

Leaflet Productions Present: CHLOROPLAST!

“A musical that take light production to another level”

Theodora R. Bennett

Overview:

The purpose of this unit is to teach the concept of Photosynthesis based on two components of multiple intelligence: Bodily Kinesthetic Intelligence and Musical Intelligence. The Kinesthetic Concepts strategy involves introducing students to concepts through physical illustration and asking students to produce a three-act play demonstrating specific concepts or terms from the lesson. Musical tones can be used as a creative tool for expressing concepts, patterns, or schemas in the subject of Biology. Both Kinesthetic and Musical intelligences will aid in the collaboration of Musical Theater and Science. This strategy offers ample opportunity for creative expression from both teachers and students. The use of musical theater in this unit will promote an enthusiastic response in musically inclined students and physically inclined students.

Rational:

This unit will enable students to learn a complex concept using innovative teaching strategies. I developed this unit to enhance in the lecture component and laboratory component of teaching Photosynthesis. The use of pictures and images in teaching Photosynthesis will reach students who are more spatially oriented, but perhaps have a different effect on those who are more physically or verbally inclined.

This unit embraces the content standard for the Pittsburgh Public Schools in the areas of *Reading, Writing, Speaking and Listening, Arts and Humanities,* and *Science and Technology*. This unit can be taught to middle school age, as well as high school age students. I am planning to implement this unit into my PSP Biology II curriculum.

“It is of the utmost importance that we recognize and nurture all of the varied human intelligences, and all of the combinations of intelligence. We are all so different largely because we all have

different combinations of intelligence. If we recognize this, I think we will have at least a better chance of dealing appropriately with the many problems that we face in the world” (Gardner 1).

Bodily Kinesthetic and Musical Intelligence can both be express through the connection of Musical Theater and Photosynthesis. Students can choreograph the movement of an electron through the transport system of a leaf using certain dance styles, such as square dancing. The student can assimilate the graceful movement of the chloroplasts as they move throughout the cell. Student can research musical lyrics that express a process of photosynthesis or utilize popular musical tones for rearrangement of lyrics to suit the photosynthetic process.

I have applied this theory in viewing my own learning/teaching style and used the Multiple Intelligences Theory to assess my teaching strengths, as well as how to identify resources I typically avoid when developing my own lesson plans. I think that students demonstrate intelligence in multiple of ways. I have observed over the years that each student possesses all seven intelligences. Most students can develop each category of intelligences to an adequate level of competence. Intelligence usually works together in complex ways. There are many ways to be intelligent within each category.

Objectives:

Reading, Writing, Speaking and Listening (1,2 and 6)

Arts and Humanities (1 and 4)

Science and Technology (1,2,4,5,8, and 9)

Students will:

Summarize the overall process of photosynthesis.

Briefly explain the theory of multiple intelligence.

Explore connections between the elements of musical theatre and the photosynthetic process using music and dance.

Identify the roles of photons, pigments, electron transport chains, and proton pumps in photosynthesis using music and dance.

Discuss how the products of the light reactions of photosynthesis are used in the Calvin cycle by simulating a two-act play.

Explore the various elements that contribute to the creation of a musical.

Strategies:

I highly recommend that teachers that are unfamiliar with the Multiple Intelligences Theory do some research on this topic before implementing this unit. I am only presenting a brief component of the Theory of Multiple Intelligences. Additional readings are listed in the annotated Bibliography.

The students will be using technology in the form of Internet research. The students will be using learning stations to aid them in connecting Theater and Science. Students will write a three-act play and rearrange familiar musical tones to describe different stages of photosynthesis.

Complete a checklist for assessing student's multiple intelligences. Design checklist using the following information.

Linguistic –

writes better than average for age, spins tall tales or tells jokes and stories, has a good memory for names, places, dates, or trivia, enjoys word games, enjoys reading books, spells words accurately, appreciates nonsense rhymes, puns, tongue twisters, etc., enjoys listening to the spoken word, good vocabulary for age, communicates to others in a highly verbal way

Logical/Mathematical –

asks a lot of questions about how things work, computes arithmetic problems in his/her head quickly, enjoys math class, finds math computer games interesting, enjoys playing chess, checkers, or other strategy games, enjoys working on logic puzzles or brainteasers, enjoys putting things in categories or hierarchies, likes to experiment in a way that shows higher order cognitive thinking processes, thinks on a more abstract or conceptual level than peers, good sense of cause-effect for age

Spatial –

reports clear visual images, reads maps/charts/diagrams more easily than text, daydreams more than peers, enjoys art activities, draws figures that are advanced for age, likes to view movies/slides or other visual presentations, enjoys doing puzzles/mazes or similar visual activities, builds interesting three-dimensional constructions for age, gets more out of pictures than words while reading, doodles on workbooks/worksheets or other materials

Bodily-Kinesthetic –

excels in one or more sports, moves/twitches/taps/fidgets while seated for a long time in one spot, cleverly mimics other people's gestures or mannerisms, loves to take things apart and put them back together again, puts his/her hands all over something he/she's just seen, enjoys running/jumping/wrestling or similar activities, shows skills in a craft or good fine-motor coordination in other ways, has a dramatic way of expressing herself/himself, reports different physical sensations while thinking or working, enjoys working with clay or other tactile experiences

Musical –

tells you when music sounds off-key or disturbing in some other way, remembers melodies of songs, has a good singing voice, plays a musical instrument or sings in a choir or other group, has a rhythmic way of speaking and/or moving, unconsciously hums to himself/herself, taps rhythmically on the table or desk as he/she works, sensitive to environment noises, responds favorably when a piece of music is put on, sings songs that he/she has learned outside of the classroom

Interpersonal Intelligence –

enjoys socializing with peers, seems to be a natural leader, gives advice to friends who have problems, seems to be street-smart, belongs to clubs, committees, or other organizations, enjoys informally teaching other kids, likes to play games with other kids, has two or more close friends, has a good sense of empathy or concern for others, others seek out his/her company

Intrapersonal Intelligence –

displays a sense of independence of a strong will, has a realistic sense of his/her strengths and weaknesses, does well when left alone to play or study, marches to the beat of a different drummer in his/her style of living and learning, has an interest or hobby that she/her doesn't talk much about, has a good sense of self-direction, prefers working alone to working with others, accurately expresses how he/she is feeling, is able to learn from his/her failure or successes in life, has high self-esteem

I would introduce multiple intelligence to the students by showing scenes from two movies, *Stand and Deliver* (1987) and *Dead Poet Society* (1989), to demonstrate this theory of learning. In *Stand and Deliver* a Hispanic high school teacher uses apples to introduce fractions, fingers to teach multiplication, and imagery and metaphor to clarify negative numbers. In *Dead Poet Society* a prep school instructor has students reading literary passages while kicking soccer balls and listening to classical music.

Classroom Activities:

Part I: Multiple Intelligence Theory

Ask the students, “How many of you think you’re intelligent?” Regardless of how many students raise their hands reinforce the question by stating, “All of you are intelligent and not just in one way.” I ask students questions that may identify each intelligence, this gives students a chance to see themselves successful in varied intelligences. How many of you can do Math and Science well? How many of you enjoy drawing? Who is involved in multiple sports? Does anyone play an instrument? How many of you enjoy working with groups of students? How many of you like to spend at least part of the time working on your own in class? These questions should be developed based on grade level.

I will utilize the classroom bulletin board to display individuals who have developed intelligence to a high level of competence: Bodily Kinesthetic intelligence display famous musical dancers and Musical Intelligence display famous musical performers. For the sake of this unit, I am only focusing on the two learning styles mentioned above. If you teach a student who demonstrates strength in another area, develop a class activity based on that intelligence.

Note: For elementary/middle schoolteachers there may be a need to break down the seven styles of learning for clear understanding. For example: linguistic can be a bit difficult for younger children to comprehend, so word smart can be used instead of linguistic.

I will lead a class discussion on the seven styles of learning listed below. Students will get a copy of the chart below to follow along with during the discussion.

Seven Styles of Learning

TYPE	IS GOOD AT	LIKES TO	LEARNS BEST BY
Verbal-Linguistic Learner	reading, writing, telling stories, memorizing dates, thinking in words.	read, write, talk, memorize, and work at puzzles.	reading, hearing and seeing words, speaking, writing, discussing and debating.

Math-Logic Learner	math, reasoning, logic, problem solving, patterns.	solve problems, question, and work with numbers, experiment.	working with patterns and relationships, classifying, categorizing, and working with the abstract.
Spatial Learner	reading, maps, charts, drawing, mazes, puzzles, imaging things, visualization.	design, draw, build, create, daydream, look at pictures.	working with pictures and colors, visualizing, drawing.
Bodily-Kinesthetic Learner	athletics, dancing, acting, crafts, using tools.	move around, touch and talk, body language.	touching, moving, processing knowledge through bodily sensations.
Musical Learner	singing, picking up sounds, remembering melodies, rhythms.	sing, hum, play an instrument, listen to music.	rhythm, melody, singing, listening to music and melodies.
Interpersonal Learner	Understanding people, leading, organizing, communicating, resolving conflicts, selling.	have friends, talk to people, join groups.	sharing, comparing, relating, interviewing, cooperating.
Intrapersonal Learner	Understanding self, recognizing strengths and weaknesses, setting goals.	work alone, reflect, pursue interests.	working alone, doing self-paced projects, having space, reflecting.

Photosynthesis and Music – Learning Stations

I will situate different learning stations around the room to demonstrate and encourage the use of the materials to rearrange lyrics and develop choreograph

based on Photosynthesis. The students will work in small groups or individually at the station. Upon approval, students can bring in additional material to use at the stations.

Note: Although learning centers are typically found more often in elementary and middle school classrooms, this technique has been found to be effective with high school students as well.

Musical station for encouraging students' Musical, Bodily-Kinesthetic, Interpersonal Intelligences

- Mat on the floor

- Cassette or CD player with headphones (optional: jack so that two students can listen to same music at the same time)

- Instruments from a variety of multicultural backgrounds

- Books about famous composers and musicians/musicals

- Books of collected lyrics

- Optional: Computer with microphone, speakers, and earphones plus MIDI connector and keyboard: music composition software, CD-ROMs designed for music study, CDs for incorporating sound into multimedia presentations

Performance station for encouraging students' Visual/Spatial, Bodily Kinesthetic, Interpersonal

- Wigs, costumes, shoes

- Washable makeup

- Masks

- Props

- Cassette or CD-player for background music

- Stage area

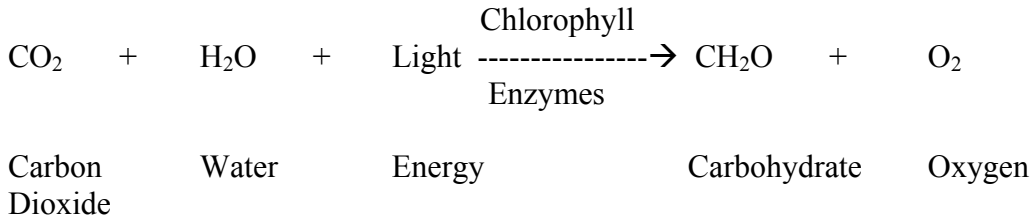
Part II: Photosynthesis and Elements of Musical Theater

Students will use the Internet to view the site [musicals 101.com](http://musicals101.com) to briefly research the different components of musical theater.

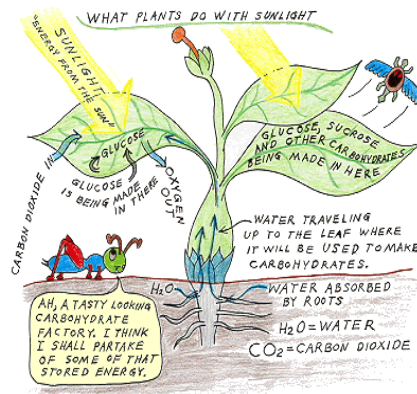
The Book - "A good book is an outline of highly compressed dramatic development that provides a working umbrella for the songs and dance that distinguish an effective production."

Photosynthesis - The Book

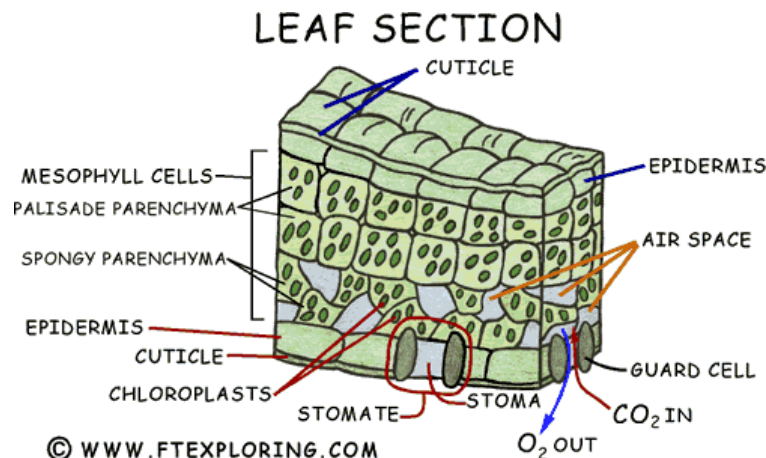
The overall process of photosynthesis can be summarized by the following chemical equation:



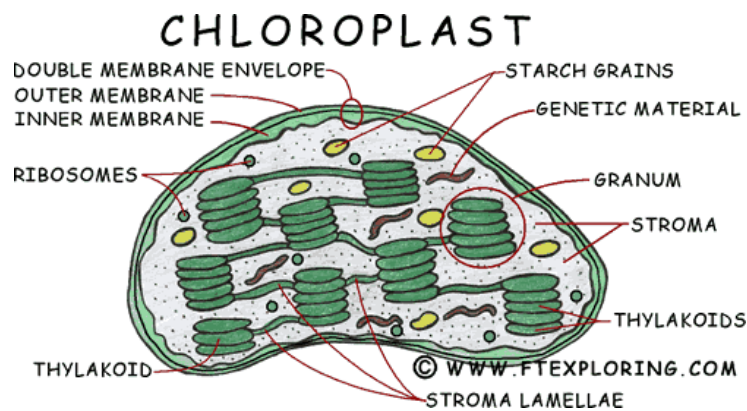
Have student's view the website entitled *FT Exploring Science and Technology* at www.ftexploring.com/me/photosyn1.html. This site gives the student an overview of the process of photosynthesis. Student will be asked to click onto numbers 1, 3 and the new leaf illustration on the site.



Students should identify Carbon Dioxide and Water as raw materials used by the plant to manufacture simple sugars. It should be stressed that there is much more to photosynthesis than what is shown in the simple reaction above. As students explore this process they will discover the beautifully orchestrated process that occurs thanks of a whole host of special enzymes and pigments. Students will need to have a clear understanding of the anatomy of a leaf, paying particular attention to the role of the chloroplast.



If you look closely at the leaf of any plant, you will notice the cuticle. The upper epidermis produces a waxy substance to protect the leaf from water loss through evaporation. Just below the upper epidermis is the palisade parenchyma. These cells contain lots of chloroplasts, which are the primary sites of photosynthesis. Note: Refer to Science textbook for additional illustrations of leaf and chloroplast cross-sections.



If you split the membrane of a chloroplast, you'll find a fluid-filled region called the stroma. Inside the stroma are structures that look like stacks of coins. These structures are the grana. The many disk-like structures that make up the grana are called the thylakoids, and they contain chlorophyll, the light-absorbing pigment and enzymes.

There are two stages in photosynthesis: the light reaction (which depends on light) and the dark reaction (which doesn't). The whole process begins when the photons (or "energy units") of sunlight strike a leaf, activating chlorophyll and exciting electrons.

Photosynthesis – The Lyrics

The Lyrics: "What contributes to the difference between word by the lyric ... a theatre lyric is a compact pattern to words that when set to music communicates information vital to the dramatic life of the show. Like all writing, lyrics put language to the task of expressing thoughts and emotions through the denotative and connotative meaning of words, patterns of literary development of form."

I would introduce music into the linguistic part of the lesson by playing the popular 1980's hit song, *I am so excited*, by the Pointer Sister. This will illustrate the reaction of electrons as they are activated and leave the chlorophyll

molecule and are passed along a series of molecules in the thylakoid, releasing energy as they go.

The lyrics of the song mentioned above should be copied and modified to fit the photosynthetic process. Students should hear the song a few times and be asked to come up with words to express the concept being covered. For example: The lyrics of "I am so excited" by the Pointer Sisters: (Lyrics.com)

I am so excited.
And they just can't hide it,
I 'm about to lose control
And I think I like it.
I'm so excited,
And I just can't hide it,
And I know, I know, I know, I know
I know I want you, want you.

Lyric rearrangement:
Electrons are so excited.
And they just can't hide it,
They are about to lose energy and I think they like it.

Traveling as part of a hydrogen atom, each excited electron leaves its chlorophyll molecule, "boards a train," and jumps to a nearby membrane protein. Then, like the baton in a relay race, each excited electron is passed, "from track to track," through a series of membrane-bound protein and pigment molecules called the electron transport chain or train. As excited electrons pass through this electron transport chain, some of their energy is used to power ATP production. Eventually, the electrons are accepted by photosystem I cluster.

"Midnight Train to Georgia" (Gladys Knight & The Pips)

Rearrangement:
"Daylight Electron Train to Photosystem I"

Oh I'm leavin' on the daytime train to Photosystem I
Said I'm goin' forward to find a new energy form
I've got to make ATP on the daylight train to Photosystem I
I'd rather leave this energy level than live without ATP
All aboard, all aboard, all aboard
On the daylight train to Photosystem I
I got to go
I got to go

I got to go

Students should enjoy this part of the lesson. I encourage students to bring their own “catchy” tones to class and do a slight lyric rearrangement to fit the photosynthetic process. I recommend that some guidelines be set in place as far as appropriate musical selections. (Example: No profanity, etc.)

Photosynthesis – The Score

The Score: “Two broad classifications will govern the introductory approach to the elements of a musical score. The first includes those elements grouped according to strongly musical characteristics, like the overture, opening number, establishing number, patter songs, rhythm songs, chorus numbers, musical scene, underscoring, seque, and reprise. The second group includes types of songs grouped according to the dramatic function implied in the lyric idea, these being the ballad, charm song, comedy song, “I am” song, “I want” song, and special material. The categories are not mutually exclusive. The establishing number asserts in music some vital idea from which the musical show can evolve.

We will listen to the song, *The Sun will come out tomorrow*, from Annie, and rearrange the lyrics to express the way the leaf may feel as it awaits the sunrise. This rearrangement of lyrics would be the establishing number of the musical CHLOROPLAST! A leaflet production. Little modification needed for the lyrics of this song. Teachers can just use the chorus of the song to introduce Photosynthesis.

The sun'll come out	Just thinkin' about
Tomorrow	Tomorrow
So ya gotta hang on	Clears away the cobwebs,
'Til tomorrow	And the nighttime fades
Come what may	Till there's none
Tomorrow!	Tomorrow!
Tomorrow!	Tomorrow!
I love ya	I love ya
Sunlight	Sunlight

Photosynthesis – The Dance

Dance: “Dance cannot define, explain, determine, or prescribe, but like music, dance can suggest it. It directs appeals to the imagination with conscious symbolic statement

The students will be asked to choreograph movements to illustrate the movement of electrons through the electron transport system. This can be done using different forms of dance such as, ballet, folk, modern, African, Latin, etc.

Photosynthesis - A Play in Two Acts and Stage Design

Photosynthesis, which is now playing in chloroplast, has two acts. The first act is the light-dependent reactions, and the second act is the light-independent reactions. Design by drawing a blue print of a revolving stage of two parts. Utilize the following props in the stage design.

1. Place these “props” on the correct “stage;” grana (thylakoids) and stoma.
2. Place these “props” on the correct “stage;” Calvin cycle, energy-capturing reactions, and synthesis reactions.
3. Place these “props” on the correct “stage;” chlorophyll and RuBP.
4. Certain actor/actresses walk on during either the first act or the second act (not both acts), and certain others walk off during either the first act or the second act. The arrows represent entrances and exits. Show where the following “actresses/actors” either walk on or walk off: CO₂, H₂O, light, oxygen, and PGAL.
5. Certain actors/actresses are in the first act, but then they change their costumes and move to the second act. Naturally, they have to get ready again for the first act. Arrows between the acts indicate movements of these actors/actresses. Show where the following “actresses/actors” belong: ADP, ATP, NADP⁺, and NADPH.

Cooperative Group Project:

Prepare a script for a three-act play that shows what takes place in the three stages of photosynthesis. With the other members of your group, perform the play for the class.

Photosynthesis - Power Point Presentation:

Students will be asked to design an end of the unit presentation. This project should depict the educational process of comprehending Photosynthesis through Musical Theater. This presentation will be grade with the use of a rubric, which can be developed by the students and the teacher.

Assessment: Students participation/responses during the PowerPoint Game

Jeopardy PowerPoint: Photosynthesis / Cell Respiration / Enzymes / Light

Grade Level: 8, 9, 10, 11

Subject(s):

- Science/Biology

Duration: 55-60 minutes

Description: A PowerPoint Jeopardy-like game that can be used as a review of biology concepts.

- All students will use classification systems to describe groups of living things; compare and contrast differences in the life cycles of living things; investigate and explain how living things obtain and use energy; and analyze how parts of living things are adapted to carry out special functions.
- Explain the process of food storage and food use in organisms.

Objectives:

1. Students will be able to review vocabulary terms related to photosynthesis, cell respiration, enzymes, and light.
2. Students will be able to give responses in a timely fashion.

Materials:

- computer with Microsoft PowerPoint
- computer projector

[Jeopardy Game](#) - PowerPoint Presentation

Clicking on the link above will open the PowerPoint Presentation in a new window for previewing.

- [Download the Jeopardy Game PowerPoint Presentation](#)

Clicking on the link above will download the PowerPoint Presentation to your computer.

Procedure:

This PowerPoint consists of a game similar to Jeopardy. The gameboard contains 42 answers, which range in value from 100-600 points. If a projector that hooks up to a computer is available, then this provides the best way for the entire class to see the gameboard. The last slide contains the questions, which should be printed out beforehand for the teacher to use. (The questions are the answer key.) None of the slides has links to the last page.

Teachers may choose to set up play in a variety of ways. The game can be used as a competition, with the team collecting the most points being the winner, or the game can be used as just a review, with no specific winner.

Set up the PowerPoint presentation in "slide show" mode. The student (or team) tells the teacher which column and point value to select. The teacher simply clicks on the point value, and the answer is shown on the screen (reminder: in Jeopardy, the answers are on the gameboard, and students will need to give a response in the form of a question). The student (or team) that comes up with the correct question will get the points. Then the teacher clicks on the answer to return to the gameboard. Notice that the hyperlink color changes, so teachers will know which answers have already been selected.

Special Comments: Teachers can easily change some of the questions in the PowerPoint game to better reflect content covered in class, if needed.

Annotated Bibliography/Resources:

For Teachers:

Richard Kislak *A look at the American Theater*. Prentice Hall, 1995. Part three describes the basic elements of a musical show: book, lyrics, score, dance, and design

Thomas Armstrong *Multiple Intelligence*. Association for Supervision and Curriculum Development, 1994. Multiple Intelligence Theory is perhaps more accurately described as a philosophy of education, an attitude toward learning, or even a meta-model of education based on progressive education.

Gardner, Howard, *Multiple Intelligence in the Classroom*,
Almost eighty years after the first intelligence tests were developed; a Harvard psychologist named Howard Gardner challenged this commonly held belief. Saying that our culture has defined intelligence too narrowly, he proposed in the book *Frames of Mind* (1)

Glasser, William, M.D. *The Quality School*. Harper Perennial Publishers, 2nd Edition, 1992. Dr. Glasser shows that traditional coercive management in schools is the root of the problem and suggests that we replace the "bossing" that turns students and staff into adversaries with a system of management that brings them together.

National Research Council, *Inquiry and National Science Education Standards*. National Academy Press, 2000. In December 1995 NRC released the National Science Education Standards...a vision of science education education that will make scientific literacy for al a reality in the 21st century.

Scott, Jeff . The American Musical Theater Reference Library. ...a free to use internet directory for anyone involved in musical theater.
www.americanmusical.com. Copyright 1998. Last Updated 6/12/03. Availability current – accessed June 1, 2003.

Kenrick, John. The Cyber Encyclopedia of Musicals. Musical Theater, TV and Film. Jbk@musicals101.com. Copyright 1996-2003. Last Updated 6/12/03. Availability current – accessed March 11, 2003.

Melton, Aubrey. University of Michigan – Flint. Education Resource Information Center. Jeopardy PowerPoint. www.askeric.org. Copyright 2/5/03. Availability current – accessed June 11, 2003.

[Michigan Curriculum Framework Science Benchmarks](#)

http://www.michigan.gov/documents/Updated_Science_Benchmarks_27030_7.pdf

For Students:

Sylvia S. Mader *Chapter 7: Photosynthesis*. McGraw-Hill, 7th Edition, 1998. Photosynthesis is an energy transformation in which solar energy in the form of light is converted to the chemical bond energy of carbohydrate molecules.

Johnson and Raven *Chapter 5: Photosynthesis and Cellular Respiration*. Holt, Rinehart, and Winston, 1989. Points out the photosynthetic and outer layers of the leaf.

Galston, Arthur W. *Photosynthesis as a Basis of Life*. BioScience, 1992. Photosynthesis support on Earth and in Space.

Wright, Coble, Hopkins, Johnson, LaHart *Life Science Laboratory Manual*. Lab #24, Prentice Hall, 1991. Leaves are specialized organs designed to carry out the process of photosynthesis.

Watson, David. FT Exploring. An introduction to photosynthesis and other energy sources that move through nature. www.Ftextploring.com/me/photosyn1. Copyright 2002-2003. Availability current – accessed March 31, 2003.

Classroom Material:

Optional - Computer with microphone, speakers, and earphones plus MIDI connector and keyboard: music composition software, CD-ROMs designed for music study, CDs for incorporating sound into multimedia presentations

Computer with Microsoft PowerPoint

Computer Projector

Appendices

Science Terms Glossary:

1. Autotroph organism that obtains energy from sunlight or chemical
- Biochemical Pathway an order series of enzyme-catalyzed chemical reactions that forms a product in a step-by-step manner
2. C₃ plant plant that fixes carbon using the Calvin cycle
3. C₄ plant that fixes carbon using an alternative pathway in which the first detectable product product is a four-carbon compound
4. Calvin cycle the second major pathway in photosynthesis involving carbon fixation and carbohydrate formation
5. Carbon fixation process by which carbon dioxide is incorporated into organic compounds
6. Photosynthesis process by which organisms use light energy to produce ATP (Adenine Triphosphate) and other organic molecules from inorganic molecules
7. Chemiosmosis process by which cells pump protons across a plasma membrane and use the resulting proton gradient to proton gradient to produce ATP
8. Chlorophyll the green pigment molecule responsible for trapping light energy in photosynthesis
9. Cuticle waxy, watertight outer covering of aboveground parts of the plant
10. Photon unit of electromagnetic energy
11. Electron elementary particle with negative electric charge
12. Electron Transport Chain series of molecules in an inner cell membrane through which high-energy electrons are passed to pump protons across the membrane and generate ATP by chemiosmosis (“Midnight Train To Georgia” Gladys Knight & The Pips)
13. Energy capacity for doing work, often described as the ability to make things move or change
14. Epidermis outermost layer of tissue, consisting of several layers of cells
15. Mesophyll ground tissue of a leaf
16. Palisade layer of a leaf, cell layer of the mesophyll consisting of one or more rows of closely packed, columnar ground tissue cells
17. Photosystem cluster of pigment and other associated molecules in a thylakoid membrane that gather light energy and boost an electron to a higher energy state (Rearrangement of “I’m so excited” Pointer Sisters)
18. Spongy layer of a leaf, the lower portion of the mesophyll, consisting of loosely packed, spherical ground tissue cells
19. Stomata specialized pores in plant cuticles that enable gas exchange to occur
20. Stroma fluid matrix of the chloroplast

Appendix-Content Standards:

Reading, Writing, Speaking and Listening

1. All students use effective research and information management skills, including locating primary and secondary sources or information with traditional and emerging library technologies.
2. All students read and use a variety of methods to make sense of various kinds of complex texts.
6. All students exchange information orally, including understanding and giving spoken instructions, asking and answering questions appropriately, and promoting effective group communication.

Arts and Humanities

1. All students describe the meanings they find in various works from the visual and performing arts and literature on the basis of aesthetic understanding of the art form.
4. All students produce, perform or exhibit their work in the visual arts, music, dance, or theater, and describe the meanings their work has for them.

Science and Technology

1. All students explain how scientific principles of chemical, physical and biological phenomena have developed and relate them to real-world situations.
2. All students demonstrate knowledge of basic concepts and principles of physical, chemical, biological and earth sciences.
4. All students explain the relationships among science, technology and society.
5. All students construct and evaluate scientific and technological systems using models to explain or predict results.
6. All students develop and apply skills of observation, data collection, analysis, pattern recognition, prediction and scientific reasoning in designing and conducting experiments and solving technological problems.
8. All students evaluate the impact on current and future life of the development and use of varied energy forms, natural and synthetic materials, and product and processing of food and other agricultural products.
9. All students demonstrate basic computer literacy, including word processing, software applications, and the ability to access the global information infrastructure, using current technology.