

# Biomathematics

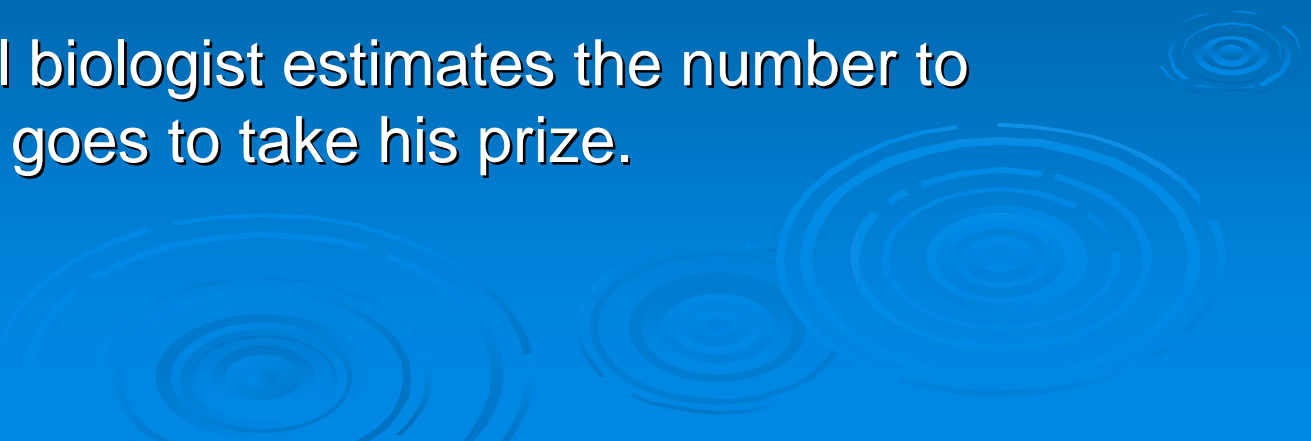
What can I do with it?  
Where can I go to school for it?

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# The biologist, the shepherd, his dog, and the sheep...

- A theoretical biologist out for a mountain hike meets a sleeping shepherd. The shepherd awakes visibly disturbed thinking he lost some of his sheep.
  - He offers the theoretical biologist one of the sheep as a reward if he is able to calculate the exact number of animals in his herd.
  - The theoretical biologist estimates the number to perfection and goes to take his prize.
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# The biologist, the shepherd, his dog, and the sheep...

- To the shepherd's amazement, the theoretical biologist fails to recognize that he has unwittingly picked the shepherd's dog instead of a sheep.
- This story often relayed as a joke quite nicely sums up a common prejudice, but it also expresses some truths about theoretical and mathematical biology.

# The biologist, the shepherd, his dog, and the sheep...

- The strength of biomathematics lies in the calculation of specific values and also in the identification of common structures and patterns at different levels of biological organization--but not the necessarily biological differences per se.

# So...what is Biomathematics?

- Biomathematics is the use of mathematical models to help understand phenomena in biology.
- Modern experimental biology is very good at taking biological systems apart (at all levels of organization, from genome to global nutrient cycling), into components simple enough that their structure and function can be studied in isolation.
- Dynamic models are a way to put the pieces back together, with equations that represent the system's components, processes, and the structure of their interactions.

# So...what is Biomathematics?

- Mathematical models are important tools in basic scientific research in many areas of biology, including physiology, ecology, evolution, toxicology, immunology, natural resource management, and conservation biology.
- Thus, while mathematical biology may sound like a narrow discipline, in fact it encompasses all of biology and virtually all of the mathematical sciences, including statistics, operations research, and scientific computing.

# What type of problems?

- How many **fish** are there in a lake? What fishing limits would maintain current fish populations? Should fishing at the lake be restricted to catch-and-release? Should fishing be banned while the population rebuilds? Should the lake be stocked?
- Should farmers plant **windbreaks** (trees planted along the borders of fields) to increase the number of species and abundance of birds and insects? Would these increased numbers provide enough protection to the crop so that chemical controls could be reduced or even avoided? Do windbreaks need to surround a field or is one or two sides enough?
- Can **fertilizer** be applied at varying rates within a field depending on the changing levels of fertility within the field?
- How do **plants** spread? Is a new species of weed that was accidentally introduced able to out-compete existing species?

# Biomathematics as a career...

- Today theoretical/mathematical biology is booming; currently it seems to offer lots of promising perspectives and possibilities for mathematicians and theoretically interested biologists.
- But such a boom raises suspicions: Is this a fad? Or does mathematical biology offer solid long-term perspectives?

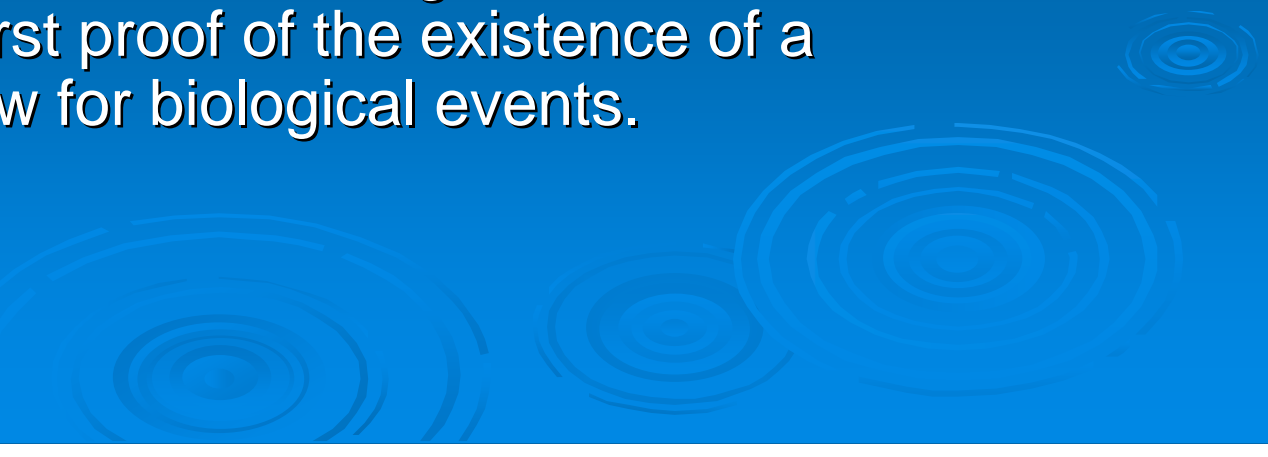
# Evolving Science

- It may come as surprise to some that mathematical/theoretical biology is nothing new.
- There are Baltic, British, French, German, Italian, and Russian roots going back as far as the late 19th century.
- The need for theoretical biology methods was strongly spurred by the enormous amounts of new data arising from the scientific observations of the time (e.g., from expeditions into colonial countries) and new emerging experimental techniques.

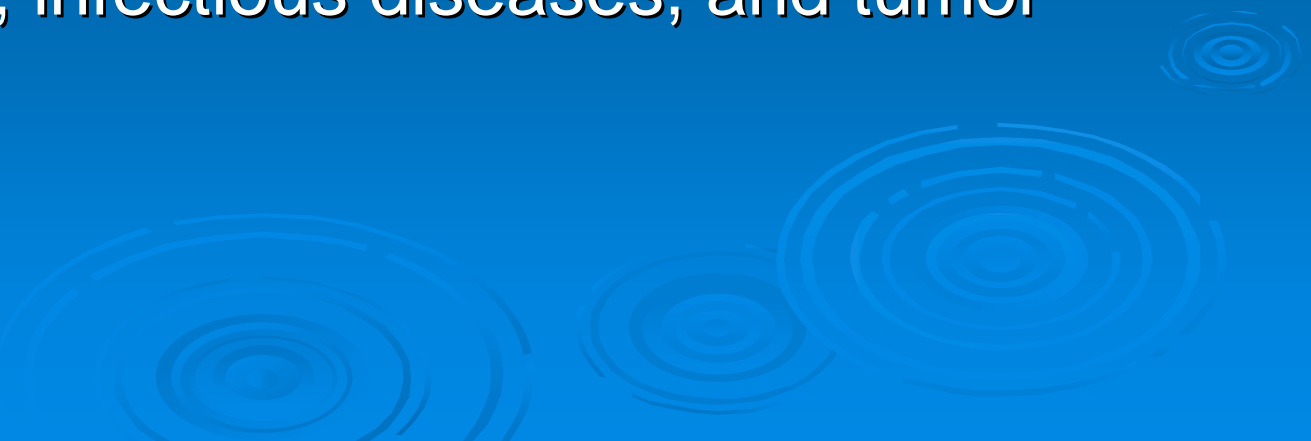
# Evolving Science

- The contemporary "data jungle", which stems mainly from newly available molecular biology methods and the development of computer processing capabilities, is responsible for the more recent boom in mathematical biology.
- As the 20th century was the "century of physics," the new century may well be the "century of biology," although this is of course difficult to state so early on in the century as 2004!

# Evolving Science

- The famous experiments of Mendel, and the fruitful communication between experimental biologists and applied mathematicians in the 1930s, marked the beginnings of population genetics and were seminal for biomathematics.
  - As early as 1896, British professor K. Pearson applied the now standard statistical techniques of probability curves and regression lines to genetic data. This was seemingly the first proof of the existence of a mathematical law for biological events.
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# Evolving Science

- Together with specialties from related disciplines such as bioinformatics and biophysics, mathematical methods are applied increasingly to biological systems.
  - Rather new and hot applications lie in the fields of bioengineering, developmental biology, immunology, infectious diseases, and tumor therapy.
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# Evolving Science

- Apart from the need to develop particular models for highly specialized biological and medical problems, mathematical biology helps to identify common patterns, e.g., to extract general principles from complex systems.
- A better understanding of such principles can then be exploited for technological applications.

# More portable mathematics

- Because mathematical biology has expanded enormously in the last decade... opportunities in mathematical biology are now excellent. Universities in North America and throughout the world are hiring in such interdisciplinary programs.

# A word of advice...

- To aspiring students of mathematical biology, a word of advice is in order: There can never be too much mathematics in a good math-biology education!
- The more techniques you practice in the formal setting of graduate school, the easier it is to become proficient in those mathematical techniques and have them available to you later.

# For starters...

- **Life Scientists Report Rising Salaries and High Job Satisfaction**  
(*ScienceCareers.org Nov. 3, 2006*)

Mean Salaries			
	2005	2006	
Academic	\$74,000	\$78,000	+5.4%
Industry	\$106,000	\$116,000	+9.4%

# For starters...

## Median 2006 Salaries

	Academic	Industry
Medicine	\$140,000	\$145,500
Pharmacology	\$99,000	\$116,000
Toxicology	\$78,000	\$105,000
Environmental	\$85,000	\$88,000
Genetics	\$73,458	\$83,750
Agricultural	\$74,000	\$99,500
Biochemistry	\$63,300	\$98,000
Physiology	\$65,000	\$88,010
Neuroscience	\$66,150	\$100,000
Biotechnology	\$63,000	\$105,000
Microbiology	\$62,000	\$89,000
Bioinformatics	\$65,000	\$103,000
Ecology	\$61,474	\$75,000
Zoology	\$59,300	\$47,000
Virology	\$57,500	\$89,000
Molecular biology	\$52,750	\$84,000
Immunology	\$54,000	\$96,525
Cell biology	\$52,050	\$84,300
Cancer biology	\$50,000	\$62,000
Developmental biology	\$45,000	\$65,130
Other	\$71,000	\$92,000

## By Age

Age	Salary
25 to 34	\$41,000
35 to 44	\$62,000
45 to 54	\$87,000
55 to 64	\$112,000
65 to 70	\$133,000
Over 70	\$133,000

# For Starters...

## ➤ **Human Genetics and Health**

### **Careers** (*ScienceCareers.org, Sept. 29, 2006*)

- *As new research avenues are opened by advances in genetics, career opportunities for young scientists are expanded. The new generation of geneticists will need to juggle basic science, genetics, statistics, clinical research, and sometimes even more disciplines. M.D./Ph.D. dual degrees--perhaps with a couple of postdocs--will be desired for those who want to enter industry. Training in mathematics and computer science can also be helpful.*

# For Starters...

## ➤ **Testing the Waters in Pharmaceutical Research** *(ScienceCareers.org, July. 29, 2005)*

- *Clinical drug evaluation is one of the many important jobs in industry. Those interested in a career in pharmaceutical clinical testing should have a strong science background and the ability to work within a team. These scientists often have research experience in academia and government but choose to use their skills to ensure that consumer medicines adhere to strict safety standards.*

# Career Development...

- *"The mathematical sciences, broadly defined, are rapidly becoming increasingly important in biology and medicine".*
- *"They have traditionally played major roles in epidemiology, physiology, imaging, genetics, pattern formation and many other fields within the biological sciences.*
- *But the recent revolution in molecular biology has caused profound changes in the paradigms and methodology of biology that are vastly increasing the importance and usefulness of mathematical and computational methods*

*Craig J. Benham  
Professor and Acting Chairman  
Department of Biomathematical Sciences  
Mount Sinai School of Medicine*

# Career Development...

## ➤ The Future of Genetics--Career Opportunities for Young Scientists *(ScienceCareers.org, Sept. 29, 2006)*

- Completed in 2003 after a 13-year international effort, the Human Genome Project placed the 25,000 or so genes that constitute the human genome within easy reach of researchers.
- The new demand," says Lindpaintner, is for people who utilize tools from genomics and clinical science "to design and execute the proper clinical diagnostic tests in the context of clinical studies," says Lindpaintner. **"We don't have enough [of them]. ... They are very desirable, very sought after."**

# Biomathematics at College...

- *Biomathematics programs at many colleges are new options for students who want to study both applied mathematics and biology.*
- *You may be familiar with the use of statistics in experimental science but Biomathematics goes beyond this.*
- *The study of epidemics (the spread of diseases) uses very sophisticated mathematical techniques. Scientists routinely use advanced mathematics to describe how the heart works, how blood flows, how nerve impulses are transmitted, how tumors grow, and how entire organisms grow.*
- *The rapid advancement of this discipline and the health industry led us to introduce an unusual major in Biomathematics.*

# Biomathematics at Illinois State University...



# Biomathematics at ISU...

- “Graduate students in the M.S. Sequence in Biomathematics will take a set of core courses that will provide the mathematical knowledge and skills appropriate for applications of mathematics to biology.”
- The sequences will be interdisciplinary, and will start with core courses from the Departments of Mathematics and Biological Sciences to provide the students with a strong foundation in both disciplines.

# Biomathematics at ISU...

- The objectives of the sequence include:
  - to provide a cross-disciplinary but focused learning environment for students enrolled in the Sequence in Biomathematics through participation in a cohesive curriculum designed to develop the students' knowledge and skills in applications of mathematics to biological problems,
  - to demonstrate to prospective students that this is a unique training opportunity offered by collaborating ISU faculty who work at the interface of these fields,
  - to enhance the effectiveness of the graduate training sequence by creating a 'cohort' experience for new graduate students,
  - to provide cohesive and focused research, learning, and training for students in the program.

# Biomathematics at ISU...

- “After the core courses the students can choose from two sets of electives that provide training which emphasizes either
  - *Biostatistics and Modeling*
  - *Computation and Bioinformatics*

# Biomathematics at ISU...

- **M.S. Sequence in Biomathematics.**
  - 30 sem. hrs. required (including thesis)
  - *Prerequisites:*
    - Three\*\* semesters of calculus, 1 semester of linear algebra, and 4 additional appropriate mathematical and/or biological courses.

# Biomathematics at ISU...

- **M.S. Sequence in Biomathematics.**
  - 30 sem. hrs. required (including thesis)
  - *Core courses* (taken by all M.S. students in the sequence):
    - Differential Equations I
    - Applied Probability Models
    - Statistics and Data Analysis
    - Quantitative Biomathematics
    - Seminar in Biomathematics

# *Emphasis in Biostatistics and Modeling*

- Time Series
  - Stat. Computing
  - Linear Programming
  - Mathematical Modeling
  - Finite Sampling
  - Regression
  - Stochastic Processes
  - Multivariate Statistics
  - Design of Experiments
  - Neurobiology
  - Plant Ecology
  - Population Ecology
  - Community Ecology
  - Advanced studies in Biostatistics
  - Evolutionary Population Genetics
  - Ethology
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## *Emphasis in Computation and Bioinformatics*

- Statistical Computing
- Discrete Math
- Graph Theory
- Advanced Topics in Discrete Math
- Molecular Biology
- Biotechnology Lab
- Genomics & Bioinformatics
- Advanced Cell Biology
- Molecular Biology of the Gene
- Microbial Genetics
- Evolution
- Evolutionary Population Genetics

# Financial support...



Home

search...

## CAS Homepage Illinois State Homepage

### Newest Additions

- Hall of Fame
- Research Support
- Intro to the College
- CAS Facilities Tour
- Available Consultants
- Internship Coordinators
- Contact Us

### Office of the Dean

- Welcome Message
- Mission Statement
- College Staff
- Deans of the College
- International Affairs
- Ombudsperson
- Dean's Addresses
- Strategic Plan (pdf)

### On Campus

- Intro to the College
- CAS Facilities Tour
- Departments / Programs
- Programs of Excellence
- Services & Centers

### People

- Accomplishments
- Current Students
- Prospective Students
- Parents & Friends
- Faculty & Staff Info

## Programs of Excellence

The Program of Excellence initiative was established to promote a unique, cutting-edge, interdisciplinary academic program that will help bring distinction to the College and the University.

### Biomathematics: MS Sequence and Cross-Disciplinary Research at the Interface of Biology and Mathematics

The "Biomathematics: MS Sequence and Cross-Disciplinary Research at the Interface of Biology and Mathematics" is a new master's sequence that incorporates cross-disciplinary research as integral to the curriculum. Through this Master's sequence, students will choose a series of courses concentrated in one of three critical areas of Biomathematics (theoretical and applied statistics, deterministic and stochastic modeling, or computation and bioinformatics) and conduct thesis research within the cross-disciplinary field of



Members of the Biomathematics  
POE Team

# Financial support...

- Funding through the POE Award
  - Research Fellowships for qualified students
  - Summer Research Stipends
  - Research Associate Support
  - Support through the usual TA, GA's

# Where to apply?

## ➤ ISU....

- Mathematics Department
  - Dr. Olcay Akman,
    - [oakman@ilstu.edu](mailto:oakman@ilstu.edu)
- Biological Sciences Department
  - Dr. Steven Juliano,
    - [sajulian@ilstu.edu](mailto:sajulian@ilstu.edu)