University Honors College & College of Science Mixer

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Physics

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A Mass Extinction Event in Our Time

5,743 species of amphibians
45% in decline
More than 33% threatened
More than 130 species extinct since 1980

"many endangered"

Scientists Detect Mysterious Decline
In Global Populations of Frogs, Toads

In the past few years, researchers have witnessed severe reductions in amphibian populations worldwide. The decline in amphibians is a global phenomenon, and scientists are calling it a mass extinction event.

"What we're seeing is a decline of all native frogs from British Columbia to Southern California to the Rocky Mountains in the west," said Andrew Blaustein of Oregon State University.

"It's a real strong feeling in the West that amphibians are taking a nose dive," said David Bradley of the University of California at Los Angeles.

"Many endangered"
Why are Amphibians Important?

- source of human medicine
- indicators of environmental health
- control insects and insect-borne diseases
- vital role in ecosystems
- role in culture/religion
- aesthetics
My Research Investigates the Causes & Implications of Amphibian Extinction Events & Causes for Loss in Biodiversity

- exotics
- pesticides
- UV
- emerging diseases
- new parasites
- pharmaceuticals
- eutrophication
- desiccation
- novel predators
- acidification
- habitat alteration
- temperature
# Research in the Cell Biophysics Lab

## How multicellular systems self-organize by utilizing
- mechanosignaling and
- chemosignaling
to communicate with each other

Caner cells can coordinate each other’s pace during collective invasion into collagen gel – talking through force.

Fibroblast cells rearrange themselves into critical point – to optimize information propagation and sharing.

- Each direction has several sub-projects focusing on physics / material / biochemistry / computation.
- We constantly accommodate 6-7 undergraduate students and they out numbered graduate students and faculties!
First generation

The cat scan.
The mathematics is the Radon transform.

\[ Rf(p,\omega) = \int f(p + t\omega) \, dt \]

What to do if the sound speed is not known?

Candidates should have:
- Substantial math
- A year of physics
- Programming skills in Matlab or python

Thermoacoustic tomography: Send in RF, generate sound measured on the boundary.

Solve the wave equation from boundary data back to initial data.

This requires knowing the sound speed.
Manipulating genomes to express natural products

Transcriptional activation
Transcriptional memory

"Histone Code"

Chr. 1
Chr. 2
Chr. 3
Chr. 4

H3K27me3
H3K4me2
ChIP-seq
centromere

The silent genome

Discover new natural products

KMT6-GFP
Cell biology
EED-GFP

WT
rich
poor

Genetics

Δcdp6
su(Δcdp6)1

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Outliers: Minimalism in Ocean Bacterioplankton

S Giovannoni
Department of Microbiology, Oregon State University

**Genome Size Vs. Gene Number for Prokaryotic Genomes**

- Free living
- Host associated
- Obligates
- Pelagibacter
- Prochlorococcus
- MMG

**CO₂**

Organic Carbon Sequestration

**Bermuda Microbial Oceanography Course**
Developing New Electrochemical Techniques to Study Complex Biological Systems

- Wound Healing
- Biofilm and Cancer
- Dental Biofilm
- Fundamental microbiology

Biomedical

Environmental

SECM

Microbiology

Energy

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BIOFILMS and CRYSTALS: Mathematical & Computational Modeling

OBJECTIVES: one or more of
- Develop/modify models for various stages of biofilm growth and pattern formation
  - use differential equations, or
  - use discrete modeling
- Implement models on a computer using MATLAB
- Study properties of the models and solutions
- Perform simulations

Ex. of two biofilm/crystal models:
\[ t=0 \quad t=2 \quad t=100 \]

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- Stipend possible for qualified students from NSF project “Hybrid modeling in porous media”
We study rhythms of life called **circadian rhythms**
All organisms have biological clock that generate circa 24 h rhythms

**Animals are active at certain time of day or night**

**Humans have times of high and low alertness**

**Biological clocks regulate physiological and molecular rhythms: what if they are broken?**

**What you could study in our lab:**
- Genome wide circadian gene expression
- How gene expression changes during aging?
- How to repair old biological clocks?
- Do strong clocks protect from aging?

Clock neurons in Drosophila brain
Burrows Group: Development of laser technology and biosensors to study biomolecular regulation and the fate of a cell

Nanomaterials & Raman Scattering

**HOLY GRAIL:** Discover a miRNA biomarker or a group of miRNA biomarkers of triple negative breast cancer

- Honors students have potential to **publish**
- Honors students have potential to collaborate with **interdisciplinary** group
Modeling Marine Protected Areas (MPA) - Resolving a Paradox?  
Enrique Thomann (Math) and Patrick De Leenheer (Math/Zoology)

MPA’s are tools for protection of population and natural habitat.

Empirical observations show an increase in relative abundance of protected species as a function of mobility of the individuals.  
Objective: To develop simple mathematical model that captures this empirical observation.  
\( x, y \) = population in MPA and fishing ground

Model 1 does not capture this behavior.  
Hypothesis: An asymmetric diffusive mixing might be enough to resolve this feature

Model 1: Diffusive mixing, \( d > 0 \) constant.  
\( r \) = growth rate of population in MPA  
\( K \) = carrying capacity in MPA  
\( r^*, K^* \) = corresponding parameters in fishing grounds, \( r^* < r, \ K^* < K. \)

\[
\begin{align*}
\dot{x} &= r \, x \left(1 - x \over K\right) - d(x - y) \\
\dot{y} &= r^* \, y \left(1 - y \over K^*\right) + d(x - y)
\end{align*}
\]

\[
\begin{align*}
D(x - y) &= d(x - y)^+ - a \, d(y - x)^+ \\
x^+ &= \max(0, x) \\
\dot{x} &= r \, x \left(1 - x \over K\right) - D(x - y) \\
\dot{y} &= r^* \, y \left(1 - y \over K^*\right) + D(x - y)
\end{align*}
\]