Engaging biology undergraduates in authentic, collaborative research throughout the curriculum
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
Key Concepts

1. **evolution** (the diversity of life-forms that have evolved over time through mutations, selection and genetic change)

2. **structure and function** (the basic units of biological structures that define the functions of all living things)

3. **information flow, exchange and storage** (the influence of genetics on the control of the growth and behavior of organisms)

4. **pathways and transformations of energy and matter** (the ways in which chemical transformation pathways and the laws of thermodynamics govern the growth and change of biological systems)

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

3. the ability to use modeling and simulation

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.
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

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

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

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

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

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

• 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.
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

Figure 8: Representative chromatograms of volatiles collected at 22 days (above) and 38 days (below).

Orange, .

Green, β-Caryophyllene.
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
Key Concepts

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2. structure and function (the basic units of biological structures that define the functions of all living things)
3. information flow, exchange and storage (the influence of genetics on the control of the growth and behavior of organisms)
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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

Where to store? In what form?

- Maintaining accurate DB
- Small pipe out (70 Mbps)
- Limited time to gain expertise

Data Capture
- 0.5 TB/day

Data Storage
- (30 TB)
- (X TB)

Schorr Center and OSG
Questions?