Vision and Change Introductory Biology Lecture and Lab

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Biology Department and GCAT

DAVIDSON

Swarthmore College
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Outline of Presentation

Why change my intro bio course now?

How is ICB different?

Hands-on activity #1 - constructing your own knowledge

Did students meet learning objectives (content and attitude)?

Can intro labs be more authentic? Hands-on activity #2

pClone: real research by first year students

Closing remarks
National Recognition of Need to Change
GRE General Test

**Verbal Reasoning:** measures your ability to understand what you read and how you apply your reasoning skills.

**Quantitative Reasoning:** measures your ability to
- understand quantitative information
- interpret and analyze quantitative information
- solve problems using mathematical models
- apply basic mathematical skills and elementary mathematical concepts of arithmetic, algebra, geometry and data interpretation
- includes real-life scenarios

**Analytical Writing:** provide focused responses to prompts so you can demonstrate your ability to directly respond.
Critical Analysis and Reasoning Skills: analyze, evaluate, and apply information provided in passages

Natural Sciences: combine knowledge of natural science concepts with their scientific inquiry and reasoning skills to solve problems that demonstrate their readiness for medical school.

Psychological, Social, and Biological Foundations of Behavior
full disclosure

ICB is a commercial product
• 3 years to write, 4 years to publish
• traditional publishers rejected
• eBook hosted by Trunity
• David Botstein gift funded book
• Bruce Alberts wrote Foreword
• demonstrated learning gains
• adopt only chapters you use
• http://goo.gl/nRA0Od
Core Concepts = Big Ideas

Vision & Change
- Evolution

Structure and Function
- Information

Energy and Matter
- Systems Biology

ICB
- Evolution
- Cells
- Information
- Homeostasis
- Emergent Properties

AP Biology
- Evolution
- Information
- Homeostasis
- Emergent Properties
V&C Core Competencies

• Apply the process of science
• Use quantitative reasoning
• Use modeling and simulations
• Integrate different disciplines
• Communicate & collaborate
• Connect science & society
V&C Core Competencies *(ICB)*

- Apply the process of science *(experimental design)*
- Use quantitative reasoning *(interpret raw data)*
- Use modeling and simulations *(work with models)*
- Integrate different disciplines *(chemistry, math, some physics)*
- Communicate & collaborate *(small group discussions, lab)*
- Connect science & society *(ELSI boxes)*
What’s Wrong with Biology Education Now?

- Vocabulary is emphasized (800-1000 vs 1400)
- Experimental approaches are minimized
- Math is absent
- Memorization is rewarded
- Critical thinking is discouraged
- Information is irrelevant to students
Present information and data...
... in the context of the big picture.
Start with the literature…
Artificial Divide within Biology

Small Biology

Big Biology
Five Levels of Organization

- Molecular
- Cellular
- Organismal
- Population
- Ecological System
Five by Five Matrix of Biology

- Information
- Emergent properties
- Homeostasis
- Cells
- Evolution

- Molecular
- Ecological System
- Population
- Organismal
- Cellular

Biology
BioMath Exploration 4.2 (BME)

How fast is the vesicle size changing?

(A) non-stressed

(B) stressed
Ethical, Legal and Social Implications (ELSI)

Are religion and evolution compatible?

Is science possible if you are uncertain about what is true?

Does basic biology have any impact on the real world?

Who owns your DNA?
Hands-on Activity #1
Did my students “learn less” content?
Core Concepts Assessment

83% response rate (new)
63% response rate (traditional)

$p = 0.06$
$p = 0.97$

percent correct

Fall 2010

new
traditional

$+/−$ SEM
Core Concepts Assessment

- 83% response rate (new)
- 63% response rate (traditional)

Fall 2010
- Percent correct: 60
- p = 0.97

Spring 2011
- Percent correct: 70
- p = 0.06
Can my students analyze data better?
Core Competency Assessment

% Correct

Traditional  New

$p = 0.043$
Core Competency Assessment

- Traditional (quiz averages)
- New (quiz averages)

- new, $p = 0.015$
- traditional, $p = 0.320$
Do *ICB* students see biology differently?

<table>
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<tr>
<th>1-5 scale 5 = extremely accurate</th>
<th>Average at Start Fall</th>
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<td>biology is definitions &amp; processes</td>
<td>2.86</td>
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<td>1.71</td>
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* p<0.05, ** p<0.01, *** p<0.001, ^ p = 0.06

no
Do *ICB* students see biology differently?

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* p<0.05, ** p<0.01, *** p<0.001, ^ p= 0.06

Yes!
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<td>-1.48***</td>
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</table>

* p<0.05, ** p<0.01, *** p<0.001, ^ p= 0.06

**Yes!**
Hands-on Activity #2
Can introductory biology labs be more authentic?

A common criticism I had gotten for 16 years was the lecture and lab were “disconnected” or were “unrelated.”
When you do research in lab:

1. Has someone prepared data collection tables for you?
2. Does someone hand you all the controls you will need for the day?
3. Does someone else do all the creative thinking for you and you merely pipet?
4. Do you only work on one project until it is completed?
5. Is your research completed in 3 hours?
My educational goals for Intro Bio Lab

1. Employ a **scientific approach** to answering biological questions and test hypotheses.
2. **Design experiments** to test hypotheses, answer questions.
3. **Analyze experimental data** and reach logical conclusions.
4. Organize an **oral presentation** for sharing scientific information with peers.
5. Prepare a **written summary** of experiments designed, performed and analyzed personally.
6. Work on three overlapping labs: **discover new promoter**, **why mammals evolved bitter taste receptors**, and **evolution of antibiotic resistant bacteria**.
Major Changes I Made to Intro Bio Lab

1. Minimal lab manual

Before you come to lab
1) At 8:30 pm on the Wednesday before your lab, one person from each lab group MUST COME TO Dr. C’s research lab (Davis room 221). Make sure to bring your protocol from last week off how to prepare the oligos for testing.

2) Answer each of these four questions in your own words or text
A) How will you figure your new promoter into a plasmid for testing?
B) What will the plasmid need to contain if you want to determine if your promoter is working?
C) How is the fluorescence of red fluorescent protein (RFP) measured?
D) How is a spectrophotometer used to measure cell density in a population of E. coli?

**********************************************

NOTE: At 8:30 pm on the Wednesday before your lab, one person from each lab group MUST COME TO Dr. C’s research lab (Davis room 221). Please be on time. We need to hold the oligos so we can ligate them tomorrow. See page 2 for details.
**********************************************

Before you come to lab
1) The afternoon before lab, one person has already boiled oligos and let cool slowly overnight.

Information: Design and Build a New Promoter (an 8 week project)

In lab: (Start lab at this point)
2) Do appropriate dilutions (day 3 of this protocol) of boiled and cooled oligos. You will ligate your promoter into receiving plasmid pJ19137.

3) You have been provided two tubes of a master mix for GGA. It already contains the receiving plasmid pJ19137, the Bad and the ligase. The volume is 9 μL in each tube. You need one tube for your promoter (P) and one for a negative control (–). Add 1 μL of your newly-ligated promoter to the P tube and 1 μL water to the “–” tube. Label your tubes. Put them in the thermocycler. GGA is program name.

4) Transform cells (see chapter 3.10) with 3 different DNAs:
   a) experimental ligated DNA (with your promoter (ligated oligo added + P)
   b) ligated negative control DNA (water added, not promoter + –)
   c) transformation positive control DNA (rare: plasmid containing RFP gene)

5) Plate each transformation on its own LB/amp plate.

6) Discuss as a group how to assay your promoter. How will you test your promoter to know if it works the way you thought it would?

7) One person from each group will need to start the cells growing 4 pm next Wednesday the day before lab. Come to Dr. C’s research lab on time.
Major Changes I Made to Intro Bio Lab

1. Minimal lab manual
2. Overlapping lab modules

- 9 weeks on promoters
- 8 weeks on taste receptor
- 7 weeks on antibioticÂ"
Major Changes I Made to Intro Bio Lab

1. Minimal lab manual
2. Overlapping lab modules
3. CATME tool  (CATME.org)
Promoter Research Using Golden Gate Assembly

Todd Eckdahl
MWSU
Eco RI

GAATTC
CTTAAAG

palindrome

type II
Bsa I

GAGACC
CTCTGG

not a palindrome

type II enzymes
Bsa I

1234nGAGACC

----nCTCTGG

type II'
Bsa I

1234nGAGACC
nCTCTCTGG

type IIIs
Bsa I

GGTCTCn
CCAGAGn1234

type II$\text{s}$
Bsa I

GGTCTCn
CCAGAGn1234

type IIIs
Bsa I

cuts left

1234 nGAGACC

---- nCTCTCTGG

GGTCTCTCn ----

CCAGAGAn 1234

cuts right
GGA Ligation Method - one step, one tube

TT + RBS + RFP

TT

BsaI + Ligase

RBS

RFP

origin

antibiotic resistance

plasmid backbone
GGA Ligation Method - one step, one tube

TT + RBS + RFP

BsaI + Ligase

plasmid backbone

TT

(origin) antibiotic resistance
GGA Ligation Method - one step, one tube
GGA Ligation Method - one step, one tube

Bsa I

\[ \text{CGAC} \text{GAGACC ( TT ) GGTCTCa GCGG} \]

\[ \text{GCTGaCTCTGG ( TT ) CCAGAGtCGCC} \]

Bsa I

ligase

TT + RBS + RFP

TT  RBS  RFP
Bsa I

CGAC\text{tGAGACC} (TT) GGTCTTCa GCGG
GCTGaCTCTGG (TT) CCAGAGtCGCC

ligase

TT + RBS + RFP

TT

RBS

RFP

Bsa I

ligase
GGA Ligation Method - one step, one tube

- promoter + RBS + RFP

no gel purifications!

plasmid backbone
50% ligation success rate
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<th>Category</th>
<th>Description</th>
<th>Creator</th>
<th>Score</th>
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<td>Regulatory</td>
<td>lacZ promoter (long sequence)</td>
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<td>Superfolder GFP</td>
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<td>Natalio Spech</td>
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<td>A promoter (CydAB) activated by the FNR enzyme</td>
<td>Phoebe Parrish</td>
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</table>
A promoter (CydAB) activated by the FNR enzyme

The promoter, CydAB, was found to be activated by the FNR enzyme, which is induced by the presence of (NH₄)₂Fe(SO₄)₂ and ascorbate. The oligo includes both CydAB, the FNR binding site, and the sticky ends needed for the Golden Gate Assembly method.

Sequence and Features

Assembly Compatibility: 10 12 21 23 25

This experience page is provided so that any user may enter their experience using this part. Please enter how you used this part and how it worked out.

**Applications of BBa_J100099**

We pipetted 200 microliters of one solution containing E. coli cells from a small colony and the activators, one with cells from a small colony and no activators, one containing cells from a large colony and the activators, and one containing cells from a large colony and no activators. We also did a positive control with E. coli cells containing known promoter that causes red fluorescence (J04450) and a negative control with cells containing a the transcriptional terminator that does not cause red fluorescence (J100091). We tested both fluorescence of our samples using a fluorometer and the light absorbance using a spectrophotometer. We measured the fluorescence of absorbance of five samples of each solution, including a control solution that just contained the growth medium. We averaged the values for each solution and subtracted the average fluorescence/absorbance of the control. We then divided the average fluorescence by the average absorbance for each solution. These values are displayed on the accompanying graph.
Registry of Functional Promoters (RFP)

Welcome to the Registry of Functional Promoters

This Registry of Functional Promoters was developed by Bill Hatfield, Laurie J. Heyer, A. Malcolm Campbell at Davidson College and Todd Eckdahl of Missouri Western State University, through the support of HHMI grant 52006292 (GCA T main page) and is freely available for others to use though no support other than the user manual is available.

If your are already a Registered User of GCAT-alog, you do not need to Reregister.

LOGIN  REGISTER AS NEW USER

For comments or questions about this website contact, Malcolm Campbell

gcat.davidson.edu/RFP/
Registry of Functional Promoters (RFP)

gcat.davidson.edu/RFP/
# Registry of Functional Promoters (RFP)

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<th>Entry No.</th>
<th>Promoter Name</th>
<th>Part Number</th>
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<th>Length</th>
<th>Citation</th>
<th>Species of Interest</th>
<th>Constitutive/Regulated</th>
<th>Inducible/Repressible</th>
<th>Regulator</th>
<th>RBS Used for Testing</th>
<th>ORF Used for Testing</th>
<th>Plasmid Use</th>
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To Edit an Entry, Enter the Entry # and press "Edit Entry"

To Delete an Entry, Enter the Entry # and press "Delete Entry"

[gcat.davidson.edu/RFP/](gcat.davidson.edu/RFP/)
Testing Known Promoters: Ptac

5’ CGACGAGCTGTGACAATTAATCATCGGCTCGTATAATGTGTGGA 3’
3’ CTCGACAACTGTTAATTAGTAGCCGAGCATATTACACACCTCGCC 5’
5’ CGACGAGCTGGTtACAATTAATCATCAGCTCGTATAATGTGTGGA 3’
3’ CTCGACAAaTGTTAATTAGTAGGCAGCAGATATTACACACCTGCC 5’

Student Sample, November 2012
Student Sample, November 2012

-35 ATAA (deleted) -10

5′ CGACGAGCTGTGGACACATGCTGCTGTAATGTGTGGA 3′
3′ CTCGACAACTGTATGAGCCGAGCATATTACACCTCGCC 5′
pClone Red
J119137

GFP | RBS | RBS | RFP

Bsa I  Bsa I
Remove Initial Promoter
J119137
Insert Non-functional Promoter
J119137
Insert Forward Promoter
J119137
Insert Bi-directional Promoter
J119137
pClone Red
J119137

Quantify with Phone and ImageJ


<table>
<thead>
<tr>
<th>Mutant</th>
<th>J119319</th>
<th>J119320</th>
<th>J119321</th>
<th>J119322</th>
<th>J119323</th>
<th>J119324</th>
<th>J119325</th>
<th>J119326</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pClone Green plate</strong></td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Isolated clones</strong></td>
<td><img src="image9.png" alt="Image" /></td>
<td><img src="image10.png" alt="Image" /></td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /></td>
<td><img src="image13.png" alt="Image" /></td>
<td><img src="image14.png" alt="Image" /></td>
<td><img src="image15.png" alt="Image" /></td>
<td><img src="image16.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Expression Ratio</strong></td>
<td>4.09</td>
<td>3.94</td>
<td>3.84</td>
<td>2.04</td>
<td>1.54</td>
<td>1.34</td>
<td>3.52</td>
<td>1.00</td>
</tr>
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</table>
pClone Blue
J119313

pClone Blue

Measure Promoter Qualitatively

J119313
### Assessment Davidson Intro Bio

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*aSignificant improvement between pre- and posttest.

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rClone Red

J119###
rClone Red

J119###

12 - 60 bp

RBS

Bsa I

RFP
tClone Red

J119361
tClone Red

J119361

60 - 230 bp

+/−

RBS

OR

Bsa I

RFP

+
actClone Red

J100204

**Diagram**

- **GFP**
- **RBS**
- **TT**
- **RBS**
- **RFP**
- **3’ PompR**

**Restriction Sites**

- **Bsa I**
actClone Red

J100204

OmpR

C1 C2 C3

60 bp

Bsa I

GFP RBS

RBS RFP

3’ PompR
repClone Red

J100205

![Diagram of repClone Red](image)
repClone Red

J100205

Ptet

54 bp

TetR
RBS

Bsa I

RBS
RFP

OR
Guess what, I taught my dog to whistle!
Teaching vs Learning

Really?!
Teaching vs Learning

Whistle! C’mon boy, whistle!
Teaching vs Learning

?????????????
I thought you said you taught your dog to whistle.
Teaching vs Learning

I did, but I didn’t say that he learned to whistle.
Acknowledgements

Lecture: A. Malcolm Campbell Laurie Heyer, Chris Paradise
Lab: Jeff Poet, Todd Eckdahl


The Duke Endowment, NSF, HHMI
Genome Consortium for Active Teaching (GCA)
Davidson College James G. Martin Genomics Program
MWSU SGA, Foundation & Summer Research Institute
Remember, teaching is supposed to be fun!