans covering the entire College Board curriculum including laboratory skills and test preparation
- A pacing calendar, a materials list, student handouts and grading rubrics
- 100% hands-on learning so the teacher can provide a student-centered classroom environment with no lecture
- Lab experiments, games, model building, debates, projects and other activities designed to promote critical thinking
- **A curriculum that exceeds all the expectations of the AP College Board Redesign for 2012**

Please visit our website at www.CatalystLearningCurricula.com to download additional sample lesson plans or to place an order.

AP® Biology
Daily Lesson Plans Curriculum

Table of Contents
(with one week of sample lesson plans to follow)

AP* Biology Daily Lesson Plans
Biochemistry Unit
(Samples of Week One)

Day 1

I. Topic: What is Life?

II. Warm-up: 5 minutes

Tell the students to look on the board everyday as they enter to find the warm-up question for the day. Tell them to start their notes for the day with a response to this question (they do not need to write the question in their notes).

Prior to class, write the warm-up question on the board or projected on a screen. Today's question is: What is the definition of the word "life"?

III. Activity One: Is It Alive? 35 minutes

Objectives:

a) The learner will (TLW) evaluate their own definition of life and compare it with the definitions offered by their peers and other sources.
b) TLW get experience exploring their comprehension and discovering misconceptions about a given subject through participation in a Socratic discussion.
c) TLW get a taste of what is in store for them in this class with an activity that piques their curiosity.

Materials:

1 potato; 1 mushroom; 1 plant; 1 candle; 1 digital clock; 1 photo of a virus; 1 fish; 1 package of bread yeast in warm sugar water (do not mix yet); 1 small bowl of vinegar and baking soda (do not mix yet).

Procedure:

1. Place the above items in a central location and ask the students to examine them. Encourage the students to use all of their senses to gather information about the items.
2. Tell the students you would like them to consider the question you are about to ask, but you do not want it answered aloud yet. Ask, "Which of

these things is alive?" Then, mix the yeast with warm sugar water, and mix the vinegar and baking soda, and ask the students to observe the reaction that occurs in each bowl.

3. Let them consider the question for a minute ("Which of these things is alive?"), then ask them to jot down a response on paper. Ask them to back up their response with a short explanation.
4. Begin a Socratic discussion by posing questions that lead the students from their present base of knowledge toward new ground. Remember to let them take control of the discussion and openly debate one another. Play devil's advocate when possible and do not try to clarify everything in absolute terms. Allow them thinking time and suggest they refer to their textbook when they reach a stalemate or want a concrete answer. Some guiding questions might include:
    a. Which of these items is alive? *(potato, mushroom, virus, fish, yeast)*
    b. Why do you think they are alive?
    c. How can I tell if something is alive? *(the item has some of the characteristics of life)*
    d. How can I tell if something used to be alive?
    e. Are the criteria for what constitutes a living thing the same for all scientists? (*no; for example, viruses are not considered alive by some scientists)*

    When new vocabulary terms are introduced ask, "How would you define the word _____?" so that the students can think about what the word means and/or debate its meaning.
5. At appropriate times, jot notes on the board. In order to have a more student-centered learning experience, pick a student to be the note-taker for the period or have each student who formulates a clear idea go to the board and add it to the class notes. Keep track of the students' conclusions and/or contradictions—not everything on the board has to be correct; you can put question marks next to ideas that are not agreed upon or you can list exceptions that are mentioned during the discussion. Some ideas that you may want to cover:
    - a list of the characteristics of life
    - examples of things that don't appear to be alive but are
    - examples of things that appear to be alive but are not
    - a clear definition of "life"
    - definitions of any terms that come up, even if they seem simple (ex: metabolism, growth, organization, cells, evolution, homeostasis); encourage students to clarify new words by coming to a consensus on their meaning
6. Once the students feel they have settled on a definition of life, ask the students how life on earth might have begun. After a few minutes of discussion, ask the students to break into pairs, or larger groups as needed, so that each team of students has an electronic device with which

to access the Internet. Ask the groups to each explore one current scientific hypothesis of how life on earth may have begun: the RNA world hypothesis; metabolism first hypothesis; the hypothesis that life was brought to earth on a meteor from another location (aka panspermia); the hypothetical origin of life in deep sea vent reactions; lightening bolt striking elements and small molecules in pools of sea water based on results from Miller-Urey experiments; clay particle origins based on Graham Cairns-Smith experiments; etc.

7. When the students are ready, have groups that explored different hypotheses join up and share what they have found. Use the remainder of the time set for this activity for discussion and debate.

Special note: Allow 5 minutes for steps 1-3, then begin the discussion. Keep the discussion lively, but let the students debate one another instead of looking to you for concrete answers. Play devil's advocate and throw challenging questions into the discussion. Alert them to exceptions to their conclusions, such as the fact that mature red blood cells do not have a nucleus or DNA; the sugar transporting cells of the phloem in a tree (sieve cells) also have little to no organelle and are supported with nutrients and ATP provided by a neighboring companion cell, many cells such as algae and muscle cells can be multi-nucleate, etc. Do not verify conclusions, but instead hint that their textbook would be a good place to look for support for their arguments. Keep the discussion portion under 25 minutes, using a timer, so that you stay on schedule.

IV. Activity Two: Introduction to AP Biology **10 minutes**

Objectives:

a) The learner will (TLW) explore the direction of this course and their role in the journey.
b) TLW learn what is expected of them and what can be expected from their teacher.
c) TLW set goals and map out a strategy for achieving them.

Materials:

One "Goal Setting for AP Biology" handout for each student.

Procedure:

1. Let your students know that this is a college-level class and it will be taught the way college courses are.
2. Inform them of what you will expect from them, for example:
    a. They will perform work for this class every day.
    b. They will be expected to complete all of their assignments on time.
    c. They will be expected to come to you with questions for clarification and help whenever needed.

3. Let them know what they can expect from you, for example:
    a. You will give them assignments that fuel their curiosity and help them understand and remember key concepts.
    b. You will guide them through difficult concepts with examples, laboratory experiments or demonstrations, activities, games and other learning adventures.
    c. You will provide access to the fascinating world of modern science by giving them the opportunity to talk to guest speakers, go on field trips and experience real-world scientific research.
    d. You will prepare them to take and pass the AP Biology Exam, which will give them one year of college credit in laboratory science.
4. Give the students a copy of the year calendar, so they can see what topics this course covers.
5. Let them know what to expect from the curriculum, for example:
    a. Daily homework, reading and note-taking
    b. Weekly videos, labs and free response essays
    c. Monthly lab reports or presentations
    d. Tests on 2+ chapters every 2-4 weeks.
6. Ask the students if they are up for the challenge presented by this course. Ask them what they would like to earn on the AP Exam. Have them write that score on their goal sheet now.
7. Ask them to plan out how they are going to work toward their goal. Have them write down how they will find the time to do 1-2 hours of work daily for this course and when and where they will study each day.
8. Have them complete their goal sheet by writing out how they will motivate themselves to maintain their study schedule.
9. Discuss what you could do to help them stay motivated. (It might help to give them examples, such as minimal lecture time, interesting classes, no "busy work", help with study skills, audiotaping classes, use of colored markers, silly songs created for mnemonic purpose, rewards such as chocolate or candy, etc.)
10. Tell them that this goal setting handout is tonight's homework assignment. Ask them to complete the handout and have three people who can support their study efforts and help them achieve their goals read it and sign it.

HW: Ask the students to read the introduction to the biology chapters in their textbook and take notes to turn in for a grade.

HW: Ask them to finish the goal setting handout to turn in for a grade.

Goal Setting for AP/IB Biology

The things I hope to gain from this class are (think of all the reasons you wanted to take this course):

Primary goals:

1.

2.

3.

Secondary goals:

1.

2.

3.

The grade I would like to make on the AP/IB Exam is: __________

The AP exam is graded on a scale of 1-5. Scores of 3-5 earn you college credit in laboratory science at some universities, with a score of 5 giving you the most college credit. The IB Biology Exam is grade on a scale of 1-7. Scores of 6-7 are most likely to earn collge credit.

I will find the time to perform 1-2 hours of work daily for this course by doing the following:

1.

2.

I will study each day at (time) ________________ in (place) ________________.

I can help myself remember my goals and work toward them by:

1.

2.

3.

My teacher can help me obtain my goals by:

1.

2.

3.

AP* Biology Daily Lesson Plans
Biochemistry Unit
(Samples of Week One)

Day 2

I. Topic: The Scientific Process

II. Warm-up: **5 minutes**

Prior to class, write the following on the board: What are the steps of the scientific process? Explain the purpose of each step.

III. Activity One: Scientific Method **30 minutes**

Objectives:

a) The learner will (TLW) question the rigor of the scientific process to understand why it is used in modern scientific research.
b) TLW debate the structure of several experiments in regard to their scientific merit.

Materials:

One "The Scientific Process Critiqued" handout per student.

Procedure:

1. Ask students to work on the handout in pairs. Have them debate the strengths and weaknesses of each experiment. Ask them to take notes as they work.
2. After they finish, ask them to reconsider the warm-up question and write a new response to it at the bottom of their handout.
3. Lead the class in a Socratic discussion. Some guiding questions might include:
   a. What is the purpose of the scientific process? *(to test hypotheses in a verifiable and credible manner)*
   b. What is the difference between a null hypothesis and a hypothesis? *(a null hypothesis is one that can be rejected—it essentially states that the variable will have no effect on the outcome of the experiment; null hypotheses are used in all scientific research so that conclusions can be drawn that "reject" or "fail to reject" the null hypothesis; see the Teacher's Version of the handout for examples)*
   c. Considering the concept that nothing in science is ever "proven", but instead ideas are supported, explain why scientists test null hypotheses instead of hypotheses. *(because you can never have enough support for a hypothesis to say that it is the sole*

explanation of a phenomenon, but you can have enough data to show that it is not the sole explanation of a phenomenon)

d. What constitutes a good scientific design? *(repeatability, large sample size, simple and elegant procedure, one variable while all other factors are controlled, etc.)*
e. What are the typical weaknesses of scientific experimentation? *(absence of one or more of the above-mentioned traits)*
f. Why does sample size need to be very large? *(to minimize undetected variables or variables that cannot be eliminated)*
g. Why does an experiment need a control? *(to serve as a comparison to measure against)*
h. What is the ideal number of variables? *(one per experiment)*
i. Why are the steps so rigid? *(consistency, repeatability, etc.)*
j. What is the difference between inductive and deductive reasoning? *(Inductive - specific information leads to a general conclusion Deductive - general information leads to a specific conclusion)*
k. What is the difference between qualitative and quantitative data? *(qualitative is descriptive data, quantitative is numeric data)*
l. Which is stronger? (*quantitative*)

IV. Activity Two: Introduction to the Free Response Essay 15 minutes

Objectives:

a) The learner will (TLW) understand what is expected on a Free Response (FR) essay question, according to the AP Biology Exam grading guidelines.
b) TLW learn to do preliminary work before beginning the written essay.

Materials:

One copy of Free Response essay question #4 from the 2004 Form B AP Biology Exam per student (this question, as well as the grading rubric, can be printed from the www.apcentral.collegeboard.com website).

Procedure:

1. Prior to class, go over the grading rubric for this and other free response questions. Become familiar with how points are scored for most questions. Learn the expectations for FR essays in terms of their structure and content (for example: lists and outlines will not be graded; venturing an incorrect idea will not count against a student, however they will not receive points for incorrect ideas, etc.). Inform the students about the Free Response portion of the AP Exam either by telling them about the exam or by giving them an "Acorn" book with the exam information in it

(the pdf book of AP Biology Course information—with the picture of an acorn on the front—can be downloaded at the www.apcentral.collegeboard.com website).

The exam will contain two longer, multi-part Free Response (FR) essay questions (typically broken into parts a., b. and c.) and six shorter (single-part) essay questions that together count as 50% of the exam grade. Ninety minutes are given to complete all six essays, which breaks down to about 7 minutes with which to work on each short essay and each part of the longer essays. Each of the longer essay questions is broken into two, three or four parts that may require separate essays, calculations or graphing, all to be completed within the suggested time frame.

In preparation for the essay part of the exam, students will write 1-5 practice FR essays per week during the school year under timed and untimed conditions. Even if an essay assignment used to prepare the student is untimed, students should note the time at which they begin and finish writing the essay and set a timer for the number of minutes allotted for completion of the essay, so that they become aware of how much time they are using.

All FR essays must be neatly written, complete and to the point, with three supporting facts, examples or statistics given for each main point. All scientific terminology should be defined and all work must be in complete sentences—outlines and lists do not earn points.

Students should always make a preliminary outline or mind map of their main points and each of the three supporting details for each point to be sure they have an answer to the question. On the actual AP Biology Exam, the students will be given 10 minutes of reading time in which they can outline their response. The reading period is intended to give students time to organize their thoughts. For this class, preliminary work in the form of an outline or notes or some other incomplete response may be graded, but on the exam preliminary work doesn't count. Only complete sentences written in the test booklet are graded.

2. Give the students a copy of the grading rubric that goes with this exam question so they can see how points are given only for specific, detailed responses.
3. Discuss what types of information are considered specific enough to earn points. For instance, if a student writes "The organisms in the Kingdom Fungi are different from the organisms in the Kingdom Plantae because they obtain their food in different ways," they are not likely to receive any credit. A more specific response would state "Organisms in the Kingdom Fungi are heterotrophs that cannot make their own food, while organisms in the Kingdom Plantae are autotrophs that are able to synthesize organic molecules from inorganic molecules". Let the student know that the essay questions are open doors that allow them to show the grader all that they know about a subject area. Remind them continuously throughout the year to earn points for their answers by:

   a. using scientific terms correctly, in context (define terms using a supporting clause if the word is new to them this year)
   b. describing specific case examples, and never using general references (name one specific organism or a single part of the anatomy or an example of a specific behavior, or whatever the topic calls for)
   c. never simply naming something, but instead always identifying and describing something with at least a phrase or a separate descriptive sentence
   d. being sure to give an answer that responds directly to what the question is asking (in this case, one molecular and one cellular example are requested)
   e. clarifying what potential essay question terms mean before you take the exam, for instance:
      i. What is the difference between "compare" and "contrast"?
      ii. What would be expected for a question that asks you to "design an experiment"?
4. Using FR question #4 for practice, help the students craft an explicit, detailed answer that is properly supported.

Special note: Tell the students that for the first semester, they will be allowed to use their textbook when answering FR questions because their background and foundation information is limited. Later in the year, you will decide, on a case-by-case basis, when they can and cannot use their textbook. You may want to give FR questions as pop quizzes whenever there is extra class time. For the first semester, you should grade the students' preliminary outlining and mind mapping (giving credit for important points and supporting facts) and their final paragraph response if development of the essay to that level has been assigned. Even if a response is incorrect, the students will get the message that the time and effort put into planning their response is worthwhile.

HW: Ask the students to finish FR essay question #4 from Exam 2004 Form B.

HW: Make 5 copies of the Paper Atomic Models for each student on cardstock paper. Ask the students to cut out the orbitals and nuclei and punch holes where indicated for use during class tomorrow.

The Scientific Process Critiqued

Read and discuss each scientific experiment. Analyze each experiment's strengths and weaknesses with your partner by answering the questions that follow.

Experiment 1:

Five tomato plants of the same height were placed in the same size pots, in the same type of soil and each was given the same amount of water. Each plant was under a light bulb of the same intensity as the others but each light was of a different color. Each day, the plants were given light (each its own color) for 12 hours and left in darkness for 12 hours. The height of each plant was measured in centimeters at the end of each week for 10 weeks.

Week # →	1	2	3	4	5	6	7	8	9	10
Light color ↓										
Yellow	4	5	6	7	8	9	10	11	12	13
Green	4	4	4	3	3	2	2	1	0	0
Blue	4	4	4	5	5	5	5	6	6	6
Purple	4	4	5	5	6	6	7	7	8	8
Red	4	5	6	7	8	9	10	11	12	13

a. What question is tested by this experiment?

b. Write two hypotheses and one null hypothesis for this experiment.

H_1:

H_2:

H_0:

c. What is the variable?

d. What factors are held constant in the experiment?

e. Is there a control? If not, what control would you suggest?

f. Write two conclusions for this experiment.

1)

2)

g. Describe the strengths of this experiment.

h. Describe the weaknesses of this experiment.

<u>Experiment 2:</u>

Five soup cans were painted black and five cans were painted white. A quarter liter of 24°C water was added to each can each morning at 8 a.m. and the temperature of the water in each can was recorded in degrees Celsius at noon each day for seven days.

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Black #1	45	37	40	41	32	35	40
Black #2	45	37	40	41	32	35	40
Black #3	45	37	40	41	32	35	40
Black #4	45	37	40	41	32	35	40
Black #5	45	37	40	41	32	35	40
White #1	41	33	36	37	28	31	36
White #2	41	33	36	37	28	31	36
White #3	41	33	36	37	28	31	36
White #4	41	33	36	37	28	31	36
White #5	41	33	36	37	28	31	36

a. What question is tested by this experiment?

b. Write two hypotheses and one null hypothesis for this experiment.

H_1:

H_2:

H_0:

c. What is the variable?

d. What factors are held constant in the experiment?

e. Write two conclusions for this experiment.

1)

2)

f. Describe the strengths of this experiment.

g. Describe the weaknesses of this experiment.

Experiment 3:

A scientist wanted to determine if classical music helped people relax more than rap music. She asked 1,000 20-year-old men and 1,000 20-year-old women to participate in her experiment at the same time each day, in the same location and under the same conditions. She had each person rest on a bed while she played a classical music recording for 30 seconds and then she asked them to describe how they felt. She would then repeat this procedure, playing rap music instead of classical music. She alternated the type of music played first, but she always used the same sample of classical music and the same sample of rap music.

a. What question is tested by this experiment?

b. Write two hypotheses and one null hypothesis for this experiment.

H_1:

H_2:

H_0:

c. What is the variable?

d. What factors are held constant in the experiment?

e. Describe the strengths of this experiment.

f. Describe the weaknesses of this experiment.

Experiment 4:

A scientist wanted to determine which language is the hardest to learn. He created an experiment using 6,000 African Gray parrots as test subjects. The parrots were left alone in a room with a tape playing all day and all night. On the tape was the word “hello” repeated 100 times in a row for each of 20 languages. Each day the scientist went into the room and checked to see if any of the parrots had learned any of the languages.

a. What question is tested by this experiment?

b. Write two hypotheses and one null hypothesis for this experiment.

H_1:

H_2:

H_0:

c. What is the variable?

d. What factors are held constant in the experiment?

e. Describe the strengths of this experiment.

f. Describe the weaknesses of this experiment.

The Scientific Process Critiqued

Teacher's Version

Read and discuss each scientific experiment. Analyze each experiment's strengths and weaknesses with your partner by answering the questions that follow.

Experiment 1:

Five tomato plants of the same height were placed in the same size pots, in the same type of soil and each was given the same amount of water. Each plant was under a light bulb of the same intensity as the others but each light was a different color. Each day, the plants were given light (each its own color) for 12 hours and left in darkness for 12 hours. The height of each plant was measured in centimeters at the end of each week for 10 weeks.

Week # →	1	2	3	4	5	6	7	8	9	10
Light color ↓										
Yellow	4	5	6	7	8	9	10	11	12	13
Green	4	4	4	3	3	2	2	1	0	0
Blue	4	4	4	5	5	5	5	6	6	6
Purple	4	4	5	5	6	6	7	7	8	8
Red	4	5	6	7	8	9	10	11	12	13

a. What question is tested by this experiment?

Does the color of light affect plant height over a 10-week period?

b. Write two hypotheses and one null hypothesis for this experiment.

H_1: *Ex: Plants will grow better in green light.*

H_2: *Ex: Plants will grow better in red light.*

H_0: *The color of the light will have no effect on plant growth rates.*

c. What is the variable? *The color of the light given to the plant.*

d. What factors are held constant in the experiment?

The type of plant, the soil, the size of the pot, the amount of water given to the plant, the amount of time each plant was in the light and in the dark.

e. Is there a control? If not, what control would you suggest?

No. A plant could be placed in full spectrum (white) light.

f. Write two conclusions for this experiment.

1) *Ex: The plants in this experiment grew tallest in yellow/red light.*
2) *Ex: The plants in this experiment did not grow as tall in green light.*

(Remind students to limit their conclusions; they should not make them too broad, since only one species was tested in this experiment.)

g. Describe the strengths of this experiment.

The question is testable, the other factors were controlled, there was only one variable being tested, etc.

h. Describe the weaknesses of this experiment.

The sample size was too small.

Experiment 2:

Five soup cans were painted black and five cans were painted white. A quarter liter of 24°C water was added to each can each morning at 8 a.m. and the temperature of the water in each can was recorded in degrees Celsius at noon each day for seven days.

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Black #1	45	37	40	41	32	35	40
Black #2	45	37	40	41	32	35	40
Black #3	45	37	40	41	32	35	40
Black #4	45	37	40	41	32	35	40
Black #5	45	37	40	41	32	35	40
White #1	41	33	36	37	28	31	36
White #2	41	33	36	37	28	31	36

White #3	41	33	36	37	28	31	36
White #4	41	33	36	37	28	31	36
White #5	41	33	36	37	28	31	36

a. What question is tested by this experiment?

What is the difference in water temperature for white or black cans?

b. Write two hypotheses and one null hypothesis for this experiment.

H_1: *Ex: The water in the white cans will be hotter than in the black cans.*

H_2: *Ex: The water in the black cans will be hotter than in the white cans*.

H_0: *The color of the can will not influence the temperature of the water in the can.*

c. What is the variable? *The color of the can.*

d. What factors are held constant in the experiment?

The size of the can, the amount of water, the time the temperature was taken, etc.

e. Write two conclusions for this experiment.

(Answers will vary but should be limited to conclusions that rely only on the data given. (Ex: The water in the black cans was 4 degrees warmer each day than the water in the white cans.)

f. Describe the strengths of this experiment.

The question is testable, the other factors were controlled, there was only one variable being tested, etc.

g. Describe the weaknesses of this experiment.

None. The design of the experiment is fairly strong.

Experiment 3:

A scientist wanted to determine if classical music helped people relax more than rap music. She asked 1,000 20-year-old men and 1,000 20-year-old women to participate in her experiment at the same time each day, in the same location and under the same conditions. She had each person rest on a bed while she played a classical music recording for 30 seconds and then she asked them to describe how they felt. She would then repeat this procedure, playing rap music instead of classical music. She alternated the type of music played first, but she always used the same sample of classical music and the same sample of rap music.

a. What question is tested by this experiment?

Does classical music help people relax more than rap music?

b. Write two hypotheses and one null hypothesis for this experiment.

H_1: (A*nswers will vary; ex: People will say that they are more*

H_2: *relaxed when they listen to classical music.)*

H_0: *The type of music a person listens to will have no effect on their level of relaxation.*

c. What is the variable? *The type of music.*

d. What factors are held constant in the experiment? *The length of time each person listens to the music sample, the place and position of their body when they listen, the age of the men and women, etc.*

e. Describe the strengths of this experiment.
Consistency of age and procedure, and a large sample size.

f. Describe the weaknesses of this experiment.

There are many: the scientist is not testing what they set out to test, the length of time the music sample is played is not long enough to allow an effect, the procedure is qualitative instead of quantitative, the effects the scientist is hoping to observe are undefined, etc.

Experiment 4:

A scientist wanted to determine which language is the hardest to learn. He created an experiment using 6,000 African Gray parrots as test subjects. The parrots were left alone in a room with a tape playing all day and all night. On the tape was the word "hello", repeated 100 times in a row for each of 20 languages. Each day the scientist went into the room and checked to see if any of the parrots had learned any of the languages.

a. What question is tested by this experiment?

The scientist wants to determine which language is the hardest to learn, but the question that is really being tested is: Which of 20 languages has the most difficult greeting for African Gray parrots to learn?

b. Write two hypotheses and one null hypothesis for this experiment.

H_1: (*Answers will vary; ex: African Gray parrots will find it easiest*

H_2: *to learn English.)*

H_0: *The difficulty of the language will have no effect on which language African Gray parrots learn first.*

c. What is the variable? *The language.*

d. What factors are held constant in the experiment? *The number of times each greeting is repeated, the housing and care of the parrots, etc.*

e. Describe the strengths of this experiment. *The sample size.*

f. Describe the weaknesses of this experiment.

There are many: The scientist is not testing what they set out to test – the hypothesis, the greeting does not represent the language, the language acquisition of parrots is not the same as language acquisition in humans, the parrots may have a significant influence on one another, etc.

AP* Biology Daily Lesson Plans
Biochemistry Unit
(Samples of Week One)

Day 3

I. Topic: Atoms and Ions

II. Warm-up: 5 minutes

(Ask the students to take and grade their quiz before they begin the warm-up. See instructions below.)

Prior to class, write the following on the board: Draw an atom and label these parts: electron, proton, neutron, nucleus and orbital.

III. Quiz: Introduction to Biology Concepts 5 minutes

Special note: For this quiz and each one that follows, write a short, ten-question quiz designed to see if the students are keeping up with reading and vocabulary. Do not use the quizzes to test deeper comprehension such as analysis and synthesis of concepts—these can be assessed during activities, homework assignments and tests. Train the students to pick up a quiz upon walking in the door while you check roll. They can take the quiz at their desks, then come up to correct the quiz at your desk using a grade sheet or a hole-punched overlay. Have each student show their quiz to you when they have finished grading it, so you can record their score. They will keep the quiz and return to their desk to begin the warm-up or the first activity.

Quizzes should be added to the students' year-long calendar or they should be pre-set for the year so that the students can be held responsible without being reminded (for instance, my students know they will have a quiz each Tuesday on the chapters that will be covered during that week). From this point on, I will not include quiz prompts in the lesson plans, since each teacher will need to customize this activity to best fit into their own schedule.

IV. Activity One: Building Atoms 20 minutes

Objectives:

a) The learner will (TLW) review some of the chemical elements by building models of atoms.
b) TLW review basic chemistry vocabulary and concepts by modeling changes in proton, neutron and electron numbers.

Materials:

For each student: one cut-out and hole-punched copy of the "Paper Atomic Model" handout, 25-30 M&M's or Skittles candies, 1 copy of the periodic table of elements; for each lab group: 3 paper cups or plastic "zipper" baggies.

<u>Procedure:</u>

1. Prior to class, sort the candy by color and place into paper cups, bowls or plastic zipper baggies. Place three colors of candy at each lab table.
2. Using the periodic table, one nucleus and one orbital, have each student make a helium atom with neutrons in one color sitting in the punched holes of the nucleus, protons in another color sitting in the punched holes of the nucleus and electrons in a third color sitting in the punched holes of the orbital. Ask the students to draw the atom they have modeled in their notes and label its parts.
3. Before discussing aloud, ask each student to jot down in their notes what this atom would be called if the proton, electron or neutron number changed. Discuss their answers and correct any misconceptions. Below are a few points and terms that would be appropriate to review at this time:

   a change in the number of protons = a new element
   a change in the number of electrons = a charged ion
   a change in the number of neutrons = an isotope
   * discuss radioisotopes

4. Have the students build a hydrogen atom with their paper atomic models. Ask them to make each of the above changes one by one, and take notes on how the atom is affected by each change.
5. Discuss the number of electrons that can fit on each orbital and have the students practice building and drawing C, N, O and F, using their cut-out orbitals and nuclei.
6. Discuss electronegativity and ask the students to note trends of electronegativity above each column on their periodic table. *(electronegativity increases from left to right across a row and decreases from top to bottom down a column)*
7. Begin a Socratic discussion as students make notes on their periodic tables and in their notes. You might begin the discussion by asking the students to make some observations about atoms and elements, or you can ask them to tell you some of the main points that they are writing down in their notes today. You may want a note-taker at the board as a guide, or you could take your own notes on an overhead projector transparency of the periodic table, to model note taking during the discussion.

Suggested guiding questions for discussion:

a. How many electrons fit on each orbital? *(2 on the inner "s orbital" and eight on the next two "p orbitals")*
b. How does the proton number compare to the electron number? *(they are the same on an element if it is unaltered/uncharged)*
c. How do you think the number of electrons on the outer orbital of each atom relates to how stable the element is? *(elements made of atoms with full outer orbitals—or valence shells—are more stable and less reactive; elements made of atoms with partially complete valence shells are more reactive; the closer the atom is to having a completely full or completely empty valence shell, the more violently it reacts with other atoms)*
d. Which elements are the most stable? *(the noble gases to the far right, in column VIII)* Why? *(because they have full outer orbitals)*
e. Which elements are the most reactive? *(the halogens, column VII)*

V. Activity Two: Building Ionic Molecules — 20 minutes

Objectives:

a) The learner will (TLW) review basic chemistry vocabulary and concepts by making models of ionic bonding.

Materials:

Same as Activity One, but with 2 cut-out and hole-punched copies of the "Paper Atomic Model" handout per student.

Procedure:

1. Ask the students to use the paper atomic models to build a fluorine atom and a hydrogen atom. From this point on, the students will not need to represent neutrons or protons in their models if they are cognizant of the fact that these atomic particles are indeed present.
2. Discuss the stability of each atom as it is modeled and show how the loss/gain of an electron will stabilize the atoms' outer orbitals by making it either completely full or completely empty. Have the students move an electron from hydrogen to fluorine to form two more stable atoms (ions).
3. Discuss how and why these atoms have formed an ionic bond. Ask them to draw a "before and after" diagram of their HF molecule and take notes on the bonding of ionic molecules.
4. Ask the students to build LiCl, MgO and BeS, drawing "before and after" diagrams of each until they feel comfortable with the concept.
5. Begin a Socratic discussion by asking what main points the students are making in their notes. Suggested guiding questions for discussion:
    a. In each of the molecules they built, which atom has become the cation, which is the anion? *(the cations are Li, Mg, Be; the anions are Cl, O, S)*

b. Which elements of the periodic table tend to become negative ions (have the greatest potential for acquiring electrons)? *(the atoms in column VII)* Why? *(because they are only missing one electron and they have the high electronegativity needed to steal one from another atom)*
c. Which elements of the periodic table tend to be positive ions (have the weakest ability to retain their electrons)? *(the elements to the far left, in column I)* Why? *(because they have low electronegativity and have only one electron on their outer orbital)*
d. Which columns would combine well in order for both to be more stable? *(columns I and VII, columns II and VI)*
e. Which elements on the periodic table tend to make ionic bonds? *(columns I and VII, columns II and VI)*
f. How does electronegativity correlate with ionic bonding? *(atoms with high electronegativity are able to steal electrons most easily, atoms with low electronegativity tend to have their electrons stolen from them)*
g. Why don't all the elements of the periodic table form ionic bonds? *(because at some point an element is unable to steal enough or give enough electrons in order to become stable because it does not have enough electronegativity to steal as many electrons as it needs or it has too much electronegativity to give away as many as would be necessary)*
h. What do atoms that cannot form ionic bonds do to become more stable? Read tonight and find out—this will be the warm-up question tomorrow.

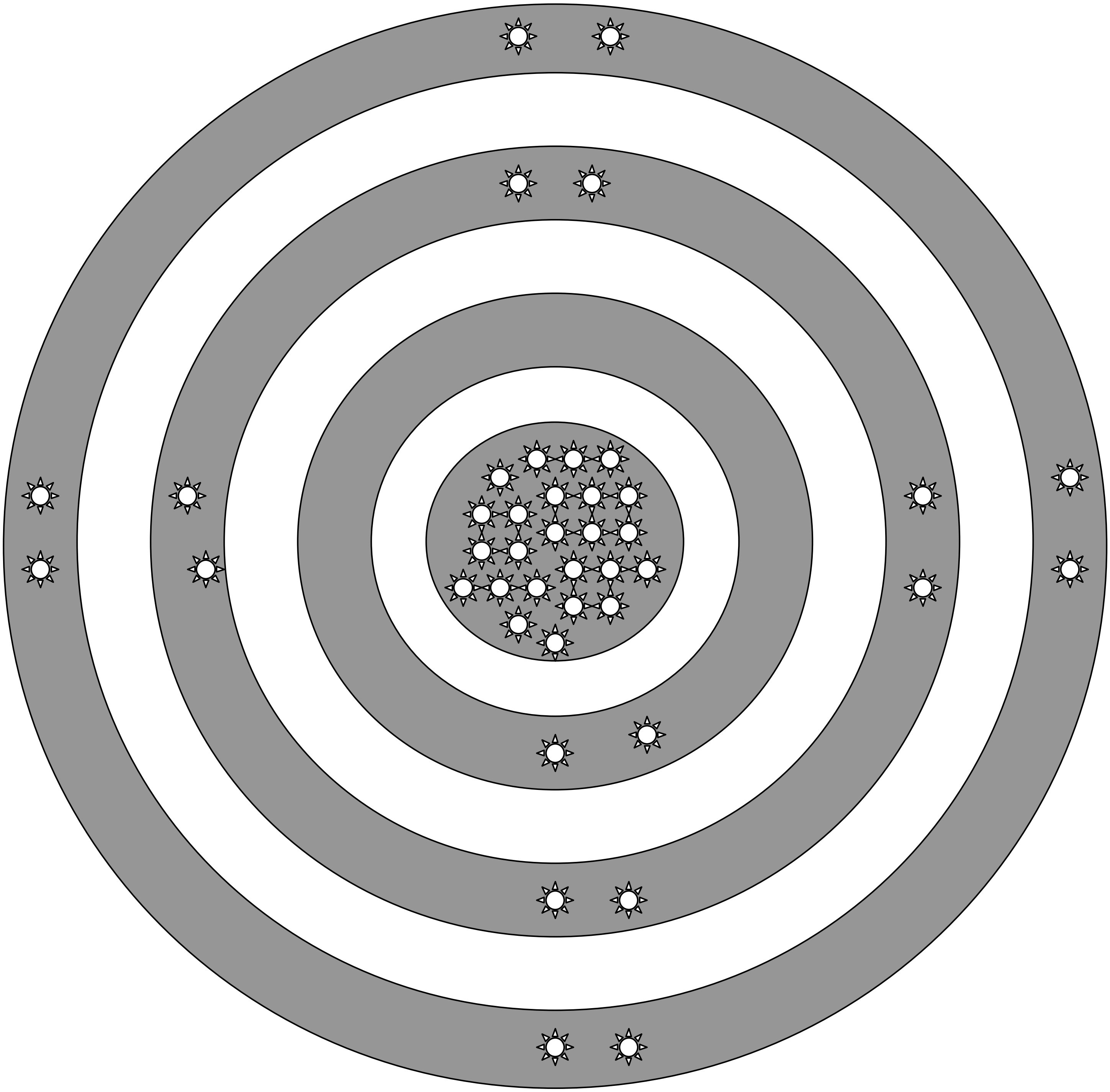
HW: Ask the students to write a response to the Free Response essay question on radioisotopes to be turned in tomorrow.

HW: Assign the chapters on chemistry review and tell the students to take notes to be handed in for grading. Tell them that from now on, they will need to look at the year schedule to see which chapter topics are assigned for each week. Remind them that they are responsible for knowing the information covered in the textbook and may be quizzed on this material at any time.

HW: Tell them that from now on, they will need to look at the year schedule to see which video topics are assigned for each week. Remind them that they are responsible for knowing the information covered in the videos and may be quizzed on this material at any time.

Paper Atomic Models

Cut out each gray ring and the gray circle in the center so that each ring is separate from the others. Using a one-hole punch, punch out each star so that there are 8 holes punched in the two large rings, 2 holes punched in the small ring, and 24 holes in the center circle.



Free Response Essay
Radioisotopes

Suggested time: 22 minutes

Start time: ________ End time: ________ Total time used: ________

Directions: Answer all questions. Answers must be in essay form. Outline form is not acceptable. Labeled diagrams may be used to supplement your response, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write.

Radioactive elements are used for many purposes in science. Use your textbook or other research sources to answer the following:

a) name three different radioisotopes
b) explain in detail how each of the radioactive isotopes you've listed can be used in biology

** Try using a main-point-plus-three-supporting-details structure to organize and write your essay. The main points will be the "answer" portion to the question that was asked. In this case, the first main point will be naming a radioisotope. The three supporting details might be additional information about that main point, such as giving a definition of each of the terms used in the main point, a more detailed description of the process or the idea of the main point, a statistic, percentage or numerical detail that is associated with the main point or an example of the point that is being made. In this case, the second main point will be a description of how the named radioisotope is used in biology and the third piece of supporting information will be a detail specific to that isotope, such as naming the macromolecule it is most frequently bound to during scientific use.

Free Response Essay Grading Rubric
Radioisotopes

10 points total maximum

a) 1 point for naming a radioisotope
- give a point only if there is a description of at least one biological use for the listed radioisotope
- give a maximum of 3 points for naming three radioisotopes

b) 2 points for describing how each isotope listed is used in biology
- give no points if the description is incomplete (for instance, if the description is a one- or two-word answer)
- give 1 point for a simple statement of how the radioisotope is used
- give 1 point for an elaboration on how it is used
- a single isotope may have two completely different uses and such a response would receive 4 points
- give a maximum of 4 points for any one isotope described; give a maximum of 8 points for this section

A selection of example answers:

	Statement of use	Elaboration statement
H^3	Used as a scintillation marker	Can be attached to organic molecules and quantified by how much light is given off as the alpha particles illuminate the surrounding medium
P32	Used as a radioactive marker	Can be attached to the phosphate backbone of DNA or RNA Used to track mRNA or find nucleic acids
C^{14}	Used to date fossils	This isotope is added to organic molecules in constant amounts when creatures are alive, so it can be used to calculate how long a once-living thing has been dead, depending on how much of the carbon has decayed to nitrogen
O^{18}	Used to make heavy water	Heavy water can be tracked through an organism during experimentation; for instance, it was used to discover the origin of the oxygen atoms added to sugar during photosynthesis
S	Used as a radioactive marker	Can be attached to proteins on the disulfide bridges of most polypeptides; for instance, it was used to make protein coats of virus particles radioactive in the Hershey-Chase experiment
I	Used in cancer treatment	Can be used to fight cancer of the thyroid because it binds with thyroid tissue and destroys the cells in this region during radioactive decay

*This chart is not complete; there are other possible responses that can earn points. Also, realize that in some students' essays, answers included in the simple statement column above may be found in the students' elaboration statements, and vice versa.

AP* Biology Daily Lesson Plans
Biochemistry Unit
(Samples of Week One)

Day 4

I. Topic: Covalent Bonding and Hydrogen Bonding

II. Warm-up: **5 minutes**

Prior to class, write the following on the board: What do atoms that cannot form ionic bonds do to become stable?

III. Activity One: Building Covalent Molecules **20 minutes**

Objectives:

a) The learner will (TLW) review basic chemistry vocabulary and concepts by modeling covalent bonding.

Materials:

Same as Activity One from yesterday, but with 5 copies of the cut-out and hole-punched "Paper Atomic Model" handouts per student (you can use about the same amount of candy as in Activity One from Day 3, since neutrons and protons will be left out this time).

Procedure:

1. Ask students to make two hydrogen atoms. Ask if these atoms are likely to form ionic bonds? *(no, because they have equal electronegativity and so cannot give or take an electron from the other)* Ask the students what the atoms can do to become stable? *(form a covalent bond)*
2. Have the students make a model of a covalent bond with their two paper hydrogen models by sliding the atoms together and having them share the electrons on their outer two orbitals (so that each is more stable with a full valence shell).
3. Have the students take notes about this process, detailing how it happens and why it happens.
4. Have the students practice covalent bonding on their own by making CH_4 and NH_3. Stop to discuss the properties of covalent bonds and ask the students to take notes, drawing diagrams of the atoms they have made.
5. Have them make a molecule with a double bond: O_2 and CO_2
6. Ask the students to divide into pairs or groups and practice making a larger covalent molecule with C_2H_6 and C_3H_8. Explain that to represent larger molecules, scientists use organic model kits. Show them how to

make C_2H_6 and C_3H_8 or a double-bonded molecule like O_2 or CO_2, using an organic model kit.

7. Begin a Socratic discussion to draw out the main points of this activity:
    a. How do the valence electrons influence molecular bonding? *(the number of open places on the valence shell determines the number of bonds the atom can make)*
    b. How does electronegativity influence molecular bonding? *(if there is a large difference between the electronegativities of the two atoms that are bonding, then the atom with greater electronegativity can steal electrons from the atom with lower electronegativity to fill its outer orbital; if the electronegativity of both atoms is equal or nearly so, then the two atoms will form a covalent bond)*

IV. Activity Two: Hydrogen Bonding — 25 minutes

Objectives:

a) The learner will (TLW) review basic chemistry vocabulary and concepts by modeling bonding between molecules.
b) TLW will compare and contrast ionic, covalent and hydrogen bonding.

Materials:

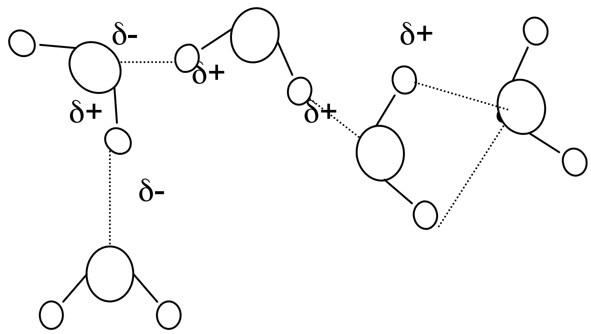
Each student needs one copy of the "Comparing Molecular Bonds" handout and an organic chemistry model kit containing the following pieces: 3 carbon atoms, 2 oxygen atoms, 8 hydrogen atoms, 1 halogen atom (F, Cl or Br), 10 single bonds and 4 double bonds.

Procedure:

1. Have the students use the organic chemistry model kits to make CH_4, C_2H_6 and C_3H_8, O_2, CO_2.
2. Ask them to take a moment to reflect and take notes on what these models show.
    a. What do the holes on each atom represent? *(the number of valence shell electrons that are missing for a full/stable outer orbital)*
    b. How many bonds can H, O and C make? *(H – 1, O – 2 and C – 4)*
3. Ask each student to make two molecules of H_2O and one molecule of H_2, O_2, CH_2F and CH_4.
4. Discuss symmetry and the concept of polarity.
    a. Which molecules are symmetrical? *(H_2, O_2 and CH_4)*
    b. Which are polar and which are non-polar? *(H_2O and CH_2F are polar, H_2, O_2 and CH_4 are non-polar)*

c. How does symmetry correlate with polarity? *(symmetrical molecules are nonpolar; asymmetrical molecules are polar)*
d. How does electronegativity correlate with polarity? *(an atom with higher electronegativity can draw the electrons to it unequally, creating an unequal distribution of charge, without becoming a charged ion)*

5. Ask the students to arrange their two H_2O molecules in the position in space that is most likely according to the polarity of each molecule. This is the position of hydrogen bonding. Have them draw two or three water molecules in their notes and show hydrogen bonding with dotted lines between negative and positive poles as below:



6. Test the students' understanding of hydrogen bonding by asking them to compare each of the three types of bonding. Also, ask them to fill in the comparison chart on the "Comparing Molecular Bonds" handout.

HW: Ask the students to finish the "Comparing Molecular Bonds" handout.

HW: If your students did not do the Free Response essay questions on statistical analysis, assign those questions over the next few class periods to check on their skills and knowledge on the application of statistics of biological data:

FR essay for question #1 from the 2013 AP Biology Exam

FR essay for question #1 from the 2014 AP Biology Exam

Comparing Molecular Bonds

1. Which type of bonding forms the strongest bond? ______________________

2. Which type of bonding forms the weakest bond? ________________________

3. Explain why hydrogen will form an ionic bond with fluorine but only forms covalent bonds with carbon.

4. Which types of bonds occur between atoms? _________________________

5. Which type of bonds occur between molecules?_________________________

6. What is the maximum number of atoms that can be bonded

   ...in an ionic bond? _______________

   …in a covalent bond?______________

   …in a hydrogen bond?____________

7. Draw an example of each type of molecular bonding below, using the molecule of your choice:

   a. ionic bond (draw a “before and after” diagram):

   b. covalent bond

   c. hydrogen bond

Comparing Molecular Bonds

Teacher's Version

1. Which type of bonding forms the strongest bond? *ionic*

2. Which type of bonding forms the weakest bond? *hydrogen*

3. Explain why hydrogen will form an ionic bond with fluorine but only forms covalent bonds with carbon.

   Fluorine only needs one electron to fill its outer orbital, so it has a very high electronegativity. Fluorine can take the electron from hydrogen, leaving both atoms charged. Carbon needs four electrons in order to fill its outer orbital. Carbon's electronegativity is too low for it to steal an electron away, but it can share an electron with hydrogen to make both atoms more stable.

4. Which types of bonds occur between atoms? *ionic and covalent*

5. Which type of bonds occur between molecules? *hydrogen*

6. What is the maximum number of atoms that can be bonded…

   …in an ionic bond? *two in the molecule, ∞ in the crystal structure*

   …in a covalent bond? *∞*

   …in an hydrogen bond? *∞*

7. Draw an example of each type of molecular bonding below, using the molecule of your choice: *(Answers will vary.)*

   a. ionic bond (draw a "before and after" diagram):

   b. covalent bond

   c. hydrogen bond

AP* Biology Daily Lesson Plans
Biochemistry Unit
(Samples of Week One)

Day 5 – Extended Class Period

I. Topics: Physical Properties of Ionic, Covalent and Hydrogen Bonds

II. Warm-up: **5 minutes**

Prior to class, write the following on the board: Describe two or three ways molecules of the same type interact. *(molecular attraction or repulsion, polar and non-polar interactions, etc.)*

III. Activity One: Comparison of Bond Properties **85 minutes**

Objectives:

a) The learner will (TLW) review basic chemistry vocabulary and concepts.
b) TLW experience how substances with different molecular bonds may react in similar circumstances.
c) TLW observe how intermolecular bonding determines many of the physical properties of a substance.

Materials:

For each lab group: 1 glass slide; 2 capillary tubes; 2 crucibles; 2 watch glasses; 1 Bunsen burner (or candles); 1 ring stand; 30g salt; 30g sugar; 10ml vegetable oil; 150ml distilled water; 1 hot plate; 1 conductivity meter; 2 Petri dishes; 8 paper clips; 4 dissection microscopes; 1 mass balance; 1 four- or six-sectioned plastic reaction tray; and each student will need one copy of the "Comparison of Bond Properties and Intermolecular Bonding" handout.

Procedure:

1. Prior to class, set up all the equipment that will be used so that the students have time to perform all of the activities covered in the handout. Also, make or bring in a model of a crystal lattice, or find a textbook photo or a laser disk visual of one.
2. Lead the students in a discussion of predictions for the lab activities (asking them to debate predictions with supporting arguments) before they begin the experiments.
3. Ask the students to perform the first activity on the handout as a class.

4. Discuss the results and explanations for the results. Stop at this point and discuss the 3-D structure of ionic solids as crystal lattices. Show the students the crystal lattice model, photo or laser disk visual, so that they can see the intermolecular bonding that is the essential concept in today's lab. Discuss the intermolecular bonding of covalent molecules (polar and non-polar) so that the students can compare the three types of intermolecular interactions. Their discussions and their answers to most of the Reflection Questions should center around intermolecular bonding.
5. Ask the students to continue performing the handout activities in lab groups. If the students' lab skills are not strong, this is a good time to review basic skills by going through each procedure together as a class.
6. Ask the students to complete the Reflection Questions for homework.

Special note: If there is a limited number of lab equipment, you can set up six stations, wherein each lab group moves from station to station. If the lab groups do not perform the experiments simultaneously, as a class, I strongly suggest you supervise the station where the students are performing the melting point experiment (Experiment D) so that the students do not overheat the substances with the Bunsen burners. If a group completes a station and is waiting for another station to become available, the students can begin working on their Reflection Questions.

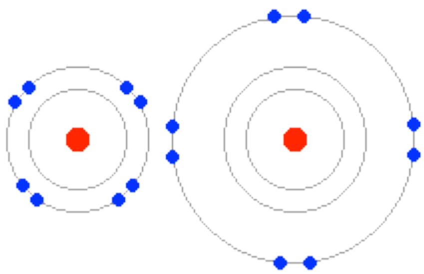
HW: Ask the students to finish the "Comparison of Bond Properties and Intermolecular Bonding" handout.

HW: Remind the students to look at the year calendar for reading and video assignments.

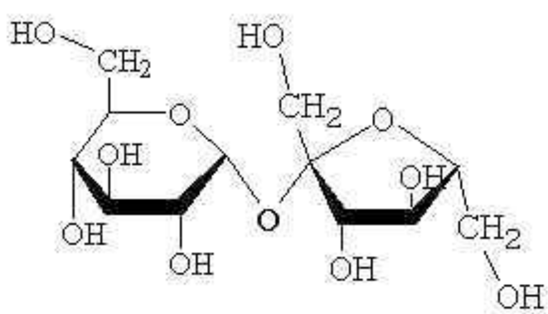
Comparison of Bond Properties and Intermolecular Bonding

Introduction:

You will use an ionic solid, salt, and a covalent solid, sucrose (sugar), in the first three lab procedures. It is important to note the structure of each of these substances.

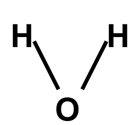


Ionic Solid – Salt

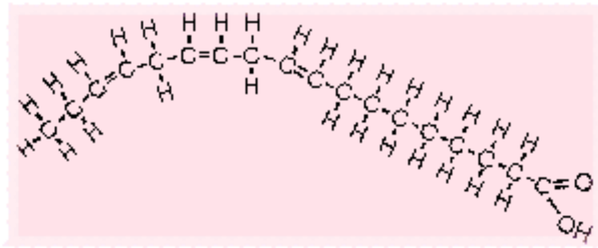


Covalent Solid – Sucrose (Sugar)

In the final three lab procedures, you will use a polar liquid, water, and a non-polar liquid, vegetable oil. It is important to note the structure of each of these substances.



Polar Liquid – Water



Non-polar Liquid – Vegetable Oil

Experiment A: Geometric Crystal Structure

Purpose: To observe the shape of an ionic solid and a covalent solid.

Hypothesis:

I think the ionic solid will / will not display a regular and orderly crystal shape. The reason I think this is…

I think the covalent solid will / will not display a regular and orderly crystal shape. The reason I think this is…

Procedure:

1. Using a dissection microscope on high power and top lighting, observe the crystal shape of an ionic solid (salt) and a covalent solid (sucrose/sugar).
2. Draw each substance accurately in the space designated at the top of the page titled "Comparison of Physical Properties Data Chart". Take the time to draw one or two typical crystals in great detail rather than trying to draw everything in your visual field.

Experiment B: Hardness of Ionic and Covalent Solids

Purpose: To test which substance is harder, the ionic solid or the covalent solid.

Hypothesis:

I think the ionic / covalent solid will be harder. The reason I think this is…

Procedure:

1. Using a dissection microscope on high power with top lighting, observe the shape of the covalent solid in a Petri dish. Use your fingernail to crush the crystals until they break, then observe them under the microscope again to note their cleavage patterns.
2. Repeat the first step, this time using the ionic solid.
3. Make note of the hardness of each type of crystal in the Comparison of Physical Properties Data Chart. Which solid was more difficult to crush? Repeat the procedure if you have any uncertainty.

Experiment C: Conductivity of Ionic and Covalent Solids

Purpose: To test whether or not an ionic or covalent solution will conduct electricity.

Hypothesis:

I think the solution with the ionic solid dissolved in it will / will not conduct electricity. The reason I think this is…

I think the solution with the covalent solid dissolved in it will / will not conduct electricity. The reason I think this is…

Procedure:

1. Fill two beakers, A and B, with 100ml of distilled water. Add 20g of the ionic solid to beaker A and add 20g of the covalent solid to beaker B.
2. Stir each with separate stirring rods until each solid is completely dissolved in the solvent.
3. Using a conductivity meter or a set of alligator clips, a battery, a light and conductivity wires, place both probes in beaker A to see if the solution in the beaker is able to conduct electricity.
4. Record your results in the Comparison of Physical Properties Data Chart.
5. Rinse the probes in distilled water and then repeat the conductivity test for beaker B.

Experiment D: Melting Point of Ionic and Covalent Solids

Purpose: To test which of the two solids has a higher melting point.

Hypothesis:

I think the ionic / covalent solid will have a higher melting point. The reason I think this is…

Procedure:

1. Using a mass balance, place 1g of the ionic solid in one crucible and 1g of the covalent solid in the other.
2. Place one crucible in the crucible holder of a ring stand and cover the crucible with a watch glass.
3. Light a Bunsen burner and adjust the air vent until the flame is low and steady (a candle can be used in place of a Bunsen burner).
4. Ask the timekeeper to begin timing the reaction at the same moment the Bunsen burner is placed under the crucible in the ring stand platform.
5. Watch carefully as the sample heats. When the ionic solid begins to brown or pop and sputter, stop the reaction and record the melting time. When the covalent solid melts on the edges and turns brown, stop the reaction and record the melting time.
6. Record both results in the Comparison of Physical Properties Data Chart.

Experiment E: Demonstration of Capillary Action

Purpose: To test the capillary action of polar and nonpolar liquids.

Hypothesis:

I think the polar / nonpolar liquid will have greater capillary action. The reason I think this is…

Procedure:

1. Using a separate dropper for each, place three drops of a polar liquid on one end of a glass slide and three drops of a nonpolar liquid on the other end of the slide.
2. Using a capillary tube, gently touch the end of the tube to the drop of the polar liquid and watch the results. Repeat the procedure with the same tube several times until the results do not change.
3. Repeat step 2 using a new capillary tube and the nonpolar liquid.
4. Describe the results in the Comparison of Physical Properties Data Section.

Experiment F: Demonstration of Surface Tension

Purpose: To test the surface tension of polar and non-polar liquids.

Hypothesis:

I think the polar / nonpolar liquid will have greater surface tension. The reason I think this is…

Procedure:

1. Add half a centimeter of the polar liquid to one petri dish and half a centimeter of the nonpolar liquid to the other petri dish.
2. Using a clean and dry paper clip, try to gently lay the paper clip on the surface of each liquid using the surface tension for support. Retrieve the

paper clip, dry it and try again if you don't do it on the first try. You should be able to have the paper clip float on at least one of the liquids.
3. Record your results in the Comparison of Physical Properties Data Chart.

Experiment G: Demonstration of Solvent Ability

Purpose: To test the ability of polar and non-polar liquids to dissolve an ionic and a covalent solid.

Hypothesis:

I think…

The reason I think this is…

Procedure:

1. Using a sectioned reaction dish, place 2ml of the polar liquid into two sections and 2ml of the nonpolar liquid into two sections.
2. Using a mass balance, measure two 0.5g portions of the ionic solid and two 0.5g portions of the covalent solid. Add 0.5g of the ionic solid to the first polar section and the first nonpolar section. Add 0.5g of the covalent solid to the second section of the polar liquid and the second section of the nonpolar liquid.
3. Record the start time.
4. Gently swirl the reaction dish so that the liquid in each of the sections can dissolve the solids.
5. Record the time it takes for each of the solids to dissolve in each of the solvents.
6. Record your results in the Comparison of Physical Properties Data Chart.

***Note: The solids in some sections may never dissolve entirely.*

Comparison of Physical Properties Data Chart

Crystal Shape of Ionic Solid

Crystal Shape of Covalent Solid

Ionic and Covalent Bonds

	Ionic Solid	Covalent solid
Hardness Test		
Conductivity Test		
Melting Point Test		

Polar and Nonpolar Liquids

	Polar liquid	Non-polar liquid
Capillary Action		
Surface Tension		
Solvent Ability: Ionic Solid		
Solvent Ability: Covalent Solid		

Reflection Questions

Experiment A

1. Which solid has greater definition and regularity? ____________________
2. Which solid is a crystal lattice with intermolecular bonding? ____________
3. Draw the intermolecular bonds of the crystal lattice structure.
4. How would intermolecular bonding change the physical properties of a substance?
5. Using your results from this test, make one inductive conclusion about the geometric shape of ionic and covalent solids.

Experiment B

1. Which solid was harder to break?__________________________________
2. Which solid has larger and more regular cleavage planes?_____________
3. Explain why cleavage planes on molecules of one type of bonding would differ in their hardness from molecules of another type of bonding.
4. Can you imagine a case in which an ionic solid and a covalent solid might be equal in their hardness? Describe the molecular structure of these (imaginary or real) example substances.

5. Using your results from this test, make one inductive conclusion about the hardness of ionic and covalent solids.

Experiment C

1. Which substance conducted electricity better?____________________
2. Explain what is happening to the molecules of the ionic solid as they are dissolved in distilled water.
3. Explain what is happening to the molecules of the covalent solid as they are dissolved in distilled water.
4. Use your answers from the two questions above to explain how electricity is more easily conducted by one substance compared to the other.
5. Using your results from this test, make one inductive conclusion about the conductivity of ionic and covalent solutions.

Experiment D

1. Which substance melted faster? ____________________________
2. Consider the molecular bonding of the substance in question 1 and use what you know about bonding to explain why one sample melted at a lower temperature than the other substance.
3. Using your results from this test, make one inductive conclusion about the melting points of ionic and covalent solids.

Experiment E

1. Which liquid moved up the capillary tube easier? _______

2. Explain how this liquid moved up the tube without a vacuum or other force being applied to the tube externally.

3. Explain the meaning of the word coalescence as it pertains to water. Include a description of how polarity plays a role in coalescence.

4. Using your results from this test, make one inductive conclusion about intermolecular cohesion of polar and non-polar liquids.

Experiment F

1. Which liquid has greater surface tension? _____________________

2. Using a diagram and a written description, explain why this liquid has greater surface tension.

3. Using your results from this test, make one inductive conclusion about intermolecular cohesion of polar and non-polar liquids.

Experiment G

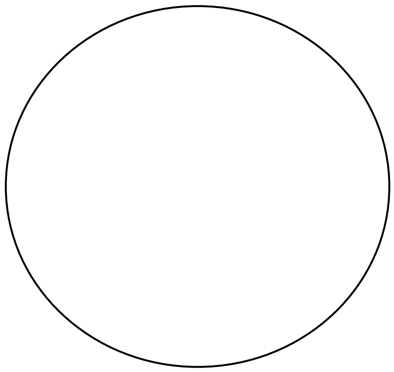
1. Which liquid was a greater solvent? _____________________________

2. Using a diagram and a written description, explain how the electronegativity of this molecule increases its solvent ability.

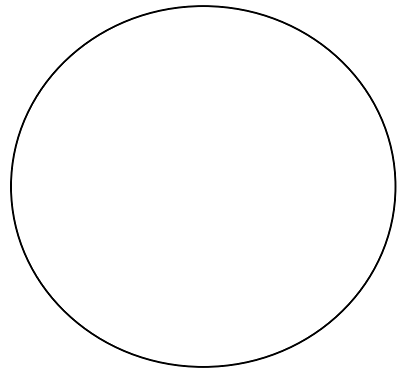
3. Discuss the role of water in the origin of life.

Comparison of Physical Properties Data Chart

Teacher's Version



Crystal Shape of Ionic Solid



Crystal Shape of Covalent Solid

Ionic and Covalent Bonds

	Ionic Solid	Covalent solid
Hardness Test	*Harder than sugar*	*Softer than salt*
Conductivity Test	*Conducts electricity*	*Does not conduct (or conducts very little)*
Melting Point Test	*Takes much longer to melt*	*Melts more quickly and thoroughly*

Polar and Nonpolar Liquids

	Polar liquid	Nonpolar liquid
Capillary Action	*Climbed tube easily*	*Did not climb tube*
Surface Tension	*Floated paper clip on surface*	*Could not float paper clip on surface*
Solvent Ability: Ionic Solid	*Dissolved*	*Did not dissolve*
Solvent Ability Covalent Solid	*Dissolved*	*Did not dissolve*

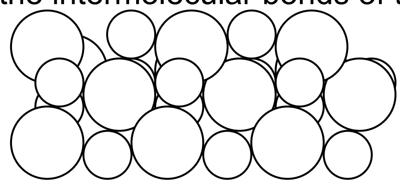
Reflection Questions

Experiment A

1. Which solid has greater definition and regularity? *ionic solid, salt*

2. Which solid is a crystal lattice with intermolecular bonding? *ionic solid, salt*

3. Draw the intermolecular bonds of the crystal lattice structure.



Each large chlorine molecule is bonded with every other sodium molecule that surrounds it on six sides. Likewise with sodium chloride.

4. How would intermolecular bonding change the physical properties of a substance?

    Intermolecular bonding allows for more bonds to hold the atoms in place so that the melting points and hardness increase.

5. Using your results from this test, make one inductive conclusion about the geometric shape of ionic and covalent solids.

    Answers will vary but conclusions should focus on ionic solids being more geometric and regular due to the crystal lattice structure dictated by intermolecular bonding.

Experiment B

1. Which solid was harder to break? *ionic solid, salt*

2. Which solid has larger and more regular cleavage planes? *ionic solid, salt*

3. Explain why cleavage planes on molecules of one type of bonding would differ from molecules of another type of bonding.

    Because the intermolecular bonding of ionic solids gives them specific properties.

4. Can you imagine a case in which an ionic solid and a covalent solid might be equal in their hardness? Describe the molecular structure of these (imaginary or real) example substances.

    This might occur when a polar covalent solid forms many regular intermolecular hydrogen bonds, allowing the molecule to be geometrically arranged in space like a crystal lattice.

5. Using your results from this test, make one inductive conclusion about the hardness of ionic and covalent solids.

    Answers will vary but should focus on ionic solids being generally harder than covalent solids.

Experiment C

1. Which substance conducted electricity better? *the ionic solution*

2. Explain what is happening to the molecules of the ionic solid as they are dissolved in distilled water.
   They dissociate and move freely as charged ions.

3. Explain what is happening to the molecules of the covalent solid as they are dissolved in distilled water.
   The molecules move away from each other as the water molecules move between them, but the atoms of sucrose/sugar stay bonded within the individual molecules.

4. Use your answers from the two questions above to explain how electricity is more easily conducted by one substance compared to the other.
   The ions are small and charged. Cations will move to the negative probe and the anions will move to the positive probe, allowing a flow of electricity, while the covalent molecule is only polar and so is less reactive to the different charged probes.

5. Using your results from this test make one inductive conclusion about the conductivity of ionic and covalent solutions
   Answers will vary but should focus on ionic solutions being good conductors.

Experiment D

1. Which substance melted faster? *the covalent solid*

2. Consider the molecular bonding of the substance in question 1 and use what you know about bonding to explain why one sample melted at a lower temperature than the other substance.
   Because there are very few intermolecular bonds and the intermolecular bonds are hydrogen bonds instead of additional ionic bonds.

3. Using your results from this test, make one inductive conclusion about the melting points of ionic and covalent solids.
   Answers will vary but should focus on a generality that covalent solids have lower melting points than ionic solids.

Experiment E

1. Which liquid was able to move up the capillary tube easier? __*polar*__

2. Describe how this liquid moved up the tube without a vacuum or other force being applied to the tube externally.

Because of intermolecular, hydrogen bonding, cohesion of molecules to walls of the tube and adhesion of molecules to one another allowed the water to climb up the tube spontaneously.

3. Explain the meaning of the word coalescence as it pertains to water. Include a description of how polarity plays a role in coalescence.

   Coalescence is the merging of water into droplets which is aided by attraction of opposite poles in polar molecules.

4. Using your results from this test, make one inductive conclusion about intermolecular cohesion of polar and nonpolar liquids.
   Polar liquids are able to hydrogen bond, thus they have the properties of cohesion and adhesion, while non-polar liquids do not hydrogen bond and so do not have these properties.

Experiment F

1. Which liquid has greater surface tension? ___*polar*_____

2. Explain why this liquid has greater surface tension using a diagram.
   (Diagram should show hydrogen bonds adhering molecules together.)

3. Using your results from this test, make one inductive conclusion about intermolecular cohesion of polar and nonpolar liquids.
   Polar liquids adhere to one another better than non-polar liquids due to hydrogen bonding, thus polar liquids have greater surface tension than non-polar liquids.

Experiment G

1. Which liquid was a greater solvent? ____*polar*___

2. Explain how the electronegativity of this molecule increases its solvent ability, using a diagram and a written description.
   Electronegative poles of water can move next to electropositive poles of the solute and electropositive poles of water can move next to electronegative poles of the solute to encourage the solid to dissolve, whereas a non-polar liquid does not have poles and so cannot work its way in between the molecules of the solute. (Any part of this response may be in diagram form.)

3. Discuss the role of water in the origin of life.
   Due to the properties of cohesion, adhesion, solubility, polarity, specific heat capacity and other characteristics, water is included in all current hypotheses of the origin of life on earth and is considered to be a necessary requirement for life on other planets. Some type of solution must have been the site for chemical reactions to have occurred

wherein elements meet and interact to form molecules and molecules randomly meet and interact to form macromolecules or undergo reactions. Because water has the properties that allow for these actions to take place, it is thought that the origin of life occurred in an aqueous solution.

Special Topics Curricula $175 (per licensed user)

Incorporating Math and Statistics into AP/IB Science
(14 lesson plans covering 20-22 class periods)

AIDS: A Case Study Approach to Exploring the Immune System, Viruses and Community Health
(20 lesson plans covering 28-32 class periods)

Diabetes: A Case Study Approach to Exploring Energy Use, the Endocrine System, Cell Signaling and Membrane Transport
(22 lesson plans covering 30-42 class periods)

Hemoglobin: A Case Study Approach to Exploring Proteins, the Cardiorespiratory System and the Evolution of a Gene Family
(24 lesson plans covering 32-44 class periods)

Full-year Curricula $570 (per licensed user)

AP® Biology Daily Lesson Plans
Full-year curriculum for AP*/IB Biology

Experimental Biology Daily Lesson Plans
Full-year curriculum for general, Pre-AP*/IB or Honors Biology using inquiry methods

AP® Environmental Science Daily Lesson Plans
Full-year curriculum for AP*/IB or general Environmental Science

** AP College Board is not involved in the production or the endorsement of this curriculum.*

catalyst learning curricula

Billing Information:

Name of Billing Contact Person:

____

Address:

____

____

Telephone:

Email:

Shipping Information:

Name of Shipping Contact Person:

____

Address:

____

____

Telephone:

Email:

Name of School: ____________________

Name of Licensed User(s): _______________Email of Licensed User(s): ____________________

How did you hear about Catalyst Learning Curricula Daily Lesson Plans? ________________

A curriculum license extends to only one teacher. Additional copies must be purchased for each teacher who will be using the curriculum in a given school or school district. Please contact us using the email address below to receive a discount for multiple user licenses.

Product Title: AP Biology, APES, or Experimental Biology; or Name of the Case Study, Game or Syllabus	**Quantity** (number of users – one user per license)	**Format Desired** (CD or download)	**Price**

Shipping ($0 for download or $14/CD, $14 per game): _______

Taxes (6.75%-8.25% sales tax, depending on local tax rates, for NC residents only): _______

Total: _______

Payment Method:

Purchase Order Number: __________________________

Checks should be made out to Catalyst Learning Curricula

Credit Card have no charge if conducted on the website, $22 charge by email or mail.

Card Number: ______________________________ Expiration date: ________

Name on card: _______________3-digit security code: ____ Billing zip code: _______

You may either email a picture of this completed form to
Kristen.Dotti@CatalystLearningCurricula.com or mail the completed form to:
Kristen Dotti, 59 Clemmons St., Asheville NC 28801 (Ph: 828-687-0807)