Building the foundation of a research-rich curriculum

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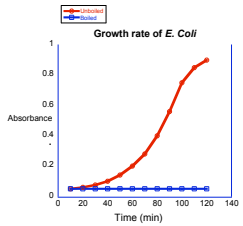
We want our graduates to:

- **understand the process of scientific inquiry**
- **be independent learners**
- **recognize that 'facts' are hypotheses well-supported by evidence**
- **be able to draw appropriate conclusions from evidence**
- **understand what kinds of issues are amenable to scientific inquiry and what kinds are not**
- **be able to collaborate effectively**

Like many of you, we try to achieve those goals by emphasizing student-designed, inquiry-driven laboratories

BUT how do we assure that student investigations aren't poorly conceived or executed?

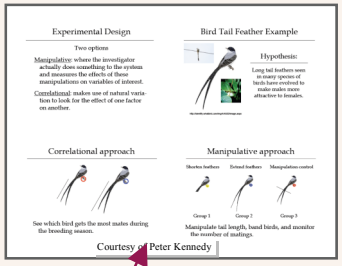
Effect of Boiling on Growth Rate in *E. coli*



Do Flip-Flops Cause Cancer? An Experimental Study

Abstract:

We attempted to train C57/Bl6 mice to wear teensy flip flops in order to test our hypothesis that flip-flop wearing would increase the frequency of foot cancer. Unfortunately…



Courtesy of Peter Kennedy

- Students must describe what they would do differently if repeating their experiment
- The lab manual provides a grading rubric

1: Use lecture time to teach experimental design and data analysis

6: Assign oral presentations of results, with emphasis on "research lessons learned"

We lay a foundation for research in the first-year core courses …

- Investigations in Ecology and Environmental Science (Bio 141)
- Investigations in Genetics and Evolutionary Biology (Bio 151)
- Investigations in Cell and Molecular Biology (Bio 200)

Their labs involve extensive student group-designed projects for which we--

2: Introduce primary literature

- Even first semester students can read carefully chosen papers
- Class discussions are used to develop ability to critically evaluate experiments
- Students develop "taste" from comparing good and flawed work
- Good experiments provide models for students designing their own

3: Provide feedback on projects prior to execution

- Student groups present research proposals to peers
- Proposals are critiqued by peers and course staff
- Students receive feedback on their experimental plan, and
- Learn from the strengths and weaknesses of other proposals

4: Monitor progress of experiments

- Obtain regular reports on progress of experiments (or make site visits to field studies)
- Helps students stay on task and assists in troubleshooting or modifying experiment
- Helps reduce last-minute scrambles for data or failed studies

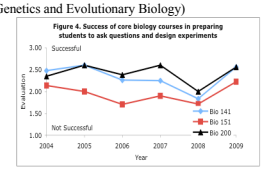
5: Assign written reports to be drafted in stages, with revision

- For multi-week projects, students write Introduction and Methods before obtaining Results.
- Instructor critiques these and students revise them
- Student groups outline Introduction, Results, and Discussion sections in lab (with instructor feedback) to assure common understanding, enrich collaborative interpretation, and reduce "you write section A and I'll write B" discontinuities.

An obligatory "Students at Work" photo

Student Outcomes

- Projects in upper-division courses are sound and sophisticated, often leading to longer-term projects and senior theses
- Interest in opportunities to collaborate on research with faculty has exploded
- 37 students have published in refereed journals under the mentorship of Biology Dept. faculty since 2004 (we graduate approximately 40 majors/year)
- 20 students since 2004 have presented at national meetings of disciplinary societies; one won the best student presentation prize and 3 were runners-up (vs. graduate student competitors)
- Many students have been accepted into top graduate and medical schools; others have chosen non-research careers in teaching, business, law, etc. where they can use their analytical and learning skills to good effect.
- Students feel that the introductory courses prepare them well for more sophisticated research in advanced courses (though there is still room for improvement; e.g., Biology 151 (Genetics and Evolutionary Biology)



Data from senior biology major exit surveys, in which students are asked to evaluate the efficacy of introductory courses in preparing them for advanced labs and research

Acknowledgements

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For further information

Please contact me: *reiness@lclark.edu*. More information on the biology program can be obtained at *www.lclark.edu/college/department/biology*

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