



HHMI Education Group

"Increasing the pipeline in STEM research fields: Student engagement through interactive lectures and early research experience. "

> Mandana Sassanfar Department of Biology

> > February 29 2012



1) Attract students to research careers

2) Teach necessary skills to succeed

- 1) Teach problem solving skills
- 2) Hands-on research experience
- 3) Experimental design
- 4) Trouble shooting
- 5) Research Careers
- 6) Interaction with scientists
- 7) Scientific Communication
- 8) Research Presentations

On-going Programs

- Interactive Lectures for Undergraduates at other institutions
- Introductory molecular biology Freshman lab course
- Teacher workshop for high school teachers
- Field trips to MIT for High school students
- Research Symposium for High school students

On-going Programs

- Interactive Lectures for Undergraduates at other institutions
- Introductory molecular biology Freshman lab course
- Teacher workshop for high school teachers
- Field trips to MIT for High school students
- Research Symposium for High school students





















Excitation with UV light. Energy transfer from CFP to YFP. Emission of yellow light.

Sorger Lab



Excitation with UV light. Energy transfer from CFP to YFP. Emission of yellow light.

FRET: Fluorescence Resonance Energy Transfer

John Densh, Sorger Lab



FRET: Fluorescence Resonance Energy Transfer

John Densh, Sorger Lab



FRET: Fluorescence Resonance Energy Transfer

John Densh, Sorger Lab

Apoptosis



Pseudomonas aeruginosa

0.5 µm

(c) 2004 Dennis Kunkel Microscopy, Inc.

P. aeruginosa releases phenazines





0.2 cm

Phenazines affect colony morphology

wt

 Δphz



Dietrich et al., Science 2008



Why wrinkle up?

 $\Delta \boldsymbol{phz}$





CCC.

000,...

00

On-going Programs

- Interactive Lectures for Undergraduates at other institutions
- Introductory molecular biology Freshman lab course
- Teacher workshop for high school teachers
- Field trips to MIT for High school students
- Research Symposium for High school students





IAP Freshman lab course 7.391 Department of Biology

- 2-weeks intensive lab course
- 6 credit P/F
- Limited to 12 freshman
- Offered since 2007

Teaching Goals:

- Basic and advanced molecular biology techniques.
- Trouble shooting
- Planning Experiments
- Problem solving
- Team Work
- Multi-tasking
- Communication (Oral presentation &Lab report)

How to make it work

- Make it engaging and visual
- Make it challenging
- Mimic real research setting
- Project Ownership

Techniques

- Accurate pipetting
- Aseptic techniques
- Growing bacterial cultures on liquid and solid media
- Isolating and growing phages
- Determining pfu for phage stocks
- PCR amplification, agarose gel electrophoresis, Cloning, bacterial transformation, mini prep, Blast
- Centrifugation (micro, high speed and ultra)
- CsCl step gradient, dialysis
- SDS PAGE
- Preparing grids for EM

Project

- Two related but independent projects
 - Identify bacterium by 16s rRNA sequence analysis
 - Isolate and characterize phage that grow on the bacterium
- Rules of engagements:
 - Fast-paced
 - Hands-on
 - Mimic basic research

The story line

1. Collect water sample from the Charles river



2. Concentrate phage by binding to DEAE Sephadex Resin





3. Elute phageswithHigh salt

4. Plate water sample on LB plates





5. Isolate bacterial strains











5a. PCR 16S rRNA gene

AB048252.1	Bacillus pumilus gene for 16S rRNA, complete sequence, strain: M1-9-
EU221329.1	Bacillus pumilus strain NM1C3 16S ribosomal RNA gene, partial seque
FM955870.1	Bacillus altitudinis 16S rRNA gene, strain Asd M5-2B
AY741720.1	Bacillus pumilus 16S ribosomal RNA gene, partial sequence
EU308309.1	Bacillus sp. TA011_2 16S ribosomal RNA gene, partial sequence
EU308308.1	Bacillus sp. TA011_1 16S ribosomal RNA gene, partial sequence
AJ831844.2	Bacillus aerophilus partial 16S rRNA gene, type strain 28K
AJ831841.2	Bacillus stratosphericus partial 16S rRNA gene, type strain 41KF2a

6a. Clone 16S rRNA gene

2802	2802	99%	0.0
2798	2798	99%	0.0
2789	2789	99%	0.0
2787	2787	99%	0.0
2784	2784	99%	0.0
2784	2784	99%	0.0
2782	2782	99%	0.0
2782	2782	99%	0.0

7a. Blast 16S rRNA sequence



8a. Phylogenetic analysis



5b. Plate phage concentrate on host bacteria



6b. Amplify from single plaque



7b. Purify phage particles on CsCl gradient



8b. Characterize phage particles



SDS-PAGE



Genomic DNA extraction and restriction digest







EM





s Aeronimosa



Trouble Shooting!!!













Phage isolated on white colonies grows on red colonies

16S rRNA sequences are identical

IAP 2012: the Art of Microbiology

http://web.mit.edu/newsoffice/2012/microbiology-iap-course.html

High School Outreach

32 school districts

- Arlington
- Belmont
- Boston
- Braintree
- Brookline
- Canton
- Cambridge
- Dedham
- Harvard
- Holliston
- Hudson

- Lawrence
- Lexington
- Lincoln-Sudbury
- Melrose
- Methuen
- Nashoba Regional
- Natick
- Newton
- Norfolk Ag
- North Middlesex

- Peabody
- Quincy
- Revere
- Somerset
- Somerville
- Stoneham
- Stoughton
- Swampscott
- Wayland
- Wellesley
- Woburn

What teachers need

- Keep up-to-date with fast-paced discoveries
- Learn new techniques
- Make biology interesting/engaging to students
- Develop hands-on class activities
- Develop new labs
- Research Sabbatical/Internships
- Networking with other teachers
- Networking with scientists

What the Department offers

- 5-day workshop for high school biology teachers
- One-day field trip to MIT for High school students
- 6-weeks research internships for teachers
- Faculty Lectures on current topics (Whitehead)
- New labs and hands-on activities
- Networking with scientists

What the Department does not offers

- Research Internships for high school students
- Help with science fair projects

On-going Programs

- Interactive Lectures for Undergraduates at other institutions
- Introductory molecular biology Freshman lab course
- Teacher workshop for high school teachers
- Field trips to MIT for High school students
- Research Symposium for High school students

Teachers' Summer workshop

BIOLOGY

Teachers' Summer workshop

BIOLOG

CRLS Wellesley Stoneham Somerset Brookline Canton Melrose Hudson Somerville Lawrence Nashoba Regional Lincoln Sudbury City Hill Charter Revere Beaver Country Day

> HHMI HOWARD HUGHES MEDICAL INSTITUTE

Workshop Format

- Limited to 16 science teachers from the Boston area
- One central topic
- Daily faculty lectures (90 minutes)
- Daily labs (4.5 hours per day)
- Team presentations on last day
- Curriculum development by teachers

TEACHERS' REQUESTS

- Lecture topics relevant to the science curriculum
- Labs that can be done in a class setting
- Labs that can be done in the allotted time period
- Cookbook protocols
- Special materials and reagents
- In class support
- Last minute help

Workshop Topics

- 2011 "Bacteria that grow on cheese."
- 2010 "Vision and the eye."
- 2009 "The brain: from anatomy to cognition."
- 2008 "The fruit fly: a great model organism for Hands-on activities."
- 2007 "Planaria biology."
- 2006 "Fresh water bacteriophages and their hosts."
- 2005: "Nematodes biology and genetics."

https://biology.mit.edu/high_school_outreach/summer_workshop_2011

Massachusetts Institute of Technology Departments of Biology MIT/HHMI Teachers' Workshop 2011

HHMI

Quorum Sensing Activity

Lydia E. Breen, Stoneham High School Jessica A. Forton, Melrose High School Amanda Tsoi, Somerville High School

Just what is *QUORUM SENSING?* Think of it as a bacteria *FLASH MOB DANCE.*

http://www.fairbanksballroom.org/wp- content/uploads/2011/06/flash-mob.jpg

"In its simplest form, quorum sensing refers to the ability of bacteria to communicate. It describes the capacity of certain bacteria to exhibit coordinated behavior in response to a particular population density. These bacteria usually rely on the production, accumulation, and subsequent response to diffusible signal molecules in order to sense population. These signal molecules accumulate in environments that can sustain a sufficiently dense population, or quorum, of the signal-producing bacteria. When the concentration of the signal molecule reaches a critical level, the quorum-sensing bacterial population responds through the concerted expression of specific target genes"

(http://accessscience.com/search.aspx?rootID=796358)

(http://en.wikipedia.org/wiki/File:Quorum_sensing_diagram.png)

Activity:

Start with 10 index cards and the students standing so they are in fairly close proximity. Each student receives a party favor noise maker with an attached message....

"Blow this only after you receive 5 pieces of any size paper."

Randomly pass the index cards to the students. When they receive the card they need to tear the card in half and pass one portion to another student and keep the other half. This process continues until the student receives 5 pieces of paper and only then can the student start blowing on the party favor.

***The students continue to rip and pass paper even while blowing on the party favor.

Massachusetts Institute of Technology Departments of Biology MIT/HHMI Teachers' Workshop 2011

The activity continues until all of the students are making noise.

Post-activity discussion:

What did it take for the students to start blowing on the party favor?

What does the paper represent?

What does the blowout represent?

How does this exercise help explain QUORUM SENSING?

AP Biology Classes

Show the video:

<u>http://www.ted.com/talks/bonnie_bassler_on_how_bacteria_communicate.html</u>
Dr. Bonnie Bassler explains quorum sensing and the work done in her lab at
Princeton University. (recommended)

2. <u>http://www.learner.org/courses/biology/archive/animations/hires/a_microb2_h.html</u> Textbook archived animation about quorum sensing and biofilm

The End

HIE