Tested Studies for Laboratory Teaching
Proceedings of the Association for Biology Laboratory Education
Vol. 33, 362-368, 2012

Modular Digital Course in Biological Education

William Grisham, Franklin B. Krasne, Natalie A. Schottler, and Jackson Beatty UCLA,

Department of Psychology, P.O. Box 951563, Los Angeles CA 90095-1563 USA

(**dr.billgrisham@gmail.com; krasne@psych.ucla.edu;nschottler@yahoo.com; Beatty@psych.ucla.edu**)

Digital labs need not be demonstrations, simulations, or cookbook exercises. Rather, digital labs can and should be inquiry-based. Scientists routinely create digital data or digital tools when modeling phenomena. We have re-purposed these actual data and modeling tools to create completely digital modules, thus melding science research and education. All of these modules are inquiry based—students gain from genuine experiences in doing actual studies. These materials give instructors the ability to provide good quality laboratory experiences regardless of resource limitations. These digital modules include materials for teaching three different modules: 1) Bioinformatics, 2) Developmental biology—effects of steroid hormones on early CNS development, and 3) Neurophysiology of circuits. We are providing these digital lab teaching tools described for free at **http://mdcune.psych.ucla.edu/**.

Keywords: digital lab, bioinformatics, developmental biology, neurophysiology

Link to Original Poster: http://www.ableweb.org/volumes/vol-33/poster?art=45

Introduction

Biology, like all of science and medicine has become essentially digital. Indeed, an fMRI of a human brain, an EKG from a heart, mapping species' location with GPS coordinates, comparing DNA sizes, or a study of cells under a microscope would all involve digital records/images. In this article, we demonstrate how digital resources can be repurposed so as to make efficacious teaching tools. We have taken actual data and modeling tools to create completely digital teaching tools. The results are inquiry-based experiences allowing students to gain from doing actual studies.

The resources offered include materials for teaching bioinformatics tools (Bioinformatics), developmental biology of the song system (Birdsong), and the physiology of neural circuits (Swimmy). All of these materials are offered for free at **http://mdcune.psych.ucla.edu/**.

Bioinformatics Module—Introducing and Using Bioinformatics Tools

In the Bioinformatics module, students quantify a phenotype that is impacted by differing genotypes, perform statistical analyses to extract meaning from the data, and use the same online databases and analysis tools employed by research professionals.

Students obtain the phenotype from using brains from the Mouse Brain Library **(http://www.mbl.org/)**, which provides brains from various recombinant inbred strains (Fig. 1). Other phenotypes could be selected; we chose olfactory bulb because it is easy to define and students obtain reliable data.

Once the data have been cleaned-up via multiple regression, a QTL analysis is performed using WEB QTL (**http://www.genenetwork.org/**). A Quantitative Trait Locus analysis links variation in phenotype to variations in genotype—identifying a locus/loci on chromosome(s) that have an impact on the phenotype.

WebQTL directly links to the UCSC Genome Browser. The UCSC Genome browser (**http://genome.ucsc.edu/**) arrays the names of genes in a particular portion of a chromosome specified by the peak in the QTL analysis (Kent, Sugnet, Furey, Roskin, Pringle, Zahler, & Haussler, 2002). These gene names are "hot-linked" to further information such as gene expression (Fig. 3). We have students use the UCSC genome Browser to find genes in that peak locus of the chromosome that show relatively high expression in their region of interest. This gives instructors an opportunity to discuss microarrays (gene chips).

The UCSC genome Browser further links to the Allen Brain Atlas, Entrez gene, and PubMed. Using the links to the Allen Brain Atlas, which presents visual libraries of *in situ* hybridizations for expressed genes, students find the cell layers in which their particular gene were found (Fig. 4). This gives instructors an opportunity to discuss this technique.

Students can find out still more about their highly expressed genes by utilizing links on the UCSC Genome browser to visit Entrez gene where they can learn the sequence of the gene and PubMed, where they can learn something about their gene's function. Ultimately, students see how biologists generate an hypothesis about candidate genes, and how to follow up on this hypothesis. More details can be found in Grisham, Schottler, Valli-Marill, Beck, and Beatty (2010).

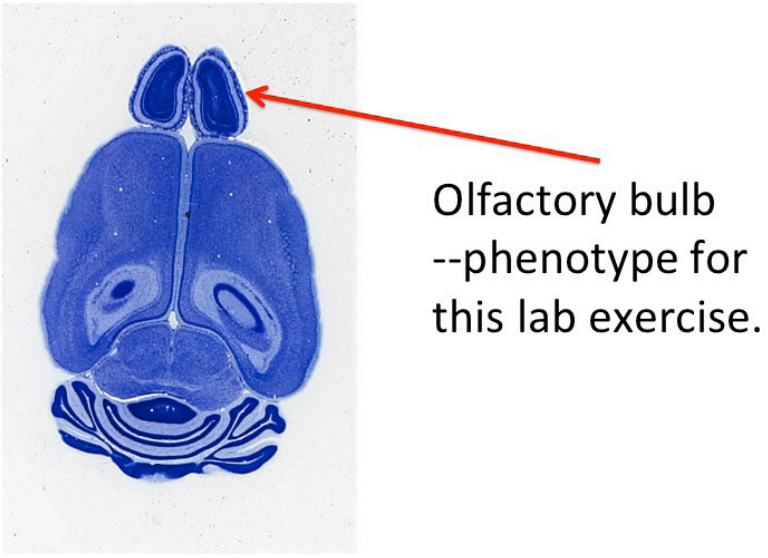

Figure 1. Horizontal section from a given recombinant inbred mouse strain from the Mouse Brain Library. Students would quantify the size of the chosen phenotype. (Each brain would have several sections containing the region of interest.)

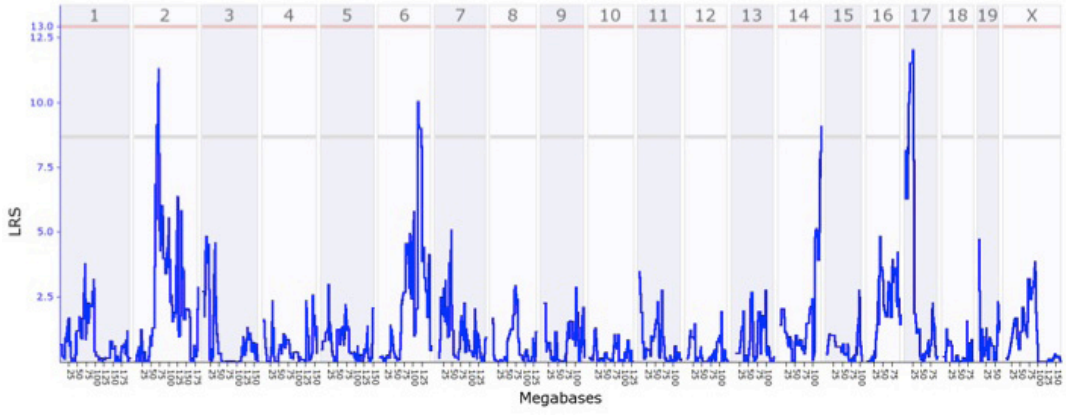

Figure 2. Likelihood ratio statistic as a function of megabases on chromosomes 1-19 and X in mice. This particular run produced four suggested peaks on chromosome 2, 6, 14, and 17. These regions of chromosome likely had an impact on the phenotype

.

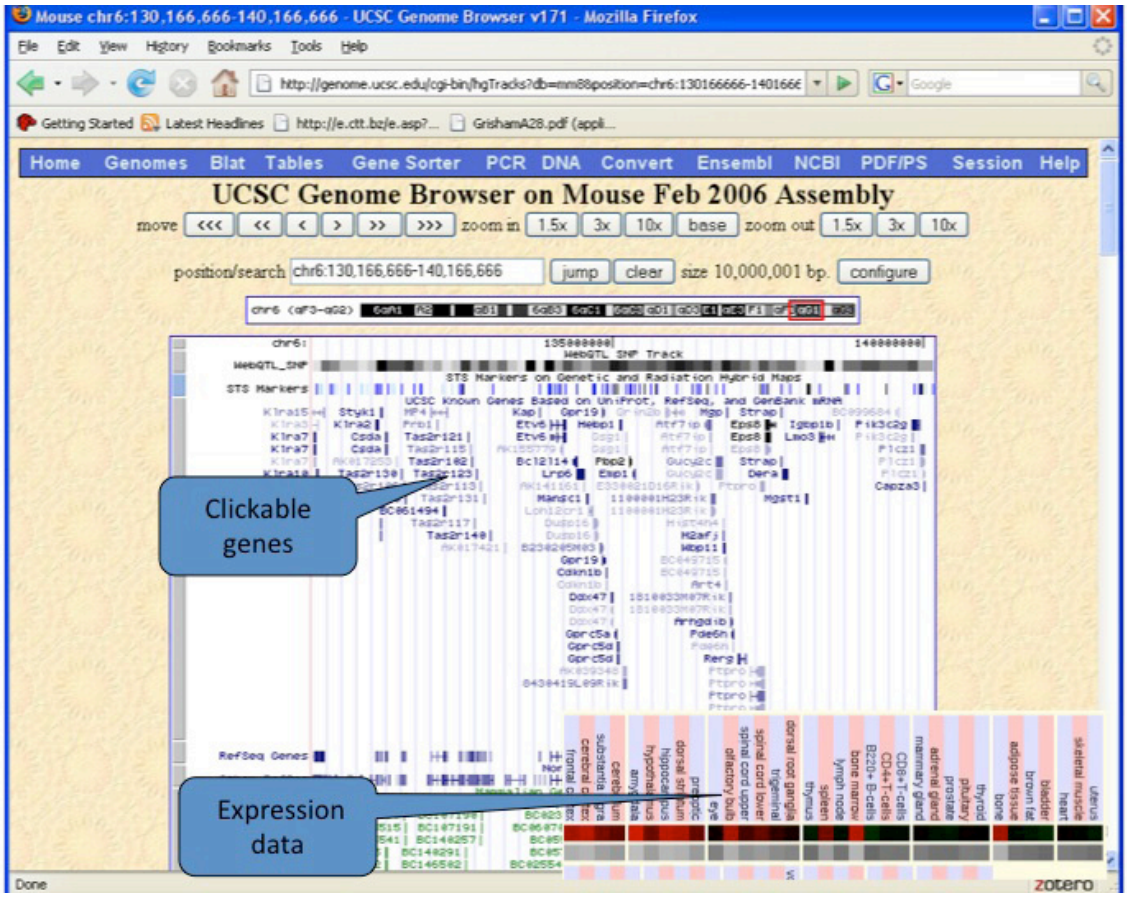

Figure 3. Screenshot from the UCSC genome browser showing representation of hot-linked genes on a distal portion of chromosome 6 and the microarray expression data displayed when the link is clicked

.

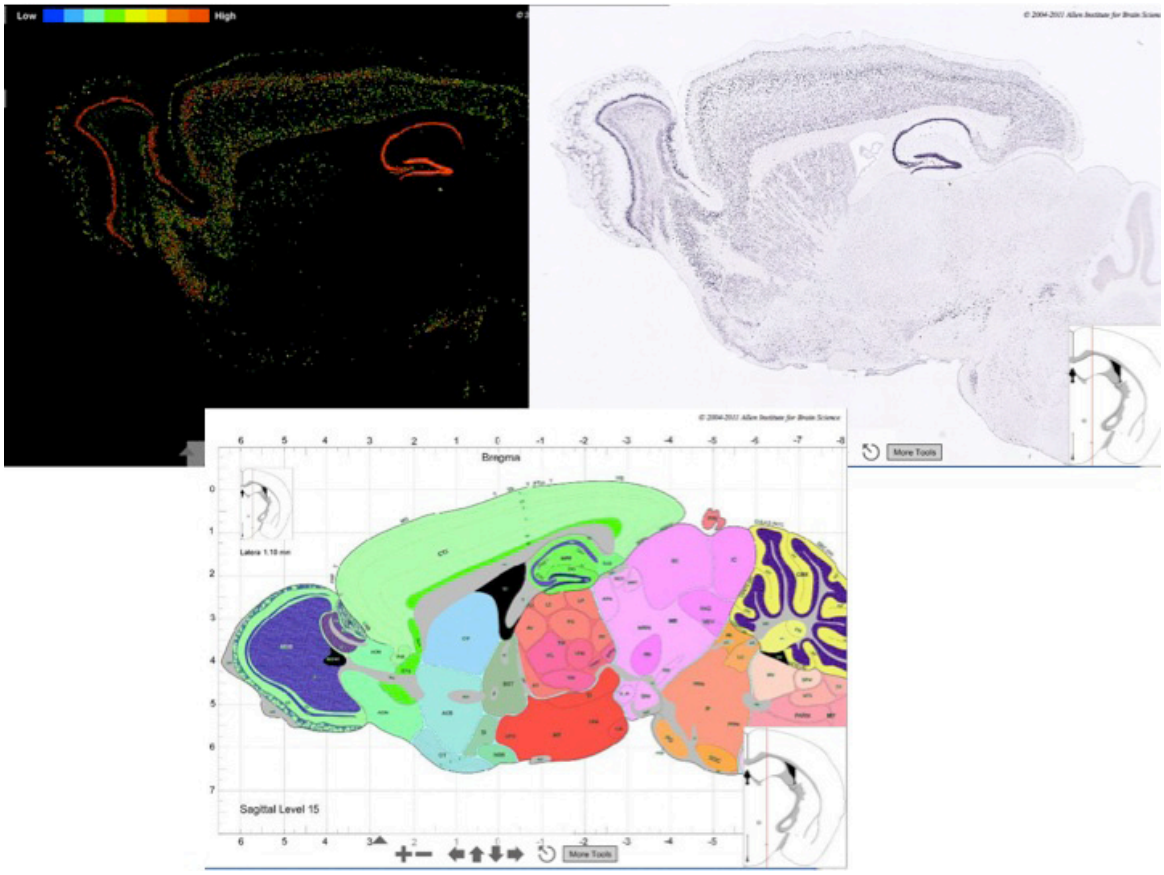

Figure 4. Screen shots of mouse brains in sagittal section from the Allen Brain Atlas showing the in situ hybridization pattern of cells expressing an identified gene. Top left is relative expression with red loop on the left showing the cell layer in the olfactory bulb expressing the gene. Top right is the actual in situ section. Bottom shows a plate from a detailed interactive atlas that would allow students to identify the highly expressing cells as the mitral layer.

Developmental Biology: Using the Bird Song System to Introduce the Experimental Method

In this module, students are introduced to an experimental approach, and appropriate data analyses for an experiment using multiple groups. Students repeat and extend a published experiment, examining the relationship between the dose of hormone given in early life and the degree of masculinization in the bird song system. The Bird Song System module employs the strategy of giving data in its rawest form (digital images) to students. Students perform every aspect of the experiment except the sectioning and staining of tissue. Specifically, students are given sets of images of adult zebra finch brains that came from either control females and males or females that were treated with 5, 15, or 50 µg of estradiol (estrogen) as hatchlings (Fig. 5).

Students learn basics of experimental design such as avoiding confounding observer characteristics with treatment conditions and avoiding experimenter bias by keeping blind to treatment. Moreover, students learn data analysis for a multiple group design, using an ANOVA with post-hoc tests. Further, they learn to interpret data in the framework of the inquiry (Fig. 6).

Students are also introduced to technical writing and content about the effect of steroid hormones on brain development. Further details about this module are available (Grisham, Schottler, Beck McCauley, Pham, Ruiz, Fong, & Cui, 2011).

Swimmy—Designing, Performing, and Interpreting Neurophysiological Experiments

Swimmy is an application written in a language known as NEURON, which investigators use to model neuronal functions. Swimmy employs a virtual neural circuit that produces oscillatory activity akin to a type of central pattern generator. In order to explore this circuit, students initially learn the basics of electrophysiology (summation and inhibition) and the basics of intracellular recording and experimental design using simple neural circuits.

Subsequently, students use a more complex circuit (Fig. 7) and devise their own experiments 1) to discern which neurons are relevant to the circuit and which are not 2) to discern monosynaptic connections among the neurons, 3) to discern

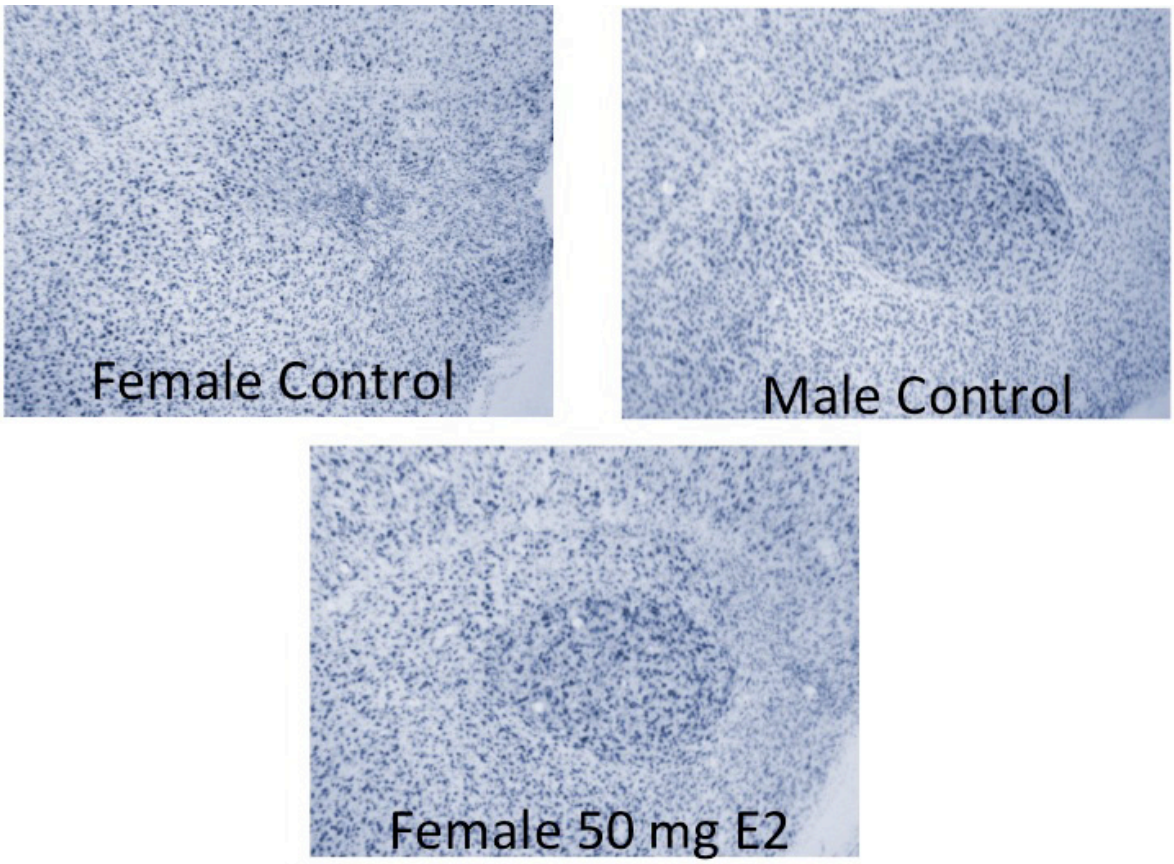

Figure 5. Photomicrographs of RA, one of the groups of neurons in songbird brains responsible for the production of song. Top two panels show the difference in this species (zebra finch) between males who sing and females who do not. Bottom panel shows the impact that exogenous steroid hormones can have on the development of this system and the profound masculinization that can be induced.

which neuron(s) are responsible for the pattern of activity in the entire circuit and the motor neurons specifically, and 4) to discern how the oscillatory pattern of activity is produced in the neural circuit. Students are challenged not only to draw conclusions but also to present their data in a clear and convincing manner. Six versions of Swimmy are provided, each of which is unique in some way—either in the labeling of the cells or in the mechanism of oscillation or both.

Pedagogical goals include 1) critical thinking and reasoning skills in designing one's own experiments and interpreting the data, 2) clarity of presenting data, and 3) learning basics of neurophysiology. More details about Swimmy can be found in Grisham, Schottler, and Krasne (2008).

Implementing the Modules

The materials offered provide instructors the ability to provide good quality laboratory experiences regardless of resource limitations. All that is required to execute any of these modules is a computer with internet access—no special equipment is required. All of these modules have been extensively field-tested and shown to be efficacious teaching tools both at UCLA and other institutions. All of the materials for teaching these materials are available at **http://mdcune.psych.ucla.edu/**. Faculty can gain access to special faculty-only materials by going to **http://mdcune.psych.ucla.edu/faculty** and setting up a faculty account.

Acknowledgements

Supported by grants from NSF DUE-0717306 and the UCLA Office of Instructional Development to WG.

Literature Cited

The GeneNetwork From the University of Tennessee. 2001. GeneNetwork Main Site **http://www.genenetwork.org/** (accessed 13 May 2009).

Grisham, W., N. A. Schottler, L. M Beck McCauley, A.P Pham, M. L Ruiz, M.C. Fong, and X. Cui. 2011. Using digital images of the zebra finch song system as a tool to teach organizational effects of steroid hormones: A free downloadable module. *CBE Life Sciences* 10(2), 222-230.

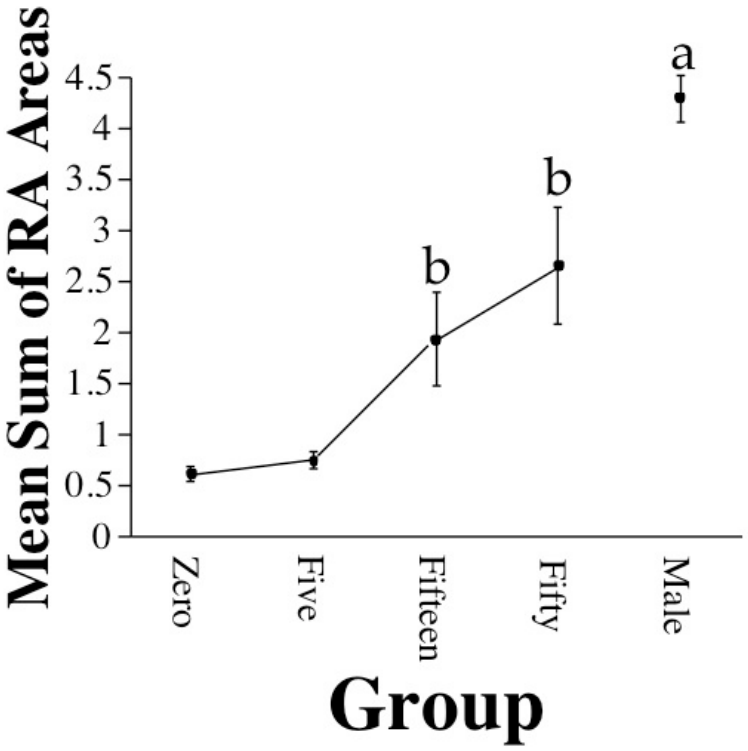

Figure 6. Data from students quantifying RA as a function of treatment group (means and SEM). Zero, Five, Fifteen, and Fifty refer to the microgram doses of estradiol administered at hatching to females. Male refers to control males. a = significantly different from all other groups, b = significantly different from other groups but not each other.

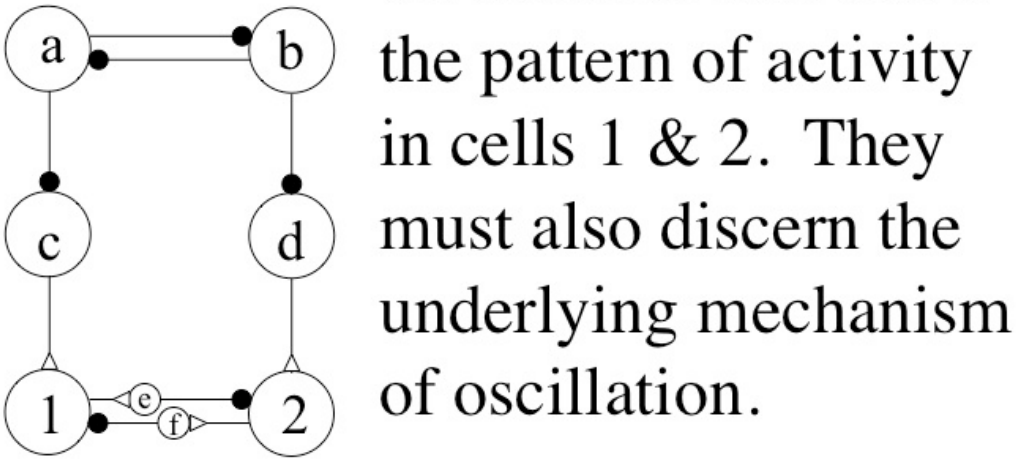

Figure 7. Schematic of circuit that students ultimately discover. Students discern monosynaptic connections and oscillatory mechanism via experiments of their own device.

Grisham, W., N. A Schottler, and F. B. Krasne. 2008. SWIMMY: Free software for teaching neurophysiology of neuronal circuits. *Journal of Undergraduate Neuroscience Education* 7(1), A1-A8.

Grisham, W., N. A.Schottler, J. Valli-Marill, L. M. Beck, and J. Beatty. 2010. Teaching bioinformatics and neuroinformatics using free web-based tools. *CBE Life Sciences*. 9, 98–107.

Kent WJ, C.W. Sugnet, T.S. Furey, K.M. Roskin, T.H. Pringle, A.M. Zahler, and D. Haussler. 2002. The human genome browser at UCSC. *Genome Research*. Jun 12(6):996-1006.

The Mouse Brain Library (2005). The Mouse Brain Library – Search the Library. **http://www.mbl.org/** (accessed 9 December 2008).

About the Authors

Dr. William (Bill) Grisham once upon a time scraped a stone (chalk) on another stone (slate) in order to make a didactic point. Since emerging from the Stone Age, he has used and developed digital tools to teach biology and neuroscience at UCLA. He is also working to give these tools away to the world for free courtesy of NSF funding.

Dr. Frank Krasne is Professor Emeritus of Psychology at UCLA and the author of the Swimmy application, which is presently the only digital tool that examines circuits of neurons and their properties.

Dr. Jackson Beatty is also a Professor Emeritus of Psychology at UCLA. Dr. Beatty had the original inspiration to bring the sophisticated QTL analysis to an undergraduate level.

Natalie Schottler has worked in the Psychology Dept. at UCLA for several years and deserves credit for making the student and instructor manuals and handouts clear enough for easy use and adoption.

Mission, Review Process & Disclaimer

The Association for Biology Laboratory Education (ABLE) was founded in 1979 to promote information exchange among university and college educators actively concerned with biology learning and teaching in a laboratory setting. The focus of ABLE is to improve the undergraduate biology laboratory experience by promoting the development and dissemination of interesting, innovative, and reliable laboratory exercises. For more information about ABLE, please visit **http://www.ableweb. org/**

Papers published in *Tested Studies for Laboratory Teaching: Proceedings of the Conference of the Association for Biology Laboratory Education* are evaluated and selected by a committee prior to presentation at the conference, peer-reviewed by participants at the conference, and edited by members of the ABLE Editorial Board.

Citing This Article

Grisham, W., Krasne, F.B., Schottler, N.A., and Beatty, J. 2012.Modular Digital Course in Biological Education. *Tested Studies for Laboratory Teaching,* Volume 33 (K. McMahon, Editor). Proceedings of the 33rd Conference of the Association for Biology Laboratory Education (ABLE), 390 pages. http://www.ableweb.org/volumes/vol-33/?art=45