

Session 1: Speculation on 2015

Workshop participants, divided into six groups, addressed the questions

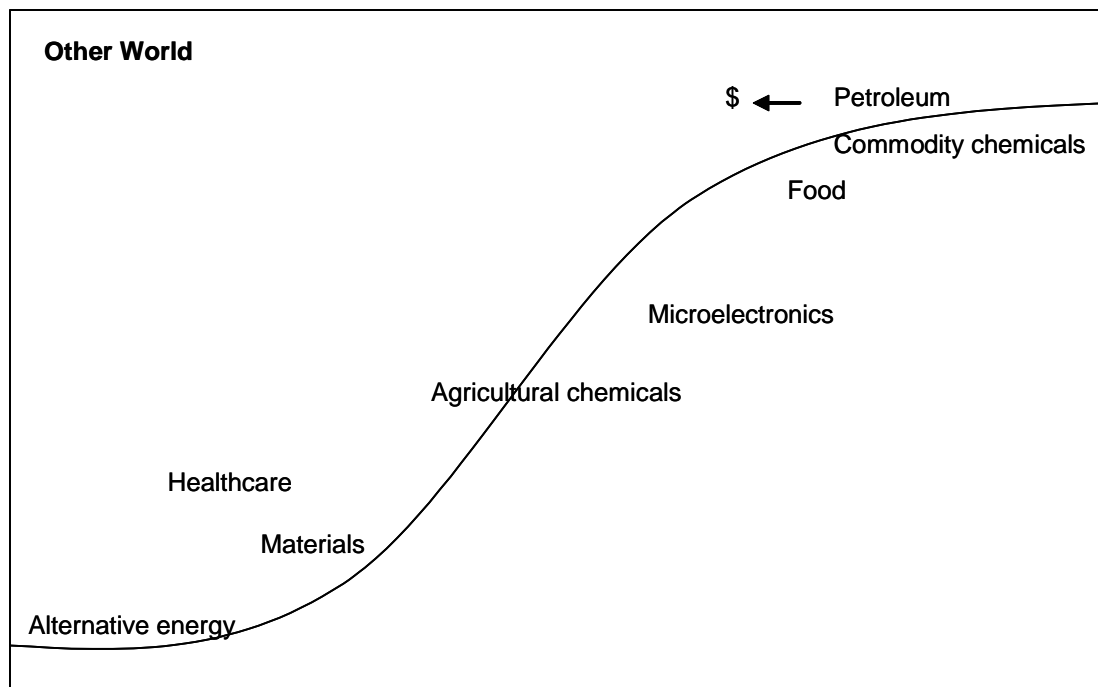
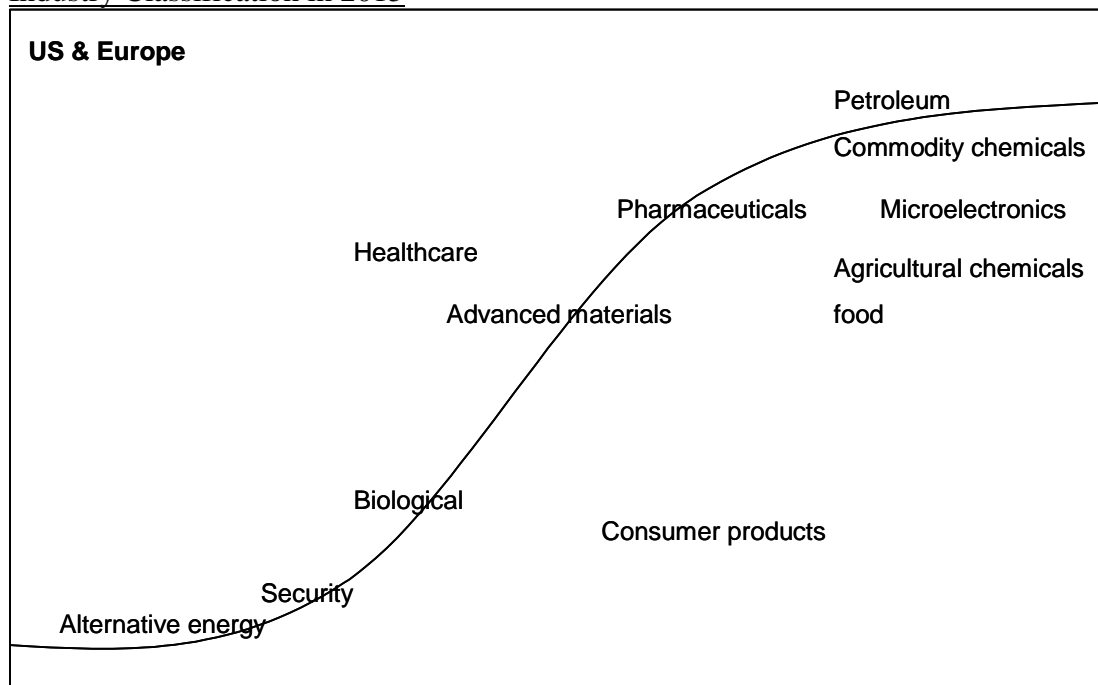
- Which industries that will hire ChEs are likely to be emerging, developing, or mature in 2015 and beyond? (depicted on S-curve)
- What are the venues (labs, office computers, manufacturing floors), processes, and products anticipated in the next decade and beyond?
- They were to distinguish between US/Europe and the rest of the world.
- The objective was to set a context for what is needed in a curriculum, and to engage the experience of the industrial practitioners.

Discussion after individual reports were presented

- In these reports, notice several new topics vs. what was emphasized in 2003 workshops
 - e.g., water supply and quality, defense, home security
 - Petrochemical seems to be more important than in 2003
- Global warming, C-tax, H₂ issues not covered
- Think fundamentally – identify the driving forces for curriculum change
- Universities should stay aware of emerging technologies, so that they can adjust ChE preparation, if needed.
- Globalization, off-shoring can be resisted, so US manufacturing may not be over yet. (e.g., Sanyo plant in Midwest US is the largest manufacturer of TV sets)
- Train ChEs to be more than innovators in high tech– they must serve the needs of mature industries, too.
- There are also replacement positions to fill in mature industries – so traditional preparation is needed
- Not much in the discussion goes outside US/Europe. Why?
 - Lack of knowledge?
 - How to help students prepare for worldwide employment?
- In Shell's international growth, the plan is to staff overseas plants with local people, so that we don't educate engineers in the US to run overseas plants.
- Who will pay for a new ChE curriculum?

Individual group reports follow:

Group 1
Industry Classification in 2015



What should the ordinates be -- demand for graduates? technology? money?

Venues for Chemical Engineers in 2015

- Home (increase!)
 - Possible because of enabling technology
- Factories (decrease)
 - Exporting of manufacturing/\$ tax
 - Enabling tech needs fewer people
- Office (increase)
 - CAD tools
 - Coordination/Project Management
- Laboratories/Pilot Plant (mixed)
 - Biological industries (increase)
 - R&D is being exported (decrease)
- Health care facilities (increase)
 - Health care demand increasing; more engineers involved.
- Road
 - Sales
 - Consultant
 - Field work

Industries that will Employ Chemical Engineers in 2015

- Pharmaceutical
- Biological
- Agriculture
- Food
- Consumer products
- Health care
- Environmental
- Polymers
- Industrial biotech
- Electronic materials
- Transportation
- Finance/management
- Technical consulting
- Law/medicine
- Fuels
 - Exploration
 - Conventional
 - Advanced
- Academics
- Grad school
- Telecommunications
- Fine chemicals
- Petrochemicals
- Engineering/construction
- Advanced materials
 - Many applications

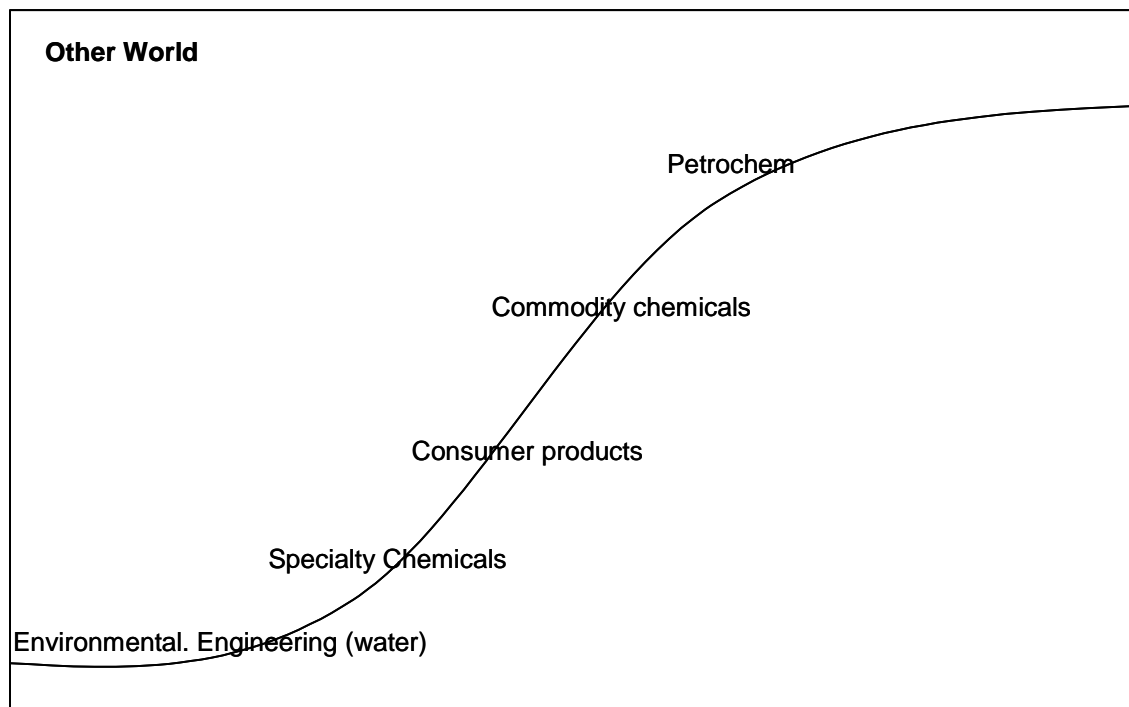
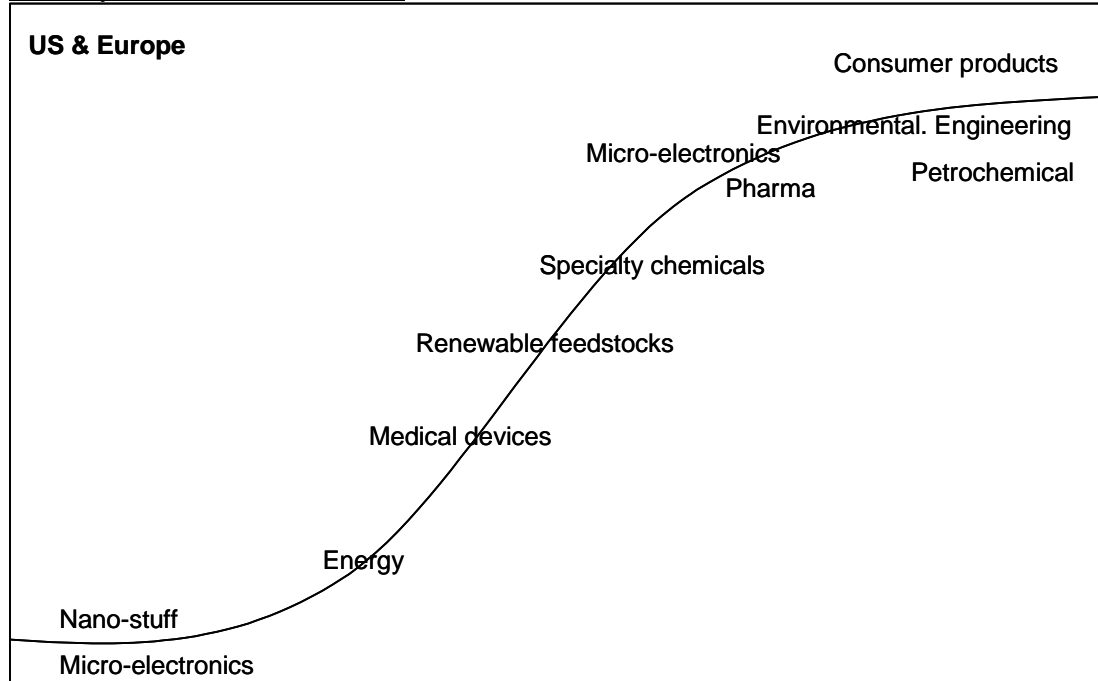
- Safety
 - Homeland security
 - Consulting
 - Sensors
- Military/defense

Processes and Products in 2015

- Green chemistry
- Life cycle analysis (value recognition)
 - (EU is ahead of US)
- Customized products (health, consumer)
 - (Especially US)
- Molecular electronics

Group 2

Industry Classification in 2015



- Trend to "Information Technology" and innovation in US (does this increase need for PhD instead of BS?) and farming out manufacturing to rest of the world
- Short-term replacement staffing
- Research more important

Venues in 2015

- Commodity Chemicals require manufacturing/office
- Labs are good for:
 - Applied statistics
 - “Messiness” of data
 - Appreciation of technical aspects
- Market Research/Product Development
 - Distill the needs of customer
- Pseudo-sales => on the road => different countries
 - engineers more directly involved with customers
- Working globally
 - Cultural issues are important
- Technology broker
 - 24-hour workforce

Products in 2015

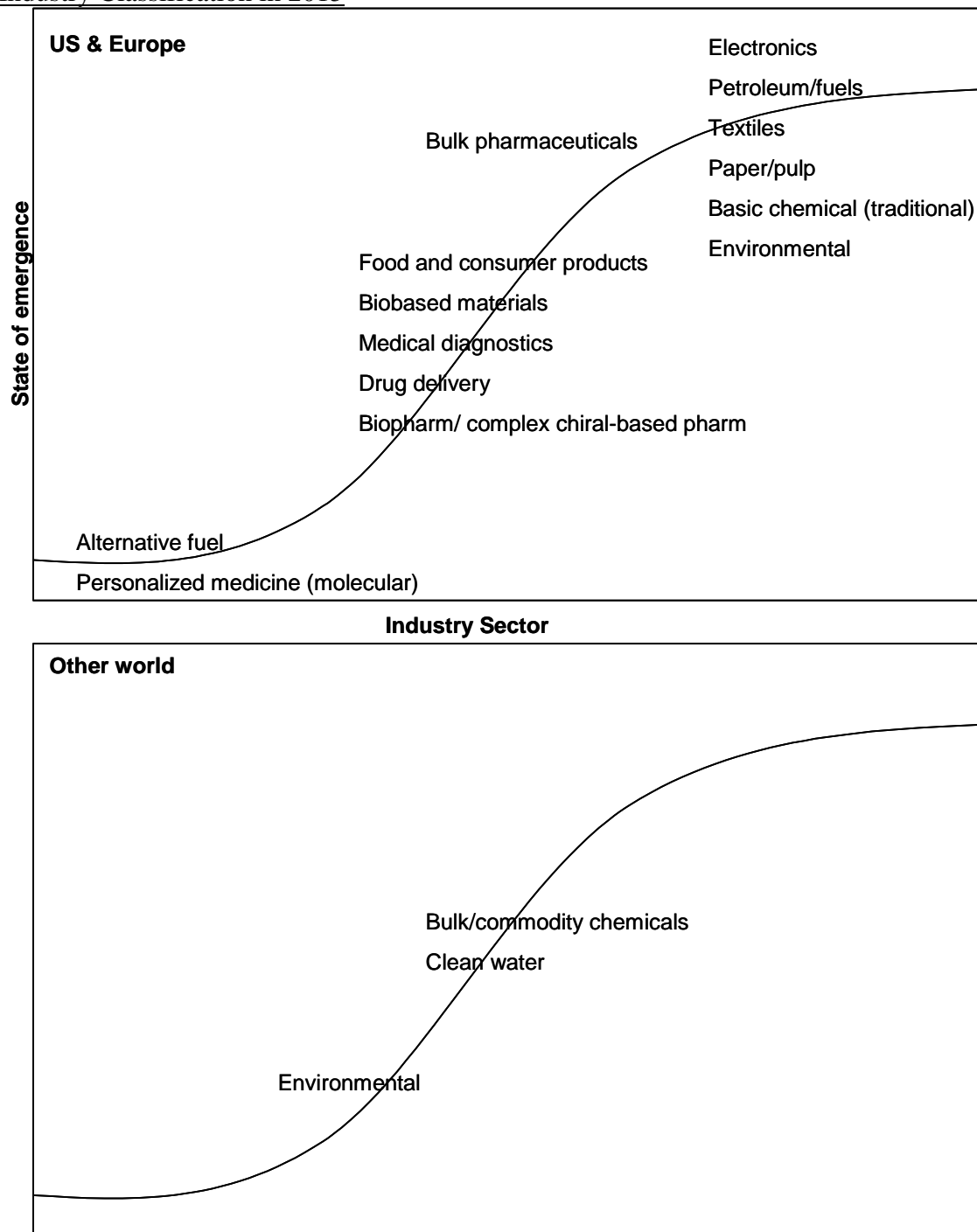
- Composites/materials
- Cheaper electronics/sensors
- Nanotechnology
- Cheaper Healthcare products
 - Medical Devices
 - 3rd World
 - Socialized medicine

Processes in 2015

- Process and products still equally important
- Process flexibility/batch processing/ scheduling/ lean manufacturing
- Smaller scale => flexible/ transportation
 - Reduce hazardous material shipping
 - Local/regional raw materials (raw material costs, rather than labor costs, are dominant influence on plant location)
- Operations (continuous improvement) & Process Optimization (at BS level)
- Is there an opportunity for engineers in “traditional” careers to stay competitive?
 - An engineering renaissance?

Group 3

Industry Classification in 2015



Industries

- Mature
 - Pharmaceuticals
 - Energy/fuels
 - Medical technology

- Basic chemicals
- Food & consumer products
- Electronics
- Middle
 - Materials
 - Transportation
 - Paper, pulp
 - Textiles
- Early
 - Packaging
 - Biotech
 - Service

Venues in 2015

- Manufacturing - specialty small-scale operations
- Tech service/ operations/ control
- Earlier (in career) leadership opportunities./ appreciation of big picture
- Non-co-located/ digitally connected
- Large computer data analysis role
- Sales
- Education of ChEs to interact with, or move to, other professions

Processes in 2015 (products are increasingly driving the processes)

- Cell-free synthesis
- Molecular engineering
- Microreactors
- HTS
- Computer aided conceptual design/ system integration

Products in 2015 (product and process are integrated/connected)

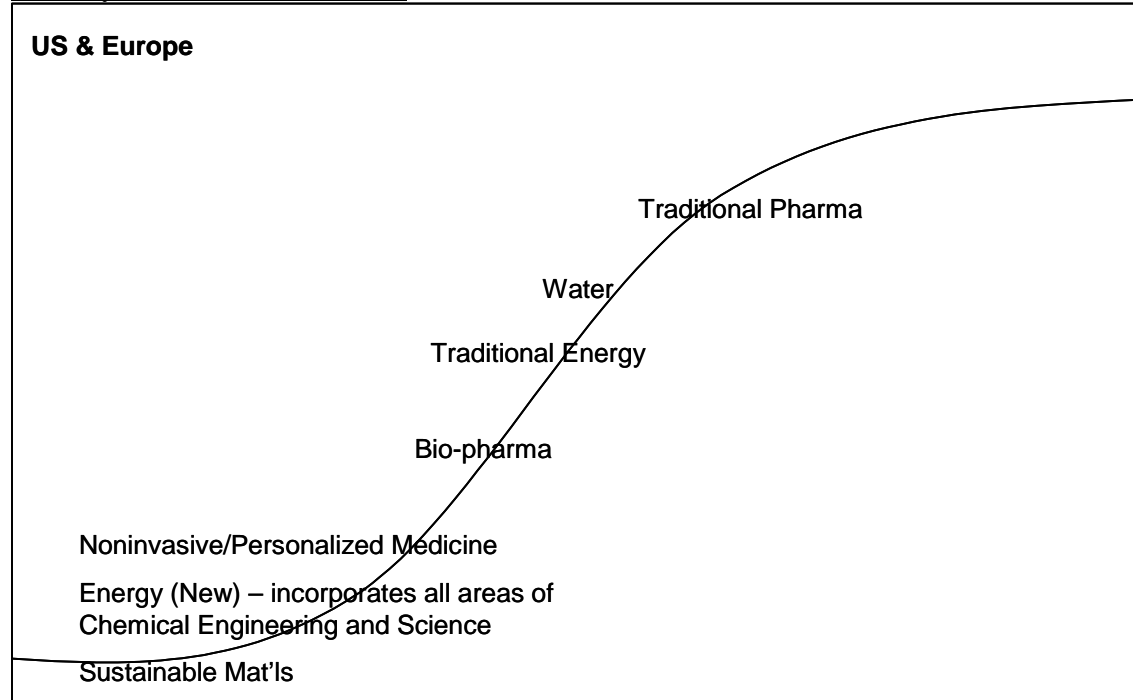
- Customer/ user driven
- Disposables/ recyclables
- Functional materials (nanocomposites)
- Drug delivery
- Body parts
- Electro/optical materials
- Microreactors

Other Thoughts

- Is there a specialty polymer industry?
- Impact of macro-trends driving forces
 - Environmental awareness, and molecular medicine
- Innovation/create new things
 - Need for engineers to innovate based on human needs rather than technology-driven
 - What are other academic areas doing?

Group 4

Industry Classification in 2015



Distinction as to state of maturity not necessarily clear for single industry

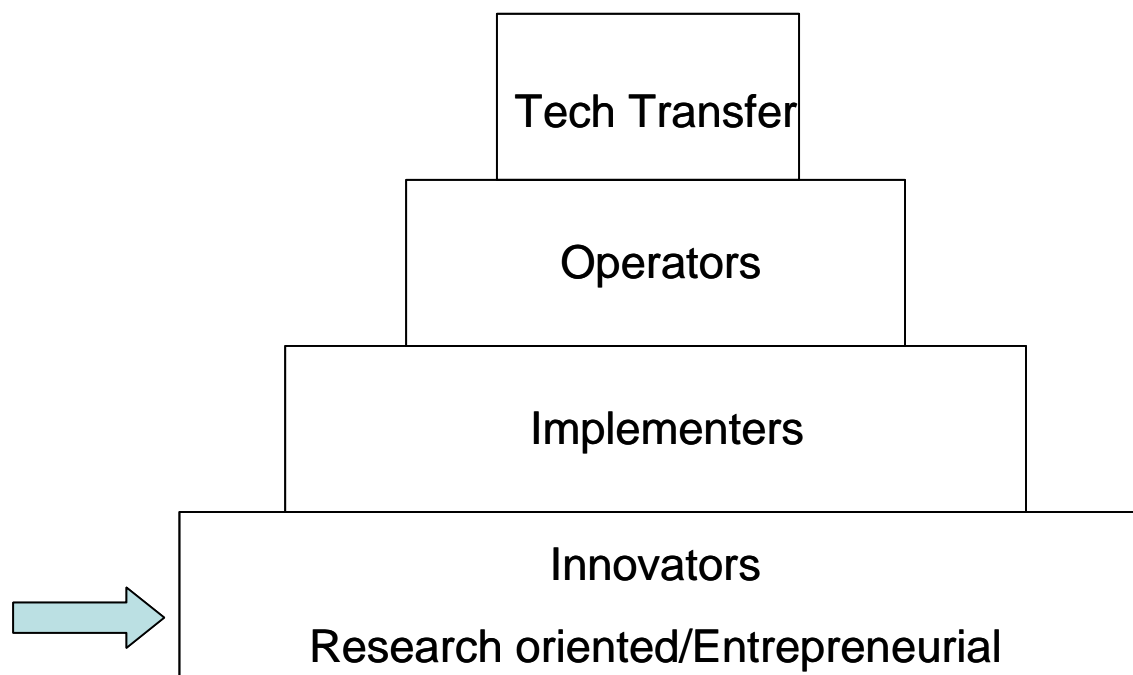
- What is limiting factor?
 - Materials
 - Intellectual
- Innovation, technical centers growing in Asia
 - Will US-trained engineers be marketable in those regions?
- Local innovation
- Consequence of globalization:
 - Growth of jobs for engineers greatest elsewhere
 - Growth in US limited to areas growing in US but not elsewhere: innovation, entrepreneurial

Drivers for the future

- Healthcare
 - Devices – new materials/nano
 - Emphasis moving from acute to chronic conditions
 - Non-invasive
 - Biomarkers
 - Imaging
 - Personalized medicine
 - Bridge to bio, electronics
- Water Quality & Management - especially the processes
 - Developing World
 - Pollution

- Improved Separations
 - Desalination
 - Contaminant removal (ions)
- Improved distribution
- New separation methods
- Energy
 - Supply
 - Demand
 - Moving to sustainable materials, and away from petroleum
 - Will ChEs contribute to nuclear energy?
- Food and nutrition
 - Standard of living up in developing world
 - Is there enough land?

Functions of US Chemical Engineers



Growing relative to other functions

Needed in US: A smaller number of people capable of more complex work.

Engineers will be innovators, bridging science and its deployment in society. Need depth of training, more than at present.

Group 5

Industry Classification

<u>Emerging in 2015</u>	<u>Mature in 2015</u>
Global finance (mergers, acquisitions) Consulting (?)	Consulting Manufacturing-commodity

- ? Making stuff
- ? New technology in mature industries
- ? “think” work vs. “do” work
 - (design/development/making molecules)

Industries in various stages will have different uses for engineers. Thus ChEs need to be educated to serve a variety of tasks in a variety of industries.

Driving Forces in 2015

- Energy supply
- Information technology/ computing/ instrumentation
- External
 - Regulatory
 - Financial buyers
 - Security
 - Changing age demographics
- Where are the ChE students going?
 - Law, finance, service, manufacturing
- Perception
 - Students
 - Public
 - Regulatory

Four Points

- 2015 is tomorrow
- ChE is vital to every industry sector (so chemical engineers need to be educated about multiple industries)
- Globalization has many facets – understand its dimensions
- Need to focus on technology/innovation rather than the emerging-vs.-mature dichotomy (if you are not “emerging”, you will not survive in 15 years)

Group 6

Characteristics of Emerging, Developing, and Mature Industries

Emerging (E)	Developing (D)	Mature (M)
Research Laboratory Simulation Product (beaker)	Increased manufacturing Process design (pilot plant) Simulation	Process Yield Quality Manufacturing Improvement Less R&D; more maintenance “virtual” management International

Note that a Mature Industry should not be disregarded; although not developing technology as fast as E and D companies, it may nevertheless have a major effect on the economy and employment.

Industry Classification in 2015

- Petrochemical (M+)
- Coatings (M)
- Microelectronics (M)
- Automotive (M)
- Transportation (M)
- Paper/pulp (M)
- Finance industries (M)
- Engineering/ Construction/ Design (M)
 - Project management
- Bulk Chemicals (M)
 - Natural products (D)
- Healthcare
 - Drugs
 - Chemical pharmaceutical (D)
 - Biological pharmaceutical (D)
 - Medical devices (D)
 - Diagnostic devices (D)
 - Consumer products (D)
 - Genetic engineering (E)
 - Artificial organs (E)
 - Tissue engineering (E)
- Materials
 - Plastics (M)
 - Polymer (M)
 - Nanotechnology (D)
 - Biological (E)
 - Advanced (E)
- Specialty Chemicals
- Energy

- Fossil fuels (coal, gas, oil) (M)
- Nuclear (M)
- Biomass (D)
- H₂ (D)
- Fuel cells (D)
- Solar (D)
- Infrastructure (D)
- Biotechnology
 - Industrial (M)
 - Food (M)
 - Environmental (D)
- Personal care (D)
 - Cosmetics
- Defense
 - Plant safety (D)
 - Sensors (E)
 - Biological counter-measures (E)
- Optoelectronics (D)
- Software tool development (D)
- Environmental consulting (D)
- Aerospace (D)
- Carbon management (E)
- Spintronics (E)