Animating the curriculum: integrating multimedia into teaching*

By Suzanne S. Stensaas, Ph.D.
Director, The Education Center
Associate Professor, Department of Pathology

Cornell University Medical College
1300 York Avenue
New York, New York 10021

At many medical schools, the medical library assists faculty in finding and integrating new technology into the classroom, student laboratories, and lecture or small group sessions. Libraries also provide faculty with a place to do development. This paper recounts the author's experience creating software-based educational materials. In the process of creating the Slice of Life videodisc and developing and distributing other medical education software, techniques that do and do not work in producing multimedia for medical education became evident. Use of multimedia features and new modalities not possible with books, rather than development of electronic versions of texts and atlases, should be emphasized. Important human factors include collaboration, continuity, evaluation, and sharing of equipment, software, code, effort, expertise, and experiences. Distribution and technical support also are important activities in which medical libraries can participate.

INTRODUCTION

Without the medical library, my accomplishments as a medical educator would be diminished. This paper is intended to convey my views of the exciting new possibilities in medical education: curriculum changes that will depend in large part on librarians.

Librarians are in a position to meet the challenges, to understand the technology, and to provide the resources to assist medical faculty in integrating new technology without fear, frustration, or failure. The library has been my ally for more than twenty-five years, since I first started teaching at the University of Utah. None of my departmental peers, chairs, or deans provided encouragement, support, or implementation of my ideas. However, the library was willing to provide me (and the students involved) with hardware, technical support, back-up, and a place to work. The library focused on service and always could be counted on.

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SLICE OF LIFE: SERENDIPITY AND HISTORY

This paper focuses on the Slice of Life Videodisc Project, an example of an idea that worked as an instrument for producing change [1–2]. First, some history. Development of the project began in 1982, when I decided to become a recycled faculty member: I was tired of doing research and being isolated. What I wanted to do was education, my original goal in 1962. I did not realize the form or the context of this commitment until 1986, when a University of Utah student who was using the National Library of Medicine (NLM) Pathology Videodisc Series in the library said, "Dr. Stensaas, this is fantastic. Can we make this here? Can we have test banks and board-type questions with videodisc images?" I said we probably could make a videodisc. To which he replied, "Well, if you make the videodisc, I'll write the program."

We each kept our word. Our videodisc is now in its sixth edition, with more than 2,200 copies of various editions located in more than 600 institutions.

Also in 1986, students voted for a self-imposed computer fee, to be assessed for each credit hour. The students sat on a committee with faculty, staff, and administrators to decide which faculty projects were worthy of their fees and what equipment and network facilities were necessary. The grant for the videodisc project took a day to write, and I found out about funding two weeks later. With the funding came one student assistant, who was the first "summer camper" to work on the videodisc and related projects. Each summer there are more students; seven students participated in the summer of 1993.

When the funding came through, I went to a meeting of the Group for Research In Pathology Education (GRIPE), where I suggested that the group's photo bank be used on the videodisc I wanted to make. I didn't know where to get pathology pictures for my course, and GRIPE seemed a logical place to start. After much discussion, GRIPE members decided that the images in video would not be adequate. Naturally, that was the stimulus for me to go home, get out some slide carousels, load them with a variety of images, go down to the television studio, put them on videotape, and then bring in faculty to review the tape and determine whether these pictures would be adequate for teaching. Those original 300 pictures are still on the very first part of the Slice of Life.

LESSONS OF EXPERIENCE

Using software in the curriculum

As course director, I controlled the course content and could implement changes. I could say, for example, "There will be no lecture on neoplasia." Instead, I could tell students, "Go to the library and look at the NLM discs and do the quizzes and you will be rewarded, because there will be something on the examination that will come from that disc." Course directors are *key* to change. If they are not interested, the battle is lost.

Getting faculty members involved in changing medical education is difficult. They are comfortable with the status quo, and their lecture notes are more or less carved in stone, like the petroglyphs in southern Utah. Gross anatomy has not changed much since the Anasazi Indians left—nor have the lectures of many of our faculty members! A lecture is easy to get out of a file drawer. What is more, during a lecture, students can read the paper, write to their mother, talk to their neighbor, eat breakfast, or fall asleep.

For most faculty members, teaching is the lowest priority, because most have to obtain part of their salary from grants or have to see patients in the clinic. The major resistance to curriculum change is that it takes more time to make interactive instruction than to lecture. Use of computer-aided instruction (CAI) materials created elsewhere is dismissed if faculty members don't like two of the fifty minutes of the program. This is the NIH (Not Invented Here) syndrome.

If faculty members do create something, the challenge is to move beyond page turning on the computer (i.e., text on the screen with pictures). Page turning can be enjoyable if you buy a good atlas of pathology, curl up in front of a fire with a cup of coffee, and turn on nice music. But beverages, music, and fires are not encouraged in libraries.

Appropriate uses of multimedia

Faculty members must start thinking about what computers can do that books can't do. Computers should not compete with publishers. The idea is to get students not only to read the text but also to learn in other ways. The first things we did on disc were quizzes. We all have questions we have used over the years that now can be reused in an interactive way. If the student gets the question wrong, software can provide feedback as to why that answer is wrong and what the right answer is; software also can provide a picture. Because of cost concerns, books generally do not have a large number of colored pictures. On a computer, a dozen pictures can be linked to a paragraph of text. Also, the text can be linked to glossary terms, labeled drawings, or photos. Think how frustrating it is for students to turn to the index of a book and see that the mitral valve is on twenty different pages. Which is the one the student wants? They often can't even find the term on a given page. As a student, how often did you get out of your chair to find another book or look up a definition? Now we have electronic links within books and into other books or indexes.

Finally, another drawback of books is that they can't *animate*. Take a picture of the larynx; I could spend five minutes gesticulating about the action of the muscles involved in vocal cord movement, or I could go step-by-step through a ten-second QuickTime animation. With animation, students can see the muscles contract and relax right in the classroom, lab, or library. Computers also can provide sound. Students can listen to heartbeats and lung sounds and grumbles and rumbles, even heavy breathing or a wisecrack (a little bit of humor never hurt).

Software development and distribution

Fearful faculty need new skills. They are timid as I was. But students are very, very eager to use computer technology, so it is useful to pair students and faculty. Summer is an ideal time for students with backgrounds in computer science, education, or instructional design to work with experts in academic content. At the end of the first year, medical students still are altruistic and willing to try to help change the system they have suffered through. In general, the most a faculty member will contribute is their expertise; they will not provide graphics, animation, or programming, but they will provide content.

Producing software is not like writing a textbook. Once a text is published, the author can throw reprints into a file for a few years, and then it is time to start on the new edition. The lull of at least two years allows time to take a deep breath, see the family, and reacquaint oneself with children. But computer technology is very different. It is never finished. When a software program is released, a mere twenty-four hours later the phone starts ringing, and someone cannot get the program to work, or they have found an error. In addition, as soon as the software works on one operating system, they come out with a faster processor that changes the timing, and the heart sounds are no longer synchronous with the animation.

Because it takes about three years to create, test, and distribute new software, there is no way to anticipate all the new capabilities that will exist when the project is finished. When we started, for example, educational Macintoshes had nine-inch screens with no motion, sound, or color. This phenomenon may contribute to software looking antiquated as soon as it is released.

Continuously evolving hardware also requires that the educational community network and share. All the technology and all the software is useless unless human resources are networked. Good projects are big, and they require a lot of time and a lot of effort to complete. It is very lonely, night after night, unless there is a great team to share the production work. Faculty and summer students work together year after year to improve the Slice of Life software and test it out on the next group of students.

Equipment and institutional resources must also be shared if the budget is tight. The costs of premastering and pressing the videodisc and studio time must be shared, even when subsidized by a university. Each person does not have a slide scanner or flatbed scanner.

Finally, if someone does create something of value, I encourage them to find ways to distribute it either free, through libraries, or through consortia for a modest fee. That way, other schools don't have to spend time and resources creating something similar. I also recommend leaving the software unlocked, so users can correct typos or grammar, insert one of their own pictures, reverse the order of things, add another question, or substitute their questions. In general, faculty are creating something for their particular course. Everyone else may want to do it a little differently.

There are only 126 accredited U.S. medical schools. None of us is going to get rich writing medical education software for such a small market, so we might as well make it affordable. So share the software. Share the code. Share the evaluation effort.

In addition to sharing expertise, we have to share experiences. It's very hard both to get started and to keep going; you need to be willing to attend national meetings and share your accomplishment even though it may seem very modest. At neurosciences meetings, we demonstrate HyperBrain [3] and Slice of Brain [4], two of our projects. We go to Association of American Medical Colleges meetings and show Slice of Life. We go to international meetings to help get European colleagues involved. We went to Guadalajara, Mexico, where the first Latin American medical informatics meeting was held, and we do faculty development workshops and demonstrations at universities as well as an annual Slice of Life workshop. We have a grant program for developing countries as well as demonstration videotapes. Slice of Life V and VI each have an hour of software demonstrations on the reverse side of the videodiscs.

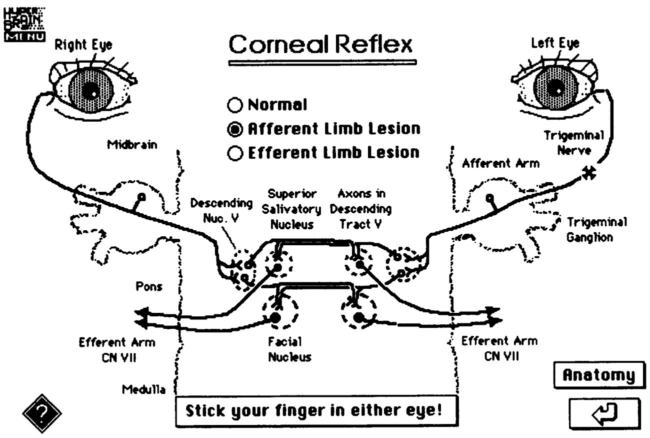
Our efforts are not exclusively videodisc based. We are experimenting with new technologies such as QuickTime, cross-platform compatibility for software, authoring systems, data projectors, monitors, and image compression. You have to be open and ready to try new technology and quickly integrate it into existing projects.

HYPERBRAIN: AN EXAMPLE OF MODULAR SOFTWARE

I will illustrate some of my views about creating and using new technology by describing HyperBrain. HyperBrain started out as my own project. It was originally a manual for a neuroanatomy laboratory, which the former course director and I developed [5]. I thought that in electronic form HyperBrain could be interactive and could be used on a computer by other people. It was very pretentious of me to think I knew neuroanatomy and could design an independent, self-study program around this topic. However, I allowed for any shortcomings by structuring the program so that other faculty could add other modules and make minor modifications. I wanted to create a resource that students could build on so that in their second year they could quickly review previous material as they learned neuropathology and neuropharmacology or went on to clinical cases in neurology, neuroradiology, or neuro-ophthalmology [6]. Finally, I wanted faculty to be able to use only the modules they wanted.

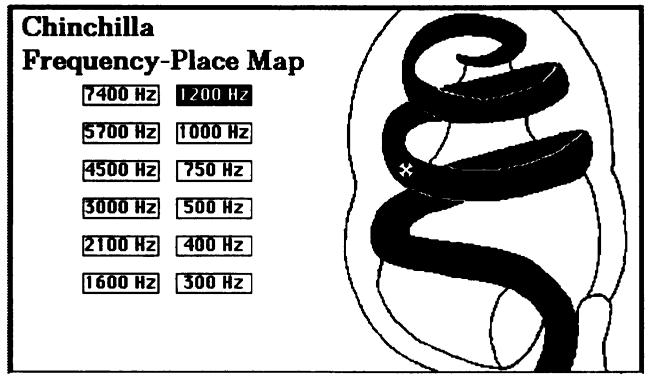
A colleague in medical informatics had a prerelease version of HyperCard, which provided a way to link pieces of the program together. To save time, the first thing we did was to recycle existing teaching materials, beginning with the syllabus. Next, terms defined in lecture notes became the nucleus of the glos-

Figure 1
Animation of the corneal reflex on HyperBrain*



* An example of the pathway involved in the corneal reflex was made by scanning an old mimeographed drawing previously used for student handouts. The illustration is now an animation on the computer and part of HyperBrain. The nerve impulse travels from the cornea to the facial (VII) nerve. On reaching the muscle to the eye lid, the lid drops and tears drip. The student can view the animation under normal as well as abnormal conditions. Here the lesion (+) is on the trigeminal nerve.

Figure 2
HyperBrain stand-alone module, Cochlear Anatomy*



* An interactive diagram produces twelve tones in Cochlear Anatomy. As the mouse moves over the hair cells located on the basilar membrane (black ribbon) the + moves, and a tone is heard corresponding to the optimal frequency (1200 Hertz) that cells in the region respond to.

sary, which was linked to images on the videodisc. By scanning, retouching, and relabeling, figures from old mimeographed handouts were recycled and linked to pictures. The blink reflex is an example. Drawn fifteen years ago, this diagram was animated by a fifteen-year-old high school student (Figure 1).

Existing textbooks can be linked. If you have not written a textbook, then borrow one. I talked to an author and his publishers and obtained permission to scan their drawings and link them to our videodisc [7]. We made these drawings into interactive pathway quizzes. Software creators should develop alliances with publishers rather than competition. We are complementing and promoting their texts; we can add animation, sound, testing, and feedback. We can reinforce the pedagogy of the books and, because there are interactive materials to go with them, increase adoption of texts. And it doesn't cost publishers anything.

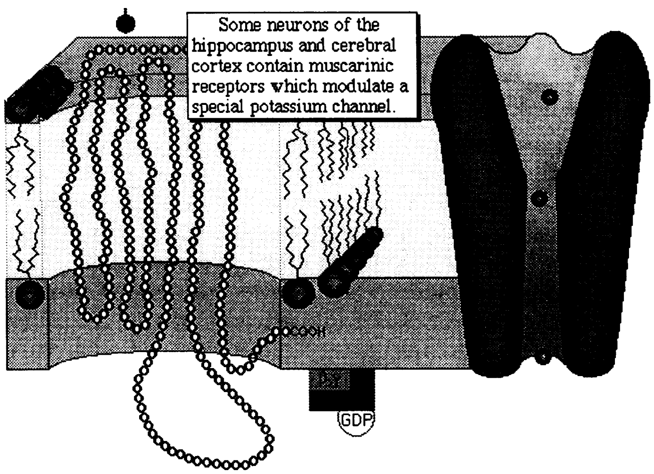
In addition to the core of HyperBrain, additional stand-alone modules that make good use of color, sound, and animation can be purchased and added to the package. Cochlear Anatomy is an example of a good use of sound and graphics with an easy navigational interface [8]. You can learn the physics of sound or what waveforms sound like when you mix them together. You can hear the tone frequency as you move a mouse over the cochlea (Figure 2). Or you can test your own hearing. Find out what happens if you have a hearing defect in the high tones, or what it might sound like if you had tinnitis.

Another way to animate the curriculum is with patient simulations. For example, HyperBrain links to the Lazy Eye, developed by a medical student at the University of Pennsylvania [9]. This program teaches eye movements and pupil responses. The patient's gaze follows movements of the mouse as if you were asking the patient to follow your finger in a particular direction. We also see what happens when a light is shined in either eye, and we can add drops of drugs to the eyes and again test the pupils. Once normal eye movements are understood, the user can select from a menu of both motility and pupil disorders. Finally, there are preprogrammed cases where the student must examine the patient's eyes, read the history, and make a diagnosis.

The same student author created another program, NeuroLogic Anatomy, which is an effective use of color for coding structures at different levels in a brain stem atlas [10]. The program allows you to turn names on and off, identify surrounding structures, and quiz yourself. In lecture, I can draw only four diagrams in an hour on a blackboard, and it is very time consuming. With this program, my portable computer, and a liquid crystal display (LCD) color projection panel, I can march up and down the brain stem many times during a class.

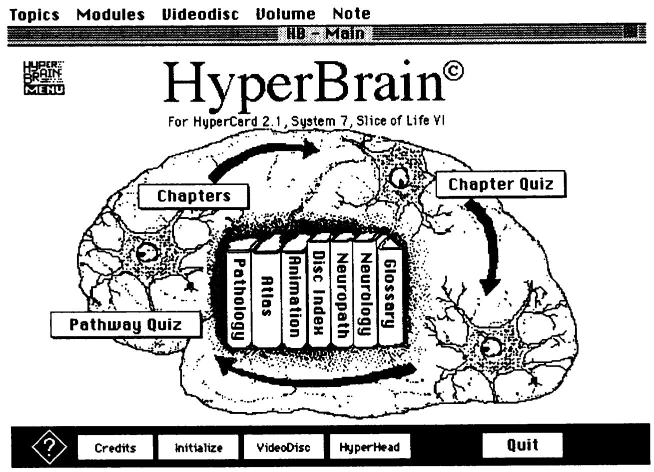
Another important thing software can do is animate molecular events that would be impossible to see in vivo. An example is Synapse: The Movie, produced at the University of Hawaii [11]. The program allows us to visualize membrane receptors on the

Figure 3
Synapse: The Movie*



* Acetylcholine receptor function is captured in a sequence of color animations in Synapse: The Movie. The open calcium channel is seen on the right. Animations are ideal for complex molecular and membrane events that cannot be seen. They can be viewed step by step or run as a "movie."

Figure 4
Starting point for HyperBrain*



* The starting point for HyperBrain is a screen with arrows indicating that the student should first select and read a chapter (rich with hypertext links to images, figures, and glossary). This activity is followed by a multiple-choice quiz with feedback and pictures and finally an animated pathway quiz from the textbook by Duane Haines. The central bookcase indicates the core resources that can be accessed at any time while using the program. The menu bar at the top is a pull-down menu to access other parts of the program. Topics include core items in HyperBrain such as glossary, atlases (in three planes), animations, and index. Under Modules, the student accesses the other programs, such as Cochlear Anatomy, Lazy Eye, Synpase, Neurology, and NeuroLogic Atlas. These other modules were written by others and their use is optional and determined by the instructor or institution.

postsynaptic membrane. You can step through the action of transmitters binding to the membrane, affecting intracellular events that result in changes in membrane properties permitting ions to move across the cell. Colored animations such as these can be used very effectively in the classroom. You can step through the animation describing each action and then play it full speed to see the entire sequence of events. Students can review it later on a library workstation. Large, clean graphics that project well are important if the software is to be used in a lecture hall (Figure 3).

Software developed at the University of Miami, Neurologic Localization, capitalizes on students' desire to quiz themselves and to do patient problems in their preclinical years [12]. Thirty-eight cases represented by question marks cover the screen. As the student solves each case, more of his or her name is exposed until finally a personal diploma is revealed. If the student is stuck and can't solve a case or gets it right and doesn't know why, he or she has the option of seeing the anatomical pathway involved.

All of these examples come from other authors at other institutions. Each program was constructed to stand alone. What we have done is link them to the core program, HyperBrain, so that a student can navigate more easily among the programs. The modular concept is very important. Faculty at different schools can build their own learning resource environment by selecting from preexisting modules or by creating additional modules (Figure 4).

TECHNIQUES THAT DO AND DO NOT WORK

In the process of creating medical videodiscs and software, I learned what generally does not work. Trying to make money doesn't work. You are lucky if you bring in enough money to do the next edition or update, start a new project, pay student fellowships, go the next meeting, upgrade software, or buy new hardware. You don't want to be stuck with developing programs for a single hardware configuration, and you certainly don't want to wait for grant support before you start.

We also learned what does work. Contributors, particularly those who provided the images that are on the Slice of Life videodisc, were committed to education and sharing. None of them requested royalties. When the project began, there was no intention of even selling the videodisc. When we decided to sell it, we had to go back and approach all the early contributors. Only one refused permission, a drug company. Now, six years later, we are doing the same thing again, getting permissions to use pictures in a digital format in a nonprofit environment. The majority of the contributors again are willing. So we accidentally selected for the types of people we wanted as collaborators. Some of them have had no further connection with the project, while others have become developers.

You need to collaborate, and if you cannot find colleagues at your own institution (the likely case), then do it across the country or internationally. The Internet has made this much easier. You need to have some key members that provide continuity. Producer and director Paul Burrows and I have been collaborating since 1986. André St. Pierre started the marketing and distribution office four years ago. Our programmer, Nate McVaugh, has spent three years on HyperBrain, now in its sixth edition with four different versions: Macintosh, Windows, a Spanish version for the Macintosh (El Cerebro Electrónico), and HyperBrain 6.0 to go with the new videodisc, Slice of Brain.

We also discovered that you really have to be flexible. In this project, there are no policies that you can't make or break. Policies must be recreated constantly to serve users and to avoid impeding development. You need institutional support in the form of a core facility with certain equipment and staff. The independence of the project also is really important. You need to be fiercely independent and go for it 100%, with or without outside funding. Once the package is out and sold, you need control as well as a certain amount of money coming back to you. Most important, you should not be penalized for creating CAI by promotion, retention, and tenure committees. Indeed, you should be rewarded, but I know few instances where activities of this type are acknowledged in reviews for promotion or tenure.

SURPRISES

One of the unanticipated uses of Slice of Life is as a resource for problem-based learning. It is almost impossible to get pictures, X-rays, biopsies, surgical specimens, lab findings, or autopsy photos for a single patient. With Slice of Life, instructors have a bank of resources with which they can simulate a patient.

Another surprise was a visit from a professor from Pamplona, Spain, who showed me a two-volume textbook of pathology he had written accompanied by more than 5,000 links to Slice of Life images as well to the figures in his book [13]. His program, in Spanish, is called "INTERPAT," for "interactive pathology" [14].

We also added to Slice of Life the images from out-of-print atlases, such as the David L. Bassett collection of anatomical dissections, which has been reissued by Videosurgery [15]. Media librarians may recall the three-dimensional (3-D) Viewmaster slide reels. All of these images, through arrangements with Stanford University and Mrs. Bassett, have been put on the Slice of Life VI videodisc in two dimensions. The atlas books now have been bar coded by the Slice of Life office and reprinted by Robert Chase, M.D. In 1994, the 1,500 images may be viewed in 3-D by plugged-in students, using LCD glasses to view a television monitor. The MTV generation, which has been visually stimulated and auditorily blasted for fifteen years, will be thrilled. Bar coding, a low-technology solution, thus made possible the viewing of the collection in 2-D or 3-D independent of the computer by using the printed atlas to identify each structure. In this way, we have reintroduced (or recycled) a valuable collection of out-of-print images.

One of our contributors, a neuropathologist at Loyola University in Chicago, passed away this year. One of the last things he did was contribute 1,000 of his neuropathology slides to Slice of Life and Slice of Brain. So we dedicated the first edition of Slice of Brain to Emanuel Ross, M.D. Sharing your collections is a way of demonstrating pride and later being remembered as an educator. After all, who is going to keep track of those slides after you are gone?

Dr. Ed Friedlander in Kansas City has made a list of all the pathology images on Slice of Life according to the order of topics in *Robin's Textbook of Pathology.* He has linked his lecture notes to Slice of Life as well. His school uses no computers. It's the simplest, low-tech technique imaginable; he just punches the numbers in on a hand controller and the image is projected on a screen in front of the class. He gives the file to all who want it through the Slice of Life file transfer protocol site.

Finally, the videodisc is moving out of the library and into the laboratory. The student laboratories at the University of Utah and Cornell University are equipped with workstations on carts or lab benches. Students dissect brains as they look up terms or images from Slice of Life or the computer. Round-the-clock access is very important, and combination door locks and plastic keyboard covers soon will be standard.

CONCLUSION

As a finale, I want to offer a glimpse of the future. All of you have heard about the coming digital video revolution. QuickTime movies can be made from videodiscs or from scratch. The University of Washington is creating 3-D animations that help students learn to visualize brain structures and how they are related. This material is distributed in analog form on videodisc [16]. It is now being recreated in digital format.

This dramatic QuickTime digital movie graphically demonstrates that energy spent developing videodiscs is not wasted.

Good educational material always can be recycled, just like faculty members. It is not a question of analog or digital. It is both. I hope you as librarians can animate your faculty and funnel their energy and expertise into creating and using interactive multimedia now.

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