UNIVERSITY OF CALGARY

Evaluating Student Learning in Large Introductory Biology Courses:
Predictors of Student Success and Lessons for Course Redesign

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Organizing the Core Biology Curriculum at U of C

Introduction to Cellular Biology (Biol 231)

Organismal Biology of Plants and Animals (Biol 233)

Principles of Genetics

Introduction to Ecology and Evolution

Introduction to Cellular and Molecular Biology

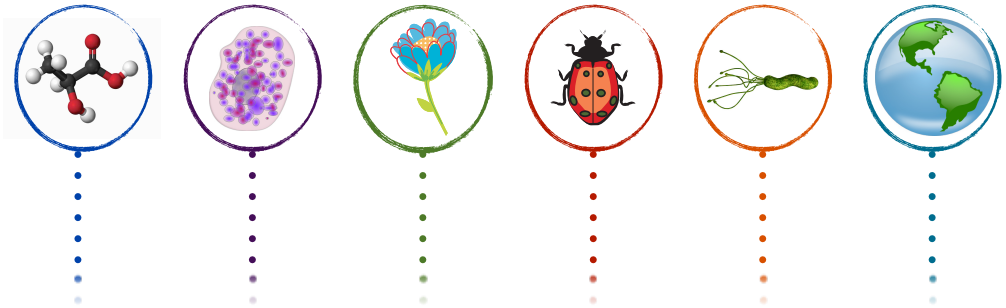
Introduction to Biochemistry

Student and Faculty Perspectives of Core Courses

Students	Faculty
Repetition from high school and between core courses	Some content repeated in several different courses
Focus on memorization of a LOT of detail	Content delivered not clearly "core" knowledge
Links between courses weak	Knowledge transfer between courses weak
Few opportunities for feedback on lecture content	Inconsistent learning experience between courses
Lab experience could be improved	Lab experience not "authentic" in all courses

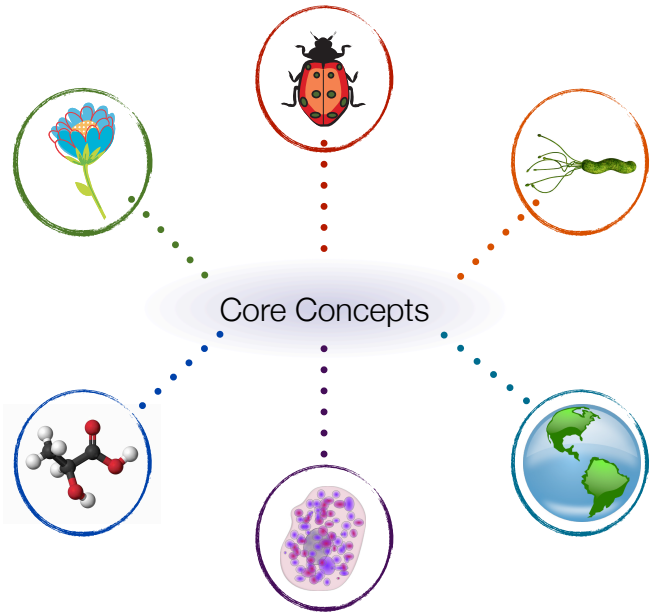
Traditional Organization of the Biology Curriculum

Core courses introduce “disciplines”, not biology



Integrated Understanding of Core Concepts

Using Core Concepts to Organize the Biology Curriculum



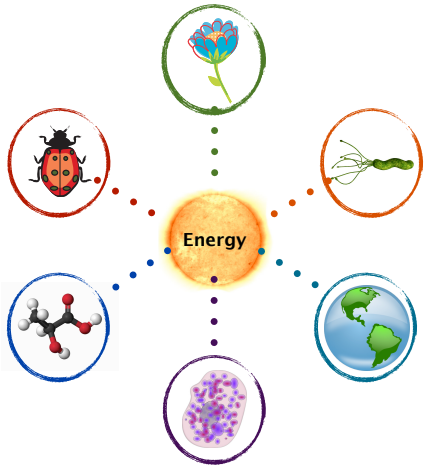
Vision and Change – 2011

Core Concepts for Biological Literacy	Core Competencies & Disciplinary Practice
Evolution	Applying the Process of Science
Structure and Function	Quantitative Reasoning
Information Flow, Exchange and Storage	Modelling and Simulation
Pathways and Transformation of Energy and Matter	Tapping into Interdisciplinarity
Systems	Communication and Collaboration
	Relating Science and Society

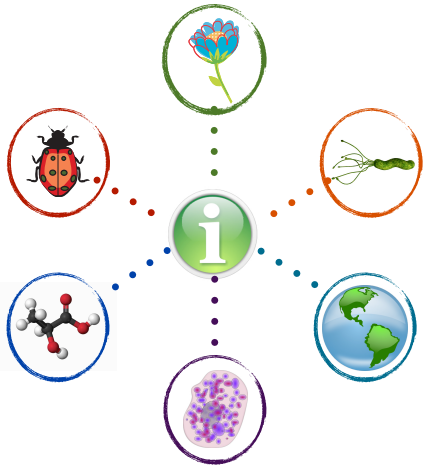
Vision and Change in Undergraduate Biology Education: A Call to Action. http://visionandchange.org

Organizing the First-Year Biology Curriculum

Energy Flow in Biological Systems



DNA, Inheritance and Evolution



Investigating the Impact of Course Redesign

Research Questions:

(1) What are the **major predictors of student success** in our first-year biology classes (e.g. study strategies, ways of thinking, prior knowledge)?

(2) How do changes to lecture approach and teaching style influence student understandings (and misconceptions) of **energy**, **evolution**, **and information**?

(3) How do redesigned laboratories impact the **acquisition and retention of student skills** around the scientific process (e.g. graphical analysis, experimental design)?

(4) How are **measures of student and faculty satisfaction** influenced by the redesigned curriculum?

Research Design: Pre-Course

ASSIST Survey (Online)
Approaches and Study Skills Inventory for Students

Conceptions of Learning **Approaches to Studying**

Learning Assessment (In-Lab)

Scientific Process Skills Assessment
(graphing, experimental design)

Energy, Evolution and Information Concept Test (Biol 231 only)

- 9 multiple-choice questions on each topic (27 total)
- 1 application-style written response question on each topic
- In-depth interviews with ~7 students

Information on ASSIST and ETL surveys can be found at http://www.etl.tla.ed.ac.uk

Research Design: Post-Course

ETL Survey (Online)
Experiences of Teaching and Learning Questionnaire

Approaches to Studying **Learning Experience**

Final Lecture and Lab Examinations

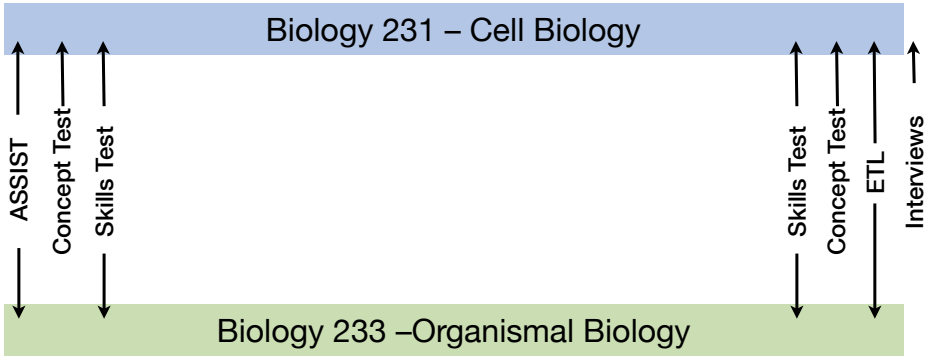
Lab exam: Similar questions to the Scientific Process Skills Assessment

Lecture exam: All items on concept test included (Biology 231 only)

In-depth interviews with ~7 students (Biology 231 only)

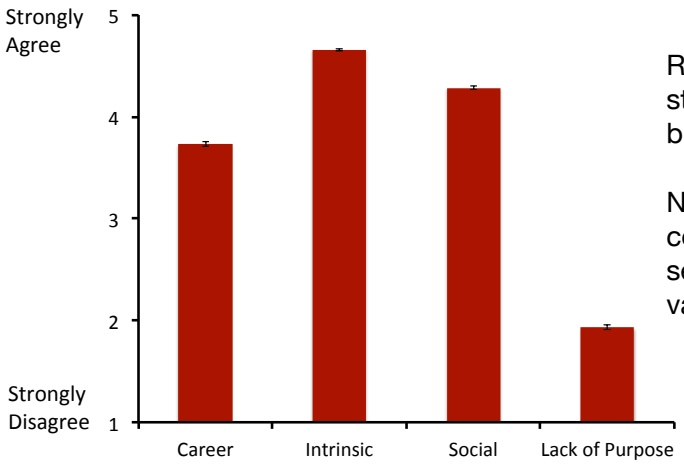
Information on ASSIST and ETL surveys can be found at http://www.etl.tla.ed.ac.uk

Research Design Overview



* Courses run both Fall and Winter Semesters
* 1732 students from both courses completed the ASSIST and ETL surveys (and the course)
* 942 students completed both pre- and post-course concept tests

Motivations for Learning



Responses from 1732 students in first-year biology.

No differences between courses, terms or lecture section were found (All p values <0.0001).

Prior Knowledge

Biology 231 Section	Natural Selection (%)	Information (%)	Energy (%)
Lecture 01 - Fall 2010	55.2±1.3	55.7±1.3	42.83±0.9
Lecture 02 - Fall 2010	55.7±1.2	50.3±1.2	41.9±0.9
Lecture 01 - Winter 2010	**67.05±1.4**	48.6±1.3	40.5±1.0

Responses from 942 students in Biology 231

* Students come into first year biology with weak conceptual understandings of energy, evolution and information

* Students achieved higher scores for evolution in Winter semester likely because they took Biology 233 in Fall semester

Predictors of Student Success

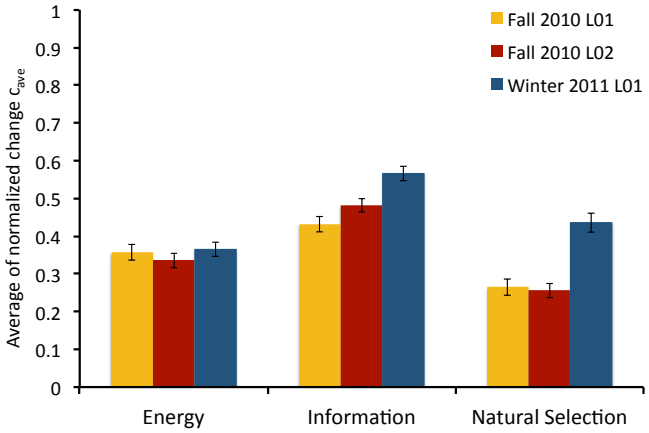
	r value	p value
Pre-Test Score	0.525	<0.0001
Deep Learning Approach	0.159	<0.0001
Surface Learning Approach	-0.162	<0.0001

Responses from 942 students in Biology 231

* Students who come into first-year biology with minimal knowledge of pre-requisite information are not able to make up the knowledge gap

* Promoting a deep approach to learning new information could help students learn more

How much are students learning?



* Normalized change values indicate only low to moderate learning of concepts in our current first year courses

Marx JD, Cummings K. 2007. Normalized Change. American Journal of Physics 75(1):87-91.

How will these results impact our course redesign?

- Students achieving higher scores on pre-test achieve higher course grades
  - Students with lower skills on fundamental course concepts are unable to make up the learning over the semester.
    - Prerequisite knowledge strongly tied with the learning outcomes articulated in the high school curriculum.
    - Students will complete a pre-learning assessment to help them identify areas where they need to review.
    - On-line activities will be provided to help students learn fundamental concepts.

How will these results impact our course redesign?

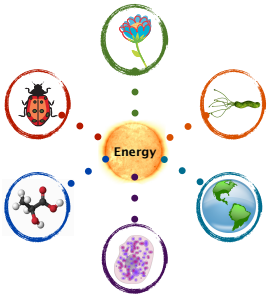
- Students who take a deep approach to learning learn more
  - Taking a student-centred approach to teaching
    - Courses developed using a backwards design model.
    - Active learning strategies intentionally embedded
      - In-class activities, small lecture assignments and clicker questions designed to help foster the development of deep learning of course material.
    - Study tips will be presented throughout the semester using course instructor blog

Wiggins GP, and McTighe P. 2005. Understanding by Design.

How will these results impact our course redesign?

- Students learning of foundational course content is limited
  - Taking a student-centred approach to teaching
    - Core concepts taught in an integrated way - from biomolecules to the biosphere

Energy Flow in Biological Systems



Theme 1: Fundamentals of thermodynamics

Theme 2: Cells and energy

Theme 3: Energy budgets and flow in organisms

Theme 4: Energy flow in ecosystems

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Acknowledgements

Cate McRae

Hao Ding

Jody Johnson

Judith Cook

American Society of Microbiology

BiologyScholars.org center for undergraduate education

NSF

This research has received approval from the Conjoint Faculties Research Ethics Board at the University of Calgary (#6600)