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Developmental Biology Courseware that Integrates Multimedia Technology into the Laboratory and Classroom Experience

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Final Report for Period: 03/2001 - 02/2005**Submitted on:** 01/11/2006**Principal Investigator:** Tyler, Mary S.**Award ID:** 0087657**Organization:** University of Maine**Submitted By:****Title:**

Developmental Biology Courseware that Integrates Multimedia Technology into the Laboratory and Classroom Experience

Project Participants**Senior Personnel****Name:** Tyler, Mary**Worked for more than 160 Hours:** Yes**Contribution to Project:****Post-doc****Graduate Student****Name:** Pratt, Jonathan**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Jon Pratt has is a new graduate student. He provided a complete critique of the beta-CD-ROM, and he has started working on developing interactive pieces for the CD as well as for the website. He developed our Zebrafish system for maintaining adults and raising embryos.

Supported by the department as a TA as well as by this NSF grant as an RA.

Undergraduate Student**Technician, Programmer****Name:** Kozlowski, Ronald**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Ron Kozlowski is the computer expert for this project. He does all the programming, set up the server, set up the web site and maintains the website. He also teaches software programs to others in the lab.

He is supported entirely by this NSF project.

Other Participant**Name:** Crawford, Karen**Worked for more than 160 Hours:** No**Contribution to Project:**

Serves as an external evaluator of the products of this project.

Name: Fink, Rachel**Worked for more than 160 Hours:** No**Contribution to Project:**

Serves as an external evaluator of the products of this project.

Name: Gilbert, Scott**Worked for more than 160 Hours:** No

Contribution to Project:

Serves as an external evaluator of the products of this project. Collaborated on the CD, Differential Expressions, filming 4 of the 6 scientists interviewed for this CD, and reviewing each of the 6 movies created.

Name: Smith, Julian

Worked for more than 160 Hours: No

Contribution to Project:

Serves as an external evaluator of the products of this project.

Name: Ernst, Susan

Worked for more than 160 Hours: No

Contribution to Project:

Serves as an external evaluator of the products of this project.

Name: Foltz, Kathaleen

Worked for more than 160 Hours: No

Contribution to Project:

Serves as an external evaluator of the products of this project.

Name: Hirshfield, Anne

Worked for more than 160 Hours: No

Contribution to Project:

Serves as an external evaluator of the products of this project.

Name: Eckberg, William

Worked for more than 160 Hours: No

Contribution to Project:

Serves as an external evaluator of the products of this project.

Research Experience for Undergraduates**Organizational Partners****Other Collaborators or Contacts**

I have been collaborating with Scott Gilbert at Swarthmore College to produce history videos as part of this project.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings: (See PDF version submitted by PI at the end of the report)

Training and Development:

The Vade Mecum CD is in the hands of over 17,000 students from the US and over 7000 students from foreign countries each year. Each of these students is being trained in how to work with and interpret the development of the model organisms used in developmental biology. The methods being taught are for low-cost experiments that show students how to construct their own tools out of common, inexpensive materials, how to adapt an inexpensive microscope to have it perform as an expensive instrument,

and how to work with the living embryos. By keeping the cost of the Vade Mecum CD to a minimum (it adds \$5 to the cost of the Gilbert textbook with which it is packaged) and making the Vade Mecum Web Site available to all, this course material is useful to learning at all institutions regardless of their financial status.

Outreach Activities:

We have presented two workshops demonstrating our materials for University professors and for future K-12 teachers.

Developing Multimedia Educational Materials for a Biology Class. Mary S. Tyler and Ronald N. Kozlowski. Maine Mathematics and Science Teaching Excellence Collaborative. First Annual MMSTEC Mid-Year Conference. Workshop, March 2, 2001. Augusta. Ours was both a morning and afternoon workshop. We were one of two invited workshops for the conference.

Multimedia in the Classroom. Mary S. Tyler and Ronald N. Kozlowski. A series of two workshops we were invited to present at the NSF Conference for Future Teachers, March 3, 2000. UMaine, Orono.

We adapted our materials on Zebrafish, the raising of adults and embryos, and the effects of environmental hazards and pharmacological agents on development for use in the University of Maine Upward Bound Summer Program for High School students, for the summer, 2003. The students did individual experiments that they designed themselves from the laboratory instructions, and wrote their findings up in a self-published journal.

Journal Publications

Tyler, Mary S., Scott F. Gilbert, and Ronald N. Kozlowski, "Journeys Through Great Experiments in Developmental Biology, as Told by Those Who Performed Them.", *Developmental Biology*, p. , vol. , (). Abstract for SDB meeting,

Tyler, M. S., and R.N. Kozlowski, "Vade Mecum2: Educational Multimedia for Developmental Biology", *Developmental Biology*, p. , vol. , (). Accepted,

Books or Other One-time Publications

Tyler, Mary S., "Developmental Biology: A Guide for Experimental Study. 3rd Edition.", (2003). Book, Published
Bibliography: Sinauer Associates

Tyler, Mary S., and Ronald N. Kozlowski, "Vade Mecum 2: A CD-ROM for Developmental Biology", (2003). CD-ROM, Published
Bibliography: Sinauer Assoc., Inc. Sunderland, MA

Tyler, M.S., and R.N. Kozlowski, "FlyCycle 2. A CD-ROM of the Lives of a Fly, *Drosophila melanogaster*", (2003). CD-ROM, Published
Bibliography: Sinauer Assoc., Inc. Sunderland, MA

Tyler, M. S., R. N. Kozlowski, and S. F. Gilbert, "Differential Expression: Key Experiments in Developmental

Biology", (2003). CD-ROM, Published
Bibliography: Sinauer Assoc., Inc.,
Sunderland, MA

Tyler, M. S., and R. N. Kozlowski, "Fly Cycle2 DVD", (2003). DVD, Published
Bibliography: Sinauer Assoc., Inc., Sunderland,
MA

Tyler, M. S., R. N., Kozlowski, and
S. F. Gilbert, "Differential Expressions: DVD", (2003). DVD, Published
Bibliography: Sinauer Associates, Sunderland,
MA

Web/Internet Site

URL(s):

<http://www.developmentalbiology.net>

Description:

This website was developed specifically for this project. It integrates with the CD-ROM that is also being developed for this project. The website is still a work in progress.

Other Specific Products

Contributions

Contributions within Discipline:

Training students to do science is a major responsibility of universities, and yet as technological advances push the costs of doing science ever higher, the costs of training undergraduates as scientists often seem prohibitive. Our solution to this problem, and the goal of this project, has been to design low-cost laboratories that maximize the use of equipment and materials and utilize multimedia technologies that can add resources without increasing costs. We have used these technologies to provide a low-cost "tool-kit" for students that increases the effectiveness of their subsequent hands-on experience. By creating a multimedia "tool-kit" that coordinates with laboratory and lecture material and introduces low-cost techniques, we are empowering students as independent learners. Our "tool-kit" consists of an interactive CD-ROM-Web hybrid that is thoroughly integrated with a laboratory textbook, to be included on the CD as PDF files, and coordinated with a major lecture textbook in developmental biology.

Not only does the CD-Web hybrid prepare students for their laboratory studies and expand that experience, it also helps train teachers and graduate teaching assistants in laboratory methods that they might previously have been unfamiliar with. A major outcome of this project is that it will provide affordable learning materials to students in developmental biology. In this regard, it should serve as a "great equalizer," offering equal opportunities in learning, encouraging students to learn science by doing science. Such a coordinated group of teaching

materials for developmental biology does not otherwise exist at present.

The need for multimedia materials in developmental biology is great. The very nature of the subject, being the study of morphological change over time, lends itself to the use of multimedia. And yet few multimedia products are available: only one developmental biology textbook is published with a CD-ROM and this is Gilbert's text (2000) with the beta-version CD that we have produced (Tyler and Kozlowski, 2000), there are several films (Fink, 1991, 1995; Tyler, Schnetzer, and Tartaglia, 1995), there is a CD-ROM covering the life cycle of the fruit fly (Tyler, Kozlowski, and Iten, 1998) and there is a CD-ROM that contains slide material of chick, frog, and pig embryos for developmental anatomy (Schoenwolf, 1997). Our courseware, therefore, adds significantly to the available materials. In addition, the history videos that we are developing are the only ones in existence that document the specific work of living developing biologists, and explains that work in the context of the larger field of development.

Contributions to Other Disciplines:

Our course material has been presented to teachers in K-12 science, and even though our material has been designed for college-level students, these teachers have been enthusiastic about using the material as background to develop exercises for their own students and as a resource for answering questions their students pose.

Our course material on Zebrafish was adapted for High School students in the University of Maine Upward Bound Summer program.

Our course material on Planaria and Drosophila has been adopted by several High Schools in the Bangor, Maine area.

Our video material on Drosophila has been used by NHNZ, a New Zealand television studio, for a nature film called, 'Mutants.'

Contributions to Human Resource Development:

Many of the students that use our course material go on into teaching, and many of my own students going on in teaching have attributed their excitement and interest in biology as having been inspired by the simple techniques, low-cost of materials, and hands-on experience that are taught in our course material.

Contributions to Resources for Research and Education:

Our CD-ROM in developmental biology has been distributed to over 25,000 students, and our website with which the CD-ROM is integrated has been visited over 196,000 times, with the number of distinct hosts served being 11,014, in the last five months. This means that we have contributed resources useful to both research and education to a large number of students, faculty, and institutions.

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Organizational Partners

Any Product

Contributions: To Any Beyond Science and Engineering

Findings

In addition to the information reported in the previous section, we can add the following.

Evaluation Process:

From the review process, we learned from the panel of external reviewers that faculty were interested in having a chapter on the Zebrafish added to the CD-ROM as well as a glossary of terms. Most faculty who reviewed the CD will be or are currently using the CD in their courses on developmental biology. The CD is considered easy to navigate. Several minor flaws in the material were reported and corrected.

From reviews submitted by faculty who are presently using the Gilbert textbook, in which the CD-ROM is packaged, we learned the following:

A total of 35 Reviews were received.

Large university – 29

Small university – 5

Small liberal arts – 1

25 schools chose to adopt the CD,

9 chose not to use the CD, usually because their courses did not include a lab portion,

1 school failed to report its use.

In the schools that reported adopting the CD, a total of 1620 students were using the CD.

In the schools not using the CD, 749 students were enrolled in the courses that might have used the CD.

Sales of the beta-CD-ROM:

Vade Mecum sales as of October 31, 2001

Packaged in the Gilbert Textbook -- 24,561

Stand alone – 315

Of these sales,

domestic sales were: 17079

foreign sales were: 7797

The Website:

In past 5 months, the website has been visited 196,775 times.

In past week: 9,935

Average per day: 1,270

Average per day in past week: 1,419

Additional Work: (2001-2002)

- We presented 3 of the history videos at the Northeast Society for Developmental Biology meeting in Woods Hole. The videos were well received, and most people who view them are anxious to get copies of the videos to show in their classes.

- The Education Booth at the National SDB meeting heard about our history videos and asked us to show them as part of their Educational Booth throughout the meeting.

Additional Work: (2002-2003)

- We presented 5 of the history videos at the National SDB meeting, in Madison Wisconsin, in July. The videos were very well received, and most people who view them were anxious to get copies of the videos to show in their classes.
- We presented all three of our CD-ROMs in a seminar to the Department of Biological Sciences, University of Maine, in January. It was well received.
- We presented our *Vade Mecum*² CD-ROM at the SDB International meeting in the summer in Boston, MA.

Additional Work: (2003-2004)

- We presented our *Vade Mecum*² CD-ROM at the SDB International Meeting in Boston, MA, July 30-August 3, 2003. It was very well received.
- We presented the same work at the NSF-CCLI invited conference, 'Invention and Impact: Building Excellence in Undergraduate STEM Education'. Arlington, VA. April 15-18, 2004.

Additional Work: (2004-2005)

- I presented our work on *Vade Mecum* at an invited teachers workshop, Improving Biology Education: Theory and Practice, in March in Boston, organized by W. H. Freeman and Sinauer Associates.
- I gave an invited seminar on Women in Science, “Differential Expressions and the Work of Elizabeth Hay,” in November at the Women In Curriculum Seminar Series, University of Maine.

Research and Education Activities Final Report

The major activities of this project were to develop multimedia courseware that would make a wealth of resources available to undergraduate college students who are exploring the field of developmental biology.

The multimedia courseware we developed consists of an interactive CD-ROM that interfaces with an interactive Web site. This CD-ROM/Web hybrid instructs students on techniques and the biology of organisms used in this field. The courseware is called *Vade Mecum*, Latin for “go with me,” which was a term used in the past to designate a manual or handbook, and is used here to refer to the portability of this courseware, aiding its usefulness as the student uses it to explore developmental biology.

These materials are meant to integrate directly with a laboratory manual developed by the PI and the major textbook in the field, *Developmental Biology*, by Scott F. Gilbert, in which the CD-ROM is packaged.

We also developed two additional educational CD-ROMs designed for Developmental Biology undergraduate courses. *FlyCycle²*, a 45-minute video on the biology of the fruit fly developed into an interactive CD-ROM and integrated with a Web site. And *Differential Expressions*, a collection of videos on major problems in developmental biology and famous scientists who have worked on them.

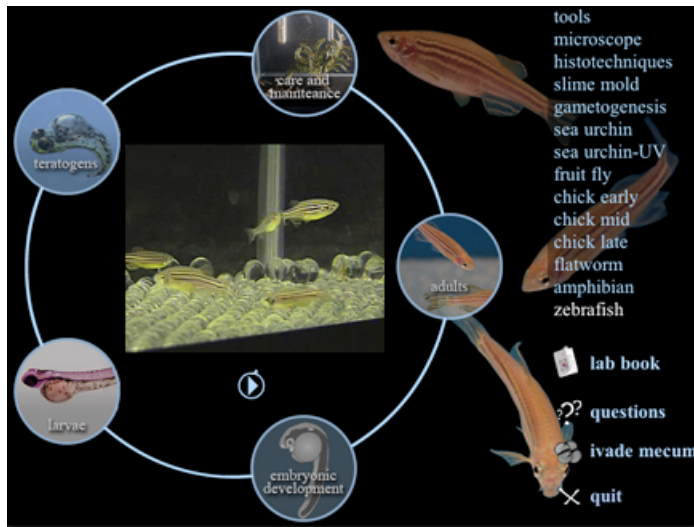
Summary of Results of Completed Work:

1) Creating Vade Mecum²: the CD-ROM/Web Hybrid:

Goal 1: Evaluation and critique of beta-version of *Vade Mecum* CD-ROM. For this, we created an electronic computerized form and evaluated the comments from 25 professors that had adopted the beta-CD, approximately 60 students using the beta-CD, and 8 external reviewers of the project.

Goal 2: Completing and publishing the enhanced *Vade Mecum²* version of the CD based on the initial evaluation. We made the following additions and alterations to the CD:

- Developed an additional chapter on zebrafish.
- Developed a searchable glossary, and added definitions that appear on rollover.
- Developed quizzes for each chapter in PDF format that can be printed.
- Designed and built a new Web site (www.developmentalbiology.net), which includes sections on the Tyler (2003) laboratory manual, laboratory safety, each of our other CD-ROMs, interactive puzzles, and a page of current news items in development that is updated weekly.



Menu screen from the *Vade Mecum*² CD.

- Redesigned the operating system of the *Vade Mecum*-CD so that data could be accessed from a database.
- Created a new feature for the CD called *iVade Mecum*, which connects users through the Internet to interactive puzzles, other Web sites, and allows users to create bookmarks.
- Set up and maintain two servers for our Web site, maximizing them for security and load balancing.

- Having built a feedback mechanism into the CD, we built a feedback Web application that can interpret the data and run various statistical analyses on them, allowing us to track what chapters users have visited, how long they spend there, and the institutions using the CD.
- Published *Vade Mecum*² (Publ.: Sinauer Associates). It is available as a stand-alone CD as well as in a package with the textbook by Scott Gilbert, *Developmental Biology*, 7th Edition.



Cover for *Vade Mecum*² CD.

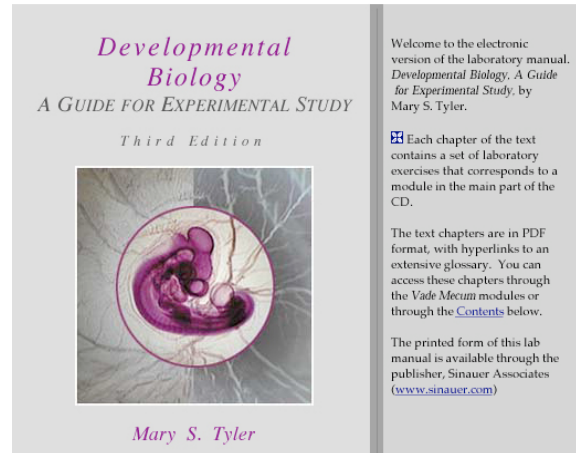
*Goal 3: Evaluation of the Vade Mecum*² CD-ROM. We have evaluated *Vade Mecum*² and its use in the classroom.

- In spring '03, we began assessment by making prepublication copies of the *Vade Mecum*² CD for 33 students (Univ. of Maine), and used it spring '03 semester in the development course. We also had students at Swarthmore College critique the CD.
- In spring '04 and continuing into fall '04, we completed our evaluation using classes at the Univ. of Maine and our evaluation team at other universities and colleges.
- As a result of our evaluation, we are continuing to modify *Vade Mecum*, and have started planning to create a completely on-line version of the program.

2) Creating a revised Tyler Laboratory Manual:

Goal 4: Create the 3rd edition of *Developmental Biology, A Guide for Experimental Study* so as to make full use of the *Vade Mecum* CD-ROM and enhance the laboratory experience.

- Added glossaries to each chapter and a new chapter on zebrafish (35 pages), with an emphasis on teratogens common in the environment and in home medicine chests.
- Created the lab manual in electronic form and included it on the *Vade Mecum*² CD-ROM. Content mirrors that of the *Vade Mecum*² CD-ROM, with the addition of a "Getting Started" chapter.
- Tested the electronic version of the Lab Manual in the spring '03 and '04 in the developmental biology course at the University of Maine (33 students and 38 students, respectively).



Cover of Electronic Version of Book

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Appendix 1: List of Recipes

Appendix 2: List of Suppliers and Addresses

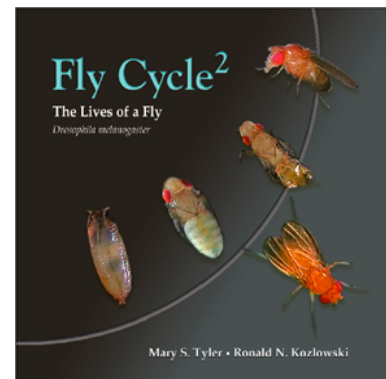
Full Glossary

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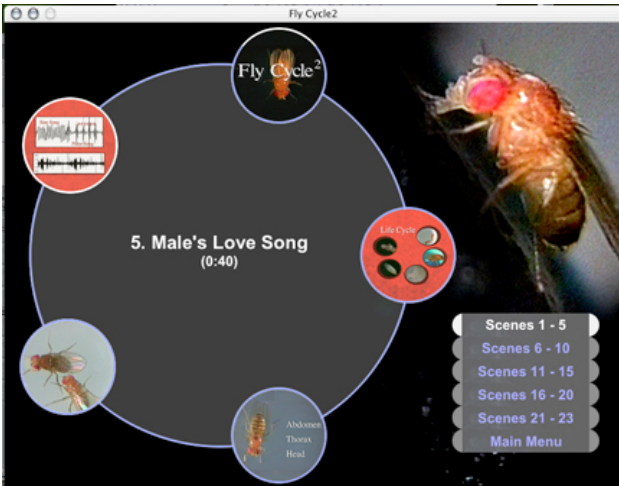
3) Creating a revised version of *Fly Cycle*²: A CD-ROM:

Additional work outside the goals of the original grant: Though not in the original project plan, we created a new version of *FlyCycleCD*. The CD includes forty minutes of QuickTime movies, depicting details on the biology and life cycle of *Drosophila*. We also created a DVD version that has been published. New on this CD-ROM are:

- A complete set of laboratory instructions and glossary terms in printable PDF format.
- Interactive puzzles and questions for each chapter of the film.
- Larger video format, with improved video and audio quality.
- A complete set of laboratory instructions and glossary terms in printable PDF format.



Cover for *Fly Cycle*² CD.



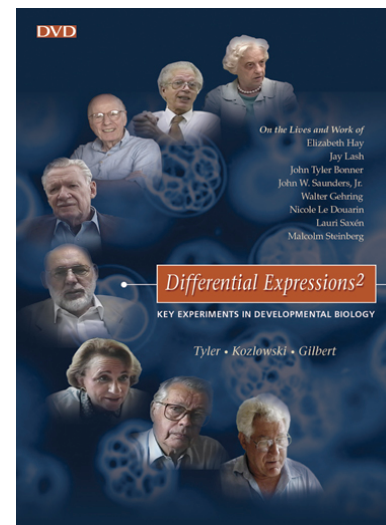
Screen shot of Interface of FlyCycle² CD.

- Interactive puzzles and questions for each chapter of the film.
- Larger video format, with improved video and audio quality.
- New "play" features, with chapter tracks throughout, allowing play-through or scene-selection.

4) *Creating a new CD-ROM, Differential Expressions: Key Experiments in Developmental Biology:*

Additional work outside the goals of the original grant: Another extension of our original plan was the development of a CD-ROM and DVD that captures the life and work of eight influential scientists in developmental biology. In collaboration with Scott Gilbert, Swarthmore College, we developed eight short (8-22 minute) videos using taped interviews and explanatory graphics. We published this first as a set of six videos, and this year have expanded it to a two-disc DVD set of eight videos.

- From Somites to Thalidomide, a Story from Jay Lash
- Chimeric Grafts, Following the Pathways of Migrating Cells, the Work of Nicole Le Douarin
- Primary Induction, The Double-Gradient Hypothesis, the Story from Lauri Saxén
- Homeosis in the Fly, A Story of Transdetermination from Walter Gehring
- Growth and Pattern in the Vertebrate Limb, the Story from John W. Saunders, Jr.
- Sorting Out and the Differential Adhesion Hypothesis Of Malcolm Steinberg
- Extracellular Matrix: The Stuff from Cells, and the Discoveries of Elizabeth Hay
- Life Cycles, Lessons from the Cellular Slime Mold, *Dictyostelium discoideum*, as Discovered by John Tyler Bonner



Measures of Success: We stayed on schedule for satisfying the goals of the grant, and exceeded the original goals. Our *Vade Mecum*²-CD-ROM has been distributed to over 17,000 students from the US and over 7,000 students from foreign countries, and our Website with which the CD-ROM is integrated, over a five-month period, has been visited over 196,000 times, with the number of distinct hosts served being 11,014, representing 56 countries.