Towards Bio2020:

Educating Biologists, Mathematicians, and Computer Scientists Collaborating to Redesign Education: Content and Pedagogy

Jason Miller, Ph.D.
Department of Mathematics
Truman State University

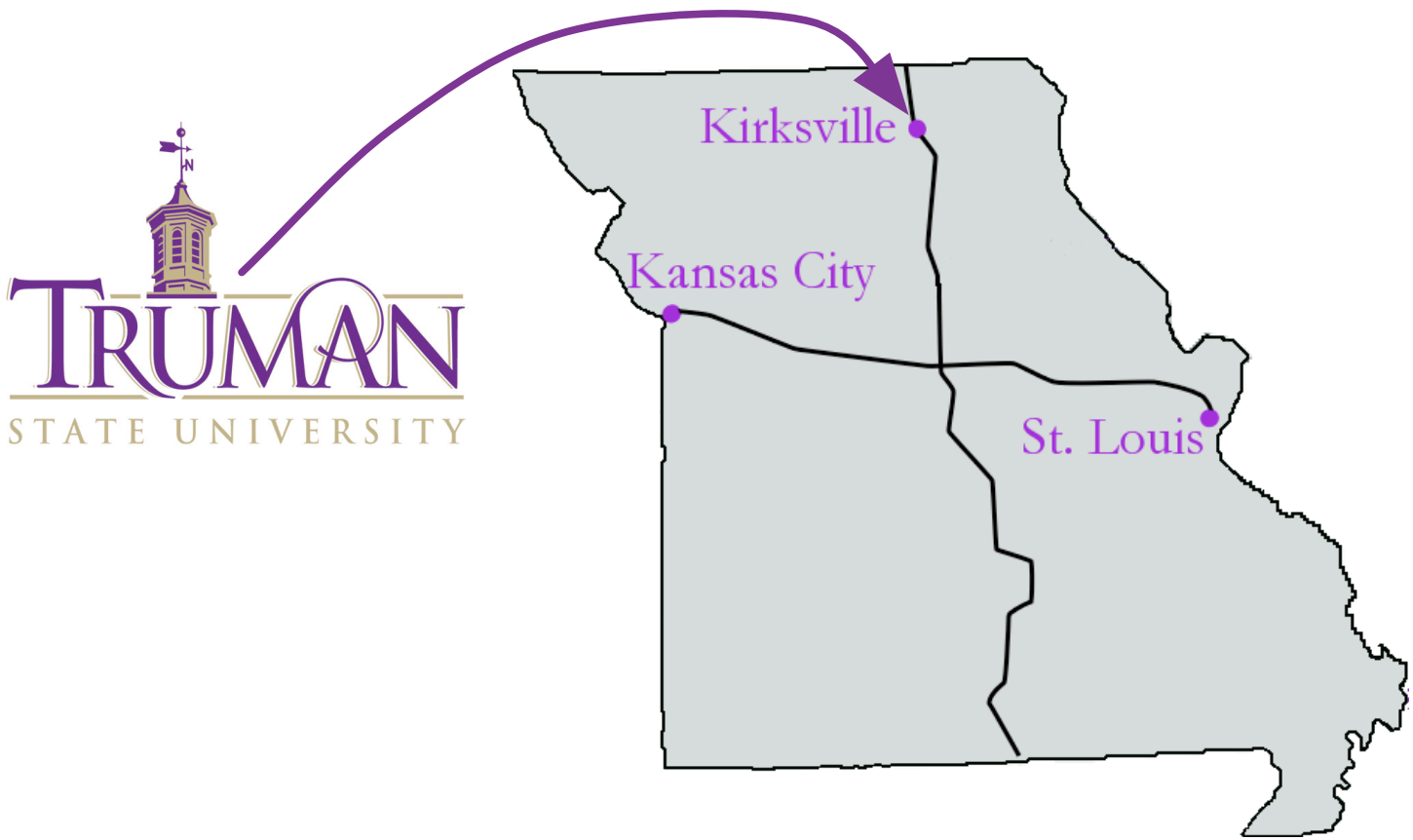
Why We're Here

- we have recognized the importance quantitative biology in the undergraduate curriculum
- we want to identify and share best practices and resources
- we want to work together to create new materials
- establish a community of educators who will continue advancing this effort for many years to come

Outline

- Introduce Truman State University
- Overview of Truman's research-focused mathematical biology program
- Take Stock of Current State Biology+Math curricular reform
- Comment on aspects of a strong QB program

Truman & Interdisciplinary Activity



Truman is in rural Kirskville, Missouri

About Truman

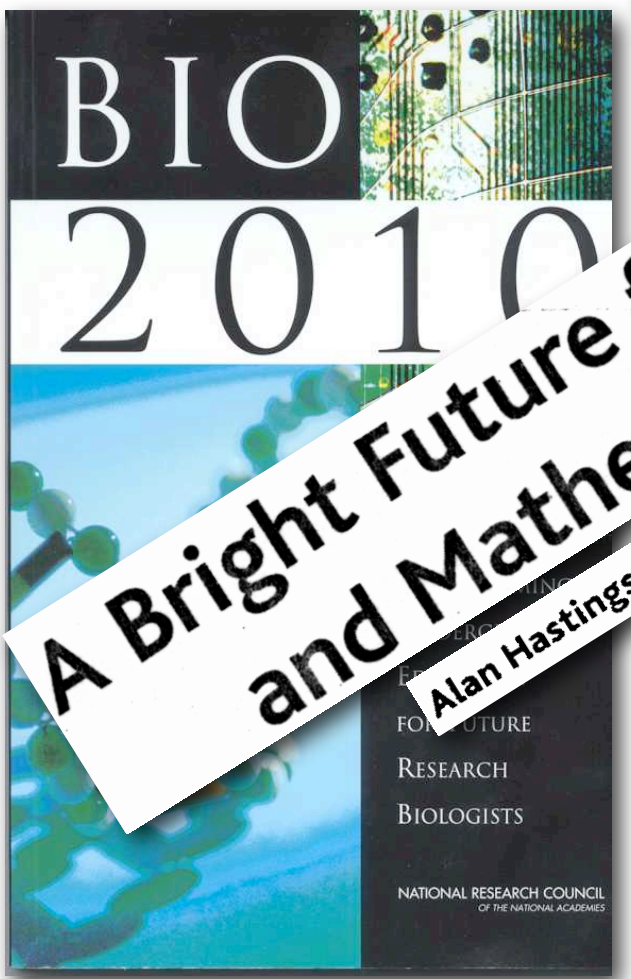
- Missouri's only "highly selective" public liberal arts University; pride in high-quality teaching, small class size
- ~6000 undergraduates, ~300 faculty, 150 Masters students
- Institutional commitment to Undergraduate Research and to Interdisciplinary teaching
    - EX: all students must take a *Junior Interdisciplinary Seminar*

About Truman

- about 25 biology faculty, 40 mathematics faculty (math+stats+CS)
- biology: research expected of faculty (with students); experienced mentors
- mathematics: teaching focus, little or no support for research activity; 10 new faculty between 1998-2000

Meeting the Challenges: Education across the Biological, Mathematical, and Computer Sci

By Victor Katz



New NSF Program Supports Undergraduate Math/Bio Training

The Directorate for Biological Sciences (BIO), the Directorate for Education and Human Resources (EHR), and the Division of Mathematical Sciences (DMS) in the Directorate for Mathematics and Physical Sciences (MPS) at the National Science Foundation (NSF) are making available opportunities for the scientific community to enhance interdisciplinary education and training for undergraduates at the intersection of the biological and mathematical sciences. The goal is to stimulate development of a future workforce, including teachers and researchers, that is prepared to work in the increasingly many areas where these two disciplines connect. Proposals for this year's cycle are due by June 2. For fur-

A Bright Future f and Mathem

Alan Hastings and

Challenges
cs and
ogy
hallenges
y

Mathematical Biology Seminar (since 2003)

- Program fulcrum
- Biweekly meeting of faculty and undergraduates
- Initially, a "Biology Fashion Show"
- Engineered several cross-disciplinary, research hook-ups
- Pairings provided us with a foundation for NSF UBM grant proposals

Our Program

- support from NSF's *Interdisciplinary Training of Undergraduates in Biology and Mathematics* (UBM) program
- use faculty-mentored interdisciplinary research projects as pedagogical vehicle
- undergraduates are collaborators
- projects are long-term so that students engage in the whole range of scientific experiences

Program Goals

- to support high quality interdisciplinary research projects for undergraduates and faculty
- to create resources for and to promote the integration of research and teaching in mathematics and biology
- create and sustain a learning-community with mathematical biology as a common interest

Research Teams

- each team has:
  - two faculty, one from each discipline
  - two student, one from each discpline
- each teams receives stipends, supply budget and travel allowance
- year-long experience (academic year + 10-week summer)

Research Teams

- selection occurs in the Fall, students start work in January (year-long)
- weekly meetings during the academic year
- Intense 10-week summer research program

Summer

Residence Hall

Meals

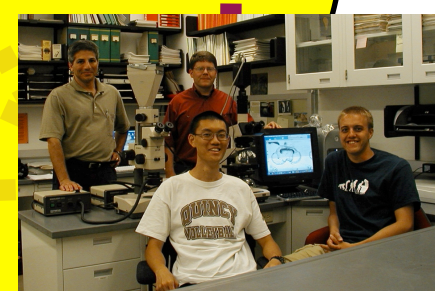
Small Group Meetings + Mentors

Community

Weekly Discussions/Workshops

Social Events

MathBio Seminar



Research Pedagogy: Epistemology

- a discipline's epistemology is the way it looks at the world and organizes information about it (Bill Newell)
- Example: Biology
  - levels of biological organization; questions about life; scientific method
- Example: Mathematics
  - 'mathematical truths' as statements of properties of formally defined objects; deductive logic; theorems

Research Pedagogy: Epistemology

- can talk about 'epistemological distance'
- close disciplines:
  - biology & chemistry
  - mathematics & philosophy
- distance disciplines
  - studio arts & business management
  - mathematics & biology

Research Pedagogy: Epistemology

- each person is deeply engaged in the other's discipline for much of the year
  - reading scientific papers, discussions
  - lab work, field work, mathematical work
- clashing epistemologies generate frustration, discomfort
- failure generates frustration, discomfort
- working through the frustrations yields learning!

Summary

- Program grew from institutional strengths and interests, meeting the needs of many
- Creates a learning-centered community for faculty and students
- Trains students through research; discomfort is a sign of success

Looking to Truman's future

- Our program was the perfect means for developing infrastructure and faculty buy-in
- It is an imperfect model for a sustainable quantitative or mathematical biology program
- (But it puts us in a very powerful position as Truman launches it next efforts.)

Important Qualities of QB programs

- properly done, quantitative methods must be part of the first biology courses an undergrad takes (and biological concepts in early mathematical courses, too)
- efforts must be scalable and sustainable (from fiscal and human resource perspectives)
- activities should count toward graduation
- must included research or research-like experiences

Taking Stock

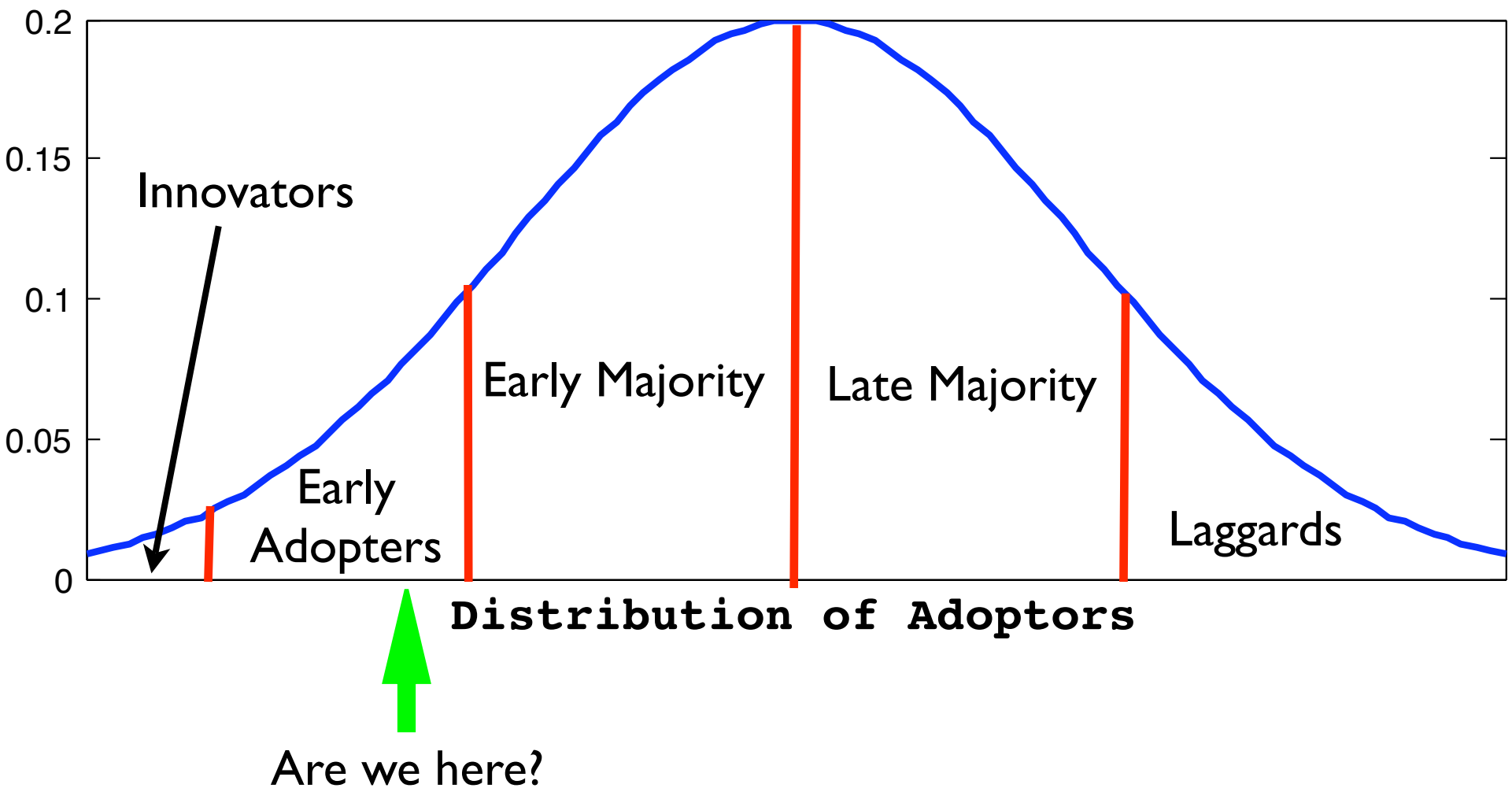
- The biology discipline began changing before Bio2010 was published in 2003

"Fifty years ago, engineering went through a change from being a discipline based on empirical evidence to a discipline based on theory. Biology is now going through a similar change."

Dan Litynski, NSF Division of Undergraduate Education, then Acting Director

Innovation Adoption

(*Diffusion of Innovation*, Everett Rogers, 1962)



Innovation Adoption

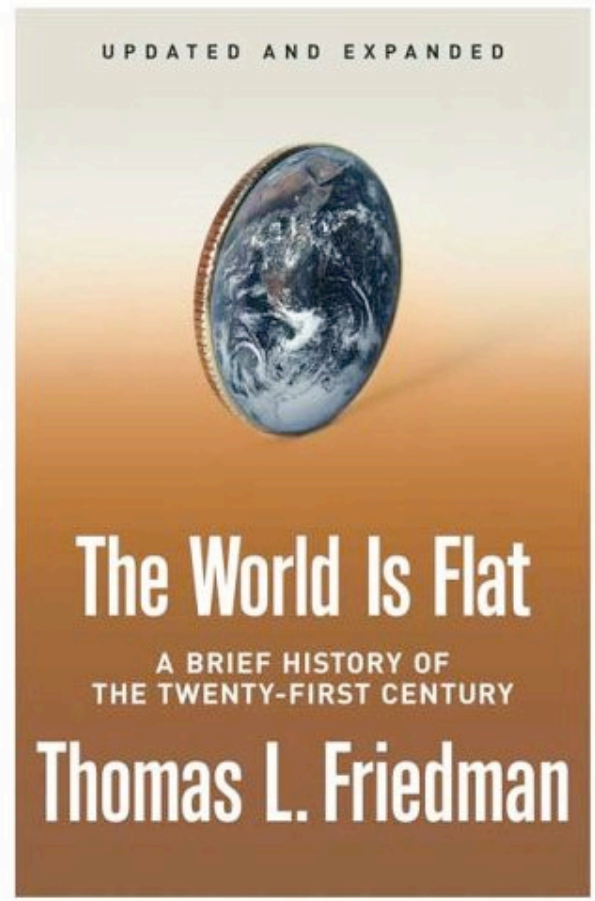
- Bio2010 recommendations are broad and deep (lots to choose from)
- Many schools and professional societies are responding, disseminating information
- Primarily:
  - new courses (many module-based)
  - certificate programs
  - minor degree programs

Innovation Adoption

- We must make efforts to push the adoption curve forward
    - make our work visible to those outside this community
    - persuade others that our innovations work prepares students (assessment!)
    - give others the tools and support that will guarantee their success
- This isn't the first time that biology has tried to go quantitative

Content v. Concepts

- Conceptual knowledge v. Encyclopedic knowledge
- We must prepare our students to approach new questions in an "expert" fashion (Tagg)
- The lecture-quiz-exam paradigm doesn't do this
- Problem Based and Case Based learning does



Content v. Concepts

- Sources of such problems:
  - BioQUEST
  - Mathematical Contest in Modeling (MCM)
  - Interdisciplinary Contest in Modeling (ICM)
  - Science Education for New Civic Engagements and Responsibilities (SENCER)
  - Project Kaleidoscope (PKAL)
  - Interdisciplinary Lively Application (ILAP)

Other Issues

- Assessing our work (interdisciplinary training)
- Increasing STEM undergraduate degree production
- Increasing participation of traditionally underrepresented groups
- Involve pre-K thru 12 and community college teachers in "the revolution"

Increasing STEM production

- Is undergraduate degree production in STEM keeping pace with national needs?
- Probably not.
- Quantitative & Mathematical Biology are uniquely positioned to attract students to science and mathematics

Social Relevance

- With quantitative techniques, students can contribute to understanding serious social issues

public health
disease control
bio-warfare
bio-technology
bio-inspired science
robotics

stem cells
genetic engineering
performance enhancement
human and non-human learning enhancement

(Chris Arney, USMA)

Symbiotechs USA

I How The XT9 ESPK Works I Pros & Cons I Important Information! I

Thank you for visiting SYMBIOTECHS USA

The XT9 Energy Storing Prosthetic Knee is the only prosthetic knee device for highly active amputees, designed to mimic the functions of the quadriceps during intense athletic and extreme sports use by athletic amputees!

The XT9 Energy Storing Prosthetic Knee (ESPK) for high activity above
rst
le AK
sports at
level.
de, light
r space
nts, the
thstand the
sports
active

ossible for
s because
sthetics.
as
for
ne sports

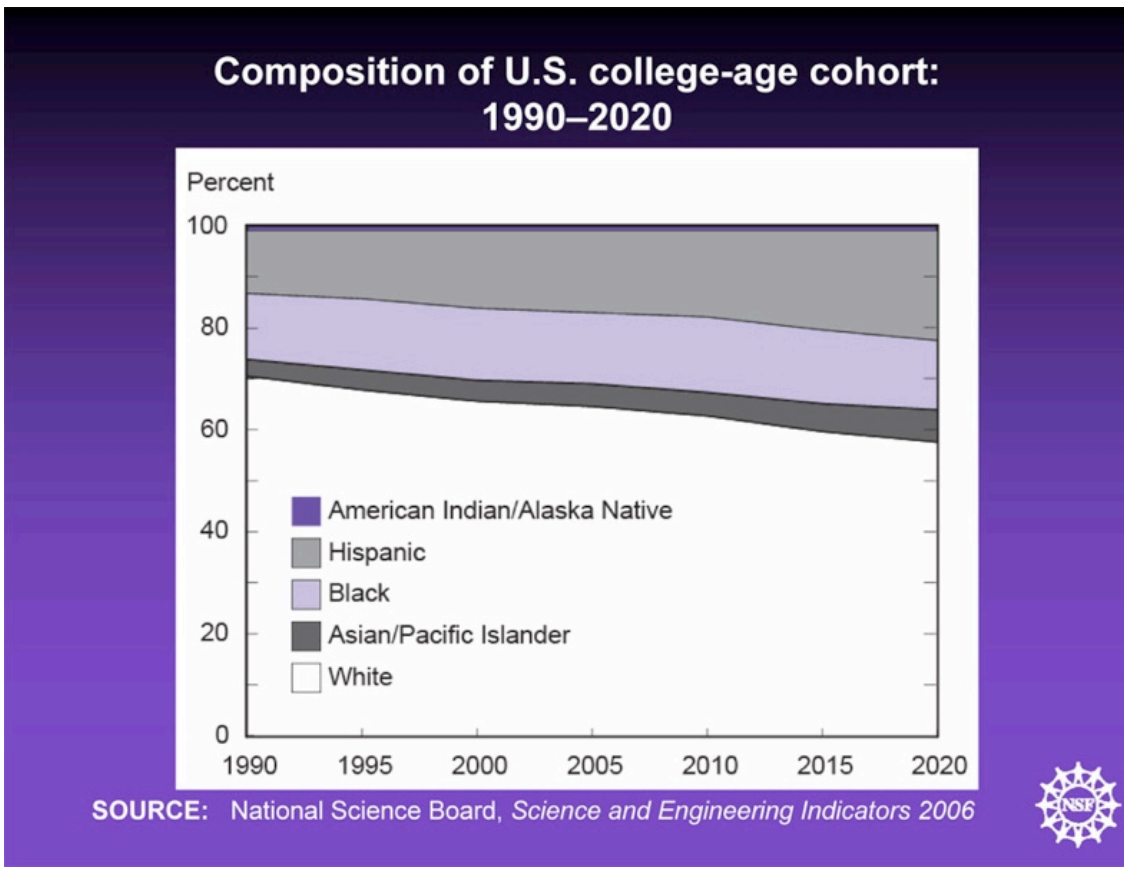
tic device,
re now
round the
ons of the
prosthetic
functions

Home
Vision
Photos
Products
Orders
Warranty
Community
Contact us

MATHBIO
Truman Mathematical Biology Program

Underrepresented Groups

- large growth as a proportion of the population (NSF)
- must be mined to meet national need
- social relevance is an important deciding factor for many (A. Barlow, 2004)



Truman Mathematical Biology

http://mathbio.truman.edu

This material is based upon work supported by the National Science Foundation under NSF UBM #0337769 and NSF UBM #0436348. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.