SimBiotic software short-shots

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SimBiotic Software is a small US company that produces interactive computer simulations for teaching biology. Our programs allow students to 'discover' important principles and concepts by doing experiments using simulations of realistic biological scenarios. In 1997, UniServe published a review of *EcoBeaker* 1.0 ™, our flagship software for teaching ecology (Montgomery, 1997). The enthusiasm for and popularity of the *EcoBeaker* software over the past several years encouraged us to develop innovations to make our software more widely accessible, and to branch out and apply our approaches to other areas of biology. UniServe Science has invited us to introduce some of our new projects here. We now have an improved version of *EcoBeaker*, and other new teaching software on topics such as diffusion and osmosis teaching (*OsmoBeaker*), evolution (*EvoBeaker*), neurobiology (*NerveWorks*), and are working on methods for online delivery of labs and assessment of student learning.

EcoBeaker 2.5™

Before describing our new projects, we would like to provide a short description of *EcoBeaker* 2.5™. This program has come a long way since the 1997 UniServe Science review. *EcoBeaker* 2.5 is a collection of over 20 laboratories, each one simulating a different ecological system. The program shows creatures running around eating each other, dying, reproducing-generally doing what organisms do. The labs guide students through experiments on these systems that uncover important ecological and evolutionary principles. Unlike *EcoBeaker* 1.0, which was published as a book and used primarily in upper level courses, *EcoBeaker* 2.5 is completely modular, with workbooks available for each lab. Instructors can choose to have us package up sets of the workbooks they select for sale in university bookstores, or they can take advantage of our economical 'self-print' option which allows more flexibility (e.g., altering labs and/or including them in course packs or lab manuals). While most of the *EcoBeaker* labs are still fairly open-ended and geared towards upper level courses, we now offer several labs designed specifically for introductory/non-majors courses. These intro-level labs are shorter, more structured, and explore the basic topics covered in most introductory-level biology courses. Other general changes to the program include a simpler and splashier interface (Figure 1), which is surprisingly important for students brought up in the age of video games, an online library of background material, and most importantly, the software runs on the most recent operating systems of both Macs and Windows-based computers.

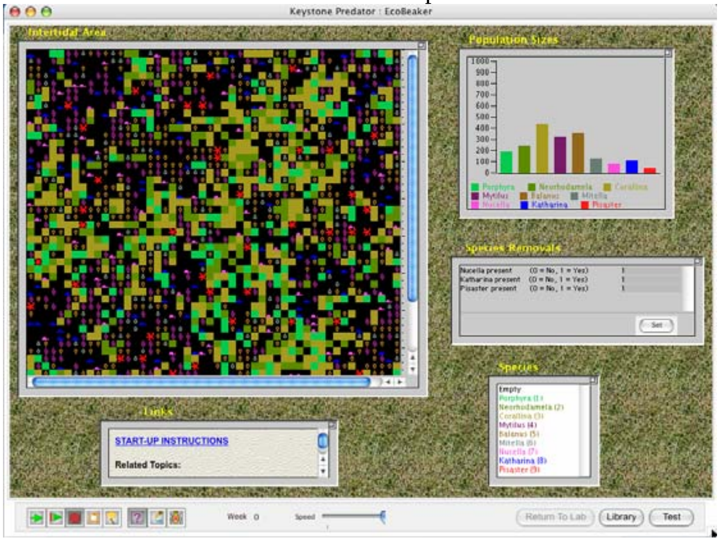

Figure 1. The Keystone Predator lab in *EcoBeaker* 2

Online delivery and assessment

Last year, a large US public university that had been happily assigning two *EcoBeaker* labs as homework in a non-majors biology course decided grading these labs was more than they could handle. We couldn't really blame them. The class had over 1200 students, no lab period, and teaching assistants who were responsible for up to 300 students each. Needless to say, grading 300 open-ended, inquiry-based labs was not enticing! Furthermore, they were concerned that students would cheat by using the completed workbooks of students who previously took the course. Being a small company still in the struggling 'start-up' stage, losing this customer was a real downer for us, but rather than give up, we did some brainstorming. This resulted in an innovative scheme in which the students purchased the program and labs online, did the labs at home or in the library, and then took an online test that would have been difficult if you hadn't completed the lab workbook. Different students received different tests to prevent cheating, and we rigged the labs so students who used the previous year's workbooks would get questions wrong. After the deadline date, we emailed the instructors a spreadsheet with all the students' scores. The system worked remarkably well, requiring little time investment from the instructors and teaching assistants but nonetheless providing their students (many of whom would have this as their ONLY science course) with a taste of laboratory experience in an otherwise lecture-only course.

This brings up a challenging problem—how do you test for understanding of complex material in large introductory classes? Even in courses with lab periods and sufficient teaching support, most tests still use multiple-choice and short answer questions, which are known to miss much of what we as science instructors consider important. With funding from the US National Science Foundation we have initiated a project to use our interactive simulation approach not only as a teaching tool, but to simultaneously assess what students know. For this project we are focusing on osmosis and diffusion, two widely-taught and often confusing topics that are amenable to computer simulations. As students work through our osmosis and diffusion labs, the program logs each experiment and manipulation that the student tries, with the ultimate goal of allowing us to correlate different sets of manipulations with different misunderstandings that students might have. Another assessment tool will involve having the program present students with problems, with their challenge being to use approaches they've learnt while working through the labs to solve the problems and thus demonstrate a working knowledge of concepts, rather than just regurgitating 'the right answers'. We're still in the early stages of this project, so we don't have any breakthrough results to report, but there's one nice short-term benefit—a new piece of software for teaching osmosis and diffusion.

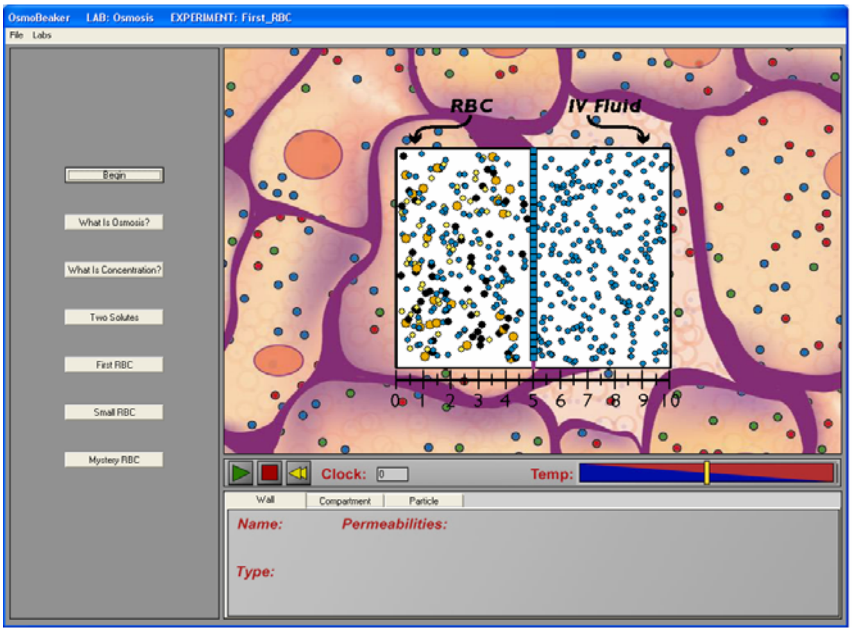

Figure 2. One experiment from osmosis lab in *OsmoBeaker*

Learning by osmosis

Some people might argue that since there are so many different wet labs available to teach diffusion and osmosis, simulations are unnecessary. Indeed there are many popular osmosis and diffusion labs, most of which seem to involve food—milk in coffee, for instance, to show diffusion (you can tell how rich the school is by whether they use instant coffee or espresso). Others are a little less edible but follow the same theme—put lettuce in salt or distilled water, watch plant cells in solutions with different saline concentrations and so on. These labs do a great job of showing what happens at a macro level. The lettuce gets mushy or crisp. The cell blows up or shrivels. But what's actually happening to cause these effects is something no one can see, and unfortunately that is where many student misconceptions lie (Odom 1995; our results in preparation).

How can you help students visualise and understand molecular motion? *OsmoBeaker* to the rescue! Our new program shows molecules bouncing around inside and outside of a cell, with the cell's membrane moving each time a molecule hits it to illustrate the influence of pressure (Figure 2). Students conduct a set of exercises in which they explore how diffusion time scales with distance, whether molecules 'want' to move towards areas of lower concentration, and how to make an intravenous fluid that won't burst red blood cells. Along the way, they confront several common misconceptions and confusions about how diffusion and osmosis work. We have designed the pilot labs explicitly with these issues in mind, using pre- and post-tests, observation, and interviews to assess whether the lab helped overcome these misconceptions. We then revised the labs based on our results.

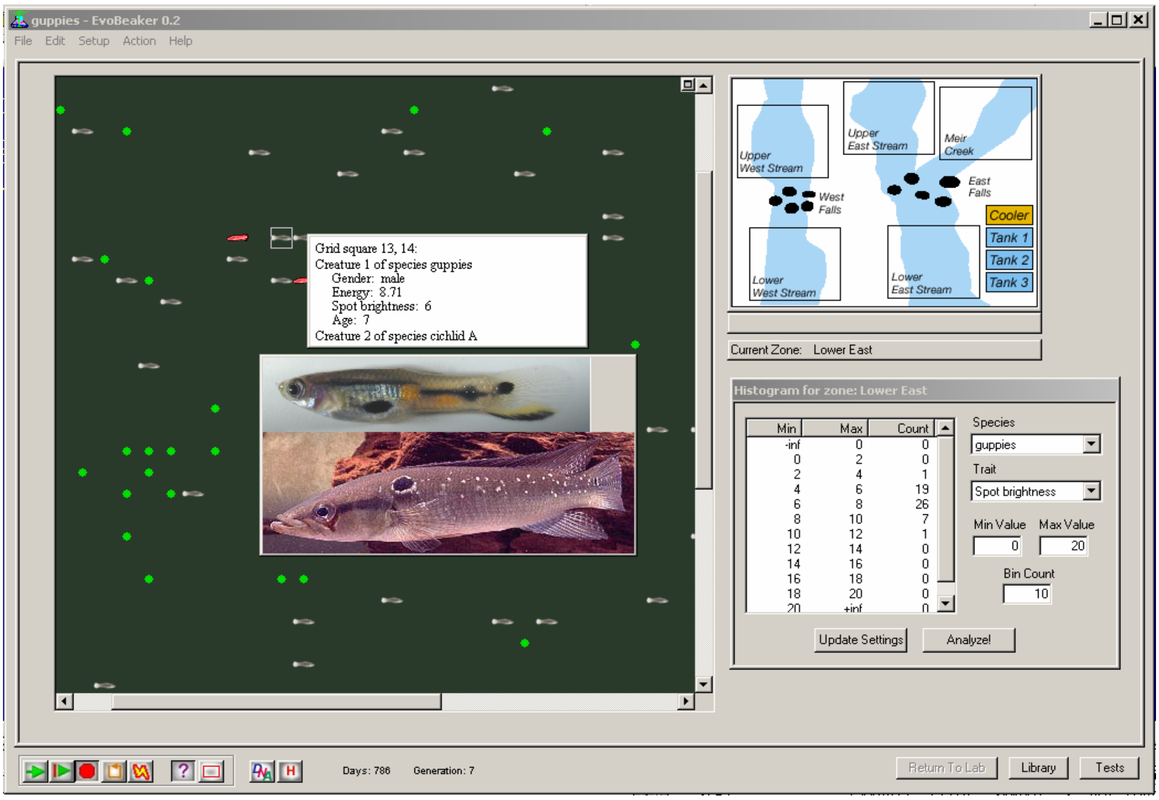

Figure 3. The Guppy lab in *EvoBeaker*

This intensive testing and rewriting can be frustrating. Just last week, after at least a dozen major rewrites of our osmosis lab, we put our latest, and (we thought) greatest, and (we hoped) FINAL version in front of a few students. Much to our dismay, they scored worse on one of our test questions after doing the lab then they had beforehand! Reviewing this distressing result, we concluded that it was due to a seemingly innocent change we had made— in that new version, most of the simulated cells happened to be the same size as the depicted outside fluid compartment. The student testers had started confusing 'equilibrium' with 'equal size', a misconception that our lab was apparently now reinforcing. We seem to have cured this by changing the size of one of the cells. This kind of iteration between testing and rewriting has resulted in two excellent labs (if you'll pardon us saying it ourselves), one on diffusion and the other on osmosis.

OsmoBeaker will be officially released this summer, in time for fall 2004 classes. A demonstration version is available from our website now. The *OsmoBeaker* labs will become part of our '101 Collection', a set of labs that we have developed specifically for introductory and non-majors biology classes. In addition to the diffusion and osmosis labs, this collection includes four of our most popular *EcoBeaker* labs, and will incorporate selected labs from our future programs as well (see below). There are now tens of thousands of students per year using 101 Collection labs both in class and as homework.

EcoBeaker 2.5 has three labs with an evolutionary bent— one on sickle-cell alleles and malaria, one on Darwin's finches, and one on optimal foraging. Although these are great labs, those of you who have used them can probably quickly see the limitations of *EcoBeaker* for evolutionary experiments. *EcoBeaker* was not designed to do macro evolution, for instance, and there is no capacity for phylogenetic trees. A couple years ago we received a grant from the National Science Foundation to write a prototype of a new program called *EvoBeaker* (Figure 3) designed specifically for teaching evolution, and we have just received continuing funding to turn this prototype into a full-fledged program. Among its features will be much more detail on the creatures so you can easily see different phenotypes in the population, macroevolutionary labs, the ability to generate phylogenetic trees, interactions between graphs that facilitate students moving between levels of analysis (e.g., from DNA sequences through phenotypic changes over time), and much more. As with *EcoBeaker*, you'll be able to build your own labs and models, and we have plans to collaborate with a group at the Massachusetts Institute of Technology to try a completely new interface for model construction that we're very excited about. You can help beta-test the next version starting in January 2005, or you can check out the prototype which is available currently on our website. We are also happy to hear suggestions for what you'd like to see included.

Finally, we have one last new program we will be releasing in Fall 2004. Called *NerveWorks*™, it's a program written by a team at the University of Washington for teaching neurobiology. Students have a simulated rig of oscilloscopes, amplifiers, voltage clamps, and all the other typical instruments you would find in a neurobiology lab (Figure 4). *NerveWorks* focuses on cellular neurophysiology—how does a neuron change its membrane potential? Labs cover the gamut from a simple introduction to recording a differential signal (Recording101), to membrane and action potential, to advanced labs on interactions between neurotransmitters, muscle physiology, and more. As with most of our other software, you can build your own labs and models—make your own cell, define your own channels and drugs, make new solutions, even drag new instruments into the experimental rig, turn them around, and connect the wires. And don't forget to hook up the ground, or you'll get 60 cycle noise (sorry, only US noise frequencies for now). This program is suitable not only for general and advanced neurobiology courses, but also for bringing students up to speed in your lab before putting them on real equipment.

For those of you who are interested in our products, you might be pleased to know that you can mix-and-match labs from all our programs to design just the collection you want, and the prices are as cheap as US$2.50 per lab per student (with some discounts for large orders). In addition, our 'student purchase' licensing procedure makes it possible to implement our labs at no cost whatsoever to your department or university. If you would like any more information, don't hesitate to write us at info@simbio.com. We also are very happy to receive suggestions, both for any of our existing programs or for topics you'd like to see us address next.

Dr. Eli Meir, President, and Dr. Eleanor Steinberg, Vice President, SimBiotic Software Software for Teaching and Research, Inc.

References

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Montomery, I. (1997) *EcoBeaker*. *UniServe Science News.* **7** [Online] Available: http://science.uniserve.edu.au/newsletter/vol7/montgomery.html

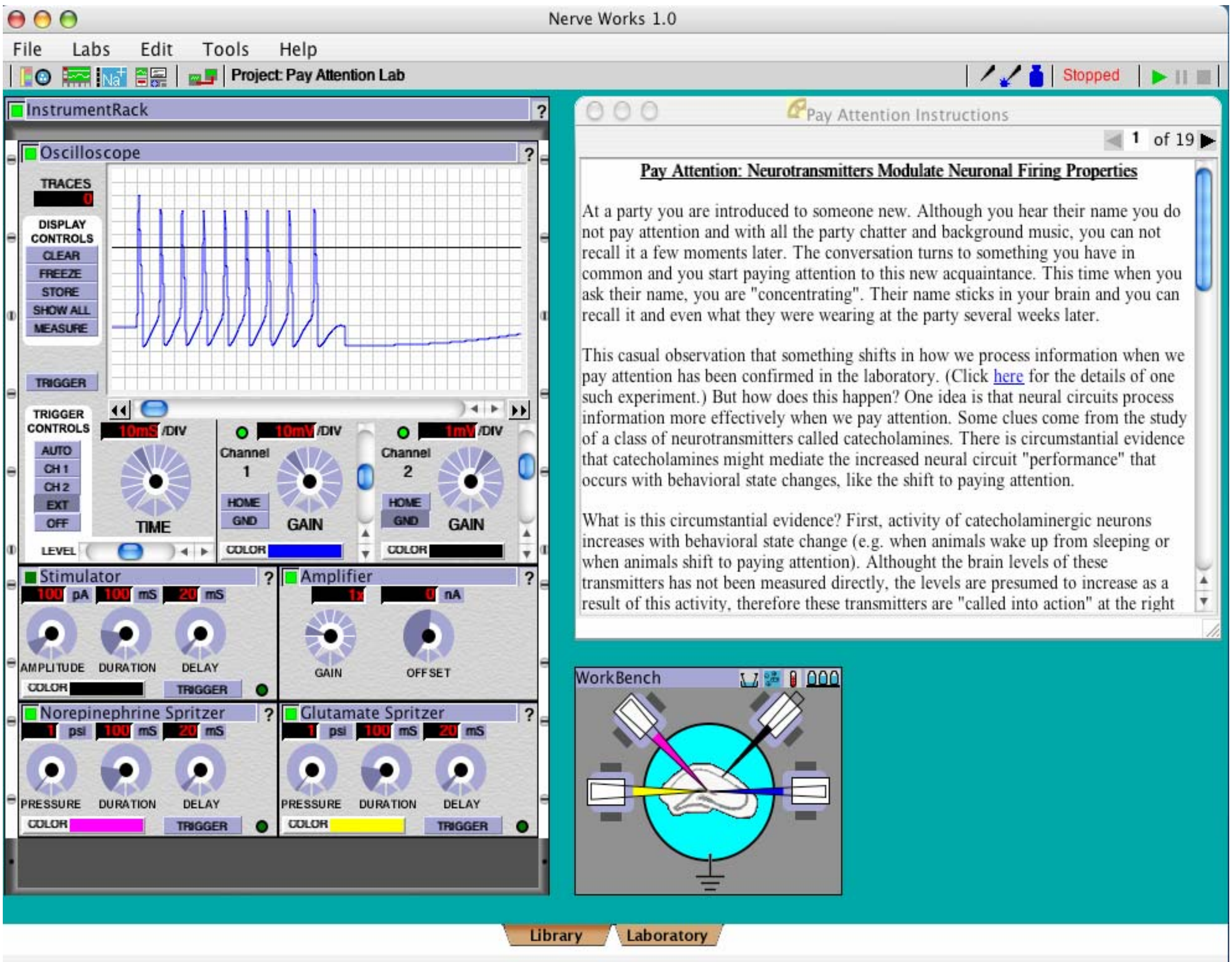

Figure 4. Pay Attention, an advanced lab from *NerveWorks*