Curriculum development efforts for an inquiry-based introductory lab course or can we have it all?

Ayce Yesilaltay
The 7.02 Teaching Team
in alphabetical order

Instructors in Lab:
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  Ayce Yesilaltay

Instructors in Lecture:
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  Mary Gehring
  Piyush Gupta
  Thomas Schwartz
  Dane Wittrup

Writing Instructors:
  Amelia Herb
  Jane Kokernak
  Marilee Ogren-Balkema
  Leslie Roldan

Lab Manager:
  Anthony Fuccione

Graduate and undergraduate TAs
Genes and Genetics: what’s not to like?
Outline

• Introduction to 7.02
• Challenges
• Development of the new curriculum
• Assessment
What is 7.02?

Introduction to Experimental Biology and Scientific Communication

- 18-unit introductory lab course
- Communications-intensive
- Prerequisite: 7.01x (Introductory Biology)
- Geared towards sophomores
- Enrollment: 110-130 students per year
Learning goals in 7.02

• Experimental techniques
  • Practice
  • Theory
  • Troubleshooting
  • Writing a lab notebook

• Data analysis
  • Scientific communication
  • Experimental design
Ways to learn in 7.02
Write a manuscript on their own work
Get writing and technical feedback
Go through revisions

SciComm Lecture

Lecture
Lecture

Lab T/R
Lab W/F
Lab T/R
Lab W/F
Write a manuscript on their own work
Get writing and technical feedback
Go through revisions

Cover and complement concepts learnt in the lab and beyond

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>9 AM</td>
<td>Lectures</td>
</tr>
<tr>
<td>10 AM</td>
<td>SciComm Lecture</td>
</tr>
<tr>
<td>11 AM</td>
<td>Lecture</td>
</tr>
<tr>
<td>Noon</td>
<td>Lab T/R</td>
</tr>
<tr>
<td>1 PM</td>
<td>Lab W/F</td>
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<tr>
<td>2 PM</td>
<td>Lab T/R</td>
</tr>
<tr>
<td>3 PM</td>
<td>Lab W/F</td>
</tr>
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</table>
Ways to learn in 7.02

Write a manuscript on their own work
Get writing and technical feedback
Go through revisions

SciComm Lecture
Lecture
Lecture

Cover and complement concepts learnt in the lab and beyond

Perform experiments with a lab partner
Write pre- and post lab notebook entries
Discuss in-lab questions with TA
The Three Modules of 7.02

Biochemistry (10 lab days)
- Mutagenesis
- Protein expression
- Protein purification
- Functional assays

Chemical Eng. (4 lab days)
- Yeast surface display

Genetics (10 lab days)
- Genetic screens
- Recombination
- Complementation
- Genetic interactions
Outline

• Introduction to 7.02
• Challenges
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Challenges? What challenges?
Who takes 7.02?
Distribution of majors in 7.02

- Biology (Course 7): 27%
- Computer Science and Molecular Biology (Course 6/7): 12%
- Chemical Biological Engineering (Course 10B): 28%
- Other: 33%

According to currently preregistered students for Fall 2014
Distribution of majors in 7.02

According to currently preregistered students for Fall 2014
Distribution of majors in 7.02

According to currently preregistered students for Fall 2014

- Chemical Biological Engineering (Course 10B) 28%
- Computer Science and Molecular Biology (Course 6/7) 12%
- Biology (Course 7) 27%
- Other 33%

PREMED REQUIREMENT
GRADUATION REQUIREMENT
Which year students take 7.02?

According to currently preregistered students for Fall 2014:

- Freshman: 0%
- Sophomore: 34%
- Junior: 52%
- Senior: 14%
Challenges recapped

Preparing content for a mixed student population

• Different majors
• Different years
• Vastly varied lab experience
• Different goals and expectations
Outline

- Introduction to 7.02
- Challenges
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From worm genetics to yeast genetics

What do the students think?

I hate worms!

Don’t get rid of the worms! I hate yeast genetics!
Considerations for the new module

• Build the course around the genetics concepts required for the students

• Design a cohesive, hypothesis-driven module with an overarching goal

• Involve students in the decision-making process

• Potential for new research findings
The topic?

The yeast mating pathway
Why do we care about yeast mating?

Signal transduction is conserved

GPCR → MAPKKK → MAPKK → MAPK → Mating genes

Piyush Gupta
Why do we care about yeast mating?

Signal transduction is conserved

GPCR → MAPKKK → MAPKK → MAPK → Mating genes

~30% all cancers

RAS → B-RAF → MAP2K1/2 → MAPK1/3 → Cell division

~50% melanoma

Piyush Gupta
Why do we care about yeast mating?

Signal transduction is conserved

GPCR → MAPKKK → MAPKK → MAPK → Mating genes

RAS → B-RAF → MAP2K1/2 → MAPK1/3 → Cell division

~30% all cancers

~50% melanoma

Most oncogenes are mutated kinases

Many cancer drugs target kinases

Piyush Gupta
Yeast mating signal transduction pathway

- **Receptor (GPCR)**
- **Heterotrimeric G protein**
- **MAPKKK**
- **MAPKK**
- **MAPK**

**Signal Transduction**

- **α-factor**
- **Cdc42**
- **Ste2**
- **Ste4**
- **Ste20**
- **Ste11**
- **Ste7**
- **Fus3, Kss1**
- **Dig1/2**
- **Ste12**
- **Far1**

**Transcription factor**

**Mating genes**

**Transcription factor**

**PRE**

AY and Mary Gehring
The new genetics module

Generate transposon-mutagenized yeast library

Select mutants defective in response to mating factor $\alpha$-factor

Perform three assays to confirm the mutant phenotype

Identify the mutants by plasmid rescue, sequencing and BLAST
The new genetics module

Generation of new unique reagents

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Decision making

Decision making
The new genetics module

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Perform three assays to confirm the mutant phenotype

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Generation of new unique reagents

Decision making

Decision making

Potential for identification of new genes
Genes identified by the class (and the number of times they were identified)

- STE2
- STE5 (2)
- STE6
- STE7 (2)
- SIR3, aka STE8 (2)
- SIR4, aka STE9 (3)
- KCC4 (3)
- TAR1 (2)
- BEM4
- FUS2
- CLB6

New gene implicated for the first time in the yeast mating pathway!
Outline

• Introduction to 7.02

• Challenges

• Development of the new curriculum

• Assessment
Students’ subject evaluation of 7.02 (out of 7)

- Spring 2012: 6
- Fall 2012: 6
- Spring 2013: 6
- Fall 2013: 5
- Spring 2014: 6

Introduction of the new module
Paper evaluations vs online evaluations

- Higher rate of response
- More detailed feedback
- Ability to ask open-ended questions
- Ability to administer self-assessment questionnaire
What was your least favorite part of the Genetics Module?

Fall 2013

“Long lab days”

“Broken pipettes”

“Not enough spectrophotometers”
What was your least favorite part of the Genetics Module?
Fall 2013

“Long lab days”

“Broken pipettes”

“Not enough spectrophotometers”

These issues were addressed for the Spring 2014 semester
Broken pipettes?
What was your least favorite part of the Genetics Module?

Spring 2014

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Most students done with lab</th>
<th>Most students done with ILQ</th>
<th>Last student</th>
<th>Comments</th>
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<tr>
<td>2/4</td>
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</table>

“That one long lab day!”
What was your favorite part of the Genetics Module?

Fall 2013 and Spring 2014

“The functional assays”

“Finding out the identity of our mutated gene”

“Seeing yeast under the microscope”
What was your favorite part of the Genetics Module?

- Generate transposon-mutagenized yeast library
- Select mutants defective in response to mating factor \( \alpha \)-factor
- Perform three assays to confirm the mutant phenotype
- Identify the mutants by plasmid rescue, sequencing and BLAST
- Potential for identification of new genes
- Generation of new unique reagents
- Decision making
<table>
<thead>
<tr>
<th>Task</th>
<th>% students who answered YES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manipulating rec. DNA</td>
<td>98%</td>
</tr>
<tr>
<td>Handling DNA/protein gels</td>
<td>98%</td>
</tr>
<tr>
<td>Manipulating bacteria/yeast</td>
<td>100%</td>
</tr>
<tr>
<td>Protein purification</td>
<td>93%</td>
</tr>
<tr>
<td>Microscopy</td>
<td>88%</td>
</tr>
<tr>
<td>Data analysis</td>
<td>100%</td>
</tr>
<tr>
<td>Statistical analysis</td>
<td>83%</td>
</tr>
<tr>
<td>Experimental design</td>
<td>88%</td>
</tr>
<tr>
<td>Writing a lab notebook</td>
<td>91%</td>
</tr>
</tbody>
</table>

Response rate: 87-89%
Learning goals in 7.02

- Experimental techniques
  - Practice
  - Theory
  - Troubleshooting
  - Writing a lab notebook
- Data analysis
  - Scientific communication
  - Experimental design
What was the most useful course component to help your understanding?

- Practice problems
- Lectures
- TAs
- Instructors
- Exams
- Review sessions
- In-lab questions
- SciComm
- Lab manual

Spring 2012-Spring 2014
What was the most useful course component to help your understanding?

- Practice problems
- In-lab questions
- TAs
- Lectures
- Exams
- Instructors
- Review sessions
- SciComm
- Lab manual

Spring 2012-Spring 2014
TAs: our most valuable resource!

- Four graduate and eight undergraduate TAs
- Graduate TAs undergo Biology Dept. TA training
- 7.02-specific training in TA Run-Through Week
- Weekly staff meetings
Can we have it all?

- Cookbook style versus open ended
- Breadth versus depth
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Graduate and undergraduate TAs
Thank you!
Acknowledgments

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Walker Lab Members
Tom RajBhandary
Caroline Kohrer
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Steve Bell
Monty Krieger
Krieger Lab Members
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Lourdes Aleman
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Wendy Salmon

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Duane Jenness

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Tim Stearns

**University of Michigan**
Anuj Kumar

**SUNY**
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Deborah Spikes

**Suffolk University**
Melanie Berkmen

**Princeton University**
Allison Gammie

**Brandeis University**
Melissa Kosinski-Collins

**Boston University**
Meredith Knight
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HHMI
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The Alumni Class Funds
supporting education at MIT since 1994
Stay tuned for the next curriculum...