# Undergraduate Research in Math (contact: M. Peszynska)

- Why research?
  - This is what mathematicians/professionals do
    - As professors in Universities
    - As researchers in national labs DOE, DOD, NCSA
    - As professional mathematicians in industry,
      - E.g., Boeing
  - Research experience is
    - excellent  when applying to Grad School
  - Learn something new, outside coursework
  - Learn new skills

# What does it mean

- Reading advanced textbooks/monographs
- Reading research articles
- Working out **new** examples
- Learning **new** applications
- Implementing **new** algorithms
- **New**=
  - New to you and/or
  - New to the world

# Undergraduate Research in Math

- How?
  - REU (Research Experience for Undergraduates) summer programs
  [http://www.ams.org/programs/students/emp-reu](http://www.ams.org/programs/students/emp-reu)
    - More on this in Winter from Prof. Bogley
    - Typically after junior year
    - MANY programs in the country
    - There are even journals focused on undergraduate research!
  - Academic year@OSU: MTH 401
    - Take junior level classes
    - Find a research adviser
  - Junior/senior year:
    - write an Undergraduate Thesis MTH 403

# What about NOW

- OSU URSA-Engage
  - Stipend $1000 for the student
  - Oriented at first-year or second-year undergrads
    - First-year transfer students
    - No prior experience is required
  - Purpose: develop a mentoring relationship with a faculty member
  - Faculty must be in Professorial rank
  - Deadline January 15

# Examples of mathematics undergraduate research projects at OSU

- **A weak type estimate for bases of rectangles in R3**
- "Modeling with ODE systems"
- **Investigation of Two Bodies With Equal Point X-Rays at Two Sources**
- "Numerical Simulation of the Chemotaxis Model for Dispersal of Biological Spieces"
- **Faster Fibonacci**
- *"Pore-scale simulations with a vorticity-stream function solver for Navier-Stokes equations"*
  - *http://www.math.oregonstate.edu/~mpesz/documents/publications/pta.pdf*
- **OSU URISC Award, "Finite Element Modeling of Uncertain Interfaces"**

# Interdisciplinary math projects @ OSU

- Flow and transport:
    - oceans, tsunamis, groundwater contamination, oil&gas& hydrate modeling, carbon storage and sequestration, ecology and forestry, salmon population, climate modeling, fluid turbulence, traffic and pedestrian and crowd modeling
- Mathematical biology
    - Infectious diseases, marine resources, bioinformatics
- Materials
    - Semiconductors (solar cells), Maxwell's equations (electromagnetics), Tomography
- Non-Differential Equations:
    - Statistics, machine learning, image processing, network modeling
    - Cryptography, discrete math, graph theory and geometry of visualization

# Interdisciplinary Mathematics needs you
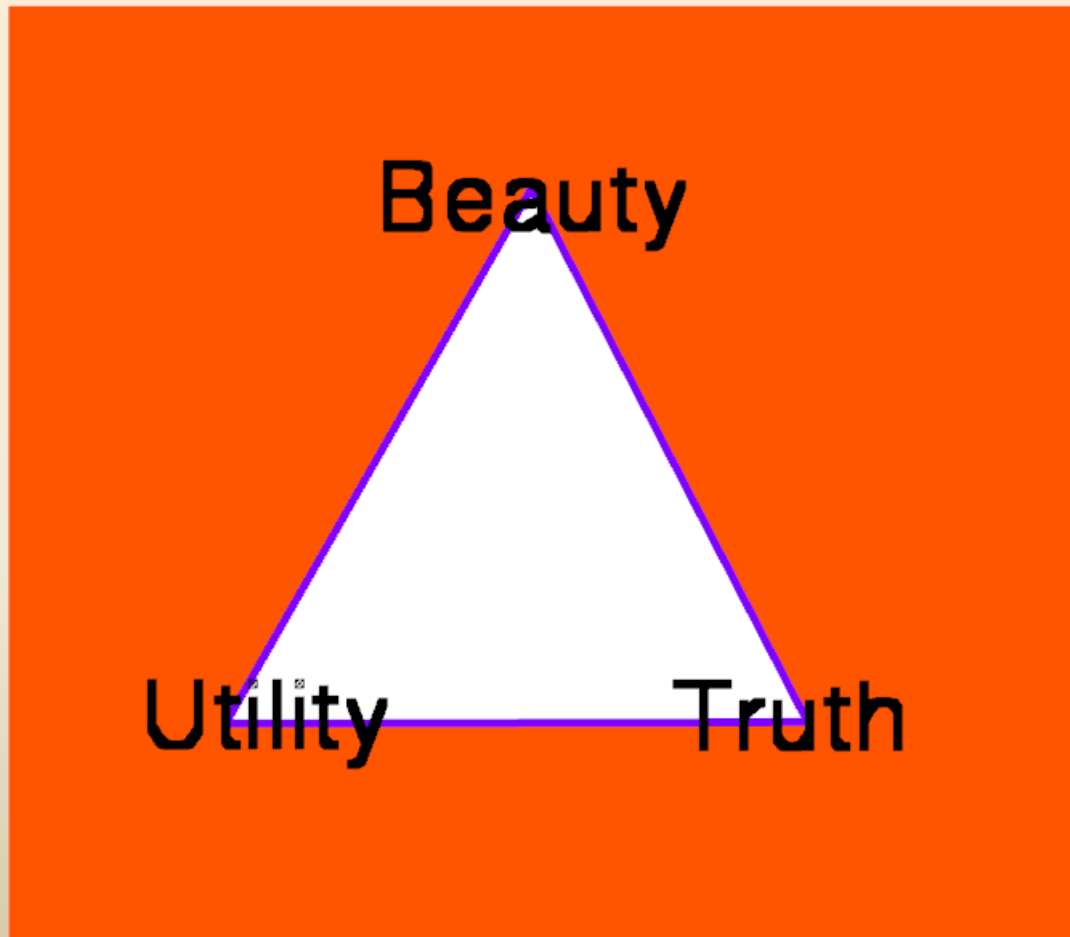
# Facebook: analyzing social networks

Linear algebra
Probability
Discrete mathematics
Computing

- Proposed and analyzed measures of comparing networks
- Hoped to increase understanding of networks
- Compared networks at Caltech, Georgetown, Princeton, UOklahoma, UNC

**Other networks**
- college football
- committee assignments
- legislation co-sponsorship, and voting blocs in the U.S. Congress
- functional groups in metabolic networks
- ethnic preferences in school friendship networks
- social structures in mobile phone conversation networks
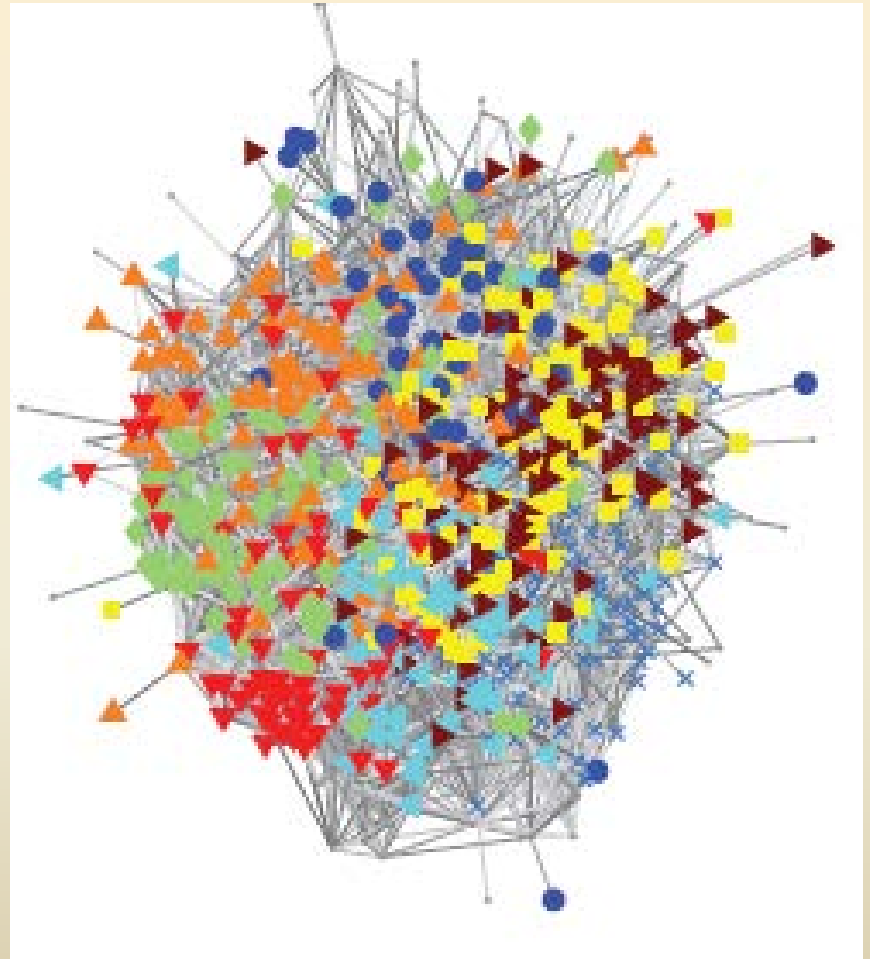


Graph theory, probability, statistics

# Multiscale Modeling

## for ice-climate studies

Study patterns and structure of ice formation

Mathematical analysis
Differential equations
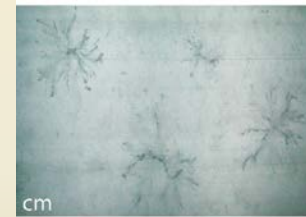Mathematical modeling
Numerical analysis
Computing
Probability

Helps to determine dynamics of ice and factors that affect ice
disappearance.



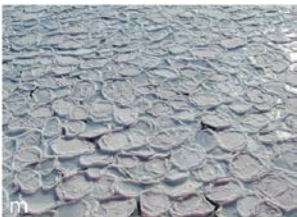brine inclusions — mm

polycrystals — cm

horizontal — cm

brine channels

vertical — dm | m

pancake ice — dm | m

# Ice studies-> Osteoporosis

Mathematical analysis
Differential equations
Mathematical modeling
Numerical analysis
Computing

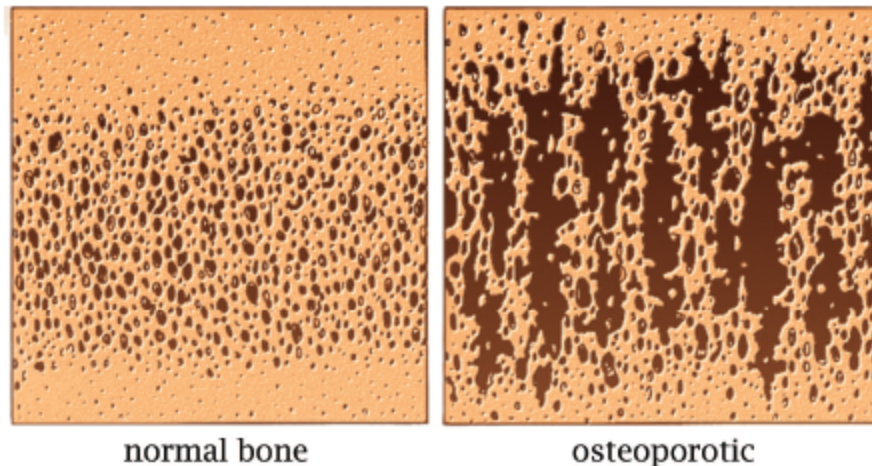normal bone               osteoporotic

Figure 23. Bone porosity can be estimated from torsional modulus data using reconstruction of the spectral measure, similar to estimating brine porosity in sea ice from permittivity data. Such work will help in monitoring osteoporosis [1]. The math doesn't care if it's sea ice or bone!

# The Netflix prize

| | SAW III | LoTR | Miss Congeniality | New Movie |
|---|---|---|---|---|
| Mark | 3 | 7 | 3 | ? |
| dude | 10 | 6 | 6 | ? |
| Professor Blake | 0 | 10 | 3 | ? |
| sweetie | 2 | 4 | 10 | ? |
| you | | | | |
| Your Mother | | | | |
| Your Grandfather | | | | |

- $1 mln prize to improve an algorithm for recommender systems
- Tight competition between several groups

Linear algebra
Computing
Numerical analysis

# Hybrid models of tumor growth

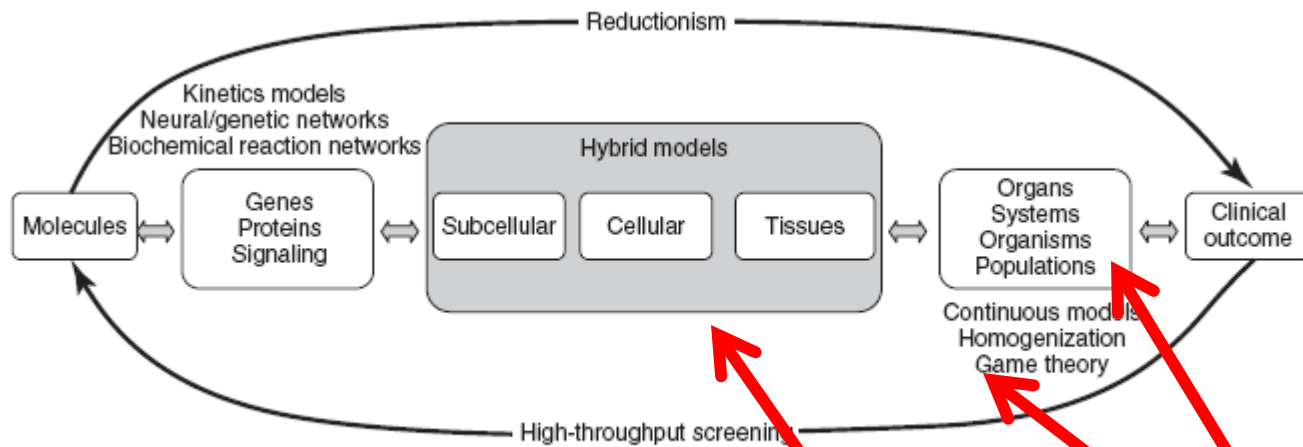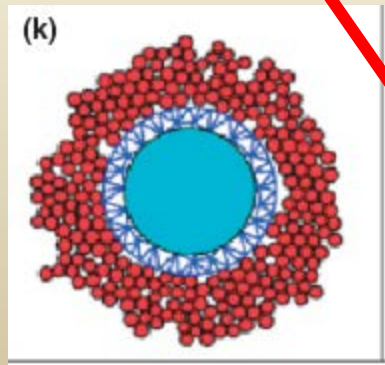Katarzyna A. Rejniak[1,2]* and Alexander R. A. Anderson[1]
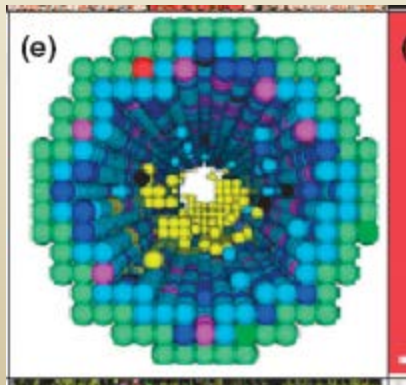


**FIGURE 3** | A schematic of modeling scales and techniques. Multiple biological scales can be bridged by various types of mathematical models.

Differential equations
Mathematical modeling
Numerical analysis
Computing
Probability

Differential equations
Mathematical modeling
Numerical analysis
Computing

Gas Flux Vector

7 days later

Fault 1d;
Layer 100md

24 days later

Permeable

Impermeabl
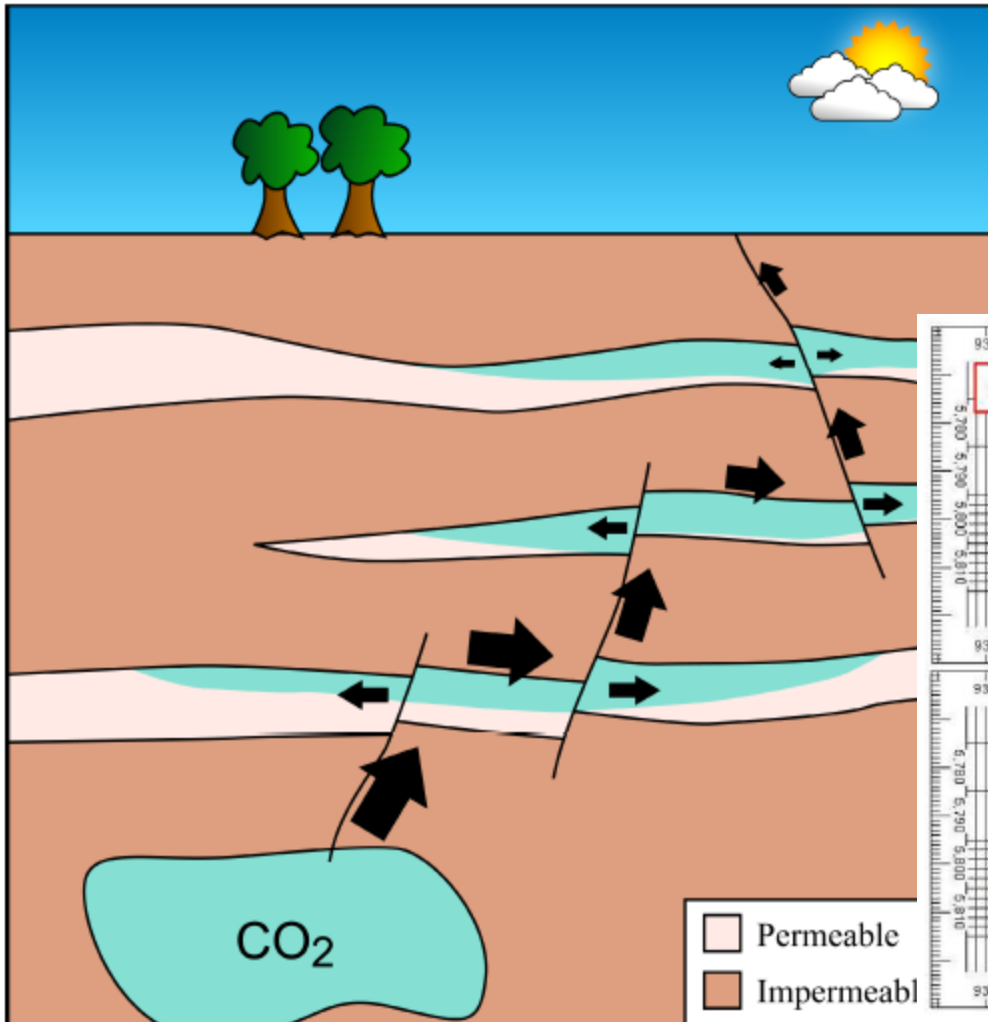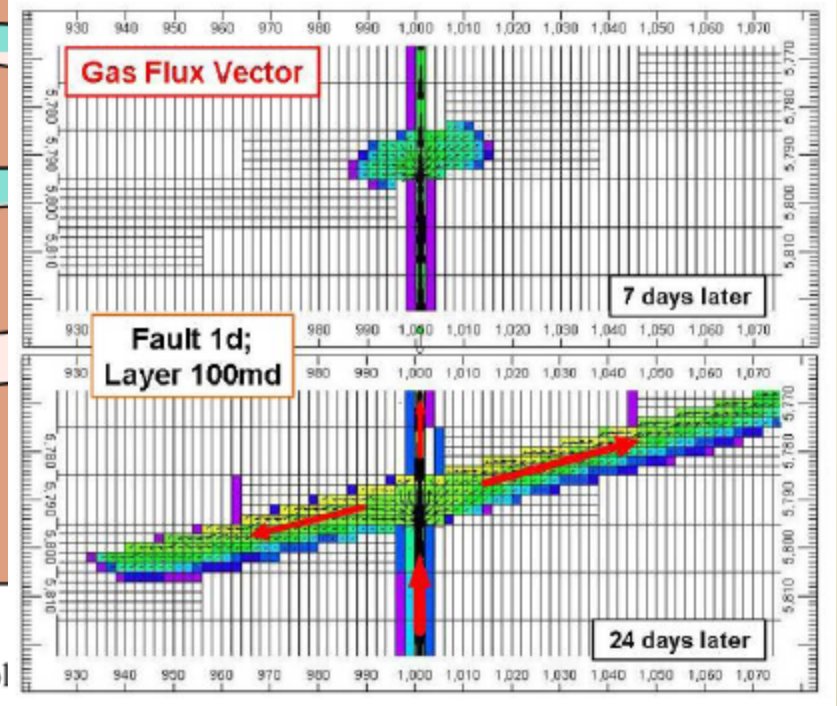
SPE 115929

# Modeling Leakage through Faults of CO$_2$ Stored in an Aquifer

Kyung Won Chang,* Susan E. Minkoff,** and Steven L. Bryant,* SPE
*The University of Texas at Austin
**The University of Maryland, Baltimore County

# Mathematics in the Wind
## By [Alfio Quarteroni](#)



- *In any sport or human endeavor, coaches regularly state "play to your strengths." One might not guess that a land-locked, mountainous country like Switzerland would have strengths that would give them a chance at winning the oldest, most competitive sailing competition in the world, the America's Cup.*

- *But it does: Switzerland has mathematics!*

Differential equations
Mathematical modeling
Numerical analysis
Computing
Mathematical analysis

[http://www.whydomath.org](http://www.whydomath.org)

# Thank you !
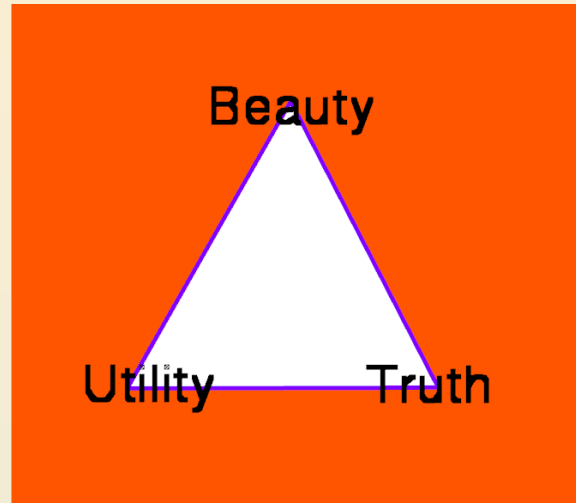


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*Classes to take? Contact your advisor!*