Nance Lab
Disease-Directed Engineering

History of Chemical Engineering and the Chemical Engineer's Role in Society

Elizabeth Nance, PhD
Clare Boothe Luce Assistant Professor
Chemical Engineering; Adjunct, Radiology

Center on Human Development and Disability
eScience Institute
Molecular Engineering & Sciences Institute

Lecture Slides
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UNIVERSITY *of* WASHINGTON

A Brief History of Chemical Engineering*

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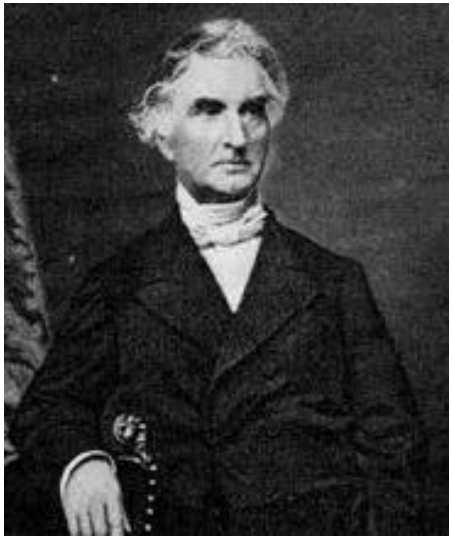
Origins of Chemical Engineering

- Newest of 4 major engineering disciplines
  - Civil and Mechanical predate it by over 100 years!
  - (Electrical is the 4th discipline)

- Arose as a distinct profession between the end of the 19th and early 20th century.

- But origins go back to the industrial revolution of the 18th and 19th century in Europe and the US, when the art and science of chemistry flourished.

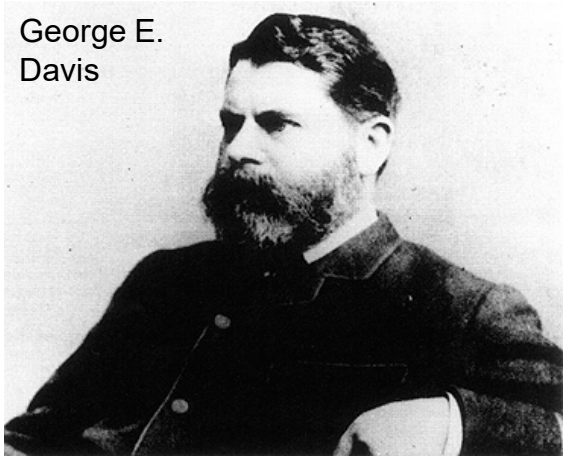
- Differentiating factor of von Liebig was his efforts to apply fundamental discoveries to development of specific chemical processes and products



Justus von Liebig – 1st great educator in chemistry

History of Chemical Engineering

- First established as a profession in the United Kingdom, when the first chemical engineering course was given at the University of Manchester in 1887 by George E. Davis


George E. Davis

- Taught 12 lectures: covered various aspects of industrial chemical practice
  - Davis applied knowledge from years of inspecting chemical plants in the industrial regions of England
  - Empirical, based on observation rather than theory
  - Focused on the operation of units, or individual pieces of equipment, that made up a chemical plant
  - This later became known as Unit operations (coined in 1915)!
- Published one of the first textbooks in 1901, *A Handbook in Chemical Engineering*

So why do we not associate the "birth of ChemE" in Europe, and with Davis?

History of Chemical Engineering

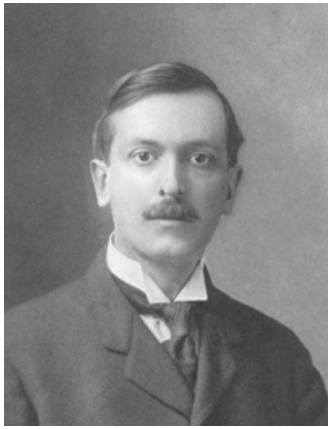
- In 1888, Lewis M. Norton, MIT Department of Chemistry, offered a new course called Course X, that is considered the world's first 4-year chemical engineering curriculum
  - Material was taken largely from Norton's notes on industrial practice in Germany, which at the time was the most advanced chemical process industry in the world.
  - Combined mechanical engineering with industrial chemistry
- In 1891, granted 7 bachelor's degrees in ChemE
- In 1893, Frank H. Thorpe, an MIT graduate, took responsibility for Norton's course


Lewis M. Norton

- 5 years later, Thorpe published the first textbook on chemical engineering (1898), entitled "Outlines of Industrial Chemistry".
  - Made mention of the chemical treatment of biological by-products – an indication of early biotech?

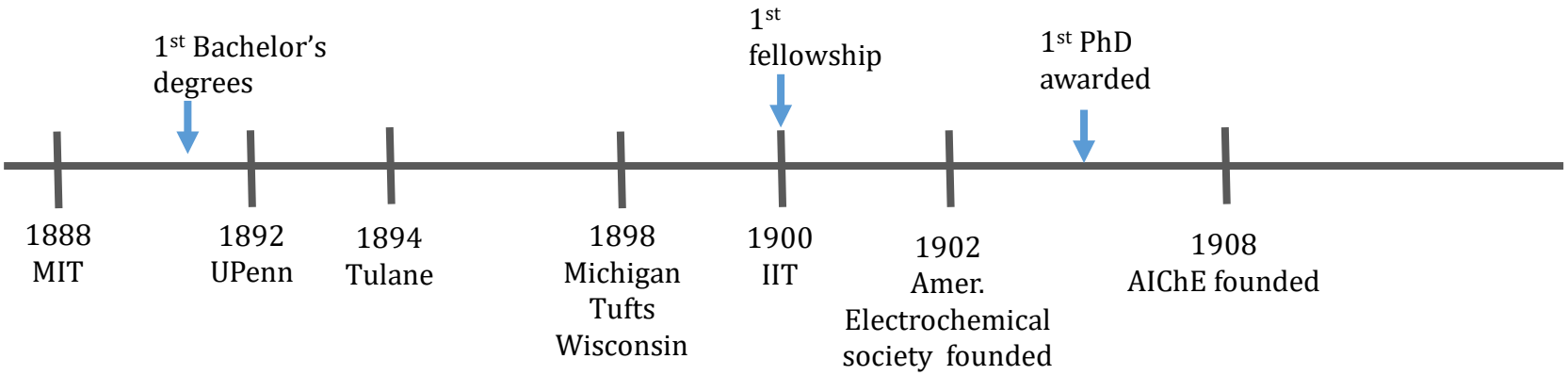
History of Chemical Engineering

- Norton and Thorpe were the pioneers of chemical engineering enthusiasm at MIT
- However, Arthur A. Noyes and later William H. Walker brought to this discipline the respect it merited within the engineering curriculum
- But, ChemE did not become a separate department until 1920 at MIT; up until then, it was housed in the Division of Applied Chemistry in the department of Chemistry, as was the case at all universities that offered 4-year curriculums in ChemE.



Arthur Noyes

William Walker



History of Chemical Engineering

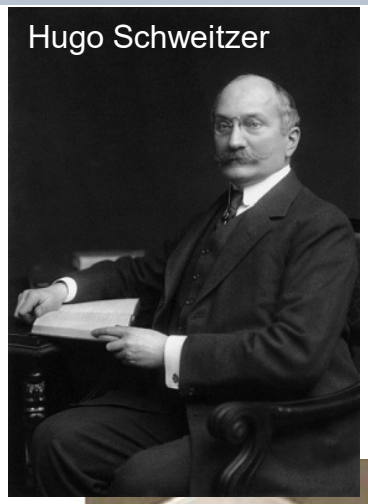
- In 1951, Neal Amundson, educated as both a chemical engineer and a mathematician, realized that further insight into chemical engineering problems lay in the analysis of chemical processes and phenomena based on a fundamental understanding of these problems.
- Partnered with Rutherford Aris in 1955 to create ChemE department and curriculum at Minnesota

- At Wisconsin in 1957, Bird, Stewart, and Lightfoot (BSL) prepared set of notes based on their individual research over previous decade.
  - Strong unifying backbone to seemingly different unit operations that describe how fluids flow, heat is transported, and chemical species move within fluid….sound familiar?
- Published *Transport phenomena (***your 330 book!***)* in 1960

And so the field became established on it's own in academia…but what about the professional side?

The establishment of a profession

- Somewhat tumultuous path to establish chemical engineering as a profession independent of chemistry
- At a 1904 American Chemical Society meeting, Hugo Schweitzer, a prominent New York industrial chemist, declared himself "absolutely against the introduction of chemical engineering in the education of chemists. "
- In the same meeting M. T. Bogert agreed with Schweitzer, saying that progress in "technical chemistry" was best achieved in research laboratories by researchers without engineering training.
- But an advocate was found in chemist Milton Whitaker at Columbia University, who stated that "a chemist was generally not the man who is capable of transmitting from a laboratory to a factory the ideas which he has developed" because he lacks education "in the engineering branches."



Marston Taylor Bogert, 1926.

Controversy soon spurred action…

3 years later…

- A group of 12 chemists and engineers met at the Chalfonte Hotel in Atlantic City to discuss the future of their profession.

- At the end of their discussion they formed the so-called Committee of Six to explore the "possibility of forming a chemical engineering organization."

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AIChE
American Institute of Chemical Engineers

- The Committee of Six represented the core of what would become AIChE's leadership, which included Walker as well as three men who would go on to become presidents of the organization: Arthur D. Little (1919), Charles F. McKenna (1910), and John C. Olsen (1931)

American Institute of Chemical Engineers

- The Committee of Six, joined by 15 other chemists and chemical engineers, held its next meeting in January 1908 at the Belmont Hotel in New York.

- Once again Bogert, by this time president of the ACS, raised the objection that his organization already served the needs of practicing industrial chemists.

- The Committee of Six stood firm and decided to form a new organization dedicated to chemical engineering.

On 22 June 1908 the first meeting of the AIChE convened at the Engineer's Club of Philadelphia.

And this point, new debate emerged around training of chemical engineers…

Development of diverse career paths

What do chemical engineers do?

- Up until 1980, easy question to answer.
  - Overwhelmingly, a person with a chemical engineering degree would go to work in the petroleum, chemical, or food processing industries.
- Some exceptions: Andy Grove earned B.S., M.S., and Ph.D. degrees in chemical engineering before heading off to found Intel
- But by and large, before 1980 if you graduated with a bachelor's degree in chemical engineering you worked to:
  - Turn crude oil, oil shale, and coal into useful fuels, lubricants, and paving materials;
  - Take petroleum-derived compounds and turn them into useful herbicides, pesticides, plastics, and synthetic fabrics;
  - Help put mass quantities of foodstuffs on America's shelves.

All have been, and continue to be, extremely important segments of the manufacturing industry

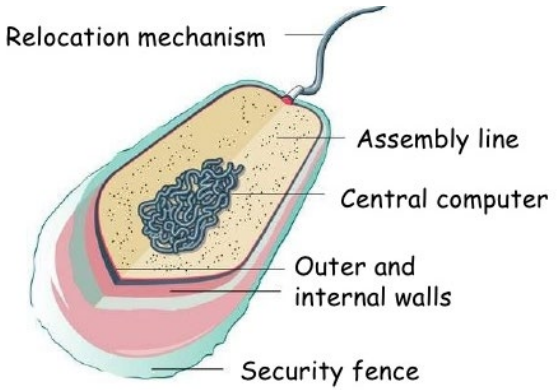
Continued growth and expansion of the chemE field

- Today, chemical engineers work in a wide array of different fields, from anthropogenic emission controls to zeolyte catalyst design.
- A fascinating feature of chemical engineering at the beginning of the new millennium is not just the diversity of disciplines, but also the diversity of scale.
- Chemical engineers design, build, and analyze processes that range in:
  - Size from Angstroms (10^{-9} inch) to kilometers (10^{4} inch), and
  - Time from picoseconds (10^{-12} seconds) to years (10^{4} seconds).
- These studies include atomic scale computers, immobilized cell reactors, full-scale chemical plants, and the ocean and atmosphere.

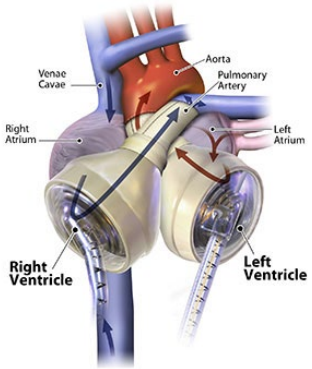
All of the different professions occupied by chemical engineers can be loosely grouped into several broad categories.

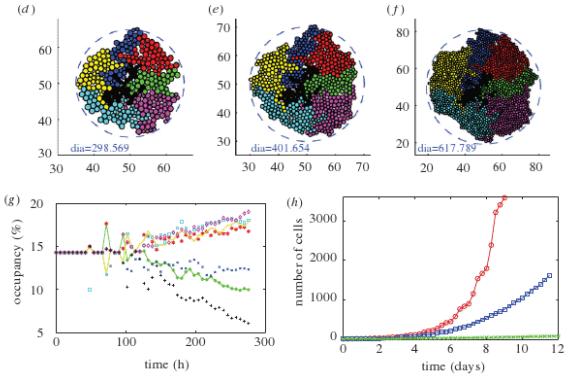
The Role of Chemical Engineers in Society

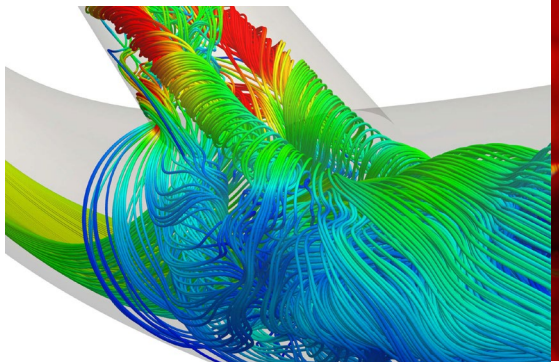
Chemical engineers in biotechnology and biomedicine

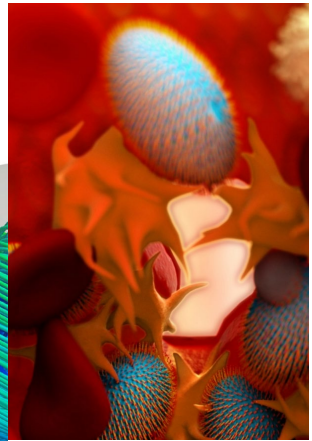


- Contributed to human health through the design and manufacture of artificial organs, diagnostic tests, and therapeutic drugs.
- Manufactured human and veterinary pharmaceuticals, and scaled-up plant cell-culture techniques.
- Used genetically engineered systems for the synthesis of chemicals and the biological treatment of waste.
- Constructed mathematical models of fundamental biological interactions
- Expanded the scope of process engineering into biological systems,
- Conducted engineering analyses of whole-organ or whole-body systems.



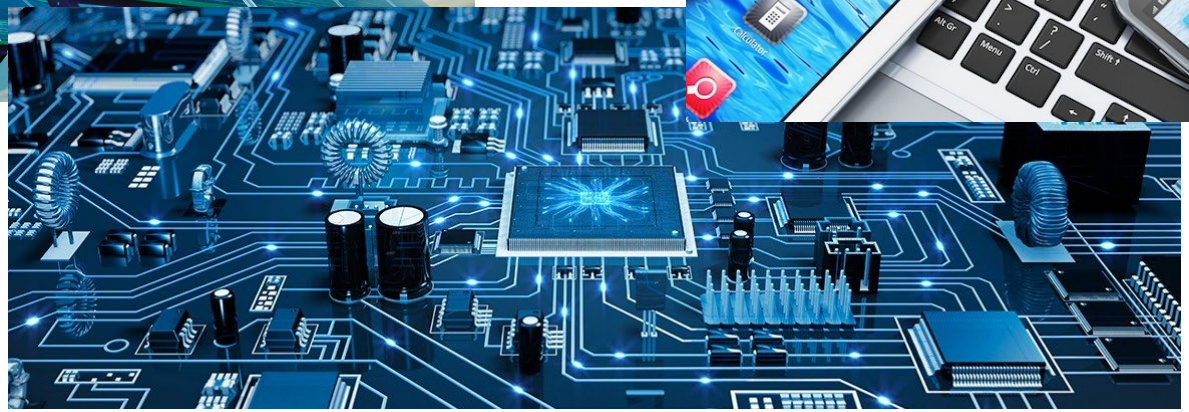






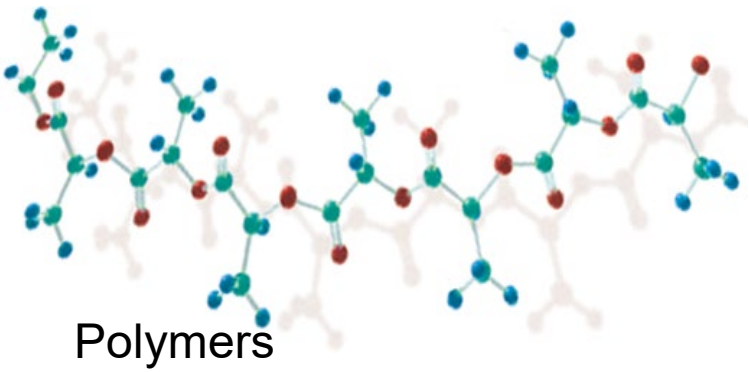
Chemical engineers in electronics and photonics

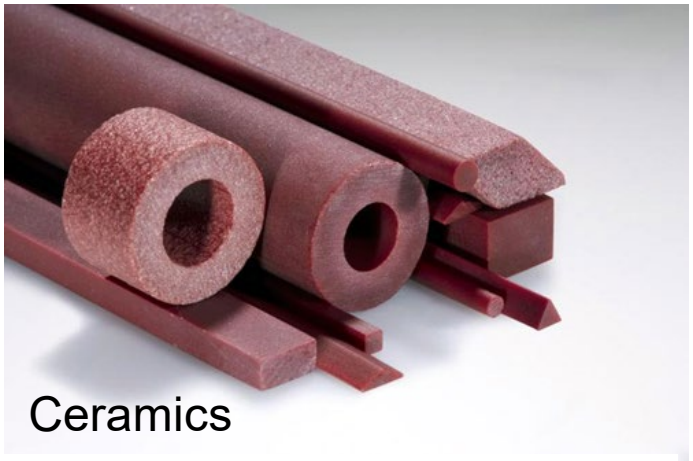
- The information technologies on which modern society depends would not be possible without integrated circuits, optical fibers, magnetic media, devices for electrical interconnection, and photovoltaics.
- Chemical processes are the means by which the physical properties and structural features of these materials and devices are established and tailored.

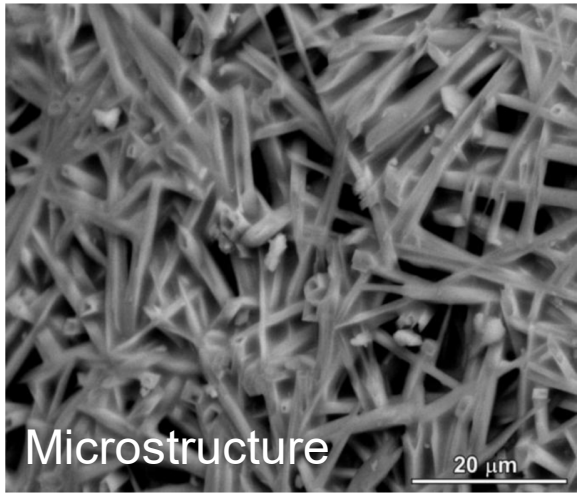


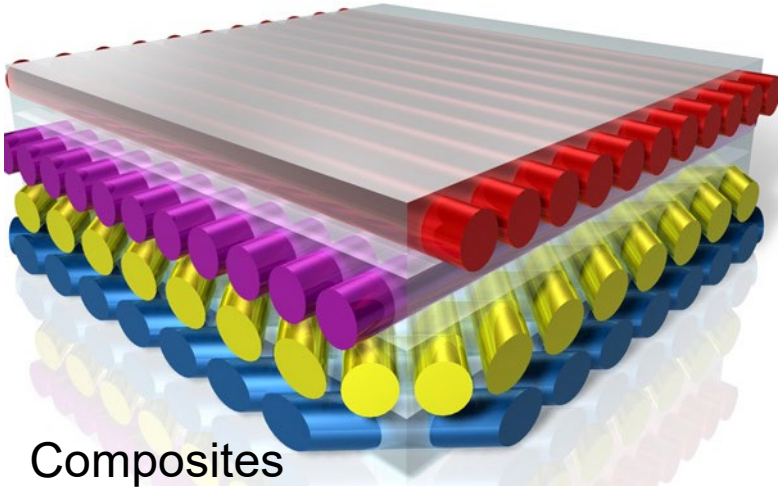
Chemical engineers in polymers, ceramics, composites

- Chemical engineers have long been involved in materials science and engineering.



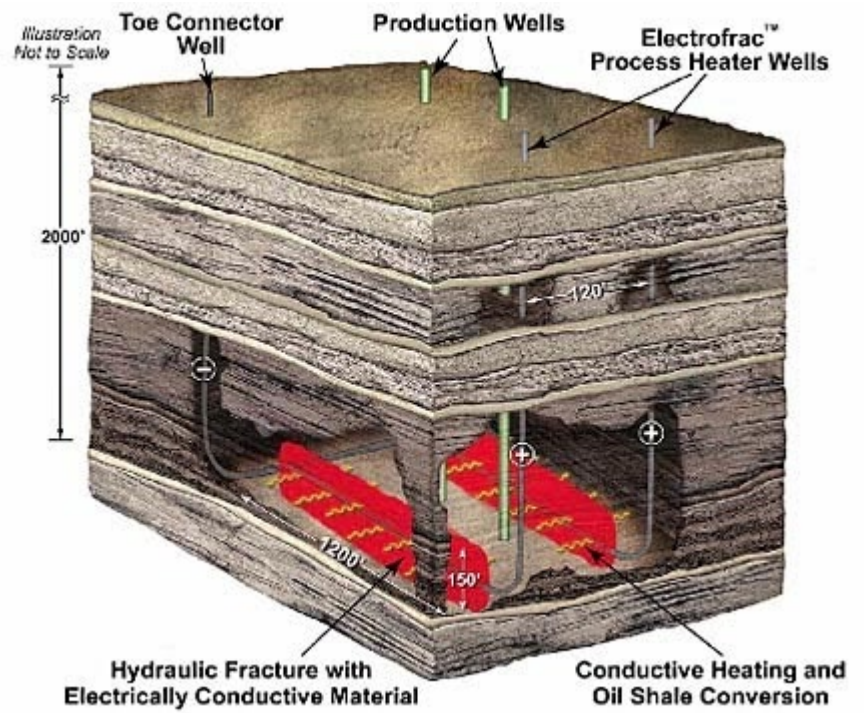


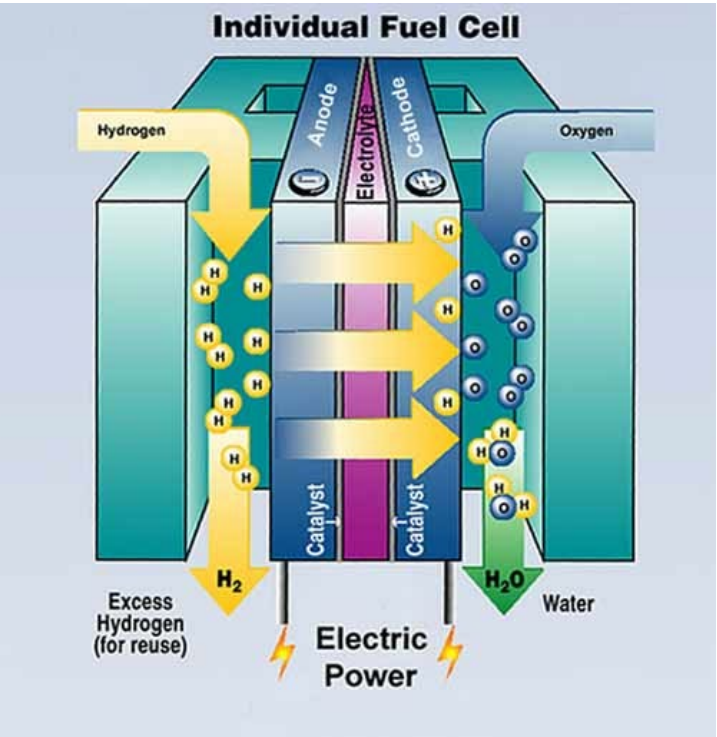




Chemical engineers in energy conversion

- Energy, minerals, and metals are three basic building blocks of our technological society. Chemical engineering has long been a part of the technologies used to convert natural resources into energy and useful products.
- The expertise of chemical engineers is needed more than ever to address problems such as enhanced oil recovery, shale oil production, coal conversion, electrochemical energy storage, solar power, pollution controls, fuel cells, and turning waste into a useful source of energy and metals.





Chemical engineers in environment protection, safety, waste management

- Chemical engineers are helping society to face important challenges associated with the imperative to protect and improve the environment.
- These challenges include:
  - designing inherently safer and less polluting plants and processes,
  - improving air quality through research on combustion and factors leading to air pollution,
  - managing hazardous wastes responsibly,
  - developing new approaches to the study of and control of pollutants in the environment,
  - and assessing and managing chemical risks to human health or to the environment.

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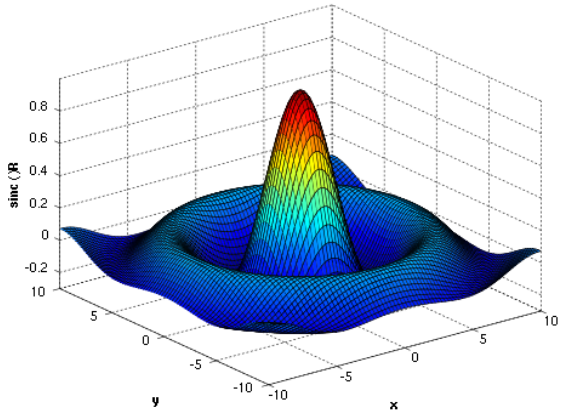
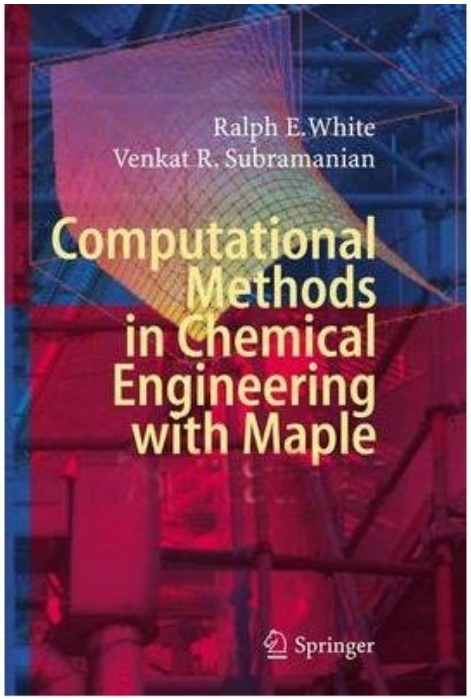
Chemical engineers in process and control engineering

- Computers and computational methods have advanced to the point where they are having a significant impact on the way in which chemical engineers can approach problems in design, control, and operations.
- A major chemical engineering contribution to the area of process control has been the design of control systems that "learn" the process over time.
- This intelligent process control approach offers tremendous flexibility for application to new systems and processes.

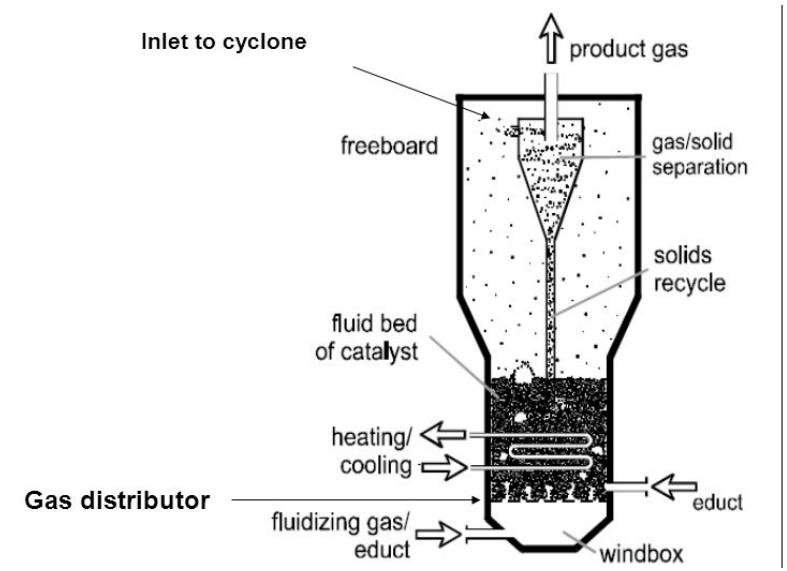
python™

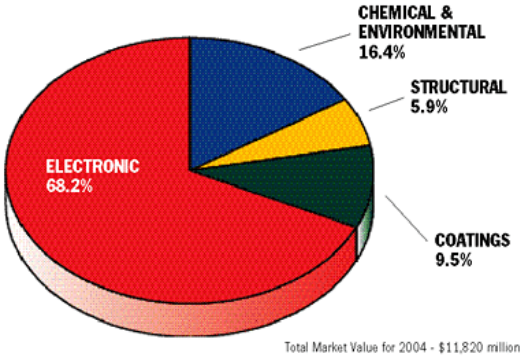


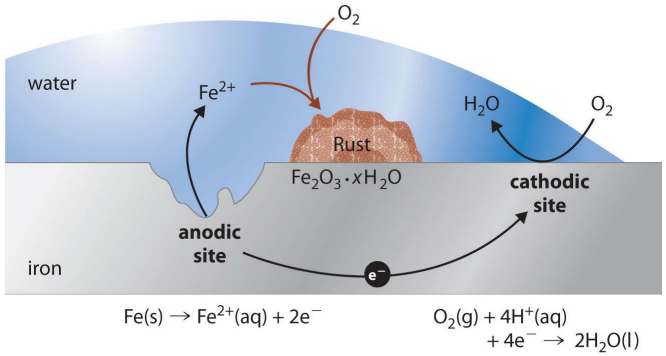


Chemical engineers in surfaces, interfaces, and microstructures

Surfaces, interfaces, and microstructures are key to an improved understanding of fluid-solid chemical reactions, electrochemistry and corrosion, processes for the manufacture of microcircuits, colloids and surfactants, advanced ceramics and cements, and membranes.



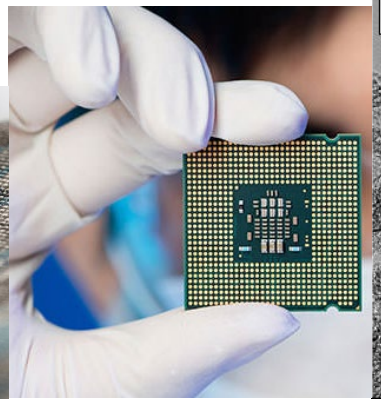


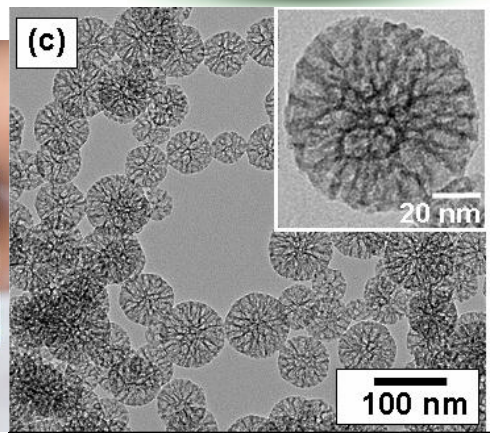


Chemical engineers use their knowledge of thermodynamics, transport phenomena, kinetics, and process modeling to explore a variety of these research frontiers.

Today's role of chemical engineers in society

- Today chemical engineers are leading the way in sustainability, nanotechnology, high-performance materials, and electronics manufacturing.
- The establishment of AIChE in 1908 gave shape to the dreams of the "converted chemists" who were calling themselves chemical engineers in the face of opposition from employers as well as professional colleagues
- Now, in the beginning of the 21st century, *chemical engineers' contributions remain critical not only to the global economy, but also to modern life.*
- In short, by recognizing that physical processes have to obey relatively simple laws, we can turn our attention to systems of ever-increasing complexity, and in doing so, address issues of foremost importance to society.



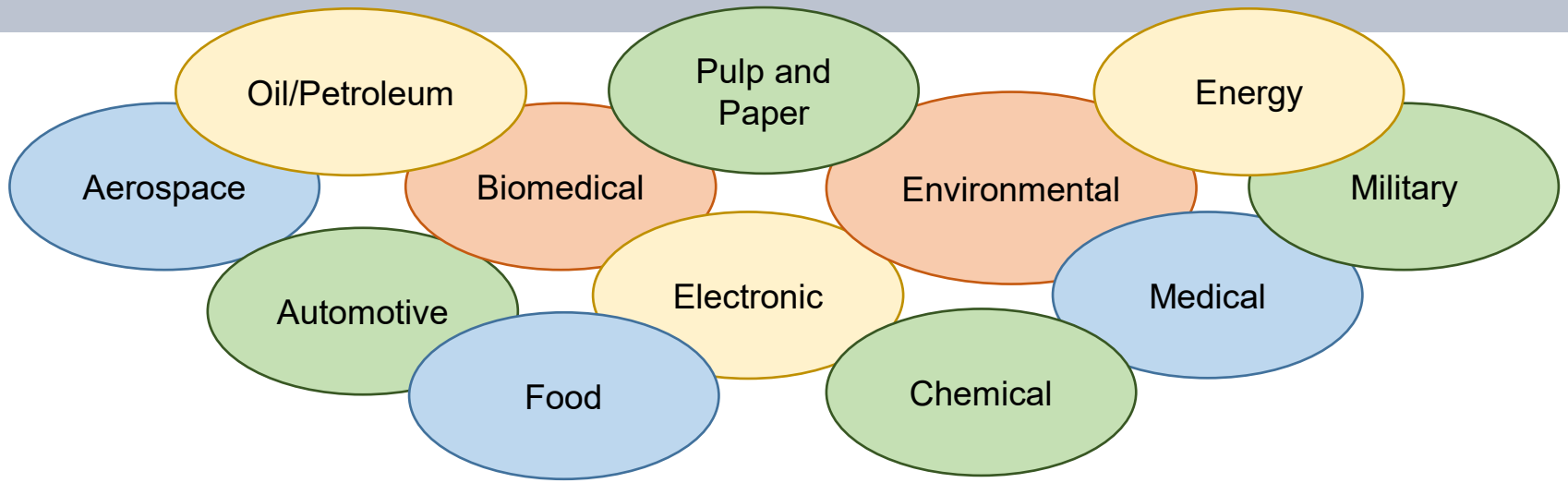


Skills required by Chemical Engineers in the Workforce

Skills required by Chemical Engineers in the workforce

Analytical Skills	Math Skills	Interpersonal Skills
Chemical engineers use analytical, problem-solving, and deductive reasoning skills to determine why a design does not work as planned and to troubleshoot to find a solution that does	Math skills are important, such as using calculus and other advanced mathematics techniques to model flow parameters	Interpersonal skills and teamwork are required, especially when identifying and solving problems between people in production and manufacturing and when working with technicians and mechanics who turn the chemical engineer's designs into reality

Industries seeking skills of chemical engineers



- Chemical engineers work in almost every industry and affect the production of almost every article manufactured on an industrial scale
- Typical tasks can include:
  - Ensuring compliance with health, safety, and environmental regulations
  - Conducting research into improved manufacturing processes
  - Designing and planning equipment layout
  - Incorporating safety procedures for working with dangerous chemicals
  - Monitoring and optimizing the performance of production processes
  - Estimating production costs