Graduate School in Chemical Engineering

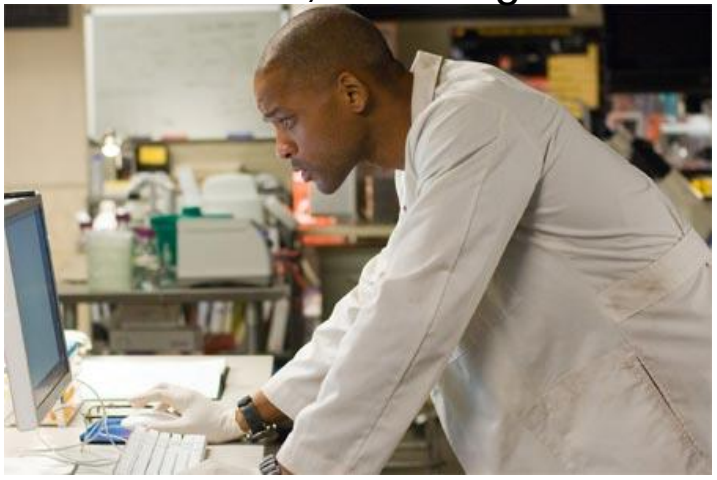
Why get a ChemE MS degree?

- **Strengthen education – opportunity to solidify core ChemE topics and enhance writing skills**
- **Increased credentials for a more design-oriented job**
- **Use as stepping stone to PhD**
- **Qualify for specific companies (e.g., Intel)**
- **Enhance qualifications for process engineering and other BS-level job openings?**

Why get a ChemE PhD?

- **Gain fundamental understanding necessary to solve cutting-edge engineering problems**
- **Learn to perform independent research**
- **Qualify for research-oriented industrial positions and academic positions**
- **Increase potential for managerial positions**
- **Establish credibility for consulting and entrepreneurial activities**

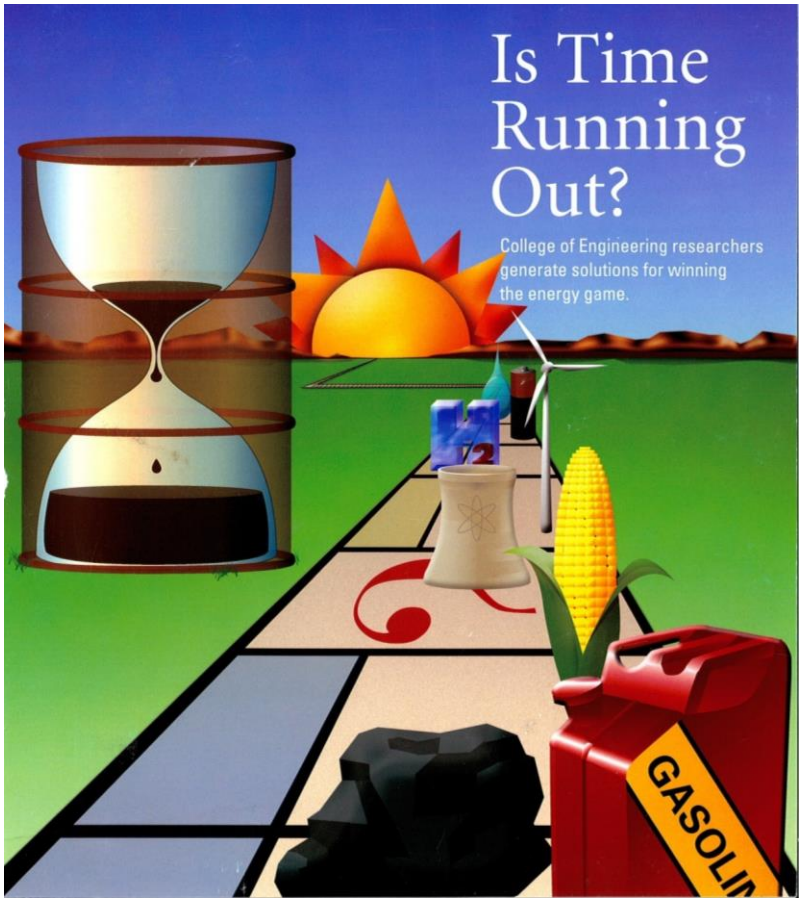
Dr. Neville, I Am Legend



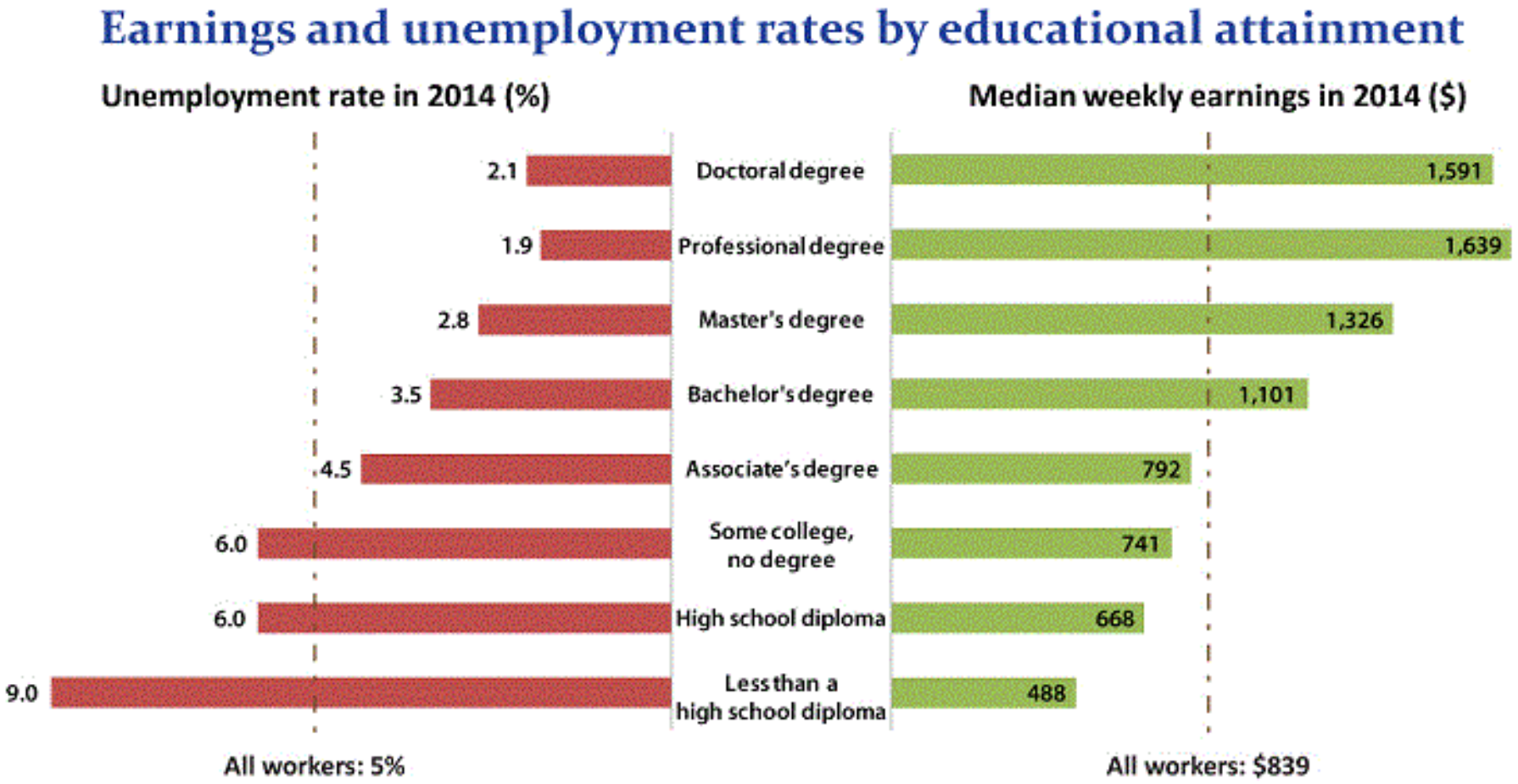
Doc, Back to the Future

Solve the Challenges Facing the World

- > 9 billion people (2050)
- Energy
- Clean water
- Infrastructure
- Transportation
- Food production
- Global warming
- Strategic Minerals
- Healthcare
- Terrorism

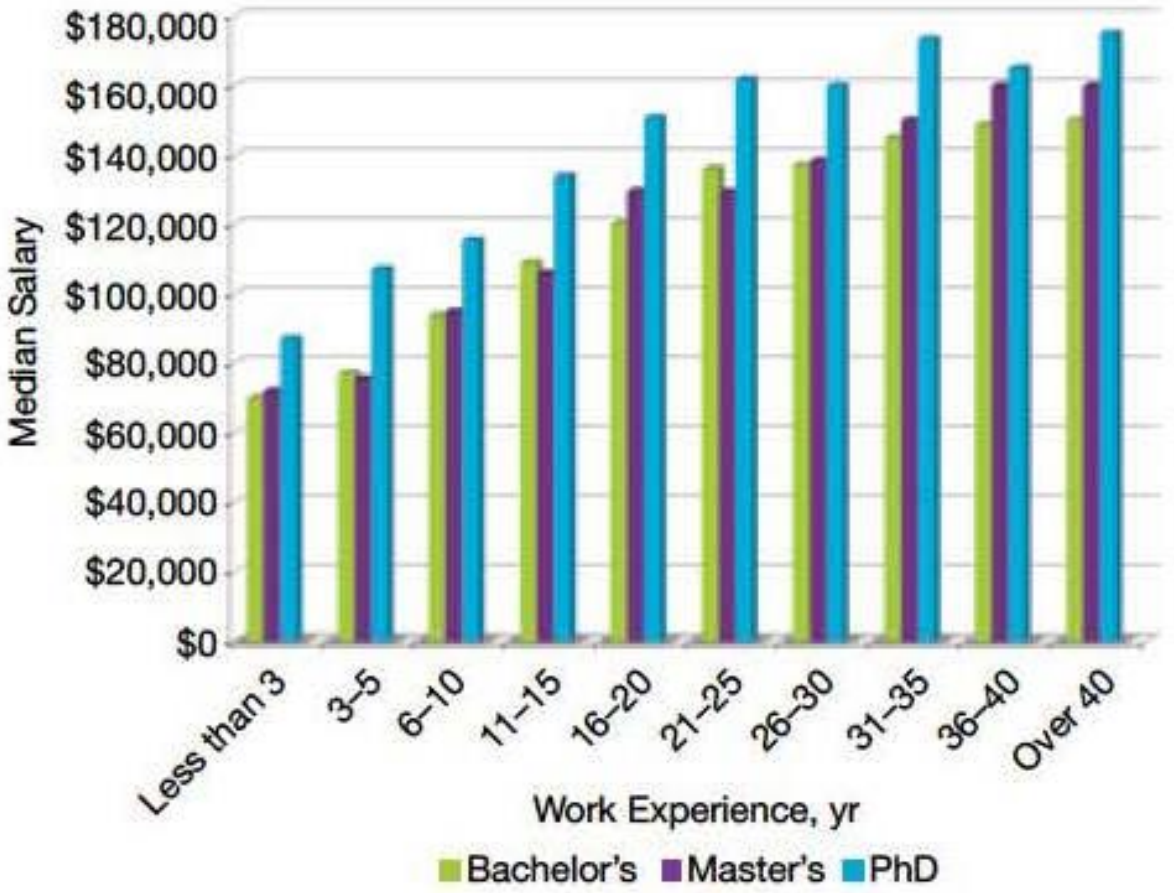


Value of Education: Education Pays



Note: Data are for persons age 25 and over. Earnings are for full-time wage and salary workers.
Source: Current Population Survey, U.S. Bureau of Labor Statistics, U.S. Department of Labor

2015 Chemical Engineering Salaries



▲ **Figure 6.** Chemical engineers with PhDs earned more than those with lower-level degrees at most work-experience levels.

Source: June 2015 Chemical Engineering Progress, AIChE Publication

The bottom line

- **There is a salary advantage to a higher degree, but the difference is probably not sufficient to justify graduate school (there are easier ways to maximize income).**
- **The career opportunities for engineers with advanced degrees are excellent**
- **Increased earning power is probably not the best justification for a graduate degree**

Is Graduate School Right for Me?

- **Lifelong career of learning and challenge**
- **Career extends beyond corporate goals**
- **Opportunities for major program and project leadership**
- **Increased opportunity to address the critical problems facing the world**
- **Opportunities to serve**

Graduate School at BYU

Graduate School Information Dinner

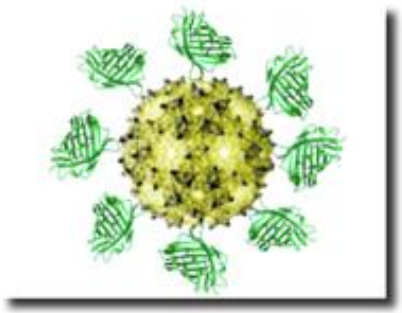
Some Facts

- Program Size
  - 15 full time faculty members, around 3 students per faculty
  - 39 PhD students
  - 8 MS students
- Entrance Requirements
  - 3.0 GPA in upper division ChE classes and 3.3 overall GPA
  - GRE general exam (must do well on Quantitative section)
  - 3 letters of recommendation—research experience is a plus
  - Fall application deadline: Jan. 31
- Financial Aid
  - Tuition
    - Ph.D.—Paid by department and advisor (research grants)
    - M.S.—Sometimes tuition support
  - Student Stipend (does not include tuition)
    - $23,500/yr for PhD, $22,500/yr for MS
  - Many competitive fellowships available
    - NSF, DOD, DOE, EPA, NASA, ExxonMobil, etc.

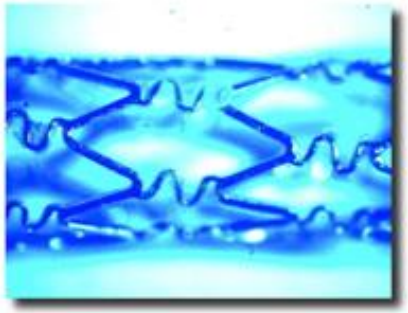
Some Facts

- Select and work with an advisor
- M.S. Requirements
  - 30 credit hours = 23 lecture hours + 7 seminar/research
    - 8 regular classes (4 required)
  - TA for 1 semester (10 hrs/wk)
  - Publish 1 scientific paper,
    - Contributes to thesis
  - Target completion = 2 years
- Ph.D. Requirements
  - 54 credit hours = 34 lecture hours + 20 seminar/research
    - 12 classes (4 required)
  - TA for 2 semesters (10 hrs/wk)
  - Publish 3 scientific papers
    - Contributes to dissertation
  - Target completion = 4-5 years

BYU Research Areas



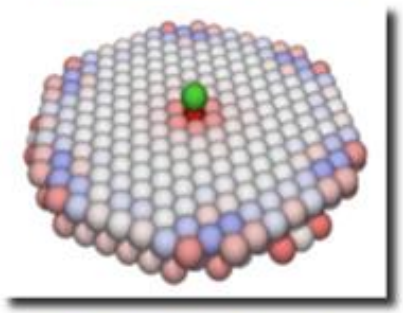
Biochemical Engineering



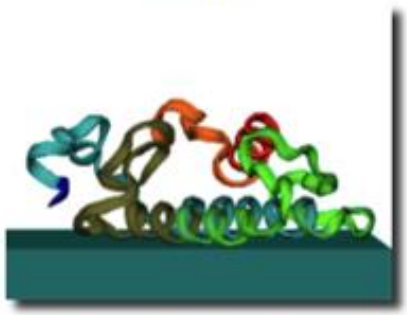
Biomedical Engineering

Catalysis

Combustion

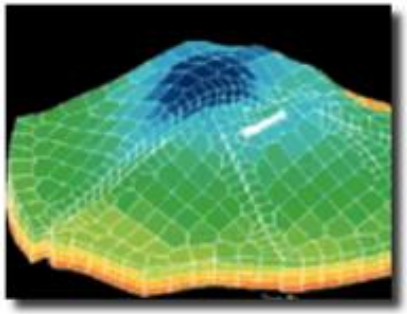


Electrochemical Systems

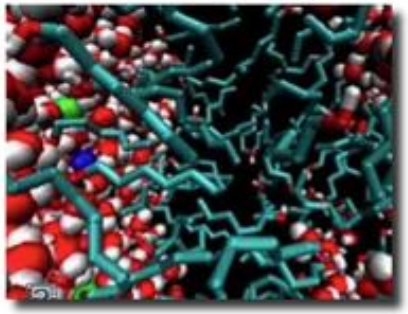


Molecular Simulations

Sustainable Energy



The International Reservoir Simulation Research Institute



Thermophysical Properties

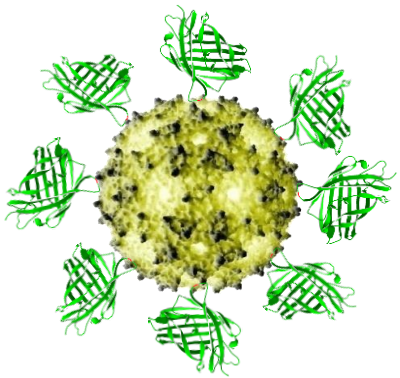
Biochemical Eng. / Biotechnology

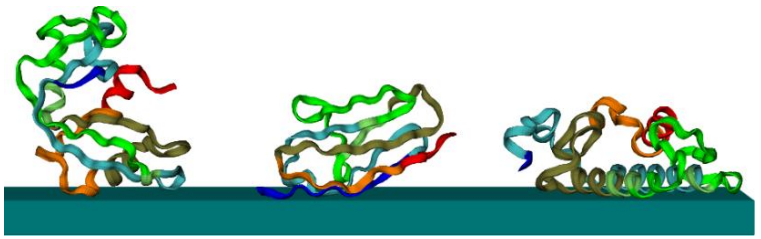
Brad Bundy

Thomas Knotts

Randy Lewis

- Kinetic modeling of bioprocesses including fermentation (Lewis)
- Production of fuel and other products from biomass (Lewis)
- Rewriting the Genetic Code with Cell-free Synthetic Biotechnology (Bundy)
- Inventing new Cancer Theraputics, Vaccines, Personalized Medicines, Biocatalysts (Bundy)
- Simulations of biomolecular systems including biosensors, DNA/protein micro-arrays (Knotts)

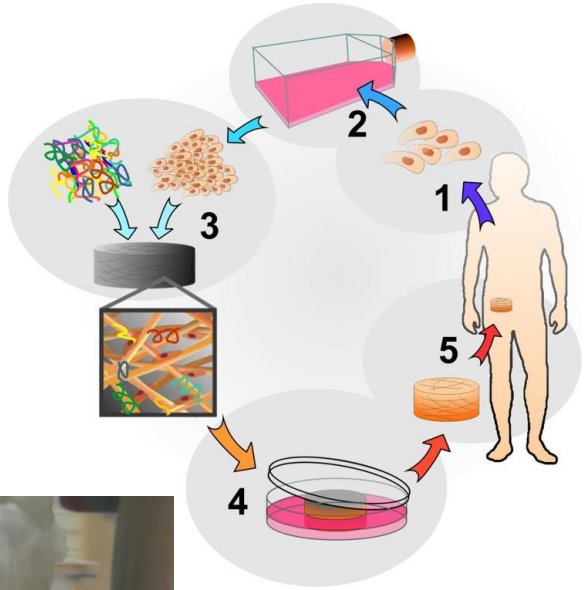




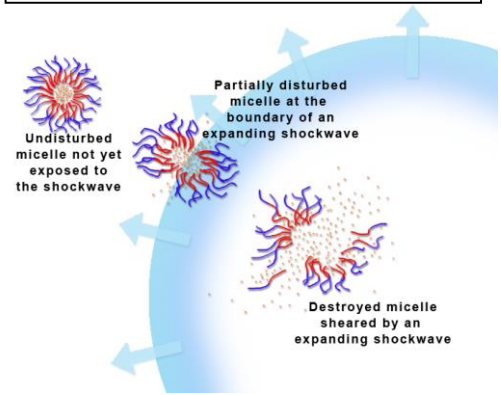
Biomedical/Tissue Engineering

Lon Cook

Tissue Engineering



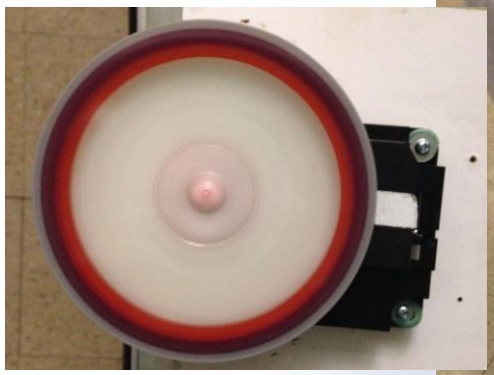
Theranostic Drug & Gene Delivery



Bill Pitt

Growing Hearts in a Bioreactor

Human Ear on Back of Mouse



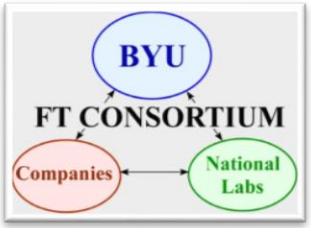
Bacteria-Blood for Sepsis Diagnosis

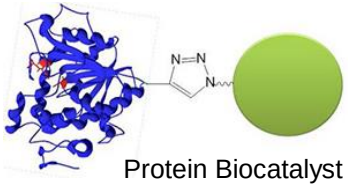
Catalysis and Kinetics

Morris Argyle

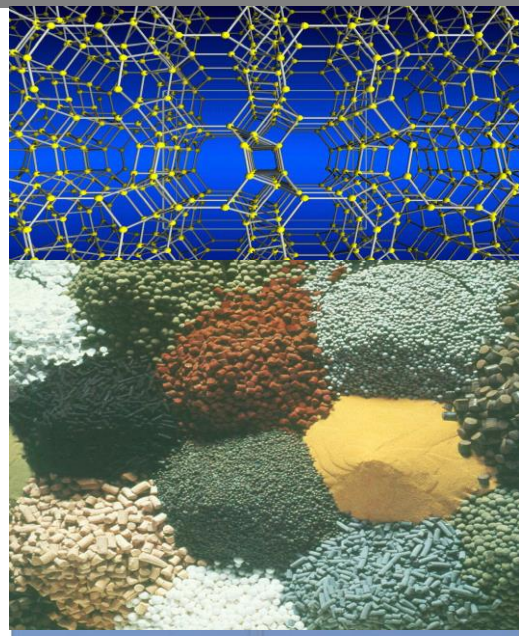
Brad Bundy

- Preparation, characterization, and testing of sophisticated nanomaterials
- Detailed kinetic measurements and kinetic modeling of catalytic reactions
- Reactor design and optimization
- Current research includes Fischer-Tropsch synthesis and hydroisomerization catalysts
- Biocatalysis optimization/immobilization





Protein Biocatalyst



Combustion

Tom Fletcher

David Lignell

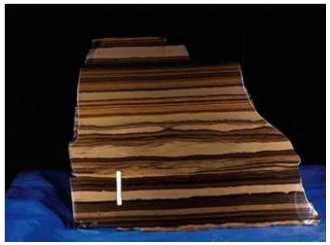
Larry Baxter

Andrew Fry

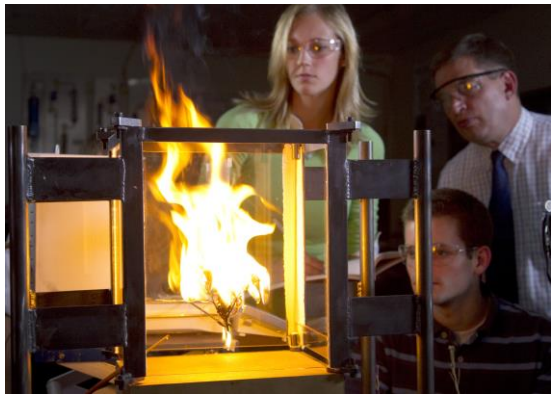
85% of world's energy comes from fossil fuels!

- Clean coal, oil shale, and biomass energy conversion
- Exa-scale simulation advanced industrial-scale coal-fired boiler
- Advanced turbulent reacting flow simulation approaches: ODT/DNS/LES
- Advanced diagnostics for combustion and gasification
- Chemistry and reaction rates of live shrubs in wildland fires
- Biomass combustion/gasification and co-firing

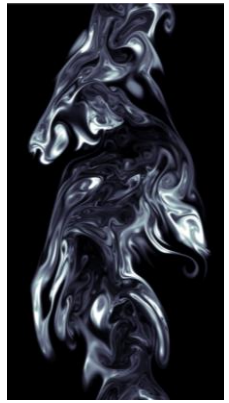
Oil shale



Wildland fires



ODT and DNS



Electrochemical Systems

Dean Wheeler

John Harb

- 3D modeling for the development of next generation devices and the mitigation of technology limiting factors
- Fabrication and optimization of high-performance electrodes and batteries
- Advanced diagnostic techniques for electrochemical devices
- Nano-scale device fabrication with use of self-assembling biological templates

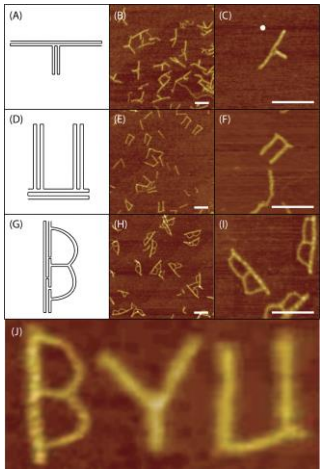
Honey, I shrunk the battery

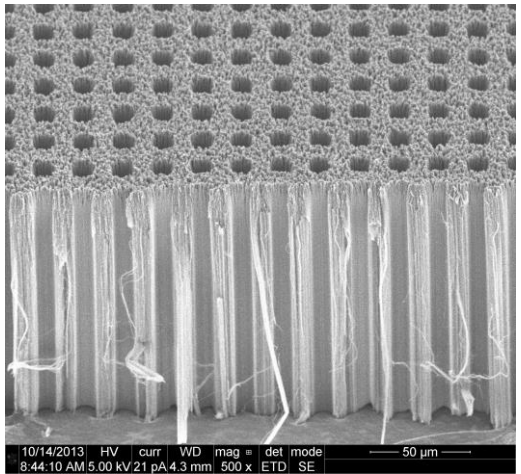
BY DAN NAILEN
THE SALT LAKE TRIBUNE

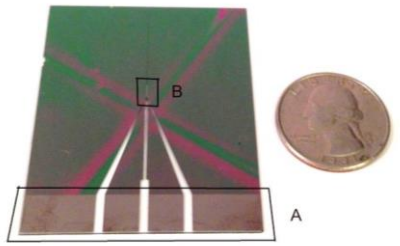
Computer researchers are not only building better gadgets as technology advances, but making them smaller, faster and cheaper.

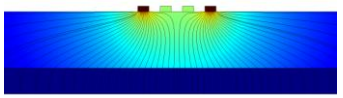
Microelectromechanical systems, or MEMS, have dominated the work of many researchers and engineers in recent years. MEMS are a series of miniature electronic structures and sensors integrated on one silicon chip. They range in size from less than one inch to a micron — one-thousandth the thickness of a nickel.

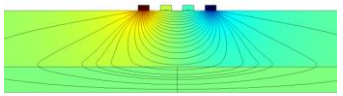
MEMS are not only compact, but usually are more precise than older systems due to the close proximity of their parts. They are already used commercially in automobile air bags, with a tiny MEMS sensor









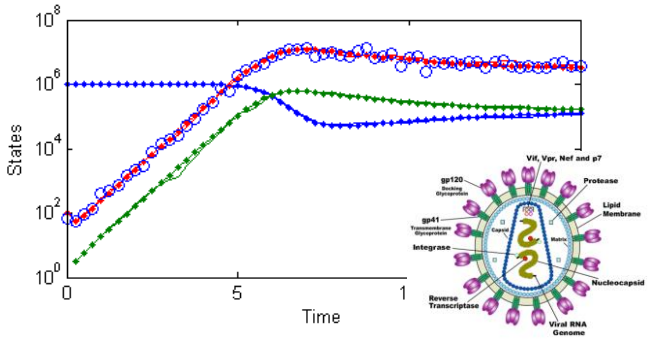


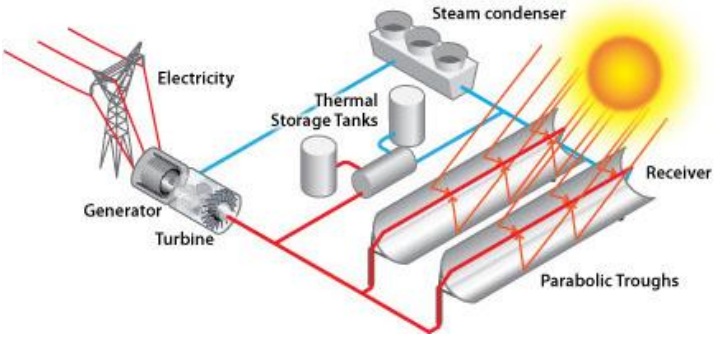
Process Control and Optimization

BYU PRISM
MODEL OPTIMIZE CONTROL

John Hedengren

- Energy Systems
- Upstream Oil & Gas
  - Drilling Automation
  - Reservoir Optimization
- Optimization Technology
- Graduate Internships





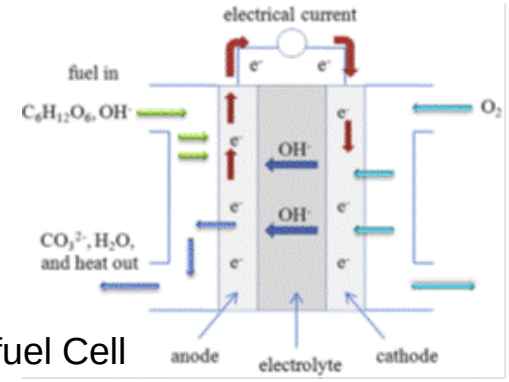
Sustainable Energy

Larry Baxter

Randy Lewis

John Harb

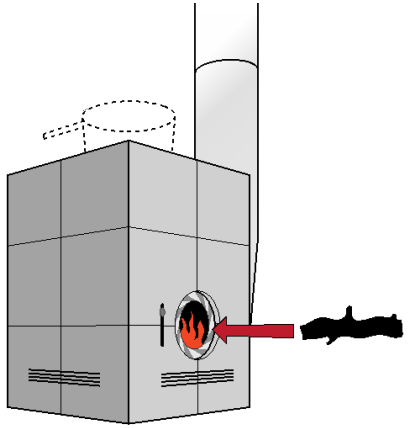
- Carbon capture process capable of CO_2 capture at 2-3 ¢/kwh – less than half of other systems
- Large, efficient, rapidly responding energy storage processes
- Biomass thermal and biological conversion to useful energy
- Advanced diagnostics for combustion and gasification
- Energy for developing countries



Biofuel Cell

Syngas conversion to biofuels and chemicals

Cryogenic Carbon Capture™ Hardware

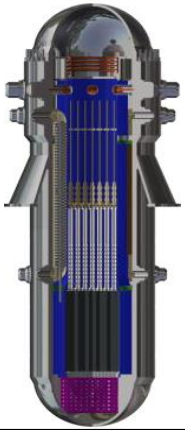


Biomass cookstove development

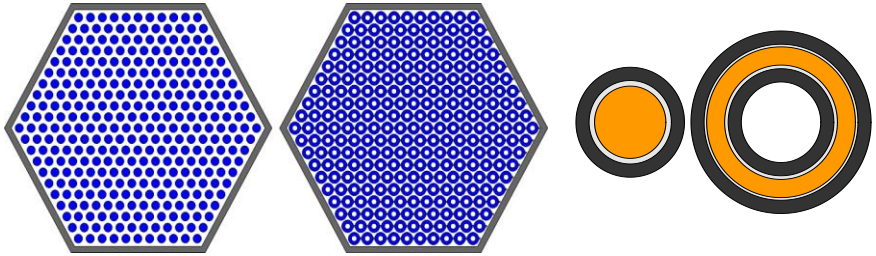
Nuclear Power / Reactor Safety

Matthew Memmott

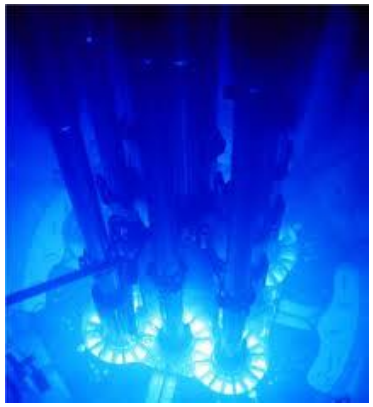
- Design of advanced nuclear reactor systems
- Integration of nuclear power with other energy systems
- Development of safer and cheaper nuclear fuels
- Development of passive safety systems to cool down nuclear core without operator action or electricity
- Hybrid Nuclear-Chemical Systems



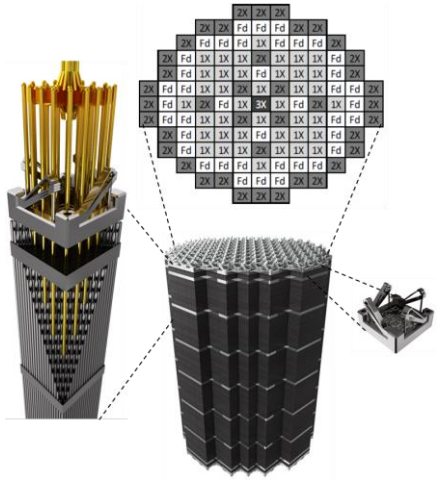
New Nuclear Reactors (I^2S-LWR)



New fuels: annular Fuel rod (20% higher power)



Safety Analysis



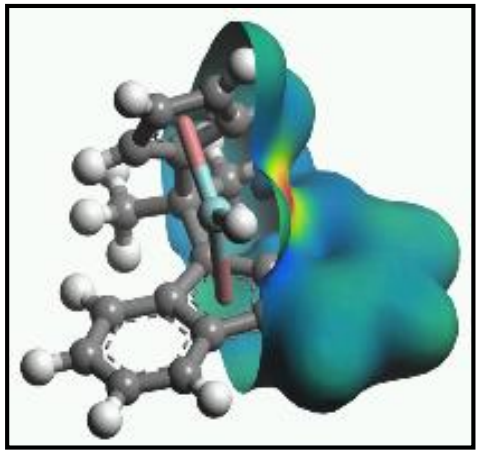
New core designs U_3Si_2, ThO_2, etc.

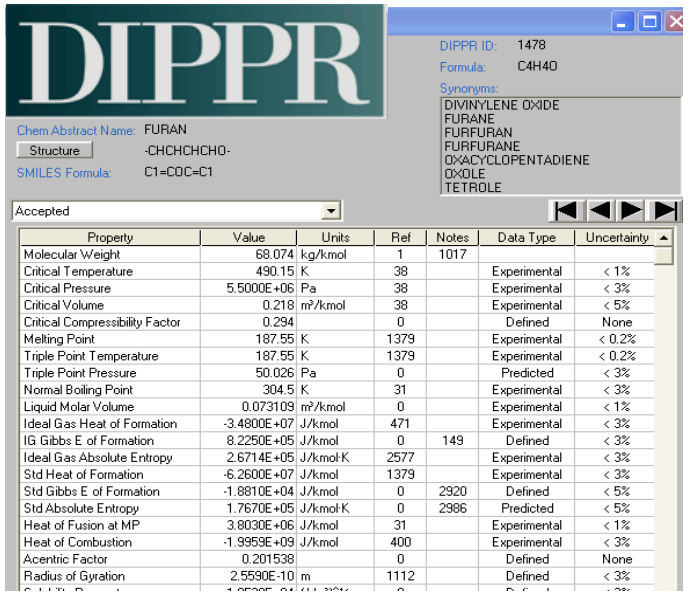
Thermophysical Properties

Vincent Wilding

Tommy Knotts

- Thermophysical property measurement and estimation
- Development and management of DIPPR database of properties of industrially important chemicals
- Molecular simulations and quantum chemical calculations





Property	Value	Units	Ref	Notes	Data Type	Uncertainty
Molecular Weight	68.074	kg/kmol	1	1017		
Critical Temperature	490.15	K	38		Experimental	< 1%
Critical Pressure	5.5000E+06	Pa	38		Experimental	< 3%
Critical Volume	0.218	m³/kmol	38		Experimental	< 5%
Critical Compressibility Factor	0.294		0		Defined	None
Melting Point	187.55	K	1379		Experimental	< 0.2%
Triple Point Temperature	187.55	K	1379		Experimental	< 0.2%
Triple Point Pressure	50.026	Pa	0		Predicted	< 3%
Normal Boiling Point	304.5	K	31		Experimental	< 3%
Liquid Molar Volume	0.073109	m³/kmol	0		Experimental	< 1%
Ideal Gas Heat of Formation	-3.4800E+07	J/kmol	471		Experimental	< 3%
IG Gibbs E of Formation	8.2250E+05	J/kmol	0	149	Defined	< 3%
Ideal Gas Absolute Entropy	2.6714E+05	J/kmol·K	2577		Experimental	< 3%
Std Heat of Formation	-6.2600E+07	J/kmol	1379		Experimental	< 3%
Std Gibbs E of Formation	-1.8810E+04	J/kmol	0	2920	Defined	< 5%
Std Absolute Entropy	1.7670E+05	J/kmol·K	0	2986	Predicted	< 5%
Heat of Fusion at MP	3.8030E+06	J/kmol	31		Experimental	< 1%
Heat of Combustion	-1.9959E+09	J/kmol	400		Experimental	< 3%
Acentric Factor	0.201538		0		Defined	None
Radius of Gyration	2.5590E-10	m	1112		Defined	< 3%

How To Prepare for Graduate School

- GRE exam
  - Study: especially the verbal and analytical sections
  - Can take online, Take early
- Application
  - January application deadlines (vary by university)
  - Letters of recommendation, written statements, transcripts.
- Can take grad classes as an undergrad
  - prepare for grad school somewhere else,
  - early start on research
- Integrated Masters Program

Prestigious National Graduate Fellowships

GRADUATE RESEARCH FELLOWSHIPS

Winners typically go to top U.S. graduate schools

Worth $30,000–60,000 per year

Aim for 3.8 GPA or higher

Participate in undergraduate research

Apply in the fall of your senior year

Generally reserved for U.S. citizens or U.S. persons

BYU's engineering program has a good track record of successful candidates

Oct. 27	Dec. 18	Jan. 19
National Science Foundation	Department of Defense	Department of Energy CSGF
NASA	SMART	STAR
Nov. 5	Dec. 1	Apr. or May

Why BYU for Graduate School?

Conclusions

- Graduate work is rewarding and opens doors to an exciting career
- Great time to be an engineer with opportunities to address technical issues with global impact
- BYU Chemical Engineering is a great choice!