Engaging biology undergraduates in authentic, collaborative research throughout the curriculum

What is the need?

A revolution is underway in biology. The major focus of the biological sciences—understanding life—remains the same, but the science has experienced a major transformation. Many of the most exciting discoveries in the biological sciences during the second half of the 20th century occurred at the intersections of established disciplines. Emerging interdisciplinary fields such as genomics, proteomics, metagenomics, synthetic biology, biochemistry, bioinformatics, computational biology, and systems biology are leading to new discoveries, and some are changing the ways we think about and engage in biological research and explore established biological fields (such as evolutionary biology). These new integrated

What to Change

Key Concepts

1. **evolution** (the diversity of life-forms that have evolved over time through mutations, selection and genetic change
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5. **systems** (the ways in which living things are interconnected and interact with one another).

Core Competencies

1. the ability to **apply the process of science**
2. the ability to **use quantitative reasoning**
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4. the ability to **tap into the interdisciplinary nature of science**
5. the ability to **communicate and collaborate with other disciplines**
6. the ability to **understand relationships between science and society.**

How to Change

- Student centered learning
  1. interactive and inquiry driven
  2. cooperative and collaborative
  3. examines problems from a variety of perspectives

Undergraduate research is a high-impact student-centered teaching tool

DOANE COLLEGE

- 1200 Undergraduates at Crete campus
- 45% First Generation, 33% Pell Eligible
- Incoming students from class of <50: 30%

The path of the Doane College Biology Department

1991

VISION
'92-'95: In order to increase student engagement, student designed experimental experience required for all biology majors

CHANGE
1997-1999:
Lied Science and Math Building built to accommodate **student** research

VISION
Fall 2006:
Restructure core courses:
- Step back from taxonomy
- Include cell, genetics, evolution, and ecology
- Develop *skills* for biology majors

CHANGE
Fall 2007:
New introductory course ***sequence:***
- New foundational didactic courses: intro cell, ecology & evolution, and genetics
- Labs focused on student–designed experiments & science communication

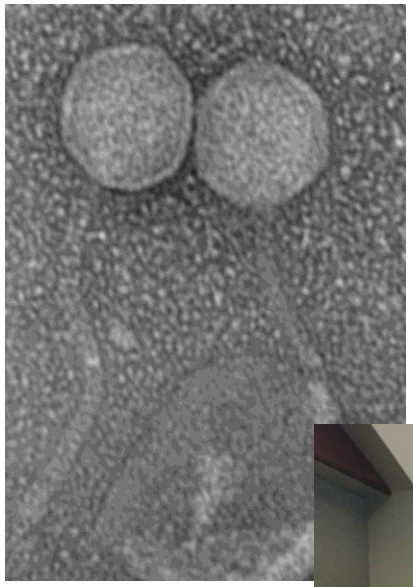
VISION
Fall 2011: Curriculum changes needed to align with V&C Core, address faculty overload, improve first year biology student retention

CHANGE
Fall 2013:
- Implementation of 1st semester inquiry **lab intensive** course for all biology majors
- Didactic courses 2nd & 3rd semester

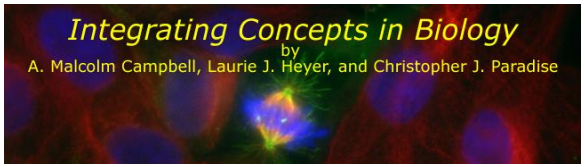
2013

Current Biology Curriculum

1. Bio 110 – Biological Inquiry



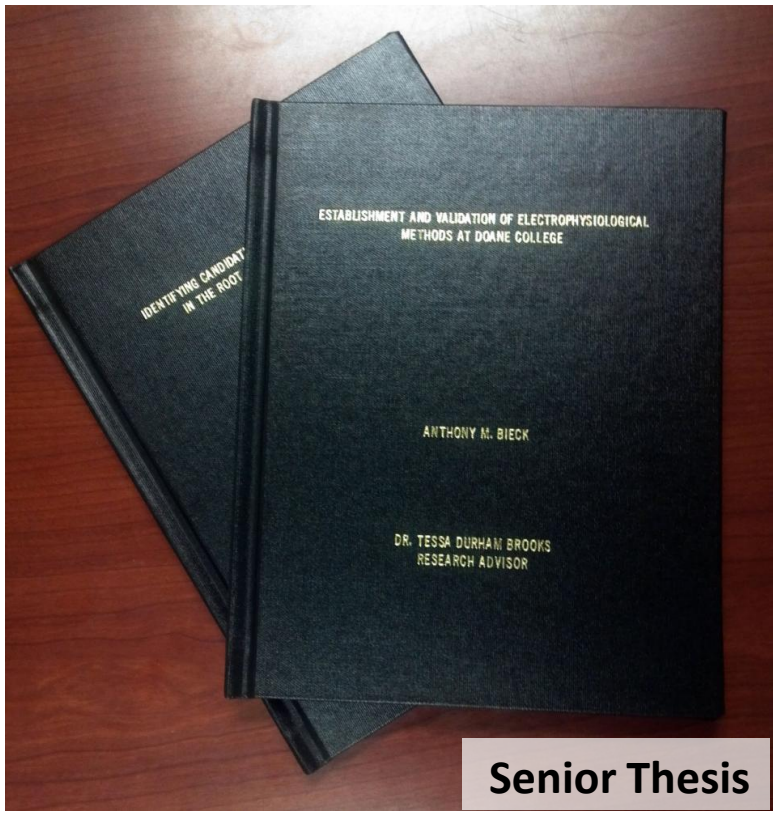
Current Biology Curriculum



2. Bio 111 – Energy of Life
   - Metabolism and energy usage from cells to ecosystems
3. Bio 112 – Information of Life
   - Information storage, utilization, and transfer from cells to ecosystems
4. Research sequence (unchanged)
   - Jr Seminar (write research proposal)
   - Sr Research I and II (conduct research, write thesis)

Research in the Division

Summer Research



Senior Thesis

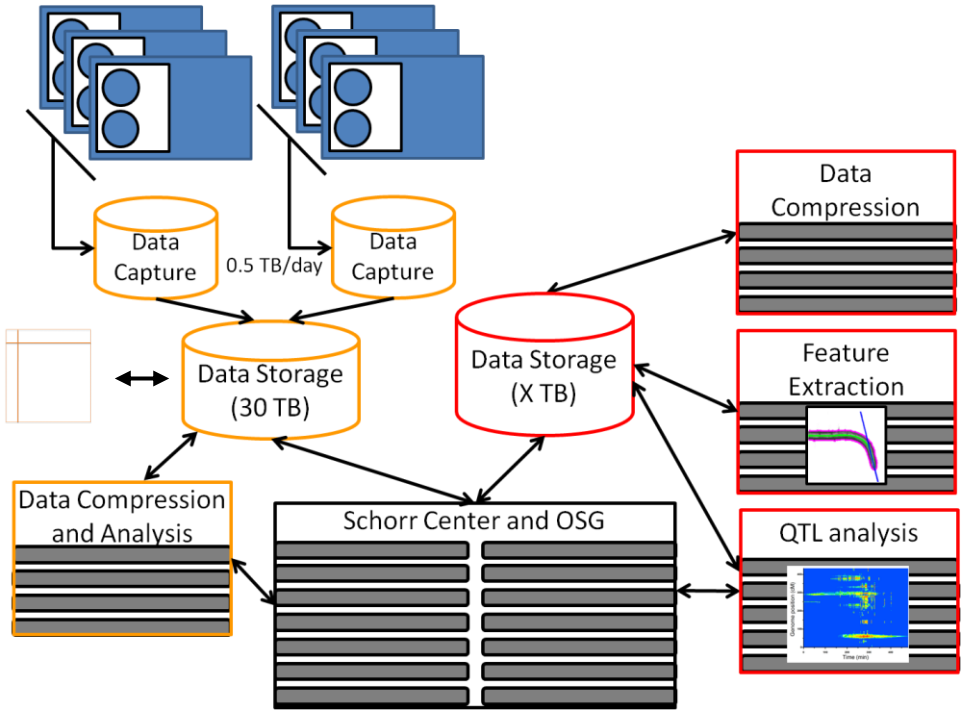

Mind Expo, Doane College

- Requirement of all majors
- Part of faculty load

Other Programmatic Changes

- New series of experiential seminars in gen. ed.
- Hire of a Computational Biologist
  - New elective in Computational Biology
- Computational Thinking minor
  - Integrates mathematics, computer science, and applied disciplinary courses
- Growing faculty interest in integrative research

All of these activities significantly contribute to the research environment of any lab.



Seedling Age	Seed Size: Small	Seed Size: Large
2d	*164 RILs + 99 NILs x 15 indiv.*	*3945 indiv.*
3d	*3945 indiv.*	*3945 indiv.*
4d	*3945 indiv.*	*3945 indiv.*

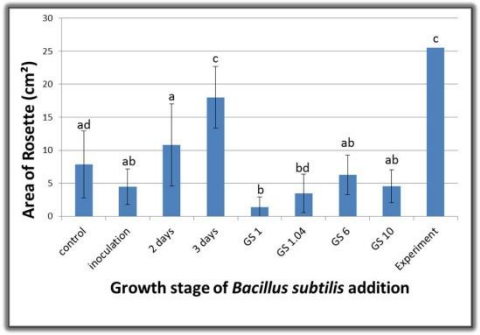
- In 1.25 years of ‘full throttle’ acquisition, collected 27,475 *successful* responses (> 70 TB)

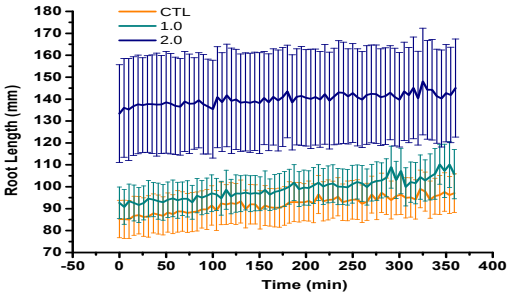
Research in the Durham Brooks Lab

- Since 2010, 12 students spearheaded collection of the genomics grid data
- 30 students have worked on independent projects related to this work
- Biology, physics, IST, and biochem students
- Average tenure in the lab is 15 months
- One publication with undergraduate authors, 19 presentations at regional and national meetings, 20 thesis papers

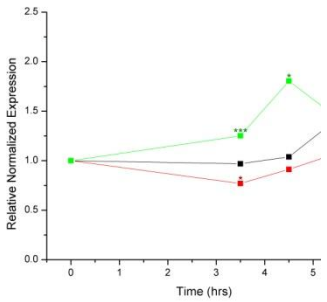
Independent projects

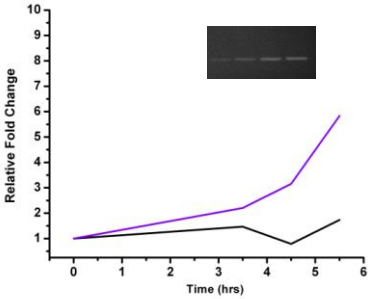
Image analysis



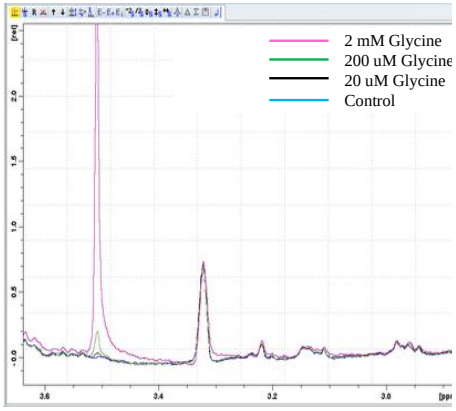


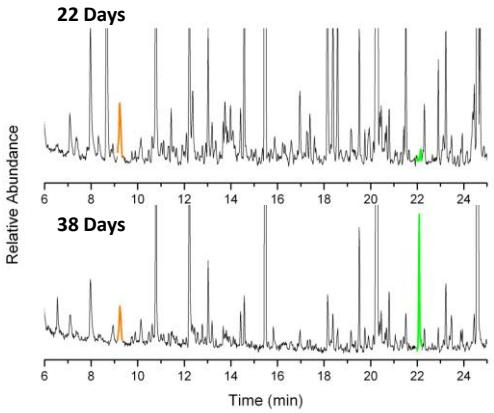
Expression analysis



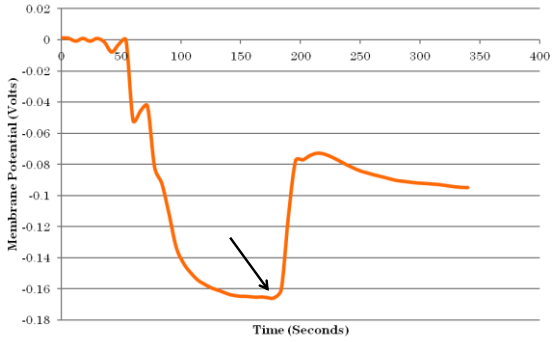


Metabolic analysis



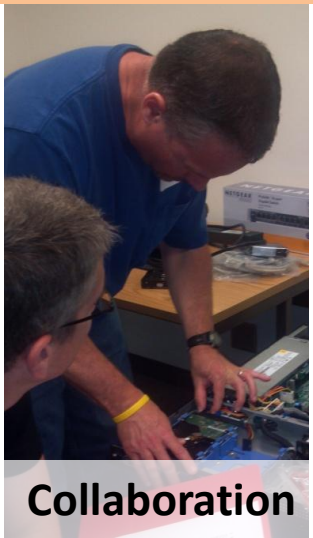


Electrophysiology



Authentic Research Experience Impacts Students

- **All for One** – all train and lead in the large-scale projects
  - Data collection and scheduling
  - Documenting methods and training
  - Database maintenance and project administration
- **One for All** – small groups initiate complimentary projects
  - Determined by interest and need, often cross-disciplinary
- Key components: Foster **leadership**, **collaboration** and peer **mentorship** within a structured framework



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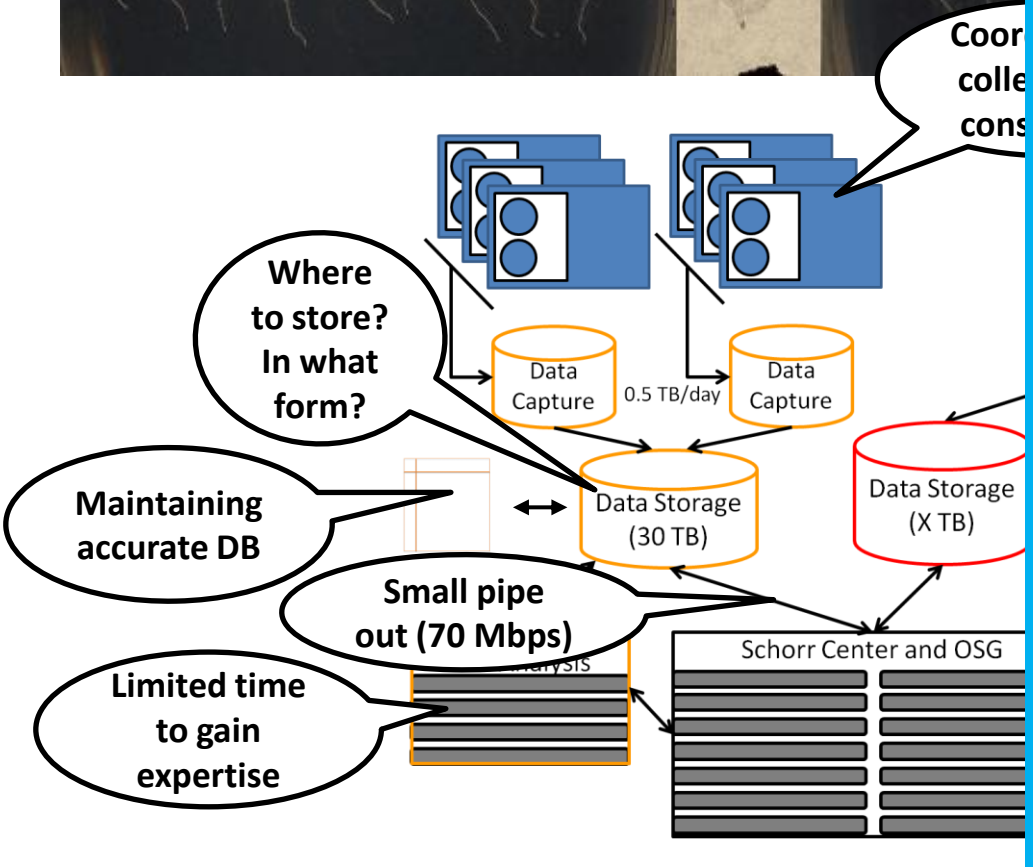
Bottlenecks



- Many bio students are afraid of math!
- Student buy-in to student centered vs traditional instruction
- Students need time (and sometimes compensation) to do meaningful research
- Faculty need time and compensation for research mentoring
- Faculty need time for development
- Requires a faculty body that embraces change

Questions?