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ABSTRACT

Interactive computer programs, developed at Indiana University's Learning Skills Center, were designed to model effective strategies for reading biology and psychology textbooks. For each subject area, computer programs and textbook passages were used to instruct and model for students how to identify key concepts, compare and contrast concepts, and graphically map relationships among key concepts. One hundred and eighty-four undergraduate students of matched ability from a major university and from a two-year community college were assigned to treatment and control groups to evaluate program effectiveness. Students who used the program significantly outperformed control group students, and learned strategies transferred to new and unmodeled textbook chapters. Data are presented in tabular form. Appendixes include a copy of a paper presented at the 1987 National Reading Conference, "The Effectiveness of Interactive Computer Assisted Modeling in Teaching Study Strategies and Concept Mapping of College Textbook Material" (L. Mikulecky), and extensive excerpts from the students' and instructors' guides for the project. (Author/GL)

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# Final Report:

# Development of Interactive Computer Programs to Help Students Tansfer Basic Skills to College Level Science and Behavioral Science Courses

Grant No: G008642081

9/1/87 – 8/31/88

Director: Dr. Larry Mikulecky
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Summary:

Interactive computer programs, developed at Indiana University's Learning Skills Center, were designed to model effective strategies for reading biology and psychology textbooks. For each subject area, computer programs and textbook passages were used to instruct and model for students how to 1) identify key concepts, 2) compare and contrast concepts, and 3) graphically map relationships among key concepts. One hundred and eighty-four undergraduate students of matched ability from a major university and from a two-year community college were assigned to treatment and control groups to evaluate program effectiveness. Students who used the programs significantly outperformed control group students, and learned strategies transferred to new and unmodeled textbook chapters.

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Titles of project reports or products:

Interim Report (2/88): Development of Interactive Computer Programs to Help Students Transfer Basic Skills to College Level Science and Behavioral Science Courses

Software Package (7/88): Reading your Biology Textbook Effectively

Software Package (7/88): Reading your Psychology Textbook Effectively

Project title: Development of Interactive Computer Programs to Help Students Transfer Basic Skills to College Level Science and Behavioral Science Courses

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## EXECUTIVE SUMMARY

Project Overview:

This study developed two three-part computer programs to guide undergraduates in effective textbook reading strategies. It also assessed the utility and effectiveness of these interactive computer programs and associated print materials in instructing and modeling for undergraduates how to comprehend and reconceptualize textbook material. Two programs of three lessons each were designed and programmed to guide students in how to 1) identify key concepts, 2) compare and contrast concepts, and 3) graphically map relationships among key concepts. The programs addressed biology and psychology textbook chapters. Early versions of the software and associated print materials were piloted with undergraduate students and refined.

Two hundred and five undergraduates from a 4-year university and from a community college enrolled in biology and psychology received class credit for participating in the evaluation of "Reading your Biology Textbook more Effectively" and "Reading your Psychology Textbook more Effectively".

Purpose:

This project addressed to major problems. The first was whether computer guided instruction based upon reading comprehension research could be applied to instruction in college textbook reading strategies in an educationally effective way. The second problem addressed the utility of using a shell program for textbook reading in biology as a base for developing similar programs in other subject areas.

Background and Origins:

This project was an extension of a research and development program, the first stages of which were funded in-house. Indiana University, a 4-year university with an enrollment of over 35,000 graduate, undergraduate , and continuing education students, attracts a number of highly trained doctoral students with research and development expertise.

Project Results:

The software's effectiveness to teach students how to 1) identify key concepts, 2) link key terms, and 3) graphically map the relationships of those key terms was measured by having treatment group students use the software to master biology and psychology text material while control group students only read the text. Both groups of students took a chapter exam on the material they had studied.

Further, to measure student ability to transfer these strategies to unpracticed text both groups of students were asked to read a second chapter one week after they had completed the first chapter.

The treatment group significantly outperformed the control group at both sites in terms of learning the strategies from the computer programs and in many cases transfering that learning to new chapters. In addition, students report a good deal of satisfaction with the programs. Students liked learning from the programs and a large percentage of students acknowledged that the strategies were new to them before using the programs.

Generally, the project has resulted in integration of software into existing curricula at the I.U. Learning Skills Center at Indiana university, Bloomington. Students using materials as part of elective courses should account for nearly 3000 hours of instruction this year at the Indiana University Learning Skills Center.

Other campuses continue to be affected by this project as well. For example, Vincennes University's Learning Skills Center, the second evaluation site for the software, has continued to receive requests from faculty there to make the project software available for students whom they will continue to refer to that Center. In addition, conference presentations have alerted other campuses nationwide of the upcoming availability of effective software at a reasonable price and phone calls and letters of inquiry have arrived at Bloomington's Learning Skills Center at the rate of about two per week.

Development of computer programs for undergraduate use continues at the Indiana University Learning Skills Center through a grant from A.T.& T. and through a small internal Indiana University grant. These include programs on time management, summary writing, test-taking, and textbook marking. Due to the limited resources for development, these programs will be less ambitious and less well evaluated than the FIPSE funded programs.

By the end of 1988, conference presentations on these computer programs will have occurred at 7 professional conferences. Manuscripts on the first year results have been submitted to the ERIC system and to the Journal of Reading. An extension grant for dissemination has enabled us to develop documentation and packaging for the programs. The Biology program was entered in the National Center for Research to Improve Post-Secondary Teaching and Learning competition for CAI programs in Higher Education. It was selected to be among the top 10% of programs to be considered in the final round of the competition. Advertisements for the programs have been placed in professional publications and will be on electronic bulletin boards at the end of 1988, and programs and accompanying print materials will be distributed at cost. It is our intention to make these programs available on a continuing basis by charging replacement cost for the materials developed through FIPSE funding.

Conclusions:

These programs are effective in the senses that they improve student performance, transfer to new textbook material, are seen as valuable by students, and have been incorporated into existing study skills programs. When part of a class receives computer instruction, instructors are able to meet individually or in small groups with the remainder of classes.

The development of conceptually valid computer programs took a good deal more time of many talented individuals than we initially estimated. The contributed time of project coordinators was more than double the amount listed on the original proposal and the time of paid personnel was approximately 30% higher than listed. These personnel were paid through other related university projects. Though experience taught us a few efficiencies, such an extensive time investment seems necessary for effective interactive software to be developed.

This investment of time needs to be understood in the context of benefits derived, however. This year, at the Indiana University Learning Skills Center, we estimate that the programs will be used for 3000 hours of instruction. Over a 5 year period of use, this comes down to approximately $5.00 per instructional hour for the FIPSE cost of program development. Copies of the materials are already being used at a minimum of 5 other institutions and are likely to be used at several dozen additional institutions by this time next year. In all liklihood, the cost to FIPSE per hour of instruction is likely to be reduced to pennies before the early 1990's. This project may be the most cost-effective investment the federal government has ever made.

A. Project Overview:

Large percentages of undergraduate students seek aid in meeting the reading demands of college, and it is likely that even larger percentages are in need of such aid. Interactive computer programs can help to meet this need when they effectively model and instruct students in cognitive and metacognitive reading strategies.

This study developed two three-part computer programs to guide undergraduates in effective textbook reading strategies. It also assessed the utility and effectiveness of these interactive computer programs and associated print materials in instructing and modeling for undergraduates how to comprehend and reconceptualize textbook material. Two programs of three lessons each were designed and programmed to guide students in how to 1) identify key concepts, 2) compare and contrast concepts, and 3) graphically map relationships among key concepts. The programs addressed biology and psychology textbook chapters. Early versions of the software and associated print materials were piloted with undergraduate students and refined.

Two hundred and five undergraduates from a 4-year university and from a community college enrolled in biology and psychology received class credit for participating in the evaluation of "Reading your Biology Textbook Effectively" and "Reading your Psychology Textbook Effectively". Treatment and control groups were assigned and matched for verbal SAT scores, high school rank, and current grade-point average. All students read a 7-10 page chapter portion from psychology or biology, the treatment group receiving instruction on the computer while the control group used any existing strategies they already had for comprehending textbook material. Chapter examinations were administered in order to determine the effectiveness of the computer programs in modeling and teaching strategies for comprehending college-level textbooks. As might be expected, the treatment group scored significantly higher on the exam of the modeled chapter portion.

One week later both treatment and control group students read a second chapter portion and took a second chapter exam. This time the treatment group did not use the computer as an aid in studying the chapter. Again, the treatment group significantly outperformed the control group on this exam, suggesting transfer of the reading strategies from the materials used with the computer to unmodeled and new materials. (See Tables I & II)

Further analysis was undertaken on scores for subsections of the chapter examinations to determine which strategies were learned most effectively. Results are found in Tables III & IV. Significant differences in the treatment group's favor at the $p<.05$ level or better exist in the majority of subsections in the aggregate data.

B. Purpose:

This project addressed two major problems. The first was whether computer guided instruction based upon reading comprehension research could be applied to instruction in college textbook reading strategies in an educationally effective way. The second problem addressed the utility of using a shell program for textbook reading in biology as a base for developing similar programs in other subject areas.

First year data on the biology textbook reading program indicated that such an effective biology program was possible. During the second year, the effectiveness of the program with community college students was addressed. The biology program and the parallel psychology program were both demonstrated to be effective with students at both types of institution.

The second problem of whether a shell program could be easily modified to other subject areas was less successfully resolved. We initially estimated that a second program could be developed with 1/3 the resources of the first program. In actual fact, this was not the case. Differences in the knowledge structures of biology and psychology necessitated major modifications of the shell program which took 2/3 the time of initial program development. No substantial savings were apparent.

The development and validation of research instruments to assess the effectiveness of the programs took more time than anticipated. So too did management of data collection and training at the community college. If the project had not been able to draw upon additional resources (i.e. university supported time of the project coordinator and program/designer time borrowed from other funded projects), it would have been impossible to complete the second year of the project as the proposal outlined it.

C. Background and Origins:

This project was an extension of a research and development program, the first stages of which were funded in-house. Indiana University, a 4-year university with an enrollment of over 35,000 graduate, undergraduate , and continuing education students, attracts a number of highly trained doctoral students with research and development expertise. Hiring these students for a nominal salary or through an assistantship made this project possible at a relatively low cost. In addition, when it became clear that the hypothesis of a shell program was not possible, the project could have failed. Extensive support beyond the projected 10% time was contributed by the Learning Skills Program Coordinator as well as by designers and programmers working on other funded projects. In these ways, the project received support from the University and from those who were directly working on it or related projects.

D. Project Description:

The instructional format of both programs is adapted from Alessi & Trollop's (1985)* suggestions for effective CAI. They include 1) explication of the concepts, 2) modeling of the strategy, 3) practice and feedback, and 4) assessment and branching. As the software was being designed and programmed, the project coordinator was responsible for the following:

1) input on a regular basis from developers (Biology dept. professor, Psychology dept. professor, CAI designers),

2) a continuous check on implementation of the activities of the proposal,

3) written feedback to designers, programmers, and participants on problems and concerns of on-going activities - instructional material and questionnaire design, student identification, computer access, and scheduling conflicts,

4) regular staff meetings to discuss modification and testing procedures,

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*Alessi, S.M., & Trollop, S.R. (1985). Computer-based instruction. Englewood Cliffs, NJ: Prentice-Hall.

5) a comprehensive record of activities, and

6) field testing.

After the software was refined it was evaluated with 205 undergraduate biology and psychology students who were assigned to matched control and treatment groups on the basis of high school rank, verbal ability as measured by the SAT, and current grade point average. Qualitative data were collected as the treatment students used the software. This data included student opinion of length, usefulness, and general attitude toward learning in this fashion. Quantitative data were collected from the two matched groups using the results of the content reading strategy examination. Significant differences in students' ability to identify key concepts, link ideas, and organize ideas into useful conceptual frameworks.

The production and evaluation processes for both software programs were identical except that it was assumed that the second program could be closely modeled after the first. "Reading your Biology Textbook Effectively", the shell program was completed first, and the hypothesis was that much less time would be spent in designing and programming the psychology program if the biology shell program could be used as a foundation. This hypothesis proved only partially true. Though the general outlines of the two programs are similar, the screen design and nature of feedback differs a good deal across programs. The knowledge structures of biology and psychology differed a good deal more than anticipated. Psychology text material is presented in such a different feshion from biology material that the design of the second program had to be modified considerably. The time estimated for the production of the second program was 25%-30% of the first program. Actual development time was closer to 60%-70% of first program development time.

E. Projects Results:

Generally, the project has resulted in integration of software into existing curricula at the Learning Skills Center at Indiana University, Bloomington. For example, a pre-college summer program which services Indiana minority students at I.U. required participating students to attend to the three lessons of "Reading your Psychology Textbook Effectively." These students were simultaneously enrolled in a course which required them to master psychology material. So successful was this pilot that the software is now courseware as part of the curriculum for that program. In addition, several other courses offered during the regular academic year (specifically, "Techniques for Textbook Reading", "Managing Learning Resources", and "Practical Applications of Learning Skills") have integrated the use of this and other software into the curriculum. The effect of so many students being required to use software has led staff to be innovative in acquiring more hardware to meet the need. General interest within the Center and at outside service agencies has increased to the point where computer-assisted instruction has become a strong service known to be offered at the Center.

Other campuses continue to be affected by this project as well. For example, Vincennes University's Learning Skills Center, the second evaluation site for the software, has continued to receive requests from faculty there to make the project software available for students whom they will continue to refer to that Center. In addition, conference presentations have alerted other campuses nationwide of the upcoming availability of effective software at a reasonable price and phone calls and letters of inquiry have arrived at Bloomington's Learning Skills Center at the rate of about two per week. In fact, a nearby university faculty member has expressed his interest in repeating our evaluation process with students at his university. It is important to conclude that the software created by this project has had instructional, research, and technological influences on the Center at which it was created as well as at other institutions. The full effects have not yet been felt as we enter stage three of the grant - dissemination.

Evaluation:

The software's effectiveness to teach students how to 1) identify key concepts, 2) link key terms, and 3) graphically map the relationships of those key terms was measured by having treatment group students use the software to master biology and psychology text material while control group students only read the text. Both groups of students took a chapter exam on the material they had studied.

Further, to measure student ability to transfer these strategies to unpracticed text both groups of students were asked to read a second chapter one week after they had completed the first chapter.

It can be concluded from Tables I, II, III & IV that the treatment groups significantly outperformed the control groups at both sites in terms of learning the strategies from the computer programs and in may cases transferring that learning to new chapters.

In addition, students report a good deal of satisfaction with the programs. Students liked learning from the programs and a large percentage of students acknowledged that the strategies were new to them before using the programs. At the end of each lesson, the treatment group was asked to complete a Likert scale to ascertain student opinions of the effectiveness of the computer in developing basic skills for comprehending a biology text. The scale ranged from 5 (Strongly Agree) to 1 (Strongly Disagree). Mean results for the three computer lessons ranged from 4.20 to 4.60. Students' attitudes toward the programs were strongly positive with no significant differences in relation to sections of the programs.

At the end of Lesson III students were asked to complete an open-ended questionnaire concerning the entire program. For the vast majority of students in the treatment group, graphically mapping concepts was a new and unfamiliar task. In addition, comparing and contrasting key terms was also only reported as familiar by 54% of the students.

In answer to the question: "Has your ability to understand text material improved?", 87.5% answered "yes". Students answering yes were asked to expand upon the ways they thought their abilities had improved. Among the elaborations provided are:

- My biggest problem is fitting concepts together. Now I have a better feel about how to do it.
- Again, through organizations of materials. Now I have a structured method of study.

- Most of these ideas were already familiar to me, but using the lessons on the computer showed how advantageous these ideas are for learning text material.

- It takes a little more time to try and do the things you have learned (locating and comparing) but the benefits make it worth it.
- By learning to link key terms together and being better

able to see the whole chapter made up of its smaller parts.

In an attempt to determine whether or not the students could see a transfer of the skills presented on the computer to other courses at the university, treatment group students were asked, "In what ways, if any, will this lesson be useful for other courses in which you are enrolled?" A sample of comments follows:

- You can apply all the concepts of the experiment to other courses with maybe the exception of math.

- Yes for sociology, etc., but not for English classes, esp. literature

- In almost all of my subjects, textbooks are used and set up in the same format. I hope to apply concepts learned to various areas.

- The ideas of locating key terms, comparing and contrasting, and mapping can all be used in other courses.

- Other courses where there is lots of reading involved such as my Human Development class which deals with many of the same concepts presented here.

## Continuing Development

Development of computer programs for undergraduate use continues at the Indiana University Learning Skills Center through a grant from A.T.& T. and through a small internal Indiana University grant. These include programs on time management, summary writing, test-taking, and textbook marking.

Due to the limited resources for development, these programs will be less ambitious and less well evaluated than the FIPSE funded programs.

By the end of 1986, conference presentations on these computer programs will have occurred at 7 professional conferences (Seventh Great Lakes Regional Conference of the International Reading Association [Indianapolis, Oct.-1987], National Reading Conference {St. Petersburg, Dec. 1987], National Association of Developmental Education [Orlando, March 1988], Western College Reading and Learning Association [Sacramento, 1988], Consortium for Computers in Education [Pittsburg, Oct. 1988], Learning Assistance Association of New England [Burlington,MA, Oct. 1988], National Reading Conference [Tucson, Dec. 1988]) in addition to the two F.I.P.S.E. Directors meetings we have attended in Washington. Manuscripts on the first year results have been submitted to the ERIC system and to the Journal of Reading. An extension grant for dissemination has enabled us to develop documentation and packaging for the programs. "Reading your Biology Textbook Effectively" was entered in the National Center for Research to Improve Post-Secondary Teaching and Learning competition for CAI programs in Higher Education. It was selected to be among the top 10% of programs to be considered in the final round of the competition. Advertisements for the programs have been placed in professional publications and will be on electronic bulletin boards at the end of 1988, and programs and accompanying print materials will be distributed at cost. It is our intention to make these programs available on a continuing basis by charging replacement cost for the materials developed through FIPSE funding.

F. Summary and Conclusions:

These programs are effective in the senses that they improve student performance, transfer to new textbook material, are seen as valuable by students, and have been incorporated into existing study skills programs. When part of a class receives computer instruction, instructors are able to meet individually or in small groups with the remainder of classes.

The development of conceptually valid computer programs took a good deal more time of many talented individuals than we initially estimated. The contributed time of project coordinators was more than double the amount listed on the original proposal and the time of paid personnel was approximately 30% higher than listed. These personnel were paid through other related university projects. Though experience taught us a few efficiencies, such an extensive time investment seems necessary for effective interactive software to be developed.

This investment of time needs to be understood in the context of benefits derived, however. This year, at the Indiana University Learning Skills Center, we estimate that the programs will be used for 3000 hours of instruction. Over a 5 year period of use, this comes down to approximately $5.00 per instructional hour for the FIPSE cost of program development. Copies of the materials are already being used at a minimum of 5 other institutions and are likely to be used at several dozen additional institutions by this time next year. In all likelihood, the cost to FIPSE per hour of instruction is likely to be reduced to pennies before the early 1990's. This project may be the most cost-effective investment the federal government has ever made.

Table I

Mean Score Differences
of Treatment and Control Subjects
on Embryonic and Blood Chapter Exams

| | Two-Year (N=51) | | Four-Year (N=50) | | Total (N=101) | |
|---|---|---|---|---|---|---|
| | C(25) | T(26) | C(25) | T(25) | C(50) | T(51) |
| Embryology | | | | | | |
| 1. | 14.4 | 13.1 | 15.2 | 18.6** | 14.8 | 17.4*** |
| 2. | 16.4 | 18.8** | 15.3 | 17.3* | 15.9 | 18.0*** |
| 3. | 27.7 | 38.8** | 31.5 | 44.0** | 29.6 | 41.4*** |
| Tot. | 56.5 | 73.8*** | 61.9 | 79.8** | 59.2 | 76.8*** |
| Blood | | | | | | |
| 1. | 15.8 | 17.6 | 16.8 | 18.4 | 16.3 | 18.0* |
| 2. | 17.3 | 18.7* | 13.8 | 18.8*** | 15.6 | 18.7*** |
| 3. | 28.2 | 35.4* | 33.2 | 42.1*** | 30.7 | 38.7*** |
| Tot. | 61.3 | 71.7** | 65.9 | 79.6*** | 62.6 | 75.6*** |

* p<.05 significance level
** p<.01 significance level
***p<.001 significance level

1. Subscore for Identifying Key Terms (20 possible)
2. Subscore for Linking Key Terms (20 possible)
3. Subscore for Mapping Relationships (60 possible)

Table II

Mean Percentage Score Differences
of Treatment and Control Subjects
on Embryonic and Blood Chapter Exams

| | Two-Year (N=51) | | Four-Year (N=50) | | Total (N=101) | |
|---|---|---|---|---|---|---|
| | C(25) | T(26) | C(25) | T(25) | C(50) | T(51) |
| Embryology | | | | | | |
| 1. | 72% | 81% | 76% | 93%*** | 74% | 87%*** |
| 2. | 83% | 94%** | 77% | 86%* | 80% | 90%*** |
| 3. | 46% | 64%** | 53% | 73%*** | 49% | 69%*** |
| Tot. | 57% | 73%*** | 62% | 80%** | 59% | 77%*** |
| Blood | | | | | | |
| 1. | 79% | 88% | 84% | 92% | 82% | 91% |
| 2. | 89% | 94%* | 69% | 94%*** | 79% | 94%*** |
| 3. | 47% | 59%* | 55% | 70%*** | 51% | 65%*** |
| Tot. | 61% | 72%* | 64% | 80%*** | 63% | 77%*** |

* $p<.05$ significance level
** $p<.01$ significance level
***$p<.001$ significance level

1. Subscore for Identifying Key Terms
2. Subscore for Linking Key Terms
3. Subscore for Mapping Relationships

TABLE III

Mean Score Differences
of Treatment and Control Subjects
on Storage Systems and Behavioral Therapies Chapter Exams

| | Two-Year (N=60) | | Four-Year (N=44) | | Total (N=104) | |
|---|---|---|---|---|---|---|
| | C(33) | T(27) | C(23) | T(21) | C(56) | T(48) |
| **Storage Systems** | | | | | | |
| 1. | 14.8 | 17.0* | 15.7 | 19.3*** | 15.2 | 18.0*** |
| 2. | 13.8 | 16.9*** | 17.2 | 19.0** | 15.2 | 17.8*** |
| 3. | 23.3 | 37.4*** | 34.7 | 43.5** | 28.0 | 40.1*** |
| Tot. | 51.9 | 71.3*** | 67.6 | 81.8*** | 58.3 | 75.7*** |
| **Behavioral Therapies** | | | | | | |
| 1. | 14.7 | 17.4** | 15.2 | 19.6*** | 14.9 | 18.3*** |
| 2. | 11.3 | 12.4 | 13.7 | 15.5 | 12.3 | 13.7 |
| 3. | 31.0 | 36.9 | 44.9 | 45.6 | 36.7 | 40.9 |
| Tot. | 57.2 | 66.7* | 73.8 | 80.8* | 64.0 | 72.6** |

* p<.05 significance level
** p<.01 significance level
***p<.001 significance level

1. Subscore for Identifying Key Terms (20 possible)
2. Subscore for Linking Key Terms (20 possible)
3. Subscore for Mapping Relationships (60 possible)

TABLE IV

Mean Percentage Score Differences
of Control and Treatment Subjects
on Storage Systems and Behavioral Therapies Chapter Exams

| | Two-Year (N=60) | | Four-Year (N=44) | | Total (N=104) | |
|---|---|---|---|---|---|---|
| | C(33) | T(27) | C(23) | T(21) | C(56) | T(48) |
| Storage Systems | | | | | | |
| 1. | 74% | 85%* | 79% | 97%*** | 76% | 90%*** |
| 2. | 69% | 85%*** | 86% | 95%** | 76% | 89%*** |
| 3. | 39% | 62%*** | 58% | 73%** | 47% | 67%*** |
| Tot. | 52% | 71%*** | 68% | 82%*** | 58% | 76%*** |
| Behavioral Therapies | | | | | | |
| 1. | 73% | 87%** | 76% | 98%*** | 75% | 92%*** |
| 2. | 57% | 62% | 69% | 78% | 62% | 69% |
| 3. | 52% | 62% | 75% | 76% | 61% | 68% |
| Tot. | 57% | 67%* | 74% | 81%* | 64% | 73%** |

* p<.05 significance level
** p<.01 significance level
***p<.001 significance level

1. Subscore for Identifying Key Terms
2. Subscore for Linking Key Terms
3. Subscore for Mapping Relationships

## G. Appendices

Appendix A: Comments to FIPSE Personnel
Appendix B: Manuscript Sent to ERIC and *Journal of Reading*
Appendix C: Sample Documentation for Programs
Appendix D: Program Diskettes

## APPENDIX A

### Comments to FIPSE Staff

Because Indiana University has access to low paid, highly trained graduate students and the volunteered time of trained researchers and content specialists, we were able to develop computer software considerably less expensively than commercial software houses. It still cost a good deal of start up money to put a development team together. Without the funds from FIPSE, it simply would not have happened.

During the course of program development, we encountered a number of small problems involving shifting funds which required rapid answers to funding questions. Francis Bergeron and Juanita Bowe were both extremely helpful, and timely in getting the answers we needed. Compared to several other federal agencies with whom I have worked, working with FIPSE staff was an absolute pleasure.

Some of the requests we've received for information about our programs have come from descriptions of our project in federal publications. This service will, I suspect, be even more important as we enter the dissemination stage of this project.

APPENDIX B

Manuscript to ERIC and to the *Journal of Reading*

# The Effectiveness of Interactive Computer Assisted Modeling in Teaching Study Strategies and Concept Mapping of College Textbook Material

Larry Mikulecky
Learning Skills Center
Indiana University-Bloomington

A presentation at the National Reading Conference
St. Petersburg Beach, Florida
December 4, 1987

Most beginning undergraduate students have the basic reading skills needed to understand a newspaper (Applebee, Langer & Mullis, 1985), but many of these students have difficulty reading and studying college textbooks. Cahalan and Farris (1986) report that 82% of all institutions of higher education and 94% of public institutions offer remedial courses to college undergraduates. The National Center for Educational Statistics reports that 25% of undergraduate students seek some form of remedial help with university-level study problems This problem of undergraduates inadequately prepared to comprehend university-level material is even greater at smaller community colleges and open admission schools. Seventy-five per cent of students at two-year and open-admissions colleges are enrolled in remedial courses ("College remedial," 1985).

Techniques for improving undergraduate reading and study skills often involve instructors modeling for students cognitive and metacognitive strategies for identifying key ideas and relating ideas to form meaningful structures. The premise of the research reported in this paper is that an interactive computer program can model and guide undergraduate students through some of the important cognitive and metacognitive processes of reading college textbook chapters in such a way that: 1) comprehension of the modeled chapters is increased and 2) students are able to transfer the processes to new, unmodeled chapters effectively.

This manuscript reports phase one results of a two-year project funded by the Fund for the Improvement of Postsecondary Education (FIPSE). This research and development project is designed to develop and evaluate the effectiveness of a series of print materials and interactive computer-guided study programs which lead undergraduate students to apply basic textbook reading strategies and concept mapping strategies to the study of science and social science textbooks. The materials and computer programs are designed to guide and help students:

* Identify key concepts in textbook chapters,

* Compare, contrast, and connect ideas by writing linking summary statements, and

* Synthesize and graphically map relationships among key concepts.

Reading Abilities and Demands of Entering Undergraduates

Over 56% of 17-18 year olds go beyond high school to some form of post-secondary education. The percentage of students that enter colleges and universities is less clear due to differing definitions of what constitutes a college, but remains in the 40-50% range (Lisack & Shell, 1985).

Though complete data upon the reading abilities of under-graduates does not exist, National Assessment of Educational Progress (N.A.E.P.) reading test results for 17-year-olds (Applebee, Langer & Mullis, 1985) allow us to draw inferences about the reading abilities of adolescents who enter colleges and universities. N.A.E.P. results for 1984 indicate that only 39.2% of 17-year-olds demonstrated adept comprehension strategies (able to find, understand, summarize, and explain relatively complicated information). Furthermore, only 4.9% attained an advanced level of strategy use (able to extend and restructure ideas in specialized texts). With current admissions in post-secondary education close to 50% of 17-18 year-olds, one can expect a significant number of undergraduates to have difficulty comprehending relatively complicated textbook material and a majority to have difficulty restructuring and extending ideas from such specialized texts.

Several researchers have identified and characterized weaknesses that differentiate less competent readers from their more capable counterparts.

Such readers are likely to have gaps in knowledge, have an impoverished understanding of relationships among facts, and are unlikely to make the inferences required to weave the text into a coherent whole (Bransford, Stein, Nye, Franks, Auble, Merynski, & Perfetto, 1982). Less able readers tend to use a listing rather than a structure strategy because they perceive all content as equally important. (Meyer, 1984b; Meyer, Brandt & Bluth, 1980; Meyer & Rice, 1982).

Structure Awareness, Concept Mapping and Improved Reading

The results of several studies suggest that students who are aware of the structure of expository materials are able to outperform students who are not aware of text structure (McGee, 1982a; McGee, 1982b; Meyer, Brandt & Bluth, 1980; Taylor, 1980; and Taylor & Samuels, 1983). In addition, readers who are actively involved in constructing a structured representation of what they have read do better than their counterparts in recall performance (Armbruster & Anderson, 1980; Slater, 1982; Berkowitz, 1986; and Danner, 1976). Some researchers examining the effectiveness of having students graphically depict the relationships among major concepts in text (concept mapping) have found carry-over benefits to related language activities. Ruddell and Boyle (1984) found that students who used concept mapping as a pre-writing exercise were able to write longer, higher quality essays than their counterparts. Geva (1983) found students who were taught to map or flowchart their understanding of expository material not only improved in mastery of the mapped material, but also improved in general reading ability as measured by a standardized reading test.

Role of Modeling and Computers

The modeling of cognitive processes has been suggested by several researchers and educators as a method for clarifying to less able readers methods of thought while reading (Brown, 1960; Davey, 1983; Smith & Dauer, 1984). Suggested techniques usually incorporate explication of the techniques being modeled, modeling of strategies and techniques to be used, and then student practice and feedback.

An instructional format for effective computer-assisted instruction has been developed by Alessi and Trollop (1985). This format also includes 1) explication of the concepts, 2) modeling of the strategy, 3) practice and feedback, and 4) assessment and branching.

Rationale of Study

Large percentages of undergraduate students seek aid in meeting the reading demands of college. It is likely that even larger percentages are in need of such aid. Interactive computer programs may be able to help meet this need if they can effectively model and instruct students in cognitive and metacognitive reading strategies shown by existing research to be effective. This study assesses the utility and effectiveness of three interactive computer programs and associated print materials in instructing and modeling for undergraduates how to comprehend and reconceptualize scientific textbook material. In addition to formative evaluation, the programs were evaluated by comparing the immediate and delayed post-program performance on textbook chapter tests of a treatment group of 25 biology students to the performance of a matched control group of 25 biology students. Post-program questionnaires and interviews given to treatment group students assessed student evaluation of computer program effectiveness.

## METHOD

Subjects

The biology textbook computer programs and associated print used in this study were field tested with the aid of 25 undergraduate students enrolled in Learning Skills courses at Indiana University. Formative evaluations examined program clarity, usefulness, and student attitudes toward the programs. Responses from students were used to refine and debug early versions of the materials and computer programs.

After the refinements had been made, 50 second semester freshman volunteer biology students ( 34% male and 66% female) who received class credit for participation were divided into treatment and control groups matched on SAT verbal scores, high school rank, and university grade point average (4.0 scale).

Student averages follow below.

| | N | SATV | GPA | H.S. Rank |
|---|---|---|---|---|
| Treatment | 25 | 422 | 2.65 | 26.8 % |
| Control | 25 | 426 | 2.64 | 27.8 % |

Instruments and Materials

Textbook Passages: Both treatment and control students read two 7-10 page selections from the embryonic development chapter and the blood composition chapter of Elements of Biological Science (Keeton & McFadden, 1983). These selections and this text were selected with the aid of biologist, Dr. Albert Ruesink, as topics, text formats, and difficulty levels typical of most college level introductory biology texts.

Computer Programs: Three 30-40 minute computer programs were designed to follow biology text material dealing with embryonic development. The programs modeled for students how to

1) identify key concepts within a text, 2) write linking summary statements which compare and contrast key concepts, and 3) graphically map relationships among key concepts.

The instructional format of the programs is adapted from Alessi and Trollop's (1985) suggestions for effective CAI. They include 1) explication of the concepts, 2) modeling of the strategy, 3) practice and feedback, and 4) assessment and branching.

- The Explication segments (generally at the beginning of each section) include a strong rationale and statement of purpose for the activity, as well as suggestions for transfer to the performance environment.

- Modeling is interspersed throughout the program and generally consists of a combination of examples and, when warranted, informative feedback.

- Students are required to Practice each step or group of steps to mastery before moving on through the program. Practice is set up in incremental steps to provide early success and reinforce each essential step in performing the strategy.

- Feedback is established as effective in CAI and the efficacy of feedback is proportional to its quality. Feedback in this program always includes knowledge of results and knowledge of correct response with feedback appropriate to the student's response--what mistake he or she is likely to make, where to look for information to self-correct, and how to avoid that error in the future.

- Answer judging always provides feedback, but sometimes includes interactive teaching if the student fails on a significant number of tries to produce a correct response. In these cases the program will Assess student performance and branch the user to remediation before returning the student to the question segment for another try.

Locus of control is offered to the students whenever possible. At least once in each program, students can opt for an "Exercises Only" or an "Explanation plus Exercises" format. This choice allows the student to determine the level of detail in which the instruction is presented. If the student who chooses "Exercises Only" has performance problems, he or she is automatically branched to the "Explanation plus Exercises" section.

The screen design follows well-established parameters for document design with appropriate modification for the screen and for the target population. For example, each screen contains a prompt at the bottom of the screen that tells the student exactly what he or she needs to do to move through the program. Content-related direction lines are often contained in the text.

Because of the students' tendency to miss the relationships between ideas, screens are designed to interlock concepts so that related concepts are presented together on the same screen and the relationship is elaborated upon to make it more specific. Relationships are presented visually at every opportunity.

Students also are given a strong advance organizer at the beginning of each segment to tap into existing background knowledge and to set up a framework for the lesson. Each lesson section is introduced with a consistently-colored screen. When the user is in a section of his or her choosing, a small box in the upper left hand corner serves as a guide to the macrostructure.

Chapter Exams: Textbook chapter examinations were developed to test the ability of students to identify key ideas in textbook chapters, compare and contrast these ideas, and accurately depict relationships among key ideas. Parallel examinations were developed and field tested for the embryonic development chapter and the blood composition chapter.

To field test these measures, two classes (40 students) at the Indiana University Learning Skills Center read and took tests on the biology chapters. Class 1 read the embryonic text first and the blood text second; class 2 reversed the process by reading the blood text first and the embryonic text second. The chapter examinations were administered to both groups after each text was read. Mean scores (from a possible 100 points) were similar for the two tests (Embryo, 60.7; Blood, 61.9). Clear-cut scoring guidelines were developed and used to attain an inter-rater reliability correlation of $r = .95$ for the two raters scoring the tests.

Monitoring of inter-rater reliability using a 25% sample of later treatment and control subjects revealed correlations of $r = .91$ for the embryonic chapter test and $r = .96$ for the blood chapter test.

Procedures

The treatment group was notified by letter to schedule three one-hour appointments a week apart and completed one lesson each week during the last three weeks of March. After each lesson the students were asked to answer a short questionnaire on the usability of the lesson. On completion of the last lesson, the chapter examinations were given along with an open-ended questionnaire about the program and its usefulness in biology and in other courses. One week later students were asked to again return to the Learning Skills Center and to read a new biology text (blood text) and to complete a chapter examination.

The control group was also contacted by letter and asked to schedule a one-hour appointment during which they were provided with only the text (embryonic text) and asked to read it without the help of the computer and to complete the same examination that had been taken by the treatment group. They also returned one week later to repeat the process with the new text (blood text).

## RESULTS

Chapter Examination Results

The chapter examinations were administered in order to determine the effectiveness of computer programs in modeling and teaching strategies for comprehending college-level textbooks. The treatment group had instruction on the computer while using the embryonic textbook chapter and was tested immediately after program completion. The blood composition chapter was read and tested upon one week later. The control group, during two sittings one week apart, read and were tested upon the two texts.

The treatment group scored significantly higher on both the embryonic and the blood chapter exams. The control group averaged 62.89 out of a possble 100 points on each chapter examination while the treatment group averaged 79.73 out of a possible 100 points on each examination. Results are displayed in Table I.

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Insert Table I.

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It was predicted that the computer program use would result in higher scores for the treatment group on the embryonic test since that was the text used in the computer lessons. Of greater educational significance is the result that the treatment group also significantly outperformed the control group a week later reading the blood text without aid of the computer programs, suggesting transfer of the reading strategies beyond the single chapter covered in the computer programs.

Further analysis was undertaken on scores for subsections of the chapter examinations to determine which strategies were learned most effectively. Results are displayed in Table II.

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Insert Table II.

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Significant differences in the treatment group's favor at the $p < .05$ level or better exist for all subsections except the identifying key concepts section of the blood composition chapter. Even in this case, the treatment group scored 92% of possible points while the control group scored 84% of possible points.

Biology class test. An unplanned indicator of program success is the fact that treatment group students outperformed control group students on items related to embryonic development on their biology class test which was not a part of this study. On questions related to embryonic development, the treatment averaged 94% correct while the control group averaged 72% correct.

Interview and Questionnaire Results

At the end of each lesson, the treatment group was asked to complete a Likert scale to ascertain student opinions of the effectiveness of the computer in developing basic skills for comprehending a biology text. The scale ranged from 5 (Strongly Agree) to 1 (Strongly Disagree). Mean results for the three computer lessons ranged from 4.20 to 4.60. Students' attitudes toward the programs were strongly positive with no significant differences in relation to sections of the programs.

The lessons were also judged to be effective by the 25 students who used the programs. Student comments during exit interviews included:

> "I hadn't thought of that before."
> "I wish they had these for my brother in high school."
> "Everything is clear about what you're supposed to do."
> "I enjoyed the lesson. It's like X151 without the extra work."
> "Oh, my god, I totally skip over drawings.
> "I wish I'd learned to study a text before I got to college."
> "Have you had success with these programs? They seem very good."

At the end of lesson III students were asked to complete an open-ended questionnaire concerning the entire program. Among the questions asked of students was: Have you ever before used the ideas presented in the computer program to:

| | Yes | No |
|---|---|---|
| a. locate key terms? | 19 | 5 |

| | | | |
|---|---|---|---|
| b. | compare and contrast key terms? | 13 | 11 |
| c. | map relationships among key terms? | 3 | 21 |

For the vast majority of students in the treatment group, graphically mapping concepts was a new and unfamiliar task. In addition, comparing and contrasting key terms was also only reported as familiar by 54% of the students.

In answer to the question: "Has your ability to understand text material improved?", twenty-one students (87.5%) answered "yes". Students answering yes were asked to expand upon the ways they thought their abilities had improved. Among the elaborations provided are:

- My biggest problem is fitting concepts together. Now I have a better feel about how to do it.

- Again, through organizations of materials. Now I have a structured method of study.

- Most of these ideas were already familiar to me, but using the lessons on the computer showed how advantageous these ideas are for learning text material.

- It takes a little more time to try and do the things you have learned (locating and comparing) but the benefits make it worth it.

- By learning to link key terms together and being better able to see the whole chapter made up of its smaller parts.

In an attempt to determine whether or not the students could see a transfer of the skills presented on the computer to other courses at the university, treatment group students were asked, "In what ways, if any, will this lesson be useful for other courses in which you are enrolled?" A sample of comments follows:

- You can apply all the concepts of the experiment to other courses with maybe the exception of math.

- Yes for sociology, etc., but not for English classes, esp.

literature.

- In almost all of my subjects, textbooks are used and set up in the same format. I hope to apply concepts learned to various areas.

- The ideas of locating key terms, comparing and contrasting, and mapping can all be used in other courses.

- Other courses where there is lots of reading involved such as my Human Development class which deals with many of the same concepts presented here.

CONCLUSIONS

With funding from F.I.P.S.E., the Learning Skills Center at Indiana University has developed a series of computer lessons to help students comprehend college level text material. Using guidelines for effective CAI and research on reading comprehension, the computer programs model study strategies and concept mapping while providing for practice and feedback.

Significant differences in examination results support the hypothesis that "how to" strategies can be taught with the use of a computer. The treatment students outperformed the control students at a statistical p <

from the computer programs to the blood text also at a $p < .001$ level. Significant differences in favor of the treatment group were also consistently found for both texts in abilty to link terms and concept map relationships. Concept mapping was reported to be a new concept by 87.5% of the treatment group.

Interview and questionnaire data indicate that computer instruction is viewed positively by students as a way to learn strategies to read difficult material. Indications were that 1) the programs were user-friendly, 2) the strategies were new and useful, 3) the ability to understand text material had improved, and 4) study strategies transferred to use with new textbook chapters.

At a time when many students are enrolling in postsecondary institutions without the necessary skills to meet required study and reading demands, the computer can be a useful tool to teach effective strategies. The Learning Skills Center is presently developing similar software for psychology texts that will be field tested in the spring of 1988.

For information on how to obtain Using Your Biology Textbook Effectively, the software discussed in this paper, contact:

Dr. Larry Mikulecky, Director or
Rad Drew, C.A.I. coordinator
Learning Skills Center
316 N. Jordan
Indiana University
Bloomington, IN 47405

Telephone: (812) 335-7313
Bitnet: MIKULECK@IUBACS or DREWR@IUBACS

Other software developed at the Indiana University Learning Skills Center includes: Using Your Psychology Textbook Effectively, Textbook Marking, Testtaking, and Time Management.

Table I.

Mean Score Differences
of Treatment and Control Subjects
on Embryonic and Blood Chapter Examinations

| | Treatment n=25 | Control n=25 |
|---|---|---|
| Embryonic Chapter Exam | 79.83 | 61.92* |
| Blood Chapter Exam | 79.59 | 63.86* |

* Differences significant at the $p < .001$ level

Table II.

Mean Sub-Scale Score Differences
of Treatment and Control Subjects
on Embryonic and Blood Chapter Examinations

| | Treatment n=25 | Control n=25 | | Sig Level |
|---|---|---|---|---|
| Embryonic Exam | | | | |
| Identifying Key Concepts | 18.6 | 15.2 | (20 possible) | .001 |
| Linking Key Terms | 17.3 | 15.3 | (20 possible) | .05 |
| Mapping Relationships | 44.0 | 31.5 | (60 possible) | .001 |
| Blood Parts Exam | | | | |
| Identifying Key Concepts | 18.4 | 16.8 | (20 possible) | N.S. |
| Linking Key Terms | 18.8 | 13.8 | (20 possible) | .001 |
| Mapping Relationships | 42.1 | 33.2 | (60 possible) | .01 |

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## APPENDIX C

### Sample Documentation of Software

1. Student's Guide for "Reading your Biology Textbook Effectively"
2. Student's Guide for "Reading your Psychology Textbook Effectively"
3. Instructor's Guide for "Reading your Psychology Textbook Effectively"

Student's Guide

# USING YOUR BIOLOGY TEXTBOOK EFFECTIVELY

Learning Skills Center, Indiana University
316 N. Jordan, Bloomington, IN 47405

812-335-7313

Bitnet Address:

Mikuleck@IUBACS
or
Drewr@IUBACS

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How long will the lessons last?.....................4

How are the lessons organized?......................5

## Software Explanation

**What are these lessons about?**

College textbooks are hard for many students to read and understand. This computer program will help you by:

* showing you ways to study and remember information in college level textbook chapters, and

* giving you immediate feedback on your use of these study strategies with a chapter from a biology textbook.

Using Your Biology Textbook Effectively is a tutorial. This means the computer will ask you questions and require you to respond. Learning with the help of a computer can be extremely effective because you can work at your own pace. If you have questions while going through the lessons, don't hesitate to ask for help.

**Who can benefit from using these lessons?**

You, like many other college students, may not be used to the level of difficulty of college textbooks. You will find these lessons especially useful if you:

* have trouble understanding and remembering what you read in college textbooks,

* have particular difficulty understanding natural science textbooks, or

* have never used a college level textbook.

College textbooks are packed with information. Sometimes it is difficult to decide what information is most important or how ideas in a chapter relate to one another. College students who have used this program said that it helped them to understand textbooks more clearly. They also enjoyed using the computer to learn.

**What skills do you need to use these lessons?**

All you need is the ability to read and understand this student guide. You don't need to know much about computers or about biology. You do need to be willing to try some new ways to read and make notes.

**What will you learn from these lessons?**

When you have completed the three lessons in this program you will be able to identify key terms or ideas in a chapter and show how they are related to each other. Remember, the study strategies you will learn can be used with almost any textbook.

**How long will the lessons last?**

Students usually spend between 30-60 minutes on each of the three lessons of Using Your Biology Textbook Effectively. Sometimes a lesson will take longer if the ideas are totally new to you. Do not rush through the lessons. Allow yourself enough time to fully learn the strategies for improving your study skills. When the program says **Do this now**, be sure to write down the information asked for. You will need this for later programs and for your instructor.

**How are the lessons organized?**

This program is divided into three lessons. The following chart explains what you will learn in each lesson.

## Using Your Biology Textbook Effectively

| Lesson I | Strategies for Finding Main Ideas in Textbooks |
|---|---|
| In this lesson you will learn to identify key terms and define them. | |

| Lesson II | Writing Linking Summary Statements |
|---|---|
| In this lesson you will learn to see the relationships between main ideas by comparing and contrasting key terms. | |

| Lesson III | Mapping Relationships |
|---|---|
| In this lesson you will draw a map that visually shows the relationships between the key terms you used in lesson 1. Drawing this map will enable you to see how all of the ideas in the chapter fit together. | |

JOB AID

Learning Strategies Series
Using Your Biology Textbook Effectively

**How to get started**

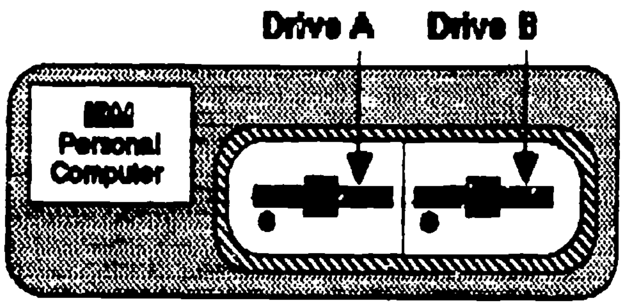
Get the following materials from your instructor or lab attendant before you start.

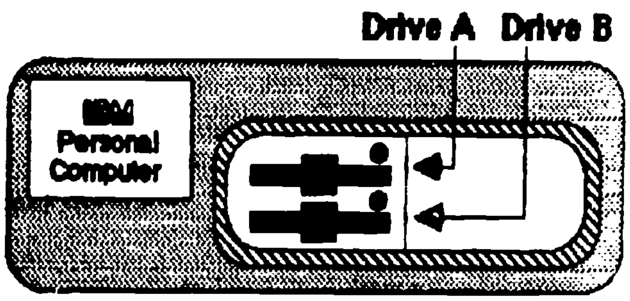
- The Biology Program Student Guide,
- 3 diskettes, and
- Note paper and pencil.

Once you have these materials, you can begin.

**Step 1.**

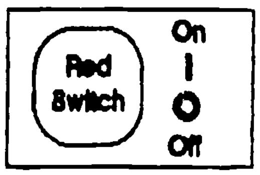
Make sure the **computer is turned off**. Take the Biology lesson 1 diskette and insert into drive A. See the illustration below. Your computer may look different from the ones below. Ask your instructor or lab attendant for help if it does. Handle the diskettes carefully. Ask your instructor or lab attendant for help if you do not know how.




**Step 2.**

Reach around the right side of the computer and turn the computer on. See the illustration below.




**What if I don't see anything?**

Your video monitor is probably not turned on. Turn it on.

## Reading Your Biology Textbook Effectively

After you have finished Lesson 1: Finding Key Terms, you will need to know the key terms and their definitions for Lesson 2: Writing Linking Summary Statements. Before you start Lesson 2, you will take a quiz over the definitions of key terms.

Instructions:

1. Read the biology chapter (pages 1-7). Use the outline and key terms that you wrote out with the computer program to help you understand the chapter.

2. Define the key terms on page 11.

   a. Look in the textbook chapter for that key term. Write down information under category and special features.

   b. Check the glossary (pages 8-9) under the key term. Add the information from the definition in the glossary. (Note: The glossary definition may not be specific enough. Don't use them without the information in the textbook.)

   c. An example of how to define a key term is on page 10.

USE THESE MATERIALS EACH TIME YOU WORK ON THESE LESSONS.

# DEVELOPMENT: FR( M EGG TO ORGANISM

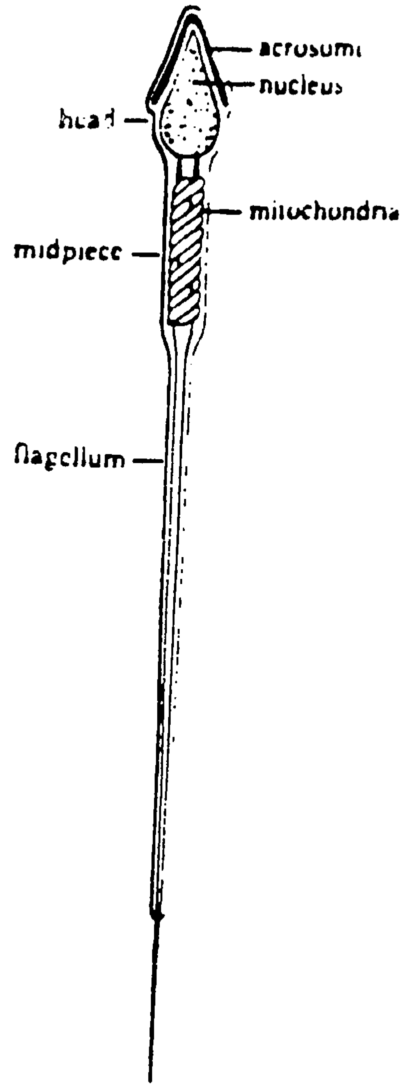
To biologists and nonbiologists alike, probably no aspect of biology is more amazing than the development of a complete new organism from one cell, a development so precisely controlled that the entire intricate organization of cells, tissues, organs, and organ systems characterizing the functioning adult comes into being with rarely a flaw. We have previously examined the genetic information that controls development and programs a mouse zygote to develop into a mouse, an oak zygote into an oak, and an earthworm zygote into an earthworm. We have also discussed possible cellular control mechanisms in development—how individual genes may be turned on or off in its course. Let us now first briefly examine a few representative patterns in animal and plant development and then try to relate these patterns to the control mechanisms we considered earlier.

## Development of a Multicellular Animal

As a first representative pattern of development, we shall take the principal events in the development of a multicellular animal, making no attempt to discuss this development in great detail or even to mention all the important events. Our purpose is simply to survey the kinds of events that any model of developmental control must seek to explain.

### FERTILIZATION

The penetration of a sperm into an egg cell stimulates the egg to begin development into an embryo. Note that *penetration* is the trig-




25.1 Human sperm cells
Left: Diagram of a human sperm cell. Three sections are easily distinguishable: the head, containing the nucleus, the midpiece, in which many mitochondria are tightly packed; and the long flagellum. In the tip of the head, immediately in front of the nucleus, is the acrosome, a membrane-bounded vesicle that contains enzymes for acting on the egg cell membrane. There is only a tiny amount of cytoplasm in the cell. Right: Photograph of human sperm on the surface of an egg. Though vast numbers of sperm may reach the egg, only one can penetrate and fertilize it. (Right: Courtesy P. Sundstrom, Gamma-Liaison.)

ger, not the fusion of the sperm nucleus with the egg nucleus, even though this fusion is the actual event of fertilization. Apparently in many animals true fertilization is not necessary to induce embryonic development. It is easy to induce unfertilized frog eggs, for example to begin development in the laboratory by pricking them with a fine needle dipped in blood. A few such eggs will develop into viable normal-appearing tadpoles.[1] Adult rabbits have been produced from unfertilized eggs by similar procedures.

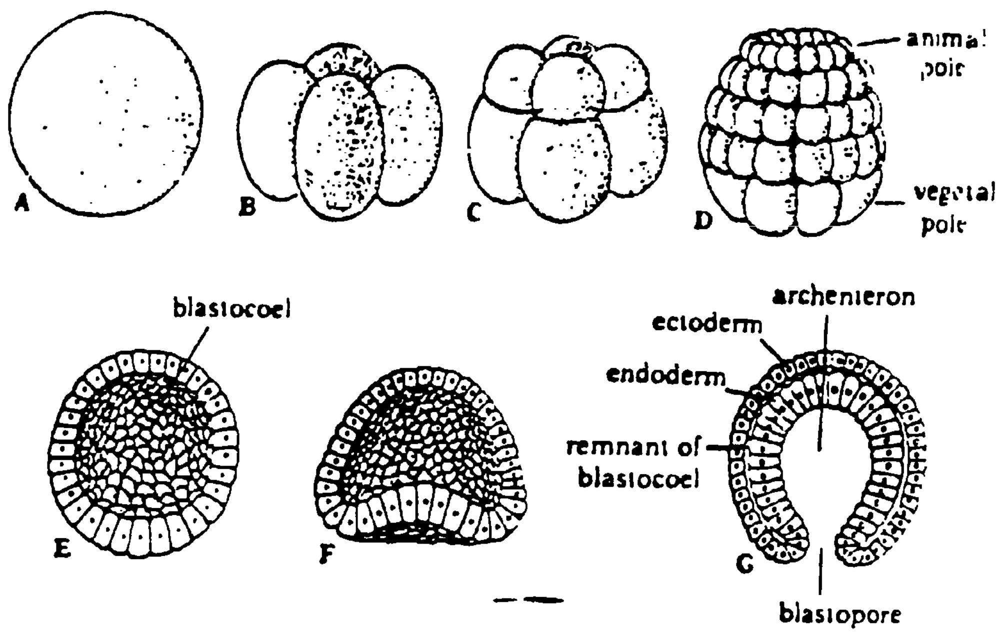
When the sperm (Fig. 25.1) makes contact with the egg, the membranes of the sperm and egg fuse and the sperm nucleus moves into the egg. Almost immediately, vesicles in the outer region of the egg cytoplasm discharge their contents into the region around the cell, forming a ***fertilization membrane*** surrounding the egg. The fertilization membrane and the plasma membrane act as a barrier against entry of additional sperm cells. Sperm penetration also brings about a host of other changes in the egg, such as altered membrane permeability and increased metabolic rate.

Important as are all the events discussed so far, they do not constitute fertilization in the genetic sense; true fertilization is the union of the two gamete nuclei. This union depends on some attraction of the sperm nucleus by the egg nucleus, the nature of which is still unknown.

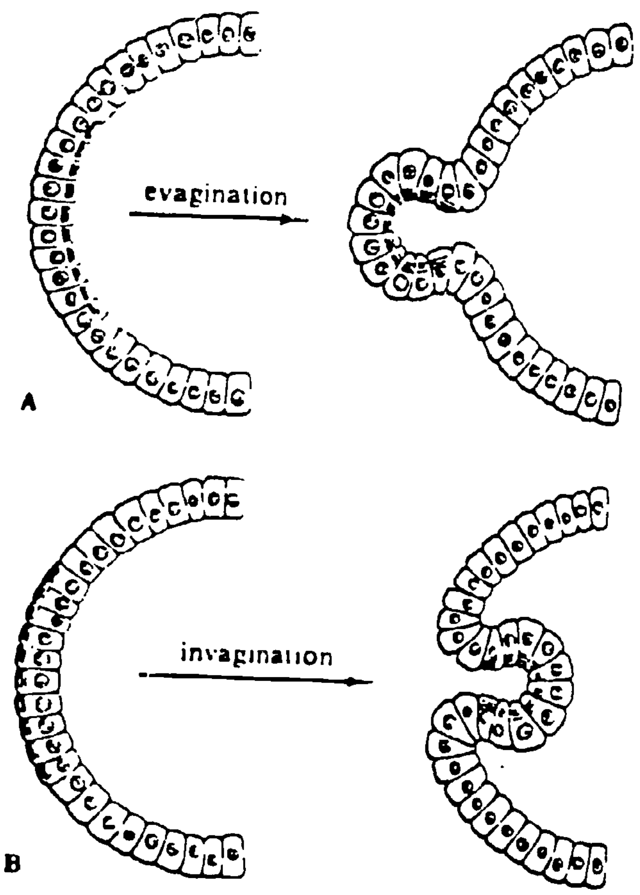
### EMBRYONIC DEVELOPMENT

**Early cleavage and morphogenetic stages** In normal development the zygote begins a rapid series of mitotic divisions immediately after fertilization has taken place. These early cleavages are not accompanied by protoplasmic growth. They produce a grapelike cluster of cells called a ***morula***, which is little if any larger than the single egg cell

[1] Most embryos developed from unfertilized eggs are haploids, which invariably die after reaching, at best, the tadpole stage. Such embryos as survive to reach adulthood are the few that undergo spontaneous chromosomal duplication, with most becoming diploid (though the two sets of chromosomes are identical).




**25.2 Early embryology of amphioxus** (A) Zygote (B-D) Early cleavage stages forming a morula (C) and then a blastula (D) (E) Longitudinal section through a blastula, showing the blastocoel. (F-G) Longitudinal sections through an early and a late gastrula. Notice that the invagination is at the vegetal pole of the embryo, where the cells are largest




**25.3 The mechanism of some morphogenetic movements in cells** Contraction of microfilaments (black), asymmetrically positioned in the cells, may change the shapes of the cells and produce evaginations (A), invaginations (B), or other alterations of the arrangement of cells in a developing organ The contractile microfilaments are of the same type as those involved in amoeboid movement and cytokinesis.

from which it is derived (Fig. 25.2C). The cytoplasm of the one large cell is simply partitioned into many new cells that are much smaller.

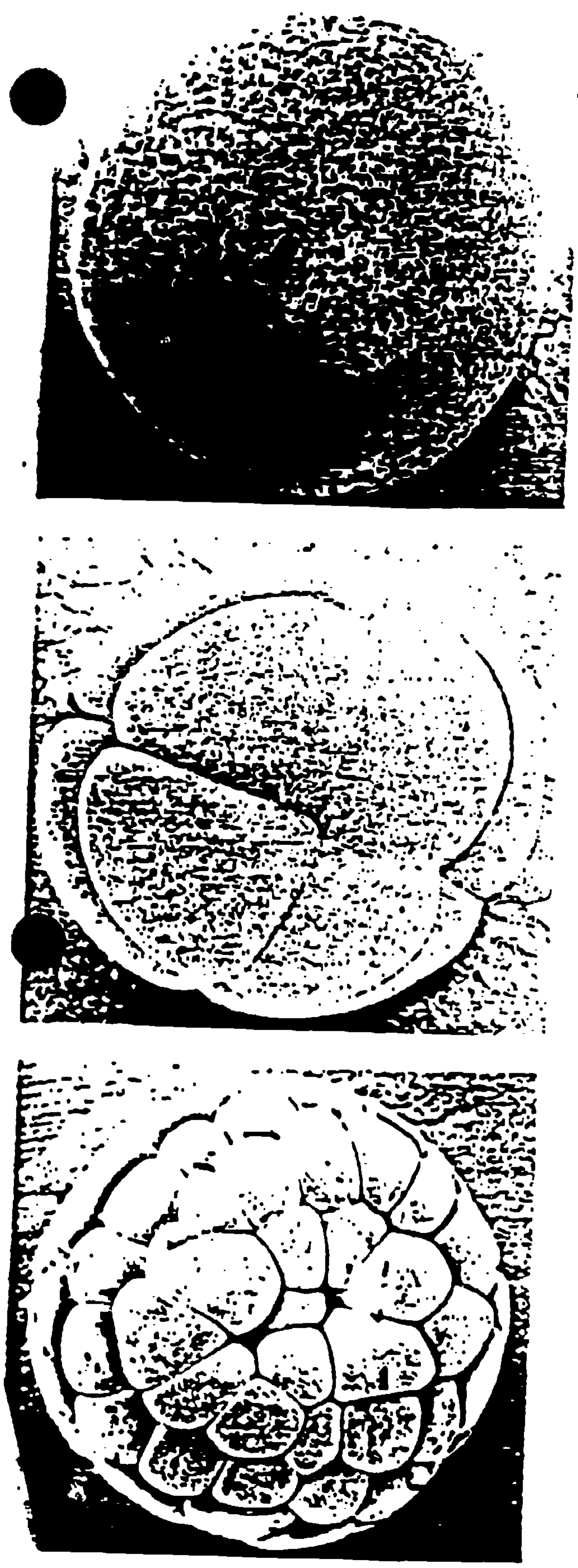
As cleavage continues, the newly formed cells (blastomeres) of many species begin to secrete a fluid into the center of the mass of cells. As a result, the blastomeres come to be arranged in a sphere surrounding a fluid-filled cavity called a ***blastocoel*** (Fig. 25.2E). An embryo at this stage is termed a ***blastula.*** Note that there is no opening into the blastocoel.

Next begins a series of complex movements important in establishing the definitive shape and pattern of the developing embryo. The establishment of shape and pattern in an organism is called ***morphogenesis*** (meaning "the genesis of form"). Morphogenetic movements of cells in large masses always occur during the early developmental stages of animals.

The mechanism of these movements is still very poorly understood. There are often changes in the shapes of the cells, probably effected by contractile microfilaments (Fig. 25.3) or by some microtubular apparatus. Possibly important in some of the movements are changes in the adhesive affinities of the cells for neighboring cells. It may be relatively easy for a group of cells that adhere tightly to each other, but have very little affinity for a layer of cells lying under them, to slide, as a group, over the surface of that underlying layer, just as it is easy for individual cancer cells, which lack cellular affinities, to move across the surfaces of healthy cells.

Since the pattern of cleavages and cell movement is greatly influenced by the amount of yolk (stored food) in the egg, we shall examine first the pattern in an animal whose eggs have little yolk, and then the pattern in animals whose eggs have more yolk.

In amphioxus (see Fig. 33.57, p. 707), a tiny marine chordate whose egg has very little yolk, the movements that occur after formation of the blastula convert it into a two-layered structure called a ***gastrula.*** The process of gastrulation begins when a small depression, or invagination, starts to form at a point on the surface of the blastula where the cells are somewhat larger than those on the opposite side (Fig. 25.2F). The differences in cell size are not very great in amphioxus embryos; they are more pronounced in many other animals. The smaller cells make up the ***animal hemisphere*** of the embryo. The



Scanning electron micrographs of frog nd some early cleavage stages Unfertilized egg. Middle: 8-cell stage. : 32 to 64-cell stage. All three aphs are at the same magnification. Note that there has been no overall size during these cleavage stages; 64-cell embryo is no larger than ll. [Courtesy R. G. Kessel and C. Y. ...un, *Scanning electron microscopy in biology*, Springer-Verlag, 1974.]

larger cells make up the ***vegetal hemisphere***. It is at the pole of the vegetal hemisphere that the invagination of gastrulation typically occurs. As gastrulation proceeds, and more and more cells move to the point of invagination and then fold inward, the invagination becomes larger and larger. Eventually the invaginated cell layer comes to lie almost against the outer layer, thus nearly obliterating the old blastocoel (Fig. 25.2G). The resulting gastrula is a two-layered cup, with a new cavity that opens to the outside via the ***blastopore***, which is at the point where invagination first began. The new cavity, called the ***archenteron***, will become the cavity of the digestive tract, and the blastopore will become the anus.

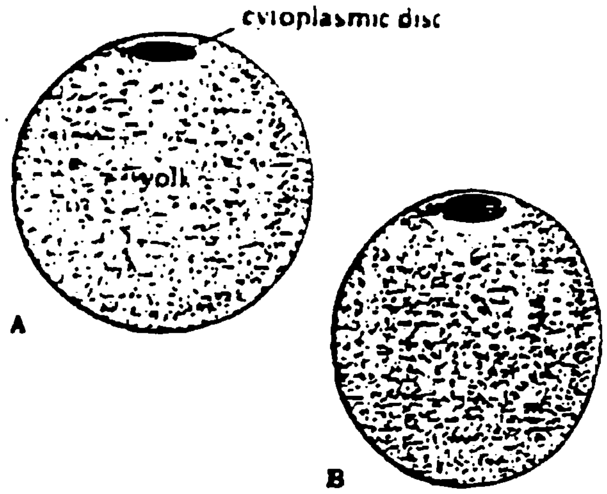
Gastrulation, as it occurs in amphioxus, first produces a cuplike embryo with two primary cell layers, an outer ***ectoderm*** and an inner ***endoderm***. A third primary layer, the ***mesoderm***, soon begins to form between the ectoderm and the endoderm. In amphioxus the mesoderm originates as pouches pinched off the endoderm (Fig. 25.4). In many other animals it arises from inwandering cells derived primarily from the area around the blastopore where the ectoderm and endoderm meet.

In the amphioxus egg, where the distinction between animal and vegetal hemispheres is only slight owing to the small amount of yolk in the vegetal hemisphere, the early cleavages are nearly equal (the new cells are of nearly the same size) and gastrulation can occur in a direct and uncomplicated manner. Many eggs have far more yolk in their vegetal hemisphere, and this deposit of stored food imposes complications and limitations on such processes as cleavage and gastrulation. Generally, the more yolk an egg contains, the more cleavage tends to be restricted to the animal hemisphere and the more gastrulation departs from the pattern in amphioxus.

Frogs' eggs, which contain far more yolk than those of amphioxus but much less than those of most birds, may serve as examples of eggs with an intermediate yolk mass. The first two cleavages, which are perpendicular to each other, cut through both the animal and vegetal poles, producing cells of roughly the same size (Fig. 25.5B). But the next cleavage is horizontal and located decidedly nearer the animal pole (Fig. 25.5C); hence the four cells produced at the animal end of the egg are considerably smaller than the four at the vegetal end. From this stage onward, more cleavages occur in the animal hemisphere of the embryo than in the vegetal hemisphere as the blastula develops. As in amphioxus, there is very little increase in total size during these early cleavage stages (Fig. 25.6).

Early in its second day of development, the frog embryo begins gastrulation. Simple invagination at the vegetal pole is not mechanically feasible, because of the large mass of inert yolk-filled cells. Instead, portions of the cell layer of the animal hemisphere move down around the yolk-cell mass and then fold in at its edge. This involution begins at what will be the dorsal side of the yolk mass, forming initially a crescent-shaped blastopore there (Fig. 25.5E). This infolding slowly spreads to all sides of the yolk, so that the crescent blastopore is converted into a circle. Movement of the other cells around the yolk eventually encloses this material almost completely within the cavity of the archenteron. The yolk-filled cells become the endoderm. The yolk stored in each cell serves as a source of energy for the growing embryo.

Birds' eggs contain so much yolk that the small disc of cytoplasm on

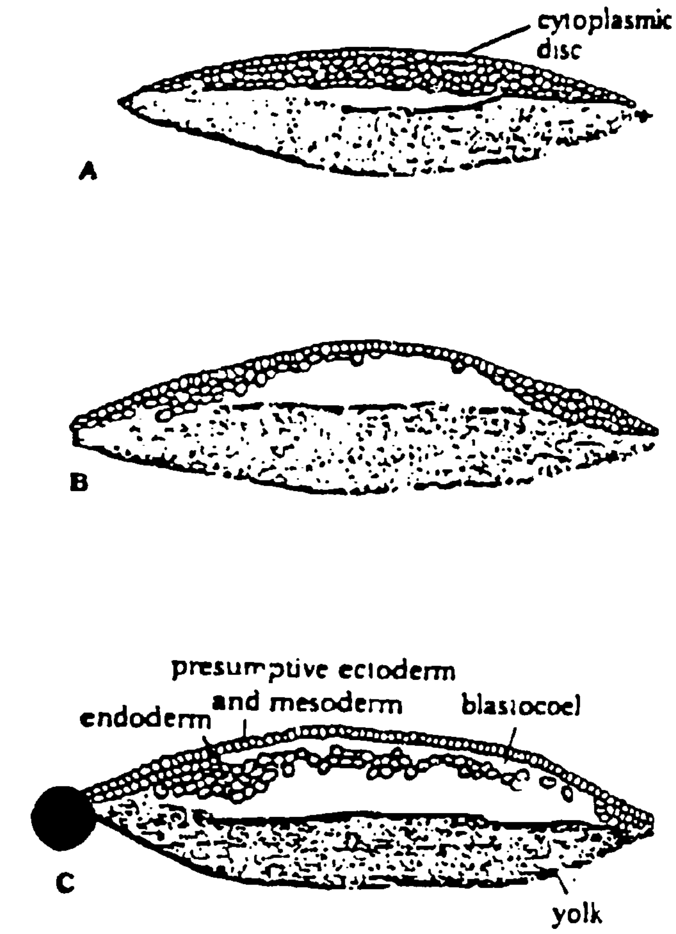


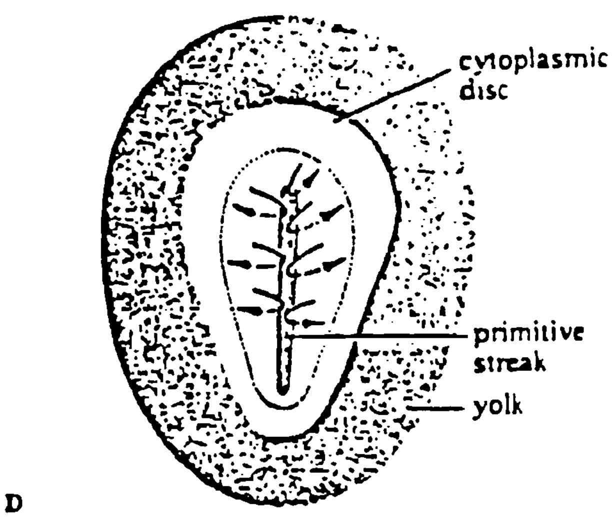

25.7 **Egg and early-cleavage embryo of a chick**
(A) The zygote. A small cytoplasmic disc lies on the surface of a massive yolk. (B) Early cleavage. There is no cleavage of the yolk.

the yolk's surface is dwarfed by comparison. No cleavage of the massive yolk is possible, and all cell division is restricted to the small cytoplasmic disc (Fig. 25.7). (Note that the yolk and the small cytoplasmic disc on its surface constitute the true egg cell. The white albumin of the egg is outside the cell.) The gastrulation process is of necessity greatly modified in such eggs (Fig. 25.8).

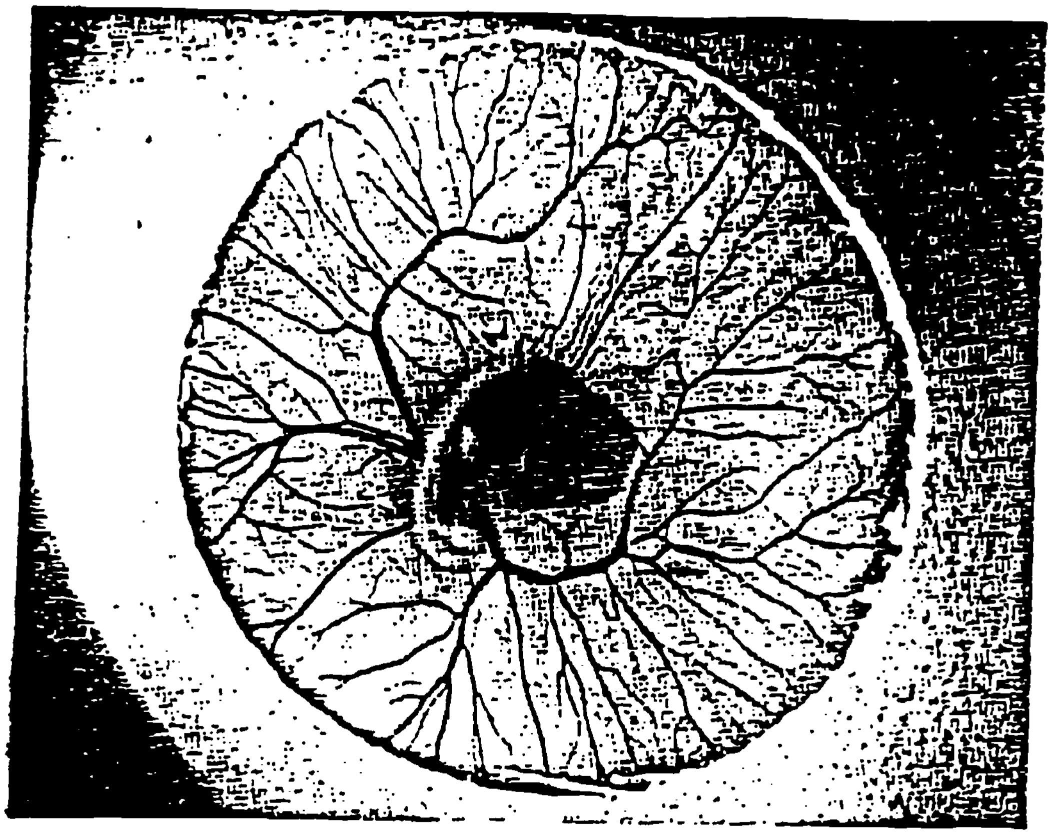
The fates of cells in different parts of the three primary layers of vertebrates have been determined by staining them with dyes of different colors and then following their movements. As you might expect, the ectoderm eventually gives rise to the outermost layer of the body—the epidermal portion of the skin—and to structures derived from the epidermis, such as hair, nails, the eye lens, many glands, and the epithelium of the nasal cavity, mouth, and anal canal. As you might also expect, the endoderm gives rise to the innermost layer of the body—the epithelial lining of the digestive tract and of other structures derived from the digestive tract, such as the respiratory passages and the lungs, the liver, the pancreas, the thyroid, and the bladder. The mesoderm gives rise to most of the tissues in between such as muscle, connective tissue (including blood and bone), and the notochord (a dorsally located supportive rod found in all chordates, at least in the embryological stages).

One major tissue located topographically between the skin and the gut does not develop from the mesoderm. This is the nervous tissue, which, curiously enough, is derived from the ectoderm. Soon after gastrulation, the neural tube begins to develop in a process called ***neurulation***. The embryo at this stage is called the ***neurula***. The ectoderm becomes divided into two components, the epidermis and the neural tube. A sheet of ectodermal cells lying along the midline of the embryo above the newly formed digestive tract and developing notochord bends inward, and forms a long groove extending most of the length of the embryo (Figs. 25.4 and 25.5G–25.5H). The dorsal folds




25.8 **Gastrulation in the chick embryo**
(A) Longitudinal section shows some larger yolk-laden cells (color) intermixed with smaller cells (B) The larger cells begin to accumulate on the lower surface of the cell mass (C) The layer of larger cells separates from the layer of smaller cells to become the endoderm, the cavity between the two layers is the blastocoel. This is the blastula stage (D) Surface view of a gastrula. Cells along the midline of the embryo move inward during gastrulation (color arrows) producing a clearly visible primitive streak, which is essentially a very elongate blastopore



**25.9 Chick embryo after four days of incubation**
The tiny embryo lies on the surface of the yolk. It has a functional circulatory system, including a beating heart, even at this early stage of its development. Note the long branching blood vessels that run out of the embryo into the yolk; they transport nutrients to the embryo. [Oxford Scientific Films.]

that border this groove then move toward each other and fuse, converting the groove into a long tube lying beneath the surface of the back. This neural tube becomes detached from the epidermis above it, and in time differentiates into the spinal cord and brain (Figs. 25.4D and 25.5I).

We see, then, that the morphogenetic movements of gastrulation and neurulation give shape and form to the embryo, and bring masses of cells into the proper position for their later differentiation into the principal tissues of the adult body. In effect, the movements mold the embryonic mass into the structural configuration on which differentiation will superimpose the finer detail of the finished organism.

**Later embryonic development** Much must happen to convert a gastrula into a fully developed young animal ready for birth: The individual tissues and organs must be formed; an efficient circulatory system must quickly come into function (Fig. 25.9); in a vertebrate the four limbs must develop; the elaborate system of nervous control must be established; and so forth. The complexity and the precision characterizing these developmental changes are staggering to contemplate. To give but one example: Approximately 43 muscles, 29 bones, and many hundreds of nervous pathways must form in each human arm and hand. To function properly, all these components must be precisely correlated. Each muscle must have exactly the right attachments, each bone must be jointed to the next bone beyond it in a certain way; each nerve fiber must have all the proper synaptic connections with the central nervous system and must terminate on the right effector cells. Incredibly sensitive mechanisms of developmental control must operate if such an intricate structure can arise from a mass of initially undifferentiated cells. Yet the developmental processes that produce all these later embryonic changes are the same ones we have seen at work in the early embryo—cell division, cell growth, cell differentiation, and morphogenetic movement

## Concepts in Brief

The process of development in a sexually reproducing multicellular animal begins with the penetration of the sperm into the ovum. *Fertilization* occurs when the two gamete nuclei fuse.

The zygote then undergoes *cleavage;* the cytoplasm of the one large cell is partitioned into many new smaller cells. Cleavage continues until a hollow ball, the *blastula*, is formed.

Next begins a series of complex movements that establish the shape and pattern of the developing organism (*morphogenesis*). The blastula is converted into a *gastrula*. Gastrulation first produces an embryo with two layers, an outer *ectoderm* and an inner *endoderm*. A third layer, the *mesoderm*, forms between them. The ectoderm gives rise to the outermost layers of the body, the nervous system, and the sense organs; the endoderm to the lining of the digestive tract and associated structures, and the mesoderm to the supportive tissue—muscles and connective tissues.

The morphogenetic movements of gastrulation and neurulation give shape and form to the embryo, and bring masses of cells into proper position for their later differentiation into the principal tissues of the adult body. The developmental processes of cell division, cell growth, cell differentiation, and morphogenetic movement convert the gastrula into a young animal ready for birth.

## Glossary

**anabolism** - The biosynthetic building-up aspects of metabolism.

**blastula** - An early embyronic stage in animals, preceding the delimitation of the three principal tissue layers; frequently spherical and hollow.

**cartilage** - A specialized type of dense fibrous connective tissue with a rubbery intercellular matrix.

**differentiation** - The process of developmental change from an immature to a mature form, especially in a cell.

**ectoderm** - The innermost tissue layer of an animal embryo.

**embryo** - A plant or animal in an early stage of development; generally still contained within the seed, egg or uterus.

**endoderm** - The innermost tissue layer of an animal embryo.

**evaginated** - Folded or protruded outward.

**fertilization** - Fusion of nuclei of egg and sperm.

**follicle** - A jacket of cells around an egg and sperm.

**gastrula** - A two-layered, later three-layered, animal embryonic stage.

**gastrulation** - The process by which a blastula develops into a gastrula, usually by an involution of cells.

**homeostasis** - The tendency in an organism toward maintenance of physiological and psychological stability.

**invaginated** - Folded or protruded inward.

**lysis** - The bursting of a cell by the destruction of its cell membrane.

**mesoderm** - The middle tissue layer of an animal embryo.

**morphogenesis** - The establishment of shape and pattern in an organism.

**mutualism** - A symbiosis in which both parties benefit.

**neurula** - That stage in embryonic development during which the neural tube forms.

**niche** - The functional role and position of an organism in the ecosystem.

**ontogeny** - The course of development of an individual organism.

**osmosis** - Movement of a solvent through a semipermeable membrane.

**phylogeny** - Evolutionary history of an organism.

**phenotype** - An organism's physical appearance, which results from the interaction of its genotype and the environment.

**polymorphism** - The simultaneous occurance of several discontinuous phenotypes in a population.

**radiation** - Divergence of members of a single lineage into different niches or adaptive zones.

**species** - The largest unit of population within which effective gene flow occurs or could occur.

**symbiosis** - The living together of two organisms in an intimate relationship.

**zygot** - A fertilized egg cell.

# Example of How to Define a Key term

Look for the term evagination on page 3 in the chapter.

The term evagination is part of illustration 25.3 on page 3. The illustration label reads:

"The mechanism of some morphogenetic movements in cells"

Because the illustration shows the mechanism of some morphogenetic movements, evagination must be a mechanism.

Therefore the category or group of the term evagination is "the mechanism of some morphogenetic movement in cells."

Now look at the illustration again.

You can see from the illustration that some of the cells in the organism are "folded outside" the other cells.

Now that you have some information from the textbook, check the glossary.

Evagination is not in the glossary, but evaginated is included.

Evaginated means "folded or protruded outward." That's another way of saying that some cells are pushed outside the other cells.

Therefore, a special feature of evagination is "being folded or protruded outward."

Finally put the key term, the category, and the special features together to made a defintion.

Your complete definition would be:

> Evagination is a mechanism of morphogenetic movements in cells that causes some cells to be folded outward.

## Worksheet for Defining Key Terms

Look in the textbook chapter and in the glossary for the category and special featuress for each key term. Write the details you find for each term on this page. Study the definitions before you start Lesson 2.

| Term | Category | Special Features |
| --- | --- | --- |
| penetration | | |
| fertilization | | |
| zygote | | |
| cleavage | | |
| blastula | | |
| morphogenesis | | |
| gastrula | | |
| gastrulation | | |
| embryo | | |
| ectoderm | | |
| endoderm | | |
| mesoderm | | |
| morphogenetic movement | | |
| neurulation | | |

APPENDIX D

Program Diskettes for IBMpc

1. Reading your Biology Textbook Effectively (3)

   a. Lesson One
   b. Lesson Two
   c. Lesson Three

2. Reading your Psychology Textbook Effectively (4)

   a. Administrative Disk
   b. Lesson One
   c. Lesson Two
   d. Lesson Three

Student's Guide

# USING YOUR PSYCHOLOGY TEXTBOOK EFFECTIVELY

Learning Skills Center, Indiana University
316 N. Jordan, Bloomington, IN 47405

812-335-7313

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What skills do you need to take these lessons?...........4

What will you learn from these lessons?..................4

How long will the lessons last?..........................4

How are the lessons organized?...........................5

## Software Explanation

**What are these lessons about?**

College textbooks are hard for many students to read and understand. This computer program will help you by:

* showing you ways to study and remember information in college level textbook chapters, and

* giving you immediate feedback on your use of these study strategies with a chapter from a psychology textbook.

Using Your Psychology Textbook Effectively is a tutorial. This means the computer will ask you questions and require you to respond. Learning with the help of a computer can be extremely effective because you can work at your own pace. If you have questions while going through the lessons, don't hesitate to ask for help.

**Who can benefit from using these lessons?**

You, like many other college students, may not be used to the level of difficulty of college textbooks. You will find these lessons especially useful if you:

* have trouble understanding and remembering what you read in college textbooks,

* have particular difficulty understanding behavioral science textbooks, or

* have never used a college level textbook.

College textbooks are packed with information. Sometimes it is difficult to decide what information is most important or how ideas in a chapter relate to one another. College students who have used this program said that it helped them to understand textbooks more clearly. They also enjoyed using the computer to learn.

**What skills do you need to use these lessons?**

All you need is the ability to read and understand this student guide. You don't need to know much about computers or about psychology. You do need to be willing to try some new ways to read and make notes.

**What will you learn from these lessons?**

When you have completed the three lessons in this program you will be able to identify key terms or ideas in a chapter and show how they are related to each other. Remember, the study strategies you will learn can be used with almost any textbook.

**How long will the lessons last?**

Students usually spend between 30-60 minutes on each of the three lessons of Using Your Psychology Textbook Effectively. Sometimes a lesson will take longer if the ideas are totally new to you. Do not rush through the lessons. Allow yourself enough time to fully learn the strategies for improving your study skills. When the program says **Do this now**, be sure to write down the information asked for. You will need this for later programs and for your instructor.

**How are the lessons organized?**

This program is divided into three lessons. The following chart explains what you will learn in each lesson.

__Using Your Psychology Textbook Effectively__

| Lesson I | Strategies for Finding Main Ideas in Textbooks |
|---|---|
| In this lesson you will learn to identify key terms and define them. | |

| Lesson II | Writing Linking Summary Statements |
|---|---|
| In this lesson you will learn to see the relationships between main ideas by comparing and contrasting key terms. | |

| Lesson III | Mapping Relationships |
|---|---|
| In this lesson you will draw a map that visually shows the relationships between the key terms you used in lesson 1. Drawing this map will enable you to see how all of the ideas in the chapter fit together. | |

JOB AID

Learning Strategies Series:
Using Your Psychology Textbook Effectively

**How to get started**

Get the following materials from your instructor or lab attendant before you start

- The Psyohology Program Student Guide,
- 4 diskettes (3 program disks and 1 administrative disk, and
- Note paper and pencil.

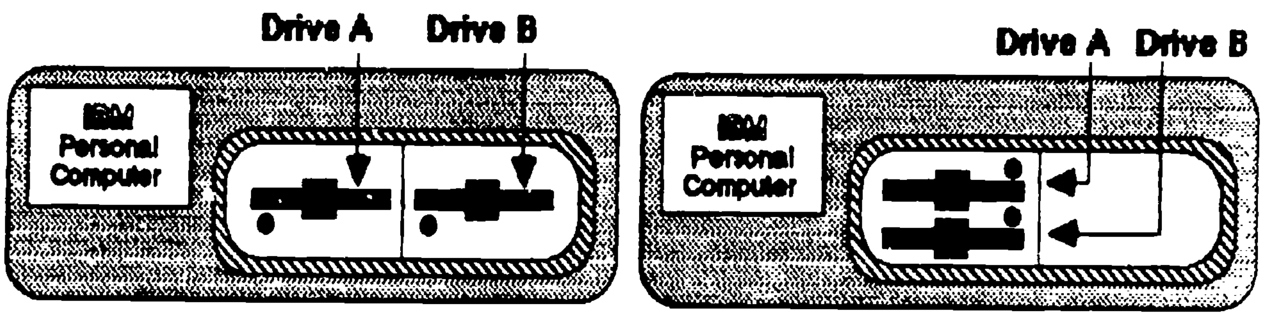
Once you have these materials, you can begin.

**Step 1.**

Make sure the **computer** is **turned off**. Take the Psychology administrative diskette and insert into drive A. See the illustration below.

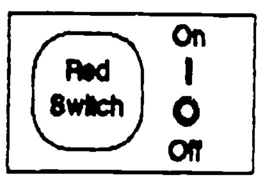
**Step 2.**

Take the Psychology lesson 1 diskette and insert it into drive B. Your computer may look different from the ones below. Ask your instructor or lab attendant for help if it does. Handle the diskettes carefully. Ask your instructor or lab attendant for help if you do not know how.




**Step 3.**

Reach around the right side of the computer and turn the computer on. See the illustration below.




**What if I don't see anything?**

Your video monitor is probably not turned on. Turn it on.

**What if I see:**

```
The IBM Personal Computer Basic
Version C1.10 Copyright IBM Corp.
62940 Bytes free
Ok

1 LIST  2 RUN  3 LOAD  4 SAVE  5 CONT  6 LPT1  7 TRON  8 TROFF  9 KEY  0 SCREEN
```

Then you inserted the diskette into drive B.

- Turn off the computer.
- Insert the diskette into drive A.
- Go back to step 2.

Reading Your Psychology Textbook Effectively

After you have finished Lesson 1: Finding Main Ideas, you will need to know the key terms and their definitions for Lesson 2: Looking at Relationships. Before you start Lesson 2, you will take a quiz over the definitions of key terms.

Instructions:

1. Read the psychology chapter (pages 1 -7). Use the outline and key terms that you wrote out with the computer program to help you understand the chapter.

2. Define the key terms on page 11.

   a. Look in the textbook chapter for that key term Write a short definition based on the information in the text.

   b. Look up the definition of the key term in the glossary (pages 8 and 9).

   c. Put the two definitions together to make one better definition.

   d. Rewrite the better definition in your own words.

   *** An example of how to define a key term is on page 10.

USE THESE MATERIALS EACH TIME YOU WORK ON THESE LESSONS.

## STORAGE SYSTEMS

The most influential theory proposing a distinction among several different kinds, or types, of memory was articulated by Richard C. Atkinson and Richard M. Shiffrin (1968, 1971). They postulated three different memory storage systems: sensory stores, a short-term store, and a long-term store. ***Sensory stores*** hold information very briefly after it has reached the sense organs. The ***short-term store*** holds the data of which people are conscious at any one moment, such as the last few words in this sentence. (This system is sometimes equated with consciousness as it was discussed in Chapter 5.) The ***long-term store*** holds memories over lengthy periods. (For an overview of Atkinson and Shiffrin's theory, see Figure 7–2).

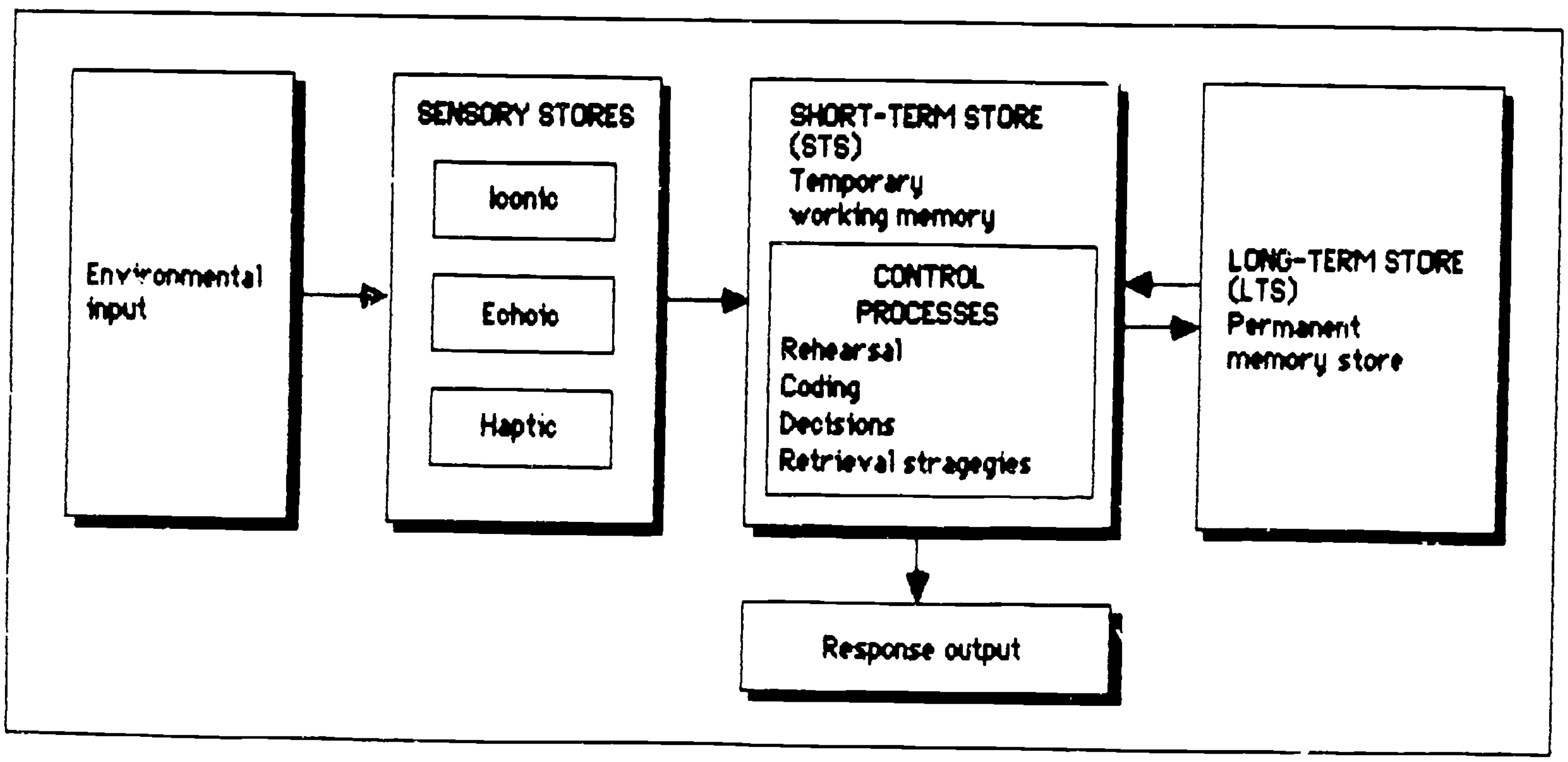
In the next few pages we will discuss the properties of these systems in more detail. But at the outset note that you should not take literally the idea that there are separate stores located in different places in the brain. The term "stores" is used in an abstract sense to refer to three systems with different properties.

### The Sensory Stores

After information has reached the sense organs, it travels through the nervous system to the brain, which interprets it. The information must linger

**FIGURE 7–2**
**Atkinson and Shiffrin's Model of Memory Storage**

The relations among the sensory stores, the short-term store, and the long-term store are depicted in this flow chart. There is probably a sensory store for each sense. (*Haptic* refers to the sense of touch.) The short-term store may be thought of as a stage of conscious activity. It controls transfer of information to long-term store as well as retrieval from long-term store. It is also responsible for deciding which response should be made. The long-term store is the permanent memory store.
*Source:* Atkinson & Shiffrin, 1971



in the nervous system briefly for the brain to have time to interpret it. This "lingering," or persistence, is referred to as sensory storage. Atkinson and Shiffrin assumed that separate storage systems existed for each sense, but only the visual and auditory systems have been studied in any detail. The assumption of sensory stores is similar to the S-system (sensory system) Broadbent (1958) postulated in his theory of attention, discussed in Chapter 5. In fact, the Atkinson and Shiffrin theory is a grandchild of Broadbent's approach in which psychologists try to chart the flow of information through the mind.

You are familiar with the visual sensory storage. When someone takes your picture and uses a flashbulb, you usually see an afterimage of the flash for a few seconds. The technical term for this afterimage is ***iconic storage***, the name of the sensory storage associated with vision (Neisser, 1967).

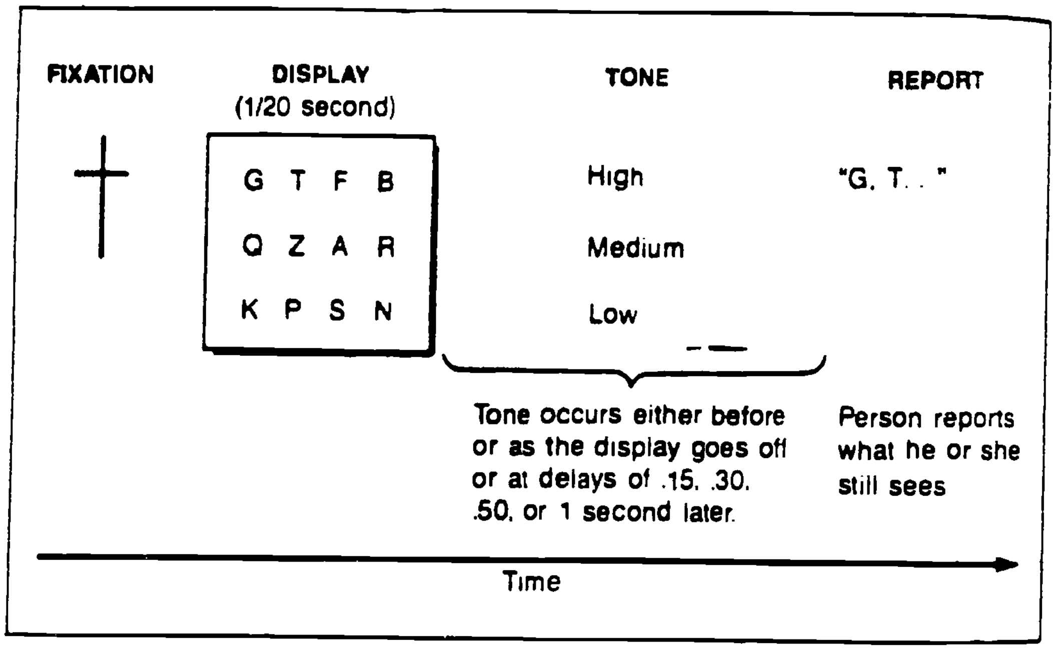
George Sperling (1960) developed a way to study iconic storage. He flashed an array of letters at a person through a device called a ***tachistoscope*** that controlled quite accurately how long the letters were displayed. Typically, Sperling used three rows of four letters and displayed them for 50 milliseconds, or 1/20 of a second. When he asked subjects to report as many letters as possible from the whole display—a situation referred to as the *whole report* condition—they averaged about 4.5 out of 12 items. This finding replicates the work of many others dating back to the 1880s.

Sperling's contribution was to introduce a *partial report* condition in which, as the name implies, a person was asked to recall only part of the display. Sperling instructed his subjects that if they heard a high-pitched tone just after a display was presented, they should report on the top row; if a medium-pitched tone, the middle row; and if a low-pitched tone, the bottom row. Sperling also varied the point at which a person would hear the tone: it would sound shortly before the display went off, simultaneously with the display going off, or at one of four times after the display went off.

A tachistoscope is a device for presenting visual information for brief periods of time. The person being tested stares down the tube and, in this experiment, pushes a button as quickly as possible when a stimulus is perceived. In Sperling's experiment the subjects reported as many letters as possible from a brief display.

**FIGURE 7–3**
**A Typical Trial in Sperling's Experiment**

Subjects fixated on a cross, and then a display of letters was flashed briefly on the screen. A tone sounded at various times to tell the person which row to report. The procedure was designed to answer two questions: (1) whether or not information can be retrieved from an afterimage (icon) of the display; and (2) if so, how quickly the image fades.



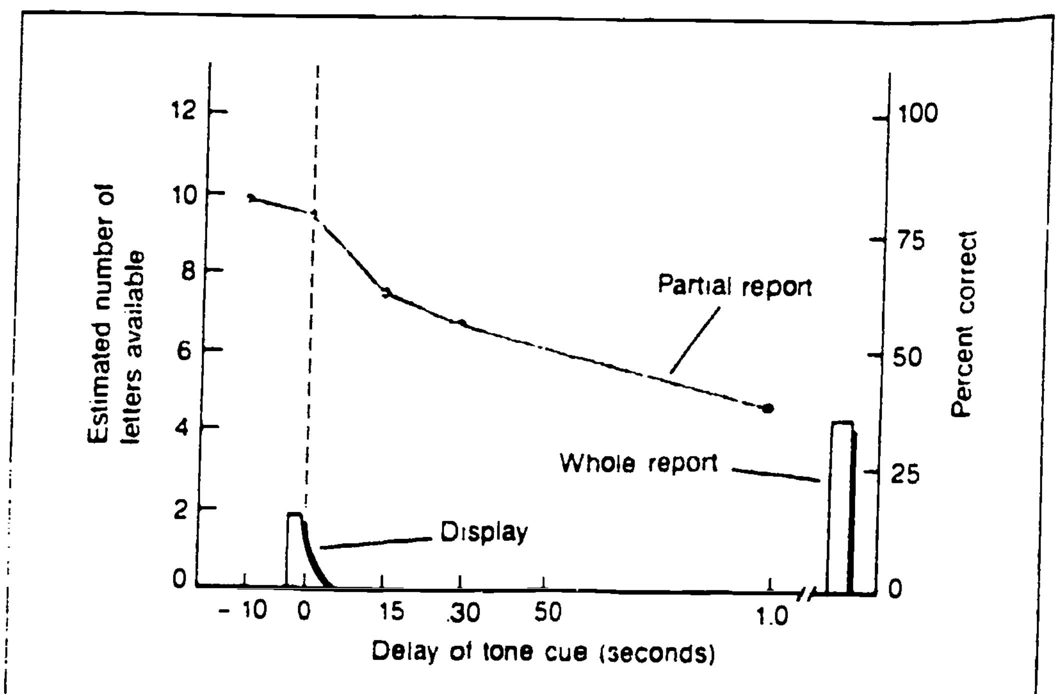

The tone was never delayed more than one second. The procedure for this experiment is illustrated in Figure 7–3.

Sperling found that when people were cued to report one row of a 12-letter display immediately after it went off, they averaged 3.3 letters. Since his subjects never knew which row they would be asked to recall (the rows were randomly cued), Sperling reasoned that they could have reported any of almost 10 letters (3 rows × 3.3 per row) just after the display was turned off. He thought people were reading the letters from an afterimage, the iconic store. If this were so, then the number of letters that could be reported from any row should decrease as the tone was delayed because the afterimage would be expected to fade. As you can see from Figure 7–4, the estimated number of letters the subjects could report decreased rapidly with

**FIGURE 7–4**
**The Results of Sperling's Experiment**

The graph shows that the number of letters available decreases with the delay of the signal to report the appropriate row. This outcome indicates the rate at which the image faded from the iconic store under the conditions of Sperling's experiment. After 1 second, the number of letters available has declined to the level of whole report (the right-hand color bar). The left bar indicates the time when the letters are displayed, while the dashed line shows when the letters disappeared from the display.

*Source:* Sperling, 1960.



the delay of the tone. Apparently the image was fading from the iconic store. From this and other evidence, it has been estimated that the image in the iconic store typically lasts from a quarter to half a second, if it is not disturbed by other information shown to the eyes. However, as you know from your experience with camera flashes, the duration of an afterimage is determined in part by how strong the visual stimulus is in the first place (Long & Beaton, 1982). Some controversy exists over whether the iconic storage studied by Sperling is more complicated than a simple afterimage (e.g., Kolers, 1983).

The comparable storage system associated with hearing is called ***echoic storage***, and it appears to last longer than iconic storage. For example, Darwin, Turvey, and Crowder (1972) used Sperling's partial report technique in a situation where people heard (rather than saw) information. They estimated that the "echo" of the information lasted from two to four seconds, which contrasts sharply with the fraction of a second the icon seems to last. On logical grounds, we might expect auditory information to persist longer in the sensory registers than visual information. Visual information is typically spread out in space—if you scan the environment and miss something, you can look back at it. Auditory information is usually spread out in time. If you miss something, you can't listen back. So it is not surprising that, on adaptive grounds, the auditory afterimage (the echo) should last a bit longer than the visual afterimage (the icon), because sounds have a greater chance of being missed.

## The Short-term Store

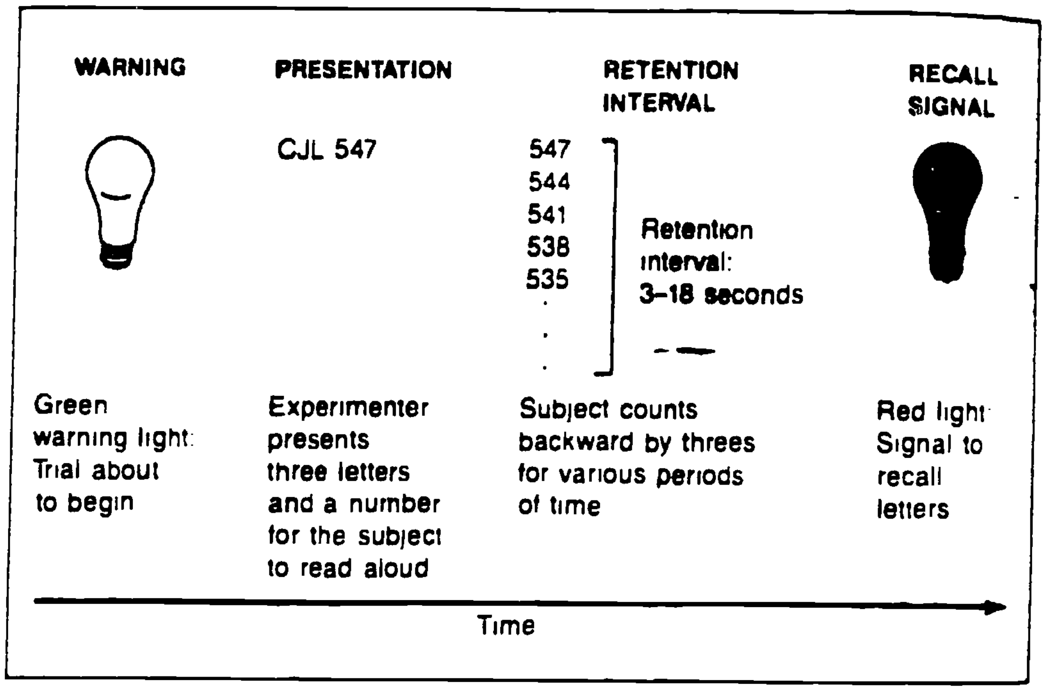
Sensory storage is activated automatically by information coming in through the senses, and how long information lasts in the system is beyond conscious control. The case is quite different for short-term store, which holds the information of which people are currently aware, such as the last few words heard in conversation. For unrelated verbal material, such as words in a list, it has been estimated that the short-term store may hold from two to five items at a time (Watkins, 1974).

The display in Figure 7–2 illustrates Atkinson and Shiffrin's view of the relations among the various memory stores. Information passes through the sensory stores (or registers) to the short-term store. It can be retained as long as a person wants in the short-term store through ***rehearsal***, or repeating it. Various ***control processes*** can also be used to transfer information from the short-term store to the long-term store. Rehearsal is one such process, but as we will see, other mental activities aid long-term memory much more than simple repetition. The short-term store also serves other functions, such as holding information that has been retrieved from the long-term store. It is sometimes called working memory, since is is responsible for much of the mental work that people do.

The short-term store is assumed to have a fairly small capacity; if information is not rehearsed, it will be lost. One way to find out how rapidly it will vanish is to give people a small amount of information and then prevent them from rehearsing it by requiring them to perform some other task, such as counting backward. After a certain time (the *retention interval*) they will be asked to recall the material. This technique is called the *Brown-Peterson method* after its inventors (J. Brown, 1958; Peterson & Peterson, 1959). The

**FIGURE 7–5**
**A Trial in the Peterson and Peterson Experiment**

Subjects were given three letters and then a three-digit number. They were to count backward by threes or fours until they were asked to recall the three letters. This procedure was followed on a number of trials, with the retention interval varying from 3 to 18 seconds. The results are presented in Figure 7–6.




Petersons gave people nonsense syllables composed of consonants (e.g., KXS) to remember and then a number from which they were to count backward by threes. After differing lengths of time, the subjects got a signal to stop counting and to recall the letters. If you were in their experiment, you would have been given the sequence steps in Figure 7–5. Recall was delayed for 3, 6, 9, 12, 15, or 18 seconds by the mental arithmetic. The results of the Peterson and Peterson (1959) study are presented in Figure 7–6. Recall dropped quickly during the 18-second period. This is one piece of evidence that leads to the conclusion that information is kept only briefly in a short-term store if rehearsal is prevented. Muter (1980) has shown even more rapid forgetting in a slightly different situation.

Another technique used to study the short-term store is examination of serial position curves in memory experiments. A ***serial position curve*** is simply a graph that shows how well pieces of information can be remembered depending on where they were presented in a series (first, second, last, and so on). For example, Bennet Murdock (1962) presented people with lists that contained either 30 or 40 words. After hearing each list, each person's task was simply to recall the words as well as possible in any order. (This task is called *free recall* because no cues or hints are given and people are free to recall the words in any order.) The results are plotted in Figure 7–7. The most striking aspect is the very good recall of the last few words that were presented. This good recall of the last few things heard or seen is called the ***recency effect*** and is caused by recall from short-term store. Just after they have heard the list, people can recall the last four or five words that are still in short-term memory. (Note that recall of about the last five items is elevated in both the shorter and longer lists.) If recall is delayed even a few seconds by some distractor task (Glanzer & Cunitz, 1966), the strong recency effect vanishes, in agreement with the findings mentioned previously (see Figure 7–6).

Another point of interest in Figure 7–7 is the elevated recall of the first item or two in the list, which is called the ***primacy effect***. The effect is rather

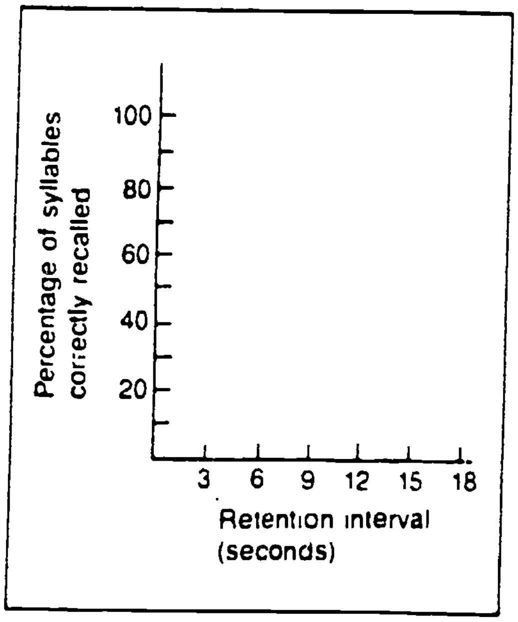



**FIGURE 7–6**
**The Results of the Peterson and Peterson Experiment**

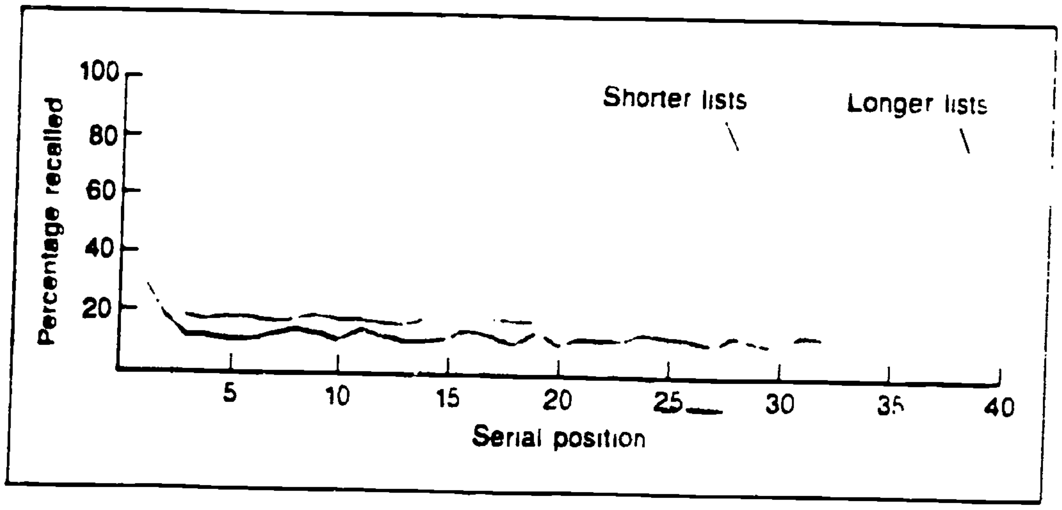
Subjects who were prevented from rehearsing three letters rapidly forgot them.

*Source.* Peterson & Peterson, 1959

FIGURE 7–7
**The Serial Position Curve in Free Recall**

After hearing word lists, people recalled them in any order. Recall was best for the last few items (the recency effect), which reflects recall from the short-term store. The better recall for the first few words relative to words in the middle of the list is the primacy effect.

*Source:* Murdock, 1962




small in the free recall task Murdock used, but in other memory tasks the primacy effect can be quite large and often is even greater than the recency effect. The primacy effect (and recall of items in the middle positions) comes from the long-term memory store, which we consider next.

## The Long-term Store

Unlike the short-term store, the long-term store is assumed to have almost unlimited capacity, and forgetting is believed to be quite slow. Three types of representation, referred to as ***memory codes,*** may be used to store information in long-term memory. Just as a signal may be sent in a code that will have to be deciphered, so people can think of their experiences as represented in memory codes that must be decoded when they remember the information. Three codes that represent information in the long-term store are *linguistic* (verbal), *imaginal*, and *motor*.

One of the most important codes is the ***linguistic code.*** People are freed from dealing only with concrete objects by being able to recode them in terms of relatively arbitrary symbols—words. There is usually no correspondence between a word, such as *iguana*, and what it stands for, except by the convention of language. If iguanas were called *dogs* and dogs were called *iguanas*, there would be no problem. Children would simply learn one term for the concept rather than another. Although several forms of linguistic coding occur, the most common coding of experience in terms of language is by meaning. Such ***semantic coding*** can be seen even in simple memory experiments. For example, suppose people study *chair* in a list of words. Later, they take a test on which they must pick out the studied words from among distractor words that were not studied. If *table* is a distractor, people will be more likely to pick it erroneously if the original list had contained *chair* than if it had not (Underwood, 1965). Such false recognitions indicate that people code even isolated words in terms of their meaning. Other evidence supports the idea that semantic coding is important in memory (e.g., Alba & Hasher, 1983).

***Imaginal codes,*** unlike the linguistic codes, are thought to bear some resemblance to the experience they represent. Try to count from memory the number of windows in your house or apartment. Given this task, people usually say they form an image of their dwelling and then mentally walk through it. A good deal of evidence suggests that such an imaginal mode of thought has properties that differ from those of linguistic representation (Kosslyn, 1980; Paivio, 1975). Shepard (1978) has collected the accounts of many famous scientists and artists, who said that such imagery was an important part of their work. For example, the chemist Kekulé hit on the conception of the benzene ring, which revolutionized organic chemistry, by dreaming of a snake that bit its own tail. Telling people to form mental images of verbal material can greatly enhance their memory of it.

A third type of code is the ***motor code,*** the means of remembering physical skills, such as how to swim. But could a swimmer give a nonswimmer a description that would allow the latter to jump into the water and swim? Probably not. Knowledge of how to swim is not stored in a verbal code. Similarly, being able to picture swimming mentally probably has little to do with knowledge of how to swim. You likely can imagine or remember a breathtaking exhibition of ice skating even if you have never skated. How to perform these skills seems to be remembered differently from other knowledge (Fitts & Posner, 1967). It is necessary to learn most motor activities by doing them, and once learned well they seem particularly resistant to forgetting. Even if you have not been swimming or have not ridden a bicycle in years, with a little practice you could probably be as good as you ever were. Although motor codes are important, less is known about their properties than those of verbal and imaginal codes.

## SUMMARY

3. Some researchers believe that different types of memory are held in different "stores." Sensory stores hold information briefly while it is analyzed; the short-term store holds information for some seconds after it has been analyzed; and the long-term store holds information for longer periods, perhaps permanently.

4. The iconic store is the name of the sensory register for vision, while the echoic store is the sensory register for hearing, or audition. It is generally assumed that the echoic store holds information longer than the iconic store.

## Glossary

| | |
|---|---|
| CONTROL PROCESSES | In the multistore model of memory, mental processes that regulate the flow of information between short and long-term memory. |
| ECHOIC STORAGE | A peripheral memory system that maintains auditory information for approximately 2-4 seconds. |
| FREE RECALL | Is a task that asks people to tell what they remember from a list in any order they want. Researchers use free recall to study memory. |
| ICONIC STORAGE | The peripheral memory system that maintains visual information for very brief periods of time. |
| IMAGINAL CODES | An interval representation or memory code for previously perceived visual sensory information. Imaginal codes are presented to bear some resemblance to the experiences they represent. |
| LONG-TERM STORE | According to the three store model of memory, the relatively permanent component of the system that is presumed to have a very large capacity for holding information. |
| LINGUISTIC CODE | Memories based on verbal recoding. |
| MEMORY CODES | Forms of representation in memory, e.g., imaginal and verbal codes. |
| MOTOR CODE | The representation that is assumed to support memory for physical(motor) activities. |
| PARTIAL REPORT | Is a task that asks people to recall only some of the letters (or other items) from a whole display. Sperling asked people to report the top row of letters in his display if they heard a high tone, the middle row if they heard a medium tone, and the bottom row if they heard a low tone. |

| | |
|---|---|
| PRIMACY EFFECT | (1) In impression formation, the fact that attributes noted early are given greater weight than attributes noted later time. (2) In memory the tendency for initial items on a list to be recalled better than other items on the list. |
| RECENCY EFFECT | In memory experiments, the tendency for subjects to recall the items at the end of the list more readily than those in the middle. |
| RETENTION INTERVAL | Is the time between giving people information and asking them to recall it. |
| REHEARSAL | The process of recycling information in short term store. It can facilitate the short term retention of information as well as the transfer of that information to long term store. |
| SEMANTIC CODE | The memory systems based on meaning that are used to store verbal information. |
| SENSORY STORAGE | The portion of the memory system that maintains representation of sensory information for a very brief interval. |
| SERIAL POSITION CURVE | The curve that results from plotting the accuracy of retention as a funtion of the position of the items in a studied list. |
| SHORT-TERM STORE | A limited capacity component of the memory system that retains information for a relatively short period of time. |
| STORAGE | The second of three stages in the memory process, it is responsible for the retention of information over a period of time. |
| TACHISTOSCOPE | A mechanical instrument capable of flashing visual displays on a screen for a very short period of time and used in perceptual testing. |
| WHOLE REPORT | Is a task that asks people to tell as many letters (or other items) as they can remember from a whole display. |

## Example of <u>How To Define</u> a Key Term

Look for the term <u>tachistoscope</u> on page 2 in this packet.

**Step 1** <u>Find the key term in the textbook chapter. Write a short definition based on the information in the text.</u>

The term appears in the middle of the page:

"A <u>device</u> that controlled how long <u>letters were displayed</u> in <u>Sperling's experiments to study iconic storage</u>."

It is also in the text next to the picture at the bottom of the page:

"A tachistoscope is a <u>device</u> for <u>presenting visual information</u> <u>for a brief period of time</u>."

Now, put all this information from the text into a definition:

"A tachistoscope is a <u>device</u> that <u>presents visual information (like letters)</u> <u>for a brief period of time</u>. It was used in <u>Sperling's studies of iconic storage</u>."

**Step 2** <u>Look up the definition of the key term in the glossary.</u>

The glossary defines <u>tachistoscope</u> as:

"a mechanical instrument capable of flashing visual display on screen for a very short period of time and used in perceptual testing."

**Step 3** <u>Put the two definitions together to make one better definition.</u>

Combine the definitions from the text and the glossary:

"A tachistoscope is a mechanical instrument capable of flashing visual displays on a screen for a very short period of time and used in perceptual testing. It controls quite accurately how long the letters were displayed in Sperling's experiment."

**Step 4** <u>Rewrite the better definition in your own words. Use shorter, simpler words that mean the same thing to help you remember the definition better.</u>

Your final definition would be:

"A tachistoscope is a machine that flashes displays (like letters) on a screen for a split second.
It is used in perceptual testing.
Sperling used it to control very accurately how long letters appeared on a screen."

WORKSHEET FOR DEFINING KEY TERMS

Use the steps outlined on page 10 to create your own definitions for the following key terms:

| TERM | Echoic Storage | Recency Effect | Serial Position Curve | Semantic Code | Motor Code |
|---|---|---|---|---|---|
| Text Definition | | | | | |
| Glossary Definition | | | | | |
| Combined Definition | | | | | |
| Your Own Definition | | | | | |

TEACHER'S GUIDE

# Using Your Psychology Textbook Effectively

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Glossary of Key Terms

How To Define a Key Term

Worksheets for defining Key Terms

## Inventory of Package Content

The Using Your Psychology Textbook Effectively package contains:

* 4 diskettes
* Job Aid
* Teacher's Guide
* Student's Guide
* 15 pages of student materials (located in Teacher's Guide to be reproduced for student use)

## Hardware Requirements

This program is designed to run on the IBC PC and compatible personal computers. Minimum hardware requirements include:

* 256K bytes of memory,
* color graphics adapter board (CGA), and
* a color monitor.

Using Your Psychology Textbook Effectively will not run on computers without sufficient memory (256K), a CGA board and a color monitor. IBM and compatible computers with 256K, but no CGA board or color monitor, may be upgraded by purchasing these components at an approximate cost of $300.00.

If the program is to be run on equiptment other than the IBM PC, the computer type must be specified (e.g., AT&T PC) before ordering the software so it can be set up to run on that specific computer. The software is not available for use on Apple computers.

## SOFTWARE EXPLANATION

### Background and Introduction

Students seek help with college reading

Most beginning undergraduates and high school seniors have the basic reading skills needed to understand print matter, but research has shown that nearly 25% of undergraduates seek help mastering university level reading demands (Education Daily, 1985). Many of these students find college level science and behavioral science text particularly difficult to comprehend. Inadequate high school training and general academic inexperience have left them without the specialized study strategies needed to succeed with university subjects. This software package was created to help meet the reading skill development needs of this large percentage of beginning university students.

Program teaches reading strategies

Using Your Psychology Textbook Effectively was developed at the Indiana University Learning Skills Center with the support of a grant from the Fund for the Improvement of Post-Secondary Education (F.I.P.S.E.). Working with professors from the Psychology and Reading Education departments at Indiana University, instructional designers and computer programmers have developed this computer-assisted instruction program. It guides students in learning reading strategies and is designed to help them improve their reading in order to effectively master behavioral science textbook material. The reading strategies employed have been documented as effective by nearly a decade of reading comprehension research.

Teaches generalizable reading strategies

Users of this software do not need to be psychology students. Although psychology content is featured in the program, the skills taught are applicable to other textual material a student will encounter in college. One purpose of this program is to teach reading strategies as they are directly applied to behavioral science textbook chapters. The primary goal, however, is to help students master generalizable reading strategies and subsequently improve their ability to comprehend specific content.

Student response has been positive

Student response to this software has been overwhelmingly positive. Over 95% of students involved in the evaluation of the software reported the following after using the program:

* printed materials are useful,
* lessons can be used without teacher assistance,
* lessons are not too long,
* independence the computer lessons allowed was appreciated,
* ability to comprehend text material improved.

They reported improved ability to:

* locate key concepts,
* see how ideas in a chapter are interrelated, and
* structure their approach to studying.

## Target Audience

Students having difficulty reading behavioral science text

The target audience for this program is college undergraduates and high school seniors who are experiencing difficulty comprehending textbook readings, especially in their behavioral science courses. Data from the National Assessment of Educational Progress suggests that more than half of entering undergraduates are likely to experience difficulty independently comprehending such textbooks.

## Suggested Use

Provides immediate help or introductory preparation

This program provides individual, guided reading instruction. It can be used to

* supplement university learning skills courses,
* provide immediate help for students experiencing difficulty comprehending psychology or other behavioral science textbooks,
* provide introductory preparation for behavioral science courses, and
* provide introductory preparation for college level reading.

Because the lessons build on one another, students benefit most if each is used individually with time provided between each one for practicing the strategies.

## Learner Prerequisites

9th grade reading level

The on-screen instruction in this program is written at the 9th grade level. Therefore, to interact effectively with this program, students need to be able to comprehend written material at a minimum of 9th grade level. Though the psychology text used in the lessons is written at a 14th grade level, the students' reading ability does not need to be this advanced for them to have success with the program.

No computer experience necessary

Students do not need to be experienced computer users. The Job Aid and Student's Guide in this package, as well as on-screen procedural instructions, will lead students through all aspects of using this program.

No psychology background necessary

It is also not necessary for students to have a background in psychology. Students will learn the necessary content while interacting with the program.

## Performance Objectives

After interacting with this program students will be able to

Identify key concepts and show relationships

1) **identify key concepts** in their psychology or other behavioral science textbooks,
2) **compare, contrast and connect** ideas by writing linking summary statements, and
3) synthesize and **graphically map relationships** among key ideas.

Reading strategies likely to transfer to other content areas

The probability is high that after using this software students will see application for these study strategies to textbooks in other content areas. This is more likely to happen if follow-up assignments are given which ask students to use these techniques with other textbooks. (See suggested follow -up activities on pages 14 and 15.)

## Lesson Organization

3 lessons take 30-60 minutes each

Psychology passage used

This software is divided into 3 lessons which each take 30-60 minutes to complete. Students with extreme reading difficulties may need more time. The amount of time required to complete each lesson depends on the reading ability and working pace of the individual student. All three lessons are **based on seven pages of a college level psychology textbook chapter.** A copy of this passage and a glossary are provided on page 22-31 of this teacher's guide. Students will need to have a copy of this passage and glossary when they use the program. Each lesson is on a single diskette, with a fourth program set-up diskette.

Lesson Content

Lesson 1: Finding Main Ideas

1. Previewing Your Textbook
   - explore preface, glossary, table of contents, chapter headings, boldface print and figures

2. Finding Key Terms
   - locate key terms using chapter headings, boldface print, etc...
   - outline headings and key terms

3. Getting Ready to Read: Previewing
   - read chapter introduction and summary
   - study figures

4. Defining Key Terms
   - define key terms accurately in own words

Lesson 2: Looking at Relationships

1. Introduction: Review of Key Terms
   - quiz over key terms

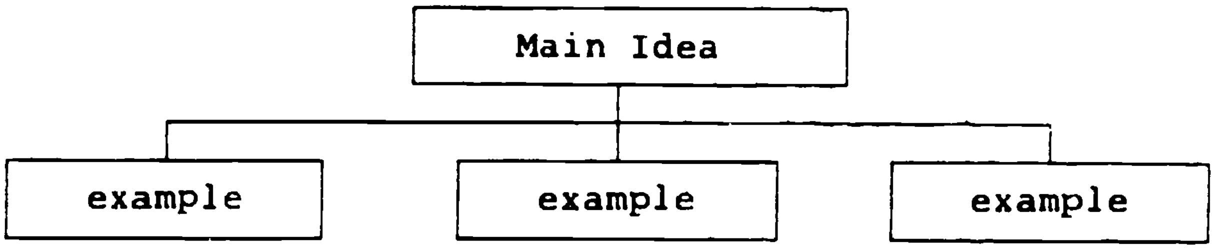
2. Comparing Parts of a Whole
   - choose best terms to compare and contrast

3. Steps for Making a Compare and Contrast Diagram
   - pick terms to compare and contrast
   - look at definitions and identify similarities and differences
   - place similarities and differences in a compare and contrast diagram

4. Review of Lessons 1 and 2

Lesson 3: Mapping Relationships

1. Introduction to Concept Maps
   - concept maps show relationships, for example:




2. Grouping Key Terms
   - organize related terms into groups

3. Making Small Maps
   - map groups of related terms

4. Mapping the Whole Chapter
   - combine small maps into larger ones

Student Interaction with the Lessons

Active involvement of students is important for the success of these lessons. During each lesson students must complete **written assignments.** The following information is provided so that you can monitor how completely your students are interacting with the program. During lesson 1 students produce:

1) an outline of the headings and subheadings, and
2) a list of key terms under appropriate outline headings.

During lesson 2 students produce:

1) passing performance on a quiz of key terms,
2) compare and contrast diagrams, and
3) a copy of the steps for finding key terms.

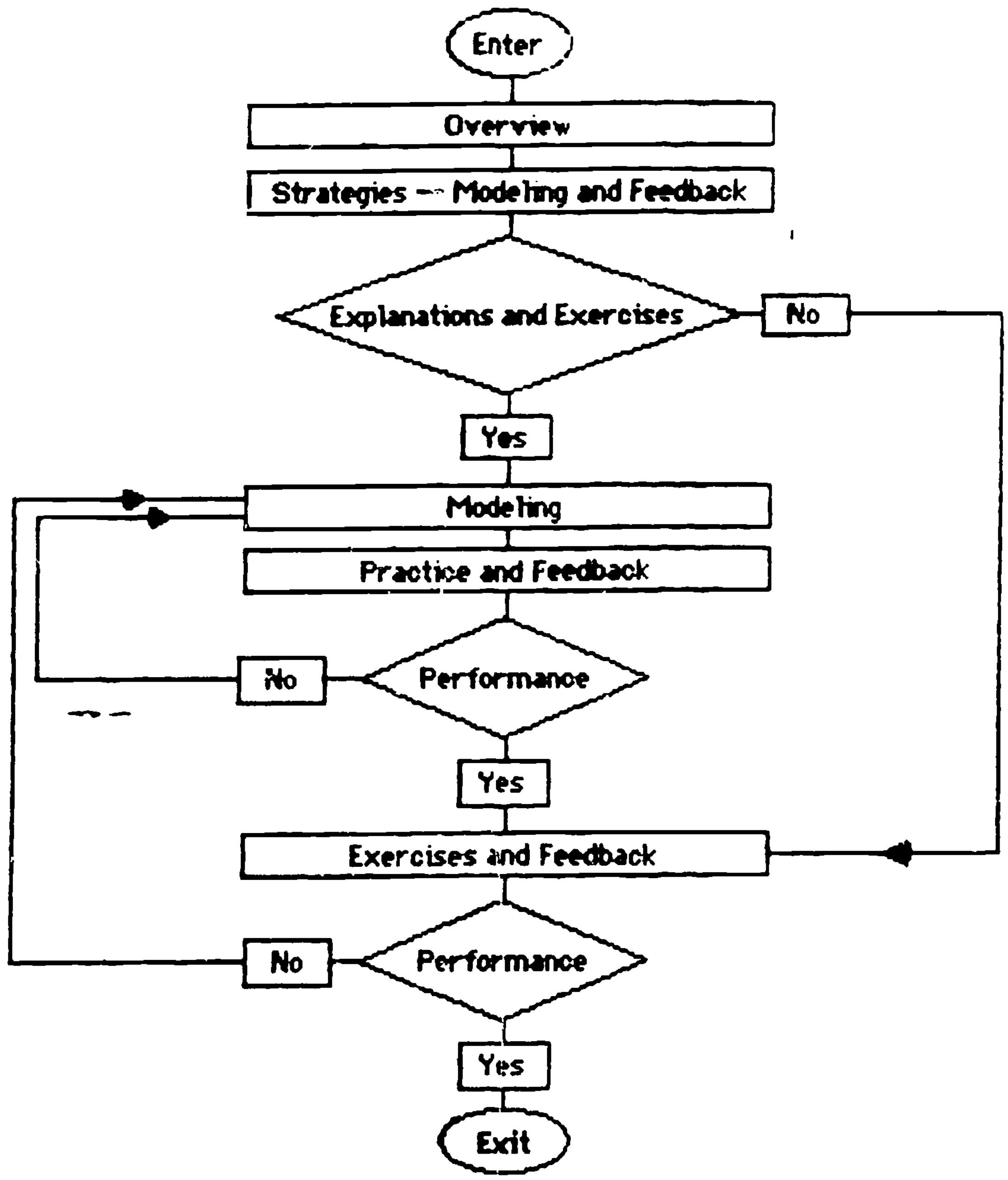
Students must bring their definitions and diagrams along with their copy of the chapter and glossary when they do lesson 3.

During lesson 3 students produce:

1) a copy of groups of closely related terms from their outline,
2) small concept maps, and
3) 2 large concept maps of all the terms in the chapter.

## Structure of the Lessons

The following flowchart demonstrates the structure of each lesson. It shows how the information in each lesson is presented to the students and when and how the students interact with the program.



## Evaluation Results

Effective program

Using Your Psychology Textbook Effectively was tested at Indiana University in Bloomington, Indiana, and a two-year community college in Indiana. These evaluations demonstrated the effectiveness of this program.

## Procedure and Results: Indiana University-Bloomington

44 volunteers at Indiana University

Forty-four volunteer Indiana University psychology students who received class credit for participation were divided into treatment and control groups. The groups were matched on SAT scores, high school rank, and university grade point average.

Treatment group guided by lessons and tested on ability to use strategies

Over a period of two weeks, treatment group students read a portion (7 pages) of a psychology chapter on memory storage systems guided by the lessons in this software. After completion of the three lessons students were asked to identify key concepts, write summary statements comparing and contrasting key concepts, and draw concept maps between the 21 key concepts in the reading. One week later students were asked to perform similar tasks on psychology chapter material (7 pages) dealing with behavioral therapies.

Control group read same passage and took same test

Control group students read the memory storage systems material and took the same test that was given to the treatment group when they had finished using this program. One week later they followed the same procedure with the behavioral therapies material. High inter-rater reliabilities (ranging from r=.98 to r=.99) were established between scorers for the four different tests.

Treatment group scores higher (p=.05) than control group

The treatment group outperformed the control group (p=.05) on both the memory storage systems (modeled chapter) and behavioral therapies (unmodeled chapter) material tests. Attitudinal data collected from students throughout their use of the computer lessons suggests that students highly valued the program and saw it to be of use for psychology as well as for other classes.

Results: Community College

Comparable results at community college

Comparable tests were conducted at a community college where students generally have lower verbal SAT scores. The results were similar to those at Indiana University -Bloomington, with the exception that students with lower verbal SAT scores seem to need more follow-up activities before use of the textbook study strategies transfers to other texts.

Conclusion

Improved ability to master text

Overall research data indicate this program is attractive, usable, and helps students improve their mastery of text material. In addition, mastery of these strategies transfers from chapters learned with the computer guidance to similar chapters learned without it (Mikulecky, 1987). Given student statements during the evaluation process, the probability is high that students will transfer the skills introduced in this lesson to other texts.

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## Support Materials

### Student Follow-Up Activities and Exercises

The activities and exercises on the following pages are designed to facilitate your use of this software in the classroom setting. The follow-up exercises were created so that you do not have to spend time creating your own exercises or lessons if time is not available for this. If you do want to create your own follow-up activities, you can use these as suggestions or secondary resources.

Exercises beginning on page 16 model strategies introduced in the individual lessons.

* Reinforce lesson 1 strategies: Exercise 1 and 2
* Review lesson 2 strategies: Exercise 3
* Practice lesson 3 strategies: Exercise 4

Only one copy of each exercise is provided. We suggest that you keep this as your master copy and reproduce it for your students.

**Suggested Follow-Up Activities**

Listed below are several suggested follow-up activities for students to do after completing the computer lessons. Although the lessons are designed to allow students to learn independently, these activities are recommended to help reinforce the strategies presented in the program. They provide students with the opportunity to practice applying these strategies with their current course material. This type of follow-up assignment is especially important for students with lower verbal SAT scores.

1. **Students outline a chapter from a student's textbook.** Before doing this, a few moments of teacher review are in order. Highlight for students how to:

1) preview a text by looking at chapter headings, and
2) find key terms using boldface print, introductions and summaries, charts and figures.

Exercise 1 is provided so that students can work independently on this. Directions, along with examples from the lessons, are provided.

2. **Analyze and evaluate transferring the program strategies to other topic areas (i.e. biology, mathematics, literature).** Stress to the students the idea that the strategies in these lessons can be applied to most other textbooks. Have them apply the strategies to a text from a different content area. Exercises 1-4 on pages 16-21 can be used here. Encourage students to discuss and find solutions for any difficulties that may be encountered in this process. This discussion can be verbal or written.

3. **Prepare for an examination using program strategies as study guides.** Have students use strategies from the program to study some of the material to be covered on their next exam. After the exam, have students evaluate their performance on questions taken from the chapters they studied using these strategies. Next, have them compare how they did on these questions to their performance on questions taken from chapters where they did not use these strategies. Have the students discuss (orally or in writing) the results of their comparison and how they plan to approach textbook study in the future.

Name_______________________________________________ Date___ ______
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_____________________________________________________________________

## PREVIEWING EXERCISES

Follow the directions below to preview your textbook. Examples from Using Your Psychology Textbook Effectively are given below the directions.

**Step 1. Outline your own textbook chapter headings and subheadings on 1-3 sheets of your own paper. Leave 3-5 lines between each heading.**

Example: I. Storage Systems
A. Sensory System
B. The Short-Term Store
C. The Long-Term Store

**Step 2. Add key terms in the space between your outline headings.(Use textbook clues: italicized words, boldface or colored type, labels of figures, etc...)**

Example: I. Storage Systems

sensory stores
short-term store
long-term store
Atkinson's model of
memory storage (fig. 7-2)

A. Short-Term Store
ionic storage
tachistoscope
whole report
partial report

**Step 3. Check for missed key terms in the introduction and summary. Add these to your outline.**

Example

* sensory store systems
* echoic stores

**Step 4. Check for missed key terms in figures and charts. Add these to your outline.**

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______________________________________________

## DEFINING KEY TERMS

Follow the directions below to define key terms from your outline. Examples from Using Your Textbook Effectively are given below the directions.

**Step 1. In your own words, define a key term from your outline. 1-2 sentences should be enough.**

Example: A tachistoscope is a device that presents visual information (like letters) for a brief period of time. It was used in Sperling's studies of ionic storage.

**Step 2. Look up the definition of this term in the glossary. Write the glossary definition down on your paper below the definition from the text.**

Example: tachistoscope is a mechanical instrument capable of flashing visual display on screen for a very short period of time and used in perceptual testing.

**Step 3. Make a better definition using ideas from both definitions above. Use your own words.**

Example: A tachistoscope is a machine that flashes displays (like letters) on a screen for a split second. It is used in perceptual testing. Sperling used it to control very accurately how long the letters appeared on a screen.

**To prepare for a test on your chapter, write definitions for the other key terms in your chapter. Use the same mix of your own words and the glossary.**

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## MAKING COMPARE AND CONTRAST DIAGRAMS

Follow the directions below for making a compare and contrast diagram. Examples from Using Your Psychology Textbook Effectively are given below the directions.

**Step 1. Pick two or more of the terms from the outline of your chapter to compare and contrast.** Remember that you can compare and contrast terms that

* are part of the same whole,
* look or sound alike, or
* are presented together in the textbook (in the text or figures).

Example: iconic storage and echoic storage are parts of the same whole, sound alike and were presented together in the textbook

**Step 2. Look at the definitions you wrote for the terms in your chapter. Single underline similarities between the definitions, double underline differences.** (In the example below, bolded information represents differences in definitions.

Example: iconic storage is the peripheral memory system that **holds visual information for about a second**

echoic storage is the peripheral memory system that **holds auditory (hearing) information for 2-4 seconds**

**Step 3. Use the similarities and differences you found in the definitions to complete a compare and contrast diagram. Refer to the model below.**

Example:

| Key Terms | iconic store | echoic store |
|---|---|---|
| Similarities | type of peripheral memory store | type of peripheral memory store |
| Differences | | |
| sensory info. | vision | hearing (audition) |
| time held | up to one second | up to 2-4 seconds |

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______________________________________________________________________

## MAPPING RELATIONSHIPS BETWEEN KEY TERMS

Follow the directions below for making concept maps. Examples from Using Your Psychology Textbook Effectively are given below the directions.

**Step 1. On a separate sheet of paper, group together small clusters of key terms from the outline you make in exercise 1 that**

* are part of the same whole,
* look or sound alike, or
* are presented in the textbook together (in the text or figures).

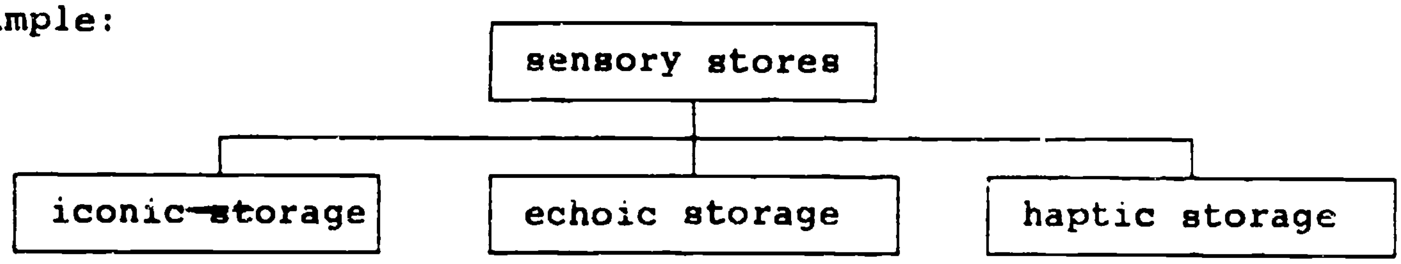
Each key term from your chapter outline should either be part of a group of terms or identified as a "leftover" (not part of a particular group).

Example: *** sensory stores, short-term store, and long-term store**
*** ionic storage, echoic storage, and haptic storage**

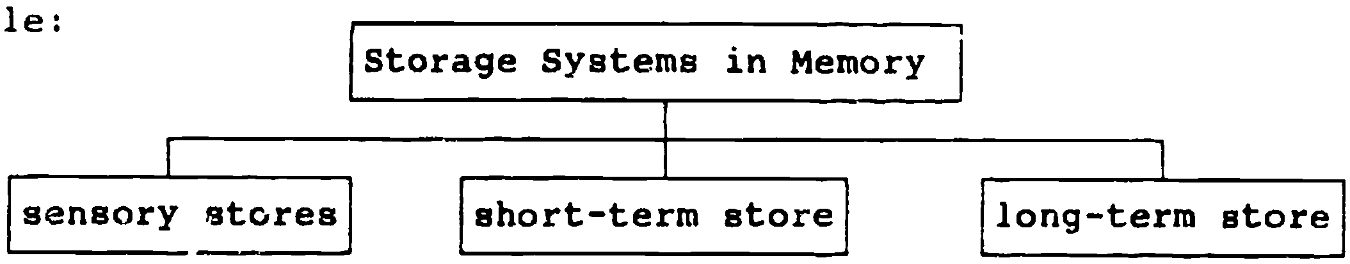
These two groups both meet the criteria set above.

**Step 2. Make small concept maps for several of the groups of key terms. Decide what all the terms in each group have in common and use this as your starting point.**

Example:




Example:



Step 3. Carefully study your small concept maps and identify ones which are parts of the same whole. Combine these into one larger concept map which shows how the separate terms of this chapter are related to one another. See the example below.

Example: