Directions in Chemical Engineering

Challenge response

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Council for Chemical Research
Why are we here?

- Identify those issues, challenges, and opportunities that are common across the chemical engineering discipline
- Develop a cohesive plan for responding to these challenges
- Articulate this plan broadly to the chemical engineering community
- Engage other appropriate stakeholders in this process
Major Issues

- Who are we and what do we want to be?
- How do we articulate this to our stakeholders?
  - Prospective and current students
  - People who advise prospective students
  - Industry
  - Funding agencies
  - Government
  - Other disciplines
- How do we change our educational programs to reflect these changes?
- How does biology affect us?
- How does information technology affect us?
Manpower Issues

- Enrollments are small relative to other engineering disciplines
  - Not necessarily bad, but we want the best
- Enrollments appear to be cyclic
  - Are they really?
  - Do they need to be?
- Employment opportunities are diverse
  - Reflects research opportunities in our departments
MIT Undergraduate Class Size

![Graph showing the number of students from 1975 to 2005. The graph includes data for sophomores (dashed line), seniors (dashed with squares line), and the total (solid line).]
Initial Placement for BS 00-01

- Industry: 55.9%
- Unknown Employment: 18.8%
- Government: 1.7%
- Unemployed: 9.5%
- Returned to Home Country: 1.3%
- Graduate/Professional School: 11.2%
- Other: 1.8%

AIChE Department of Career Services
September 2001
Industrial Employment for BS

- Chemical 23.3%
- Electronics 15.9%
- Fuels 15.7%
- Food/Consumer Products 10.6%
- Biotech./Related Industries (Pharma) 9.3%
- Materials 3.1%
- Pulp & Paper 2.1%
- Engrg. Svcs.-Environmental 2.4%
- Engrg. Svcs.-Environmental & Testing 1.8%
- Engrg. Svcs.-Design & Cnstrctn. 5.6%
- Business Svcs. 5.8%
- Other 3.9

AIChE Department of Career Services
September 2001
Initial Placement for MS 00-01

- Industry: 44.1%
- Graduate/Professional School: 33.1%
- Returned to Home Country: 4.7%
- Unemployed: 4.5%
- Unknown Employment: 7.4%
- Academic Employment: 1.8%
- Government: 2.2%
- Other: 2.2%

AIChE Department of Career Services
September 2001
Industrial Employment for MS

AIChE Department of Career Services
September 2001
Initial Placement for PhD 00-01

Industry 57.8%

Academic Employment 16.5%

Unknown Employment 6.4%

Other 1.7%

Unemployed 2.8%

Returned to Home Country 0.1%

Graduate/Professional School School 13.1%

Government .8%

AIChE Department of Career Services
September 2001
Industrial Employment for PhDs

- Chemical: 21.3%
- Fuels: 10.6%
- Electronics: 29.5%
- Biotech/Related Industries (Pharma): 15.9%
- Materials: 3.4%
- Food/Consumer Products: 4.3%
- Business Svcs.: 2.9%
- Engrg. Svcs.-Des./Cnstrctn.: 1.9%
- Research & Testing: 3.4%
- Environmental: 1.5%
- Pulp & Paper: 1.5%
- Other Industry: 3.9%

AIChE Department of Career Services
September 2001
Manpower Issues

- Public perception of “chemical” is negative
- Other disciplines are beginning to recognize the importance of molecules/molecular engineering
- Biological engineering departments displace our natural growth path
  - 91 bioengineering departments/programs at end of 2001
  - Will draw away students
  - Will draw away fiscal resources
- We are currently dealing individually with these issues, particularly the response to opportunities with molecular biology
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Our identity crisis

- Paradigm shift
- Industry shift
- Drift towards a broad research agenda
- Basic science shift
- ...

... Is this a shift to the center?
# Evolution of Chemical Engineering

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<th>Year</th>
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<td>1960</td>
<td>Engineering Science</td>
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*First articulated in the Visiting Committee Report of 1915, written by Arthur D. Little to the MIT President.
Chemical Industry Trends

- The chemical industry is cyclical
- The industry is becoming increasingly global
- Mergers of companies and product lines
- Chemical companies are becoming life science companies and spinning off chemical units
- Virtual companies - out-sourcing of services - incl. research
- Chemical engineering no longer is dominated by petrochemicals/bulk chemicals
- Graduates can expect to have multiple professional jobs
- Chemical engineering graduates go into a broad range of careers:
  - Chemicals, biochemical, materials, consumer products, ……
  - Teaching
Evaluation of Research Opportunities

-1.00 -0.50  0.00  0.50  1.00

-1.00 -0.50  0.00  0.50  1.00

Biochemical engineering
Biomedical engineering
Catalysis and Chemical Kinetics
Colloid Science and Separations
Energy Engineering
Environmental Engineering
Materials (Electronics, Ceramics...)
Polymers
Process Systems Engineering
Computational Chemistry
Transport Processes
Information Technology
Electrochemistry

External
Internal
Opportunities

- Chemical engineering is a uniquely positioned at the interface between molecular sciences and engineering with many exciting opportunities, including:
  - Life sciences (genetics, pharmaceuticals ….)
  - Energy - fuel cells, catalysis,
  - Sustainable systems
  - Molecular control of processes and devices
  - …

- Other disciplines have opportunities in these areas as well and are beginning to have interest in process, synthesis, analysis issues traditionally addressed within chemical engineering

- We need to have a clear vision of chemical engineering in order to function effectively in multidisciplinary research
Vision

- Chemical engineering is a vibrant discipline with a central role in many new and emerging technologies - specifically in the translation of molecular information and discovery into products and processes.
- We have evolved from a discipline closely tied to a single industry, the petrochemical industry, to one which interacts with many different industries across a broad spectrum of biological and chemical applications.
Vision

- We have had and must continue to hold a well defined core that defines the discipline and provides the basis for quantification, integration, and relevance in problem solutions.

- A close, broad coupling to sciences - physics, chemistry, and biology - is essential to the discipline, enabling the chemical engineer to impact across all scales - systems, processes, products, and molecules - at different levels of focus and providing interdisciplinary perspectives on technology innovation and development.
Chemical engineering has a unique position at the interface between molecular sciences and engineering
Challenges

- Need to balance the tension between diversity in research application areas and a coherent, strong core
  - Molecular transformations, quantitative understanding, systems treatment, multiscale analysis
- Need to balance the desire to teach many specific topics vs. using these to educate students for the future
- Need to balance applications with fundamental knowledge, synthesis with analysis
- Need to integrate biology appropriately as a basic science for our discipline
- Need to attract the best and brightest young minds into our discipline
  - Need to project an accurate, exciting image of our discipline to students/employers
The future

- What picture of the future do we share?
- Are we at a turning point?
- Balance between analysis and synthesis
- Incorporation of biology?
- What industries do we serve?
- What do we call ourselves?
- What does this mean for
  - Educational institutions
  - Industry
  - Professional society
- Is it to our advantage to work together? If so on what aspects of this big picture?