

# **Cellular Respiration Chapter Implementation Report Year 1**

**Exploring Life NSF Evaluation**

**May 23, 2001**

## Methodology

After implementing the Cellular Respiration chapter, in their classrooms, participants completed a post implementation survey (Appendix A) and submitted a Web-based journal (Appendix B). These instruments were designed to address the main formative evaluation questions stated in the NSF grant proposal:

- Do the materials address the important goals of biological science teaching and learning?
- Are inquiry and activity the basis of the learning experiences?
- Are the topics of the unit and the modes of instruction developmentally appropriate?

Additional data was gathered from teacher interviews during field observations and follow-up phone interviews with each participant.

## Participants

### Number of Participants

Eighteen participants (including one student teacher) attended the Lehigh 2000 workshop in August 2000. Eleven participants attended the NABT 2000 workshop in late October 2000. About half of the teachers who were trained to use the Exploring Life materials used them. It was expected that many of the NABT workshop participants would not implement the pilot materials in the 2000-01 school year because they may have already covered the cellular respiration content prior to attending the workshop.

We experienced attrition with some participants from our first two workshops. Some attrition resulted from technical issues with using the Web-based materials in their schools. After returning to their schools from the evaluation workshop, some participants realized they did not have the minimum hardware and software system requirements on their computers to use the Exploring Life materials. To resolve this issue, a test page with a Flash animation was designed on the *Exploring Life Call for Participation* Web page. Furthermore, additional participant screening was put into effect to make sure participants' school computers had all necessary system requirements to use Exploring Life. Some participants have removed themselves from the study due to circumstances beyond their control, i.e. change of teaching assignment, leaving their school system, etc. Additional participants will be added to future workshops to compensate for the current attrition.

It remains unclear why a few participants did not implement the prototype materials this school year. We hypothesize that their lack of participation may be caused by discomfort with the initial prototype materials or their perceived inability to use a Web-based curriculum in their biology classroom. We will be monitoring these participants closely during the next school year.

Fourteen participants used the Exploring Life materials

- 7 participants - implemented Chapter 4 prototype
- 7 participants - implemented Chapter 7 prototype (includes one student teacher pair with a mentor teacher)

Field observations

- 1 participant - Chapter 4 prototype
- 2 participants - Chapter 7 prototype

#### **Academic Level of the Students**

- 9 participants - 9<sup>th</sup> and 10<sup>th</sup> grade regular biology students
- 1 participant - general biology (special Ed)
- 1 participant - mixed regular and honors
- 2 participants- 10<sup>th</sup> grade honors (includes one student teacher pair with a mentor teacher)
- 1 participant - Biology 2 students 11<sup>th</sup> and 12<sup>th</sup> grade

## **Teacher Use of Materials**

### **Number of days teachers used materials**

The number of classroom days the participants used the Cellular Respiration prototype chapter varied greatly. Participants used the materials in their regular level biology classes for as little as seven 42 minutes class periods to as much as twenty 52 minute periods. The average number of classroom minutes the materials were used was 518. There was a large variance in the amount of time the materials were used (standard deviation = 341 minutes). The data reveals that participants who used the laboratories spent more time using the materials. The honors classes typically used the materials for two days during a block schedule. It should be noted that one of these participants predominantly lectured to her students and used the Exploring Life Web-based materials as reinforcement to the lectures.

### **Exploring Life Activity Usage**

The following lists the activity usage of the participants that was reported in journals, phone interviews, and field observations.

4 participants - All activities

2 participants - All activities except Explore

2 participants - Online concepts only (includes one student teacher pair with a mentor teacher)

1 participant - All activities except labs

1 participant - All activities except Fastplants labs

1 participant - Computer activities only

1 participant - All Reading and Book questions

1 participant - CalorieQuest and sunlight powers life only

### **Activities Not Used By Participants**

#### Laboratory activities:

The laboratory activities were the most skipped activity. Four participants did not implement any laboratory activities. These participants noted that they did not have enough time to incorporate the labs into their curriculum. One of these participants noted that she did not have time to obtain the seeds and beads needed for the FastPlants

laboratory. She thought they were being supplied with the kit and didn't make prior arrangements.

Other Web-based interactivities:

The Explore! and CalorieQuest were also mentioned as activities that were not implemented by the teachers. The reasons cited for not using these activities included not enough time or poor Web connections. Some offered the activity as an enrichment activity for students.

Teachers who did the least activities:

One teacher, who relied mostly on lecture for her instructional delivery, implemented none of the labs, Explore!, or Webquest activities. This classroom teacher felt the labs were at a higher level than that of her honors biology students. Similarly, the Explore and Webquest activities were believed to be too time consuming. The concepts that were explored were more easily presented through lectures.

A second teacher had to abandon implementing the materials when she realized her computers lacked the basic system requirements to handle the Website. Prior to using the materials, she consulted her school's technology systems administrator and was assured the computers were adequate.

**Additional Teacher Developed Materials Used**

6 participants- study guides

1 participant - hands-on activity

1 participant - concept map

5 participants - none reported

Six participants that used the Exploring Life materials developed study guides. The study guides were used by the teachers as an accountability measure to ensure that students were working through the program and not just clicking through. Some teachers noted that they used these guided study sheets as a form of assessment. One participant used concept maps and another participant used ball and stick models to represent cellular processes.

**Assessment**

Teachers used a variety of assessment measures in addition to the pre/posttests and the end of the chapter quiz. Additional assessment measures reported by participants included:

Teacher constructed quizzes and test (7)  
 Reproducing and explaining illustrations (2)  
 Journal entry focused on the key idea of each concept (2)  
 Bumper sticker slogans (1)  
 Lab reports (1)

### **Computer Use**

In general, most participants used the computers for over 50% of their class time. The following chart lists the context in which students accessed computers (Data obtained from 11 participants).

Group only	3
Learning station only	2
One student per computer only	2
One student per computer and group	2
Whole class, one student per computer and group	1
Whole class, one student per computer, group and station	1

### **Technology Implementation Issues**

It appears that teachers will always have technology issues when they use the Exploring Life materials. Participants experienced a variety of problems. These problems included crashing computers, slow network connections, using the wrong Web browser and the inability to load helper applications and plug-ins on computers. Teachers should be aware that no matter how well they have planned, they will have to deal with students working in pairs due to not enough equipment or crashing computers.

The following lists technology issues reported by teachers and program evaluators:

- One participant had hardware problems and abandoned implementing the materials after two days.
- During two field observations, some of the computers unexpectedly quit. The teacher had to regroup students on the remaining available computers.
- The computers didn't have all of the plug-ins and time was taken for downloading.
- Poor web connections existed in some schools.
- One teacher commented that if she did not have the computers in her room, she would not have been able to schedule a computer lab since they were too busy.

- Not all the required helper applications and plug-ins were installed in the Web browsers on the computers.
- Students had to carry their computers until they found they were in range of one of the three wireless airport hubs that serviced the room. The airport hubs not located in this participant's classroom.
- Insufficient number of electrical outlets available. Students had to plug computers into high table lab counters. There were no high stools available for students to sit on, so the students had to push desks close to the counter or sit on the counter to use the computers. Batteries were unreliable.
- Systems administrators who were not knowledgeable about the computers' hardware and software.
- Difficulty in scheduling tightly reserved computer labs.

## Main Findings

### Content Knowledge

Note: Content knowledge scores of one participant's Ch.4 student scores and one participant's Ch.7 student scores have not been entered into the database. A paired T-test will be run after this data has been entered into the database.

The scores of the pretests and posttests for both interfaces of the Cellular Respiration chapter show that students' content knowledge increased significantly. (See Table 1). Table 2 shows the percentage of each item that was answered correctly on the content assessments for the Ch.4 prototype and Ch.7 interface. On the Ch.7 assessments, the percentages of 10 items increased on the posttest. The score of question 6 decreased on the posttest and the posttest score of question 4 increased only by 3.65%. It appears that some students are having difficulty applying the concept of a calorie to an everyday situation and also do not comprehend the main function of photosynthesis.

Table 1. Mean scores of Cellular Respiration content assessment

	Ch.4 Pretest	Ch.4 Posttest	Ch.7 Pretest	Ch.7 Posttest
Mean score	5.99	8.83	5.48	8.18

Table 2. Cellular Respiration content assessment item scores.

Question number	Ch.4 Pretest % correct (n=353)	Ch.4 Posttest % correct (n=283)	Ch.7 Pretest % correct (n=184)	Ch.7 Posttest % correct (n=186)
1	66.86	86.22	64.13	77.42
2	45.89	84.81	44.02	76.34
3	54.96	92.23	52.72	86.02
4	60.06	78.80	60.33	63.98
5	75.07	74.91	62.50	75.27
6	71.95	70.32	67.93	63.98
7	39.38	67.84	26.63	65.05
8	35.69	55.83	34.24	54.84
9	20.11	53.00	14.13	52.69
10	27.48	73.14	26.09	65.05
11	60.06	71.38	53.80	66.67
12	41.36	74.56	41.85	70.43

The scores listed in Tables 1 and 2 are raw data and, at this early stage, have little comparative data in which to interpret their entire meaning. They do, however, indicate that students are learning from the materials. We feel that the developers are on the right track.

- We cannot say how the scores compare to students who are not using the Exploring Life materials.
- We also have not had the opportunity to determine why Chapter 4 scores are higher than Chapter 7 or if it is important.
- We will need to investigate further as to why we did not observe larger increases on the percentages on some posttest question items.

## Implementation Survey Results

Table 3 displays the results of the Post Implementation survey. In general, these results indicate that the teachers believe that the Exploring Life Cellular Respiration materials engage students actively in learning biology. They utilize some features of inquiry in the delivery of content. They contain unit topics and modes of instruction that are developmentally appropriate for the majority of the sampled population of students. Finally, they address important goals of biological science teaching and learning. Each survey item is discussed in more detail in the sections below.

Table 3. Post Implementation Likert Item Survey Responses.

Scale: 1-Strongly disagree, 2- Somewhat disagree, 3- Neutral, 4- Somewhat agree, 5- Strongly Agree (Ch.4: n=7; Ch.7: n=7)

Item	Ch.4 Avg.	Ch.4 SD	Ch.7 Avg.	Ch.7 SD
The Exploring Life materials promote constructivist learning in the biology classroom	4.43	0.53	4.33	0.52
The Exploring Life materials encourage active learning for all students.	4.29	0.76	4.17	1.17
The Exploring Life materials did not improve my students' understanding of fundamental biological concepts.	1.86	1.07	2.17	0.98
The Exploring Life materials helped to increase my students' self-confidence in and skill in scientific reasoning and inquiry.	3.57	0.79	3.33	0.82
The Exploring Life materials enhanced my students' ability to apply biological knowledge and the methods of science to important social issues.	3.71	0.49	2.67	1.03
The Exploring Life teacher support materials assisted me in implementing the materials in my classroom.	3.86	0.38	2.33	1.37
Inquiry is the basis of the learning experience with the Exploring Life materials.	4.43	0.53	4.17	0.41
The topics of the Exploring Life chapter and the modes of instruction are developmentally appropriate for my students.	4.14	1.21	4.00	1.41

The scores on the teacher materials should be taken with caution and do not represent the quality of the product. It should be noted that the Exploring Life teacher support

materials were not fully developed during the implementation of these materials.

### **Active Learning of Biology**

The laboratories and many of the interactivities in the Cellular Respiration chapter encourage active learning of biology. Learning is something that students do with the Exploring Life materials. Participants noted that students are actively engage in learning biology with the Webquest, laboratories, Explore! and interactive animations that provide immediate feedback. Participants did note that interactivities such as the downhill skier and watching the pinball animation did not assist learners in understanding the concepts being presented.

#### Comments pertaining to active learning of biology:

- The laboratory activities fall into this category as students take a hands on approach to understanding the concepts. But, also, active learning is most certainly going on as the students interact with the Website. Specifically I believe the animations promote active learning. It was the animations that I felt were the strongest component of the program, many students returned to them several times.
- Beginning with the images of explanation the drag and drop or fill in the blank definitely promoted active learning. The calorie quest was a great example of engagement and concept development that required individual students to be actively learning.
- By presenting a concept through animation and then asking the students to interpret the animation, it helps them to develop an understanding of the concept within a "natural" context. I think it is important for the students to not only understand a principle.
- The interactive computer lesson segments all promoted active learning, although not all to the same extent. The Webquest was exemplary. Moving the correct objects in the tree picture proved to be effective too. With some students, winning the downhill race became an end to itself. They lost sight of the cognitive aspect of the task. This also occurred with the pinball simulation.
- I thought the web presentations were excellent. It allowed students to visualize the abstract and replay a process until they really understood what happens in the process. The book is an excellent "back up" providing the support and foundation for the concepts.
- The students were actually asked to perform activities with the animations and labs. They definitely had to go through the animations to answer the questions.

## **Constructivist learning in the classroom**

The Cellular Respiration chapter presents materials with which learners are familiar. The Calorie Quest introduces the main ideas of the chapter in a context that is meaningful and relevant to the learners. These ideas are developed further as learners engage in interactive simulations and hands-on laboratories.

### Comments pertaining to constructivist characteristics:

- The topics were sequential and built upon previous assignments.
- Began with material with which students are familiar: food, the carbon cycle (relationship of plants and animals).
- The materials start with and include throughout, things students know about and things that are of interest to them, i.e., fast food and exercise or an automobile engine and a marshmallow over a fire.
- At that time, I found that the webquest was the most helpful in enabling students to make sense of their diets and better understand their energy requirements. I think that the lab also would have helped them make sense of cellular respiration better. Other aspects of the unit, I thought, were less constructivist and more conventional although engaging.
- The concepts are definitely a building process. I had taught my students about the cell structures before we went the elife unit on cell energy. The unit explains what energy is and then where it comes from. The investigation with the calorimeter brings the units of energy and how to measure these and where some of the cell energy may come from. These concepts then are taken into the cell with several visuals with the laboratory exercise with respirometers demonstrating possible variables occurring with cellular respiration and the other cycles. The student is allowed to create their own investigation and come up with their own conclusions based on knowledge from booklet, online and results of experimentation.
- Student centered learning resources are very useful in constructivism. The individually accessible computer simulations as well as the labs help students to find their own meaning.
- Reviewed the key ideas about cellular respiration and continued to refer to both plants and animals. This reference to both was helpful since students have the idea that plants make the oxygen and the animals use it.

## **Improving students' understanding of fundamental biological concepts**

Key aspects that helped improve students' understanding of fundamental biology concepts include students being able to work through materials at their own pace and providing visual imagery of complex biological processes. The following are teacher comments categorized by topic:

### Student centered characteristics

- Actually by doing hands-on activities, by going through the animations, they were forced to be involved.
- The micro-respirometer transforms the level of understanding for biology students.
- Students were able to learn at their own pace.
- My students came away with a better understanding of respiration and photosynthesis than I have ever seen in past years. They had a much better sense of the complexity of the processes and are better able to relate cell respiration to breathing. I think
- The materials initially presented the concepts in a very simple manner. This allowed students to review what they already knew about the topic. The majority already had a basic understanding of photosynthesis from middle school.

### Addressing student misconceptions

- My students came away with a better understanding of respiration and photosynthesis than I have ever seen in past years. They had a much better sense of the complexity of the processes and are better able to relate cell respiration to breathing. I think
- The ATP molecule is often identified but never explained or developed as a concept in most texts.
- Students clearly understood:
  - 1) cellular respiration & photosynthesis are opposite reactions
  - 2) understood plants do both (common misconception)
- Students grasped the basic understandings and were less confused between cellular respiration and photosynthesis than in the past. I think I can attribute this to the materials.

### Student use of visualizations

- Cell energy is a hard concept for many of my students to grasp. I felt the working visuals probably helped the most by seeing the energy flow through things and through the reactions. The pinball machine is an excellent visual of seeing how energy is processed through the cycles of respiration, Krebs cycle and electron chain. The audio is turned off on most of my computers but I feel that the audio makes the pinball more effective.

- Provides visual illustrations of very complex concepts.
- The use of visual analogies was excellent. Students were able to explain how these represented the concepts.
- Difficult concepts were easier to understand due to all the visuals and the repetition.
- The visuals or graphs enabled students to visualize the difficult concepts associated with cellular respiration particularly how energy is used and produced.
- The visual beginnings progressed to the more abstract molecular interactions.

#### Concepts students learned

- Made them realize the role ATP plays in providing energy to every organism in the food chain/pyramid.
- The connection of peanut energy seen as a flame with the quantity of calories consumed per student was on a daily basis was surprising to most.

#### Reinforcement

- Exploring life didn't directly improve my students' understanding of fundamental biological concepts. It indirectly reinforced their understanding of energy use and production during cellular respiration that was gained through other classroom activities.
- reinforce concepts
- I used EL to reinforce concepts.
- Exploring life reinforced concepts that were introduced in class through lecture.

#### Student understanding of vocabulary

- The vocabulary was balanced between general and scientifically specific.

#### **Increasing students self-confidence and skill in scientific reasoning and inquiry**

The interactivities and visuals helped increase the learners' understanding of the content. The questions provided with the interactivities enabled students to think more critically about the presented concepts. Participants noted that their students were more prepared to implement the laboratory protocols when they used the online laboratories prior to the actual implementation.

Three participants did not think that the materials helped to increase the students' self-confidence and skill in scientific reasoning and inquiry.

The following are teacher comments categorized by topic:

### Limitations

- Cannot say that it did.
- Having only done 2 chapters of Exploring Life, I saw some improvement in my student's scientific reasoning and inquiry skills. Because it was limited to a few weeks of instruction, I didn't see a huge improvement, but I would expect that with this mode of instruction throughout the year, students would show a greater amount of improvement and they would gain more confidence.
- Did not really change due to extensive exposure previously. Our school does an extensive study on the nature and history of science. If they had not had this background I would say that the EL materials would have contributed more.
- I'm not sure that they did. What evidence would I look for?

### Labs

- My students still have a difficult time reading and following directions which I am working on. My students want to be told the answer because it is easier than thinking. The labs had very good result and if used with good pre and post lab discussions are very effective. I'm not sure that the materials increased their self confidence but their skills in reasoning and inquiry were evident by the way they manipulated the materials and equipment.
- Students were encouraged throughout to evaluate what they had learned. In the lab activities they were encouraged to develop their own procedures. I found this valuable in the Peanut Lab; many students came up with unique, but valid, procedures.
- They really enjoyed working through the peanut lab, and it made them think quite a bit. They felt pretty good about their experiments.

### Online labs

- Since I was able to have one person on a computer, they had to go through the information. Doing the online labs helped prepare students ahead of time when they completed the labs in class.

### Use of visuals

- Comparing my standard (direct instruction) approach to cellular respiration to Exploring Life- the visual analogies were help. I think that if students see the relationship, they have processed this information.
- It helped their self-confidence by helping their understanding of the material by using visuals.

### Questioning

- Since the students did not participate or complete the lab, web quest and the extension activities I can not answer with accuracy. However, the concepts & questions they explored did probe them to think more critically about what was occurring in the visuals.

### Individual reading

- The individual reading and practice of the web pages gave students a confidence level greater than normal for this most difficult of biological concepts.

### Miscellaneous

- They were initially intimidated, but soon became comfortable with the format. As they began to understand the concepts they gained more confidence.

### **Enhancing students' ability to apply biological knowledge and the methods of science to important social issues**

The CalorieQuest and the Explore! activity appeared to enhance students' ability to apply biological knowledge and the methods of science to important social issues. The materials presented concepts of diet and the breakdown of metabolic energy in a context that students were able to relate to their daily lives.

Five participants noted they did not see how the materials in this unit enhanced their students' ability to apply biological knowledge and the methods of science to important social issues. Two of these participants did not use the CalorieQuest with their students.

The following are teacher comments categorized by topic:

### CalorieQuest

- The calorie quest illustrated how metabolism and the amount of energy consumed is directly related to their lives.
- The issue of diet and calories was done as a class discussion, with the basis of factual calorie data.
- The calories counting activity did provide students with some thoughts about their own diet. Most of my students were able to choose appropriate food without much help. This topic was discussed earlier in the year.
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- Perhaps a little bit with the idea of eating disorders.
- We had discussions on nutrition and eating disorders and Lance Armstrong's feat as a result of EL. Emphasis on fast foods was a negative.
- The materials certainly helped them with planning their diets. In the future, I think I would take a period to explore cultural aspects of eating and the restaurant business in our country. But I didn't do that this year. I think that would be worthwhile.

### Materials did not apply biological knowledge and methods of science to important social issues

- I do not see how this enhanced their abilities with this particular unit on application of important social issues. This may be because I missed something? :)
- I am honestly not sure. I did not use the Web Quests, the Photosynthesis Unit or the labs.
- It did not because the program was not completely implemented. However the Chocolate activity has the potential to do so.
- no comment

### Greenhouse Effect

- We had talked about the Greenhouse Effect. The students didn't realize what it really was and how photosynthesis would have any connection whatsoever. After completing the chapter and discussing it, students were able to intelligently connect what they'd learn.

### Global Warming

- With photosynthesis, we were able to touch on global warming and begin to explore the data that supports this interpretation of the last 50 years. I think this was the first time my students had seen an actual application of something so scientific and a

### Visuals

- The ethnic flavor of the lead characters put students at ease to explore this topic.

### Teacher Support Materials

It should be noted that the Exploring Life teacher support materials were still in the conceptual development stages during the first year pilot testing. Additional teacher resources appeared in the new interface. This section is still under development.

The following are teacher comments categorized by topic:

#### Inadequate

- I was disappointed in the lack of teaching materials and the hidden nature of these tools. The suggestions to lab procedures were helpful but teacher prep and time lines were lacking. The question of writing a daily lesson plan was totally unassisted.
- Did not use them that much.
- I used this in a limited manner.
- N.A.
- Lab materials were very difficult to work with. Alternative procedures would have helped.
- When I did the unit, there wasn't as much support as there is now. I didn't have much to use then.

#### Adequate

- The teacher support materials were adequate but I am glad that I had gone through the materials a Lehigh before attempting them in my classroom.
- The teacher material did not assist in the implementation of Exploring life. I would have like to have been given more implementation strategies. In other words, ways in which you could successfully implement the activities and or sequence of events.
- I was part of the crew when things were switching. At times that was kind of difficult. The biggest stumbling block was lab instructions. They need to start at 0 for people who have no experience or information. For example, I know how to make KOH, but the teacher materials need to be specific and explain that. Also, for the Sodium

Bicarbonate, the directions said to get a beaker and sprinkle Sodium Bicarbonate on bottom. I teach the students to measure everything when they are doing labs. I have also expressed a need for other handouts that can be printed from the Web site.

- We did the test piloting materials cleanly in 5 days w/ only the use of the materials. Implies goals and procedures were clear.

### Good

- The teacher support materials have great ideas about in what order to do things (text vs. online); the reminders about students answering questions and suggestions of having a personal journal were very useful; the tip about the pinball game was RIGHT ON!!
- The lab activities with the teacher information were helpful.

### **Use of inquiry**

The Fastplants lab is an inquiry-based laboratory. Students are guided through an investigation. Next, they are prompted to formulate their own driving question, conduct a second investigation where they gather and analyze data, and formulate a conclusion. The CalorieQuest and the peanut laboratory contain some essential features of inquiry. However, these activities are not full inquiries.

The following are teacher comments categorized by topic:

### Web-based activities

- First it begins with the animations because the kids had to make logical guesses. Dragging things made kids think about what they were doing.
- The calorie quest is a great way to spark a "need to know" in students. The computer simulations do a pretty good job of breaking down a difficult concept into smaller more digestible bits.
- The lab based activities, and the caloriequest were all examples of inquiry based learning.
- The interactive Web concepts allowed the students to do inquiry at a basic level. (Not the full blown 5 steps.)
- Obviously, the webquest is my favorite example, but I think that wherever there are open-ended questions that engender exploration, inquiry is fundamental. What the role of oxygen is in cellular respiration is another example.

### Labs

- Calorimeter data collection and how it applies to diet and leads to other investigations. The respirometers as well as the previous experiment gives guided research and then allow for further research of different variables.
- I did not use the labs so I don't feel I can answer this question.
- With the labs, it asked the students how the labs should be modified and students had to do this.
- The prelab activity for the peanut lab is a good beginning but the final exercise of true inquiry is not developed. My idea of inquiry is lab based and the web pages did a good job of simulating this in the snow boarding activity. The student conclusion
- The lab based activities, and the caloriequest were all examples of inquiry based learning.

### Combination of characteristics

- 1. lab designs. 2. analogies. 3. go from the known to generate questions. In my direct instruction sessions, students asked excellent questions showing a true attempt to understand-not just memorize.
- Inquiry was used throughout, first in the CalorieQuest and then in the laboratory activities. In calorie quest students were gathering data based on their own preferences and analyzing it with an eye to their own activity levels. The peanut lab had students thinking.

### Develop and explore

- Inquiry is the bases of learning with Exploring Life by having students develop their own experiments and explore concepts via the web quest.

### Developmentally appropriate modes of instruction

Participants noted that the topics of the Cellular Respiration chapter are appropriate for their 9<sup>th</sup> and 10<sup>th</sup> grade biology curricula. Most participants stated that the modes of instruction are developmentally appropriate for their regular level and honors biology students. The concepts are presented in an appropriate sequence. The Web-based interactivities helped learners to understand the concepts. An interesting phenomenon appearing here is that some teachers claim that the program is only for advanced students while other teachers report that lower level students do well. The success of the program may be that it is adaptable to diverse learners. It also may be a result of using content materials that are often not covered thoroughly in regular and lower level biology courses.

The following are teacher comments categorized by topic:

### Regular biology students

- I think I answered this in another section. Starting with the basis of where energy comes from and how it is used and processed by cells is very complete.
- Students at the tenth grade level are able to add details and sophistication to their understanding. I felt that this was happening as we explored this material. Students are also eager to use technology and the combination, I felt was appropriate.
- They flow very well, with each section building on the concept of the previous one. It is very appropriate for tenth grade biology the way it is taught in Tennessee.
- These are difficult concepts for students to comprehend. The visual activities helped them relate to the information and to assimilate it. They are computer savvy and skilled at computer games and this took advantage of this to keep their interest
- The topics are standard fare for high school Biology, but I especially liked the mode of instruction. It is especially well adapted to the "Sesame Street" generation that we are teaching now. Our students tend to be high visual, but not very imaginative.
- At first inspection I felt that the calorie quest was fluff. After additional topics were completed, I found the concept was strategically located in order to build upon the students understanding of energy. I liked the discussion of anaerobic after aerobic
- The graphics (old design) was a little young. The content was right on, especially for our 9th graders.
- The materials are geared to the young teenager in a number of ways:
  - \*The visuals are appealing to a 14 or 15 year-old
  - \*The vocabulary is at the right level ( although the there are more technical words than I think I would have included in light of the National Standards and my state's standards)
  - \*Concrete activities and explanations are offered to help explain theoretical constructs
  - \*Concepts are related to the students' everyday life
  - \*The chapter is divided in pieces that students can handle in one learning session

### Honors

- 1. Sequence. 2. Active learning (engaging the student in specific activities which support the ideas). 3. Reading level of material appropriate for my college prep students.

- The level of the Respiration unit was very good for my Honors Biology. Yet the lab on respiration (peanut lab) is not developmentally appropriate for these honors biology) students.
- Most of the explanations of the concepts, the web quest, and the extension activities are developmentally appropriate for honors biology.
- There is too much material in the chapter for my students. I don't normally teach cell respiration in nearly that much depth! I have ninth grade regular students. I thought a lot of it was more on my AP students' level.

### **Teachers comments on student reactions to Exploring Life**

Below are the comments from the teachers organized by categories. Note that some of the teachers stated that lower to average students were responding well to the materials. In our teacher focus groups and in response to other survey items, some teachers perceived that the material was best suited for higher level students.

The data reveals other interesting teacher perceptions of student use of computers. Teachers noted that the computer was taking over much of the responsibility of the instructional delivery. Some of the *negative* comments from the teachers stated that the students learned better from them, not the computers. Perhaps the importance of the teacher in the "vital new role of facilitator" should be emphasized in the *Exploring Life Teacher Resource Materials*.

### General student attitude comments

#### *Positive*

- They really liked the concept. The ones who were able to see the graphics enjoyed the lessons.
- For the most part students reacted favorably to the website.
- For most of the students the response was positive.
- Interest in the materials was so high that several students stayed after school to complete activity.
- Overall students were positive

#### *Neutral*

- As the newness wore off of the new program the students seemed to want more feedback as to how they were progressing.
- The students thought it was "fun", but some materials were not well-utilized.

- They initially raced through the material as if there was a race to finish. When I questioned them about what they learned, they retained little. After realizing that they were responsible for the material, they began to take it more seriously.
- Like everyone, excited at first, but resistant to change. Once they realized that it wasn't exactly all fun and games they were unmotivated. Good teachers know how to change that.

### *Negative*

- Students frustration was high upon losing emailed quizzes to teacher because of wrong email address
- Much of the material was at too high a level for my ninth graders - they didn't GET it without a lot of extra help from me.
- Interestingly after the completion of the activity, a student stated that they did not learn the concepts from the program but rather from the lectures.

### General comments on computer use

- I had a couple students that were reluctant to spend so much time on the computer, but they paired up with another student and did fine.
- They offered several suggestions as to how their computer work could be improved.
- Initial response was -"now you are not going to teach us we have to teach ourselves."
- Students wanted me to give them information before they used the computer. They said that the information was too confusing at first.
- Students are used to using the computer for review not for initial learning.
- Students were excited to use computer in a new format.
- The computer simulations were very good, but we had to look at those in groups since most of my computers were not high-powered enough to make them work right.
- The students tended to let one person run the computer while the others goofed off.

### Lower level students

- Even my curmudgeonly student was interested!
- I really felt my learning disabled population did pretty well with the format.
- My weaker students had the most difficulty with my approach of allowing them to receive the first information from the program.
- My average students asked the best questions when I reviewed the information the next day.

### Animations and graphics

- Initially the students were overwhelmed by the animation of the program. Specifically, the students had a hard time following the "pinball machine". In fact, the students replayed many of the animations several times before they were able to answer the questions.
- They were attracted to the animations.
- They liked the downhill racer simulation as well.

### Labs

- They enjoyed the peanut lab although our results weren't all that good.
- They really enjoyed the peanut lab.
- Most students were very enthusiastic and enjoyed the calorimeter lab. They did not respond to the respirometer lab as well. (It may have been that they had to come up with their own variable to change and that took some individual thinking.)

### Teaching style

- After each topic was introduced on the computer, I reviewed the information the next day after they had rewritten their journal entries. This provided them an opportunity to change their information or clarify information.

## **Participant suggestions for improving Exploring Life**

### Labs

- Provide some data to be analyzed for comparison of cellular respiration in plants and animals.
- More information or a lab activity on fermentation vs. aerobic respiration. See BSCS Blue lab-life with oxygen.
- The respiration lab had a confusing data table and directions as to calibration or placement of plunger may vary with syringe type.
- First I believe that the lab activities are geared toward a higher-level ability group and not toward the average student. There should be more flexibility or options in regards to the type of lab activities offered. Similarly, if the email is a wonderful option and had it been functional I would not have developed the guided questions for the activity.
- Ideally lab groups would be two or less. My lab groups are usually 3 because of my lab stations set up. The third person is sometimes a hindrance to the group. Encourage teachers to go through the labs. The success of any project is if the

instructor has first hand knowledge of what can go wrong by having made some of these themselves.

### Miscellaneous

- I didn't like the printed chapter review. There were too many instances where the questions required prior knowledge that I did not feel would have been introduced in the previous chapters, if we'd been using the series.
- E-mail quizzes need to be saved by server because many were misdirected due to email address mistakes. A second possible solution would be to allow teacher to input his own email address prior to student access.
- Materials were good and the colored copies are great.

### Student Levels

- Have two pathways - one for honors and one for regular students. All the detail about the different reactions involved is WAY more than I expect them to learn. I concentrate on the big picture at this level. Even the pinball simulation, while it was "cute", didn't mean anything to them. ATP syntheses?, electron transport chain?, you've got to be kidding! My AP students have critiqued it for me also, and they suggested having audio to say the text out loud in addition to having the print version. They thought it was less than exciting without that. They also couldn't figure out the simulation while reading at the same time. They suggested having more interactive fun games and less worksheets to fill out. They wanted to play pinball and not just watch it! In doing definitions, the key word "aerobic" wasn't defined well in the print. For Caloriequest, it was useful to just put in a restaurant and get the whole menu rather than entering specific foods, and I found the interactive food finder just didn't work well in general. We spent way more time on this chapter than I normally would, but I am not sure the students learned any more as a result.
- Concept 4.5 could have greater depth for higher level students.
- The explanation of glycolysis was very helpful to my students. I hope the krebs cycle and electron transport sections will be as easy to follow.

### Animations

- Allow students to have more control of the speed of the simulations on the screen.
- Some of the different interactive concepts are too big to be seen on the screen. For example, the ATP pinball. I had to scroll to the right to see what was going on in addition to scrolling up and down. Several of the activities have the same problem. Not everyone in the world has a 19-inch monitor.

## Appendix A. Post Implementation Survey

**I. Using the Likert scale below, please indicate to what extent you agree or disagree with the following statements.**

1	2	3	4	5
Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree

- The Exploring Life materials promote constructivist learning in the biology classroom.
- The Exploring Life materials encourage active learning for all students.
- The Exploring Life materials did not improve my students' understanding of fundamental biological concepts.
- The Exploring Life materials helped to increase my students' self-confidence in and skill in scientific reasoning and inquiry.
- The Exploring Life materials enhanced my students' ability to apply biological knowledge and the methods of science to important social issues.
- The Exploring Life **teacher support** materials assisted me in implementing the materials in my classroom.
- Inquiry is the basis of the learning experience with the Exploring Life materials.
- The topics of the Exploring Life chapter and the modes of instruction are developmentally appropriate for my students.

**II. Open-ended questions. Please respond to the questions below.**

- How do the Exploring Life materials help you implement constructivist learning in your biology classroom(s)?
- Which Exploring Life materials promoted active learning of biology?
- How did the Exploring Life materials improve your biology students' understanding of fundamental biological concepts?
- How did the Exploring Life materials improve your students' self-confidence and skill in scientific reasoning and inquiry?
- How did the Exploring Life materials enhance your students' abilities to apply biological knowledge and the methods of science to important social issues?
- How did the teacher support materials assist you with implementing the Exploring Life materials in your classroom?

- How is inquiry the basis of the learning experience with the Exploring Life materials? Provide a few examples.
- How are the topics of the chapter and the modes of instruction developmentally appropriate?

## Appendix B. Web-Based Journal

Number of classroom days you used the chapter materials.

Length of classroom period in minutes.

Amount of time (in days) students are in front of computers

Whole class demonstration

One student using one computer

Group using one computer

Learning station or activity centers use

Other \_\_\_\_\_

Method of instruction. Please assign a percentage to your use of the Exploring Life chapter materials in your classroom. For example, for 90%, enter 90.

Lecture

Hands-on activities

Discussion

Demonstration

Other \_\_\_\_\_

Other \_\_\_\_\_

Which Exploring Life activities did you use in your classroom?

Which Exploring Life activities did you not use with your students?

Describe in detail why you did not use these activities?

Briefly describe other activities you used with the Exploring Life materials?

Why did you incorporate these materials?

Describe the assessments you used.

Describe in detail your students' reactions to the Exploring Life materials.