PROJECT ACTIVITIES

The technical objectives presented in this grant comprise:

a) developing an educational product in which students interact with the full, detailed Visible Human data set,
b) targeting teachers and students in grades 7-12,
c) providing a product that does not require an investment in additional hardware or software support,
d) creating an intuitive, easily navigated interface.

An earlier project, the *Digital Cadaver*, though targeted toward a college (pre-medical school) population, provided us an initial framework for this effort. Further discussion with teachers and publishers helped set the priorities for our work.

Our first priority was to develop a program for grades 7-12 using a broader stylistic approach to meet the above objectives while retaining the original open-inquiry philosophy of *Digital Cadaver*, an earlier project targeted toward a pre-med-school population. Our second priority was to have an independent evaluator introduce this program to teachers and have them use and critique it. Our third priority was to implement suggested changes.

Overall, our approach to this Phase I was to evaluate the *Digital Cadaver* project from the standpoint of younger students, develop modules to meet their perceived needs, and have potential students and teachers actually use the software. A teacher workshop, scheduled for June was used as an opportunity to conduct the evaluation. In line with the Phase I objectives, these high school teachers examined this proposed product for technical merit and feasibility from their individual pedagogical perspectives. An independent evaluator was present to collect their feedback in an objective format.

Our first activity was a review and reevaluation of the original *Digital Cadaver* project. This precursor project had three main aspects: easy user navigation of the set of Visible Human imagery, user selection and annotation of images, and user-built custom models based on the userís delineation of structures within a series of individual slices. After demonstrating the *Digital Cadaver* software to local instructional-design experts and reviewing feedback from students and teachers during previous classroom trials we concluded that the building of custom models, while desirable when a quality model resulted, was tedious and complex at the college level and would be even more so for secondary-school students. This was confirmed in the June teacher evaluation. Of its many components, the *Digital Cadaver* slice navigation interface was the most approachable, and, on its own, was judged to be an excellent vehicle for secondary students to explore the full set of Visible Human imagery.

Our second activity was to create a design that met our learning objectives. Through association with the NSF-funded TRAILS project *(Grant No. 0205625)*

at the University of Colorado, Boulder, we explored the idea of using a design based upon . We met with Alexander Repenning and followed his *Games for Education* class this spring semester, which provided a foundation for our basic design. Our approach consists of a series of challenges, presented in a computer-gaming context, at progressively increasing levels of difficulty. Design ideals of computer gaming captured student attention, and varying levels of difficulty flexibly address a range of student sophistication. Novice students can spend as much time as needed at each level, gathering the prerequisite knowledge necessary for succeeding challenges, while advanced students can breeze past early levels and spend most of their time at advanced levels commensurate with their skills and knowledge.

Our next activity was to build a series of demonstration modules to realize this design. We chose a single specialized anatomical system, the digestive system, as the content for the various demonstration modules. We reasoned that should the design prove viable, the product would evolve vertically by fleshing out the thread of functionality through the challenge levels, and horizontally by implementing other systems ó e.g., the circulatory system, the nervous system, etc. ó in the same way.

The prototype has four challenge levels:

I. the prologue: teaching / reviewing basic anatomy and physiology
II. navigating virtual-reality panoramas inside the digestive tract
III. Visible Human slice navigation and structure identification
IV. *Digital Cadaver* as open-inquiry model building

In the prototype, modules are loosely coupled to facilitate their use as separate entities depending on a teacherís style and their target student audience. Module I, for example, could stand alone in earlier grades. Within each module, our intent was not necessarily to be complete, but to present a ìpalette of options,î exploring a variety of directions that, though possible, may not all be desirable in a final product. In this way, we received feedback from both students and teachers on the full array of possibilities in the palette.

This first module establishes basic anatomical knowledge, with the addition of some physiology. Prerequisite to successfully identifying bodily structures within the full set of Visible Human imagery is a basic grasp of what these structures look like and where they are located with respect to the body surface and each other. In this module, students work with simplified 2D schematics, starting with elemental models of structures before advancing to the real-world complexity of the Visible Human imagery. This module requires a user to recognize and place structures properly within a general outline of the body, as shown in Figure 1.

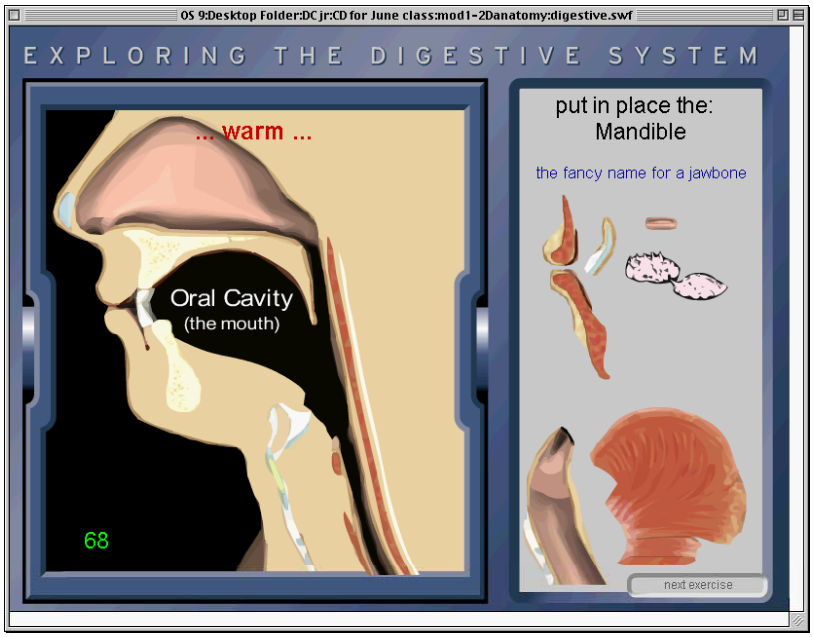

Figure 1: Teaching / reviewing basic anatomy and physiology, from Module I.

At the next challenge level (module II), the student works with 3D models, navigating through virtual-reality panoramas inside the digestive tract and identifying structures and functions along the way. This module presents an inside-looking-out perspective, in contrast to the outside-looking-in perspective in the first module. The panoramas of module II, an example of which is shown in Figure 2, are visually arresting and intended to capture the studentís attention, though they are still somewhat idealized; e.g., thereís no food in the digestive tract.

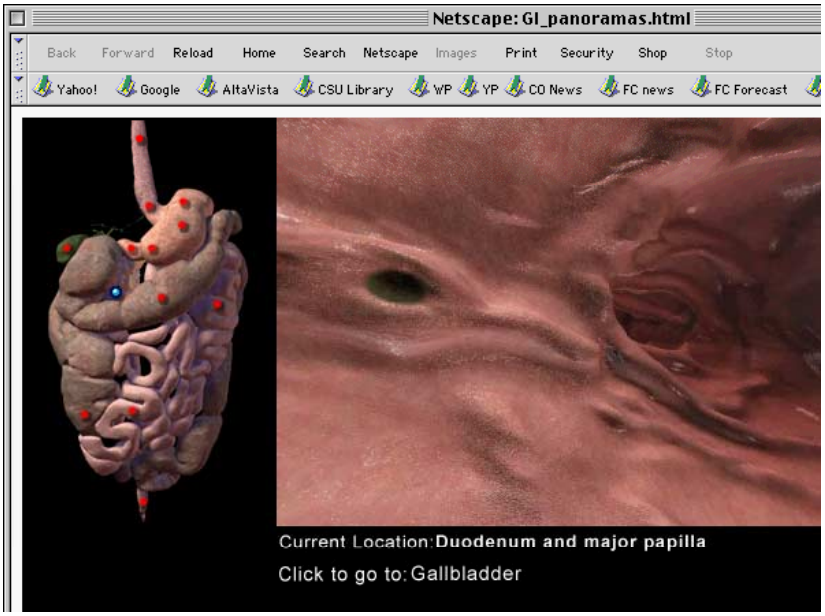

Figure 2: Navigating virtual- reality panoramas inside the digestive tract

Module III exposes the student to the full set of Visible Human cryosection images and pseudo-sectioned images constructed to simulate sagittal and coronal slice planes, as illustrated in Figure 3. Upon arriving at this level, the student has successfully worked with both 2D and 3D models of systemic anatomy, and is now expected to identify the structures from earlier modules in the complexity of real-world sectional imagery. A responsive interface screen allows quick navigation through scaled-down slice images. Once the student selects a particular transverse, coronal, or sagittal slice, the student can easily access the full-scale, high-resolution version of that slice and locate pertinent anatomical structures.

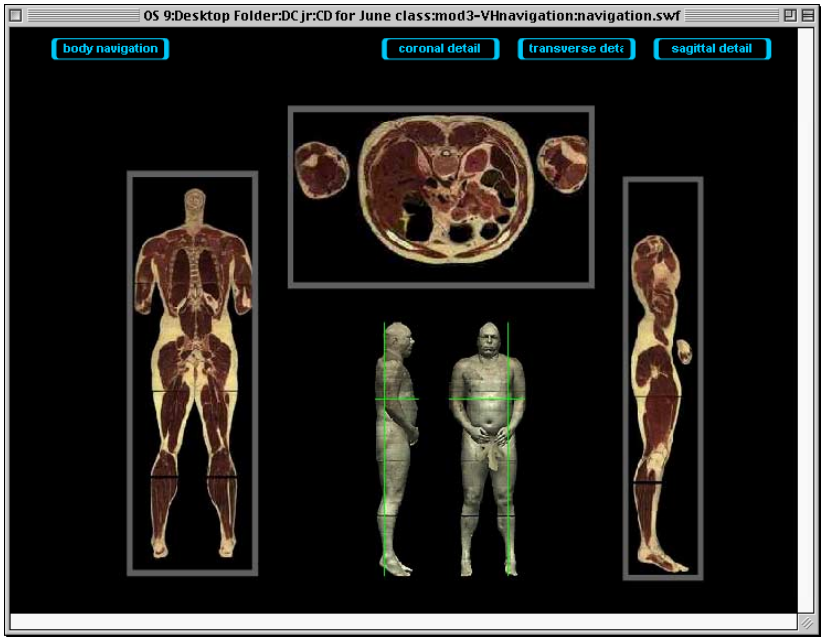

Figure 3: Visible Human slice navigation and structure identification

Module IV, the highest level of challenge for the most sophisticated and motivated student, offers the unconstrained structure-outlining and model-building that was the object of the original *Digital Cadaver* project

As versions of the modules were being developedó particularly module I since it departed the most from previous projectsó we showed them to potential users and incorporated their feedback into revisions. We presented module I, for example, to several students from fifth to tenth grade, who found the modules interesting and each provided constructive feedback.

In implementation, one objective was to <u>not</u> require installation of any expensive or specialized software. Our prototype requires only players for Flash, QuickTime, and Shockwave, all of which are available free on the Internet. *(Flash and Shockwave players come installed as part of most current web*

browsers.. Our modules work well on 4-year-old hardware, and port easily to computers in the UAMS (University of Arkansas Medical Sciences) lab. That our system provides a complete multi-platform solution for Windows, Mac, Linux, and Unix operating systems is an added advantage.

The final activity was to bring the prototype pieces to a group of teachers for their use and evaluation. Our collaborator, Dr. E. Robert Burns, arranged a teacher evaluation workshop was organized by our collaborator, Dr. E. Robert Burns, in Little Rock, Arkansas, for 14-16 June. Dr. Burns, the Director of *the K-12 Partners in Health Sciences Program* at the UAMS center, has a 13-year relationship with high school and community college teachers, having provided them with an ongoing set of summer study opportunities. From this pool, he selected ten of the best teachers in biology and science to review our work under this ìInteractive Anatomy for Grades 7-12î grant.

In line with the overall objectives of a Phase I grant, the teachers were asked to serve as evaluators of merit and feasibility from their pedagogical perspective. Would it work for them? Do they envision it working for their students? In anticipation of a follow-on Phase II proposal, these teaching experts were asked to provide input and direction for features to implement, to suggest biological systems to include, and to supply some preliminary sketches of curriculum-support modules that would assist in integrating our work into their curricula.

A full discussion of the teacher evaluations and feedback, compiled by independent evaluator Leonard Albright, appears in the findings section. Commentary from the evaluations provides avenues for further exploration in a follow-on Phase II research effort. For example:

- Two key prerequisites were identified as necessary in conveying the 3-dimensional shape of sectional imagery. One is knowledge of a structureís shape and location; the other is a general intuition of how 3D shapes appear when sliced. The first prerequisite was addressed, but the second was identified only during conversation with the teachers.

- Strictly speaking, knowledge of anatomy is all that is necessary to locate structures in the Visible Human sectional imagery. However, anatomy and physiology are taught hand-in-hand, and the teachers wanted a balance of both anatomy and physiology in the program.

- Tedium and quality issues associated with *Digital Cadaver*ës model-building capabilities could be overcome with pre-stored outlines that could be triangulated with build-as-you-go modeling capabilities.

The primary objectives and priorities of the Phase I grant were realized, while some minor details discussed in the grant changed, as occurs in any research endeavor.