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ABSTRACT

An interactive videodisk (IVD) program was developed to reinforce learning of the biological concept of protein synthesis for high school students. The laser videodisc "The Living Textbook Life Science" was the source of frames, and the authoring system of G. Smith was used to create the disc. The interactive program was designed to make the material relevant to the learner at the tenth-grade level. Four high school students pilot tested the program, and 43 students (19 ninth graders, 22 tenth graders, 1 eleventh grader, and 1 twelfth grader) tested the completed version. After using the program and completing its multiple choice test, students completed essays about the content. Students did well on the multiple choice test, which they were able to score immediately, but not as well on the essays. Students responded well to the program and were positive about its usefulness. Students who took more time with the program achieved higher posttest scores. The program appears to be an effective method to help students understand the concept of protein synthesis. Thirteen appendixes present supplemental information, including the multiple choice questions. Six tables present study findings. (Contains 34 references.) (SLD)

The Development Of
An Interactive Videodisc Program
On Protein Synthesis

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A Project

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I also thank the students who participated in the testing of the IVD program, for this project. I hope that it was of benefit to them.

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CHAPTER 1

INTRODUCTION

In this chapter the objectives of this project are presented. The significance of this study, hypothesis, definitions, assumptions, and limitations are also discussed.

Statement of Objectives

The objectives of this project are:

1. To develop a computer assisted instructional program integrated with a laser videodisc, to reinforce the concept of protein synthesis to high school students.
2. To perform an evaluation of this program.

Significance of Study

The primary purpose and goal of science education today should be to have all students achieve scientific literacy (Michigan Essential Goals, 1991). Scientific literacy means that students should be literate in the areas of science, mathematics, and technology (Project 2061, 1989). All students need to have a basic understanding of science, mathematics, and technology, so that they can appreciate and understand the world in which they live. This will allow them to make responsible decisions concerning their society, and enable them to

secure jobs and be productive with the technology presently used in society.

The amount of new science information is increasing at an incredible rate. This new scientific information has changed our concepts of the Universe, the atom, the gene, and the continents. We have enjoyed a higher standard of living and economic wealth because of this new knowledge. However, to continue to benefit from this new knowledge will be directly related to our society's ability to use it. We must be able to learn and apply this knowledge in a productive way (Molnar, 1979).

According to a report by the National Science Foundation, the education high school students are getting does not meet the requirements for scientific, technical, and mathematical literacy of the jobs in their future (Bunderson, Olsen & Baillo, 1981).
According to Bunderson et al. (1981), some reasons for this are: a) Science is not seen as one of the "basic" subjects of education. It is not considered a high priority subject, b) Science is primarily presented through reading, reciting, testing and discussion, c) Student interest and motivation in science and mathematics is decreasing.

A few ways in which scientific literacy can be achieved are, by teaching fewer science topics but in greater depth, allow students to explore, reason logically and critically evaluate these concepts, present

these concepts so they are relevant to the learner by relating them to real life situations, reduce unnecessary vocabulary, and present science with technology currently used in society (Michigan Essential Goals, 1991).

Computer assisted instruction coupled with the videodisc is a technology that combines the power of the computer with the audio and video capabilities of the laser videodisc (Gay, 1986). The use of the interactive videodisc (IVD) is surely in accord with the philosophy of science education, the students are enjoying their discovery, concept driven learning is taking place, the students are using technologies that are up to date and the materials pertain to relevant real world contexts (Mashiter, 1988).

This IVD program will be designed to reinforce the biological concept of protein synthesis. Instead of the students learning this concept through verbal abstraction, memorization, and recitation, where too much information and vocabulary is presented, the student will interact with relevant text, audio, high quality visuals both stills and motion sequences, pacing their own learning. They will learn the material in appropriate depth and in a manner relevant to the learner. They will also interact with this concept on technology currently being used in society. It is this authors hope that this instructional strategy will provide another learning environment that will enhance science learning,

increase student motivation and interest in science, and contribute to the achievement of scientific literacy.

Hypothesis

The Interactive Videodisc Program on protein synthesis, developed by the author, is an effective method of assisting high school students to understand the science concept of protein synthesis.

Definitions

Interactive Videodisc (IVD) System: IVD system consists of a CAV laser videodisc, videodisc player, color monitor, a microcomputer and computer monitor, an author program, interface and a student program.

Interface: The interface links all of the components of an IVD system together and allows them to function as an integrated system (Lehman, 1986).

Disc: The accepted spelling for the video disc (Daynes & Butler,1984).

Disk: The accepted spelling for the magnetic media, such as, floppy disks, hard disks (Daynes & Butler, 1984).

Assumptions

The students took part in this study willingly. They also had been introduced to the concept of protein synthesis in their biology class prior to testing.

Limitations

The students who performed this investigation might not be familiar with the computer and its options.

A small number of science students in one suburban high school participated in this study. Therefore, the result of this study should be generalized to the science students in this school.

The students who participated in this study were given extra credit by their science teacher to encourage their participation.

CHAPTER 2

REVIEW OF THE LITERATURE

In this chapter the review of the literature is discussed. A summary and preview of succeeding chapters is also presented.

Overview of Interactive Videodisc in Education

New scientific information is increasing at an incredible rate. In order to benefit from this new information we must devise new ways to expand human capacity and reasoning. The right side of the brain processes information related to spatial imagery and the left side processes serial, analytical or linguistic information. Perhaps presenting abstract concepts by using both verbal forms and mental images would utilize both sides of the brain and improve learning. The use of interactive graphics show strong positive effects of mental imagery on both learning and memory. Technological systems may be capable of organizing information into a form that can improve learning and extend long term memory (Molnar, 1979).

The television and computer when used as instructional tools can amplify human capacity. Combining computer technology and videodisc technology would make one system which would have the power and logic of the computer and the visual and auditory features of television (Molnar, 1979).

The way information is presented, for example, in words, pictures, graphs, can effect how well the student understands the concept. The IVD uses clear, understandable, and mentally manipulatable representations of both objects, for example, cells and chromosomes and processes, for example, protein synthesis. These various methods of presenting information help students to develop richer concept networks and avoid misunderstandings and misconceptions (Bunderson, Baillo, Olsen, Lipton & Fisher, 1984).

One of the most promising innovations in education today is the integration of computer technology and telecommunications technology, the interactive videodisc, a computer interfaced to a laser videodisc (Lehman, 1986). This new technology will require imagination and creativity on our part if we are to benefit from its full potential (Lehman, 1985). To appreciate IVD technology, design applications around the capabilities of this medium, instead of designing applications as replacements for existing media or traditional methods (Jones, 1987).

An analysis of 19 IVD studies showed that in 17 of the studies the students learned as much or more by using IVD instruction than traditional methods. The students using the IVD required less learning time and were more positive about their learning experience than the students using traditional methods. This is enough information to warrant

the acceptance of IVD as a viable educational tool (Stevens, Zech & Katkanant, 1987).

According to Trowbridge and Bybee (1986) students a) enter a classroom at different cognitive levels b) learn concepts at various rates c) vary in their motivational level toward learning d) vary in their levels of psychomotor skills e) have different attitudes, values and concepts regarding science. Instruction should be modified to accommodate all of these individual differences. The IVD may be one way to individualize instruction to meet student needs and maximize student development.

The computer linked to a videodisc and video monitors is different from simple film or video because of its interactivity. IVD forces the students to become active participants in their learning process (Huang & Aloe,1988). Learners take responsibility for their own learning by controlling the pace and sequencing of the lesson, depth of study, and style of instruction. Feelings of self–efficacy and self–determination are enhanced by learner control (Gay, 1986).

This marriage of the videodisc and microcomputer combines the visual and dramatic impact of television with the ability of the computer which allows the user to tailor the lesson to individual needs (Weiss & Jarvis, 1986). Since this multi–media presents instruction through a variety of video, audio, and computer information it addresses a wide variety of different learning styles (Hoeffer, Radke & Lord, 1992).

The National Science Foundation supported the development and testing of the IVD entitled,"Development of Living Things" by WICAT systems , which examined the effectiveness of interactive video instruction in science instruction. The results showed that IVD students displayed higher achievement, reduced learning time, greater student motivation and increased student confidence compared to students taught by traditional classroom methods (Bunderson et al., 1981).

Students also need to be familiar with advanced technology currently used in industry if they are to secure future jobs and be productive in society. The IVD is already widely used in industry and business (Lehman, 1985). General Motors, Sears and Roebuck and Company, Ford and the U.S. Army, to name a few, are using the interactive videodisc (Bosco, 1984).

Science, today, is too often presented through verbal abstractions. Video is a warm medium and the IVD allows instruction to be interactive, visual and experimental rather than verbal and abstract. It provides an interactive discovery or inquiry approach to science, provides for individualized instruction and immediate feedback. Its no wonder the IVD can improve interest, enthusiasm, and motivation lacking in most science classrooms (Bunderson et al, 1981).

Criticisms of the Interactive Videodisc in Education

Zakariya (1984) writes that one reason more schools don't use IVD is because of the high cost of IVD systems. There were 7,000 videodisc players in Americas' 85,000 schools in 1986 and a predicted 35,000–43,000 by 1988. These figures show that IVD technology is increasing rapidly in the public schools. When schools reach a saturation point with computer equipment educational technology funds will be directed to videodisc technology (Helsel, 1988). IVD system costs are declining as mass production increases. Within 5 years an IVD system should cost $1200.00 (Molnar, 1979).

Another concern is the scarcity of good educational videodisc programs (Zakariya, 1984). According to Helsel (1988) more videodisc and authoring programs are now available. A number of firms are now producing videodiscs for education. A 1984 Electronic Learning survey listed approximately 33 educational videodiscs, many of which are directed toward science education (Lehman, 1985).

Some view the IVD as another panacea that will follow the path of other educational innovations, such as teaching machines and instructional television. if IVD is to be used as a successful tool for education it is up to the teacher to examine the potential of this technology and create ways to use it (Bosco, 1984).

History and Description of Videodisc Technology

James Logie Baird invented the videodisc, a phonograph record on which television images were stored, in 1926. These first discs were made for early transmissions (Daynes & Butler, 1984).In 1934, Selfridge Department store in London sold the prerecorded discs. Few of Baird's "phonovision" discs sold because television was still in a very primitive state (Bosco, 1984).

In the early 1960's, David P. Gregg, Wayne Johnson, and Dean DeMoss developed the first videodisc capable of recording and playing back full band width images on an "optical", lasers were not available yet, videodisc. It was not until the 1970s that scientists in both the U.S. and Holland, simultaneously, developed a similar optical disc with playback strategies using laser. This became known as the laser disc (Daynes & Butler, 1984).

The video and digital information is recorded on the surface of the optical laser videodisc as a series of microscopic pits. When the laser passes over the pits, light is reflected back into a receiver and decoded (Lehman, 1985).

The continuous angular velocity (CAV) is most conducive to education (Lehman, 1986). CAV means that the velocity remains constant throughout the playback. This enables the disc to have the same number of frames per revolution. Then each revolution of the disc

can be given an identification number or numbers. In the CAV laser videodisc each picture occupies a separate track or concentric circle. This allows each video frame to be referenced by number (Daynes & Butler, 1984). This feature permits freezing of frames, frame by frame stepping and forward and reverse slow motion (Lehman, 1986). The frame can be accessed in any order and can be viewed as long as desired without damage to the videodisc (Bunderson et al., 1984).

The CAV laser videodisc can also store a lot of images. One side of a 12 inch videodisc can present 30 minutes of standard video or it can randomly access any of 54,000 individual pictures in a matter of seconds. This is enough area to store the Encyclopedia Britannica or 86 billion bits of digital information (Molnar, 1979). The 54,000 images on each side of the videodisc is equivalent to a picture book containing 108,000 pictures or 20,000 printed text pages (Bunderson et al., 1984).

The videodisc has many more attributes. They are coated with a thin clear plastic layer which can be wiped clean of spills or smudges. Small scratches do not affect the disc because the focal length of the laser light is so small (Daynes & Butler, 1984).

The laser videodisc has two audio tracks which can be used to provide either stereo or two sound messages. The two sound messages can be for bilingual usage or for two intellectual levels, one for beginners and the other for advanced viewers (Bunderson et al., 1984). The two

tracks could also be used for separate applications, such as, tutorial on one and testing on the other.

The read only feature is one of the main disadvantages of the videodisc. You can playback the videodisc but you can't record one. However, this feature provides a built in copyright protection for the material and ensures developers to receive a return on their investment (Molnar, 1979).

Then in 1975, participants at a National Science Foundation conference felt that videodisc technology would have promising applications for education and recommended that the NSF explore the possibility of linking computers with the laser videodisc (Molnar, 1979).

Applications of the IVD in Science Education

The videodisc can enhance traditional forms of computer based instruction, such as, drill and practice, problem solving, tutorials, and simulation by including audio and a library of clear visuals accessed in a matter of seconds as still frames or motion sequence of frames (Lehman, 1986). Schools can use the IVD to simulate "dry laboratory" experiments without the cost of linear accelerators, nuclear reactors, telescopes, or other huge science laboratory or equipment systems (Molnar, 1979).

Leonard (January, 1985) simulated two laboratory investigations, "Respiration" and "Climate and Life" using the IVD. The "Respiration" investigation simulated a "real" experiment which could be performed in

the laboratory. The students were able to practice most of the science process skills including manipulating and controlling for variables. "Climate and Life", could not be performed under typical laboratory conditions. In this activity the students explored the major biomes in the world and their corresponding physical and biological conditions. The students in the conventional laboratory did a pencil and paper investigation on biome distribution. The students using the IVD went on a simulated giant field trip to the major biomes of the world. This lesson differed from the conventional laboratory because of the high level of interactivity between the student and the system and the high quality video motion sequences which simulated "real life" organisms living in these biomes which were viewed by the student (Leonard, January 1985). Through an IVD biology field trip, students can visit a variety of interesting environments, see ecological relationships and identify organisms in their natural habitat. This would be costly and difficult to accomplish otherwise (Bunderson, 1981).

The IVD is also applicable in situations where: a) a large amount of multi–media material is to be presented and stored b) there are many students and they cannot get together at the same time c) a high degree of individual interaction is required d) students have different interests and needs e) the lesson requires continuous practice or periodic reeducation f) the lesson requires simulation of

expensive equipment or infrequent catastrophes g) the lesson requires teaching processes and procedures to enhance problem solving and decision making (Weiss & Jarvis, 1986).

IVD technology can be used as a possible substitute for animal dissection (Huang & Aloi, 1991). It can also be used for observing visual images and processes that are not visible like cell division (Bunderson et al., 1984).

Particular biological laboratory investigations can be studied more thoroughly through IVD.

> Biology in its various branches predominantly deals with conversational and classification knowledge at the present time. Some classification procedures require procedural knowledge, as in keying out an organism by checking it through a binary decision tree. However, students are not able to have access to many organisms to learn classification and identification. The organisms mature at different times of the year and in different parts of the world. They are difficult, expensive or dangerous to obtain. The videodisc can provide a wide variety of close-ups, micrographs, shots of different aspects and features of organisms that classification and identification are possible. Thus, experience with a much wider variety of organisms could be provided. The current method of teaching with a few dried up specimens could be replaced with a much richer experience (Bunderson et al., 1981).

Vitale and Romance (1992) used the IVD to teach pre service teachers core concepts in physical and earth science. The teachers using the IVD displayed a greater understanding of science knowledge and more positive attitudes towards science teaching at the elementary

level compared to the pre service teachers who were taught by traditional methods.

Advantages of the IVD in Science Education

Some attributes of IVD are: random access to data, color visuals of high quality, learner self pacing, access to data and images rapidly, learner control over sequencing, immediate feedback and remediation, integration of a variety of media, for example, text, image, sound, and CAI, integration resource and presentation materials, replacement of expensive "hands on" equipment in training, replicability, resistance to deterioration through age and handling, availability at the convenience of the learner and interactivity (Jones, 1987).

The videodisc appeals to a wider range of emotions than classroom presentations because of its novelty, its perceived importance in education, the visual imagery and the interplay of styles of presentation (Bunderson et al., 1984). The IVD has all of the capabilities of the videodisc, freeze frame, slow motion, playback, random rapid access of images plus the capabilities of a computer, user control of the learning process, permits branching, provides immediate feedback and allows access to video information (Lehman, 1986).

The IVD allows one to make an instructional program which can be repeated in the same way, with total replicability. This is an

advantage if one must present an instructional message to a number of learners, at their convenience, in a constant manner (Bosco, 1984).

The IVD also accommodates for individual differences among learners. Interactivity allows the student to pace the lesson to accommodate their own needs and capabilities (Bosco, 1984).

Since the discs are read by lasers they, theoretically, do not wear out. This infinite shelf life holds a significant advantage over slides, films, and videotape. Slides, videotape and film are in linear form which make it more difficult to access images quickly compared to the IVD. The quality of the image on the IVD, especially when it is on freeze frame, is far superior to videotape images (Clark, 1984). The biggest difference between film and videodisc is cost. The cost of videodisc is 10% that of an average film. If a school converted to videodisc it could increase the number of titles in its library tenfold (Van Horn, 1987).

Huang and Aloe (1991) performed a study using the IVD "Professor Sam", to teach introductory Biology at Riverside Community College for five semesters. The results from the study showed that both teacher efficiency and student performance are enhanced by using the IVD program. Student interest, grasp of subject matter and retention increased compared to the students taught using traditional classroom methods.

In a study by Bunderson et al. (1981), to compare the effectiveness of the IVD to traditional classroom instruction, the IVD users made the following comments regarding what they liked about the IVD: a) pacing their own learning b) reviewing materials with ease c) the interactive practice, answers and feedback frames d) visual images and motion sequences e) well organized and thorough lessons f) ease of understanding the content g) the videodisc is interesting and attention holding i) more learning time is saved with the videodisc j) can study materials one paragraph at a time.

Students who used the IVD in Leonard's study (April 1985), which was discussed in applications, made these remarks regarding the IVD: 1) "I can gather data more quickly." 2) "I don't have to wait around." 3) "There are fewer disruptions from other students." 4) "We can do more (variables, organisms, biomes) in the same time period."

The results of a study performed by Ebner et al. (1984),showed that students using the IVD learned faster and retained their information longer than those taught by traditional methods. The audio visual images are engaging and this contributes to lasting retention (Meyer, 1984). Increased retention is an indicator of a successful project because students will become more interested in learning when they can relate what they've already learned to new information (Huang & Aloi, 1991).

Summary

It is evident, based on the literature material, that technology based instruction especially the use of the IVD can enhance learning and traditional classroom instruction. The ability of the IVD to accommodate for individual differences, through interactivity, and integrate text, high quality visuals and sound are especially appealing. It is the hope of this author that teachers will take the extra time and effort to examine the attributes of the IVD and develop lessons based on these capabilities. Perhaps the IVD can help achieve scientific literacy by enabling the students to understand a concept in more depth and familiarize them with current technology being used in society.

Preview of Succeeding Chapters

Chapter 3 of this project will describe the subjects, instrumentation and the procedures followed for developing and testing this IVD cn protein synthesis. Chapter 4 details the results and responses from the students using this program. It also contains an analysis of the data. Chapter 5 discusses the conclusions, based on the data, implications from this project, future recommendations and a summary of this project.

CHAPTER 3

METHOD

Chapter 3 describes the subjects and instrumentation utilized in this project. Also discussed are the procedures followed for developing, testing, and evaluating the results of this project.

Apparatus

In creating this interactive videodisc program on protein synthesis, the author used the equipment located in Room 249 of the College of Education at Wayne State University.

Microcomputer and Printer

Originally the IVD, for this project, was developed on a Unisys microcomputer and monitor by Burroughs. However, final editions were made on the Apple Macintosh SE microcomputer which had a color monitor. The printer used was the Apple Personal Laser Writer. This computer change occurred to accommodate the type of computers available at the high school testing this IVD program.

Authoring Program and Textbooks

Smith's authoring program and manual, Smith (1989), was used to develop this IVD program. A high school biology textbook by Miller and Levine (1991) was also used.

Biology Laser Videodisc and Laser Videodisc Player

The laser videodisc entitled, Principles of Biology, Side 1, August, 1986, by Optical Data Corporation was used to prepare the IVD program, for this project. The laser videodisc player was a Pioneer LDV 4200. The player was attached to an Amdek, Color 1, TV monitor.

Apparatus at High School

The completed IVD program, on protein synthesis, was tested at a suburban high school on the following equipment.

Microcomputer, Laser Videodisc and Videodisc Player

The IVD program for this project was tested on an Apple, Macintosh SE which had a color monitor. This computer was located in a Biology laboratory.

The laser videodisc entitled, The Living Textbook Life Science, Side 1, by Optical Data Cooperation, 1976, was used while this program was tested. This laser videodisc was also kept in the Biology laboratory. Also used was the laser videodisc player, Pioneer LDV 2200 which was attached to a color TV monitor. The laser videodisc player and TV monitor were on a movable cart. It was kept on reserve in the media center. The author took it daily, to the Biology laboratory, while this IVD program was being tested. The microcomputer was interfaced to the laser videodisc player, whenever, this program was tested.

Procedure

The author designed this IVD program on protein synthesis, (Appendix A), to meet some of the current guidelines for science education in Michigan as stated in Michigan Essential Goals and Objectives for Science Education (K–12) and Project 2061 Science for all americans. These books stressed making science material more relevant to the learner and making the student a more active learner in their education. These were also some of the goals of the author while creating this IVD program. The author made the science material more relevant to the student through the use of real life examples. The student was made a more active learner by allowing the learner to discover some of the concepts for themselves.

Another goal of the author was to create a well balanced interactive program. This was accomplished by presenting the right amount of written material correlated with a videodisc frame, or frame sequence, followed by a multiple choice, multiple response or essay question. The sequence of options profile for this program, (Appendix B), showed a good balance between the statements, videodisc frames or sequence frames and questions. There were three instances where there were three consecutive statements. The material was complex and the author felt that by presenting less material, on the screen, but using more than one screen, the student would not lose interest in the topic.

The vocabulary profile for this program is in (Appendix C). It classified the vocabulary of the text according to the difficulty of the words.

While developing this program, consideration was given to the age, grade level and individual differences between students. The sentences constructed were easy to comprehend and the science vocabulary and concepts presented were appropriate to grade level of the student, which in this case, would be tenth grade. The profile of the estimate of the readability, for this program (Appendix D), estimates the reading grade level of this program. This program was designed primarily for tenth grade biology students. According, to the Fleschman Grade Equivalent Index, this program has a grade level reading level of 10.01.

A reference section was also included, in this program, to be used by the students.

The author designed the IVD program for this project in the computer laboratory in Room 249, Located in the College of Education, at Wayne State University. The author viewed the laser videodisc on protein synthesis and wrote down specific frame numbers and a description of each frame. The writer then located a high school biology textbook by Miller & Levine (1991) currently being used in a suburban high school and correlated the videodisc frames to the text material. The

manual, Smith's author system to create interactive videodisc instruction, by Smith (1989) served as a guide for developing this IVD program. Copies of the worksheets, from this manual, were made and used to organize statements, video frames, and questions.

The author went to the computer laboratory several times a week and wrote, entered the information into the microcomputer, edited and ran this IVD program. After this IVD program on protein synthesis was completed the writer test piloted this program on four high school students. Afterwards, final editions were made on this program.

The author then located a suburban high school where the science faculty were both excited and interested in using this IVD program to reinforce the concept of protein synthesis with their students.

Procedure for Test Pilot of IVD Program

Four high school students test piloted the IVD program, for this project, prior to testing it on a larger number of students. The four students were ninth graders, two were female and two were male. They attended suburban high schools, and were, presently, taking high school biology. Their science teachers had already discussed protein synthesis with their class.

The author brought two of the students on May 5, 1993 and the other two students on June 6, 1993, to the computer laboratory at WSU, to test run this IVD program on protein synthesis. The author designed a

questionnaire (Appendix F), to be answered by the students after they completed viewing the program.

While the students were testing this program, the author recorded their reaction to using this IVD program for instruction, for example, any areas on the program they repeated viewing, the length of time it took them to complete the program, and any visible signs of anxiety while using this IVD program. After reading their recommendations and interpreting the data collected, the author made final editions on this program.

Procedure for Testing this IVD Program

On April 8, 1993, the author contacted the chairman of the science department, at a suburban high school, to see if they would be interested in testing this IVD program with their Biology students. The chairman was interested in IVD technology and in using this new instructional strategy in their classrooms. However, first he wanted to discuss this with his science teachers.

On April 27, 1993, science teacher A contacted the author and scheduled a meeting for May 5, 1993 to view the IVD program. Science teacher A liked this IVD program. Science teachers A and B had already taught protein synthesis to their classes and this would reinforce the concept of protein synthesis and help their students for their final exam.

The teachers gave the students extra credit as an incentive to use this IVD program (Appendix G).

The author also examined the physical set up of the laboratory where the computer and videodisc equipment would be set up. The room was quiet, well lighted, and the two doors that led into the laboratory could be locked when the equipment was not in use. The author and science teacher A located a microcomputer, laser videodisc player,and monitor and a compatible laser videodisc. The author interfaced the equipment and ran through the program.

On May 12,1993, the author gave science teachers A and B a transparency, (Appendix H). The diagram on the transparency showed one arrangement of IVD equipment and a learner flow chart. The author felt that this transparency would help the teachers introduce the students to the IVD adventure that they were going to embark on.

The author made weekly sign in schedules (Appendix I) and gave one each week to the participating science teachers. This would let the writer know who and when the student would be coming to the science laboratory to run the program.

Forty three high school students participated in this study. Nineteen of the students were in the ninth grade. Fourteen of the ninth graders were male and five were female. Twenty two of the students were in the tenth grade. Twelve of the twenty two students were female

and ten were male. There was one male student in the eleventh grade and 1 female student in the twelfth grade. They were currently taking high school Biology and their teachers already taught protein synthesis to them.

The author was present during the entire testing period, to help the students when necessary. After each student finished viewing this IVD program, they filled out a questionnaire identical to the one the test pilot students completed, (Appendix F).

The students knew how they performed on the multiple choice and multiple response questions immediately after completing the program. However, they were asked several essay questions which required them to type in their own answers. After the author obtained a copy of the student's output file, the author corrected their essays and returned them to the students.

The essays were corrected using the following procedure. The correct answer for essay 2, which asked the students to give the correct pairing of the nitrogen bases for DNA is, adenine pairs with thymine and cytosine pairs with guanine. Fifty percent was recorded if one of the answers were given, and 100% was recorded if both answers were given. The students who received 100%, answered the question correctly, and received the comment very good. Those receiving 50%, answered the

question incorrectly, and received the comment reread, the incorrect part of the answer was circled.

The acceptable answer for essay question 7, which asked the students to explain how the genetic information in DNA is copied into messenger RNA, was divided into four parts: the answer to part 1, an enzyme moves along a DNA strand; part 2, as it moves along the DNA, it causes it to unwind; part 3, as the DNA unwinds the enzyme reads the bases on the DNA strand; part 4, and matches complimentary bases to the single DNA strand forming messenger RNA. Twenty five percent was recorded for each part the student answered correctly. Students who received a 75% or 100%, answered the question correctly, and received the comment good for 75% and very good for 100%. Students who received less than 75%, answered the question incorrectly, and received the comment reread, some of the incorrect areas were circled.

The acceptable answer for essay question 15, which asked the students to describe the entire process of protein synthesis, remembering the role of RNA polymerase, m–RNA, t–RNA and the ribosome, was divided into 7 parts. The acceptable answers to parts 1,2,3, and 4 were identical to the answers for essay question 7, just given. The acceptable answer for part 5 was, m–RNA goes to a ribosome, part 6, anticodons on transfer RNA pair with the codons on m–RNA. part 7, then the t–RNA releases the appropriate amino acid to be added to the growing

polypeptide chain. One seventh or 14.3% was recorded for every part the student answered correctly. Students who received 1 error or less (86% or higher) answered the question correctly and received a comment of good for 86% and very good for 100%. Students who received less than 86% answered the question incorrectly and received the comment reread, some of the incorrect areas were circled.

The acceptable answers for essay question 16, which asked the students to give 2 ways their body uses proteins are: a.) to form antibodies which fight infection, b.) to form Insulin, which regulates the amount of sugar in your blood, c.) to form Hemoglobin, which carries oxygen to different parts of our body, d.) to form digestive enzymes which help break down the food we eat, e.) to store energy, f.) to increase bone strength, g.) to build muscle, h.) to repair damaged cells, i.) as enzymes in chemical reactions, and j.) stored as fat. Fifty percent was recorded if one of the above answers was given and 100% was recorded if any two of the above answers were given. The students who received 100%, answered the question correctly and received the comment very good. The students who received 50%, answered the question incorrectly, and received the comment reread, the incorrect part of the answer was circled.

Sample and Population

The sample for this study consisted of 43 high school students. Nineteen were in the ninth grade, twenty two were in the tenth grade, one was in the eleventh grade and one was in the twelfth grade. They attended a suburban high school in metropolitan Detroit. The population to whom the results of this study would apply are pupils studying Biology at this school.

The testing of the IVD program for this project began on May 14 1993, and continued almost everyday, all day, for three weeks until June 4, 1993. The author completed the testing of the IVD program for this project on June 4, 1993.

CHAPTER 4

ANALYSIS OF RESULTS

Chapter 4 details the results and responses from student use of the IVD program on protein synthesis. It also contains discussion of the data.

Forty three students viewed this IVD program on protein synthesis. The average time it took each student to complete this IVD was thirty seven minutes. Five students were unable to complete viewing this program in one visit. All of these five students completed the program in two visits.

All students answered three types of questions: multiple choice, multiple response, (Appendix J), and essay questions, (Appendix K). Table 1 shows the number of students that answered the multiple choice and multiple response questions correctly and incorrectly. Table 2 shows the number of students that answered the essay questions correctly and incorrectly. Table 3 shows the percent correct that the students achieved after they answered the essay and multiple choice and response questions.

Table 4 shows student responses to a questionnaire, (Appendix F), which each student completed after viewing the IVD program on protein synthesis. Table 5 shows a sample of some of the student responses to question 12 of the questionnaire. Question 12 asked the

students to state any suggestions or comments that would make this program more helpful to them. Twenty seven students chose to answer this question. A complete listing of their responses is in Appendix M.

Table 6 shows the averaged scores in percent the students achieved, on the multiple choice/multiple response questions and the essay questions with respect to the length of time it took them to view this IVD program.

Table 1

Student Responses to the Multiple Choice and Response Questions

Question (12 questions)	# of correct responses	# of incorrect responses
1. Responsible for resembling parents	43 (100%)	0
2. Location of DNA in cell	42 (98%)	1 (2%)
3. Identification of Nucleotide	30 (70%)	13 (30%)
5. Match bases of DNA strand	42 (98%)	1 (2%)
6. Nitrogen bases of RNA	39 (91%)	4 (9%)
8. Nucleotide sequence of m–RNA	41 (95%)	2 (5%)
9. Cell structure to exit nucleus	37 (86%)	6 (14%)
10. Cell structure for protein synthesis	43 (100%)	0
11. Basic structure of proteins	43 (100%)	0
12. Nucleotide length and # of codons	34 (79%)	9 (21%)
13. Anticodon for codon AGU	40 (93%)	3 (7%)
14. RNA that decodes codon	42 (98%)	1 (2%)

Table 1 shows the number and percentage of students that answered the 12 multiple choice/multiple response questions, (Appendix J), correctly. Forty three of the students (100%) knew what was responsible for them resembling their parents. Forty two students (98%) knew where DNA was located in their cells, 1 student (2%) answered this question incorrectly. Thirty students (70%) were able to identify the components of a nucleotide. Thirteen students (30%) were unable to answer this question correctly. Forty two students (98%) were able to match the base pairs of a DNA strand, 1 student (2%) answered this question incorrectly. Thirty nine students (91%) knew the nitrogen bases of RNA, 4 students (9%) answered this question incorrectly. Forty one students (95%) were able to determine the nucleotide sequence of m–RNA from a section of a DNA strand. Two students (5%) were unable to answer this question correctly. Thirty seven students (86%) knew which cell structure permitted m–RNA to leave the nucleus of the cell. Six students (14%) did not answer this question correctly. Forty three students student (100%) knew in which cell structure protein synthesis occurred. Forty three students (100%) knew the basic structure of proteins. Thirty four students (79%) knew how to determine nucleotide length and the number of codons in the nucleotide. Nine students (12%) answered this question incorrectly. Forty students (93%) were able to determine the anticodon from codon AGU. Three students (7%) were

unable to answer this question correctly. Forty two students (98%) knew which RNA decodes a codon. One student (2%) were unable to answer this question correctly.

Table 2

Student Responses to the Essay Questions

Question (4 questions)	# of correct responses	# of incorrect responses
1. Pattern of base pairing in DNA	41 (95%)	2 (5%)
7. DNA transcription into m–RNA	20 (47%)	23 (53%)
15. Process of protein synthesis	15 (35%)	28 (65%)
16. Examples of protein utilization	32 (75%)	11 (26%)

Table 2 shows the number and percentages of students that answered the four essay questions, (Appendix K), correctly and incorrectly. Forty one students (95%) were able to describe the pattern of base pairing in DNA. Two students (5%) were unable to answer this question correctly. Twenty students (47%) were able to explain how DNA was transcribed into m–RNA. Twenty three students (53%) answered this question incorrectly. Fifteen students (35%) were able to explain the entire process of protein synthesis. Twenty eight students (65%) answered this question incorrectly. Thirty two students (75%) were able to give examples of protein utilization in their body. Eleven students (26%) answered this question incorrectly.

Table 3

Percentage of Correct Student Responses to Questions

# of Students	Percent multiple choice and multiple response correct (12 questions)	Percent essay responses correct (4 questions)
8	100	100
5	100	75
5	100	50
4	92	100
2	92	75
5	92	50
3	92	25
1	92	0
3	83	50
3	83	25
1	75	50
2	75	25
1	67	75

Table 3 shows the percent correct that the students achieved after answering the essay and multiple choice/multiple response questions. Eight students achieved a 100% on both their multiple choice/multiple response and on their essay questions. Five students obtained a 100% on their multiple choice/multiple response questions and a 75% on their essay questions. Five students obtained a 100% on their multiple choice/multiple response questions and a 50% on their essay questions. Four students achieved a 92% on their multiple choice/multiple response questions and a 100% on their essay questions. Two students obtained a 92% on their multiple choice/multiple response questions and a 75% on their essay questions. Five students achieved a 92% on their multiple choice/multiple response and a 50% on their essay questions. Three students achieved a 92% on their multiple choice/multiple response questions and a 25% on their essay questions. One student achieved a 92% on their multiple response/multiple response questions and a zero on their essay question. Three students achieved an 83% on their multiple choice/multiple response questions and a 50% on their essay questions. Three students achieved an 83% on their multiple choice/multiple response questions and a 25% on their essay questions. One student achieved a 75% on their multiple choice/multiple response questions and a 50% on their essay questions. Two students achieved a 75% on the multiple choice/multiple response questions and a 25% on

their essay questions. One student achieved a 67% on their multiple choice/multiple response questions and a 75% on their essay questions.

There was a low, negligible, correlation between the student scores on the multiple choice/ multiple response questions versus their scores on the essay questions. This is supported by a Contingency Coefficient, C = .15. Appendix L provides the statistical summary of the data for this contingency coefficient. This implies that the multiple choice/multiple response questions were measuring a different achievement level of understanding of the concept than was being measured by the essay questions. Therefore, the combination of the two types of questions is a more precise measurement of each pupils understanding of the subject in this IVD program than any one alone.

Table 4

Student Responses to a Questionnaire about this IVD Program

	Student responses					
Question #	Yes	Unsure	No	Excellent	Good	Poor
1. Understand main idea	43 (100%)					
2. Rate overall quality				24 (56%)	19(44%)	
3. Video sequences helped	40 (93%)	3 (7%)				
4. Audio sequences helped	37 (86%)	6 (14%)				
5. Text was understandable	38 (88%)	4 (9%)	1 (2%)			
6. Examples helped	34 (79%)	9 (21%)				
7. Clarified misconceptions	29 (67%)	12 (28%)	2 (5%)‡			
8. Rate challenges presented				6 (14%)	37 (86%)	
9. Comfortable with computer use	41 (95%)	2 (5%)				
10.Difficulty navigating through lesson	2 (5%)	1 (2%)	40 (93%)			
11. Future interest in IVD	37 (86%)	4 (9%)	2 (5%)			
12. Suggestions and comments		Responses to this question are in Appendix J				

‡one student did not have any misconceptions

Table 4 shows student responses to a questionnaire, (Appendix F), which each student completed after viewing this IVD program on protein synthesis. Forty three students (100%) stated that they understood the main idea of this lesson. Twenty four students (56%) rated the overall quality of this program as excellent. Nineteen students (44%) rated it as good. Forty students (93%) felt the video sequences helped them understand protein synthesis. Three students (7%) did not feel that the video sequences helped. Thirty seven students (86%) felt the audio sequences helped them understand protein synthesis. Six students (14%) felt the audio sequences did not help them. Thirty eight students (88%) felt the text was understandable. Four students (9%) were unsure and one student (2%) was unable to understand some of the text. Thirty four students (79%) felt the examples helped them understand protein synthesis. Nine students (21%) did not feel that the examples helped them. Twenty nine students (67%) felt this program helped clarify misconceptions they had about protein synthesis. Twelve students (28%) were unsure if it clarified their misconceptions. One student (2%) felt this program did not clarify his misconception, and one student (2%) stated that he did not have any misconceptions. Six students (14%) rated the challenges presented in the program as excellent, and thirty seven students (86%) rated them as good. Forty one students (95%) were comfortable using a computer, two students (5%) were unsure, and two

students (5%) had difficulty navigating through this lesson. Thirty seven students (86%) would like to use the IVD instructional strategy in their future learning, four students (9%) were unsure, and two students (5%) would not like to use this instructional strategy again. A complete listing of the suggestions and comments about this program, and how to make it more helpful is in Appendix M.

Table 5

A Sample of Student Responses to Question 12 from the Questionnaire

Question 12 – Please state any suggestion or comments which would make this program more helpful to you.

Favorable (9)	Unfavorable (4)	Suggestions (14)
More use of this system.	It was good but the viewings were hard to understand.	More visual and less reading.
I realized that I forgot all about protein synthesis and this helped me remember it.	It's too easy after already learning it in class, the pictures show practically the same thing over and over.	Use a faster computer and videodisc player to get the information on the screen quicker.
It should be required for every student. The modernized concepts are easier to understand than the boring, old film strips.	I couldn't delete very easily or when I needed help, like in the middle of an essay. I was not familiar with the computer.	Maybe instead of one long videodisc program including everything about protein synthesis, several shorter once so students can concentrate on a specific part of it.
The essay questions, though long, were very helpful because you couldn't guess at an answer and have it right. You had to think. Will be very useful in the years to come.	The repeated video sequences became distracting so did the sudden endings to the video clip.	Chance to review text before answering questions. More screen animation.

Note: There were 27 student comments and suggestions.

Table 5 shows a sample of the student responses to question 12 from the questionnaire the students filled out after viewing this IVD program. Question 12 asked the students to state any suggestions or comments which would make this program more helpful to them. Twenty seven of the forty three students answered this question. There were 9 favorable comments. One student commented that they would like to use the IVD system again for instruction. Another student said they forgot all about protein synthesis and this IVD system helped them remember it. A third student commented that IVD instruction should be required for every student. They also felt that concepts are easier to understand using this system as opposed to boring film strips. Another student liked the essay type questions because a student couldn't guess at an answer like with multiple choice type questions. They also felt that the IVD system would be useful in the future. The remaining favorable comments are in Appendix M.

There were four unfavorable comments. One student thought this IVD program was good but found the visuals hard to understand. Another student felt that this IVD program was too easy after already learning the subject in class. They also felt the video portion of the program showed the same thing over and over. A third student had difficulty because they were not familiar with using the computer. Lastly,

a student did not like the repeated video sequences and sudden endings to the film clips.

Fourteen students offered suggestions which they felt would make this IVD program more helpful to them. One student suggested more usage of visuals and less text on the screen. Another student suggested a faster computer and videodisc player. This would get the information on the screen quicker. A third student suggested several shorter IVD lessons, each on a specific part of protein synthesis, instead of one long IVD program on the entire process of protein synthesis. A fourth student suggested having a chance to review their text before answering any questions. Another student suggested more screen animation. The remaining suggestions are listed in Appendix M.

Table 6

Average Student Scores in Percent and Duration of Viewing this IVD Program.

	Time Intervals (10 minutes)					
	15–24	25–34	35–44	45–54	55–64	65–74
# of Students	3	13	18	6	2	1
% MC and MR correct	86%	88%	93%	99%	96%	92%
% Essay correct	50%	60%	67%	67%	88%	50%
% Total correct	77%	82%	87%	91%	94%	81%

Note: Scores are for 12 multiple choice (MC) and multiple response (MR) questions, and 4 essay questions for a total of 16 questions.

Table 6 shows the student percent scores for the multiple choice/multiple response and essay questions with respect to the length of time, in minutes, it took them to view this IVD program. Three students took between 15–24 minutes to view this IVD program. They achieved an averaged score of 86% on the multiple choice/multiple response questions and an average score of 50% on the essay questions. They achieved an averaged total score of 77%. Thirteen students took between 25–34 minutes to view this IVD program. They achieved an averaged score of 88% on the multiple choice/multiple response questions and an averaged score of 60% on the essay questions. Their averaged total score was 82%. Eighteen students took between 35–44 minutes to view this IVD program. They achieved an average score of 93% on the multiple choice/multiple response questions and an averaged score of 67% on the essay questions. Their averaged total score was 87%. Six students took between 45–54 minutes to view this IVD program. They achieved an averaged score of 99% on the multiple choice/multiple response questions and an averaged score of 67% on the essay questions. Their averaged total score was 91%. Two students took between 55–64 minutes to view this IVD program. They achieved an averaged score of 96% on the multiple choice/multiple response questions and an averaged score of 88% on the essay. Their averaged total score was 94%. One student took between 65–74 minutes

to view this IVD program. He achieved a score of 92% on the multiple choice/multiple response questions and a score of 50% on the essay questions. His total score was 31%.

CHAPTER 5

CONCLUSIONS

Most of the students did well on the multiple choice and multiple response questions. Forty two students (98%) obtained a score of 75% or higher on the multiple choice/multiple response questions. Thirty students (70%) answered question 3 correctly. Question 3 asked the students to identify the components of a single nucleotide. The components of a nucleotide were listed in their Biology textbook. However, the author feels since 41 students were in the ninth and tenth grade they, probably, had not had a Chemistry course. They were, therefore, unaware of the importance of knowing about the parts of a nucleotide. This IVD program made the students aware of their score immediately after they viewed the program. The students were, therefore, able to review weak areas prior to taking their final exam. Lehman, (1985), writes that one advantage of the IVD is that it provides immediate feedback.

The students did not do well on all of the essay questions. Twenty students (47%) achieved a score of 75% or higher on the essay questions. Forty one students (95%) answered question 1 correctly, and thirty two students (75%) answered question 16 correctly. However, 20 students (47%) answered question 7 correctly and 15 students (35%) answered question 15 correctly. Essay question 1 asked the students to

write the nitrogen base pairing pattern for DNA. Question 16 asked the students to give two examples of how their body uses proteins. Question 7 asked the students to explain how DNA is transcribed into m–RNA. Question 15 asked the students to explain the process of process of protein synthesis. The author felt that the students probably did better on essay questions 1 and 16 because they required short answer. This author, also, feels that it takes more time to answer an essay question than a multiple choice question. Questions 7 and 15 required a long answer. Perhaps, the students were not accustomed to essay questions and/or feared that they would be late for their next class if they took the additional time to answer these 2 questions thoroughly. The students were made aware of their essay results shortly after viewing this program. They were, therefore, able to review their weak areas prior to taking their final exam.

There was a low, negligible, correlation between scores achieved on multiple choice/multiple response questions and essay questions, C = .15. This implies the combined scores provide increased precision in measuring each students understanding of the subject in this IVD program.

The students completed a questionnaire after viewing this IVD program. Based on the their responses, this program helped them understand the concept of protein synthesis. Forty students (93%) felt

the video sequences helped them understand protein synthesis. These comments are similar to comments made by students in a study by Bunderson et al. (1981). These students said they liked the visual images and motion sequences.

Thirty seven students (86%) felt the audio sequences helped them understand the concept of protein synthesis. Thirty eight students (88%) said the text was understandable. Jones (1987) states that some attributes of the IVD are the integration of a variety of media, such as, text, image, and sound.

Thirty four students (79%) said the examples used in this IVD program helped clarify their misconceptions. According to Bunderson et al. (1984), the way information is presented, can effect how well the student understands the concept and avoid misunderstandings and misconceptions.

One student commented that he forgot all about protein synthesis and this IVD program helped him remember it. Another student said that concepts are easier to understand using IVD technology, instead of boring, old, film strips. Huang & Aloe (1988) feel that the IVD system provides interactivity as opposed to film or video.

The author feels that perhaps this IVD program helped students, who took longer to view this program, achieve higher scores on their multiple choice/multiple response and essay questions. For example, 13

students took between 25–34 minutes to view this program and achieved an averaged multiple choice/multiple response score of 88% and averaged essay score of 60%. Their averaged total score was 82%. Eighteen students took between 35–44 minutes to view this IVD program and achieved averaged scores of 93%, 67%, and 87% respectively. Perhaps, the students who took longer were learning more from this IVD program.

The students enjoyed using this IVD program on protein synthesis. According to the questionnaire responses, thirty seven students (86%) would like to use IVD technology for their education. One student commented that he wanted more use of this system. Another student commented that this system would be useful in the future.

There were suggestions made by the students, regarding this IVD program which were of interest to the author. One was the use of more screen animation. This is dependent on the amount of animation on the videodisc. The other suggestion was making several shorter IVD programs for each specific part of protein synthesis.

SUPPORT OF HYPOTHESIS

Based on the conclusions, the Interactive Videodisc Program on protein synthesis, developed by the author, is an effective method to assist high school students to understand the science concept of protein synthesis.

IMPLICATIONS

Since most of the students felt that this IVD program helped them to understand the concept of protein synthesis in Biology, perhaps, IVD technology could also be used in the other sciences, for example, in Chemistry, Physics, Geology, and Astronomy. This IVD technology could also be used to teach laboratory lessons. Another implication from this study, would be to use IVD technology in the non sciences, for example, in Mathematics, Foreign Languages, Language Arts, and Social Studies.

RECOMMENDATIONS FOR FURTHER STUDY

In the future, the author would like to examine laser videodiscs which contain more animation, in addition to, accurate content material. This author would also like to make shorter IVD programs, which focus on limited sections of a concept, and have fewer essay questions. Students would have ample time to answer the essay questions thoroughly. This author is also interested in the effect of time on learning. Perhaps, with shorter IVD programs, the students would take longer to view the IVD program and as a result learn more. This author is also interested on the effect of IVD technology and the retention of content material.

These are a few areas of recommendations for future study.

SUMMARY

The author developed an IVD program on protein synthesis. The author developed this program by using, Smith's Authoring System and Smith's author system to create interactive videodisc instruction, (Smith, 1989), Biology, (Miller and Levine, 1991), The Living Textbook Life Science, (Optical Data Corporation, 1976,. Michigan essential goals and objectives for science education (K-12), (Michigan State Board of Education, 1991), Project 2061 science for all americans, (American Association For The Advancement Of Science, 1989). An Apple Macintosh SE microcomputer with color monitor and a Pioneer LDV 2200 laser videodisc player attached to a color TV monitor was also used.

This IVD program was tested on 43 high school biology students, to determine if this program would assist them to understand the concept of protein synthesis. These students attended a suburban high school and were already taught the process of protein synthesis by their Biology teachers. However, they would be tested again on this concept during their final exam. Their Biology teachers gave the students extra credit as an incentive to use this IVD program for review.

The results showed that 98% of the students achieved a score of 75% or higher on the multiple choice/multiple response questions. The immediate feedback from the program, enabled the students to review their weak areas, prior to taking their final exam. Forty seven percent of

the students achieved a score of 75% or higher on the essay questions. Their essays were corrected by the author and returned to them shortly after they viewed this IVD program. Once again, they had ample time to strengthen their weak areas, prior to their final exam.

There was a low, negligible, correlation between scores achieved on multiple choice/multiple response questions and essay questions, C = .15. This implies the combined scores provide increased precision in measuring each students achievement.

The students completed a questionnaire after viewing this IVD program. Based on their responses, this IVD program helped them understand the concept of protein synthesis. Ninety three percent said the video sequences helped them understand protein synthesis. Eighty six percent said the audio sequences were helpful. Eighty eight percent stated that the text was understandable. Seventy nine percent stated that the examples used in this IVD program were helpful. Sixty seven percent said this IVD program helped clarify misconceptions they had about protein synthesis. One student commented that he forgot all about protein synthesis and this IVD program helped him remember it. Another student commented that concepts are easier to understand using IVD technology.

Some implications from this study are to use IVD technology to teach laboratory lessons and content material in the other sciences, and non science subject areas.

Some recommendations for further study are, 1) to select laser videodiscs with more animation, in addition to, accurate content material. 2) to make shorter IVD programs, which focus on limited sections of a concept, 3) and fewer essay questions so students have ample time to answer this type of question thoroughly.

APPENCICES

APPENDIX A

IVD Program on Protein Synthesis

APPENDIX A

*REFERENCE

A PEPTIDE BOND is a bond that joins individual amino acids.

A POLYPEPTIDE forms when many amino acids are joined together by peptide bonds.

A PROTEIN is made up of one or more polypeptide chains. The sequence or order of the amino acids, determines the special characteristics of the protein.

A NUCLEOTIDE consists of:

1. A 5-carbon sugar (pentagon shaped).
2. A phosphate group
3. A nitrogen containing base group.

The 5 nitrogen bases which can form a nucleotide are: Adenine, Thymine, Cytosine, Guanine, Uracil.

NUCLEIC ACIDS are polynucleotides. They are formed when many nucleotides are joined together.

DNA is a nucleic acid. It consists of 2 polynucleotide chains twisted to form a double helix,. The chains are made of repeated segments of nucleotides. One of the following bases can be used for each nucleotide, Adenine, Thymine, Cytosine or Guanine. The sugar (which is different from the sugar for RNA) and phosphate groups are on the outside of the ladder and the rungs of the ladder are the nitrogen bases. The bases follow specific pairing rules, Adenine pairs with Thymine and Cytosine pairs with Guanine.

RNA is a nucleic acid. It consists of 1 polynucleotide chain. The chain is made of repeated segments of nucleotides. One of the following bases can be used for each nucleotide, Adenine, Uracil, Cytosine or Guanine. The bases follow specific base pairing rules, Adenine pairs with Uracil and Cytosine pairs with Guanine.

A CODON is a series of 3 nucleotides. Every 3 nucleotides is a code for a specific amino acid.

The BASES OF THE ANTICODON are complementary to the codon of messenger RNA.

TRANSCRIPTION is the transfer or copying of genetic information from DNA to messenger RNA.

TRANSLATION is the transfer of information from messenger RNA into amino acids by transfer RNA. It is the translation from the language of nucleic acids to the language of proteins.

This IVD program is designed for high school students, to reinforce the concept of protein synthesis.

The textbook used is, "Biology,' First Edition, Prentis Hall, 1991.

The Laser Videodisc used is, "Principles of Biology," Side 1, August, 1986, Optical Data Corporation.

The author of this program is Charlene Hazan, Graduate Student at Wayne State University, MAT Masters Project.
*$END
*REPEATS
*NOACCESS
*$SECTION=5
*FRAME
22841
*$END
*$SECTION=10
*STATEMENT

This Interactive Videodisc (IVD) program is intended to reinforce the material discussed in your science class, specifically, the chapter in your Biology text, regarding, DNA, RNA, and protein synthesis within the cell.

This will be accomplished by viewing pictures on the TV screen and reading statements on this microcomputer monitor.

You may view the film clip sequence as often as you feel necessary. Instructions on how to do this will appear on the screen after every film clip.

*$END
*$SECTION=20
*STATEMENT

There is also a reference section to which you can refer. This section contains definitions and explanations of certain words or ideas.

You can do this by pressing the H key.
*$END

*$SECTION=22
*STATEMENT
You will then be asked to answer one of three types of questions. The questions will either be multiple choice, multiple response, or essay type questions.

Consider each question carefully, and answer by either typing the number of the correct answer or by typing out your answer. The method that you use will depend on the type of question that you are asked.
*$END
*$SECTION=30
*FRAME
43701
*$END
*$SECTION=35
*MULTIPLE CHOICE QUESTION 1
What is responsible for you looking like your parents or relatives?

1. DNA

2. Ribosomes

3. Nucleus

4. Cytoplasm

*$END
1 =CORRECT ANSWER
#FOUND
You are correct! Our genes consist of DNA and DNA contains the genetic information that is passed from one generation to the next, from parent to child,

$END

#NOT FOUND
Your answer is incorrect. Our genes consist of DNA and DNA contains the genetic information that is passed from one generation to the next, from parent to child.
*$END
-----END OF QUESTION-----
*$SECTION=40
*FRAME
34110
*$END
*$SECTION=45
*STATEMENT
The large circular structure, on the screen, is the nucleus of the cell. Deoxyribonucleic (dee OK seh ry boh noo KLEE ik) acid or DNA lives in the nucleus of the cell. Written in the structure of DNA are the instructions that control your cell's activities.
*$END
*$SECTION=48
*STATEMENT
Before a building is built blueprints are made which describe a detailed outline of the plan for the building. This includes a timetable as to when construction on certain rooms are to begin and be completed. It may also include the color scheme and decor for the building. Your DNA acts like a blueprint for your cells.

Now listen to a film clip about DNA and pay close

attention to the role of DNA within your cells.
*$END
*$SECTION=50
*PLAY
34110
34684
*$SECTION=55
*MULTI RESPONSE QUESTION 2
4 CHOICES POSSIBLE
2 =PREFERRED RESPONSE
Where is DNA located in your cells?

1) Nuclear Envelope

2) Nucleus

3) Cytoplasm

4) Ribosome

*$END
#1
The nuclear envelope permits communication between the nucleus and the rest of the cell. The correct answer is the nucleus.
*$END
#2
Your answer is correct. DNA is located in the nucleus of your cells.
*$END
#3
The cytoplasm contains the cell structures. The correct answer is the nucleus.
*$END
#4
Proteins are made in ribosomes. The correct answer

is the nucleus.
*$END
-----END OF QUESTION-----
*$SECTION=60
*FRAME
22696
*$END
*$SECTION=65
*STATEMENT
The picture, on the screen, represents

a DNA molecule. Notice that it consists of 2 strands

of DNA and is twisted, forming a double helix.

It is similar to a ladder which is twisted.
*$END
*$SECTION=70
*FRAME
22963
*$END
*$SECTION=75
*STATEMENT
On the screen, is a close up of a

section of a DNA molecule. Imagine, a ladder that is

on its side. If you look at the bottom side of the

ladder you can see that it is made of repeated segments

of individual nucleotides.

DNA is a made of 2 twisted chains of polynucleotides

"Poly" means many, hence, many nucleotides joined together.

A nucleotide is made of a phosphate group, represented

by a plus sign, on the screen, a sugar group, represented

by a green pentagon, on the screen, and a nitrogen

containing base group.

*$END
*$SECTION=80
*MULTIPLE CHOICE QUESTION 3
Which of the following identifies a single nucleotide?

1) A 5-Carbon sugar.

2) Cytoplasm.

3) A phosphate group, a sugar group and one nitrogen containing base group.

4) Adenine, Thymine, Cytosine, Guanine, and Uracil.

*$END
3 =CORRECT ANSWER
#FOUND
Your answer is correct. A nucleotide is made of, a

phosphate group, a sugar group, and a nitrogen

containing base group.
*$END
#NOT FOUND
Your answer is not correct. A nucleotide is made of a

phosphate group, a sugar group, and a nitrogen containing

base group.
*$END
-----END OF QUESTION-----
*$SECTION=85
*FRAME
22963
*$END
*$SECTION=90
*STATEMENT
The nitrogen bases for DNA are: Adenine (A), Thymine(T),

Cytosine(C) and Guanine(G)

Analyze the nitrogen bases on the other side of the

ladder or polynucleotide chain.

Now, reexamine the nitrogen bases on the bottom DNA strand.

Do you see a pattern in the way the nitrogen bases pair together? I am going to be asking you a question about this pattern.

*$END
*$SECTION=91
*OPEN ENDED QUESTION 4

What is the pattern you discovered for the pairing of the nitrogen bases for DNA?

(You will see if you are correct when you continue with this program.)

*$END
#NOWORDS
-----END OF QUESTION-----
*$SECTION=92
*STATEMENT

Let's see if you are correct. Flatten your hand and cover the letters on the upper left hand section of the DNA molecule. Now, read the letters on the lower section of the DNA molecule, begin with T for Thymine and match Thymine with its correct base. Slide your hand to the right to see if you are correct. Do this until you feel that you understand the base pairing rules for DNA.

*$END
*$SECTION=94
*STATEMENT
The order of these bases provide a code for a particular protein. Just like a scanner is needed to read one of those parallel-lined product codes, for example, on a box of cereal. Proteins carry out the genetic instructions written on your DNA.

Now, listen to a film clip about DNA.
*$END
*$SECTION=95
*PLAY
22696
23242
*$SECTION=100
*MULTIPLE CHOICE QUESTION 5
If a section of one strand of a DNA molecule has the nucleotide sequence AGGTCC, what would be the nucleotide base sequence of the same section, on the other DNA strand?

1) TCCAGG

2) GAACTT

3) CTTGAA

4) AGGTCC
*$END
1 =CORRECT ANSWER
#FOUND
Your answer is correct! Adenine pairs with Thymine and Guanine pairs with Cytosine.
*$END

#NOT FOUND
Your answer is incorrect. The correct answer is #1,

Adenine pairs with Thymine and Guanine pairs with Cytosine.
*$END
-----END OF QUESTION-----
*$SECTION=105
*FRAME
23625
*$END
*$SECTION=110
*STATEMENT
The picture, in the center of the screen is that of

messenger RNA (m-RNA) being formed. It is one of three

types of RNA in your cells.

Notice that, Ribonucleic acid (ry boh noo KLEE ik) acid

or RNA is a single stranded polynucleotide. Its nucleotide

contains a phosphate group, a nitrogen base group and

a different sugar group than DNA.

The nitrogen containing base groups for RNA are:

Adenine, Cytosine, Guanine, and Uracil instead of Thymine.

*$END
*$SECTION=115
*MULTIPLE CHOICE QUESTION 6
What are the nitrogen bases for RNA?

1) Adenine, Thymine, Guanine, Cytosine.

2) Adenine, Lysine, Cytosine, Guanine

3) Adenine, Uracil, Guanine, Cytosine.

4) Thymine, Guanine, Uracil, Cytosine.
*$END

3 =CORRECT ANSWER
#FOUND
Your answer is correct! The nitrogen bases for RNA

are Adenine, Uracil, Cytosine, and Guanine.
*$END
#NOT FOUND
Your answer is incorrect. The correct answer is #3,

The nitrogen bases for RNA are Adenine, Uracil, Guanine and

Cytosine.
*$END
-----END OF QUESTION-----
*$SECTION=120
*FRAME
23392
*$END
*$SECTION=125
*STATEMENT
It is now time to make a protein. Since DNA remains

inside the nucleus, its genetic message must be copied

or transcribed and then taken out of the nucleus to the

cytoplasm (SYT oh plazum). Think about how this might happen and

let's look at the next picture.
*$END
*$SECTION=126
*STATEMENT

The picture on the screen shows how the genetic

information in DNA is copied. An enzyme group, represented by the

blue circles, attach to a start spot on the DNA molecule

The enzyme, RNA polymerase moves along one of the DNA

strands and causes the DNA to unwind. The enzyme then

facilitates or helps in the formation of messenger-RNA.
*$END
*$SECTION=135
*FRAME
23614
*$END
*$SECTION=136
*STATEMENT

This picture shows how RNA polymerase helps in the formation of m-RNA. As you can see in the picture, the enzyme chemically reads the bases on one DNA strand and matches complimentary nucleotide bases to the single DNA strand forming messenger RNA. The nitrogen base, Adenine pairs with Uracil (instead of Thymine), and Cytosine pairs with Guanine.

Finally, the enzyme reaches a stop spot, on the DNA strand and releases itself and newly formed m-RNA from the DNA strand.

The newly formed m-RNA now contains a copy of the genetic information from the DNA molecule.

Now, look and listen to a film sequence explaining how the genetic information in DNA is copied or transcribed to messenger RNA.
*$END
*$SECTION=138
*PLAY
23242
24867
*$SECTION=139
*OPEN ENDED QUESTION 7

Explain in a few sentences how the genetic information in DNA is

copied or transcribed into messenger RNA.

(I will check your answer and inform you of your results).

*$END
#NOWORDS
-----END OF QUESTION-----

*$SECTION=160
*MULTIPLE CHOICE QUESTION 8
If the nucleotides in a section of DNA were

TACTTCAAA, and an enzyme was copying this section of DNA,

what would be the sequence of the nucleotides in the

newly formed messenger-RNA?

1) AUGAAGUUU
2) ATGAAGTTT
3) CGCCUGGGG
4) GCAGGACCC

*$END
1 =CORRECT ANSWER
#FOUND
Your answer is correct. The base pairing rules for

RNA are, Adenine pairs with Uracil and Guanine pairs with

Cytosine.
*$END
#NOT FOUND
Your answer is incorrect. The correct answer is #1,

The base pairing rules for RNA are, Adenine pairs with

Uracil and Guanine pairs with Cytosine.
*$END
-----END OF QUESTION-----
*$SECTION=170
*FRAME
35612

*$END
*$SECTION=175
*STATEMENT
Messenger RNA, represented by the orange curved line,

must now take its copy of the genetic information from

DNA, DNA is represented by the yellow double helix, to

the cytoplasm

Think about how m-RNA would leave the nucleus,

to communicate the transcribed message of DNA to

the rest of the cell.
*$END
*$SECTION=176
*STATEMENT
Messenger RNA leaves the nucleus of the cell through

the nuclear envelope. Notice that the nuclear envelope

is a double membrane which surrounds the nucleus.

The nuclear envelope is outlined in red on the screen.

There are tiny openings in the nuclear envelope.

It is through these openings that m-RNA leaves the

nucleus.

Now, look and listen to a film sequence about the

function of the nuclear envelope.
*$END
*$SECTION=180
*PLAY
34730
35041
*$SECTION=190
*MULTI RESPONSE QUESTION 9

4 CHOICES POSSIBLE
3 =PREFERRED RESPONSE
Which cell structure permits m-RNA to leave the

nucleus of the cell?

1) Ribosome

2) Cell membrane

3) Nuclear envelope

4) Nucleolus
*$END
#1
Your answer is incorrect. Proteins are made in

ribosomes. The correct answer is the nuclear envelope.
*$END
#2
Your answer is incorrect. The cell membrane surrounds

the cell and allows certain substances to enter and leave

the cell. The correct answer is nuclear envelope.
*$END
#3
Your answer is correct. Messenger RNA leaves the nucleus

through the openings in the nuclear envelope.
*$END
#4
Your answer is incorrect. Ribosomes are made in the

nucleolus. The correct answer is the nuclear envelope.
*$END
-----END OF QUESTION-----
*$SECTION=195
*FRAME
25112
*$END
*$SECTION=200
*STATEMENT

Once m-RNA leaves the nucleus through the openings of the nuclear envelope, it travels to a ribosome which is located in the cytoplasm of your cells.

The ribosome, represented on the screen as the large blue structure, consists of two subunits, a large one and a smaller one. Proteins are made in the ribosome.

Now listen to a film clip about m-RNA and the function of a ribosome.

*$END
*$SECTION=205
*PLAY
24942
25137
*$SECTION=210
*MULTI RESPONSE QUESTION 10
4 CHOICES POSSIBLE
4 =PREFERRED RESPONSE

In which cell structure are proteins synthesized or made?

1) Nuclear envelope

2) DNA

3) Golgi Complex

4) Ribosome

*$END
#1

The nuclear envelope permits communication between the nucleus and the rest of the cell. The correct answer is the ribosome.

*$END
#2

DNA is not a cell structure. It is located in the nucleus

of your cells. The correct answer is the ribosome.
*$END
#3
The Golgi complex collects and alters materials made

on the endoplasmic reticulum to form substances used outside

the cell. The correct answer is ribosome.
*$END
#4
Your answer is correct. Proteins are made in the

ribosomes of your cells.
*$END
-----END OF QUESTION-----
*$SECTION=215
*FRAME
25727
*$END
*$SECTION=220
*STATEMENT
On the screen , the long rope-like chain represents

a protein, each circle represents a particular amino acid.

We already discussed in class that proteins are made up

of individual amino acids which are connected by peptide

bonds. Remember, "poly" is a prefix and means "many"

hence, many amino acids linked by peptide bonds.
*$END
*$SECTION=222
*STATEMENT
Each polypeptide or protein contains a combination

of any of 20 different amino acids. The sequence

of the amino acids on the chain determines the protein.

Just like there are 26 letters in our alphabet and the arrangement of these letters makes a certain word.
*$END
*$SECTION=225
*MULTIPLE CHOICE QUESTION 11
What makes up polypeptides or proteins?

1) Long chains of amino acids linked by peptide bonds.

2) The letters of the alphabet.

3) Enzymes.

4) Fats and carbohydrates.
*$END
1 =CORRECT ANSWER
#FOUND
Your answer is correct. Proteins are made of long chains of individual amino acids which are linked by peptide bonds.
*$END
#NOT FOUND
Your answer is incorrect. Proteins are made of long chains of individual amino acids which are linked by peptide bonds.
*$END
-----END OF QUESTION-----
*$SECTION=230
*FRAME
22963
*$END
*$SECTION=235
*STATEMENT
DNA is responsible for which protein your cell makes.

You will recall that the genetic instructions for a particular protein are written in your DNA

as a series of nucleotides. Every 3 nucleotides is a code or codon for a particular amino acid.

For example, on the screen, is a close up of a DNA molecule. Three nucleotides, on the left of, the bottom strand of DNA reads TCA, m-RNA will copy this section as AGU, and AGU is a code or codon for the amino acid Serine. The next 3 nucleotides on the DNA molecule are GTC, m-RNA will copy this as CAG and CAG is a code or codon for the amino acid Glutamine.

Now, look and listen to the following film sequence.
*$END
*$SECTION=240
*PLAY
24942
25449
*$SECTION=245
*MULTIPLE CHOICE QUESTION 12
This is a two part question. If a small polypeptide is 4 amino acids long, a) how many nucleotides long is it? and b) how many codons does it contain?

(Remember, 3 nucleotides = 1 codon and 1 codon = 1 amino acid)

1) 12 nucleotides and 4 codons
2) 8 nucleotides and 4 codons
3) 4 nucleotides and 3 codons
4) 0 nucleotides and 4 codons

*$END
1 =CORRECT ANSWER
#FOUND
Correct! 3 nucleotides = 1 codon and 1 codon = 1 amino acid, so, 3 nucleotides also equals 1 amino acid. Since there are

4 amino acids in the protein, 4x3 nucleotides =12 nucleotides.

1 codon = 1 amino acid and since there are 4 amino acids,

there are 4 codons.
*$END
#NOT FOUND
Incorrect. 3 nucleotides = 1 codon and 1 codon = 1 amino acid,

so 3 nucleotides also = 1 amino acid. Since there are 4 amino

acids in the protein, 4x3 nucleotides = 12 nucleotides.

1 codon = 1 amino acid and since there are 4 amino acids there

are 4 codons.
*$END
-----END OF QUESTION-----
*$SECTION=248
*STATEMENT
The code or codons which are arranged in sequence along m-RNA

cannot be recognized by the amino acids themselves. Think about

how the code in m-RNA will be translated into amino acids, as we

continue with this program.
*$END
*$SECTION=250
*FRAME
25386
*$END
*$SECTION=255
*STATEMENT
The hooked shaped structure represents transfer RNA.

The 3 structures at one end represent 3 nucleotides called

an anticodon. These 3 nucleotides are called anticodons

because they are complimentary to the 3 nucleotides on

messenger RNA.

That is, the 3 nucleotides on transfer RNA will base pair with

the codon on m-RNA. Adenine will pair with Uracil and

Guanine will pair with Cytosine.

Messenger RNA is represented by the horizontal structure

on the screen.
*$END
*$SECTION=260
*MULTIPLE CHOICE QUESTION 13
What is the anticodon for a section of m-RNA which has

the codon AGU?

1) UCA

2) GTC

3) GCT

4) UCG
*$END
1 =CORRECT ANSWER
#FOUND
Your answer is correct! Adenine pairs with Uracil and

Guanine pairs with Cytosine.
*$END
#NOT FOUND
Your answer is incorrect. Adenine pairs with Uracil

and Guanine pairs with Cytosine. The correct answer is

UCA.
*$END
-----END OF QUESTION-----
*$SECTION=265
*FRAME
25460
*$END

*$SECTION=270
*STATEMENT
Every anticodon of transfer RNA attaches to one amino acid. The amino acid is represented by the colored circle at the other end of transfer RNA.

It is transfer RNA's job to translate or decode the 3 nucleotide codons of m-RNA into amino acids, and bring the appropriate amino acid to the ribosome to be added to the growing polypeptide chain.

Transfer RNA is similar to an interpreter, one who can translate from one language to another, so what is said will have more meaning. Only transfer RNA is translating from the language of nucleic acids to the language of proteins.
*$END
*$SECTION=275
*MULTI RESPONSE QUESTION 14
4 CHOICES POSSIBLE
3 =PREFERRED RESPONSE
Which RNA translates or decodes the three nucleotide codon on m-RNA into an amino acid and brings the amino acid to the ribosome to be added to the growing polypeptide chain?

1) ribosomal RNA
2) another m-RNA
3) transfer RNA
4) RNA

*$END
#1
Your answer is incorrect. Ribosomal RNA remains in the

ribosome. The correct answer is transfer RNA.
*$END
#2
Your answer is incorrect. Messenger RNA copies the

genetic information from DNA and brings it to the ribosome.
*$END
#3
Your answer is correct!
*$END
#4
Your answer is incorrect. There are three kinds of RNA,

ribosomal RNA, messenger RNA, and transfer RNA. The

correct answer is transfer RNA.
*$END
-----END OF QUESTION-----
*$SECTION=280
*FRAME
25460
*$END
*$SECTION=285
*STATEMENT
The ribosome (RY boh sohmz) is the place where

protein synthesis occurs. The ribosome is represented

by the large blue 2 unit structure, on the screen.

It acts as a meeting place for both m-RNA and t-RNA.

Notice that the ribosome is holding the m-RNA. Then

the first anticodon of t-RNA recognizes the start codon

on m-RNA, by using the base pairing rule for RNA. It

temporarily binds to the codon as it brings the first

amino acid which begins the protein or polypeptide chain.
*$END

*$SECTION=282
*STATEMENT
Then the anticodon of another t-RNA binds to the next m-RNA codon. This second t-RNA carries the second amino acid that will be placed into the chain of polypeptides.

The polypeptide chain continues to grow until the ribosome reaches a stop codon on m-RNA. At this point, a water molecule instead of an amino acid is added to the polypeptide chain, freeing the polypeptide or protein from the ribosome.
*$END
*$SECTION=284
*STATEMENT
The amino acids being added to the polypeptide chain are like words being added to make up a sentence. The terminal codon is like the period at the end of the sentence.

Now look and listen, to a film sequence and pay close attention to the process of protein synthesis.
*$END
*$SECTION=290
*PLAY
22696
25797
*$SECTION=300
*OPEN ENDED QUESTION 15
Describe the process of protein synthesis, remember the role of DNA, RNA polymerase, m-RNA, t-RNA, and the ribosome.

(I will correct this question, and inform you of your results.)

*$END
#NOWORDS
-----END OF QUESTION-----
*$SECTION=305
*FRAME
25720
*$END
*$SECTION=306
*STATEMENT

A human has tens of thousands of different kinds of proteins, each with a specific structure and function.

A few ways in which our body uses proteins will now be discussed.

Our white blood cells form antibodies, which are proteins that fight bacteria, viruses, and other foreign substances in our bodies.

*$END
*$SECTION=308
*STATEMENT

Our red blood cells make the iron containing protein Hemoglobin, which carries oxygen from our lungs to other parts of our body.

Enzymes are proteins made by our cells, they regulate the chemical reactions of our cells.

*$END
*$SECTION=309
*STATEMENT

Insulin, a protein made by our cells, helps regulate the concentration of sugar in our blood.

The cells in our pancreas make digestive enzymes

which are released outside the cell. The enzymes are then used by the intestine to break down food.

These are just a few of the many ways our body uses the proteins it makes.
*$END
*$SECTION=310
*OPEN ENDED QUESTION 16
Give 2 examples of how your body uses the proteins it makes?

I will correct the answer to this question and inform you of the results.
*$END
#NOWORDS
-----END OF QUESTION-----
*$SECTION=315
*STATEMENT
I hope that this computer lesson, coupled with the visuals and sound from the laser videodisc, helped to reinforce the concept of protein synthesis and clarify any misconceptions that you may have had regarding this concept.

I would like you to now answer a short questionnaire on paper, regarding your reaction to this lesson and teaching method.

Thank you for your participation.
This IVD program is Copyright 1994 Charlene Corey Hazan.
*$END

APPENDIX B

Sequence of Options Profile for IVD Program

SEQUENCE OF OPTIONS SELECTED FOR FILE: dnatxt7.profile

```
 [REF ]-> [ SF ]-> [STMT]-> [ SF ]-> [Q-MC]-> [ SF ]-> [STMT]-> [SFS ]->  V
                   [STMT]                              [STMT]             V
                   [STMT]                                                 V
                                                                          V
                                                                          V
                                                                          V
V  <-[STMT] <-[ SF ] <-[Q-MC] <-[STMT] <-[ SF ] <-[STMT] <-[ SF ] <-[Q-MR]
V
V
V
V
V
 [Q- N]-> [STMT]-> [SFS ]-> [Q-MC]-> [ SF ]-> [STMT]-> [Q-MC]-> [ SF ]->  V
          [STMT]                                                          V
                                                                          V
                                                                          V
                                                                          V
                                                                          V
V  <-[STMT] <-[ SF ] <-[Q-MC] <-[Q- N] <-[SFS ] <-[STMT] <-[ SF ] <-[STMT]
V    [STMT]                                                         [STMT]
V
V
V
V
 [SFS ]-> [Q-MR]-> [ SF ]-> [STMT]-> [SFS ]-> [Q-MR]-> [ SF ]-> [STMT]->  V
                                                                [STMT]    V
                                                                          V
                                                                          V
                                                                          V
                                                                          V
V  <-[STMT] <-[ SF ] <-[STMT] <-[Q-MC] <-[SFS ] <-[STMT] <-[ SF ] <-[Q-MC]
V
V
V
V
V
 [Q-MC]-> [ SF ]-> [STMT]-> [Q-MR]-> [ SF ]-> [STMT]-> [SFS ]-> [Q- N]->  V
                                              [STMT]                      V
                                              [STMT]                      V
                                                                          V
                                                                          V
                                                                          V
                              <-[EOF]* <-[STMT] <-[Q- N] <-[STMT] <-[ SF ]
                                                           [STMT]
                                                           [STMT]
```

APPENDIX C

Frequency and Percent of Commands for IVD Program

PROFILE OF FILE : dnatxt7.profile
NUMBER OF LINES IN THE FILE : 1117
NUMBER OF SECTIONS IN THE FILE : 70

FREQUENCY & PERCENT OF COMMANDS USED IN FILE

FREQ OPTION

```
 7:[SFS ]  | ****
17:[ SF ]  | ***********
 0:[BR-C]  |
 0:[BR-U]  |
30:[STMT]  | *********************
 4:[Q-MR]  | **
 8:[Q-MC]  | *****
 4:[Q- N]  | **
 0:[GS-T]  |
 0:[GS-Q]  |
 1:[REF ]  |
             ----+----+----+----+----+----+----+----+----+----+
            0                   50                       100
                              P E R C E N T
```

LEGEND

[SFS]	A frame of Sequence(presentation)
[SF]	One or more single frames
[BR-C]	Conditional branch
[BR-U]	Unconditional branch
[STMT]	Statement(instruct or explain)
[Q-MR]	Multiple response question
[Q-MC]	Multiple choi question
[Q- N]	Open ended qu ion
[GS-T]	Graphic scree 'th text
[GS-Q]	Graphic screen with question
[REF]	Reference Section
[EOF]*	End of File

APPENDIX D

Estimate of Readability of IVD Program

ESTIMATE OF READABILITY OF TEXT FOR FILE dnatxt.7

ANALYSIS OF SECTION 1

SUMMARY

Characters/word	= 4.73
/sentence	= 67.72
# Sentences	= 137
# Words	= 1963
# syllables	= 3077
# Monosyllables	= 1172
# Hi-cal words	= 406
Ave. sentence length	= 14.33
Ave. syllables/word	= 1.57

INDICES

Flesch Index	= 59.68
Dale Index	= 8.37
Flesch grade equiv.	= 10.01
Fog Index	= 12.00
Smog Index	= 9.43
Mugford reading level	= 13.19
Mugford WL. score	= 2394.50

APPENDIX E

Analysis of Vocabulary of IVD Program

results
Wednesday, September 29, 1993 10:31 AM

Analysis of File : dnatxt.7
Vocabulary File : bio.sl

CATEGORY	#WORDS	%MATCHES	CUM.%
0	1061	65	65
1	160	9	75
2	16	0	76
3	112	6	83
4	213	13	96
5	63	3	100
6	0	0	100
7	0	0	100
8	0	0	100
9	0	0	100

TOTAL WORDS = 1964 TOTAL MATCHES = 1625 % TOTAL = 82

```
     0 |********************************
C    1 |****
A    2 |
T    3 |***
E    4 |******
G    5 |*
O    6 |
R    7 |
Y    8 |
     9 |
       .----.----.----.----.----.----.----.----.----.----.
       0   10   20   30   40   50   60   70   80   90  100
                             PERCENT
```

APPENDIX F

Student Questionnaire

Name ________________________
First Last

Student Questionnaire

I would like you to answer this questionnaire about your reaction to this computer video disc program.

Please circle the answer of your choice:

1. Did you understand the main ideas of this lesson?

   a.) Yes b.) Unsure c.) No

2. How would you rate the overall quality of this program?

   a.)Excellent b.) Good c.) Poor

3. Do you feel the video sequences helped you to understand protein synthesis?

   a.) Yes b.) Unsure c.) No

4. Do you feel the audio sequences helped you to understand protein synthesis?

   a.) Yes b.) Unsure c.) No

5. Was the text printed on the screen understandable to you?

   a.) Yes b.) Unsure c.) No

6. Did you find that comparing the different parts of protein synthesis to examples that you could relate to, helped you to understand protein synthesis better?

   a.) Yes b.) Unsure c.) No

7. Did this lesson help clarify any misconceptions you may have had about protein synthesis?

   a.) Yes b.) Unsure c.) No

8. How would you rate the challenges presented to you by this lesson?

   a.)Excellent b.) Good c.) Poor

9. Were you comfortable working with the computer?

   a.) Yes b.) Unsure c.) No

(OVER)

10. Did you have any difficulty navigating through this lesson?

a.) Yes   b.) Unsure   c.) No

11. Would you like to have the opportunity to use a computer and video disc to support your learning?

a.) Yes   b.) Unsure   c.) No

12. Please state any suggestions or comments which would make this program more helpful to you?

APPENDIX G

Description of Extra Credit Choices

EXTRA! EXTRA!
EXTRA CREDIT

What follows are five possible ways to earn extra credit for this marking quarter.
You may choose to participate in:

#1 only	#2 only
#1 and #2	#3 only
#1 and #3	But NOT #2 and #3

1- DNA and Protein Synthesis review using interactive laser disk and computer. You must sign up to come and use the program. The program is designed to REVIEW the characteristics of DNA and the complicated process of protein synthesis in the cell.

Completing the review will allow you to replace a low homework assignment at 100%

2- Dissection of a fetal pig during 4th and 5th hours help sessions. There may be a nominal fee involved in this activity. Large double injected pigs cost approximately $7.90.

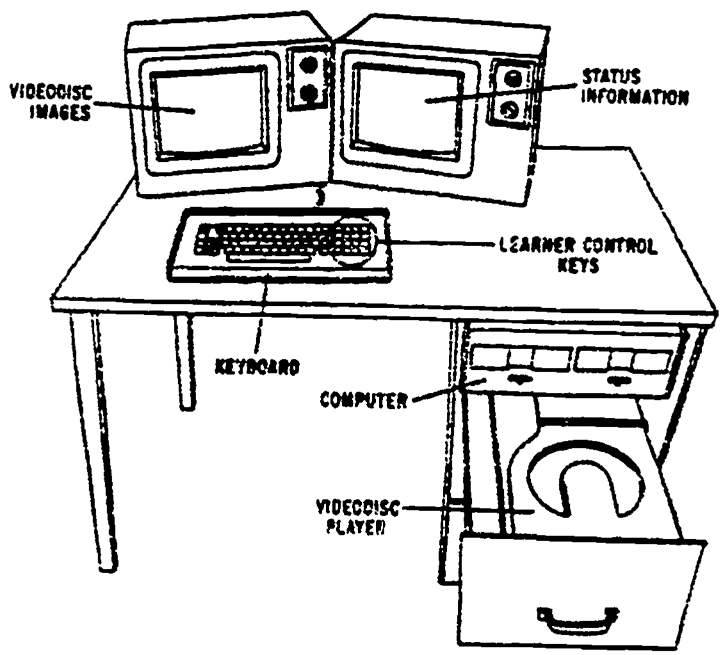
Completing the dissection will earn one extra quiz grade at 100%. It will NOT replace a lower quiz grade.

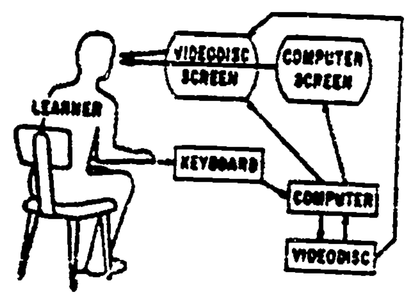
3- Mounted and labeled collection of flowers taken from living specimens currently available in your neighborhood. The collection should be divided between herbaceous flowering plants (tulips, daffodils, trillium, and dandelions), deciduous (meaning trees and shrubs) flowering plants, and gymnosperms (meaning cone bearing evergreen type of plants).
There are to be no repeated flowers and the selection should be evenly distributed amongst the 3 groups.

10 flowers = 75% of an extra quiz grade
12 flowers = 85% of an extra quiz grade
14 flowers = 95% of an extra quiz grade
15 flowers = 100% of an extra quiz grade

APPENDIX H

Transparency Demonstrating IVD Equipment





Information flow.

APPENDIX I

Weekly Student Signing-in Schedules

APPENDIX I

SIGN UP SHEET TO USE THE INTERACTIVE VIDEODISC

ON PROTEIN SYNTHESIS

You will need the entire class period so please be on time.

CLASS PERIOD	STUDENT'S NAME	
		FRIDAY 5/14/93
2nd	–	
1st	–	
4th	–	
5th	–	
8th	–	
7th	–	
6th	–	
		MONDAY 5/17/93
2nd	–	
3rd	–	
4th	–	
5th	–	
6th	–	
7th	–	
8th	–	
		WEDNESDAY 5/19/93
2nd	–	
1st	–	
4th	–	
5th	–	
8th	–	
7th	–	
6th	–	
		THURSDAY 5/20/93
2nd	–	
3rd	–	
4th	–	
5th	–	
6th	–	
7th	–	
8th	–	
		FRIDAY 5/21/93
2nd	–	
1st	–	
4th	–	
5th	–	
8th	–	
7th	–	
6th	–	

APPENDIX J

Multiple Choice and Multiple Response Questions

APPENDIX J

Multiple Choice and Multiple Response Questions

1. What is responsible for you looking like your parents or relatives?

    1. DNA *

    2. Ribosomes

    3. Nucleus

    4. Cytoplasm

2. Where is DNA located in your cells?

    1. Nuclear Envelope

    2. Nucleus *

    3. Cytoplasm

    4. Ribosome

3. Which of the following identifies a single nucleotide?

    1. A 5–Carbon sugar

    2. Cytoplasm

    3. A phosphate group, a sugar group and one nitrogen containing base group.*

    4. Adenine, Thymine, Cytosine, Guanine, and Uracil.

5. If a section of one strand of a DNA molecule has the nucleotide sequence AGGTCC, what would be the nucleotide base sequence of the same section, on the other DNA strand?

    1. TCCAGG *

* Correct answer to question

2. GAACTT

3. CTTGAA

4. AGGTCC

6. What are the nitrogen bases for RNA?

   1. Adenine, Thymine, Guanine, Cytosine.

   2. Adenine, Lysine, Cytosine, Guanine.

   3. Adenine, Uracil, Guanine, Cytosine. *

   4. Thymine, Guanine, Uracil, Cytosine.

8. If the nucleotides in a section of DNA were TACTTCAAA, and an enzyme was copying this section of DNA, what would be the sequence of the nucleotides in the newly formed messenger–RNA?

   1. AUGAAGUUU *

   2. ATGAAGTTT

   3. CGCCUGGGG

   4. GCAGGACCC

9. Which cell structure permits m–RNA to leave the nucleus of the cell?

   1. Ribosome

   2. Cell membrane

   3. Nuclear envelope *

   4. Nucleolus

10. In which cell structure are proteins synthesized or made?

* Correct answer to question

1. Nuclear envelope

2. DNA

3. Golgi Complex

4. Ribosome *

11. What makes up polypeptides or proteins?

    1. Long chains of amino acids linked by peptide bonds. *

    2. The letters of the alphabet.

    3. Enzymes.

    4. Fats and carbohydrates.

12. This is a two part question. If a small polypeptide is 4 amino acids long, a) how many nucleotides long is it? and b) how many codons does it contain?

    (Remember, 3 nucleotides = 1 codon and 1 codon = 1 amino acid)

    1. 12 nucleotides and 4 codons. *

    2. 8 nucleotides and 4 codons.

    3. 4 nucleotides and 3 codons.

    4. 0 nucleotides and 4 codons.

13. What is the anticodon for a section of m–RNA which has the codon

    AGU?

    1. UCA *

    2. GTC

* Correct answer to question

3. GCT

4. UCG

14. Which RNA translates or decodes the three nucleotide codon on m–RNA into an amino acid and brings the amino acid to the ribosome to be added to the growing polypeptide chain?

1. ribosomal RNA

2. another m–RNA

3. transfer RNA *

4. RNA

* Correct answer to question

APPENDIX K

Essay Questions

APPENDIX K

Essay Questions

4. What is the pattern you discovered for the pairing of the nitrogen bases for DNA?

7. Explain in a few sentences how the genetic information in DNA is copied or transcribed into messenger RNA.

15. Describe the process of protein synthesis, remember the role of DNA, RNA polymerase, m–RNA, t–RNA, and the ribosome.

16. Give 2 examples of how your body uses the proteins it makes?

APPENDIX L

Chi Square and Contingency Coefficient Showing Correlation between Multiple Choice/Multiple Response Questions and Essay Questions

APPENDIX L

Chi Square and Contingency Coefficient to Show the Correlation Between the Essay and Multiple Choice/Multiple Response Results

Scores		# of Students with Multiple Choice/Multiple Response		
	Essay Scores	Scores in Percent Correct		
		75% or Less	76–100%	Total
# of students with Essay scores in % correct	76–100%	0 (1)	12 (11)	12
	75 or Less	4 (3)	27 (28)	31
	Total	4	39	43 = N

Chi–Square = .50 (with Yates correction for continuity).
df = 1, Chi Square ($\alpha = .05$ level) = 3.84.
Not Significant.
Contingency Coefficient = .15.
Not Significant.

APPENDIX M

Student Responses to Question 12 from the Student Questionnaire

APPENDIX M

Student Responses to Question 12 from the Questionnaire

Question 12 – " Please state any suggestions or comments which would make this program more helpful to you?"

(All of the students participating in this study did not answer this question.)

Favorable Responses:

1. More use of this system.
2. It was a hoot!
3. It's fine like it is.
4. Everything was good, except some of the essay questions had me confused.
5. I realized that I forgot all about protein synthesis and this helped me remember it.
6. It should be required for every student. The modernized concepts are easier to understand than the boring, old filmstrips.
7. The essay questions, though long, were very helpful because you couldn't guess at an answer and have it right. You had to think. Will be very useful in the years to come.
8. Nothing, everything is good.
9. I felt that the program was very informative. It was fun using both the laser disc and computer. Great idea! You should do this again as

another extra credit assignment. It actually was kind of fun.

Unfavorable Responses:

1. The repeated video sequences became distracting so did the sudden endings to the video clips.
2. It was good but sometimes the viewings were hard to understand.
3. I couldn't delete very easily or when I needed help, like in the middle of an essay I wasn't that familiar with the computer.
4. It's to easy after already learning it in class. The pictures show practically the same thing over and over.

Suggestions:

1. Chance to review text before answering questions.
2. For observing new pages on computer screen, press one key to continue and a series of keys to quit etc.
3. More screen animation.
4. Clearer text on screen and better word processing capabilities.
5. I would like it if it could do word wrap or essay questions. I like the "eep" noise it makes.
6. The questions could be a little more difficult.
7. Have a review at the end so you could look back at anything that made you unsure.
8. Try to make it shorter, the program seemed to get very dull after a while.
9. More visual, not as much reading.

10. Maybe, instead of one long videodisc program including everything about protein synthesis, several shorter ones so students can concentrate on a specific part of it, the part they understood least.
11. A lunch session where you can sign up at any time and practice for each test.
12. Use a faster computer and videodisc player to get the information on the TV screen quicker.
13. The video seemed to be repeating itself, so I think that there could have been either more in depth information put there or else just make the program shorter.
14. Possibly more questions to reinforce what I know.

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