[redacted]

No. A-278

MECC

The Living Cell

Instructional Computing Courseware
for **Apple**® II Series Computers

This manual is compatible

with

The Living Cell disk

Version 1.x

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The living cell [computer file]. — Version 1.0.

1 computer disk ; 3 1/2 in. + 1 manual.
System requirements: Apple II series computers; 128K RAM; ProDOS; BASIC; 1 disk drive; monochrome or color monitor.
Title from title screen.
Edition statement from disk label.
Copy-protected.
Audience: Grades 7-12.
Issued also on 5 1/4 in. computer disk.
Summary: A simulation that enables students to increase their knowledge and conceptual understanding of the equilibrium that cells maintain with their environment. Students investigate cell respiration and active transport by assuming the role of the cell membrane and regulating the flow of seven substances into and out of the cell.
"A-278"— Disk label.
1. Biological transport—Regulation—Software.
2. Biological transport—Software. I. Minnesota Educational Computing Corporation.
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TABLE OF CONTENTS

INTRODUCTION

The Living Cell is designed to help students investigate the equilibrium that cells maintain with their environment (homeostasis), cell respiration (aerobic and anaerobic), and transport (specifically active transport). The product is designed for teacher-centered demonstrations as an "electronic chalkboard" in a single-computer classroom. It is, however, also well suited for individual, small-group, or large-group student explorations in a computer lab. The programs are meant to be integrated into classroom presentations, textbook chapters, and laboratory investigations on the topics of active and passive transport, homeostasis, and aerobic and anaerobic respiration.

The Living Cell includes two instructional programs, **Living with Oxygen** and **Living Without Oxygen**, to enable students to increase their knowledge and conceptual understanding of the dynamic processes that take place in a living cell. Specifically, the programs simulate those functions that actively take place in the cell membrane as it attempts to maintain a dynamic equilibrium with its environment. The major focus of the simulation, active transport, is a key process that cells have at their disposal to help maintain a constant internal environment.

The Living Cell is an open-ended, unguided, learning environment in which students investigate the movement of substances into and out of the cell. Students constantly find themselves challenged to create their own models by asking "what would happen if?" questions to determine which substances to transfer and how much of them to transfer in order to keep the cell alive long enough for it to mature and divide into two daughter cells.

Living with Oxygen has three simulations. The students are required to maintain an appropriate balance of seven substances: glucose, potassium ions, sodium ions, chloride ions, water, waste, and oxygen. In Constant Environment, the cell is in a medium that does not change in response to the cell's metabolic processes. Students must regulate seven substances in order to be successful. In Controllable Environment, the cell is in a medium that responds to the cell's own metabolic processes. Students must regulate the substances in both the cell and the cell medium in order to be successful. In Uncontrollable Environment, the cell is in a sealed medium that responds to the cell's own metabolic processes. Students find that they can regulate the substances in the cell, but they *cannot* regulate the medium the cell is in. Success in this simulation is measured in terms of efficiency, that is, the number of generations that remain alive.

Living Without Oxygen enables you to engage students in the problem-solving processes inherent in keeping a cell alive in an anaerobic environment. The simulation assumes that the cell lives in an unchanging environment (medium). The students are required to maintain an appropriate balance of six substances: glucose, potassium ions, sodium ions, chloride ions, water, and waste.

It is assumed that students will receive preparation before and guidance while using ***The Living Cell***. This product is designed to emphasize and support the use of science process skills as well as to provide a channel for learning and understanding recommended basic concepts and principles. The goal is that these programs will either lead to or follow from student-centered laboratory investigations dealing with cellular processes, especially the movement of substances across a membrane and aerobic and anaerobic respiration. Thus, while the product is firmly grounded in recommended content, it also supports a strong process orientation.

DESCRIPTION

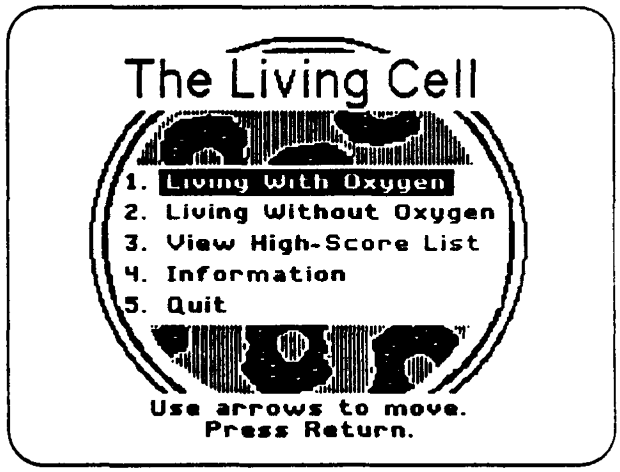
The Living Cell is a set of easy-to-use simulations that enables students to get a first-hand experience of a cell's struggle for life. In these simulations, the student assumes the role of the cell's membrane, regulating the flow of substances into and out of the cell. The student's immediate objective is to maintain the life of the cell until it is mature enough to divide into two daughter cells. The student's long-term goal is to maintain life through as many generations of daughter cells as possible. It is expected that teachers will use these programs as a part of their classroom presentations on active and passive transport and on cell respiration.

Curriculum Area:	Biology, Life Science
Subject:	Aerobic and Anaerobic Respiration
Topic:	Active Transport
Type:	Discovery-Learning Simulation
Grade Range:	7-12
Operational Mode:	Individual Instruction, Large-Group Demonstration
Hardware:	Requires an Apple II series computer with at least 128K of memory and one disk drive; a color monitor is optional, but recommended.

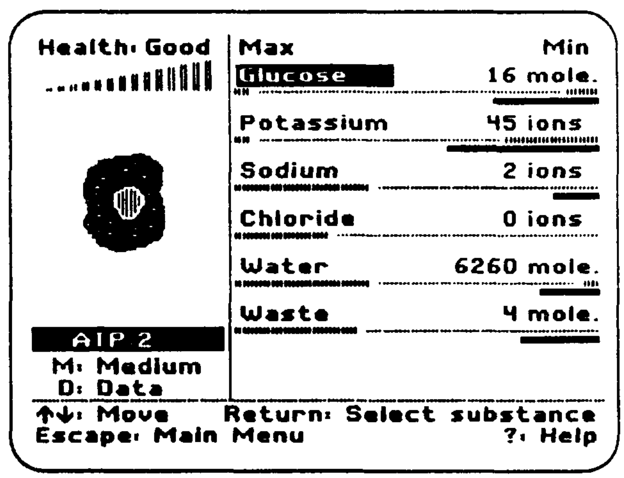
THE PROGRAMS AT A GLANCE

This section provides a general description of the two programs included in ***The Living Cell***. For information about specific programs, see the Table of Contents. Each program has a similar screen format and method of interaction. To begin using one of these programs, place the disk in the disk drive, turn on the computer, and proceed to the main menu.

Main Menu



The main menu displays five options. Option 1 begins the **Living with Oxygen** program. Option 2 begins the **Living Without Oxygen** program. Option 3 presents a list of the highest scores. Option 4 provides a program description and MECC product information. Option 5 ends the current session of ***The Living Cell.*** To continue with this walk-through, use the arrow keys to highlight Option 1 or 2 and press Return.



After selecting Option 1, **Living with Oxygen**, the program displays a second menu (shown here) with three options: Constant Environment, Controllable Environment, and Uncontrollable Environment. The first option allows students to regulate the substances in the cell as well as view those in the cell's constant environment. The second option allows students to view *and* to regulate the substances in the cell as well as those in the cell's environment. The third option allows students to view, but *not* to regulate the substances in the cell's changing environment. When the program screen appears, the students are ready to begin.

When Option 2, **Living Without Oxygen,** (main menu) is selected, an introductory screen appears followed by the program screen (shown here). When the program screen appears, the students are ready to begin.

THE PROGRAMS AT A GLANCE (continued)

Program Interaction Screen

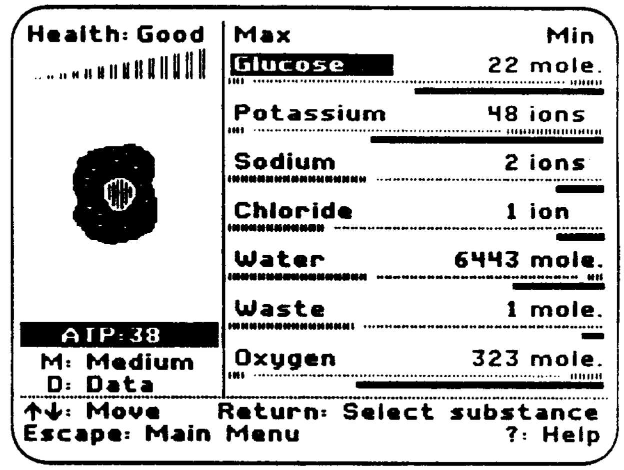
Each program has a similar screen format and method of interaction, and each program interaction screen is divided into several distinct areas. What follows is a brief description of the concentration-indicator bars on the right side of the screen.

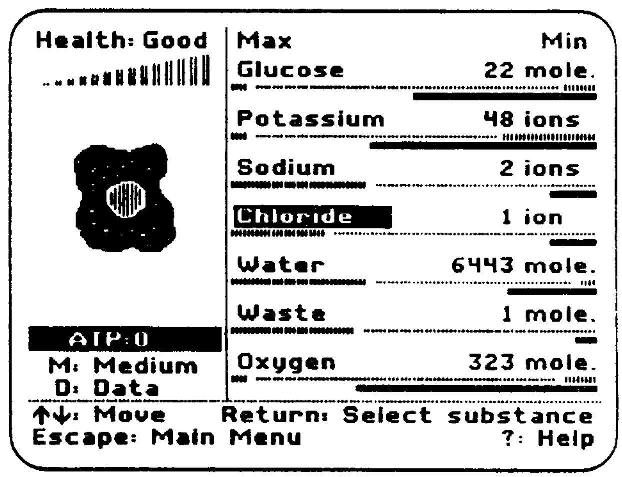
Concentration-Indicator Bars
The right side of the screen displays six or seven horizontal sets of concentration-indicator bars. These indicator bars represent the substances (variables) that students can adjust. Each concentration-indicator bar includes the following information:

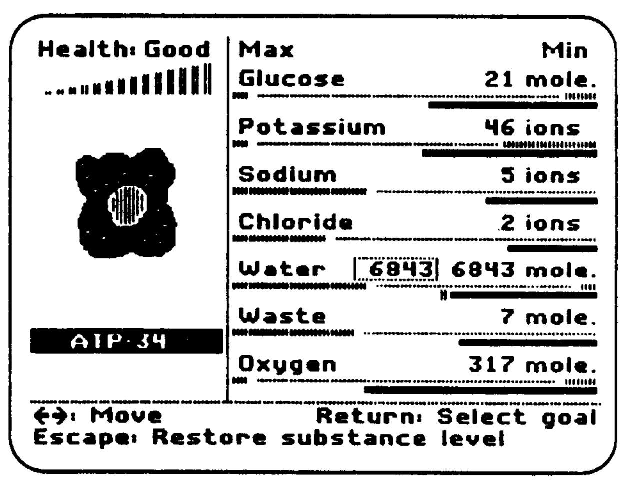
- the name of the adjustable substance;
- the current number of molecules or ions;
- the sliding concentration-indicator bar (white);
- the safe concentration zone (green); and
- the maximum and/or minimum alert zones (orange).

Only one substance can be selected and adjusted at a time. Select one of the substances by using the Up- or Down-Arrow Keys to move the cursor (highlighting a substance name) and press Return. This causes two things to happen:

- a marker (violet) appears on the end of the concentration-indicator bar, and
- a box (violet) appears showing the current concentration of that substance.



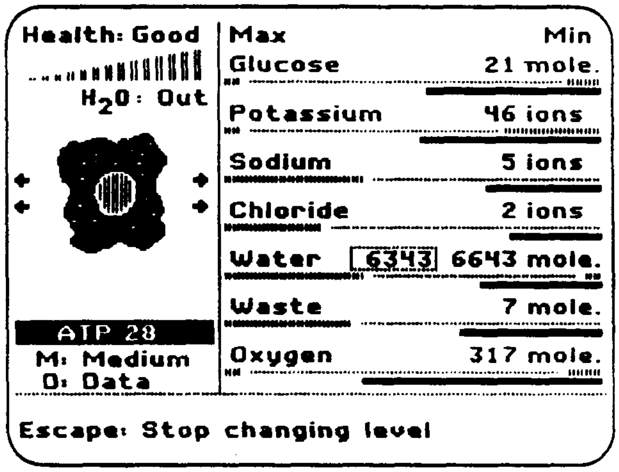




THE PROGRAMS AT A GLANCE (continued)

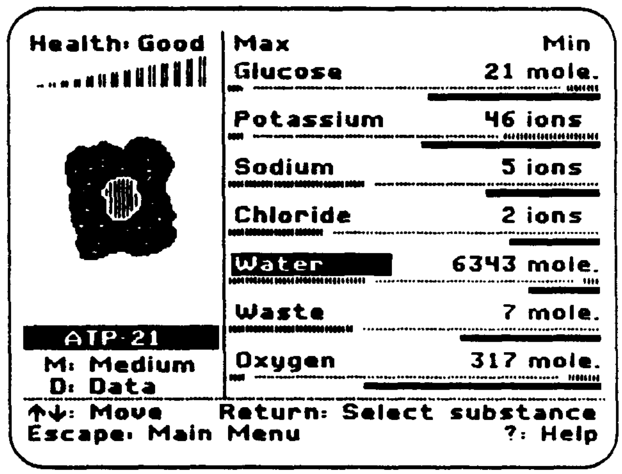
Program Interaction Screen (continued)

Change Concentrations
You begin changing the concentration of a substance by using the Right- or Left-Arrow Keys to move the concentration-indicator marker. The newly selected concentration can be read in the box above the marker. When the desired new concentration is acceptable, press Return. The concentration will then be adjusted one increment at a time.



When the Return Key has been pressed, the following events occur:

- the cellular processes begin increasing or decreasing the amount of substance as indicated;
- the left end of the indicator bar will move to the location of the marker;
- the current concentration number (right side) will increase or decrease appropriately until it matches the number in the box; and
- the other concentration-indicator bars will also change as those substances automatically adjust as a result ofcellular respiration processes.



When the desired concentration is reached, the box and marker will disappear and students can make another selection and adjustment.

Note: An indicator bar may increase or decrease during or immediately following the movement of the indicator bar to your goal. This indicates that the substance has increased or decreased due to cell activity in the process of adjusting to the new level.

Note: Pressing Escape during the concentration-changing process stops the process and returns the name-highlighting cursor.

THE PROGRAMS AT A GLANCE (continued)

Program Interaction Screen (continued)

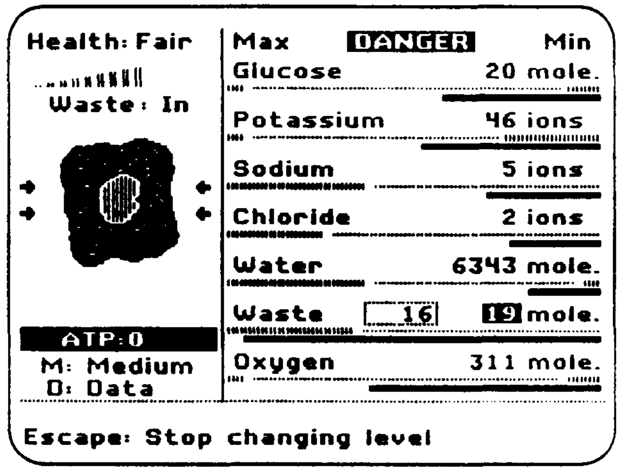
The left side of the screen displays four information areas: a health meter, an animated cell graphic, an ATP meter, and a command key display.

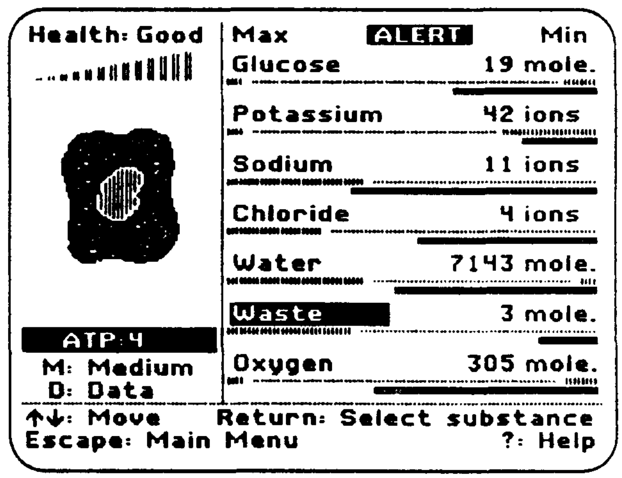
Health Meter
The health meter changes as the general health of the cell changes. A one-word health description (Good, Fair, Poor, Dying) is displayed above the health-indicator bar.

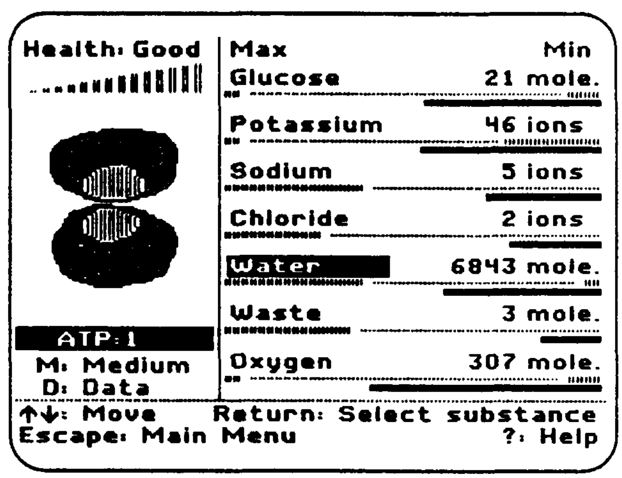
At the top of the right side of the screen, the word "ALERT" is displayed when one or more substance is near or at the minimum or maximum end of its acceptable range. The word "DANGER" is displayed when the situation has reached a critical state (i.e., when the cell is dying).

Cell Graphic
The graphic of a generalized cell changes interactively with concentration adjustments that occur in the cell. These changes may have been made directly or indirectly by the students. Other changes take place periodically, such as the movement of water into the cell from the medium. The cell increases or decreases in size to indicate its general health and maturity. It divides into two daughter cells at maturity, or it may shrivel and die.

ATP Meter
The ATP (adenosine triphosphate) meter displays the number of ATP molecules (energy units) that are currently available. The meter displays the number of ATP molecules available to the cell. When the meter reaches zero, more oxygen and glucose will be used to produce additional ATP. Two ATP molecules are gained from each glucose molecule in anaerobic respiration; 38 ATP molecules are gained in aerobic respiration.







THE PROGRAMS AT A GLANCE (continued)

Program Interaction Screen (continued)

Additional program commands provide students with several options while using these programs. These commands are displayed below the cell graphic and at the bottom of the screen. A brief description of those program options are given below.

Cell and Medium Interaction Screen Options
In **Living with Oxygen**, students can switch between two interaction screens. The Cell Screen displays a large cell. The concentrations shown and changed on this screen are those of the cell's internal environment. The Medium Screen displays a small cell. The concentrations shown and changed on this screen are those of the cell's external environment. While viewing the Cell Screen, the Medium Screen can be viewed by pressing the "M" Key. Pressing the Space Bar or Escape (Esc) Key, while viewing the Medium Screen, returns the students to the Cell Screen.

Help Option
The Help Option is available whenever the "?: Help" command is displayed at the bottom of the screen. Pressing the "?" Key enables students to review some of this simulation's basic assumptions.

Escape Option
The Escape command is displayed at the bottom of the screen along with its destination. Press the Escape Key to quit the program at any time.

Data Option
The Data Option (press the "D" Key) enables students to review previous cell concentrations. Concentrations are recorded at regular intervals. The chart displays data from the most recent 28 events. After that, the data from the 29th event replaces the data from the first event and so on. The data are erased at the beginning of each new cell generation and not saved to disk. The data screens can, however, be printed (see Management Options).

Cell Concentration Data

	Interval			
Substance	5	4	3	2
Glucose mole.	25	26	27	28
Potassium ions	37	39	41	43
Sodium ions	12	9	6	3
Chloride ions	7	6	5	4
Water mole.	8020	7620	7220	6820
Waste mole.	27	21	15	9
ATP Level	38	34	38	34
Oxygen mole.	248	254	260	266

←→: Scroll between screens
Escape: Return to cell P: Print

Printing Option
Data screens can be printed by pressing the "P" Key whenever the "P: Print" command is displayed at the bottom of the data screen. Use the Management Options to correctly set the program to be used with your printer (see Management Options and Printer Options, both on page 15).

THE PROGRAMS AT A GLANCE (continued)

Goals and Assumptions

The Students' Task
While using the simulation, the students' immediate objective is always to keep the cell alive and healthy. A long-range objective is to keep the cell alive until it can divide into two daughter cells. The ultimate goal is to see how many times the process can be repeated.

The simulation begins when the cell-interaction screen appears. At that point, the cell has begun burning glucose and other cellular processes are operating. When the program begins, the students are thrust into the role of the cell membrane. It is their responsibility to regulate the flow of substances into and out of the cell. If nothing is done, the cell will die.

Simulation Assumptions

- Extra-cellular concentrations may be held constant or allowed to change.
- Glucose enters the cell by way of a molecule-carrier mechanism.
- All metabolic energy in these cells is derived from oxidizing glucose.
- Glucose, oxygen molecules, and energy units are used:
  - to remove waste;
  - to operate the sugar carrier complex;
  - for ion transport; and
  - for water removal.
- Since "living" cells are complex, some operations in this simulation occur on a regular basis in addition to user-commanded operations. They may include:
  - metabolic energy depreciation;
  - energy for other miscellaneous functions such as preparation for reproduction; and
  - waste build-up from respiration.
- Daughter cells inherit the same concentrations the parent cell had before dividing.
- The concentrations given in these programs are relative numbers.
- All other factors of life and death are ignored.

DESCRIPTION

Living with Oxygen enables students to get a first-hand experience of an aerobic cell's struggle for life. In this simulation, the student assumes the role of the cell's membrane regulating the flow of substances into and out of the cell. There are seven substances to control: chloride, glucose, oxygen, potassium, sodium, waste, and water.

The **Living with Oxygen** program provides three cell-environment options.

1. The Constant Environment simulation offers the students the ability to regulate the changing concentrations of substances in the cell, while those in the cell's environment (medium) remain constant.

2. In Controllable Environment, the cell's environment changes as the cell itself changes. The simulation offers the students the ability to regulate the changing concentrations of substances in the cell as well as those in the environment.

3. In Uncontrollable Environment, the cell's environment changes as the cell itself changes. While the concentrations in the environment can be viewed, however, the simulation does *not allow* the student to regulate the changing concentrations of substances in the environment.

In all three programs, the student's immediate objective is to maintain the cell until it is mature enough to divide into two daughter cells while the long-term goal is to maintain life through as many generations of daughter cells as possible.

A Help Option provides basic information about the simulation (see page 7). For specific product instructional and hardware configurations, see page 2.

LEARNING OBJECTIVES

When using this program, students will be able to:

- control variables and observe their effect on the life of a cell;
- collect, organize, analyze, and interpret data;
- apply the knowledge gained to successfully maintain the life of a simulated cell;
- compare aerobic and anaerobic respiration in terms of energy units (ATP);
- describe the complex dynamics of cellular respiration;
- explain that the cell membrane is semi-permeable; and
- explain and compare active transport and passive transport.

PROGRAM HIGHLIGHTS

The **Living with Oxygen** program provides three cell environment options: a Constant Environment, a Controllable Environment, and an Uncontrollable Environment.

Constant Environment

After selecting **Living with Oxygen** from the main menu and selecting Constant Environment from the next menu, the Constant Environment simulation begins. When the cell interaction screen appears, the cell begins to burn glucose and the other cellular processes begin operating. Students are now ready to begin.

At that point, students are thrust into the role of the cell membrane with the responsibility to regulate the flow of substances into and out of the cell. If nothing is done, the situation will degrade and the cell will die.

In addition to the presence of oxygen, the Constant Environment simulation assumes that the condition of the cell's immediate environment will not be degraded as a result of the processes of cellular respiration. The concentrations of the substances in the medium the cell lives in will always remain constant throughout the simulation and the concentrations cannot be changed.

In the Constant Environment simulation, students will find that the cell's "metabolism" speeds up as they become more proficient at maintaining a healthy cell until it divides into two cells. The simulation speeds up slightly after each of the first five divisions until it matches the speed in the other two aerobic simulations. This pace increment is only present in the Constant Environment simulation.

Although the students can view the concentrations in the cell's constant environment, they need to focus their attention on the cell. To be successful, students need to control the concentration of the substances in the cell. Students are required to control the concentrations of seven substances: chloride, glucose, oxygen, potassium, sodium, waste, and water. As always, success is measured in terms of the number of generations of daughter cells that are produced.

While viewing the Cell Screen, the Medium Screen can be viewed by pressing the "M" Key. Pressing the Space Bar while viewing the Medium Screen returns the students to the Cell Screen. Both screens have the same screen format.

Note: While viewing the medium-interaction screen, the life processes in the cell are not continuing. Students will find that the concentrations of the seven substances in the cell have not changed when they press the Space Bar to switch back to a view of the cell-interaction screen.

Within the cell, changes in the concentration of the seven substances take place interactively. Also, since the cell is "living," some changes take place automatically, whether or not the students elect to make a change. In this program, however, changes within the cell do not cause concentration changes in the cell's environment.

PROGRAM HIGHLIGHTS (continued)

Controllable Environment

In addition to the presence of oxygen, the Controllable Environment simulation assumes that the condition of the cell's immediate environment *will be* changed as a result of the processes of cellular respiration.

As a result, students need to focus their attention and control on both the cell's concentrations and its environment in order to be successful. Students are required to control the concentrations of seven substances: chloride, glucose, oxygen, potassium, sodium, waste, and water. As always, success is measured in terms of the number of generations of daughter cells that are produced.

While viewing the Cell Screen, the Medium Screen can be viewed by pressing the "M" Key. Pressing the Esc Key, while viewing the Medium Screen, returns the students to the Cell Screen. Both screens have the same screen format and method of interaction.

Note: While viewing or adjusting the medium, the life processes in the cell are not continuing. Students will find that the concentrations of the seven substances in the cell have not changed when they press the Esc Key to switch back to a view of the cell-interaction screen.

Within the cell, changes in the concentration of the seven substances take place interactively. Also, since the cell is "living," some changes take place automatically, whether or not the students elect to make a change. Changes within the cell automatically cause concentration changes in the cell's environment whether the medium-interaction screen is being viewed or not.

PROGRAM HIGHLIGHTS (continued)

Uncontrollable Environment

After selecting **Living with Oxygen** from the main menu and Uncontrollable Environment from the second menu, the Uncontrollable Environment simulation begins. When the cell-interaction screen appears, the cell begins to burn glucose and the other cellular processes begin operating. Students are now ready to begin.

At that point, students are thrust into the role of the cell membrane. It is their responsibility to regulate the flow of substances into and out of the cell. If nothing is done, the situation will degrade and the cell will die.

In addition to the presence of oxygen, the Uncontrollable Environment assumes that the condition of the cell's immediate environment is sealed and *will be* changed as a result of the processes of cellular respiration. As a result, students need to focus their attention on both the cell and its environment.

Note: While students can select the medium-interaction screen and view the ever-changing concentrations of the substances in the cell's environment, the arrow keys are *not* active and the concentrations *cannot* be changed.

To be successful, students need to control the concentration of the substances in the cell as *efficiently* as possible while remaining aware of the ever-changing environment. Students are required to control the concentrations of seven substances: chloride, glucose, oxygen, potassium, sodium, waste, and water.

Note: Success is measured in terms of the greatest number of generations of daughter cells that can be produced before the environment becomes unable to maintain life. Students will find that the most critical factor in the environment is oxygen. The greatest number of generations that can be produced is fewer than ten and depends on the simulation's random starting point.

While viewing the Cell Screen, the Medium Screen can be viewed by pressing the "M" Key. Pressing the Space Bar, while viewing the Medium Screen, returns the students to the Cell Screen. Both screens have the same screen format and method of interaction.

Note: While viewing the medium-interaction screen, the life processes in the cell are not continuing. Students will find that the concentrations of the seven substances in the cell have not changed when they press the Space Bar to switch back to a view of the cell-interaction screen.

Within the cell, changes in the concentration of the seven substances take place interactively. Also, since the cell is "living," some changes take place automatically, whether or not the students elect to make a change. Changes within the cell automatically cause concentration changes in the cell's environment whether the medium-interaction screen is being viewed or not.

LIVING WITHOUT OXYGEN

DESCRIPTION

Living Without Oxygen enables students to get a first-hand experience of an anaerobic cell's struggle for life.

In this simulation, the student assumes the role of the cell's membrane, regulating the flow of substances into and out of the cell. There are six substances to control: chloride, glucose, potassium, sodium, waste, and water.

In the **Living Without Oxygen** simulation, the environment in which the cell is immersed always remains constant.

The student's immediate objective is to maintain the cell until it is mature enough to divide into two daughter cells. The student's long-term goal is to maintain life though as many generations of daughter cells as time allows.

A Help Option provides basic information about the simulation (see page 7). It is expected that teachers will use this program as a part of their classroom presentations on active and passive transport and cellular respiration. It can, however, also be used by individuals or small groups of students as a resource to provide them with an opportunity to review the concepts. For specific product instructional and hardware configurations, see page 2.

LEARNING OBJECTIVES

When using this program, students will be able to:

- control variables and observe their effect on the life of a cell;
- collect, organize, analyze, and interpret data;
- apply the knowledge gained to successfully maintain the life of a simulated cell;
- compare aerobic and anaerobic respiration in terms of energy units (ATP);
- describe the complex dynamics of cellular respiration;
- explain that the cell membrane is semi-permeable; and
- explain and compare active transport and passive transport.

PROGRAM HIGHLIGHTS

After selecting **Living Without Oxygen** from the main menu, the cell-interaction screen appears, the simulation is running, and the students are ready to begin. When the cell-interaction screen appears, the cell begins to burn glucose and the other cellular processes begin operating.

At that point, students are thrust into the role of the cell membrane, with the responsibility to successfully regulate the flow of substances into and out of the cell. If nothing is done, the situation will degrade and the cell will die.

In addition to the lack of oxygen, the **Living Without Oxygen** program assumes that the condition of the cell's immediate environment will *not* be degraded as a result of the processes of cellular respiration. The concentrations of the substances in the medium in which the cell lives will always remain constant throughout the simulation. Because of the energy constraints, the anaerobic simulation runs about one-fifth slower than the fastest pace of the aerobic simulation.

As a result, students can focus all of their attention on attempting to successfully control the concentration of the substances in the cell itself. Students are required to control the concentrations of six substances: chloride, glucose, potassium, sodium, waste, and water.

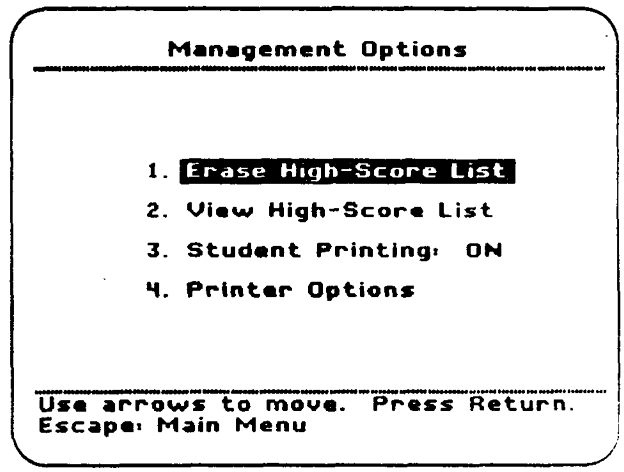
While using this simulation, students have the Medium Option available to them. Pressing the "M" Key switches the view from the cell-interaction screen to a view of the medium-interaction screen. When the medium screen is displayed, however, they will find that the concentrations of the six substances in the cell's environment do not change; the arrow keys are not active; and they cannot make any changes to the concentration of the six substances displayed on the concentration indicator bars.

Note: While viewing the medium-interaction screen, the life processes in the cell are not continuing. Students will find that the concentrations of the six substances in the cell have not changed when they press the Space Bar to switch back to a view of the cell-interaction screen.

Within the cell, changes in the concentration of the six substances take place interactively. Also, since the cell is "living," some changes take place automatically, whether or not the students elect to make a change and whether or not the cell-interaction screen is being viewed.

MANAGEMENT OPTIONS

You can access the Management Options by pressing Control-A (hold the Control Key down while pressing the "A" Key) while viewing the main menu.



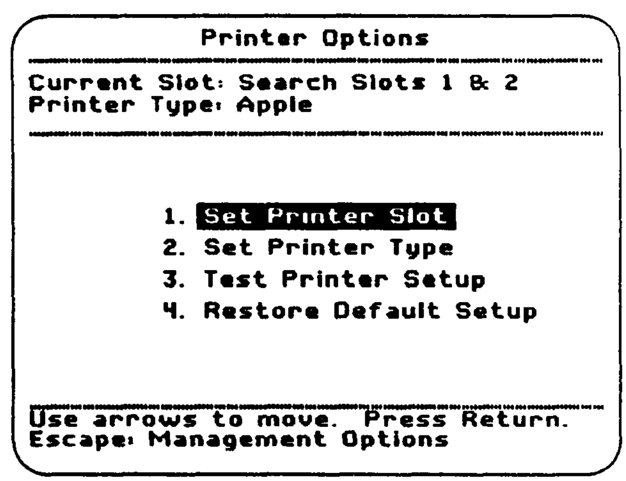
Printer Options (Option 4) enable you to set the product to work with your printer and to decide whether or not to enable the students to print the data screens. If you decide not to enable students to print the data screens, the "P: Print" command will not appear on the data screen.

Any changes you make will remain in effect until you return to the Management Options to change these options again.

PRINTER OPTIONS

This product is initially set to work with a standard Apple printer card located in either Slot 1 or Slot 2. If you have this setup, you do not need to do anything further. If your printer uses another setup, or if you want to select or use special commands, use Printer Options.

Printer Options appears on the ***The Living Cell*** Management Options menu. You may access the Management Options from the main menu by typing Control-A.



PRINTER OPTIONS (continued)

Selecting Option 4, **Printer Options,** from the Management Options menu, takes you to the Printer Options menu. The current printer settings are shown at the top of the screen.

```
                Printer Options
Current Slot: Search Slots 1 & 2
Printer Type: Apple

        1. Set Printer Slot
        2. Set Printer Type
        3. Test Printer Setup
        4. Restore Default Setup

Use arrows to move.  Press Return.
Escape: Management Options
```

Option 1, **Set Printer Slot,** allows you to specify the slot in which your printer interface card is located. If you are using an AppleShare® Network, choose Option 8. This setting will automatically select the correct printer slot for each computer on the network.

```
                Set Printer Slot
Current Slot: Search Slots 1 & 2
Printer Type: Apple

        1. Slot 1
        2. Slot 2
        3. Search Slots 1 & 2
        4. Slot 4
        5. Slot 5
        6. Slot 6
        7. Slot 7
        8. AppleShare (R) Network
Use arrows to move.  Press Return.
Escape: Printer Options
```

Option 2, **Set Printer Type,** allows you to select the type of printer you are now using—either an Apple, an Epson, or a special configuration.

Apple Printer allows you to choose one or more of the options shown in the **Apple Printer** screen. You are not able to select both semi-condensed and condensed or add line feeds and suppress line feeds at the same time. Selecting Default clears from the program all other customized options or special commands. To ensure that the printer clears all previous commands, turn the printer off, wait several seconds, and then turn it back on again before printing.

Epson Printer allows you to choose one or more of the options shown in the **Epson Printer** screen. You are not able to select both emphasized and compressed at the same time. Selecting Default clears from the program all other customized options or special commands. To ensure that the printer clears all previous commands, turn the printer off, wait several seconds, and then turn it back on again before printing.

PRINTER OPTIONS (continued)

Special Configuration allows you to enter commands that enable certain types of printers to operate. These special commands are listed in the manufacturer's printer manual.

Note:
- Do not set up the printer to use a proportional font. This setting will cause printed student records to be formatted incorrectly.
- To enter special commands, type the exact characters required. When finished, type -Escape to end.

Option 3, **Test Printer Setup**, prints out all of the keyboard characters. If these characters are not printed correctly, check the settings on your printer or interface card, check to see whether your printer has been connected correctly, or refer to your interface card manual for special commands.

Note: To ensure that previous printer commands are cleared, turn the printer off, wait several seconds, and then turn it back on again before performing this test.

Option 4, **Restore Default Setup**, returns all printer settings to their original state. The original printer setup provides a search of Slots 1 and 2 for a default Apple printer.

Note: All changes made to the Printer Options settings are saved on the disk and are permanent until you use the Printer Options again to change the printer settings.

BACKGROUND INFORMATION

Most animal cells, unlike plant cells, are totally dependent on the environment in which they exist for the materials that they need to maintain life. Animal cells cannot make their own food. All cells, however, draw materials from their environment and return other materials to it. They must carry on a constant effort to maintain a proper balance getting and keeping the materials that they need and getting rid of or keeping out those materials that may be harmful.

The natural physical forces of diffusion can be both a blessing and a problem to the cell. The forces of diffusion cause materials to move from an area of high concentration to an area of low concentration. And, in the case of cells, the process of diffusion ends when the concentration of each kind of material is equal on both sides of the membrane. As a result, some materials that the cells use internally are replaced naturally by diffusion, and/or some materials that are generated internally migrate by diffusion across the membrane out into the cell's environment. Diffusion of materials across the cell's membrane is called passive transport and does not consume any of its precious energy supply.

The problem arises when the cell needs to maintain an internal concentration of some material that is lower than that of its environment or vice versa. To maintain a balance of this sort, the cell must expend energy in order to move these materials against the concentration gradient, that is, to move the material from an area of low concentration to an area of high concentration. This process is called active transport and it requires the cell to expend some of its energy supply.

In addition to active transport, the cell needs to expend energy for other life processes, such as growth, repair, maintenance, and reproduction. In animal cells the primary source of energy to do all these activities is the chemical bonds of glucose molecules. The energy that binds the atoms of the glucose molecule together comes from sunlight captured by plants as part of the photosynthetic process of which glucose is a product.

In the photosynthetic process, energy from the sun is combined with the atoms of water and carbon dioxide to form glucose molecules. In the respiration process, the arrow in the equation is reversed. As a part of the respiration process, the cell removes the atoms of the glucose molecule in a controlled fashion, releasing and then capturing that energy. The energy released in the breakdown of the glucose molecule is used in the formation of energy-rich phosphate bonds.

Adenosine triphosphate (ATP) is formed when a third, terminal, high-energy phosphate group is bonded to adenosine diphosphate. ATP serves as the energy-storage molecule for the cell. The captured energy is stored in the bonds holding the phosphate groups together. The energy is released to perform cellular activities when the terminal bonds are broken.

The process of releasing energy from the glucose molecule is called respiration. There are two kinds of respiration: aerobic (with the use of oxygen) and anaerobic (without the use of oxygen). Anaerobic respiration is also called fermentation. Both kinds of respiration begin by breaking the glucose molecule into two smaller molecules call pyruvic acid. This process is called glycolysis.

BACKGROUND INFORMATION (continued)

In anaerobic respiration (fermentation), the further break down of pyruvic acid molecules can follow one of two paths. In alcohol fermentation, the pyruvic acid molecules are converted to ethyl alcohol, carbon dioxide, and ATP. In lactic-acid fermentation, the pyruvic-acid molecules are converted to lactic acid and ATP. Both anaerobic processes produce a net gain of two ATP molecules. Alcohol fermentation occurs in cells such as yeast. Lactic-acid fermentation occurs in animal cells where insufficient oxygen is available.

In aerobic respiration, a further breakdown of pyruvic-acid molecules takes place in a series of steps called the Krebs cycle. The events of the Krebs cycle take place in the mitochondria. In the series of reactions that follow, each pyruvic-acid molecule is converted to carbon dioxide, water, and a large amount of energy. The reactions of the Krebs cycle produce an additional two ATP molecules. As a result, in aerobic respiration, glycolysis and the Krebs cycle combine to produce a net gain of four ATP molecules for each glucose molecule entering the process.

The Krebs cycle also produces 12 carrier molecules. Twenty-four hydrogen atoms and high-energy electrons are transferred by these molecules and move through an electron-transfer chain. The energy held by these electrons is carefully released until 34 ATP molecules are formed. Oxygen is the final hydrogen/electron receiver and ingredient in the formation of water. As a result, glycolysis, the Krebs cycle, and the electron-transport chain produce a net gain of 38 ATP for each glucose entering the process.

The Krebs cycle is also linked to the respiration of fats and nitrogen-based compounds. Not all pyruvic acid enters the Kerbs cycle. It is also involved in the formation of amino acids, fatty acids, and high-energy phosphate bond enzymes.

USE IN AN INSTRUCTIONAL SETTING

The Living Cell is designed to be used to help students investigate and gain a conceptual understanding of the equilibrium or homeostasis that cells maintain with their environment.

A quick look at the textbook correlations (pages 30-32) will show that ***The Living Cell*** can be used in connection with instruction on a number of related topics, some of which are listed below.

- Cell respiration
- Aerobic respiration
- Anaerobic respiration
- The general equation for aerobic and anaerobic respiration reactions
- Fermentation
- Active transport
- Passive transport
- Diffusion
- Osmosis
- Sodium-potassium pump
- ATP (adenosine triphosphate)
- Chemical energy
- Homeostasis

Teachers may find, using a single computer and a large-screen monitor as an "electronic chalkboard," that the program can be put to best use as an integral part of a series of introductory lessons. In a large-group classroom setting, the level of difficulty can easily be selected to match the needs and abilities of the group of students. A simple set of group dynamics can be used to involve sub-groups or individual students in the decision-making process as well as to evaluate the appropriateness of each correct or incorrect response.

The program could also be made available as an auxiliary learning experience at a single-computer learning station or in a computer-lab setting, to be assigned following a classroom presentation and/or as a part of make-up work for those students who may have missed the lesson. In preparation for individual or computer-laboratory use, refer to the Management Options to set the product to work with your printer and/or to view, print, or erase the High-Score List (see page 15).

All instructional material is most powerful when used with other educational experiences rather than when used in isolation. ***The Living Cell*** is specifically designed to support and complement actual hands-on laboratory investigations. The programs encourage active intellectual involvement by providing an open and creative environment in which students can develop and apply problem-solving strategies by emphasizing the development and use of appropriate science inquiry skills and by capitalizing on the students' natural curiosity while learning scientific content.

USE IN AN INSTRUCTIONAL SETTING (continued)

The Living Cell is easily tailored to meet your specific instructional objectives. The teacher-student-computer interaction is always more effective (i.e., leading to achievement by the largest number of students) when your students are thinking throughout the lesson. The way you guide the inquiry process and student interaction is essential to high levels of student involvement and learning. To maintain a high level of student interaction during a demonstration, consider a lesson format that includes the processes suggested below.

1. Question students to find out what they already know about the dynamic struggle in each cell to maintain an equilibrium with its environment, the functions of the cell membrane, and active transport in particular. Discuss any misconceptions they may have and provide the background information necessary for them to be able to understand the basic concepts presented in the programs.

   Some student questions may include: What is the cell theory? Why is the cell theory important? What are the major parts of a cell and what are their functions? How is a cell membrane important to a cell? What is diffusion? What is osmosis? What is passive transport and how does it differ from active transport? What is a concentration gradient? What determines whether or not a substance passes through a membrane? What energy source does the cell use to carry out active transport? What is the role of ATP in the energy requirement of the cell? What is glycolysis? What is the Krebs cycle?

2. Clearly state the instructional objectives and results that you expect all students to have achieved by the end of the lesson.

   Be specific. For example, state "By the end of today's lesson, you will be able to explain how a living cell keeps itself alive and in balance with its immediate environment."

   The science inquiry skills involved in planning and carrying out an investigation and evaluating the results should also be included in your objectives: "By the end of today's lesson, you will be able to explain how a living cell keeps itself alive and in balance with its immediate environment, based on the events you have observed and the data you have collected and analyzed while using ***The Living Cell*** simulation."

3. Through class discussion, involve the students in planning and evaluating some problem-solving methods for keeping a cell alive until it divides into two daughter cells.

   Have the students help you to classify some substances that enter and leave a cell by active or passive transport.

4. Provide the students with a summary of the concepts and principles that have been investigated.

   Have the students volunteer to summarize what they have learned. Have someone write the summarized points on the board as they are being discussed.

USE IN AN INSTRUCTIONAL SETTING (continued)

5. If the students are going to use either of the programs individually or in small groups, you may want to demonstrate the programs before they begin.

   Demonstrate how:
   - to interact with the concentration-indicator bars on the cell-interaction screen;
   - the concentration-indicator bars on the medium-interaction screen function in a similar manner; and
   - to use the data screens to review automatically recorded substance concentrations.

6. The development of the learner's processes often depends upon the teacher's ability to ask effective questions. Be sure to use questions that require students to record and interpret information.

   Present your questions in the form of a problem. Allow time during the investigations for students to digest what is happening and to formulate and ask their own "what happens if?" questions. Call upon the class to suggest ways to determine the answers. Group discussion and decision-making are ways to involve the entire class, proving methods of restating or reinforcing learning that has taken place and feedback on how well students really understand the concepts and principles involved.

7. Have the individual or small groups of students create a report summarizing the investigation and their conclusions.

   Have the students define, explain, demonstrate, or describe the events they have experienced and the processes they have investigated in their own words.

   You can evaluate whether individual students have met the stated objectives and can check their understanding with unguided practice in the form of a report.

   In particular, check for misconceptions that students may have regarding cell respiration and active transport.

THINKING SKILLS

Using MECC Science Products to Reinforce Core Thinking Skills

The MECC science inquiry products have as their primary goal to provide an environment in which students can learn and reinforce the use of science inquiry or science process skills. This set of skills includes observing, collecting or recording data, organizing data, analyzing data, forming hypotheses or predictions, constructing models, and testing models. The purpose of the scientific method is to provide an organized process for approaching problematic situations and determining solutions.

Each step in the inquiry process is, of course, related to and supported by a web of core thinking skills. A good science observer also displays good focusing skills, information-gathering skills, remembering skills, and so on. A good scientist is, therefore, skilled at both appropriate scientific techniques and appropriate thinking skills.

Even though science inquiry skills and core thinking skills share some terminology, the former specifically relates to what science is and what a scientist does while the latter are life skills necessary for the well-being of everyone in every situation. One can possess science inquiry skills and be a poor scientist because one has poor thinking skills. Alternatively, having good thinking skills alone does not make one a good scientist. Therefore, science inquiry skills and core thinking skills, though closely intertwined, really present the teacher with two quite different sets of teaching objectives.

While the primary goal of the MECC science products is to highlight and reinforce science inquiry skills, the rich environment each product presents is also well-suited to fostering good thinking skills. As a result, these products can easily be adapted by teachers in any subject area to highlight and to reinforce core thinking skills as outlined in the following pages.

When teaching thinking skills with these science products, please keep in mind that, although only one example of the use of a particular thinking skill is correlated to a particular part or use of a program, the same skills can be practiced on many levels and in many aspects of these programs.

Using Computer Software in a Thinking Skills Environment

Teachers are faced with the tremendous task of preparing today's students for tomorrow's world—a world characterized by change in an information-rich environment. Thinking skills are at the heart of this thriving, changing environment, for these are the behaviors students must practice in school and continue to apply for the rest of their lives.

It wasn't long ago that thinking skills were considered exclusive to gifted and enrichment classes. Today, however, thinking skills are viewed as an essential component of the total school curriculum. Developing these skills is the goal of each individual discipline. Many educators have, in fact, come to view thinking skills as perhaps the most basic of the basic skills because they facilitate the acquisition of all other learning.

THINKING SKILLS (continued)

At MECC, we view computer software as a vehicle for fostering students' thinking. Our products are curriculum-based, with thinking skills as a thread within subject areas. This provides an environment with many opportunities for teachers to highlight and reinforce thinking skills.

We believe teachers play a critical role in determining the classroom environment for thinking. Naturally, many teachers have taught thinking skills and will continue to do so, using a variety of strategies. Our commitment is to provide teachers with the materials that help them do their job well: high-quality software that promotes the application of thinking skills.

Our approach to thinking skills reflects what both research and effective classroom practice has shown. That is, the approach that is most effective and appeals to most teachers is one that infuses thinking skills into existing content areas. Educators have told us they are interested in thinking skills as a method used in the instruction of a topic, not as a subject. By infusing thinking skills into existing content areas, MECC products integrate easily into teachers' curricula while providing a rich environment for students to practice skillful thinking. We strive to meet the challenge teachers face in promoting the skills that students need.

If schools are to integrate the teaching of thinking with regular academic instruction, they need to know which aspects of thinking to teach. After exploring the research that has been done in the area of thinking skills, MECC has chosen as a base the *Dimensions of Thinking* framework, published in 1988 by the Association of Supervision and Curriculum Development (ASCD). We chose this framework because it pulls together research and models from a variety of sources and brings the theory to the classroom level, applying it to that environment. In addition to knowing the subject matter that is covered, teachers now can see the specific thinking skills that are challenged within a product.

This section of the manual highlights ways in which teachers can use ***The Living Cell*** to promote thinking skills with their students. The following pages provide examples of how ***The Living Cell*** relates to the ASCD core thinking skills framework. Although only one thinking skill per category is correlated to a specific part of the product, each skill can be practiced on many levels and in many aspects of the product.

We realize the importance of thinking skills in the curriculum. We believe it is essential that students be taught thinking skills so that they have the tools to understand the past, deal with the present, and prepare for the future. We are confident that you will find ***The Living Cell*** of considerable value in your classroom as you foster student thinking.

A Framework for Thinking

The components used in thinking are referred to as *core thinking skills*. This framework defines those skills that appear in the repertoire of the model learner. Each skill selected is documented in research as important to learning or thinking, is teachable, and is valued by educators as important for students to learn.

The core skills of the ASCD framework are listed and defined below with examples of applications within ***The Living Cell***. The skills are neither discrete nor hierarchical. In fact, individual skills draw on other skills and can be used repeatedly in the thinking process. The selected examples are not exhaustive but highlight ways in which these thinking skills are used in ***The Living Cell***.

Source: *Dimensions of Thinking*, Association for Supervision and Curriculum Development (ASCD), 1988.

Definition of Core Thinking Skills Categories	Core Thinking Skills Components	***The Living Cell*** Application
Focusing Skills allow students to attend to selected pieces of information and ignore others. Focusing occurs when students sense a problem, an issue, or a lack of meaning.	**Focusing Skills** • Defining Problems • Setting Goals	In ***The Living Cell***, as students assume the role of scientists, they set out to discover how the balance of a set of substances influences the life of a cell. The programs help the students to focus their attention on variables including chloride, glucose, oxygen, potassium, sodium, waste, and water.
Information-Gathering Skills involve obtaining information and clarifying issues and meanings through inquiry.	**Information-Gathering Skills** • Observing • Formulating Questions	Students create their own experiments and observe the results. The results of each attempt inevitably lead to the formation of "What if?" questions. Students are encouraged to make their own choices and ask their own questions. The results of each experiment are recorded by the program.
Remembering Skills are those activities or strategies that students consciously engage in to store and retrieve information from long-term memory. Activating prior knowledge falls under this category.	**Remembering Skills** • Encoding • Recalling	As the students set out to find patterns, they recall the results of previous trials in order to create new experiments. The knowledge and understanding of active transport gained in the **Living Without Oxygen** program can also be applied in the **Living with Oxygen** program.

Definition of Core Thinking Skills Categories	Core Thinking Skills Components	*The Living Cell* Application
Organizing Skills are used to arrange information so that it can be understood or presented more effectively.	**Organizing Skills** • Comparing • Classifying • Ordering • Representing	While attempting to determine how each variable influences the life of a cell, students keep records of each event, the variable changes, and the results. The information gathered is represented pictorially and numerically and organized in chart form.
Analyzing Skills are used to clarify existing information by examining parts and relationships. Through analysis, students identify and distinguish components, attributes, claims, assumptions, or reasoning.	**Analyzing Skills** • Identifying Attributes and Components • Identifying Relationships and Patterns • Identifying Main Ideas • Identifying Errors	The students set out to determine how six or seven variables influence the life of a cell. They observe and analyze the results of their experiments, identifying trends and patterns. The results of each experiment can be correlated to the physical appearance and general health of the cell.
Generating Skills involve using the students' prior knowledge to add information beyond what is given. Connections between new ideas and prior knowledge are made as new information and ideas are recast into new structures.	**Generating Skills** • Inferring • Predicting • Elaborating	By using the information they have collected, the students can draw conclusions and make predictions about the results of experiments before they are concluded. Students are encouraged to analyze results and to predict the results of new experiments.
Integrating Skills involve putting together the relevant parts or aspects of a solution, understanding, principle, or composition and incorporating this integrated information into a new understanding.	**Integrating Skills** • Summarizing • Restructuring	Throughout the simulation, students observe the results of their experiments. An on-going analysis of their experiments forms a basis for further investigations. The trends and patterns that they discover lead them to a general conceptual understanding of the dynamic and predictable events in a living cell.
Evaluating Skills involve assessing the reasonableness and quality of ideas.	**Evaluating Skills** • Establishing Criteria • Verifying	By repeated investigations, students establish a set of objective criteria for determining what will happen when a substance is moved into or out of a cell. In the open-ended, investigatory environment, they can easily verify the appropriateness of their actions and conclusions.

CLASSROOM ACTIVITIES

Much of the appeal of a biology course lies in the chance of finding out how or why things work. Most of the questions that our students have about how things work biologically and chemically relate to what is going on around them in their everyday world. They are curious about things that are familiar to them as a result of direct experience or as a result of newspaper, magazine, radio, or television news or advertising. To increase interest and motivation, attempt to relate student-centered activities directly to current issues of health, nutrition, physical exercise, medicine, pollution, and so on.

Investigations that demonstrate active transport generally require sacrificing organisms such as frogs, fish, or hamsters and using equipment that may not be a part of the average middle or secondary laboratory. As a result, even though it would be ideal, activities on active transport are not included in this manual. If investigations on active transport are suitable in your situation, many good activities may be found in introductory physiology texts.

In addition to those activities that are already part of your instructional units on cell structure and function, cell respiration, and active and passive transport, the following activities are suggested for your consideration.

Test for alcohol as a by-product of anaerobic respiration (yeast fermentation)

Have the students prepare two flasks and into each add an equal quantity of solution. Into one flask they should add a quantity of a yeast-glucose solution and into the second only a glucose solution. Next, the students should seal the flasks tightly with stoppers and incubate the solutions at about 37°C for several days.

Have the student distill each of the solutions. The alcohol fraction will distill off at about 78°C. Next, they should test the collected distillate for the presence of alcohol by lighting it with a burning splint. The experimental flask, containing the yeast-glucose solution, should test positive by igniting and burning briefly. The control flask, containing only a glucose solution, should produce no flame.

Comparing the by-products of anaerobic and aerobic respiration in yeast

The students should prepare four flasks and into each add an equal quantity of solution. Into two flasks they should add a quantity of a yeast-glucose solution and into the other two a quantity of only a glucose solution.

Next, the students should tightly seal with a stopper one flask containing a yeast-glucose solution (experiment) and one flask containing only a glucose solution (control). Have them seal the other two flasks with two-hole stoppers. Each two-hole stopper should be fitted with a tube connected to an incoming supply of air (oxygen). Students should then incubate all four solutions at about 37°C for several days.

Have the students distill each of the solutions. The alcohol fraction will distill off at about 78°C. Next, they should test the collected distillate for the presence of alcohol by lighting it with a burning splint. The distillate collected from the tightly sealed experimental flask should test positive by igniting and burning briefly. The distillate collected from the aerated experimental flask should not test positive for the presence of alcohol. The control flasks, containing only a glucose solution, should not test positive for the presence of alcohol.

CLASSROOM ACTIVITIES (continued)

The role of plants in the production of oxygen

Have the students use the funnel method of collecting oxygen generated by a sprig of elodea. They should then insert several sprigs of elodea, stem first, into a funnel and invert the funnel and place it into a beaker filled with water. Next, they should invert a test tube filled with water in the same beaker and place the test tube so that the up-ended spout of the funnel is inserted up into the mouth of the test tube.

Next, the students should place the beakers under bright lights until the next day. Students should observe bubbles of gas rising from the elodea and collecting in the up-turned test tubes. Have them test for the presence of oxygen in the test tubes. To do so, they should have a glowing splint ready when they carefully remove the test tube from the beaker and insert the splint into the test tube. There will not be enough oxygen present for the splint to flare up. The students should, however, be able to observe a positive test.

Pathways in photosynthesis and respiration

Have the students investigate the oxygen requirements of respiration in animals. Individual students, or team of two students should begin with two test tubes. In one test tube, they should place one small snail. In the other test tube, they should place one small snail and sprig of elodea. They should then fill each test tube with an equal quantity of aquarium water and seal the tops tightly with rubber stoppers. Tightly sealed plastic bags can be substituted for the test tubes. Place the sealed containers in a bright light, but not in direct sunlight.

The students should find that eventually the lone snail cannot survive without the oxygen that is generated by the plants and added to the snail's environment.

Diffusion of iodine through a membrane

Students start by filling the two test tubes. They should fill one test tube with dilute Lugol's iodine solution and tightly cover the top with a wet semi-permeable membrane (goldbeater's) held on with a rubber band. They should fill the second test tube with a 1% starch-paste solution and tightly cover the top with wet goldbeater's membrane held on with a rubber band.

Next, they should add Lugol's iodine solution to one beaker (one-half filled) and add a 1% starch-paste solution to the second beaker (one-half filled). Then they should invert the test tube filled with the Lugol's iodine solution and place it in the beaker with the quantity of Lugol's iodine solution. They should then invert the test tube with a 1% starch-paste solution and place it in the beaker with the quantity of Lugol's iodine solution.

Students will observe that the iodine molecules can pass through the membrane in either direction; however, the molecules of starch are too large and cannot pass through the membrane in either direction.

CLASSROOM ACTIVITIES (continued)

Diffusion of water (osmosis) through a membrane

Student teams will need a thistle tube, a beaker, a ring stand, and a buret clamp.

To begin, one student will need to hold the thistle tube and place a finger tightly over the opening at the end of the stem. A second student then carefully fills the bulb of the thistle tube with heavy molasses. Next, they should tightly cover the top of the bulb with a wet semipermeable membrane (goldbeater's) held on with a rubber band. They should then quickly inverse the thistle tube so that the bulb is hanging upside down, clamp the thistle tube in the ring stand, and lower the bulb of the thistle tube into a beaker filled with water.

Students should observe that the liquid in the stem of the thistle tube will begin to rise.

Cell structure under a microscope

Have the students investigate cell structure by examining plant cells such as elodea, onion, yeast, or spirogyra and by examining animal cells such as human-cheek epithelial tissue, striated beef muscle, human blood cells, paramecia, or amoeba. You can also use prepared slides of various frog tissues: nerve, muscle, blood, epithelium, and so on. See the references on page 38.

Cell structure models

Have the students draw pictures and make models of cells. They should include appropriate organelles and labels. See the references on page 38.

For further investigation

Investigate:

- the role of fermentation in bread-making;
- fermentation in brewing alcoholic beverages;
- aerobic and anaerobic respiration on physical exercising;
- metabolic rate on physical endurance or strength;
- dietary intake on metabolic rate;
- body size (weight) on metabolic rate;
- gender on metabolic rate;
- oxygen intake on metabolic rate;
- the relationship between the amount of oxygen intake and carbon dioxide output during respiration; and
- how differing or changing metabolic rates might have an impact on prolonged space travel.

TEXTBOOK CORRELATION

The Living Cell is designed to be integrated into your biology lessons to support and enhance those sessions that deal with the equilibrium that cells maintain with their environment (homeostasis), cell respiration (aerobic and anaerobic), and transport (specifically active transport). Although the product can easily be correlated to the chapters in your textbook that deal with these topics, you will also find that it can also be used effectively throughout the year in conjunction with other chapters that address related topics, especially when used in a demonstration mode.

The following charts correlate specific chapters and sections in four popular biology textbooks that relate directly to the use of this product. The textbooks are *Biology: Living Systems*, Merrill; *Biological Science: A Molecular Approach*, Heath; *Biological Science: An Ecological Approach*, Houghton Mifflin; and *Modern Biology*, Holt, Rinehart and Winston.

***Biology: Living Systems*, Merrill, 1986**

Chapter	Section	Page(s)	Topic
4	4:1	59-60	Changes in forms of energy
4	4:2	61	Activation energy
4	4:7	65-66	ATP
4	4:8	66-68	Respiration with oxygen
4	4:9	68-69	Respiration without oxygen
5	5:3	75-76	Cell membrane
5	5:4	76-77	Diffusion
5	5:5	78	Osmosis
5	5:6	79	Passive transport
5	5:7	80	Active transport
5	5:8	80	Factors of permeability
5	5:10	82	Protoplasm
6	6:5	102-104	Mitosis
Appendix B		704	Glycolysis
Appendix B		704	Forming Acetyl-co-A
Appendix B		704	Krebs cycle
Appendix B		704	Electron transport chain
Appendix B		705	Krebs cycle diagram
Appendix B		706	Other energy sources
Appendix B		706	Anaerobic respiration

TEXTBOOK CORRELATION (continued)

Biological Science: A Molecular Approach, **Heath, 1985**

Chapter	Section	Page(s)	Topic
2	2-1	17-18	The cell is the basic unit of life
2	2-4	21-26	Cell structure
6	6-1	113-114	Cell organization requires energy
6	6-2	115	Organic compounds are used as energy sources
6	6-3	116-118	Energy can be released from chemical bonds
6	6-5	121-123	All cells can use the chemical energy of ATP
6	6-6	123	Energy carried by ATP has many uses
6	6-7	123-124	Life without oxygen: the process of fermentation
6	6-8	125-126	Fermentation is a source of energy
6	6-9	127-128	Cells have a membrane
6	6-10	129	Osmosis
6	6-11	129-130	Molecules can also enter the cell by active transport
8	8-2	156-158	In respiration, oxygen is used to release energy
8	8-3	158-160	The carbon pathway in respiration
8	8-4	160-163	The hydrogen pathway in respiration is linked to the energy-releasing reactions
8	8-5	163-164	Respiration releases energy and supplies building materials for the cell
8	8-6	164-165	Respiration takes place in special parts of a cell
11	11-1	215-217	All cells come from pre-existing cells
11	11-2	217-218	Mitosis and cell division follow a pattern in plants
11	11-3	218-220	Mitosis and cell division are similar in plants and animals
Appendix	5-C	692	Energy
Appendix	6-B	697-698	Structural formulas for ATP, ADP, and AMP
Appendix	6-C	699	Fermentation of glucose to ethyl alcohol or lactic acid
Appendix	8-A	707	The Krebs cycle
Appendix	8-B	708	The respiration chain

TEXTBOOK CORRELATION (continued)

***Biological Science: An Ecological Approach*, Houghton Mifflin, 1982**

Chapter	Section	Page(s)	Topic
11		362-365	Cell structure
11		366-371	Some cell physiology
11		371-377	Cell duplication
Investigation	11.1	360	Observing cells
Investigation	11.2	370	Diffusion through a membrane
Investigation	11.3	375	Mitosis and cell division in plants
12		387-389	Energy
12		405-407	How energy is released from food
12		409-411	Cellular respiration
12	T12.4	T412A	The principle events in cellular respiration
Investigation	12.3	404	Food energy
Investigation	12.4	407	A study of biochemical reactions

***Modern Biology*, Holt, Rinehart, and Winston, 1986**

Chapter	Section	Page(s)	Topic
3	3.3	41-42	Energy
Laboratory		43	pH and living systems
4	4.1	47-48	Compounds important to life
4	4.2	49-54	Organic compounds
Laboratory		55	Testing food nutrients
5	5.2	66-74	Parts of a cell
Laboratory		77	Comparing plant and animal cells
6	6.1	81-83	Diffusion and osmosis
6	6.2	84-88	Other kinds of transport
Laboratory		89	Osmosis and turgor pressure
7	7.1	93-95	The need for energy
7	7.3	103-108	Respiration

1

Life with Oxygen

Name ____________________________

Each time that you or the cell cause a change in the amount of a substance in the cell, that occurrence is called an "event." Record the event number (1, 2, 3, and so on) within the parentheses. As the changes occur, record the new amount of each substance in the spaces provided below.

Event #	( )	( )	( )	( )	( )
Substance					
Glucose	______	______	______	______	______
Potassium	______	______	______	______	______
Sodium	______	______	______	______	______
Chloride	______	______	______	______	______
Water	______	______	______	______	______
Waste	______	______	______	______	______
Oxygen	______	______	______	______	______
ATP	______	______	______	______	______

Notes:

____

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____

____

2

Life Without Oxygen

Name ______________________________

Each time that you or the cell cause a change in the amount of a substance in the cell, that occurrence is called an "event." Record the event number (1, 2, 3, and so on) within the parentheses. As the changes occur, record the amount of each substance in the spaces provided below.

Event #	( )	( )	( )	( )	( )
Substance					
Glucose	______	______	______	______	______
Potassium	______	______	______	______	______
Sodium	______	______	______	______	______
Chloride	______	______	______	______	______
Water	______	______	______	______	______
Waste	______	______	______	______	______
Oxygen	______	______	______	______	______
ATP	______	______	______	______	______

Notes:

____

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____

3a

What I Found Out
Evaluation Sheet

Name ______________________________

Based on your cell investigations, answer the following questions:

1. What are some factors that control the flow of substances across a cell membrane?

____

____

2. What is the relationship between a glucose molecule and the number of energy units that cells need to live without oxygen?

____

____

3. What is the relationship between a glucose molecule and the number of energy units that cells need to live in the presence of oxygen?

____

____

4. What is the relationship between oxygen and the energy that a cell gains from a glucose molecule?

____

____

5. Why does a cell need to use energy in order to move some substances across the membrane into or out of the cell?

____

____

6. From your experience, describe in your own words what you think the life for a cell is like. What are some of the difficulties a cell has to overcome to thrive and reproduce?

____

____

____

3b

What I Found Out

Answer Sheet

Based on your cell investigations, answer the following questions:

1. What are some factors that control the flow of substances across a cell membrane?

   The concentration of a substance on both sides of the membrane forms a diffusion gradient. The size of the ion or molecule, the need for energy to transport substances in or out, and availability are some other factors.

2. What is the relationship between a glucose molecule and the number of energy units that cells need to live without oxygen?

   In an anaerobic environment, cells derive two energy units (ATP molecules) from each glucose molecule.

3. What is the relationship between a glucose molecule and the number of energy units that cells need in order to live in the presence of oxygen?

   In an aerobic environment, cells derive a maximum of 38 energy units (ATP molecules) from each glucose molecule.

4. What is the relationship between oxygen and the energy that a cell gains from a glucose molecule?

   Aerobic respiration requires six oxygen molecules for each glucose molecule. Oxygen is the final hydrogen acceptor in the energy-releasing process.

5. Why does a cell need to use energy in order to move some substances across the membrane into or out of the cell?

   Energy is needed to accelerate the movement of molecules or ions across a membrane or to move molecules or ions against a natural diffusion gradient.

6. From your experience, describe in your own words what you think the life for a cell is like. What are some of the difficulties a cell has to overcome to thrive and reproduce?

   Answers will vary. However, most will deal with the dynamics of keeping a proper balance of substances in the cell. Moving needed substances in and unneeded substances out—and in the proper amounts—is both crucial and constant. Living in an anaerobic environment is more demanding because the amount of energy derived from each glucose molecule is greatly limited.

CREDITS

The Living Cell was produced by a MECC development team that included Gene Breault, Ed Gratz, Mark Hanson, and Kevin Neff.

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TO THE READER

MECC has made every effort to ensure the instructional quality of this courseware package. Your comments—as user or reviewer—are valued and will be considered for inclusion in any future revision of the product. Please address your comments to:

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St. Paul, MN 55126-8097

REFERENCES

Bartow, Dennis, H. "Videomicroscopy." *The Science Teacher* 55, 3 (March 1988): 44-47.

Carver, Deborah, J. "Cell Theory Rap." *Science and Children* 21, 3 (November/December 1983): 25.

Crouch, Nancy, R. "Learning Cells." *Science Scope* 13, 5 (February 1990): 8-10.

Morholt, Evelyn, et al. *A Sourcebook for the Biological Sciences*. New York: Harcourt, Brace and World, Inc., 1966.

Vaszily, Diane, A. "Ziplock Cell Models." *Science and Children* 24, 7 (April 1987): 22.

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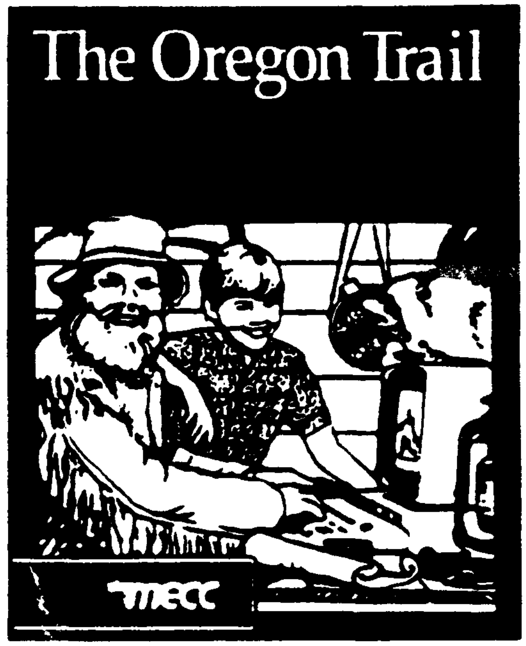

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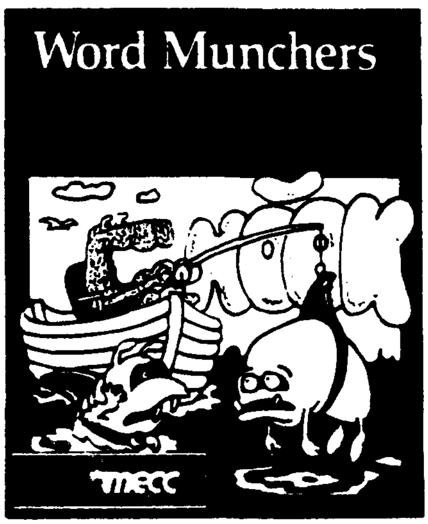

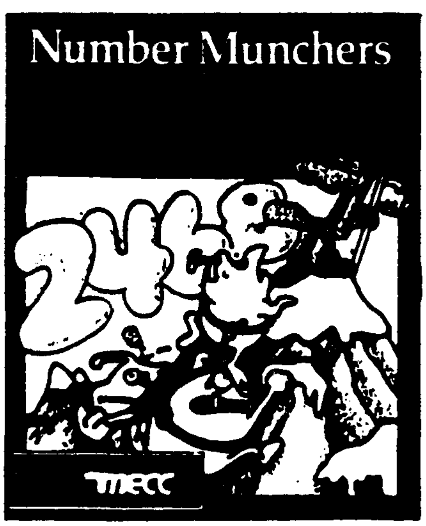

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Q. *What exactly does the law say about copying software?*

A. The law says that it is illegal to make or distribute copies of copyrighted material, including software, without authorization. If you do so, this is piracy, and you may face not only a civil suit, but also fines of up to $100,000 and jail terms of up to 5 years.

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Q. *But aren't schools allowed to make copies for educational purposes?*

A. No. Like individuals and corporations, educational institutions are bound by the copyright law. Because of their unique position of influence, schools have a particular obligation to abide by the copyright law and educate students about their own responsibilities when using software. Just as it would be wrong to buy one textbook and photocopy it for use by many students, it is wrong for a school to duplicate software without the authorization of the publisher. This means that educators cannot make unauthorized copies for their students, either to use in school or to take home.

Q. *At our school, we share programs all the time. We assume this must be okay, since the school purchased the software in the first place.*

A. Many educators are not aware of how the copyright law applies to them. Without the publisher's authorization to make copies, your school needs to purchase as many copies of a program as you will use. However, many software firms do offer special sales arrangements to schools. These include reduced priced lab packs (a number of programs sold together) and site licenses (arrangements which permit schools to copy for a specific location at a fixed price). **Because these arrangements vary from publisher to publisher, it is essential that you read and understand the license agreement for each program before making any copies.**

Q. *We're planning to install a network for our students. How do we know how many copies of software we'll need to purchase?*

A. Remember that the installation of a network does not change your obligations with regard to the copyright law. When purchasing software for a network, be sure to ask the publisher what types of licensing arrangements are available for networks. Some software publishers allow schools to purchase a network license that authorizes the school to install stand-alone software on a network. In addition, many software publishers create special network versions that license the program to be run on the file server of a network. Because some publishers limit the number of workstations that are permitted to legally access the software on the network, it is very important to check the license agreement for any restrictions that may apply.

Q. *I've read the license agreement for one of the software packages purchased by our school. What if I'm not sure that I understand the arrangement correctly?*

A. If you have trouble understanding the license agreement, help is available. Your school district's media or computer specialist may be able to answer your questions. In addition, you can always contact the software publisher and ask for a clarification of the license agreement as it applies to your school. Finally, if you still have questions, contact the Software Publishers Association for more information about software and the copyright law.

Q. *I'll bet most of the people who copy software don't even know they're breaking the law.*

A. Because the software industry is relatively new and because copying software is so easy, many people are either unaware of the laws governing software use or choose to ignore them. It is the responsibility of each and every software user to read and understand the license agreements of the products they use and to be sure that their software use complies with copyright law. See what you can do to initiate a software use policy statement in your school that everyone respects. Finally, as an educator, help set an example for your students that responsible computer users should be "software legal."

If you have any questions about how the copyright law applies to you and your school, please contact the
Software Publishers Association at 202-452-1600.

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