Grade 7
Science
Unit 1: Chemistry of Life

Time Frame: Approximately four weeks

Unit Description

In this unit, the essential elements, chemical symbolism, how materials move into and within cells, and the chemical energy processes of photosynthesis, aerobic respiration, and fermentation (anaerobic respiration) will be explored.

Student Understandings

Living organisms are composed of various chemicals. A basic knowledge of chemical elements, symbols, formulas, equations, and energy processes is essential for appreciating and comprehending life. Students should be able to describe the transport processes of osmosis and diffusion and predict the direction water will move between cells in different concentrations of solutions. Students should also explain how the functions and processes of photosynthesis and aerobic respiration relate to each other and differentiate between aerobic and anaerobic respiration.

Guiding Questions

1. Can students list the elements essential for life?
2. Can students describe the difference between osmosis and diffusion?
3. Can students describe the functions of photosynthesis and respiration, the reactants and products of each, and the relationship between these processes?
4. Can students cite what plants need in their environment to carry out photosynthesis and, ultimately, to live?
5. Can students explain the difference between aerobic and anaerobic respiration?

Unit 1 Grade-Level Expectations (GLEs)

GLE #	GLE Text and Benchmarks
Science as Inquiry	
Note: The following Science as Inquiry GLEs are embedded in the suggested activities for this unit. Other activities incorporated by teachers may result in additional SI GLEs being addressed during instruction on the Chemistry of Life unit.	
1.	Generate testable questions about objects, organisms, and events that can be answered through scientific investigation (SI-M-A1)
2.	Identify problems, factors, and questions that must be considered in a scientific investigation (SI-M-A1)
3.	Use a variety of sources to answer questions (SI-M-A1)
4.	Design, predict outcomes, and conduct experiments to answer guiding questions (SI-M-A2)
7.	Record observations using methods that complement investigations (e.g., journals, tables, charts) (SI-M-A3)
11.	Construct, use, and interpret appropriate graphical representations to collect, record, and report data (e.g., tables, charts, circle graphs, bar and line graphs, diagrams, scatter plots, symbols) (SI-M-A4)
12.	Use data and information gathered to develop an explanation of experimental results (SI-M-A4)
13.	Identify patterns in data to explain natural events (SI-M-A4)
14.	Develop models to illustrate or explain conclusions reached through investigation (SI-M-A5)
19.	Communicate ideas in a variety of ways (e.g., symbols, illustrations, graphs, charts, spreadsheets, concept maps, oral and written reports, equations) (SI-M-A7)
22.	Use evidence and observations to explain and communicate the results of investigations (SI-M-A7)
23.	Use relevant safety procedures and equipment to conduct scientific investigations (SI-M-A7)
Physical Science	
1.	Identify the elements most often found in living organisms (e.g., C, N, H, O, P, S, Ca, Fe) (PS-M-A9)
Life Science	
3.	Illustrate and demonstrate osmosis and diffusion in cells (LS-M-A1)
7.	Construct a word equation that illustrates the processes of photosynthesis and respiration (LS-M-A4)
8.	Distinguish between *aerobic* respiration and *anaerobic* respiration (LS-M-A4)
Science and the Environment	
39.	Analyze the consequences of human activities on ecosystems (SE-M-A4)
41.	Describe the nitrogen cycle and explain why it is important for the survival of organisms (SE-M-A7)

GLE #	GLE Text and Benchmarks
42.	Describe how photosynthesis and respiration relate to the carbon cycle (SE-M-A7)

Sample Activities

Activity 1: Safety in the Science Classroom (SI GLEs: 3)

Materials List**:** Class set of teacher prepared large index cards with safety symbols and pictures**,** yarn, poster board**,** Safety Contract BLM (one per student)

With the increased focus on science as inquiry, it is imperative for students to practice safety within a science classroom and laboratory. Prior to class, prepare lab safety index cards with pictures of safety symbols on some and matching safety rules on others. Attach yarn to the cards to create a necklace. Place students in two groups: one the safety symbol group and the other, the safety rule group. Students should not look at their cards while hanging them on their backs so that other students may view them. Explain that they have just become either a safety symbol or rule. It's their job to determine which one by interviewing other students. Students will circulate around the classroom for five minutes in search of their matching symbol or rule once they have determined which they are. They can ask other students three yes-or-no questions to help determine what they are, such as

- Am I used when heating glassware?
- Am I an object that is worn?
- Am I a rule that must be considered when handling living organisms?

The questions asked should be used to help determine what they are representing and can only be yes-or-no questions. At the end of the five minute time, students should stand together as a pair, safety symbol and accompanying safety rule. The pair must explain how they are connected. On a new index card, the pair will create a billboard style design explaining their safety rule. Arrange all safety rules together and laminate and post in the classroom as a safety guideline poster. Students may use computer software to import and/or manipulate images, if available.

Students can view a comparison of proper and improper lab practices identified at the following site: http://www.chem.unl.edu/safety/hslabcon.html.

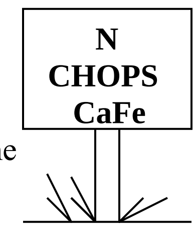
Provide students with a copy of the Safety Contract BLM to be signed by them and their parents/guardian and placed in a classroom file. Check with your science supervisor to see if there are any system-wide regulations that should be included. Other examples of contracts can be found at http://nerds.unl.edu/pages/preser/sec/safety/?M=A.

Just as safety is a concern within the science classroom, it is also important in a kitchen with beginning cooks. Ask students to describe their favorite meal and write all safety procedures that should be used in the kitchen during preparation. Compare the safety precautions to those used within the science laboratory. Draw possible kitchen safety symbols that could be placed in a school home economics classroom.

Activity 2: Served with a Grain of NaCl (SI GLEs: 3, 11, 19; PS GLE: 1)

Materials List**:** copy of periodic table, large newsprint, student access to research material

Put the graphic below on the board or on a transparency and ask students to interpret it. Ask them if the letters have any significance. Accept all reasonable responses.



Served with a "grain of NaCl."

Ask students leading questions that draw them toward the conclusion that the letters are symbols for the elements. Explain that these are the chemical elements that are essential for most living organisms. Ask them why the graphic says *Served with a grain of NaCl*. Lead them to realize that NaCl is salt and contains elements that are essential for most life forms. Give students a copy of the periodic table and have them locate these symbols and record the names for each element. Students should describe the importance of chemical elements and compounds in the body, such as calcium, carbon, nitrogen, hydrogen, phosphorus, oxygen, sulfur, iron, and sodium chloride
.

Instruct students to create a list placing the essential elements in order of importance and to estimate the total percentage present in the human body. Discuss the student-generated list and correct any misconceptions. Provide students with the correct percentages.

Oxygen-65%
Carbon-18.5%
Hydrogen-9.5%
Nitorgen-3.2%
Calcium-1.5%
Phosphorus -1.0%

Allow students to infer why the elements are arranged in this order. With the information provided, instruct students to create a circle graph to display elemental presence.

Place students in groups to research how each chemical element or compound provides an important role to the human body. They should also discuss any dietary deficiencies that may occur due to the lack of an element or compound. Students may find that there are other elements that are essential to living organisms. With the researched information, instruct students to create a wanted poster describing the chemical element or compound. Follow up with a review of the use of chemical symbols to represent elements.

Activity 3: Elemental Information (SI GLE 19; PS GLE: 1)

Materials List: Newsprint or other large paper such as a poster, student copy of "What Am I?" BLM

Assign student groups to research element characteristics by posing questions about elements found in the body from Activity 1, such as Is the element a metal or nonmetal? Which family is the element located in? Other historical information can also be included, such as the atomic number, mass number, and common chemical compounds that contain these elements. This researched information can be placed on a classroom and student *word grid* (view literacy strategy descriptions); see What Am I? BLM. This strategy involves building a grid in which the elements found in the body are listed on the vertical axis of the grid. The elemental properties such as metal, nonmetal, family, type of bond, location of element, and state at room temperature can be listed on the horizontal axis. Students should fill in the grid, indicating the extent to which the key words posses the stated features or are related to important ideas. Once the grid is completed, students are lead to discover both the shared and unique characteristics of the vocabulary words. Students can also replicate the elements as they appear on the periodic table onto a poster display.

Students should choose one of the elements studied to construct an atomic model, displaying protons and neutrons in the nuclei and the possible location of electrons. Students should use items such as yarn for the nucleus, cotton balls for the protons, buttons for the neutrons, and straws for the electrons or other available materials.

Following this, instruct students on how formulas are written and interpreted, including the meanings of subscripts and coefficients. Place a list of chemical formulas and symbols on the board and ask students to distinguish the formulas from the symbols. Provide students with simple equations and practice balancing them.

Activity 4: Detecting Carbon Dioxide (SI GLEs: 1, 2, 7, 22, 23; LS GLE: 8)

Materials List: Bromothymol Blue solution or pickling lime, protective eyewear, cups and straws, index cards

Safety note: Protective eyewear is required to complete this activity.

Due to its unique atomic structure and bonding ability, carbon forms several very important compounds including carbon dioxide. Carbon dioxide is an atmospheric gas that is produced by living things. During the process of photosynthesis plants chemically combine carbon dioxide from the air with water to produce sugar compounds and release oxygen that other living things utilize during respiration. The process of respiration, which releases energy from the carbon compounds (food), takes place within animal and plant cells.

Lead students through an inquiry investigation by distributing protective eyewear, a cup containing a carbon dioxide indicator, and a straw. Ask students to determine what safety procedures should be followed based upon the materials provided. Review relevant safety procedures.

Allow students to generate testable questions about the carbon dioxide indicator and predict the outcome of the investigation prior to beginning the activity by providing them with an index card to write their prediction on one side and the actual observations on the other.

Bromothymol Blue solution or limewater can be used to test for the presence of carbon dioxide. The Bromothymol Blue indicator will turn yellowish in the presence of carbon dioxide; the limewater indicator will become cloudy in the presence of carbon dioxide. This simple test involves students blowing through a straw into a solution of the indicator. A solution of limewater can be prepared by the following recipe: Fill a one-quart jar with water, add 1 tablespoon of lime (used in making pickles), and stir. Fasten the lid and allow the solution to stand overnight. Carefully, filter the limewater into a second jar. Keep the jar of the limewater tightly sealed as it is not very stable and should be used within a day or two of preparation.

Students should place the straw into the cup with the indicator and slowly exhale into the straw producing bubbles. Students are to be cautioned not to siphon the indicator, but blow outward. They should describe any noticeable change of appearance and explain what caused the change in their science *learning logs*. (view literacy strategy descriptions). A learning log is an organized way for students to record data in a notebook or a created folder. Allow students to determine if their predictions were correct based upon the evidence and observations of the investigation. Allow students to exchange index cards to discuss and compare the results of other groups.

Follow up this activity by providing students with a description of aerobic and anaerobic respiration and the distinguishing characteristics of each. Review how the activity relates to respiration.

Activity 5: Photosynthesis (SI GLEs: 11, 19, 22; LS GLE: 7)

Materials List: Index cards, a variety of living plants and animals or pictures of animals and plants if living species are not available.

Begin this activity by using an *SQPL,* (Student Questions for Purposeful Learning) (view literacy strategy descriptions). This strategy involves generating a statement related to the reading material that would cause students to wonder, challenge, and question. The statement does not have to be true as long as it provokes interest and curiosity. Students are provided the statement and allowed time to generate questions they would like answered. Student questions should relate to the statement and should not be purposely farfetched or parodies.

To determine student knowledge about the processes of photosynthesis and respiration, provide them with a statement such as "Without green plants, life on Earth would not exist as we know it." This statement should be written on the board or on a piece of chart paper. Ask students to turn to a partner and think of a question to be answered. After three rounds, write the students' questions on the board and place a star to signify questions that have been repeated. When students have finished, contribute teacher questions to the list, if needed. Provide students with reading materials from a text or reference source that help explain the difference between photosynthesis and respiration.

For this activity, display a living plant and living animal (if no living animals are available, an illustration of an animal will suffice).
During the first round of this activity,

- Allow students to silently brainstorm (Silent brainstorming allows each student to write their thoughts without talking during an allotted time.)
- Provide small strips of paper to write thoughts about the essential resources needed for plant survival

During the second round,

- Students should describe how plants obtain energy
- Each student should turn to a partner and combine and arrange their strips of paper, grouping similar pieces of information

Next, provide student groups with a set of teacher created index cards, some sets containing the major steps and products of photosynthesis and other sets containing the process of respiration. Allow time for the groups to arrange the steps, then carousel around the room to view the order of their classmates' cards and their rationales. Continue until all groups have viewed the work of others. As a class, discuss the correct arrangement of the cards that will explain the role and products of both photosynthesis and respiration. Be sure to include the role of chlorophyll in photosynthesis.

During the class discussion write the steps of photosynthesis in order on the board and convert them into a word equation and then into a chemical equation identifying the reactants and products. Student groups should be provided a set of formulas for respiration and instructed to put them in correct order to form the correct equation.

Activity 6: Plants and Food (SI GLEs: 1, 2, 4, 7, 12, 13, 22; LS GLE: 7)

Materials List**:** Diagram of simple starch molecule, 100ml beaker, several small, leafy plants such as a geranium, 95% ethyl alcohol, baby food jar with lid, iodine, heat source

Review the process of photosynthesis and discuss the end products as discussed in Activity 5. Be sure to emphasize that starch is a complex carbohydrate made from the combination of many sugar molecules and that plants store sugar as starch. Provide students with the formula for glucose sugar and relate it to the formula for photosynthesis.

Allow students to explain what they think causes the leaves of trees to change colors during the fall season. Ask if they think that the amount of starch is affected? They should be led to the conclusion that without chlorophyll, photosynthesis and starch storage will not occur. Provide students with appropriate reading materials that discuss photosynthesis. Sample reading material can be found at http://www.sciencemadesimple.com/leaves.html.

To ensure students are learning to take responsibility for constructing meaning from these reading materials, set up a *QtA*, Questioning the Author (view literacy strategy descriptions). This process involves the teacher and the class in a collaborative process of building understanding during reading. The teacher strives to elicit readers' thinking by encouraging students to ask questions of the author as they read. Make a poster of the types of questions students are expected to ask based upon the reading material. These should be modeled by the teacher and students should be encouraged to ask their own.

The teacher should demonstrate the following test, for starch as alcohol is extremely flammable. Students should sketch and describe the appearance of the leaves before and after boiling and testing for the presence of starch.

To test for the presence of starch, pour 100 ml of alcohol into a beaker with a few geranium leaves and allow them to boil over a low temperature heating source for five to ten minutes. Note: The geranium plant should have been in bright sunlight or artificial light several days prior to this experiment. Remove the beaker and allow it to cool. Remove the leaves and lay them flat on a paper plate. Place several drops of iodine on each leaf and observe any color change; students should record this information in their science journals.
Ask students the following questions:

Why were the leaves boiled? (*Boiling the leaves in alcohol removes their pigments.*)
What is the iodine used to test? (*Iodine is used to test for the presence of starch which indicates photosynthetic activity.*)

What does a color change indicate? A bluish-black or very dark brown color indicates the presence of starch. A light brown color indicates little or no starch. A model of a starch molecule can be obtained at the following site:
http://web.visionlearning.com/custom/chemistry/custom/CHE2.1-pg-starch.shtml or
http://www.lsbu.ac.uk/water/hysta.html.

After recording the observations and discussing the results, have students predict if the results would be the same for a leaf that has been covered for a few days. Provide students with stickers of different shapes or allow them to create their own by cutting paper and taping it over a leaf on a plant for 2-7 days. Students should observe and record the results of the leaf daily in their science *learning log*. (view literacy strategy descriptions).When the area under the sticker begins to lighten, allow the students to discuss possible explanations with other students. Once the discoloration has occurred, the teacher demonstration should be completed again to compare the results of the leaves that were covered to those that were uncovered.

Follow up this activity by assigning students to construct a word equation of photosynthesis and respiration.

Activity 7: Aerobic and Anaerobic Respiration (SI GLEs: 2, 7, 12, 19, 22; LS GLE: 8)

Materials List: Pictures and/or examples of bread, pickles, yogurt, and sauerkraut; yeast; water; sugar; salt; test tubes; flour

Begin with a review of the equation for *aerobic respiration,* and be sure that students identify oxygen as an essential reactant in this process. This is a good time to talk briefly about how the term "aerobic exercise" relates to respiration and what that really means. Ask students if any organism can live in an environment that has no oxygen. Recent discoveries at the bottom of the ocean have uncovered tubeworms and certain bacteria that live near the undersea volcanoes and do not use oxygen. Discuss how these animals are able to survive.

Display pictures and or actual examples of bread, pickles, yogurt, and sauerkraut. Ask students what these foods have in common. Accept guesses, but most students will be stumped. Explain that the foods are all produced through the process known as fermentation, an energy generating process that is a type of respiration. The process is called *anaerobic respiration*. This process also breaks down molecules to obtain energy, but unlike aerobic respiration, it does not require oxygen and does not provide as much energy.
Foods that can be pickled such as cucumbers, cabbage, etc. are submerged in a salty water solution with vinegar added. Bacteria create the lactic acid that gives the food it distinctive flavor and helps to preserve it. Some students may be familiar with this process because they may have a family member that has done this at home; allow time for discussion of the process.

Mention that when muscles become sore after extreme physical activity, it is because of lactic acid build up in the muscles during anaerobic respiration (lactic acid fermentation) when the oxygen level was low.

Display a packet or cube of yeast and ask students what it is used for. Answers will vary, but lead students to the idea that it is used in food preparation such as baking bread. Ask students to hypothesize what is required to carry out fermentation or anaerobic respiration and to generate testable questions to determine how fermentation can be simulated. Accept all answers. Follow up with the guided fermentation inquiry activity described below.

Four mixtures can be assembled in a test tube and tested to determine if fermentation occurs. These are

1. yeast and room temperature water
2. yeast, water, and a small amount of sugar
3. yeast, water, and a small amount of salt
4. yeast, water, and a small amount of flour

The suggested amount of yeast is 20 grams to 50 milliliters of water, and 10 grams of sugar, salt and flour. The amounts and temperature of the water can be varied. When the temperature of the water added to the yeast is increased, more carbon dioxide gas is released (bubbles appear—CO_2 gas). Discuss the process of making bread with students and allow those that have participated in this process at home to share their experience.

Students will notice that the mixture with the sugar will become cloudy, form lumps, and create CO_2 gas bubbles.
Have students record and analyze the data, draw conclusions, and communicate their results. Conclude with a comparison of aerobic and anaerobic respiration.

Activity 8: Moving Molecules (SI GLEs: 1, 7, 11, 12, 13, 14, 19, 22; LS GLE: 3)

Materials List: Cubed potatoes, measured piece of string, beakers, clear corn syrup, salt, distilled water, scale, finger nail polish or vinegar

Discuss the terms *diffusion* and *osmosis* prior to beginning the investigation. Open a bottle of finger nail polish or vinegar and ask students to raise their hands as the smell diffuses throughout the room. Discuss the movement of particles across the room and relate it to the movement of particles from an area of heavy concentration to an area of lesser concentration.

In an investigation, students will use three equal sized cubed potatoes to model the movement of particles across a membrane. Place each potato, with a measured piece of string tied around its center, into clear beakers—each containing an equal amount of one of the following solutions: hypotonic (distilled water), hypertonic (clear corn syrup), and isotonic (a 7 percent salt solution). Label each beaker. Allow students to generate a testable question about each potato placed in the solutions. Their questions should relate to movement of particles.

Have students observe the potatoes daily, recording and sketching their observations. Potato cubes should be massed each day, and the string should be observed noting any changes. The string on the potato in the hypotonic solution should show signs of becoming tighter. The sting on the potato in the hypertonic solution should loosen, while the string on the potato in the isotonic may appear to have little or no change. Discuss the apparent movement of the water in the three containers, being sure that students understand that the water molecules are moving in both directions trying to establish an equilibrium but that the movement is greater toward the direction where there is a less concentration of water molecules and less movement toward the area where there is a higher concentration of water molecules. Students should create a model that will show the result of the observations as seen during the investigation.

Explain *turgor* and *osmotic* pressure and their importance to the existence of plants. A simple teacher demonstration, using a celery stalk placed in water and one that has been left out, will show that the one without water will become limp over time. Allow students to hypothesize what will happen prior to the demonstration. Once the celery has become limp, ask students to explain how the process could be reversed. Allow students to explain what happens when they forget to water their plants and how do they know a plant is in need of water? To summarize, have students complete a *Venn diagram* (view literacy strategy descriptions) on *diffusion* and *osmosis*. Venn diagrams are an organized way for students to compare concepts.

Activity 9: Round and Round They Go (SI GLEs: 3, 11, 13, 19; LS GLEs: 7; SE GLEs: 39, 41, 42)

Materials List: resources to explain the carbon and nitrogen cycles

Ask students to explain how the carbon in their carbonated soft drink could have been part of a green plant that is now extinct or that the nitrogen making up a strand of their DNA could have been part of muscle tissue from a Tyrannosaurus Rex who lived millions of years ago. (Both of these elements are recycled.) Have student groups examine the equations for photosynthesis and respiration discussed in Activity 4 and develop a *graphic organizer* (view literacy strategy descriptions) such as a concept map, thinking map, or web that will trace the path of the carbon and oxygen in a cycle format. Students should consider how the carbon and oxygen cycles (travels) through the atmosphere.

Next, ask students to list sources of carbon compounds other than those discussed through the process of photosynthesis and respiration (volcanic action, burning of fossil fuels, weathering, etc.).Their challenge is to add these sources to their cycle graphic organizer. After students have completed their graphic organizers and summary, display a graphic of the carbon cycle and have students compare their work to it. Discussion should follow. Carbon cycle reference: http://www.cet.edu/ete/modules/carbon/efcarbon.html

Students should soon realize that the carbon cycle is very complex and that photosynthesis and respiration play an important role in the process that moves these chemicals that are essential for life, from the environment to the living organism and back again to the environment. Have students summarize this relationship of photosynthesis and respiration to the carbon cycle.

The nitrogen cycle http://www.nps.gov/archive/olym/hand/process/ncycle.htm http://www.enviroliteracy.org/article.php/479.html is another biochemical cycle that is important in the ecosystem. Ask students to recall what percentage of the air we breathe is made up of nitrogen gas (78%). Point out to students that multi-cellular plants and animals do not have the means by which to utilize this elemental form of nitrogen and are totally dependant upon bacteria such as rhizobia to convert or "fix" it in a form that they can utilize. Have student groups research the nitrogen cycle, diagram the cycle, and develop a class presentation that, in addition to explaining why it is important for survival, also includes negative ways in which man intervenes in this natural process.

As a review, students can also write a poem, song, or rap explaining the process of one of the biochemical cycles that were studied.

Sample Assessments

General Guidelines

Assessment will be based on teacher observation/checklist notes of student participation in unit activities, the extent of successful accomplishment of tasks, and the degree of accuracy of oral and written descriptions/responses. Journal entries provide reflective assessment of class discussions and laboratory experiences. Performance-based assessment should be used to evaluate inquiry and laboratory skills. All student-generated work, such as drawings, data collection charts, models, etc., may be incorporated into a portfolio assessment system.

- Students should be monitored throughout the work on all activities.
- All student-developed products should be evaluated as the unit continues.
- When possible, students should assist in developing any rubrics that will be used and should be provided with the rubrics during task directions.

General Assessments

- The student will interpret basic formulas.
- The student will complete a Venn diagram comparing diffusion and osmosis.
- The student will design an investigation to determine optimum conditions for photosynthesis.
- The student will prepare a laboratory report on aerobic and anaerobic respiration.

Activity-Specific Assessments

- Activity 5: Students should create a Venn diagram comparing photosynthesis and respiration. Using the Venn diagram, they should write four sentences explaining the similarities and differences.

- Activity 7: Provided with an unidentified description of photosynthesis and respiration and the reactants and products of each, students will properly identify the processes. Students will write and balance chemical equations for photosynthesis and respiration.

- Activity 8: Students are to label and describe the processes of osmosis and diffusion using a pictorial illustration.

Resources

- *High school lab safety* pictures available at http://www.chem.unl.edu/safety/hslabcon.html

- *Periodic Table Facts. Interactive Periodic Table.* Available online at http://www.webelements.comhttp://photoscience.la.asu.edu/photosyn/education/learn.html
- *Interactive Periodic Table.* Available online at
- http://www.webelements.com

- *Illuminating Photosynthesis.* http://www.pbs.org/wgbn/nova/metselah/photosynthesis.html

- *The Magic School Bus: Gets Planted.* Available online at http://www.scholastic.com/magicschoolbus/games/teacher/planted/index.htm

- *Photosynthesis* www.educationworld.com/a_lesson/lesson/lesson024.shtml

- *Aerobic Respiration*. Available online at http://www.purchon.com/biology/aerobic.htm

- *Cell Biology*. Available online at http://www.starsandseas.com/SAS%20Cells/Link_Cells.htm
- *Fermentation.* Available online at http://biology.clc.uc.edu/courses/bio104/cellresp.htm
- *Guided Inquiry Module on Cell Transport*, Louisiana Department of Education. Available online at http://www.doe.state.la.us/lde/uploads/2542.pdf
- *Osmosis*. Available online at http://www.tvdsb.on.ca/westmin/science/sbi3a1/Cells/Osmosis.htm

- Rubistar http://rubistar.4teachers.org/index.php