Labs

Laserdiscs

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Experience with living things is one of the most important requirements for developing biological understanding. Unfortunately, this requirement is one of the most difficult problems for the biology teacher. Many courses in biology contain little or no direct experience with living materials. Ideally, one would like to have instant access to the appropriate living materials and the ability to manipulate them as desired to teach basic principles about them. The development of the laserdisc now makes this possible.

If one thinks of biology as a large collection of relatively short-term events, e.g., a bird flying, a cell dividing, or a muscle contracting, then it should be possible to put together a visual database for biology. I had the pleasure of putting together such a database for Optical Data Corporation in 1985 and 1986. Called "Principles of Biology," it consists of about 3,000 still pictures and 164 motion picture clips that range in length from two seconds to five minutes.

The film clips vary, depending on their intended use. Some are very short—four cycles of a beating mammalian heart or a jumping kangaroo—but can be made into instant loops which provide continuous interaction with the phenomena. After the loop has been made it can be analyzed as needed; shown in slow motion, stopped, speeded up, run backward —the kind of use that wears out videotape rapidly. Other segments are narrated short explanations of basic phenomena, e.g. cell division, muscle contraction or honey bee social organization. The total time for the motion picture clips is about two hours. They are contained on two laserdiscs or four sides of 30 minutes each. Also included on each side are the 3,000 still pictures so that any still picture is available no matter which motion picture clip is being used. The motion picture clips are grouped so that most related concepts are on the same side of the disc.

A New Way To Teach

This kind of visual database allows one to teach in a way never before possible! Now, if you want to teach about contractile vacuoles, you can bring one into your classroom instantly. You can ask questions about it, explain how it works and visually analyze it in action. Depending on how you teach, your students can be given help so they all see a contractile vacuole when they study protists and they can be given a more detailed understanding of its structure and function or both. This kind of access to living phenomena should allow teachers to use their own and their student's time more effectively. One of the most important skills is inquisitive observation. By looking at phenomena several times, with different perspectives, we should be able to help our students learn to observe and think about what they see. If we discuss ways to test the questions raised, we can give them a better understanding of science.

Many kinds of living materials cannot be utilized in the classroom unless they are experienced vicariously. You can't easily take your class on an African safari, into an operating room or give them state of the art microscopes. These experiences are, of course, readily available via film and videotape. Most teachers would like to be able to use the quality of visual material commonly seen on public television.

Other Technologies

Film and videotape, however, are not widely used in biology classrooms, for several important reasons. One of the most difficult limitations is time. If a teacher has an hour or two to teach about the heart and circulation, it is hard to justify spending 20 to 30 minutes of that time showing a film, which is often too general, so students can see a few pictures of a living human heart. The use of selected portions of motion picture film is awkward without fast forward capabilities. Videotape machines have improved this situation, but it is still cumbersome to use several excerpts unless segments are edited together, and this is illegal. The image quality and rapid access of laserdisc make it a much better medium for interactive use.

Two technologies that could challenge the superiority of laserdisc are interactive videotape and compact disc-interactive. Both technologies have inherent limitations that will make this difficult, despite the claims of some advocates. Interactivity can be accomplished in two ways with videotape. If the tape is shuttled back and forth, any part of the tape is accessible. Unfortunately, there is no way a tape can move fast enough to compete with a laser that only has to move a few inches, even if multiple tracks are used. Two VCRs could be used, but this is only effective if one image is used long enough for the other to be accessed. By using multiple tracks, it is possible to allow instant switching, but this is limited to only four choices with current technologies. Multiple tracks could be used with highly structured programs that depend on limited choice. This is likely to happen with VCR games that now are appearing on the market. It would be impossible, however, for several users to use the same database for different applications, e.g. slide shows, with this technology. Even if good interactivity could be developed, image quality would not approach the quality available on laserdisc. Interactive videotape has been used to simulate videodisc interactivity during development for many years, and it is widely regarded as an inferior medium. It is of interest only because there are so many VCRs.

Compact disc-interactive is being discussed for much the same reason. There are large numbers of compact disc players in the marketplace and great interest in the technology. Because compact discs are much smaller, the amount of motion video, of the same resolution as broadcast television, that can be stored on the disc is very small in comparison to videodiscs. CD technology requires that these images be stored in digital rather than analog form. Because of the resolution of broadcast television and be-

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cause 30 images per second are required for motion, a computer far more powerful than any current microcomputer would be required to process this information. Therefore, it is clear that if CD-1 discs are going to be available with full screen and full motion video, new technology and new hardware will have to be developed. CD-1 will be used to store large databases of still pictures, computer programs and data. As this technology develops, smaller parts of the screen will be used for motion video, as is currently being done with digital TVs and VCRs, and it is likely that slow speed, lower resolution, full screen images will be used. Whether CD-1 will ever be able to compete with the videodisc as an inexpensive motion visual database is questionable. Since the videodisc technology is here now, why wait five or ten years for something that may be a better learning station but will probably never be a better motion visual database.

Because Videodiscs and VCRs came on the consumer market about the same time, laserdiscs have been slow in gaining acceptance by the public. The recording capability of VCRs makes them extremely useful and cost effective. Locally produced videotapes of science fair projects, procedures for use of special equipment, and many other special topics are very helpful. However, most of one's classroom time will be spent discussing principles of biology that are common to all biology courses, and the basic question then becomes: "How can one utilize visual material in the most effective way?" Laserdiscs are clearly a better medium, although not the only medium. Videotape and film are still very important. Big screen movie images always will be better than video, and VCRs will be useful for recording and linear program playback. For the use of short segments in teaching, review and testing, however, no visual aid can compare with the laserdisc.

In the 1960s, film loops became very popular because they allowed teachers to use a variety of short programs. Their use has gradually decreased, however, as films have worn out and replacements have become unavailable. The cost of loop film projectors has increased and now is about the same as VCRs and videodisc players. BSCS recently released its film loops on videotape. Some of the Iowa State botany film loops were used in the principles of biology videodisc project. Because videotape wears better than film and because of the large number of VCRs in schools, it is likely that most film loops will be released on tape. As the number of laserdisc players increases, film loops and other programs will become available on disc as well. How long that will take will, of course, depend on the acceptance of laserdiscs and that is directly related to teacher understanding of the medium.

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Videodiscs

RCA was one of the primary promoters of videodisc technology. They developed a videodisc process that was less expensive than the laser system developed by Phillips. This format was called CED and utilized a stylus to transmit changes in capacitance. In 1983, RCA decided it could make more profit in the VCR market and dropped its videodisc products. Many people assumed that event marked the end of consumer interest in the videodisc. Because the largest part of the consumer market is interested in linear playback of motion pictures and music, the videodisc has been successful only with a smaller market segment that is interested in the higher quality images available with laserdisc.

The interactive and educational part of the consumer market has not been very successful financially despite the availability of some excellent programs. Many of the discs produced by Optical Programming Associates, which is now out of business, are available at cutout prices—often less than ten dollars—at large retailers such as Tower Video or Video Shack because they have not sold well in these stores. Programs like "The Master Cooking Course" with Craig Claibourne and Pierre Franey, the NFL's "How to Watch Pro Football," "The History Disquiz," "The First National Kidisc" and "Fun and Games" are excellent educational products that take advantage of the interactive capabilities of the laserdisc.

The success of the VCR caused many people to see the videodisc as a technology bound for extinction, but the marketplace is not so predictable. The investors, who had great expectations for the videodisc and were disappointed, predicted the compact audio disc would not be highly successful either. The CD has been the most successful consumer electrontics device ever developed. Its success has stimulated new interest in the videodisc since both are laser based technologies.

Laserdiscs

Even though CDs and videodiscs are laser technologies, there are major differences between them as far as image storage is concerned. However, before we can discuss those differences, we need to talk about laserdiscs in general.

The success of compact audiodiscs is mainly due to the fact there is no surface noise and a larger dynamic range is possible. Because the laser does not touch the disc, like tape heads or a stylus do, no surface noise is produced. The same qualities apply to videodisc audio and video. The video equivalent of surface noise is snow or dropout. Videotape is in contact with heads so dropout increases as the videotape wears out. Dropout also develops with age, since the information is stored in magnetic form.

Information is recorded on laserdisc in the form of reflective and nonreflective areas, which cause the laser to transmit a series of pulses. The data is digital on compact discs and analog on videodiscs. In digital form, it consists of a series of equally spaced nonreflective pits, all of the same size, which turn the laser on and off. This results in a binary code that consists of 1's and 0's. It is in analog form if the distance between the pits varies. This produces a series of pulses that are analogous to wave length, an FM signal.

The increase in dynamic range comes from the fact that the dynamic range is not compressed, as in analog recordings. Because CDs produce sound that can go instantly from absolute silence to 90 decibels, they have great impact.

In video there is an increase in resolution. North American standard television (NTSC) consists of 525 horizontal lines. Until recently there has been little discussion of resolution, the number of points that are discernible in one of these lines. This is measured in terms of the number of vertical lines that can be seen and, therefore, is easily confused with the number of horizontal scanning lines, a number which does not change unless the broadcast standard is changed. 625 scanning lines are used for PAL and SECAM broadcasts in other parts of the world. There is talk about changing to a worldwide 1,125 line standard, but this is not likely to happen soon. High resolution television sets now are available with 500 lines of resolution. One could say that vertical and horizontal resolution would be nearly identical with such a system. At the fastest tape speeds, consumer VCRs produce about 250 lines of resolution. Most laserdiscs players produce about 350 lines, but the newest models are capable of 400 lines.

One of the main advantages of disc versus tape format is random access. The information stored on a videodisc is contained on a track, which forms a spiral starting at the inside and unwinding outward. It consists of 54,000 nearly concentric circles, 600 per millimeter. The information necessary to produce a still image is contained in each circle. If the laser, which moves along the radius of the disc, stays in one place, it reads the information in one circle and produces a still image. Since the disc is rotating constantly at 1800 r.p.m. and motion is produced only as the laser moves, no damage can be done to the disc if a still image is maintained continuously, and there is no loss in image quality. Because the laser can move rapidly along the radius, images can be shown in any order quickly. By controlling the movement of the laser, instant loops can be produced and images can be analyzed at any desired speed or direction. Consequently, laserdisc images are permanent images that can be repeated and analyzed in ways that are not possible with other media. Each side of a laserdisc contains 54,000 still images, which, if run at the standard video speed of 30 frames per second, produces 30 minutes of motion.

Actually, each circle contains enough information for two images, but the images must be the same to produce a still image. When film, which is produced at 24 frames per second, is transferred to video at 30 frames per second, six frames must be added per second. This produces two different images per circle on some of the frames and results in flicker, unless the master tape is edited to prevent stopping on these frames. This "three two" problem comes from the fact that some frames have to be used three times, instead of two, to produce 30 frames per second.

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Videodiscs that allow still framing have to contain only one image per rotation. Discs that do this rotate constantly at 1800 r.p.m. and are in the CAV (constant angular velocity) format. CAV discs contain 30 minutes of motion video per side. If constant linear velocity (CLV) is used, 60 minutes of motion can be recorded on each side. CLV format is commonly used for linear programming, for example, of motion pictures. Videodiscs contain codes that tell the player which format is being used.

Pioneer has just released an industrial videodisc player that can still frame CLV discs. Presumably, this is accomplished by using a microchip, which grabs a still frame. A number of biology videodiscs have been released in CLV format, e.g. several National Geographic programs; these discs can now be analyzed in slow motion using the newer players. Before the introduction of these players the consumer was in a difficult position. If one already had a videodisc player and a VCR, one had to choose between wearing out a tape of the program using slow motion features or getting high quality images that could not be analyzed on disc.

Costs

There will always be a variety of audiovisual devices for teaching biology. Motion pictures, film loops, filmstrips, slides and slide tape shows have been the most widely used media until recently. Now many of these formats have been adapted to videotape. Because most schools have large film libraries and continue to add to them, film is likely to be used. However, since most schools now have VCRs, there will be a gradual shift to videotape for some programs. Motion pictures are 20 to 50 percent less expensive on tape than on film. Filmstrips, on the other hand, are twice the cost of film, in video format.

Because the cost of a variety of useful programs is many times the cost of a VCR or motion picture projector, it is important to consider the total cost of programs and equipment when justifying the use of a specific kind of medium. The "Principles of Biology" videodiscs contain such a large portion of the images used in teaching introductory biology that the cost of the discs and player is a small percentage of what it would cost to acquire an equivalent database in any other medium. The cost of two hours of videotape of the same quality would be at least the same price as the discs. However, the cost of a set of videotapes that would cover the same database would be at least twenty times the expense. Duplicating the still pictures also is very costly. Slides sell for at least one dollar each. The 3,000 still pictures on the "Principles of Biology" discs or the 6,000 still pictures on Videodiscovery's "Bio Sci" disc are extremely cost effective by comparison. The cost of the player becomes insignificant.

The Ultimate AV Machine

What is even more important than cost is the usefulness of the images on videodisc compared to other formats. The videodisc player is the ultimate audiovisual machine, the only device capable of all of the functions of the other devices: a random access slide projector, a motion picture projector and an instant loop film projector. There are no bulbs to replace, no heads to clean, no tape or film to wear out—the most reliable AV machine. When combined with the microcomputer as an optical storage device, even more things are possible.

Industry and the military have been using videodisc technology for education and training since the 1970s. When a microprocessor or computer is linked to a videodisc player, interactive instruction can be developed. The best programs can simulate real situations and provide feedback so students can learn from their own decisions and experience. Because different levels of interaction can occur between a videodisc player and the user, the following levels of activity have been defined and generally agreed upon by instructional designers:

Level 0 Linear playback with no still frame or random access capabilities.

Level 1 All of the interactivity normally possible using the nonprogrammable, infrared hand control unit that comes with the player: random access to frame and chapter stops, still framing of motion, speed and direction control of motion, and a choice of dual, bilingual, and stereo audio. Instant loops can be produced with some low cost players.

Level 2 Programming without the use of a microcomputer. Most industrial players have hand control units that can be programmed so, for example, a series of still and motion picture images can be selected and played back in the same order. Level two discs contain programming which is dumped to a microprocessor in the player. These programs respond to user choices but are not changeable because the information is permanently encoded on the disc.

Level 3 Computer control of the videodisc player with separate or alternate screens for computer and video input.

Level 4 Computer control with integrated computer and video images and graphic overlays.

Intelligent Videodiscs

The terms "intelligent videodisc" have been used to describe interactive videodisc learning systems. WICAT, the World Institute for Computer Assisted Teaching, developed a prototype learning system for biology entitled "The Development of Living Things." This system was tested and compared with a traditional college lecture course in the early 1980s. Results indicated that students learned quickly and better than in the traditional course. Because the development cost of the instructional system was high, the National Science Foundation has not supported more work on videodisc learning systems. WICAT now sells a videodisc entitled "Videodisc in Science Education," which summarizes the results of the study and rather elegantly explains how videodisc systems could help improve science teaching. Most of the videodisc material for "The Development of Living Things" is contained on the disc. Unfortunately, the hardware and computer-based instructional programs are not available. The disc itself, however, has many useful images for teaching about current methods used in cell biology and is a good value at $75. It is available from WICAT Education Institute, 931 East 200 North, P.O. Box 1727, Provo, UT 84601.

Another prototype videodisc system, which is available for use with the IBM PC and the Apple II, is the "Interactive Videodisc Science Project," produced for the Annenberg/CPB Project by the Nebraska Videodisc Design/Production Group. It contains three videodiscs, one each on biology, chemistry and physics. Each disc contains two lessons, one on each side. The programs are designed to give laboratory-like experiences and have well-developed interactive programming. The biology disc has a program on respiration and one on climate and life. The chemistry disc has programs on titration and unknowns. Physics is concerned with studies in motion and energy transformations. Bill Leonard, who is well known to NABT members, developed the biology programs [see ABT 47: 38-40, Jan. '85]. The respiration program is a simulated lab experiment using several organisms. The climate and life program is a comparison of major biomes and uses motion pictures to take students on the ultimate field trip where they use climatograms to characterize each biome. Besides being used as a stand alone program, the biomes program can be used as a database for teaching about these concepts. All three discs and software are available for $425 from Nebraska ETV Network, P.O. Box 83111, Lincoln, NE 68501.

The National Geographic Society, in conjunction with the Nebraska group, developed a Whales videodisc in the early 1980s. It is a level two disc and must be played on an industrial player to be interactive. It is an excellent interactive program and is available from the society for about $95. National Geographic has also released several videodisc programs of its one-hour films. These are in the CLV format, sell for about $30 each, and are available in video and book stores.

The only other stand-alone, instructional videodisc program I know of is "Math and Biology," produced at the University of Washington. It is a college level program, which appears to be oriented toward students in medical technology type programs. There are also a number of specialized programs in medicine but these are expensive and inappropriate for biology. One of the best is a program which uses a manikin with sensors to teach CPR.

All of the above systems have been produced with grant support. A private company, Optical Data Corporation (formerly Video Vision Associates), began developing space science videodiscs for the consumer and education markets in the late 1970s. To date, they have produced more than a dozen videodiscs. Their ideas about how the discs are best used by teachers differ from those of the instructional designers who developed expensive educational systems. ODC saw the need for visual databases and inexpensive applications. Through continual feedback from teachers, they have concluded that teachers prefer a system which fits into existing curricula and requires little or no time to learn or use. The result is a series of well-organized, visual databases which can be used alone or with software and an Apple II computer. The software, called "The Living Textbook," is designed to present the images in the database in the same order they are used in major textbooks. The software also can be used to develop a variety of programs without a large time investment. In this environment, the database can be used by teachers to produce lessons and by students to develop presentations or to teach their peers. Optical Data has programs in earth, life, physical and space sciences. Their Principles of Biology disc set contains 3,000 high quality still pictures, two hours of motion picture clips which cover the main topics presented in introductory biology, and is bilingual, containing narrated segments in both English and Spanish. It sells for $800 and is available from Optical Data Corporation, PO Box 97, Florham Park, NJ 07932-0097.

Videodiscovery has produced two biology videodiscs and a number of software lessons and lecture support programs. Their first disc, the Bio Sci disc, contains 6,000 high quality still pictures and about 10 minutes of motion picture film of cell and developmental biology. Their second disc, Life Cycles, has about 4,000 still pictures, primarily from Oxford Scientific Films, and about 20 minutes of motion picture film from 16 OSF films showing major reproductive and ecological events in plants and animals. The videodiscs sell for about $500 each and are available from Videodiscovery, P.O. Box 85878, Seattle, WA 98145-1878.

The biology videodisc products that are available now complement each other well and cover most of the topics discussed in modern biology. The Principles of Biology set is by far the most comprehensive visual database. Even though it and the Life Cycles disc use OSF materials, there is very little overlap. The Videodiscovery discs are the next most comprehensive collection and are an excellent complement to the Optical Data product. Videodiscovery has done an excellent job of putting toether a large collection of commonly used, still images for lecturing about biology. Optical data has put together a basic collection of images used in lecture and lab plus about 150 diagrams from Helena Curtis's BIOLOGY. The WICAT disc will be useful to those who want more material on cell biology, e.g. the use of radioactive materials. The Nebraska biology disc is superb for illustrating the relationship between climate and biogeography. And the Whales disc will bring interest to any classroom. This basic collection will fill most of the time teachers have for using AV material. A few favorite films, videotapes and other special images and there won't be time for more.

AVs Should Be Complements

This column is called labs and I want to close with an important point. Direct experience with living things is difficult to simulate with the best of media. The use of AV materials should complement and support the use of living materials in the classroom, not replace them. When properly used film and video can increase students' understanding and awareness of living things. By using the best living materials and the best AV materials together, we should be able to concentrate more on teaching the principles of biology and to create more understanding. I hope that the development of a motion visual database for biology will help teachers become more aware of that goal and enable them to reach toward it with their students.

Next time I'll talk about the use of living organisms in the classroom and the current concerns about animal rights and welfare.

Call for Papers

Papers are now being accepted for a special Golden Anniversary issue of the *American Biology Teacher.* To be published in January, 1988, this special issue will focus on the history of biology teaching and of the National Association of Biology Teachers. Submit your manuscript to Randy Moore, Editor, Dept. of Biology, Baylor University, Waco, TX 76798 by June 1, 1987. Be sure to indicate that your paper is specifically for the anniversary issue. Papers for this issue will undergo the same review process as other issues of the journal and must comply with the normal procedures and formats. For authors' guidelines, see the September 1986 issue of the *American Biology Teacher* (Vol. 48, No. 6). Guidelines are also available from the NABT national office (11250 Roger Bacon Dr. #19, Reston, VA 22090) and from Randy Moore.