Chemistry of Food and Respiration

Grade Level: 8th Grade
Presented by: Mike Hill, Lubbock Christian School, Lubbock, Texas
Length of Unit: 4 Lessons (Approximately 15 days)

I. ABSTRACT

Unit will provide students with an understanding of how energy is transformed for use in organisms. The students will be able to track energy from the sun to the final product, ATP. The students will perform laboratory activities to reinforce the concepts and skills. The students will understand the interrelationship between plants and animals. The students will gain an understanding of human respiration, the interaction of blood, oxygen, and carbon dioxide. The students will gain knowledge concerning proper human diet.

II. OVERVIEW

A. Concept Objectives:
1. The student will become knowledgeable about the transfer of energy through metabolic pathways in organisms.
2. The student will gain knowledge of how chemical compounds are utilized in the transformation of energy.
3. The student will develop an awareness of the interrelationship between plants and animals.
4. The student will gain awareness in the function of human systems and proper diet in the use of food energy.

B. Content from the *Core Knowledge Sequence:*
1. Energy for most life on earth comes from the sun, typically from sun, to plants, to animals, back to plants.
2. Living cells get most of their energy though chemical reactions.
3. Energy in plants: photosynthesis
4. Energy in animals: respiration
5. Human nutrition and respiration
6. Human health

C. Skill Objectives:
1. The student will be able to map energy from the sun to the final product, ATP.
2. The student will perform lab activities dealing with metabolism and energy.
3. The student will graph information from lab activities.
4. The students will use research skills.
5. The students will summarize a concept presented in class.

III. BACKGROUND KNOWLEDGE

A. For Teachers:
1. Alcamo, I. Edward, *Biology,* Lincoln, NB: Cliff Notes, 1995. 0-8220-5306-3
2. Hogland, Mahon & Dodson, Bert, *Exploring the Way Life Works-The Science of Biology*, Sodbury, MA: Jones and Bartlett Publishing, 2001. 0-7637-1688-X
3. Knight, David, "Photosynthesis and Respiration". Available URL: http://iusd.k12.ca.us/uhs/cs2/photosynthesis.htm, 2001

B. For Students
1. Cells: Structure and Processes, Grade 5 Core Knowledge (II. p.127)
2. Plant Structures and Processes, Grade 5 Core Knowledge (III. p.127)
3. Chemical Bonds and Reactions, Grade 7 Core Knowledge (II. p.175)

IV. RESOURCES

A. Hogland, Mahon & Dodson, Bert, *Exploring the Way Life Works-The Science of Biology.* Sodbury, MA: Jones and Bartlett Publishing, 2001. 0-7637-1688-X

B. Ross, Bill, *Straight from the Bear's Mouth: The Story of Photosynthesis.* New York: Simon and Schuster, 1995. 0-6893-1726-3

V. LESSONS

Lesson One: Energy and Chemical Reactions (3-4 days)

A. *Daily Objectives*

1. Concept Objectives
   a. The student will become knowledgeable about the transfer of energy through metabolic pathways in organisms.
   b. The student will gain knowledge of how chemical compounds are utilized in the transformation of energy.
   c. The student will gain awareness in the function of human systems and proper diet in the use of food energy.
2. Lesson Content
   a. Energy for most life on earth comes from the sun, typically from sun, to plants, to animals, back to plants. (IV. p.201)
   b. Living cells get most of their energy through chemical reactions (IV. p.201)
3. Skill Objectives
   a. The students will be able to identify the chemical components of energy. (TEKS 8.9)
   b. The students will perform an experiment showing the amount of energy in food. (TEKS 8.1, 8.2, 8.3, 8.4, 8.9)
   c. The students will perform an experiment showing the effects of enzymes on food. (TEKS 8.1, 8.2, 8.3, 8.4, 8.9)

B. *Materials*

1. Pen/pencil
2. Student notes
3. Vocabulary worksheet
4. Energy of Food lab equipment (See Appendix B-1)
5. Enzyme lab equipment (See Appendix B-2)

C. *Key Vocabulary*

1. Enzyme-A protein molecule used as a catalyst in chemical reaction
2. Catalyst-A chemical compound that changes a chemical reaction without being change itself
3. Organic-Chemical compounds that contain the element Carbon, often from living organisms

D. *Procedures/Activities*

1. The instructor will provide notes and vocabulary to the students.
2. Students will demonstrate the amount of energy in different foods. (Energy of Food lab, Appendix B-1)
3. Students will observe the action of enzymes on different foods. (Enzyme lab, Appendix B-2)
4. Students will complete a lab report for lab activities.
5. Students will list foods that contain carbohydrates, proteins, and fats.

E. *Assessment/Evaluation*

1. Observe students during notes and lab activities.
2. Question and Answer session

3. Instructor will evaluate lab reports.

Lesson Two: Energy in Plants: Photosynthesis (4-5 days)

A. *Daily Objectives*
   1. Concept Objectives
      a. The student will become knowledgeable about the transfer of energy through metabolic pathways in organisms.
      b. The student will gain knowledge of how chemical compounds are utilized in the transformation of energy.
      c. The student will develop an awareness of the interrelationship between plants and animals.
   2. Lesson Content
      a. Energy in Plants: Photosynthesis (IV. p.201)
   3. Skill Objectives
      a. The students will map the conversion of energy from the sun to the production of glucose. (TEKS 8.6, 8.10)
      b. The students will perform an experiment showing the relationship of light intensity/duration to the production of glucose. (TEKS 8.1, 8.2, 8.3, 8.4, 8.5, 8.9)
      c. The students will complete a research project that compare and contrast the difference between CAM, C3, and C4 plants using the internet. (TEKS 8.6, 8.3)
      d. Graph information gathered from experiment. (TEKS 8.4)

B. *Materials*
   1. Pen/pencil
   2. Student notes
   3. Photosynthesis worksheet (See Appendix A-2)
   4. Photosynthesis lab equipment (See Appendix B-3)
   5. Computer with Internet access and printer
   6. Graph paper

C. *Key Vocabulary*
   1. Glucose-$C_6H_{12}O_6$-A simple sugar composed of Carbon, Hydrogen, and Oxygen.
   2. Chloroplast-An organelle of the cell that specializes in photosynthesis
   3. ATP-Adenosine Triphosphate-The main energy carrier in cells, produced by aerobic respiration.

D. *Procedures/Activities*
   1. The instructor will provide notes and vocabulary to the students. (Appendix A-1)
   2. Students will observe the relationship of light and photosynthesis. (Photosynthesis lab, Appendix B-3)
   3. Students will use computers to research the difference between CAM, C3, and C4 plants and turn in a completed project. (Appendix C-1)
   4. Students will use data from the lab to create a graph.
   5. Class discussion of the importance of CO_2/O_2 exchange between plants and animals.
   6. Students will complete a vocabulary worksheet.

E. *Assessment/Evaluation*
   1. Observe students during notes and lab activities.
   2. Question and Answer session.
   3. Instructor will evaluate lab reports and written work.

Lesson Three: Energy in Animals: Respiration (4-5 days)

A. *Daily Objectives*
   1. Concept Objectives
      a. The students will become knowledgeable about the transfer of energy through metabolic pathways in organisms.
      b. The students will gain knowledge of how chemical compounds are utilized in the transformation of energy.
      c. The students will develop an awareness of the interrelationship between plants and animals.
   2. Lesson Content
      a. Energy in animals: respiration (IV. p.201)
   3. Skill Objectives
      a. The student will map the conversion of energy from glucose to ATP. (TEKS 8.6, 8.10)
      b. The student will perform an experiment demonstrating anaerobic respiration. (TEKS 8.1, 8.2, 8.3, 8.4, 8.5, 8.9)

B. *Materials*
   1. Pen/pencil
   2. Student notes
   3. Glycolysis/respiration, Kreb's worksheets (See Appendix A-3)
   4. Anaerobic Respiration lab equipment (See Appendix B-4)
   5. "From Sun to ATP" worksheet (See Appendix C-2)

C. *Vocabulary*
   1. Fermentation-An anaerobic pathway that produces ethyl alcohol in plants and lactic acid in animals
   2. Aerobic-A metabolic pathway utilizing oxygen that converts glucose into ATP
   3. Anaerobic-A metabolic pathway that occurs in the absence of oxygen, also called fermentation.

D. *Procedures/Activities*
   1. The instructor will provide notes and vocabulary to the students. (Appendix A-1)
   2. Students will observe fermentation in grape juice. (Anaerobic Respiration, Appendix B-4)
   3. Students will complete the worksheet, "From Sun to ATP". (Appendix C-2)
   4. Students will complete the Glycolysis/respiration, Kreb's worksheets. (See Appendix A-3)

E. *Assessment/Evaluation*
   1. Observe students during notes and lab activities.
   2. Question and Answer session.
   3. Instructor will evaluate lab reports and written work.

Lesson Four: Human Respiration and Diet (2-3 days)

A. *Daily Objectives*
   1. Concept Objectives
      a. The student will become knowledgeable about the transfer of energy through metabolic pathways in organisms.
      b. The student will gain knowledge of how chemical compounds are utilized in the transformation of energy.
      c. The student will gain awareness in the function of human systems and proper diet in the use of food energy.
   2. Lesson Content
      a. Human nutrition and respiration (IV. p.202)
      b. Human health (IV. p.202)

3. Skill Objectives
   a. The student will summarize the exchange of O_2/CO_2 in the human body. (TEKS 8.6)
   b. The student will log daily food intake (TEKS 8.1, 8.3, 8.3, 8.4)

B. *Materials*
1. Pen/pencil
2. Student notes
3. Vocabulary worksheet
4. Computer with Internet access

C. *Key Vocabulary*
1. Carbohydrate-A simple sugar used for cell building, energy stores, and usable energy
2. Protein-a large molecule used for cell building (i.e. muscle cells) and other cellular functions
3. Fats-Lipids-A greasy or oily compound used for energy stores and cell building (i.e. cell membrane)
4. Hemoglobin-An iron-containing, oxygen-transporting compound that gives red blood cells their color
5. Vitamins-Organic substances that animals require in small amounts to maintain normal cell functions but generally cannot make themselves

D. *Procedures/Activities*
1. The instructor will provide notes and vocabulary to the students.
2. Students will complete a research project concerning proper diet in humans. (Appendix C-3)
3. Students will keep a log of their daily intake of carbohydrates, proteins, and fats. (Daily log, Appendix C-4)
4. Students will determine the percentages of their daily intake and make a personal "Food Pyramid". (Appendix C-5)

E. *Assessment/Evaluation*
1. Observe students during notes and activities.
2. Question and Answer session.
3. Instructor will evaluate daily logs and pyramid.

VI. CULMINATING ACTIVITY

A. The students, as a class, will plan a balanced meal to be eaten in class.

VII. HANDOUTS/STUDENT WORKSHEETS

A. See Appendices

VIII. BIBLIOGRAPHY

A. Campbell, Neil A., *Biology.* Redwood City, CA: Benjamin Cummins, 1990. 0-8053-1800-3

B. Core Knowledge Foundation, *Core Knowledge Sequence*. Charlottesville, VA, 1999. 1-890517-20-8

C. Hogland, Mahon & Dodson, Bert, *Exploring the Way Life Works-The Science of Biology.* Sodbury, MA: Jones and Bartlett Publishing, 2001. 0-7637-1688-X

D. Hopson, Janet L. & Wessels, Norman K. *Essentials of Biology.* New York: McGraw-Hill, 1990. 0-07-557108-0

E. McCourt, Richard M. *Essentials of Biology, Laboratory Manual.* New York: McGraw-Hill, 1990. 0-07557625-2E.

F. Mooney, Brian *Test Yourself-Introduction to Biology.* Lincolnwood, IL: NTC Learning Works, 1997. 0-8442-2364-6

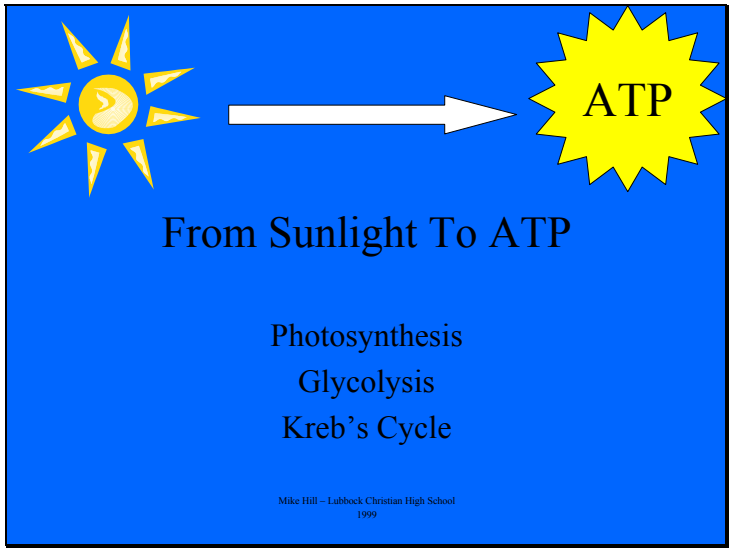
F. Knight, David, "Photosynthesis and Respiration". Available URL: http://iusd.k12.ca.us/uhs/cs2/photosynthesis.htm, 2001

G. Perry, James W. & Morton, David, *Biology: The Unity and Diversity of Life, Laboratory Manual.* Belmont, CA: Wadsworth, 1995

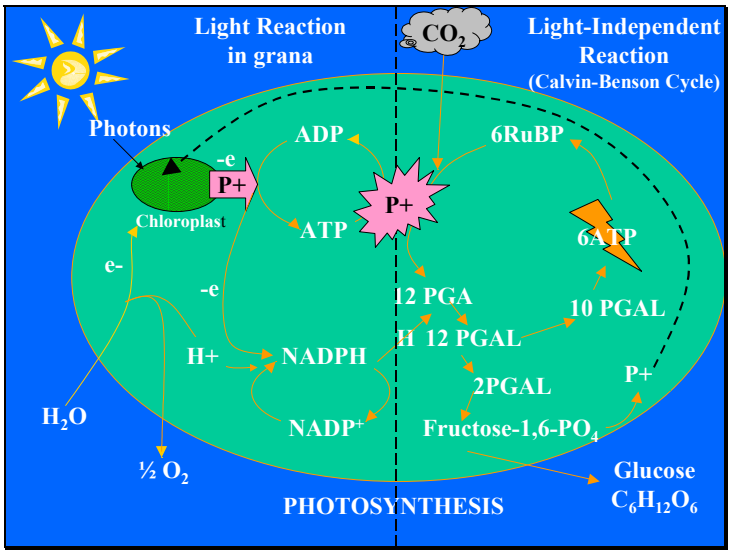
H. Ross, Bill, *Straight from the Bear's Mouth: The Story of Photosynthesis.* Simon and Schuster, 1995. 0-6893-1726-3

I. Starr, Cecie & Taggart, Ralph, *Biology: The Unity and Diversity of Life.* New York: ITP, 1995. 0-534-21060-0

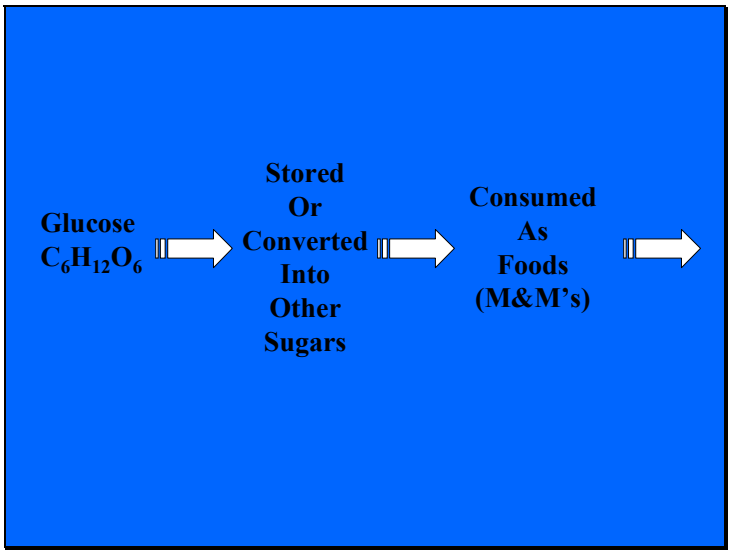
Slide 1


ATP
From Sunlight To ATP
Photosynthesis
Glycolysis
Kreb's Cycle
Mike Hill – Lubbock Christian High School
1999

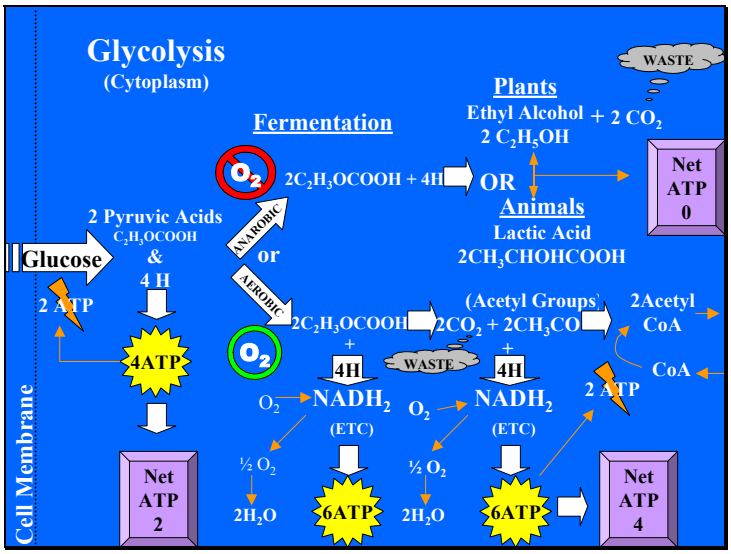
Slide 2


Light Reaction
in grana
CO_2
Light-Independent
Reaction
(Calvin-Benson Cycle)
Photons
-e
P+
Chloroplast
ADP
ATP
P+
6RuBP
6ATP
e-
-e
12 PGA
10 PGAL
H+
NADPH
H 12 PGAL
2PGAL
P+
H_2O
$NADP^+$
Fructose-1,6-PO_4
½ O_2
Glucose
$C_6H_{12}O_6$
PHOTOSYNTHESIS

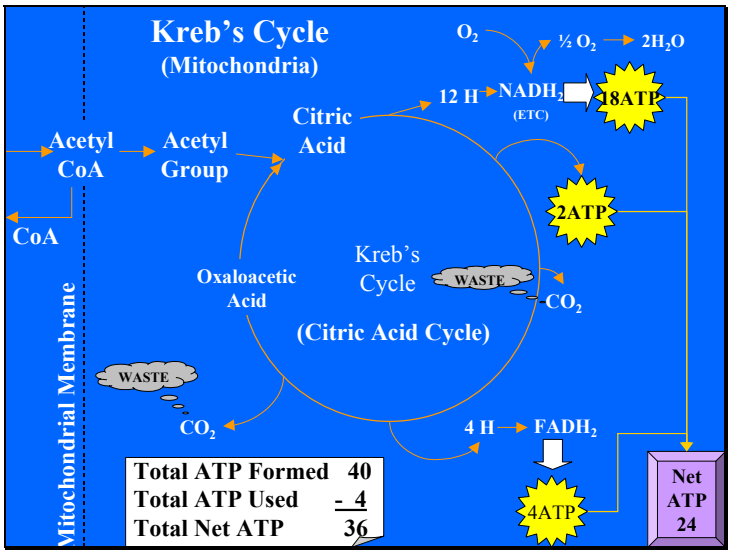
Slide 3


Glucose
$C_6H_{12}O_6$
Stored
Or
Converted
Into
Other
Sugars
Consumed
As
Foods
(M&M's)

Slide 4


Glycolysis
(Cytoplasm)
Cell Membrane
Glucose
2 ATP
2 Pyruvic Acids
C_2H_3OCOOH
&
4 H
4ATP
Net ATP 2
Fermentation
ANAROBIC
or
AEROBIC
$2C_2H_3OCOOH + 4H$
OR
Plants
Ethyl Alcohol + 2 CO_2
2 C_2H_5OH
WASTE
Net ATP 0
Animals
Lactic Acid
$2CH_3CHOHCOOH$
$2C_2H_3OCOOH$
+
4H
O_2
$NADH_2$
(ETC)
½ O_2
$2H_2O$
6ATP
WASTE
$2CO_2 + 2CH_3CO$
(Acetyl Groups)
2Acetyl CoA
CoA
2 ATP
Net ATP 4

Slide 5

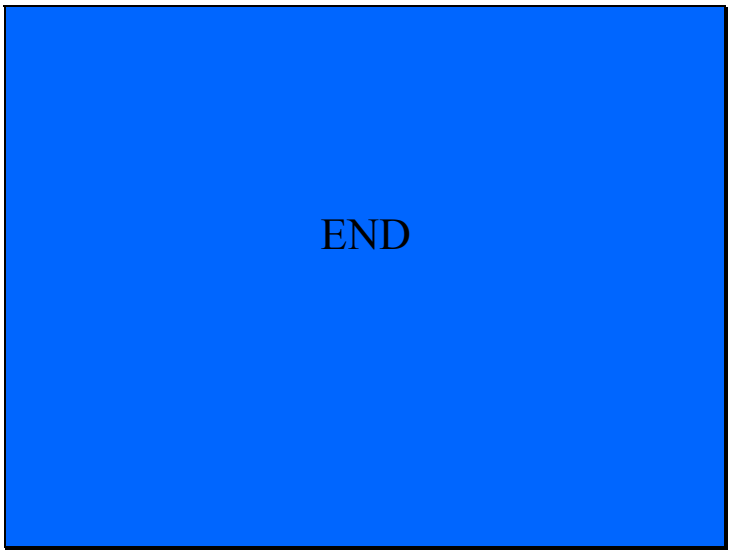

Kreb's Cycle
(Mitochondria)
O_2
½ O_2
$2H_2O$
12 H
$NADH_2$
(ETC)
18ATP
Citric Acid
Acetyl CoA
Acetyl Group
CoA
2ATP
Kreb's Cycle
WASTE
CO_2
Oxaloacetic Acid
(Citric Acid Cycle)
WASTE
CO_2
4 H
$FADH_2$
4ATP
Net ATP 24
Mitochondrial Membrane
Total ATP Formed 40
Total ATP Used - 4
Total Net ATP 36

Slide 6

Summary

•Sunlight is used to decompose water in the Light Reaction forming, through several processes, ATP to be used in the Dark Reaction.
•ATP from the Light Reaction binds CO_2 to RuBP, forming Glucose through a series of reactions.
•Glucose enters the cell membrane and enters either the anaerobic (no oxygen) or aerobic (with oxygen). If glucose enters the anaerobic no ATP is formed, Ethyl alcohol (plants) or Lactic acid (animals). If glucose enters the aerobic pathway 16 ATP are formed and 2 Acetyl groups are sent to the mitochondria. (2 ATPs are used in glycolysis and 2 are used to transport the Acetyl groups to the mitochondria.

Slide 7



Appendix A-2

Photosynthesis

1. What compound is contained in the grana?

2. The energy that is formed in the light reaction is used for what purpose?

3. Where does the Hydrogen come from that is used in the Light Independent Reaction?

4. Carbon dioxide and Hydrogen are recombined in photosynthesis to form what compound?

5. Why is sunlight needed for photosynthesis?

6. Before the early 1600's, people believed the substances that make the plant came from the earth in which they grew. In 1630, Jean Baptista van Helmont performed an experiment using a willow tree. He planted a 5 pound willow branch in 200 lbs. of soil. He waited five years then weighed the tree and soil. The tree now weighed 170 lbs. but the soil only lost 2 oz. Van Helmont concluded that the material that forms the tree couldn't have come from the soil – it must have come from the water. He was only half right. From our study, give the other half of the source of materials for the growth of the willow.

7. What are the electrons used for in the light reaction?

8. What is the final product of glucose and what primary compounds where used to make it?

Appendix A-3

Glycolysis and Respiration

1. How many ATPs are formed during glycolysis and how many are used during glycolysis?

2. Anaerobic means…

3. Aerobic means…

4. How many ATPs are formed in fermentation?

5. What do plants form in fermentation and what is a common use for it?

6. What do animals form in fermentation and how does it affect us?

7. What is required for Hydrogen to be used in the Electron Transport Chain and what is the byproduct?

8. What is a waste product of the aerobic pathway.

9. What is the function of Coenzyme A and what is the cost?

10. How many ATPs are produced in the aerobic pathway and how many are used in the pathway? Be careful, only the aerobic pathway.

Kreb's Cycle

1. Where does the Kreb's Cycle occur?

2. What enters the mitochondria to join oxaloacetic acid to form citric acid?

3. How many Hydrogens are released in the Kreb's cycle?

   A. How many enter the $NADH_2$ (ETC)?

   B. How many enter the $FADH_2$ chain?

4. How many ATPs are formed from the ETC?

5. How many ATPs are formed directly from the Kreb's cycle?

6. How many ATPs are formed from the $FADH_2$ chain?

7. How many ATPs are formed in the entire Kreb's cycle?

8. How many ATPs are formed in the whole process of a cell using glucose and how many are used in the whole process?

9. How many ATPs are netted if a glucose molecule is allowed to go through aerobic respiration?

Appendix B-1

Energy of Food

Lab
Unit: Chemistry of Food and Respiration

Introduction

Humans eat a variety of foods everyday. Some of these foods contain lots of energy while others contain less. In this lab, you will compare the amounts of energy in certain foods.

Objectives

The student will test samples of food to determine which has more energy.

Safety

-Sharp edges and objects
-Hot objects
-Fire
-Glass breakage
-Do not eat any of the samples

Student materials (per 2-3 student group)

1 – Vegetable can (i.e. greenbean)
1 – Condensed soup can (i.e. Campbell's) should nest inside the larger can.
4 – Jumbo paper clips
250 ml beaker
Water
Thermometer
Matches
Several small portions of food provided by your instructor

Procedure

1. Straighten the paper clips and insert two in the each of the lower holes in the large cans.
2. Place a food sample on the lower paper clips.
3. Place the remaining two paper clips in the each of the upper holes.
4. Position the smaller can in the larger so it rests on the upper paper clips
5. Pour 100 ml of water into the smaller can
6. Record the temperature of the water
7. Using a match, light the food sample through one of the lower vent holes.
8. Monitor the temperature and record the highest temperature in the data table.
9. Discard the water
10. Discard the burned food sample
11. Repeat 2-11 with remaining food samples

Energy of Food
Lab
Unit: Chemistry of Food and Respiration

Data Table

Food Sample	Temperature
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Questions:

1. Which sample raised the temperature of the water the most?

2. Why do you think it did?

3. What do you think is in the food to produce the energy involved?

Appendix B-1

Energy of Food
Lab
Unit: Chemistry of Food and Respiration

Teacher Prep Sheet

Student materials (per 2-3 student group)

1 – Vegetable can (i.e. greenbean)
1 – Condensed soup can (i.e. Campbell's) should nest inside the larger can.
4 – Jumbo paper clips
250 ml beaker
Water
Thermometer
Matches
Several small portions of food
Various nuts and chips work (burn) well

Teacher material

1 – Punch-type can opener (Juice can opener)
16d nail
Hammer
Eye protection

Teacher prep

Depending on the ability of the students and amount of time allotted, teacher needs to punch 3 vent holes in the lower side (closed end of can) of the larger can. Use the hammer and nail to punch holes for the paper clips. The lower paper clip holes should be 2.5 cm from the closed end of the can and 1cm apart. The upper paper clip holes are located 7 cm from the bottom and should be 3cm apart.

The number of samples is dependent on the amount of time allotted. Two or three examples of nuts and two or three examples of chips is desirable. Peanuts, walnuts, sunflower, pecans, are good examples of nuts. Potato, corn, Wow, tortilla, Porkrinds, Cheetos, etc. can be used for the chips. Look for a broad spectrum of samples.

Weigh out the samples of equal masses. 2-4 grams work well. Find a convenient mass from one of your nut samples and align the remaining samples with this mass.

Extension activities

1. Have the students measure out the samples.
2. Have the students determine calories, specific heat, etc.

Appendix B-2

Enzyme Lab
Unit: Chemistry of Food and Respiration

Background

Enzymes allow life to occur. Enzymes are catalysts, compounds, usually proteins, that change chemical reactions without themselves changing. They do not cause the change, only affect the speed of the chemical reaction. Other factors determine how well an enzyme works. Temperature, pH, and concentrations all affect how fast the enzyme can work. In this activity you will be using the enzyme, catecholase. The reaction of this enzyme with oxygen causes the browning of fruit.

Safety

Sharp objects
Hot objects
Do not eat or drink any samples

Materials

1 – 250 ml beaker
Apple
Warming oven or warm window sill
2 – Petri dish
Lemon or lemon juice
Distilled water
Mortar and pestle
Knife

I. Procedure

1. Cut the apple in half and give the other half to another group for their use.
2. Cut the remaining half into six equal pieces.
3. Place on piece in a beaker of ice. Label this section A
4. Place one piece in the oven (at low temperature) or on a warm windowsill. Label this section B
5. Place one piece on a petri dish and squeeze lemon juice over the surfaces. Keep this piece moist with lemon juice. Label C
6. Place one piece on a petri dish and moisten with distilled water. Keep this piece moist with distilled water. Label D
7. Mash one piece in the motar and pestle and place pulp on a petri dish. Label E
8. Place the last section in a petri dish and set to the side. Label F

II. For each of the procedures, determine which factor is altering the rate of reaction.

A. _____ D. _____

B. _____ E. _____

C. _____ F. _____

III. Check the sections ever few minutes for the first half hour. Record the time and intensity of the color changes of the apple.

Apple section	Time of first browning	Time course of further browning
A. _____	_____	_____
B. _____	_____	_____
C. _____	_____	_____
D. _____	_____	_____
E. _____	_____	_____
F. _____	_____	_____

IV. After a half hour of checking, continue to check periodically until the end of class. Record any further changes in intensity.

Proceed to next page

V. Interpret the results in terms of how each treatment affected the enzyme activity.

Apple section Effect of treatment on enzyme activity

A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

VI. Questions

1. Which of the treatment(s) is (are) the control for this experiment?

2. Would an uncut apple be suitable for a control? Why or why not?

Appendix B-3

Photosynthesis Lab

Unit: Chemistry of Food and Respiration

Objective

The student will observe the effects on different light on the rate of photosynthesis

Safety

Glass breakage
Electric hazard
Hot objects
Sharp object

Materials

6 – 13x200mm test tubes
3 – One-hole stoppers – to fit test tube
3 – Two-hole stoppers – to fit test tube
1 – Length of glass tubing – to fit holes in stoppers. Do not insert tubing past the inside surface of the stopper.
3 – 2 or 3 liter soda bottle – top cut off at shoulder
Stalk of Elodea
Distilled or spring water
Black construction paper
1 – Clamp on light
Graduated cylinder

Procedure

Measure the amount of water that will fill a stoppered test tube.

Record here _____ml

1. Obtain from your instructor a length of glass tubing with a one-hole stopper on one end and a two-hole stopper on the other.

Do steps 2-4 underwater. Your instructor will provide tubs of water for you. All tubes and glass tubing should be filled with water.

2. Place a stalk of elodea in one test tube and fill with water.
3. Place the one-hole stopper in the test tube with the elodea. Make sure there Is no air in the tube or tubing .
4. Place the two-hole stopper in the other tube.
5. Fill the soda bottle with water
6. Put your finger over the open hole in the two-hole stopper and carefully move the apparatus to a soda bottle. Make sure the elodea tube is on the bottom. It is acceptable for the apparatus to lean in the soda bottle.
7. Repeat steps 1-6 for the two remaining apparatus
8. Wrap one of the bottles in black paper.
9. Place one set-up in the normal classroom light
10. Place the clamp on light so it shines on one set-up
11. Place the blacked out set-up were instructed by you instructed
12. Leave until next class period.

Next class period

1. Carefully remove each apparatus. Be sure not to let any water spill out of the inverted tube (two-hole stopper).
2. Carefully remove the two-hole stopper from the test tube. Be careful not to spill any water.
3. Measure the amount of water left in the tube. Record in data table
4. Subtract the amount of water left from the initial amount of water. Record in data table
5. Disassemble the apparatus and clean up as instructed.
6. Repeat for the remaining apparatus.

Data table

Dark set-up	**Normal set-up**	**Bright set-up**
_____ ml air	_____ ml air	_____ ml air

Questions

1. Which tube had the most air?

2. Why do you think it had more air?

3. Draw a bar graph showing your data.

Appendix C-1

CAM, C3, and C4 Plant Research

This project is to have the student use the Internet to research the different ways plants fix carbon dioxide. The student should give the advantages of each type of fixation.

Requirements:

1” margins
12 font
Arial or New Times Roman
1-2 pages
At least two sources
Bibliography

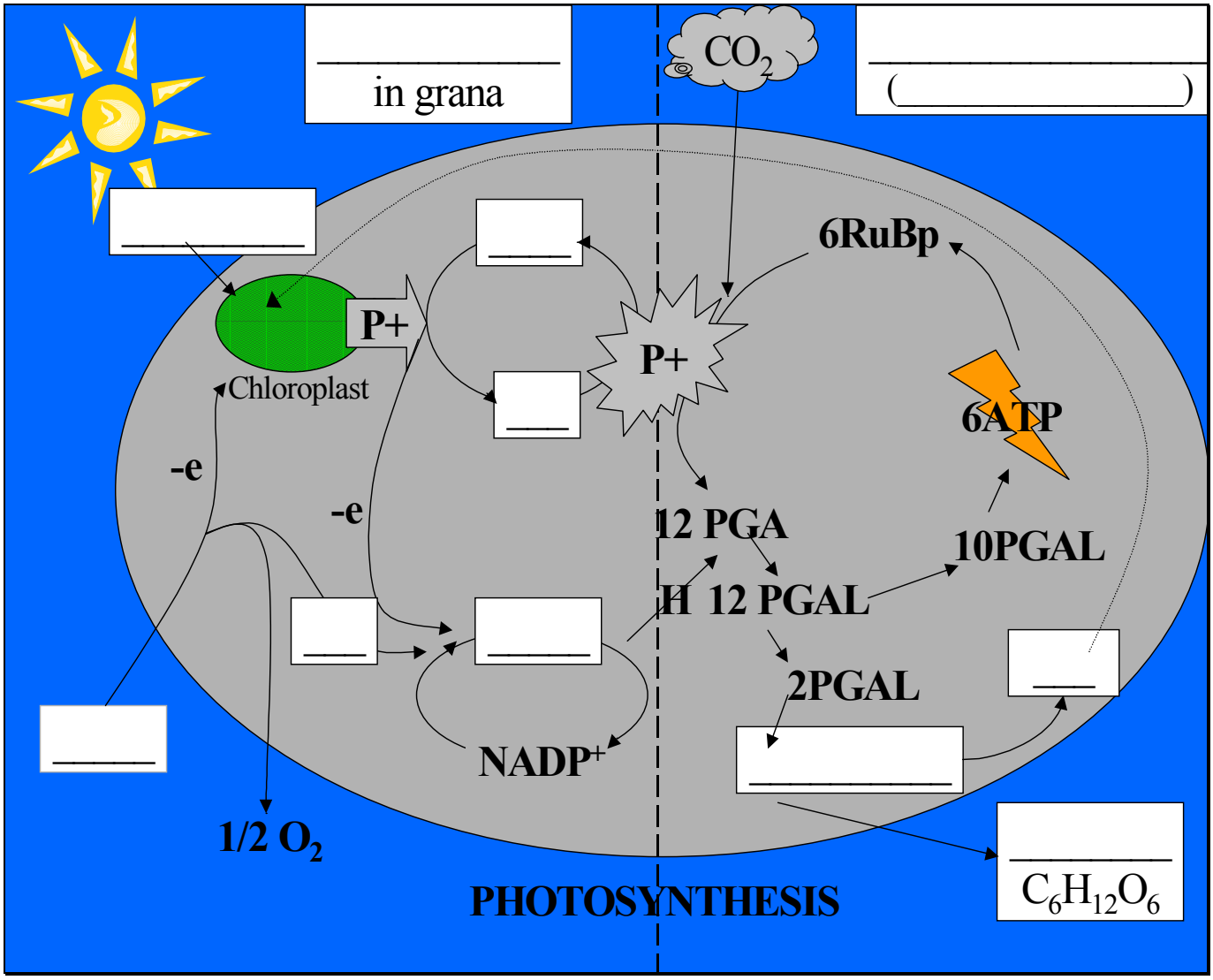
Rubric

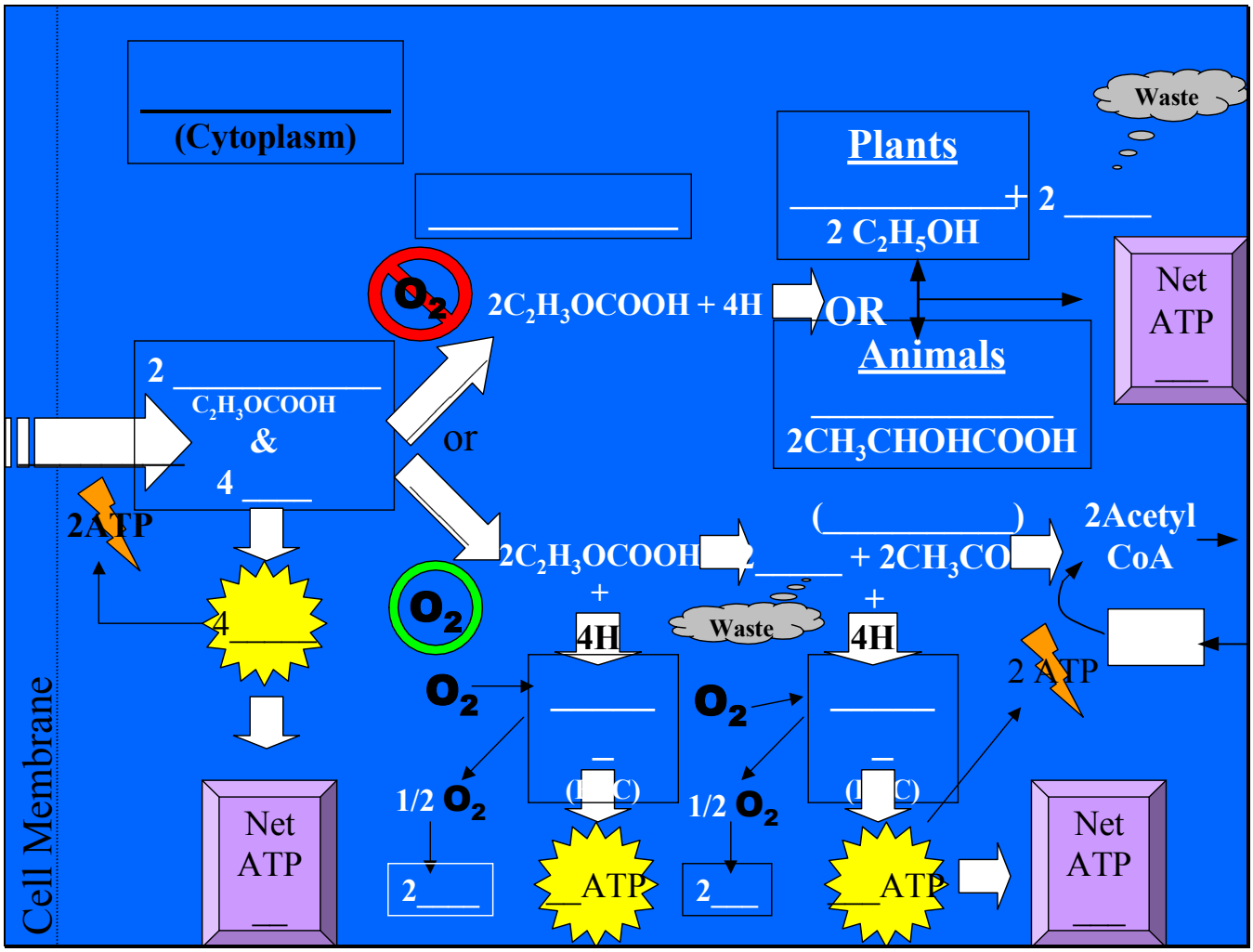
1-2 pages	10 pts
Format	10 pts
Bibliography	20 pts
CAM advantages	up to 20 pts
C3 advantages	up to 20 pts
C4 advantages	up to 20 pts

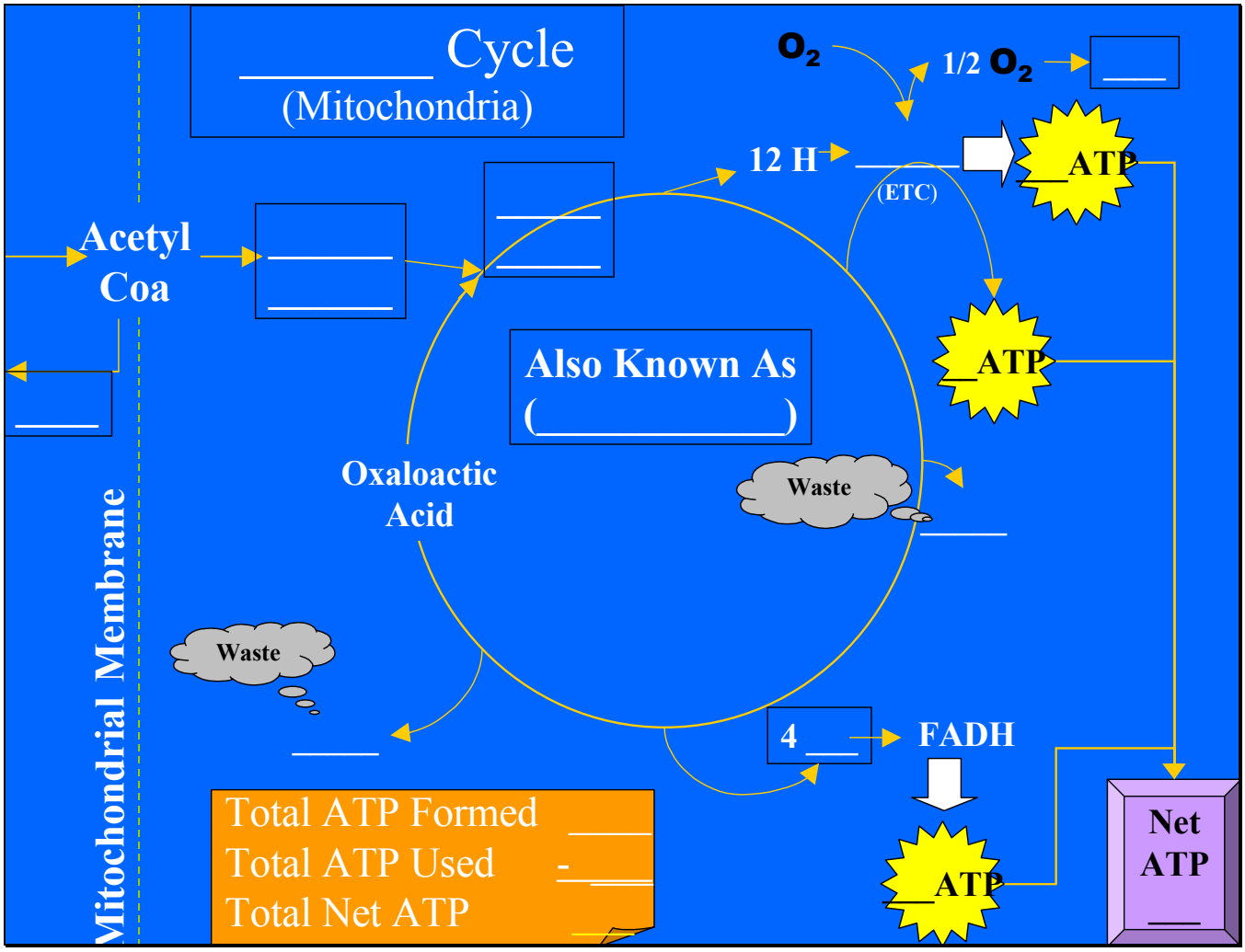
Appendix C-2

From Sun to ATP

Worksheet




(Cytoplasm)
Plants
+ 2
2 C_2H_5OH
Waste
O_2
$2C_2H_3OCOOH + 4H$
OR
Animals
$2CH_3CHOHCOOH$
Net ATP
2
C_2H_3OCOOH
&
4
or
2ATP
$2C_2H_3OCOOH$
+ $2CH_3CO$
2Acetyl CoA
4
O_2
4H
Waste
4H
2 ATP
O_2
O_2
1/2 O_2
1/2 O_2
2
2
ATP
ATP
Net ATP
Net ATP
Cell Membrane


_____ Cycle
(Mitochondria)
O_2
1/2 O_2
____
12 H
____
(ETC)
____ATP
Acetyl Coa
____
____
____
____
____ATP
____
Also Known As
(_____)
Oxaloactic Acid
Waste
____
Waste
____
4 ___
FADH
____ATP
Total ATP Formed ____
Total ATP Used -____
Total Net ATP ____
Net ATP
___
Mitochondrial Membrane