Calculus, Zombies, Community, and QUBES:

Education at the interface of mathematics and biology

Carrie Diaz Eaton

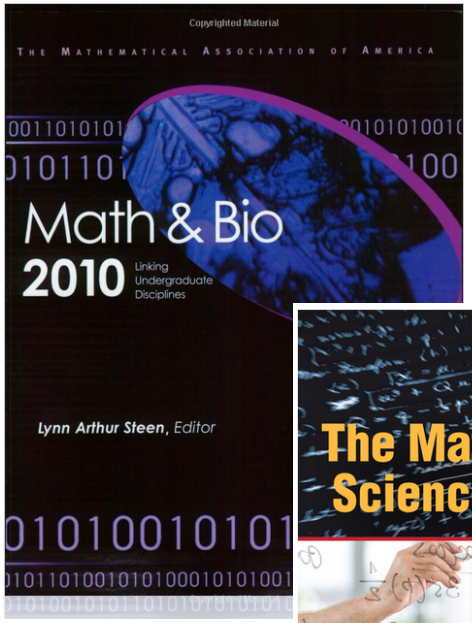
Unity College

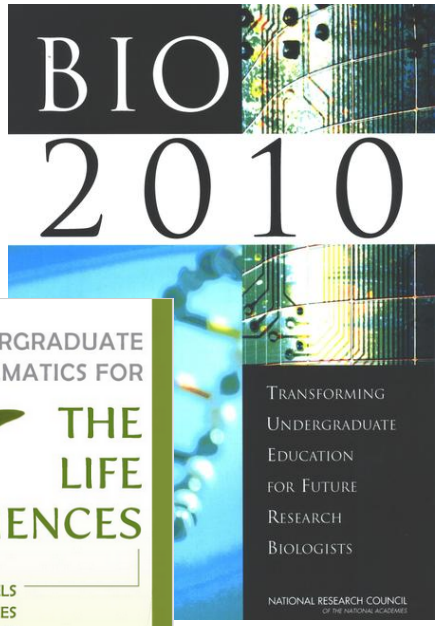
Math and biology education

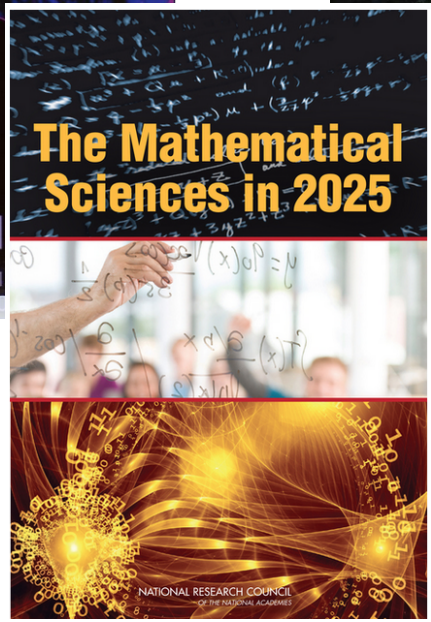
Mathematical biology
Quantitative biology
Quantitative skills for biologists
Quantitative literacy for biologists

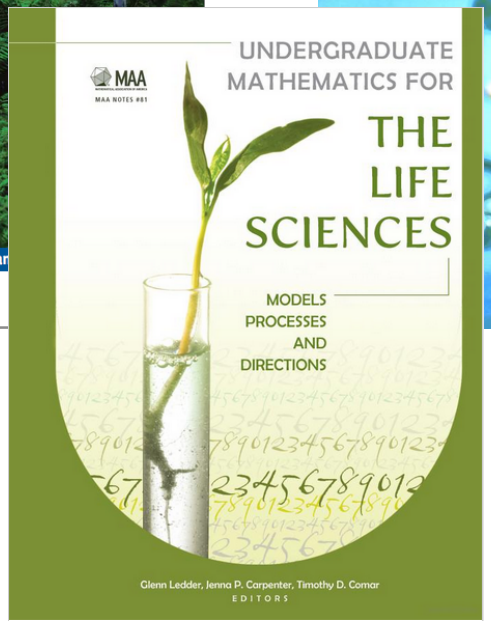
Biology
Life science
Environmental and biological sciences

Math and biology education









Why is math good for biology?

Reports -

Bio 2010, Vision and Change, PCAST

- Helps advance theory in biology (*e.g.* Servedio, 2014)
- To interpret the output and understand the assumptions of computational tools (*e.g.* bioinformatics)
- Helps process large amounts of data (*e.g.* genome sequencing, ecological indicators).

Why should math consider serving biology?

- To meet the needs of all students - Life science students may underperform in traditional math courses
- PCAST report - if we don’t do it right, let the biologists do it
- Adjusting requirements by biology programs may reduce math requirements
- To uncover latent talent
  - Did you know I was a life science student first?

Working together might look like...

- Aligning content of prerequisite or corequisite courses to companion courses
- Changing biology program requirements
- Designing special life science-focused math and statistics courses
- Integrating biology-oriented examples or projects into math courses
- Emphasizing quantitative skills in biology courses
- Interdisciplinary student research opportunities

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- Interdisciplinary student research opportunities

Example - redesigning Calculus

- Environmental college in Unity, Maine
  - ~600 undergraduates
  - Interdisciplinary Centers (Carrie Diaz Eaton in Center for Biodiversity)
  - No math department, no math major
  - Hands-on learning and environmental and ecological emphasis
- Academic Master Planning (AMP) in prep for accreditation review by NEASC - push to 40-40-40

Eaton and Callender (submitted to *CBE*)

Example - Redesigning Calculus

- Calculus required by Wildlife Biology, Earth and Environmental Science
- Option for Biology*, Marine Biology*, and Sustainable Energy Management
- Population management and climate change drive Calculus content, not MCATs
- History of co-teaching/collaborative course design

*Required prior to AMP (& Wildlife)

Eaton and Callender (submitted to *CBE*)

Course Design (Unity)

Surveys and follow-up interviews

(UC IRB #2011-06)

1. It must be called Calculus (external requirement)
2. It must be rigorous (*je ne sais quoi*)
3. It must deepen the understanding of foundational principles in modeling feedback and interactions (in complex systems)

Eaton and Callender (submitted to *CBE*)

Course Design (Unity)

Book: Mathematics for Life Science, Bodine, Gross, and Lenhart

Calculus I (3-credit, no lab)	**Calculus II (3-credit, no lab)**
• **Sequences** • **Linear discrete-time models and equilibria** • Limits • Continuity • Derivatives • Optimization • **Modeling with ordinary differential equations** • **Exponential models and equilibria** • **Partial derivatives** *Low-stakes reflectionary writing* *Group professional recommendation* *Group lab reports* *Excel*	• Integration • Series • Antiderivatives • **Continuous probability distributions** • **Exact solutions to 1-D separable (ODEs)** • **Bifurcations and tipping points** • **Numerical solutions and qualitative analysis of 1-D and 2-D autonomous ODEs** *Readings and discussion on complex systems and computing* *Individual lab-reports with peer review (Eaton and Wade, 2014)* *MATLAB*

Eaton and Callender (submitted to *CBE*)

Calculus I Learning Outcomes (Unity)

Content

1. Interpret **sequences, limits, and continuity** algebraically, numerically, visually, and verbally.
2. Interpret **derivatives** algebraically, numerically, visually, and verbally.
3. **Model** simple scenarios of **change** through either difference equations or differential equations.
4. **Apply** principles of **derivatives** to optimization and relative change.

Disposition

5. **Recognize** limits and derivatives in the **practical and professional** world, particularly in environmental and life science.
6. **Investigate** problems using a **computer** algebra system or spreadsheet system.
7. Work in **groups** to investigate problems and **communicate** solutions on an introductory level.
8. Practice time management and **discipline** in self-paced study.

BEER Intervention

Faculty all over are working on the same problem, at different places, not knowing.

BEER changed all that.

BEER Intervention

We were both working on the same problem, two different places, not knowing.

BEER changed all that.

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No, not that kind of beer…

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the International Symposium on **B**iomathematics and **E**cology **E**ducation and **R**esearch

Assessment and Results

Content Outcomes Assessment

> MATH PERFORMANCE

Dispositional Outcomes Assessment

> ATTITUDES AND PERCEPTIONS

Lots of case studies, anecdotal.

We share lots of experiences and ideas, but how are we doing at assessment of those implementations?

Eaton and Callender (submitted to *CBE*)

Assessing Math Performance - At risk pop now as good as or better

Unity College - assessment through CCI (Epstein, 2013)

- High pass rates, low W rates
- Average of approximately 17% learning gain for 3-credits (4 semesters, 5 sections)
- Perhaps equivalent to about 25% for 4-credit (CCI Traditional [-?, 21]% and IE [21,44]%)

University of Portland - assessment through common quiz compared to traditional calculus

- Biocalculus students scored better (t-test significant) on final

Eaton and Callender (submitted to *CBE*)

Attitude Results - UP and UC Positive change in attitudes

Students showed a significant change (p-value < 0.05) or near (< 0.10) Wilcoxon signed-rank, non-parametric:

- *Students agree more that their **attitude** towards math **affects their ability** to do math.
- Students **disagree** more **that ordinary students cannot expect to understand mathematics**, they expect simply to memorize it and apply what they have learned mechanically without an understanding.
- Students agree more that math is **creative** and they can **discover** things on their own.
- Students agree more that try to learn mathematics because it **helps develop their mind** and helps them think more clearly in general.

Eaton and Callender (submitted to *CBE*)

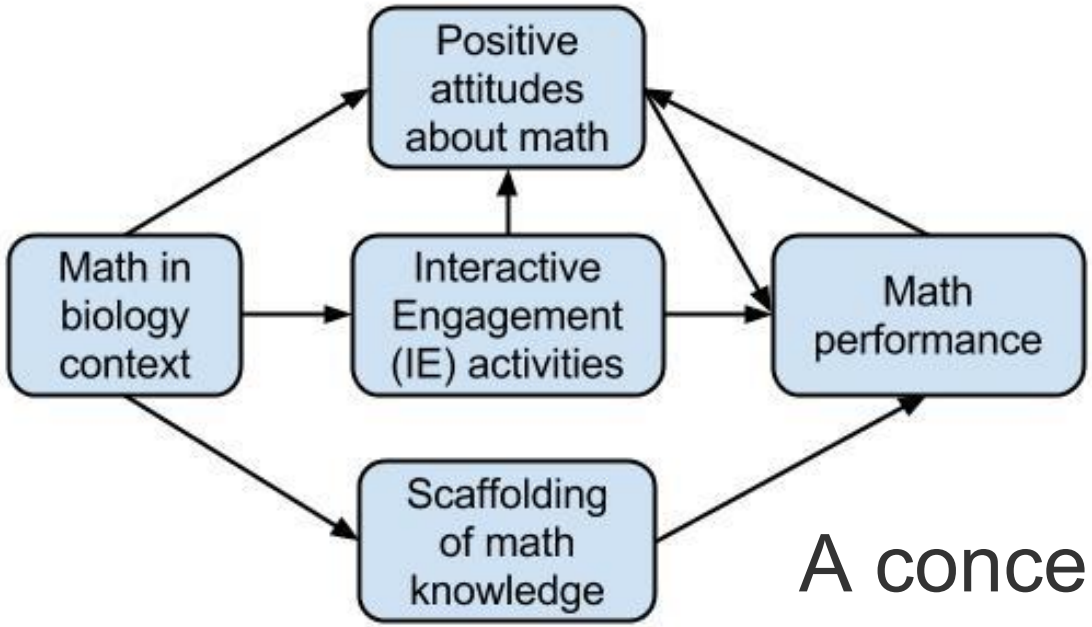
Attitude Results - Unity specific

For UC, the questions that yielded a significant difference (p-value<0.05), but not for UP were

- Students agree more that using the web or **computer can help them learn mathematics**. *(Excel for exploration, 6)*
- Students **disagree** more that **math is** a **solitary** activity *(Work in teams, 7).*
- Students agree more that the **skills** they learn in this class will **help them in other classes**. *(Math in context, working directly with stakeholders, 5)*

Eaton and Callender (submitted to *CBE*)

Why teach biology driven math?



A conceptual model

- Bigger picture through collaboration
- Adds to piccture bigger picture of what works and what doesn't
- BEER intervention

Eaton and Callender (submitted to *CBE*)

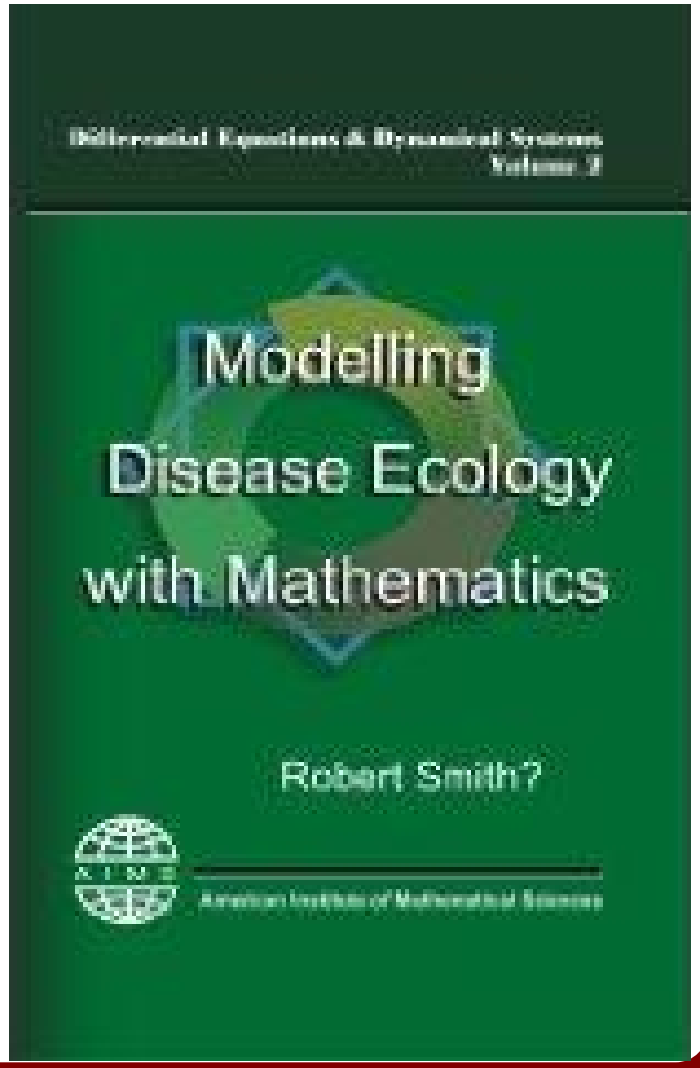
Example - Undergraduate Research

Students can go from Calculus II to and ODE modeling course

SIR modeling

Other ODEs like predator-prey interactions

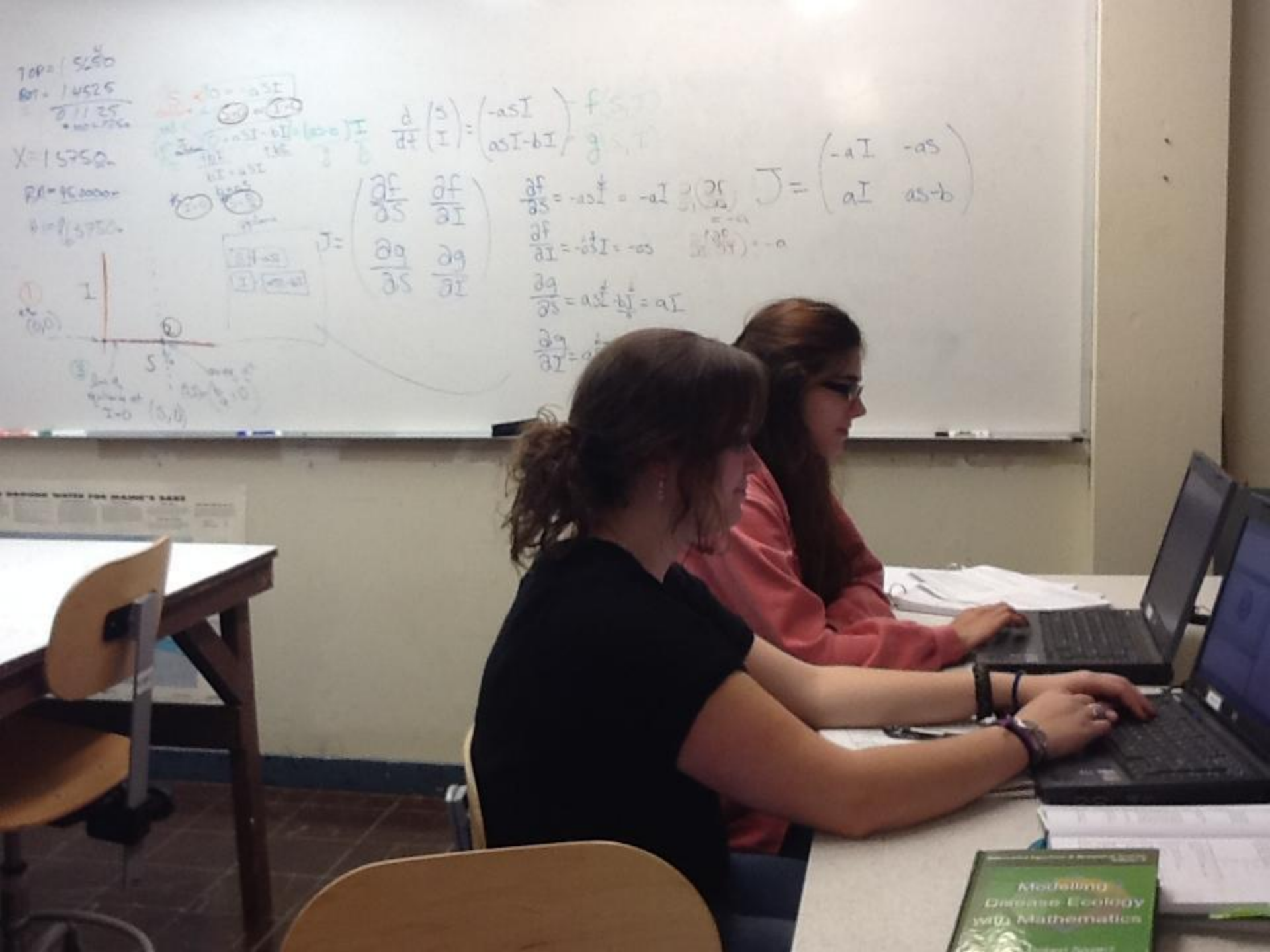
Zombies and Ticks



Zombies are fictional undead creatures regularly encountered in horror and fantasy themed works. They are typically depicted as mindless, reanimated corpses with a hunger for human flesh, and particularly for human brains in some depictions.

- wikipedia

- Night of the Living Dead

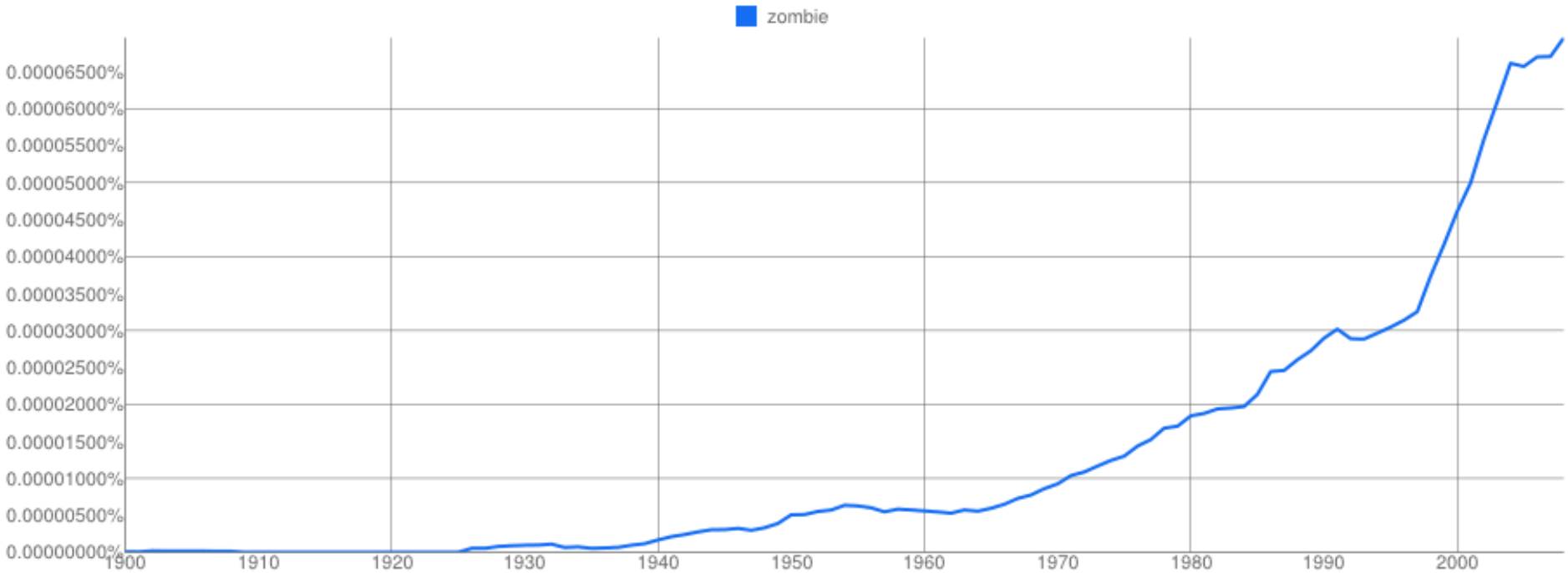

Modelling
Disease Ecology
with Mathematics

Google books Ngram Viewer

Graph these ***case-sensitive*** *comma-separated phrases:* zombie

between 1900 *and* 2008 *from the corpus* English *with smoothing of* 3 .

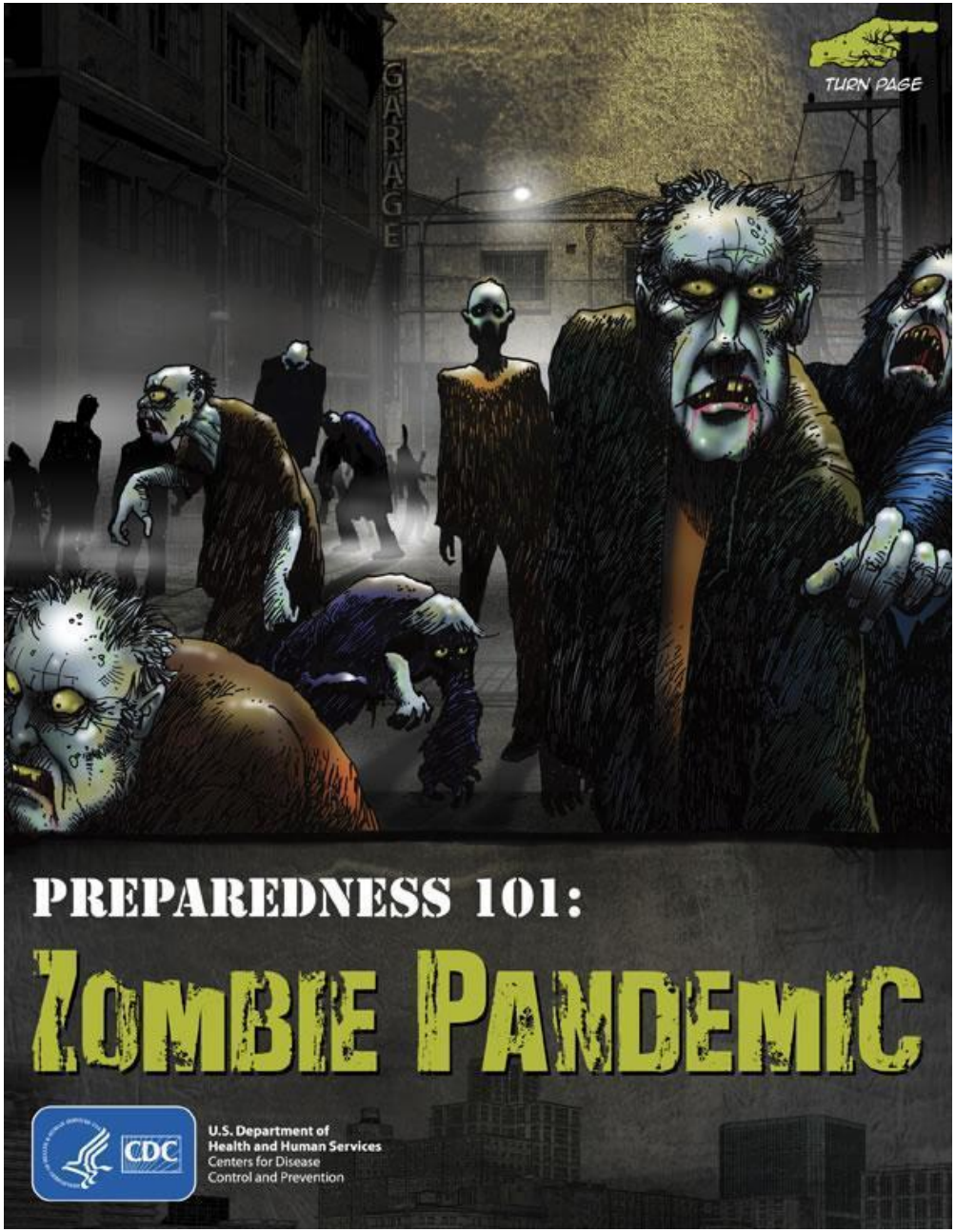
Search lots of books



Search in Google Books:

1900 - 1966	1967 - 2002	2003 - 2004	2005 - 2006	2007 - 2008	zombie (English)

Increasing in popularity


GARAGE
TURN PAGE
PREPAREDNESS 101:
ZOMBIE PANDEMIC
CDC
U.S. Department of
Health and Human Services
Centers for Disease
Control and Prevention

Zombie Apocalypse: Bangor, Maine Prepares For Hordes Of Undead Minions

The Huffington Post | By Andy Campbell
Posted: 06/24/2012 9:36 am Updated: 06/24/2012 10:14 am

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1,583 share | 86 tweet | 23 +1 | 155 email | 406 comment

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FOLLOW: Zombies, Bangor, Bangor Zombies, Maine, Pandemic Preparedness, Zombie Apocalypse, Zombie Preparedness, Zombies Take Over Maine, Weird News

res?um=1&hl=en&sa=N&rlz=1C1CHMO_enUS483...

Grab your zombie bullets and your running shoes, the undead have reached Maine!

Just days after the federal government denied the existence of zombies, the city of Bangor took the zombie apocalypse craze to a whole new level. Officials began "preparing" for the undead by running a daylong pandemic exercise Thursday that *Bangor Daily News* reported

The Zombie War is Coming

About Humans vs. Zombies

WHAT IS HUMANSVSZOMBIES?

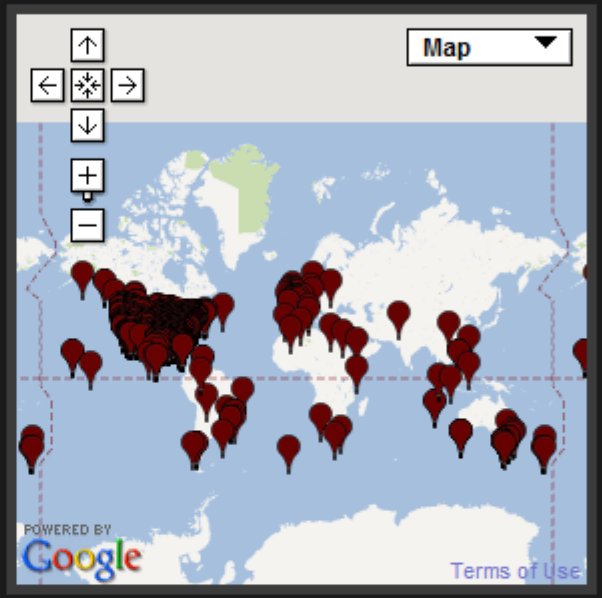
Humans vs. Zombies (HvZ) is a game of moderated tag played at schools, camps, neighborhoods, military bases, and conventions across the world. Human players must remain vigilant and defend themselves with socks and dart blasters to avoid being tagged by a growing zombie horde. Read more, or watch the documentary.

AP npr The New York Times Slashdot The Colbert Report

Since beginning at Goucher College in 2005, Humans vs. Zombies has developed an international fan base and received prominent press coverage from the New York Times, the Washington Post, NPR, the Associated Press, FOX "News," and Stephen Colbert, who named us the number one threat to America. HvZ is played on six continents, with games in diverse locations such as Australia, Namibia, Spain, and Denmark.

Humans vs. Zombies is always free to play, and made available under a Creative Commons license.

Get Involved



ADD YOUR SCHOOL TO THE MAP

Find us on Facebook

Humans Vs. Zombies

Like

Humans Vs. Zombies

Just 4 more days until the

HVZ
HUMANSVSZOMBIES

"The antidote for the ailments of a generation."
- The International Herald Tribune

ABOUT HVZ | THE RULES | PR

Humans vs Zombies: Outbreak at Unity College

jacpac007 | Subscribe | 6 videos

HUMAN RULES

Staying On Campus: Humans must sleep on campus. If you need to leave campus for longer than 24 hours, contact the game moderators and remove yourself from the game.

I.D. Number: Humans must keep an index card with their unique identification number on them at all times.

Stunning a Zombie: Humans may stun a Zombie for 15 minutes by blasting them with a dart blaster or throwing a sock at them.

When Tagged By a Zombie: When tagged by a Zombie, a Human is required to distribute their ID card. One hour after being tagged, tie your bandanna around your head – you are now a member of the Zombie team! Go tag some Humans.

Wearing a Bandanna: Humans must wear a headband around an arm or leg to identify them as players of the game. (This headband will come in handy when you become a zombie!)

ZOMBIE RULES

Feeding: Zombies must feed every 48 hours. A zombie feeds by reporting their tag on the website.

Wearing A Headband: Zombies must wear a bandanna around their heads at all times. The Original Zombie does not need to wear a headband.

HvZ

Game of tag to spread zombie disease

In: Infectious Disease Modelling Research Progress ISBN 978-1-60741-347-9
Editors: J.M. Tchuenche and C. Chiyaka, pp. 133-150 © 2009 Nova Science Publishers, Inc.

Chapter 4

When Zombies Attack!: Mathematical Modelling of an Outbreak of Zombie Infection

***Philip Munz*[1,*], *Ioan Hudea*[1,†], *Joe Imad*[2,‡], *Robert J. Smith?*[3,§]**
[1]School of Mathematics and Statistics, Carleton University,
1125 Colonel By Drive, Ottawa, ON K1S 5B6, Canada
[2]Department of Mathematics, The University of Ottawa,
585 King Edward Ave, Ottawa ON K1N 6N5, Canada
[2]Department of Mathematics and Faculty of Medicine, The University of Ottawa,
585 King Edward Ave, Ottawa ON K1N 6N5, Canada

Abstract

Zombies are a popular figure in pop culture/entertainment and they are usually

UC HvZ game 2012, 2013

$$\frac{dH}{dt} = -k_1 HZ$$

$$\frac{dW}{dt} = -k_2 WZ$$

$$\frac{dZ}{dt} = k_1 HZ + k_2 WZ - bZ$$

$$\frac{dC}{dt} = bZ$$

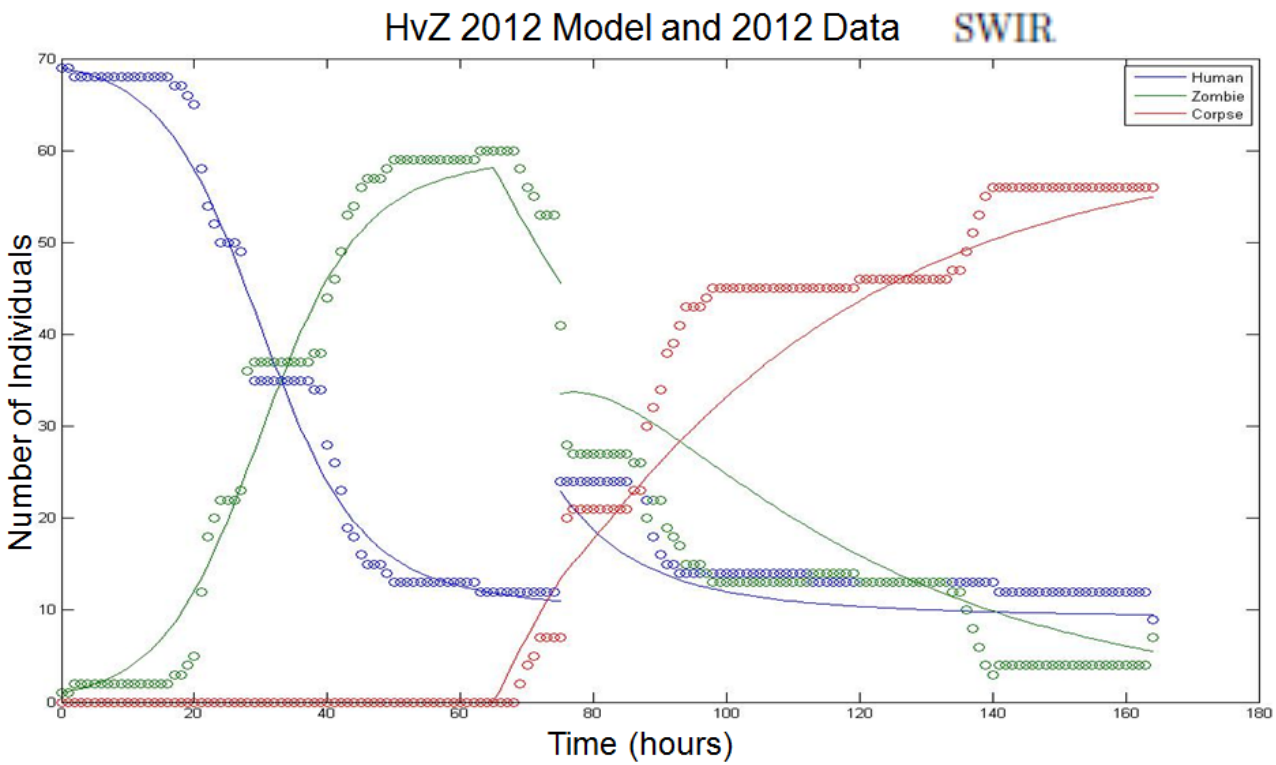
Parameter	Meaning
H	Humans
W	Warriors
Z	Zombies
C	Corpses
k_1	Rate constant H to Z
k_2	Rate constant W to Z
b	Rate constant Z to C

Lemelin and Eaton (2015, under revision for Letters in Biomathematics)

UC Game 2012

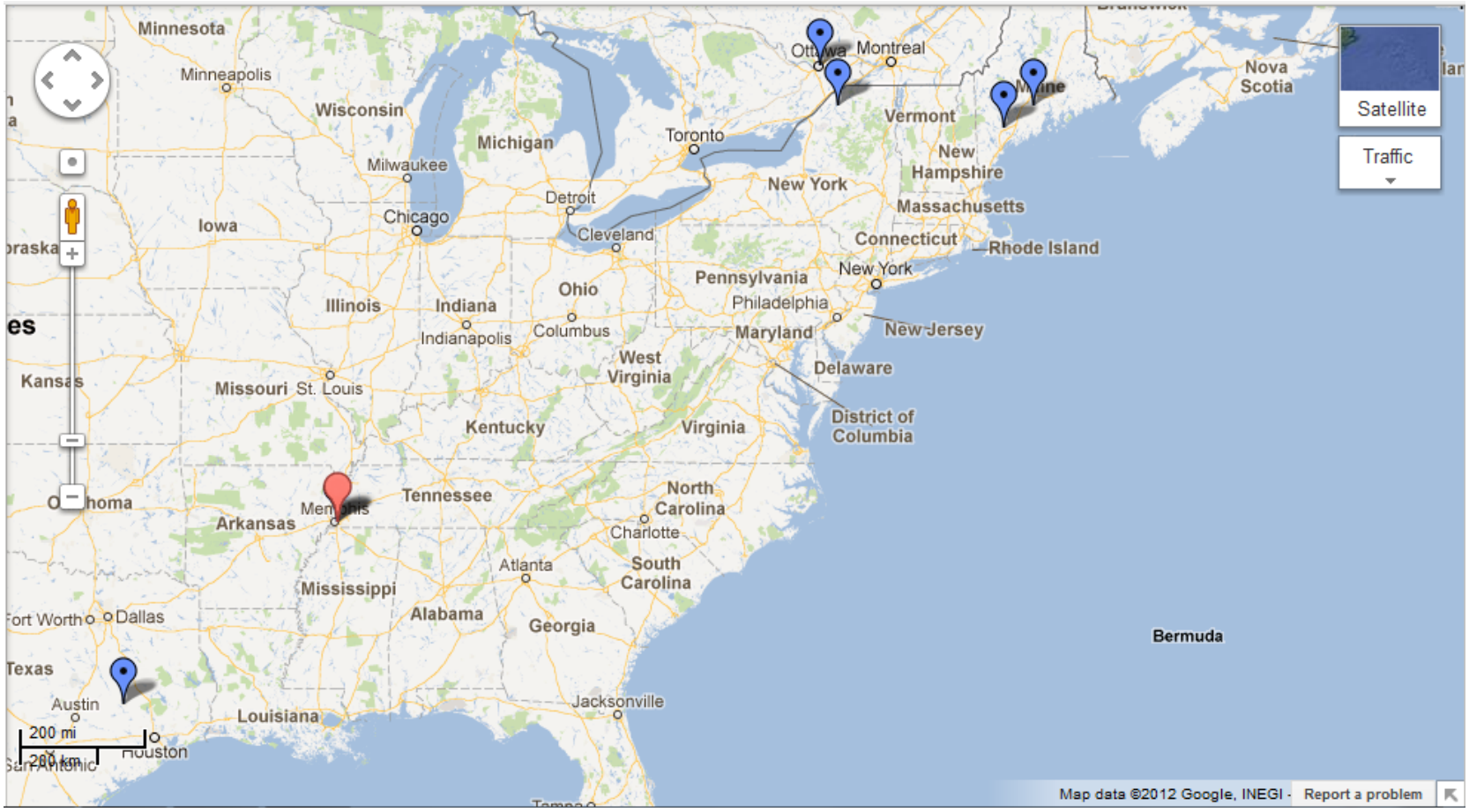
SWIR model

Phased Model Name	SSE	K	AIC
SIR	**39208**	4	923
Type II predator-prey	66772	6	1021
Typle III predator-prey	73908	6	1038
Sinusoidal sleep cycles	53158	5	978
SIR	52606	2	961
SWIR	51388	3	963



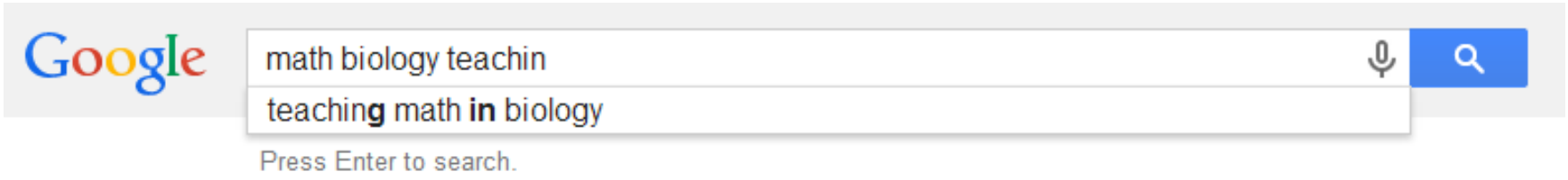
Lemelin and Eaton (2015, under revision for Letters in Biomathematics)

Some of the Math Zombie research sites



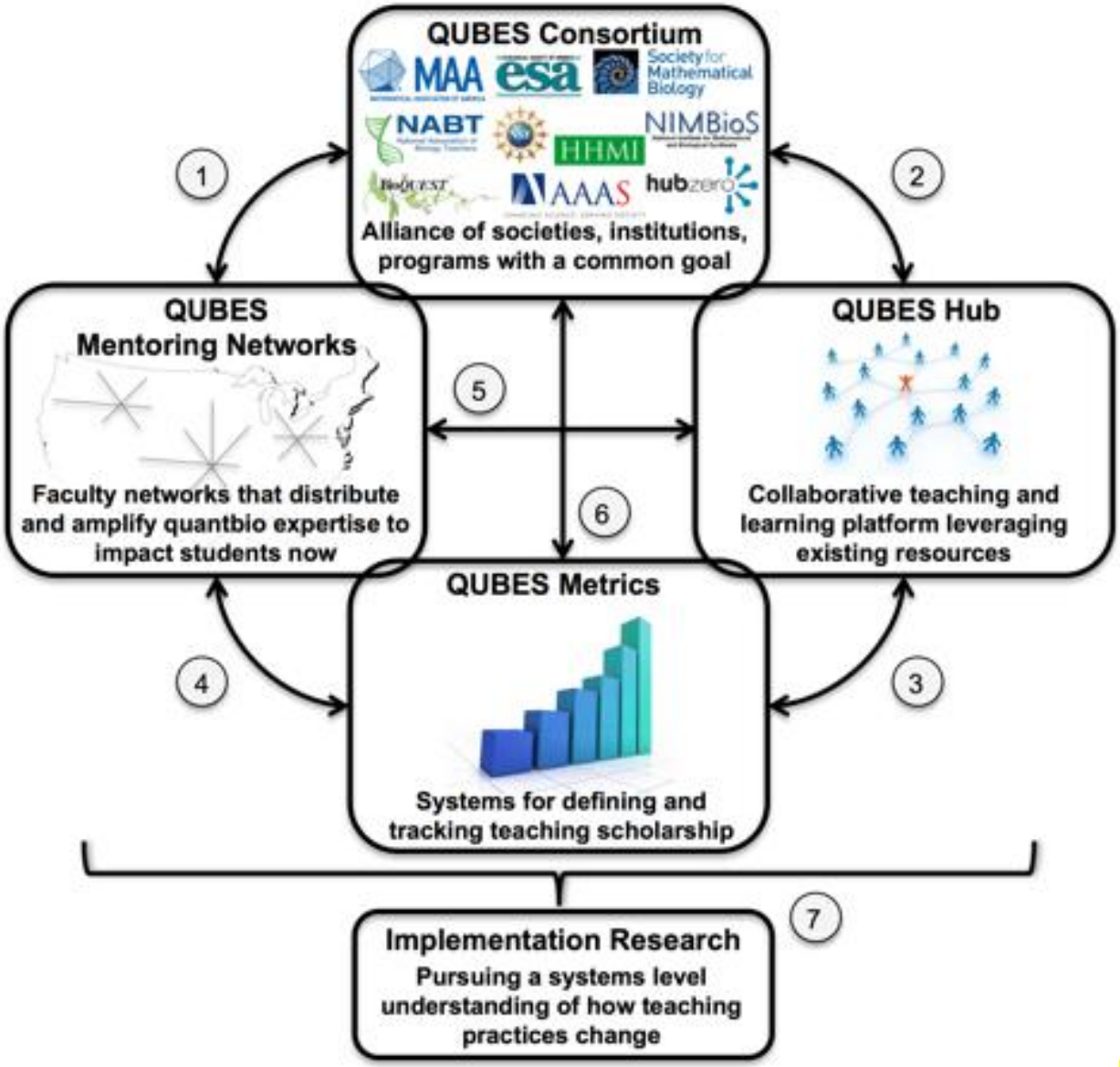
We should be working together - meta-analysis!

QUBES: Quantitative Undergraduate Biology Education and Synthesis



The **synthesis** problem: Entities from mathematics and biology are working **independently** to create curriculum, content, and **educational experiences**, at the interface of these two fields, with the intended audience both **mathematics and biology** students.

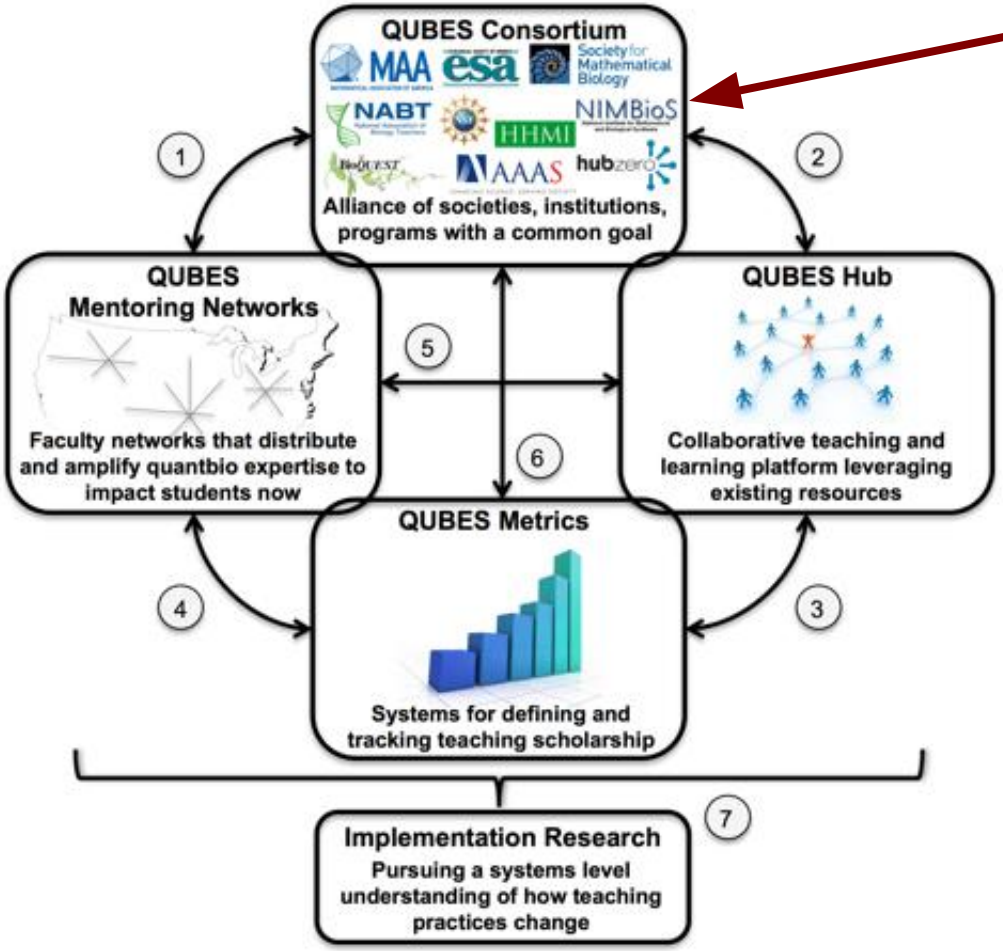
How do we bring it all together??



Scope of work under the **$2.9 million NSF IUSE** Ideas Lab grant.

- W&M,
- Unity College,
- Roanoke College,
- Radford,
- UPitt,
- UW, and
- BioQUEST

QUBES Consortium



- Communications with community, Consortium liaisons, and advisory board.
- Develop partnerships,
- Leverage resources,
- Education and Outreach plans

QUBES Consortium members

- NIMBioS
- BioSIGMAA
- SMB
- MBI
- AAAS
- HHMI
- BioQUEST
- ESA
- TWS
- 12 other institutions and organizations

QUBES Activities

to connect the community

BIO-SIGMAA and NSF RCN Incubator Grant start

Development team meeting at RC

Summit at NIMBioS at UT Knoxville

Submitted NSF IUSE Ideas Lab Proposal

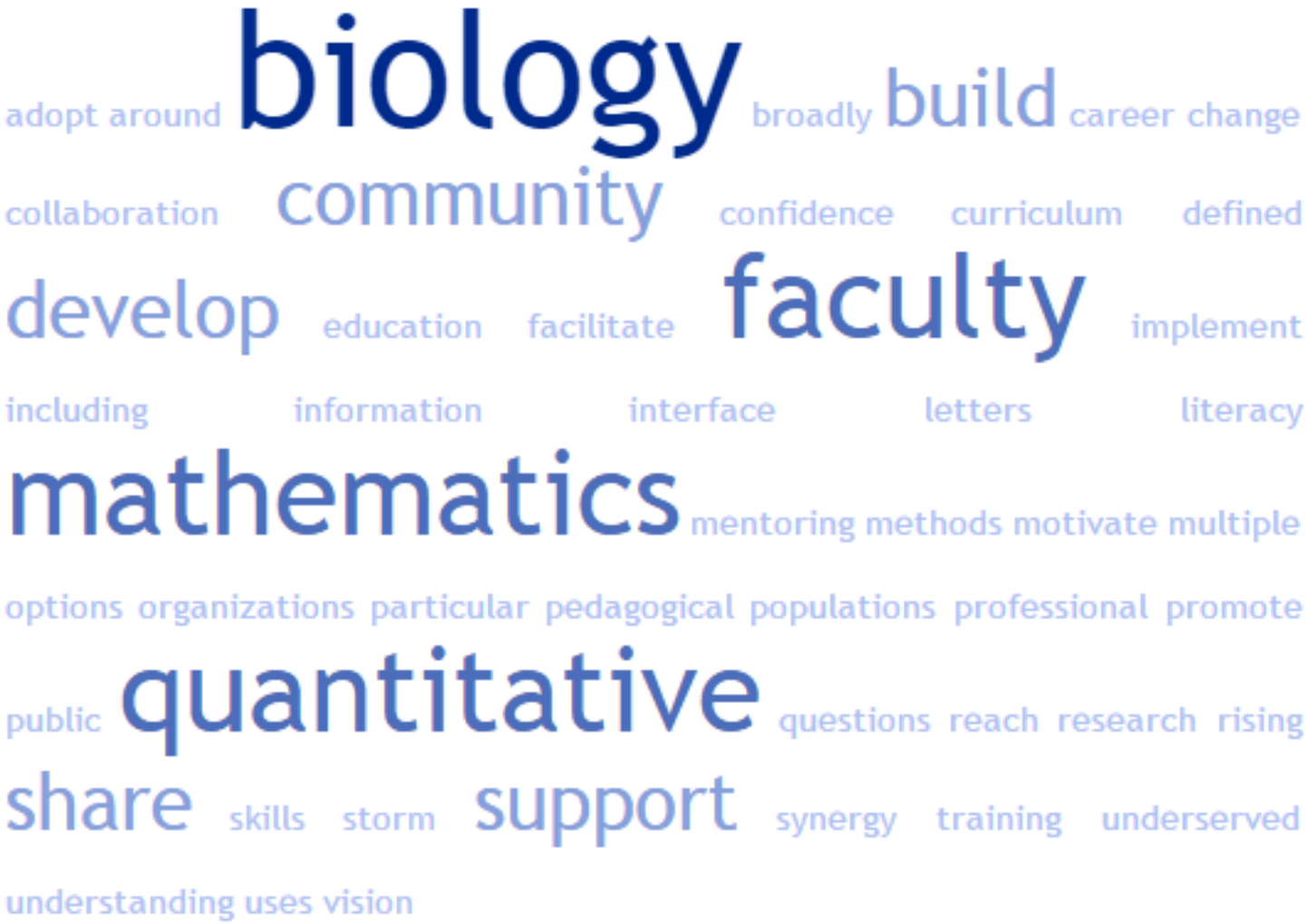
$2.9 million, 5-year NSF IUSE award

QUBESHub, HubZero site online

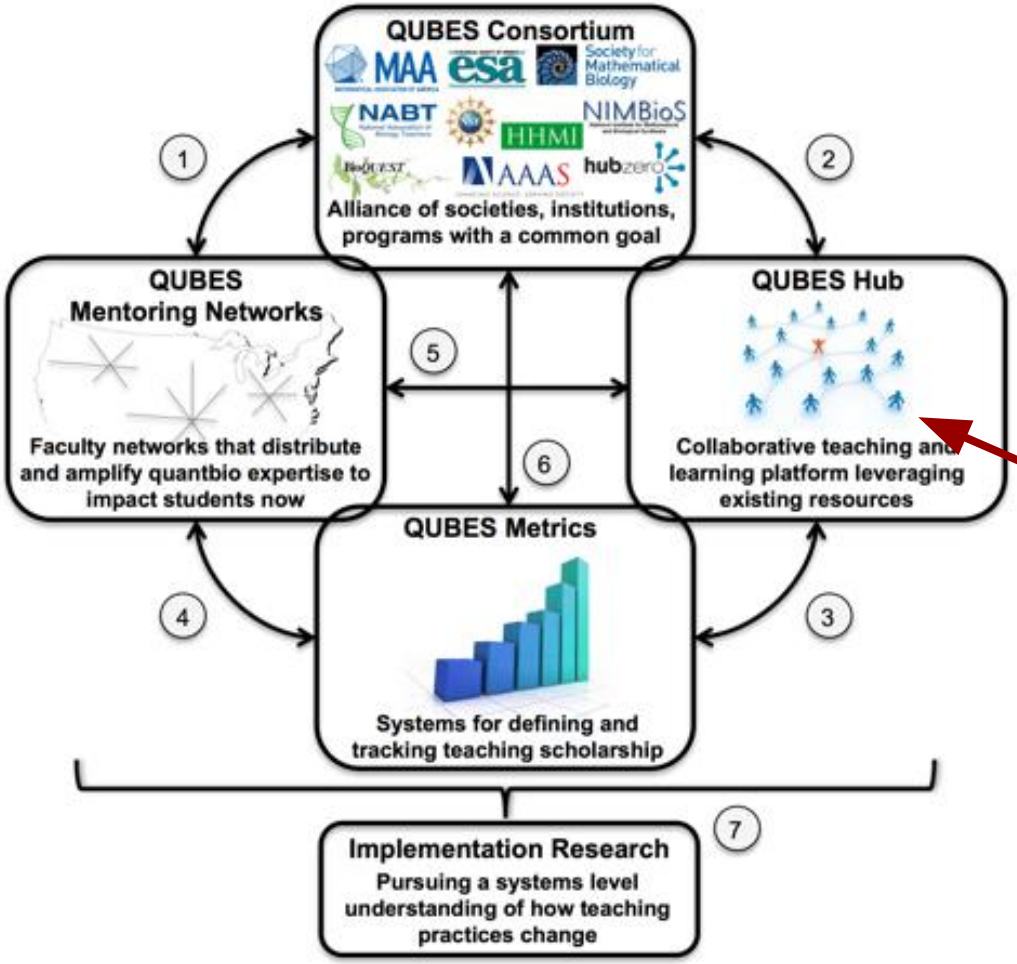
2nd Summit with Data Inquiry RCN at NESCent

Jan 2014 | Mar | May | June | Sept | January 2015 | February

Consortium vision for QUBES



QUBES Hub



Virtual space to bring the math-biology education community together.

Hub Team w/HubZero:

M. Drew LaMar

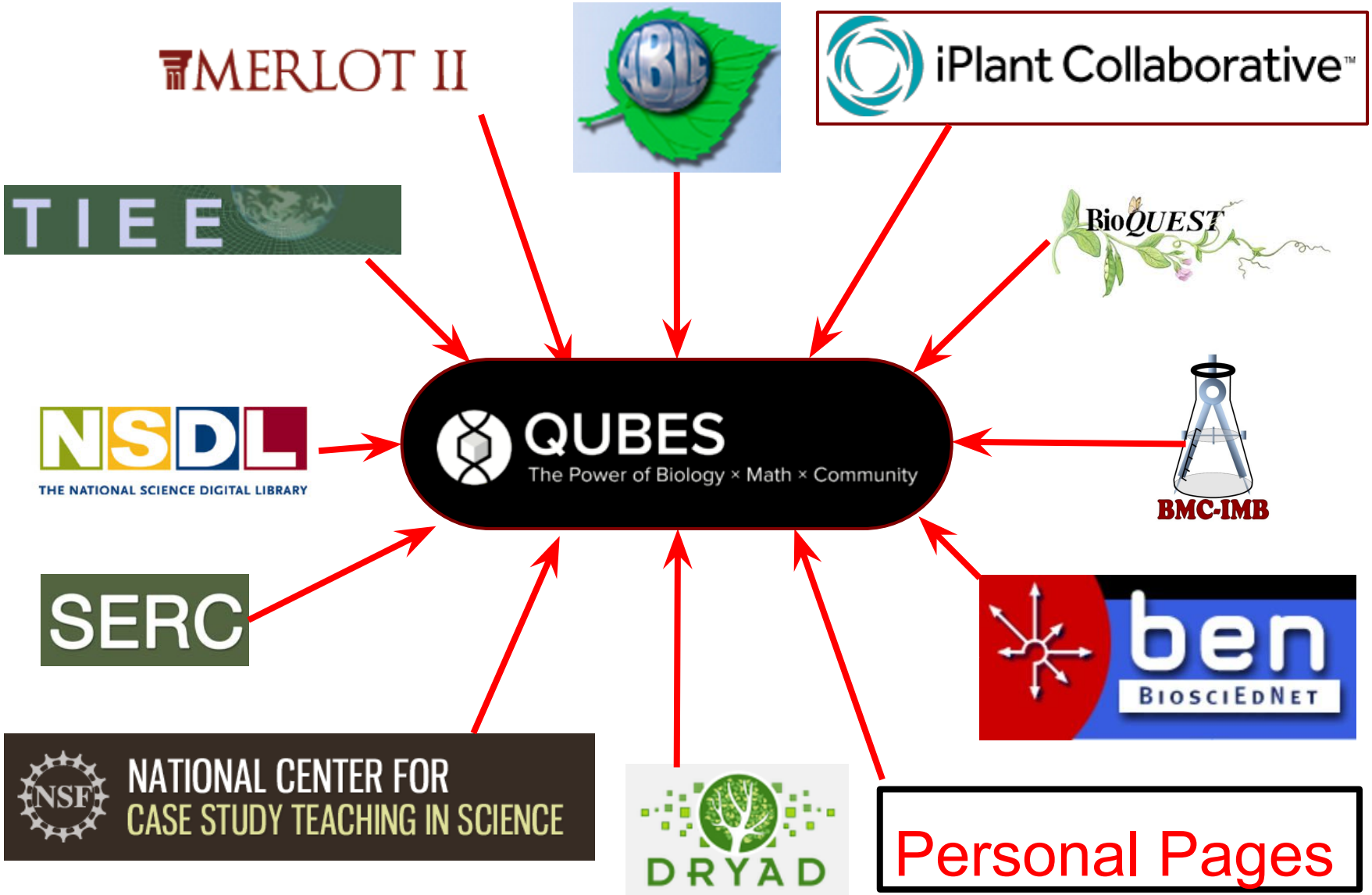
Bob Sheehy

DB Poli

Jennifer Cartier

Michael McLennan

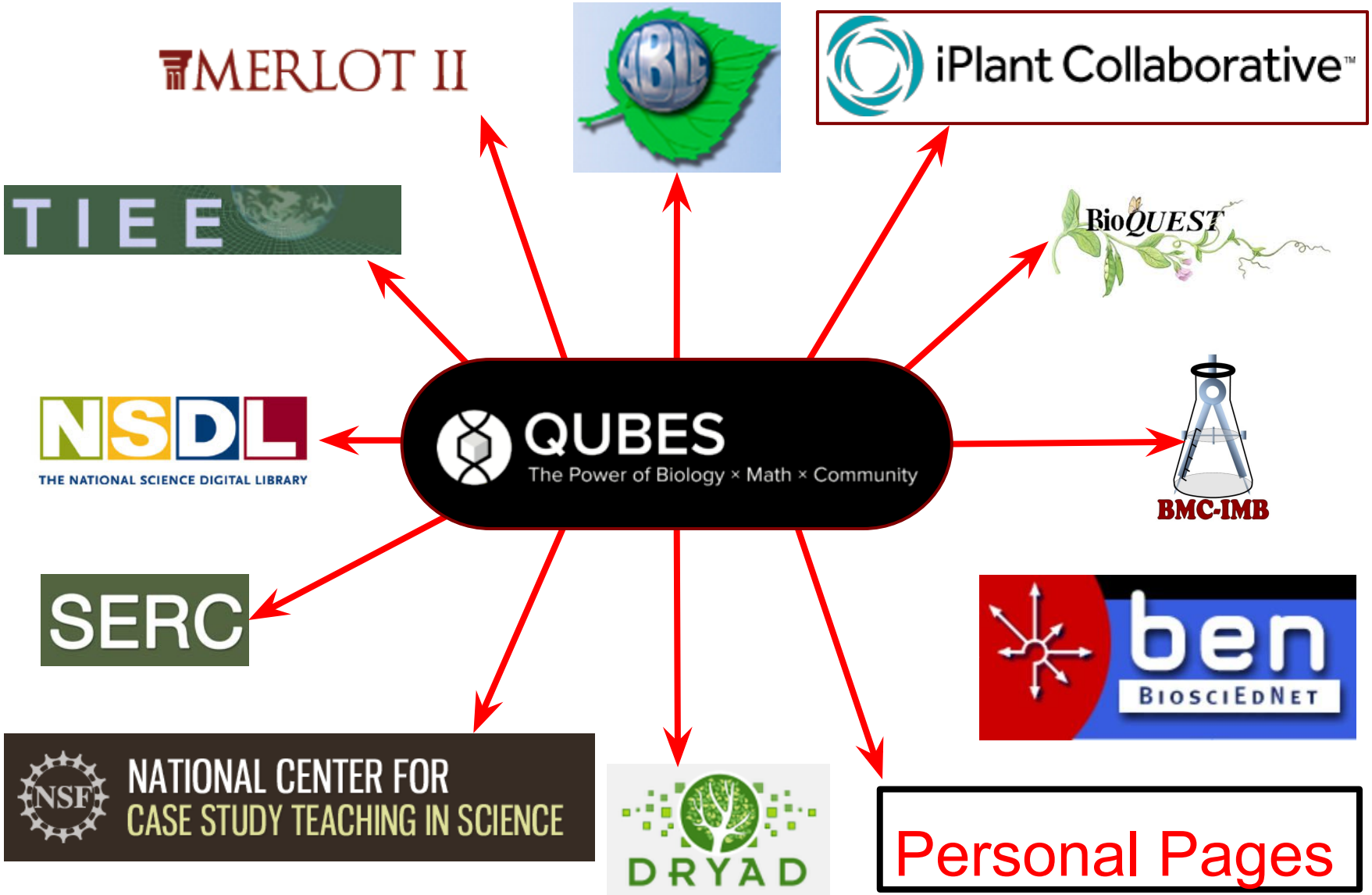
J. Patrick Mulligan


MERLOT II
ABLE
iPlant Collaborative
TIEE
BioQUEST
NSDL
THE NATIONAL SCIENCE DIGITAL LIBRARY
QUBES
The Power of Biology × Math × Community
BMC-IMB
SERC
ben
BIOSCIEDNET
NSF
NATIONAL CENTER FOR
CASE STUDY TEACHING IN SCIENCE
DRYAD
Personal Pages

From Idea to Product

Collaboration space

http://www.webmd.com/parenting/d2n-stopping-germs-12/slideshow-kids-germs-handwashing
http://sf.funcheap.com/event-series/carve-san-francisco-sandcastle-building-contest/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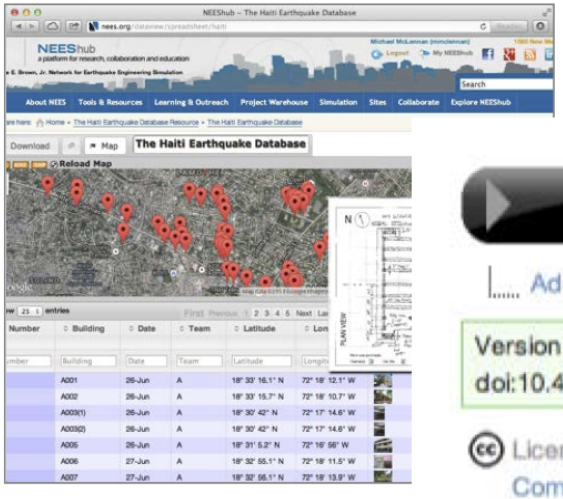
Vision for QUBES Hub

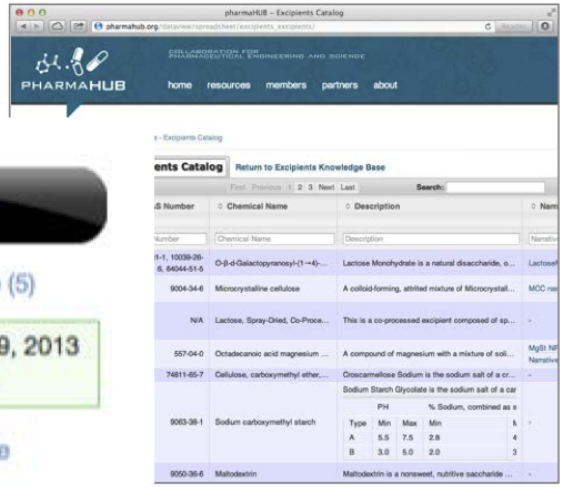
1. Foster collaboration beyond silos (language, place)

Vision for QUBES Hub

1. Foster collaboration beyond silos (language!)
2. A hub/repository for multiple types of curriculum/research objects, such as:
   a. labs, data, modules, assessments (*version control, customizable*)
   b. web-based simulators/data analyzers
   c. implementation guides

HUBzero: Databases and Digital Assets





- ✓ Databases and digital publications
- ✓ Uploaded by researchers in the community
- ✓ Digital Object Identifiers and license options
- ✓ Data ↔ tools for analysis

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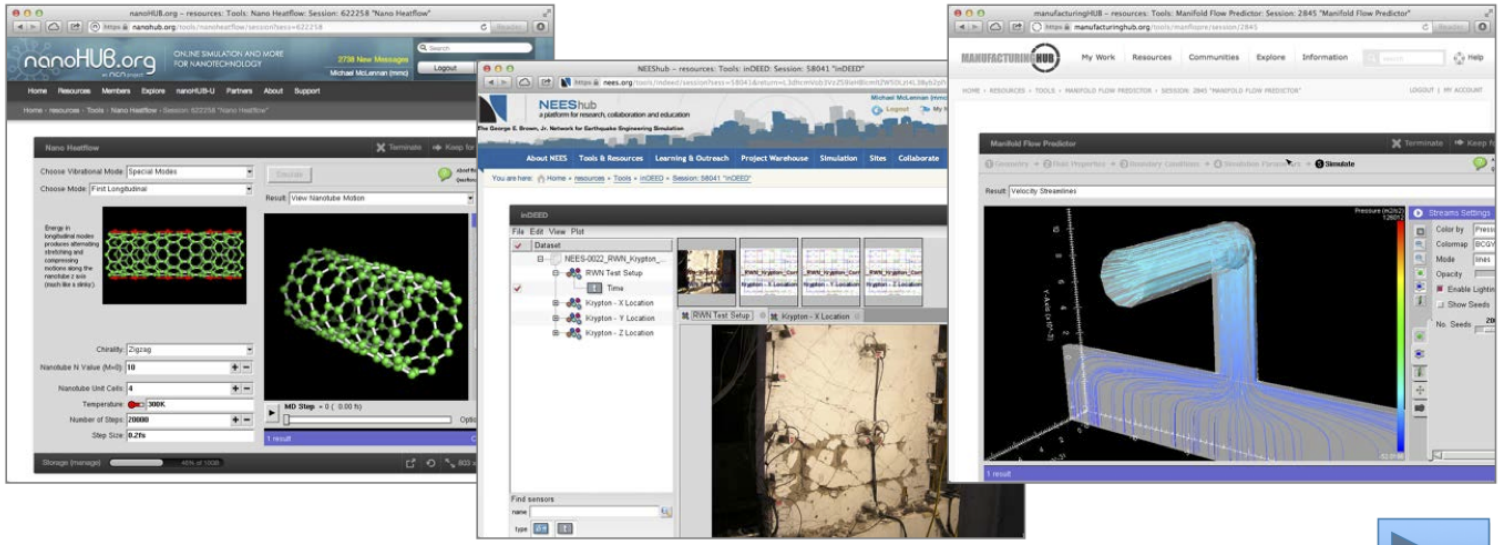
HUBzero Foundation, LLC

HUBzero: Simulation/Modeling Tools



- ✓ Powerful research codes
- ✓ Uploaded by researchers in the community
- ✓ Run on cloud/grid/cluster resources
- ✓ Integrated visualization

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Vision for QUBES Hub

1. Foster collaboration beyond silos (language!)
2. A hub/repository for multiple types of curriculum/research objects, such as:
   a. labs, data, modules, assessments (*version control, customizable*)
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3. Nested tagging system, a powerful search engine, and fluid content navigation tools

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   b. web-based simulators/data analyzers
   c. implementation guides
3. Nested tagging system, a powerful search engine, and fluid content navigation tools
4. Ability for informal and formal peer review

More than just a repository

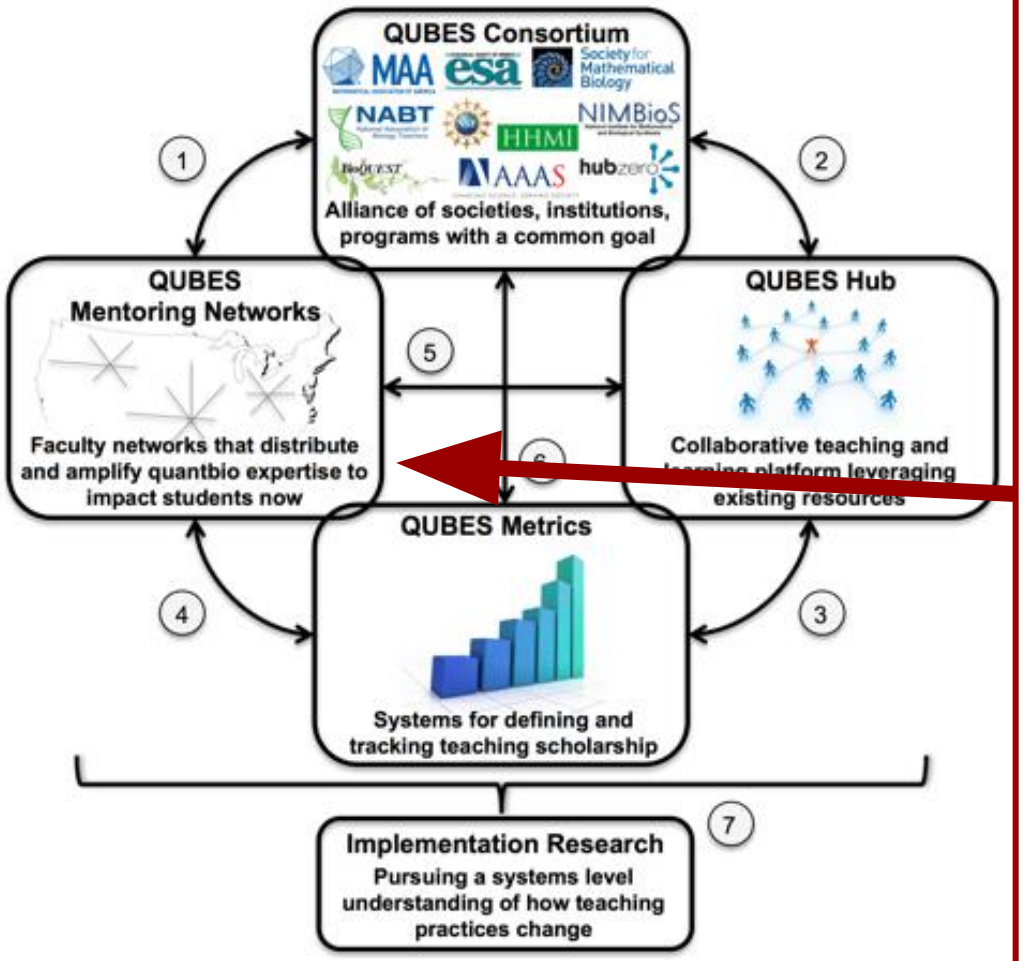
With the ability to like, rate, dynamically add and link content.

A HUB where curriculum content can be *created*, **shared**, **modified**, **stored**, and **organized**, all in a heavily **social**, **adaptive** and **collaborative** context.

QUBES

The Power of Biology × Math × Community

QUBES Mentoring Networks - Backbone of the QUBES community



- Distributing Faculty Expertise
- Mentoring programs
  - F2F and virtual
- Community curriculum development and assessment
- Senior Personnel
  - Sam Donovan
  - Jeremy Wodjak
  - Kristin Jenkins

QUBES

The Power of Biology × Math × Community

QUBES

HOME RESOURCES COMMUNITY ABOUT SUPPORT EXPLORE

QUANTITATIVE
UNDERGRADUATE
BIOLOGY
EDUCATION AND
SYNTHESIS

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Learn more about QUBES...

QUBES Consortium

MAA Mathematical Association of America
esa Ecological Society of America
Society for Mathematical Biology
NABT National Association of Biology Teachers
NSF
HHMI
NIMBioS National Institute for Mathematical and Biological Synthesis
BioQUEST
AAAS Advancing Science, Serving Society
hubzero

Alliance of societies, institutions, programs with a common goal

FEATURED IN COMMUNITY

BioQUEST Curriculum Consortium
hhmi
ScienceCaseNet

Count the Ways: Engaging Students in Quantitative Biology Education

June 13-20, 2015
Harvey Mudd College

FEATURED IN RESOURCES

COPASI
Octave
R Studio
NetLogo

NEWS AND EVENTS

FEB 22, 2015
NSF funding opportunity: BIGDATA program

MAR 30, 2015
SABER 2015 Abstract Deadline

Thank you!!

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