Directions in Chemical Engineering

Challenge → response

Charles F. Zukoski
Ronald W. Rousseau
Robert C. Armstrong
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

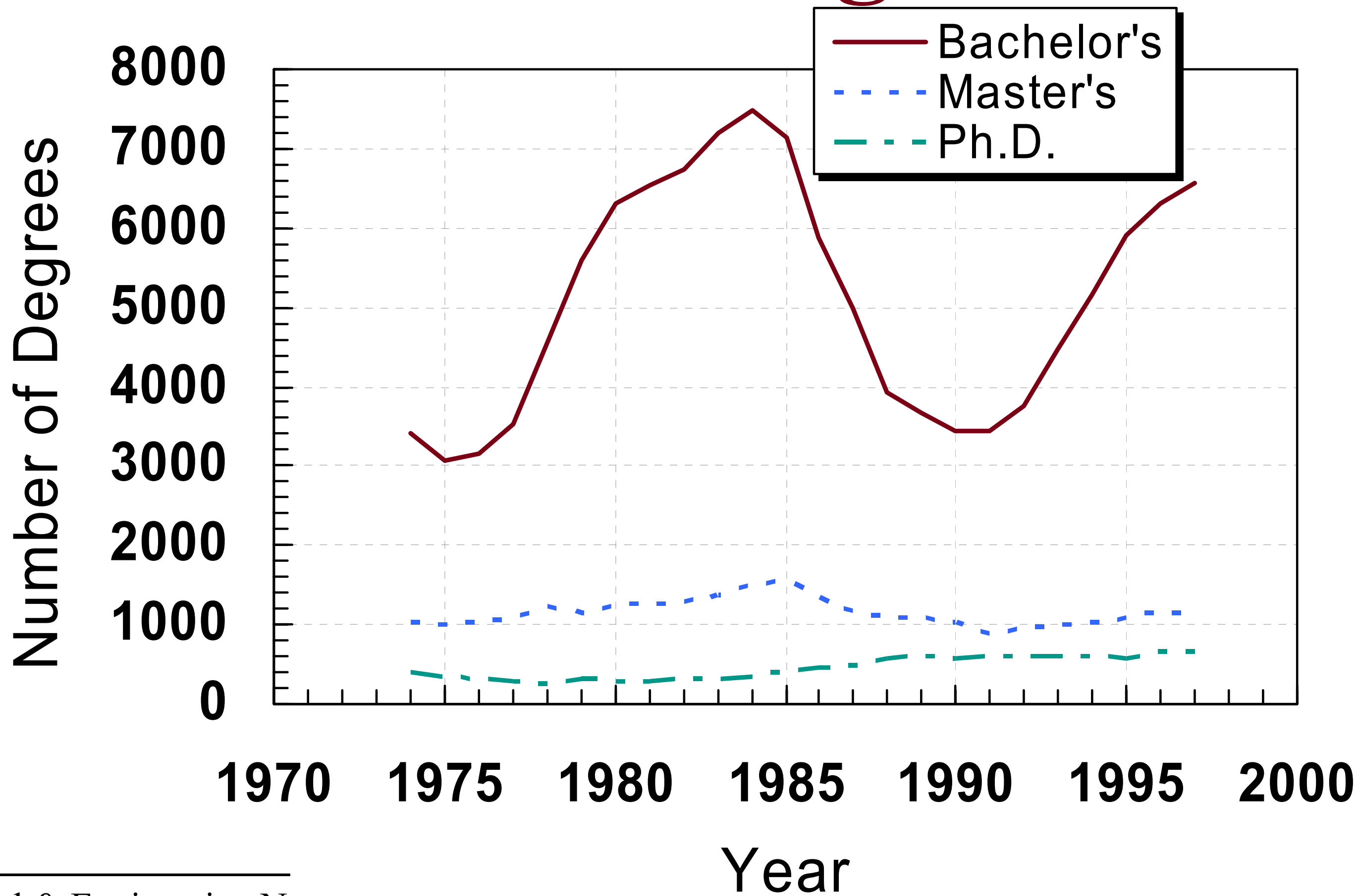
Major Issues

- 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

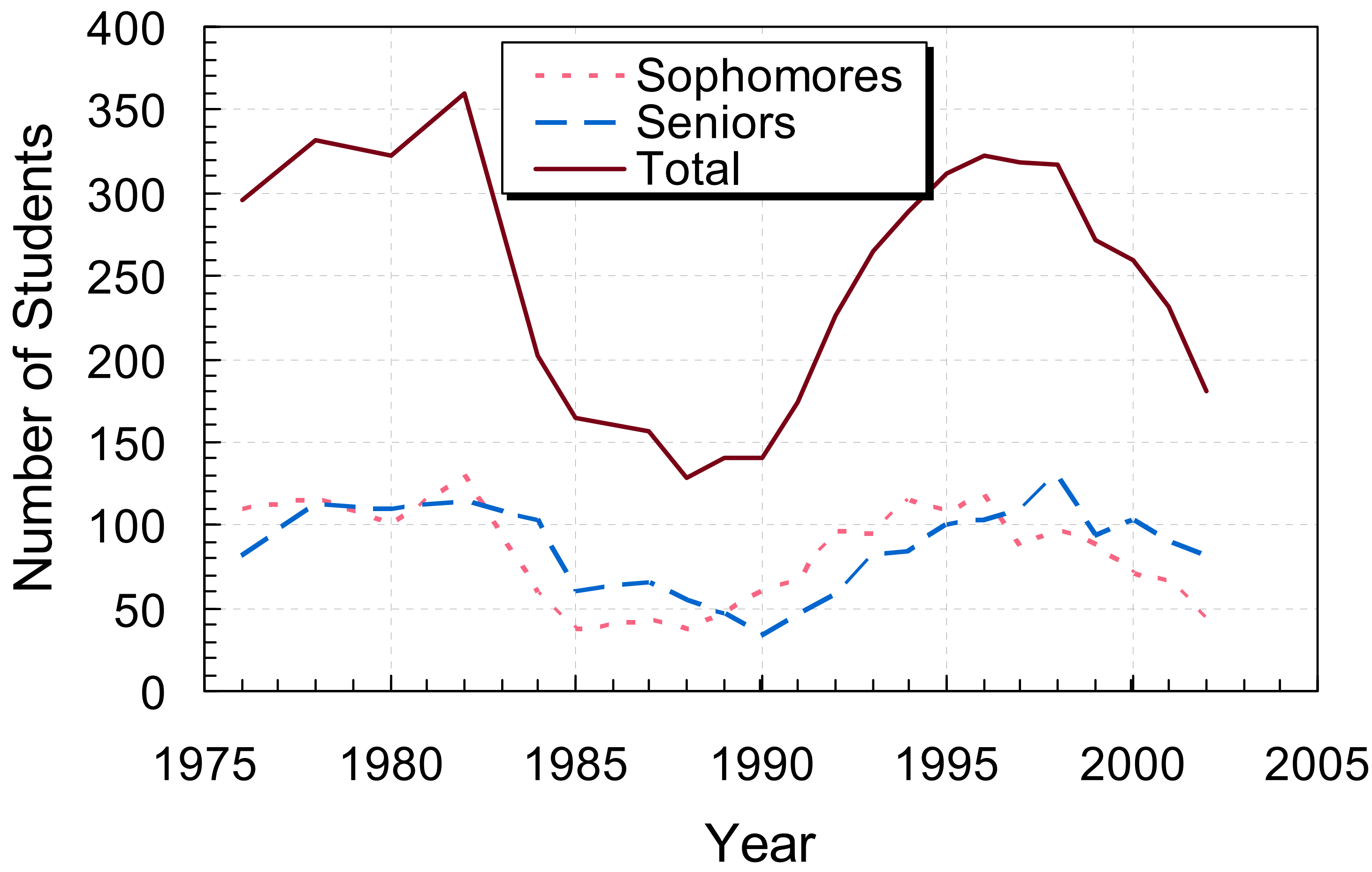
- Enrollments are small relative to other engineering disciplines
  - Not necessarily bad, but we want the best
- Enrollments appear to be cyclic
  - Are they really?
  - Do they need to be?
- Employment opportunities are diverse
  - Reflects research opportunities in our departments

U.S. Chemical Engineering Degrees 1974-97

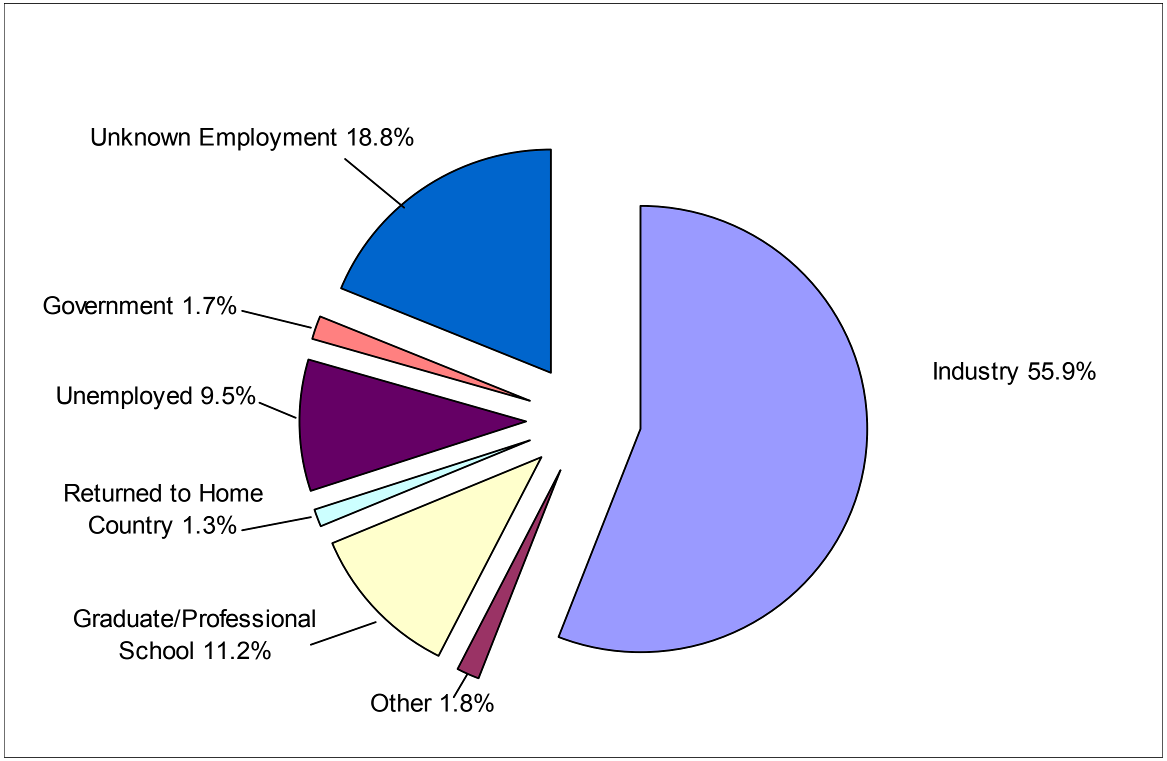


Chemical & Engineering News

MIT Undergraduate Class Size

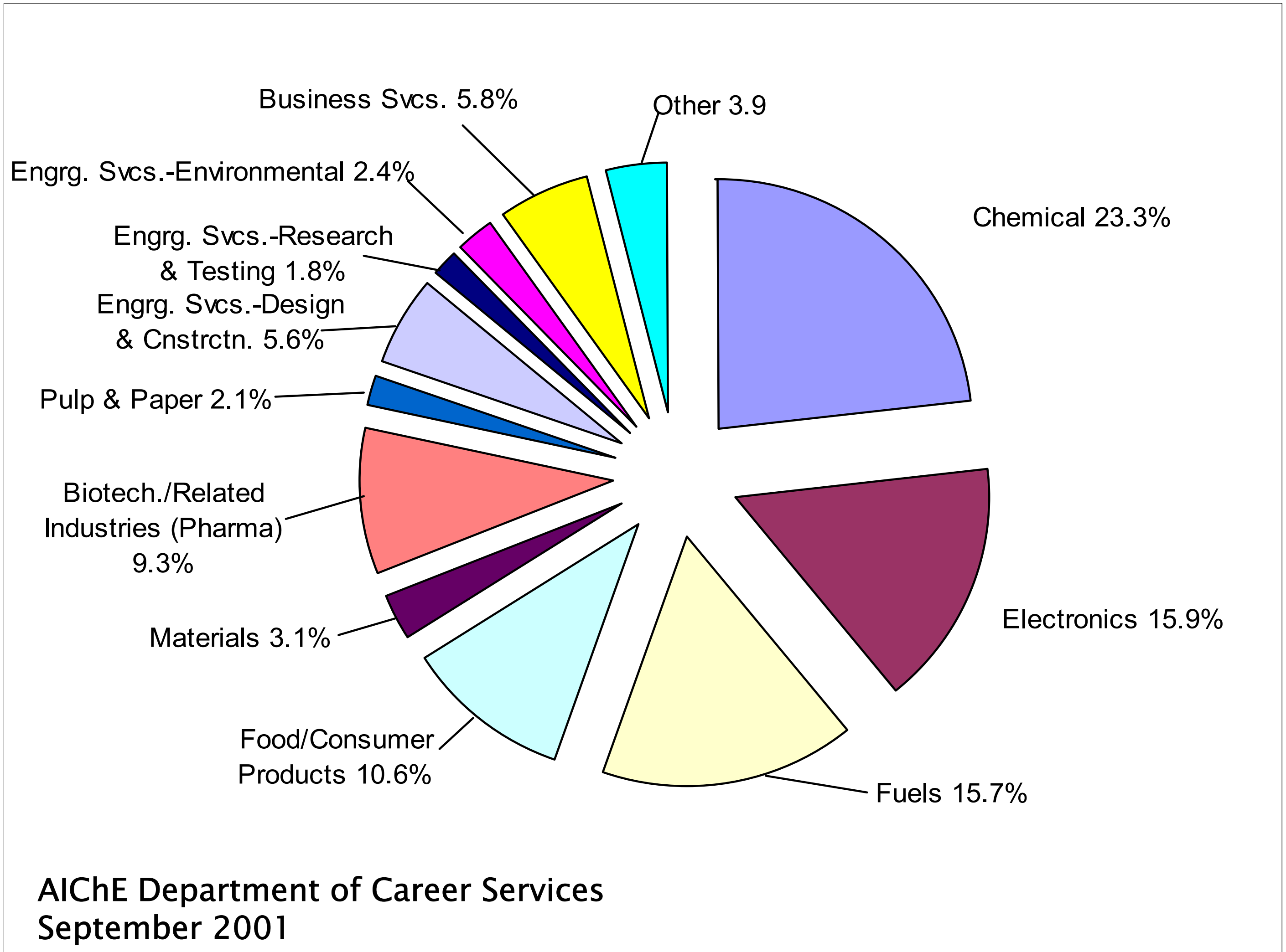


Initial Placement for BS 00-01

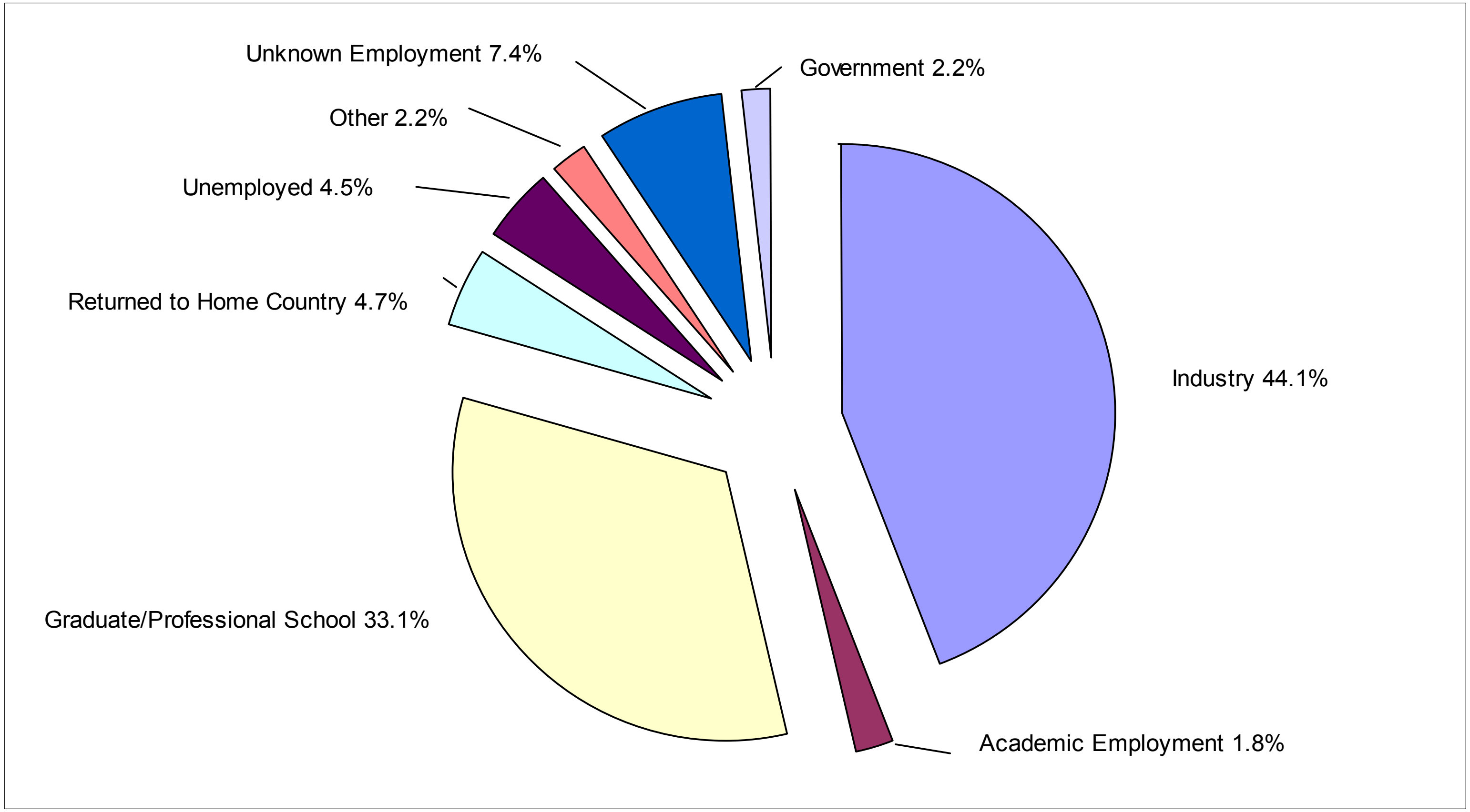


AIChE Department of Career Services
September 2001

Industrial Employment for BS

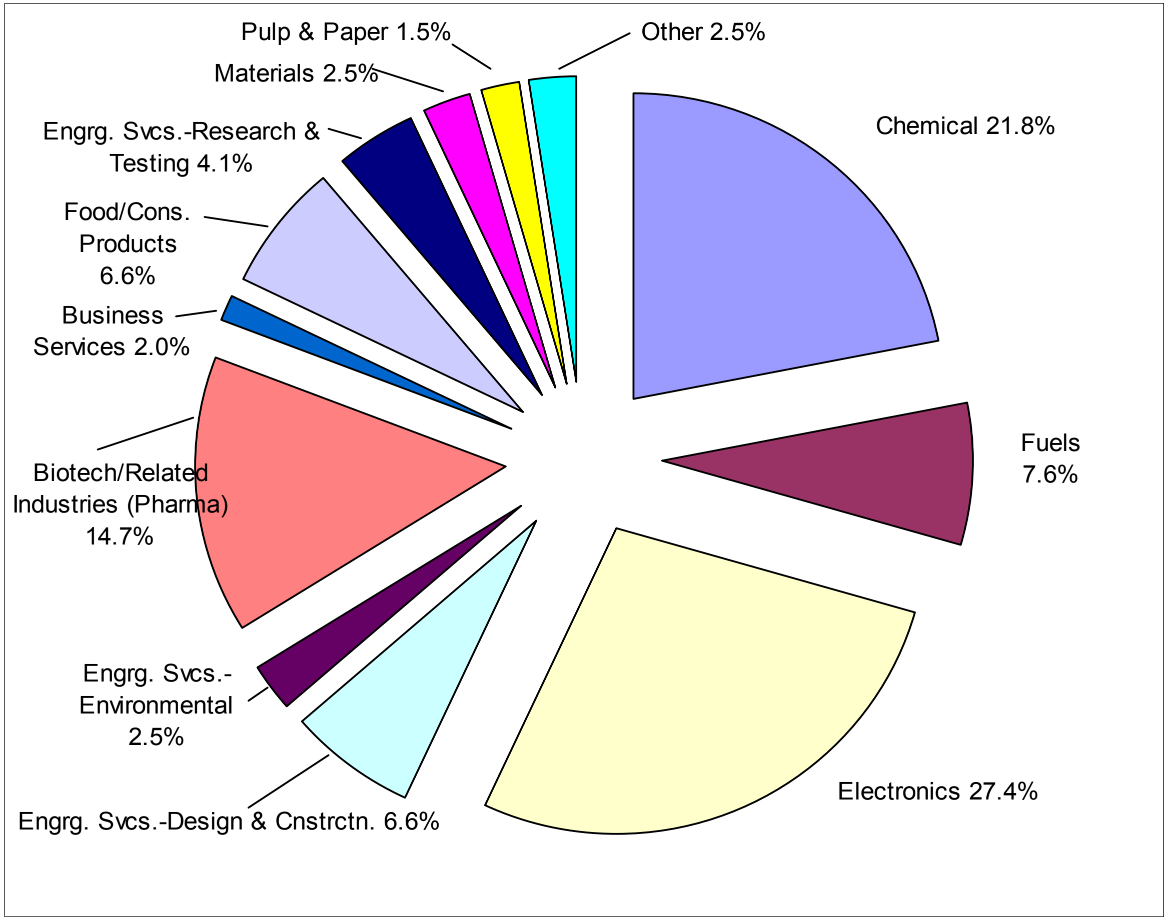


Initial Placement for MS 00-01



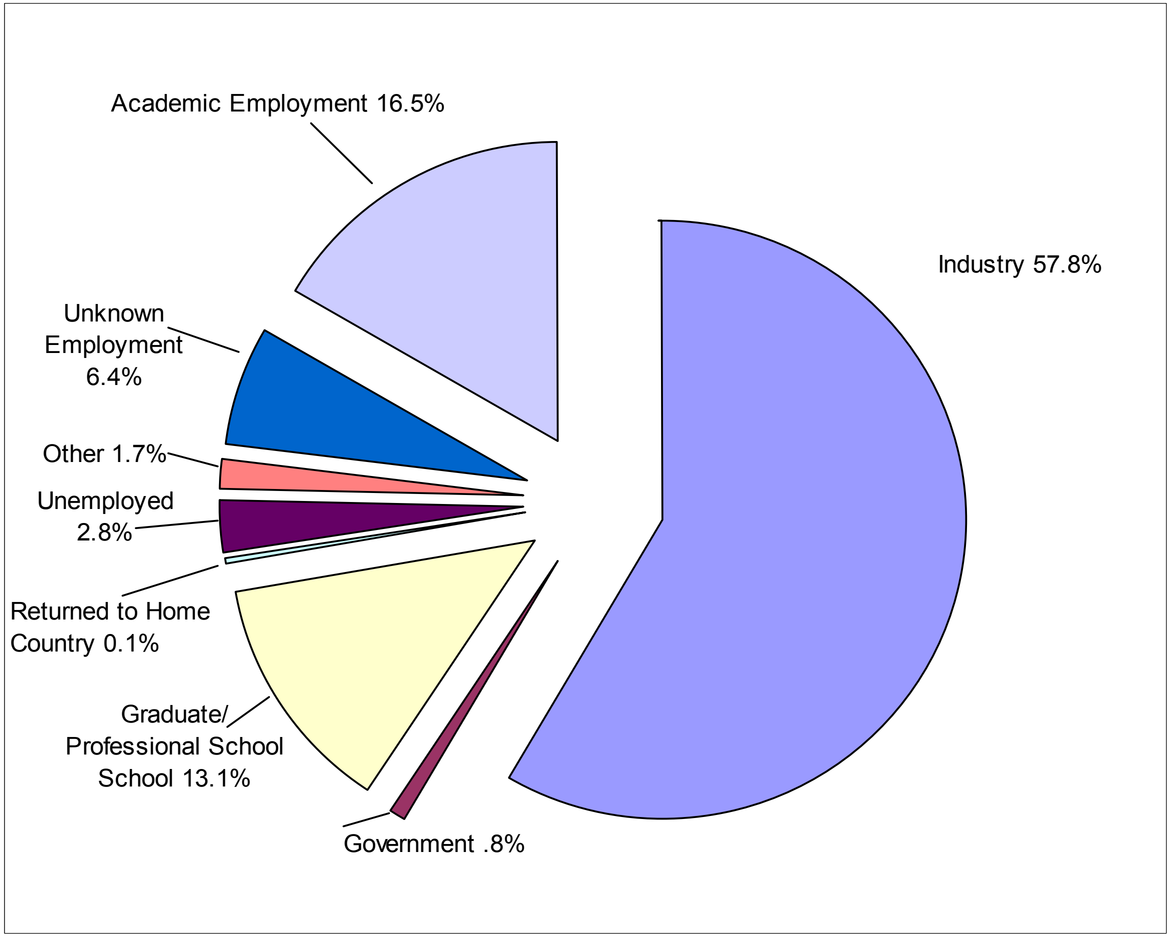
AIChE Department of Career Services
September 2001

Industrial Employment for MS



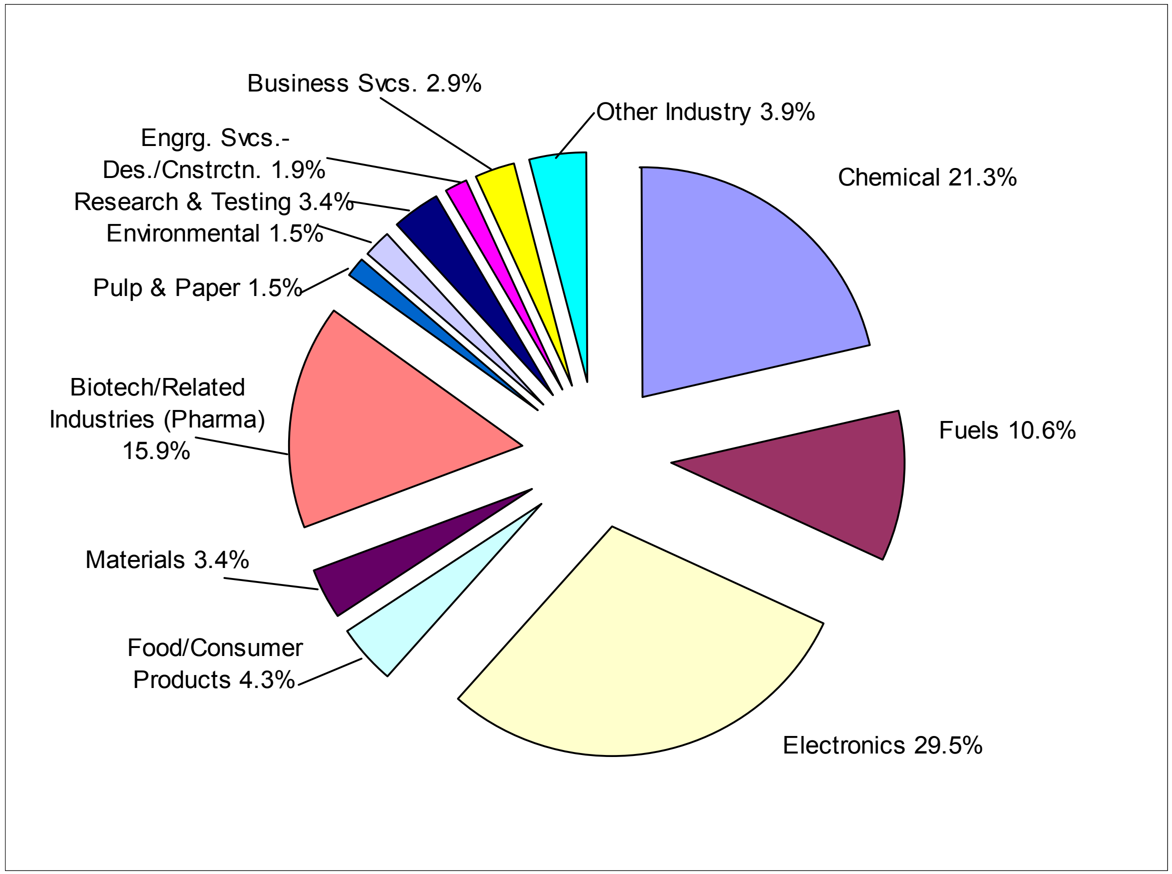
AIChE Department of Career Services
September 2001

Initial Placement for PhD 00-01



AIChE Department of Career Services
September 2001

Industrial Employment for PhDs



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

				ASEE Faculty Data (F99)				
institution	current admin structure	date current admin est.	chair/director	teaching tenure FT	teaching nonten FT	research FT	BS	year BS est.
Alfred University	Biomedical Materials Engineering Science Program	1999	Alan Goldstein					
Arizona State University	Bioengineering Program	1985	Eric J. Guilbeau	9.5	1	1.2	major	1985
Boston University	Department of Biomedical Engineering	1966	Kenneth R. Lutchen	24	0	1	major	1966
Brown University	Concentration in Biomedical Engineering	1999	Michael J. Lysaght				concen	1999
Carnegie Mellon University	Biomedical Engineering Program	1970	Michael M. Domach	0	4	1	major	2000
Case Western Reserve University	Department of Biomedical Engineering	1968	Patrick E. Crago	19	0		major	1973
Catholic University of America	Department of Biomedical Engineering	1998	Ayden Tozeren				major	1968
City College, CUNY	Center for Biomedical Engineering	1994	Stephen Cowin				concen	1995
Clemson University	Department of Bioengineering	1984	Larry Dooley	7	1		minor	1998
Cleveland State University	Applied Biomedical Engineering Program	1998	Orhan Talu					
Columbia University	Department of Biomedical Engineering	1998	Van C. Mow				major	1966
Cornell University	Program in Bioengineering	1994	Michael Shuler					
Dalhousie University	School of Biomedical Engineering	1999	J. Michael Lee	3	0			
Drexel University	School of Biomedical Engineering	1997	Banu Onaral	4	0	1	major	1998
Duke University	Department of Biomedical Engineering	1970	Morton Friedman				major	1967
Florida A&M-Florida State University	Program in Biomedical Engineering	2000	Michael H. Peters				major	2000
Florida International University	Biomedical Engineering Institute	1999	Richard T. Schoephoerster				minor	1999
Georgia Tech/Emory	Department of Biomedical Engineering/Bioengineering	1997	Don Giddens	2	0	1	minor	1999
Harvard University -- MIT	Division of Health Sciences and Technology	1970	Martha L. Gray					
Illinois Institute of Technology	Program in Biomedical Engineering	1999	Vincent Turitto	3	0	0		
Indiana University-Purdue University at Indianapolis	Program in Biomedical Engineering	1997	Edward J. Berbari					
Johns Hopkins University	Department of Biomedical Engineering	1970	Murray B. Sachs	18	0	5	major	1979
Louisiana Tech University	Department of Biomedical Engineering	1972	Stan A. Napper	6	0		major	1972
Massachusetts Institute of Technology	Division of Bioengineering and Environmental Health	1998	Douglas Lauffenburger	6	0		minor	1998
Marquette University	Department of Biomedical Engineering	1989	Jack M. Winters	8	1		major	1978
Mayo Graduate School/Mayo Foundation	Biomedical Engineering Program	1998	Richard A. Robb					
Michigan Technological University	Center for Biomedical Engineering	1997	David A. Nelson				major	1997
Milwaukee School of Engineering	Biomedical Engineering Program	1972	Vincent R. Canino				major	1972
Mississippi State University	Biomedical Engineering Program	2001	Jerome A. Gilbert					
New Jersey Institute of Technology	Department of Biomedical Engineering	2000	David Kristol				major	2000
Northwestern University	Biomedical Engineering Department	1985	Robert A. Linsenmeier	14	1	3	major	1971
Ohio State University	Biomedical Engineering Center	1971	Mauro Ferrari	6	0			
Oregon State University	Bioengineering Program	1996	Joseph McGuire				major	1996

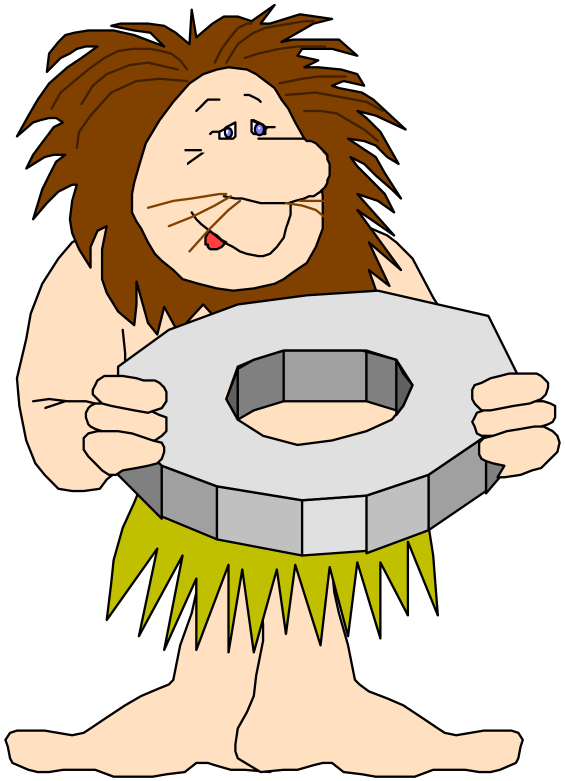
Our identity crisis

- Paradigm shift
- Industry shift
- Drift towards a broad research agenda
- Basic science shift
- …
- … Is this a shift to the center?

Evolution of Chemical Engineering

Major Paradigm Shifts	
1915	Unit Operations*
1960	Engineering Science
2000	Molecular Engineering of Products and Processes

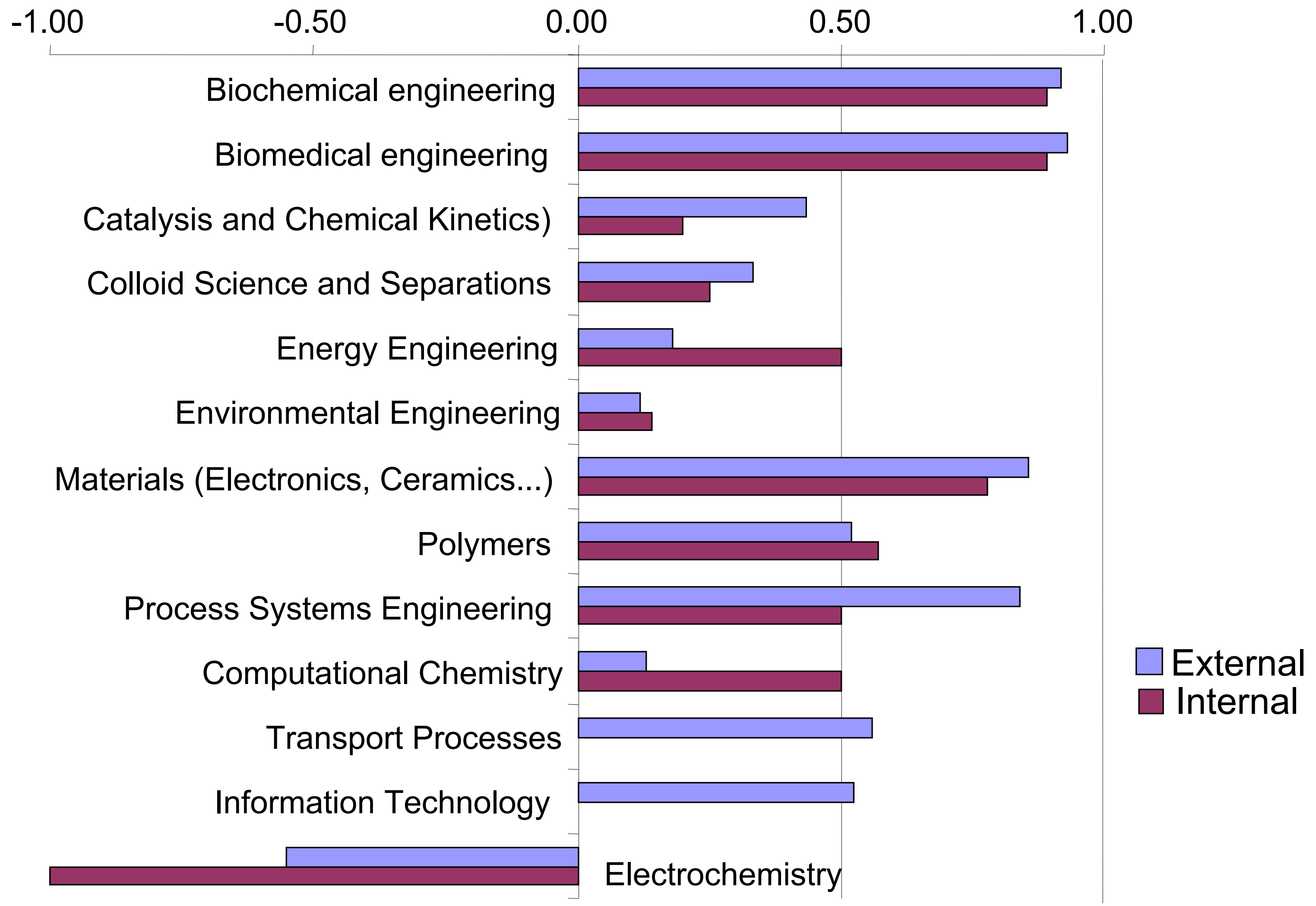
*First articulated in the Visiting Committee Report of 1915, written by Arthur D. Little to the MIT President.



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



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*

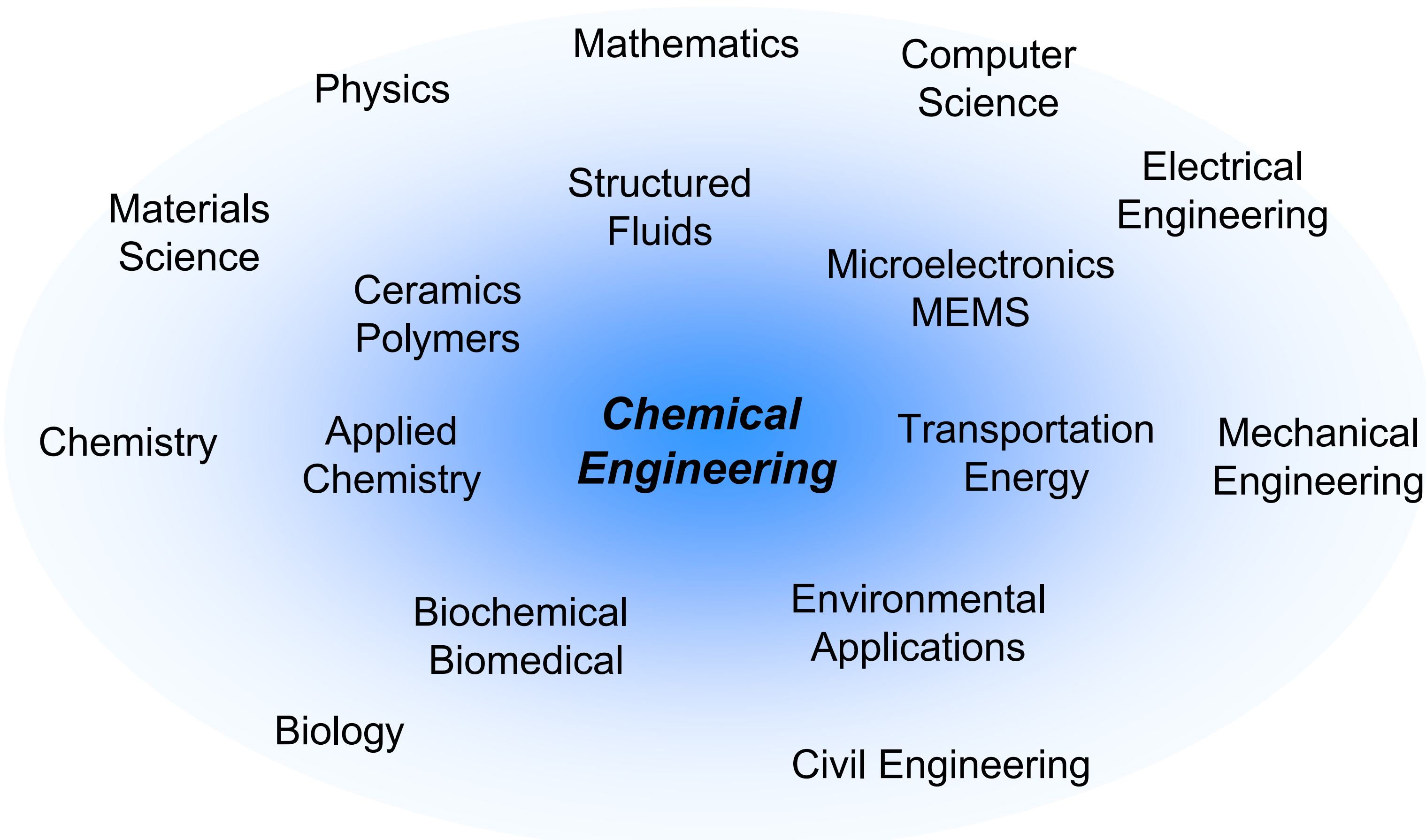
Vision

- 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

Central Engineering at the Center



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?