

ECOR 1010

Introduction to Engineering

Lecture 2

What is Engineering?

- How does Engineering differ from Science?
- Engineers design the “stuff” that society uses (including scientists and other engineers)!
 - Problem solving & critical thinking (applied analysis)
 - Design (synthesis)
 - Professionalism (formal organization, ethics)

“A scientist can discover a new star, but he cannot make one. He would have to ask an engineer to do that.”

— *Gordon L. Glegg, American Engineer, 1969*

What is an Engineer?

- *Ingenium* (Latin)
 - innate quality, especially mental power, capable of clever invention
- First used to describe those who had ability to invent / operate weapons of war – *military engineer*
- The word became associated with design / construction of works
 - Ships, roads, canals, and bridges.
 - People skilled in these fields were non-military or *civil* engineers.

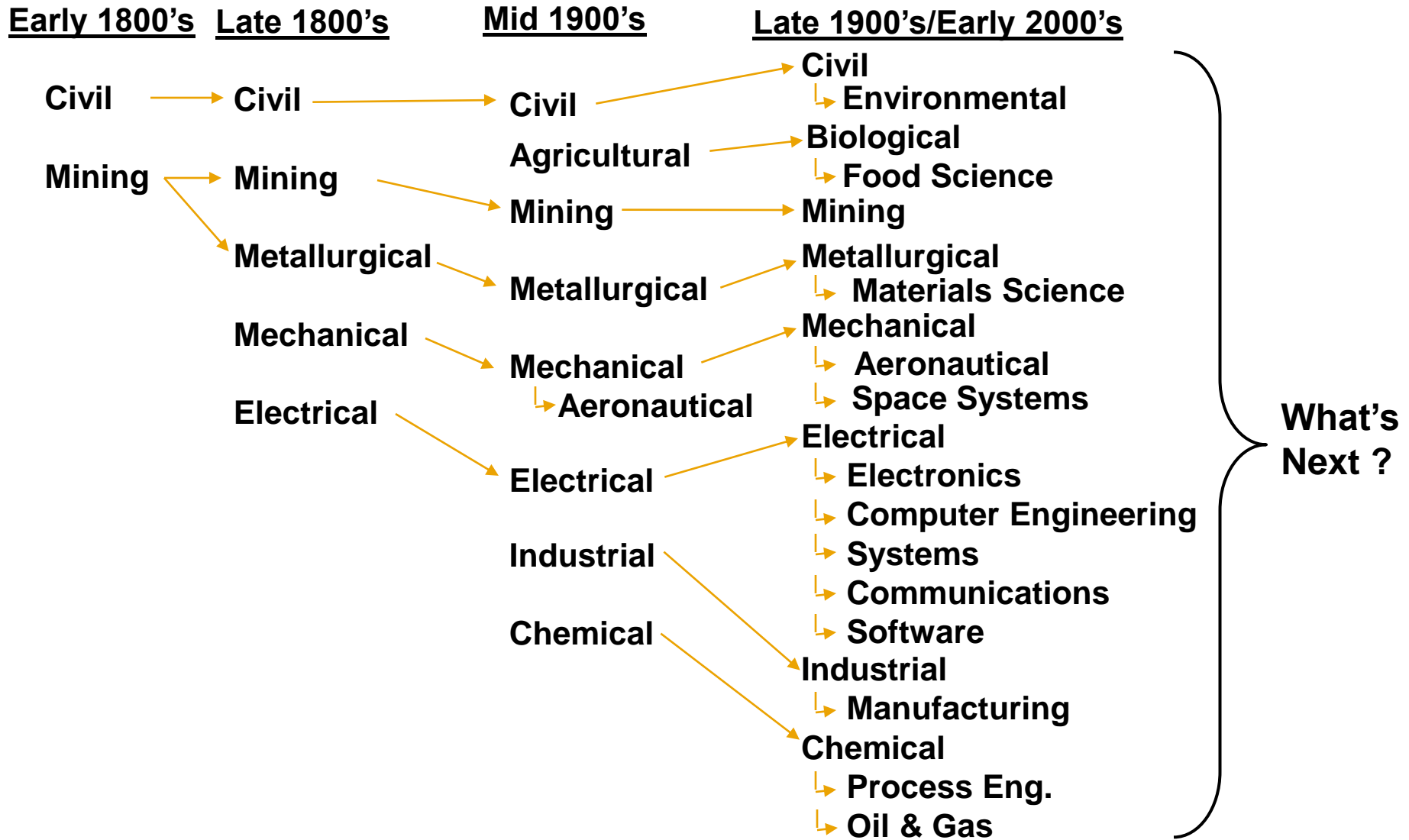
Definition of an Engineer

- An engineer is: (from textbook)
 - A person who uses science, mathematics, experience, and judgement to create, operate, manage, control, or maintain devices, mechanisms, processes, structures, or complex systems. Does this in a rational and economic way with human, societal, and natural resources and environmental constraints.

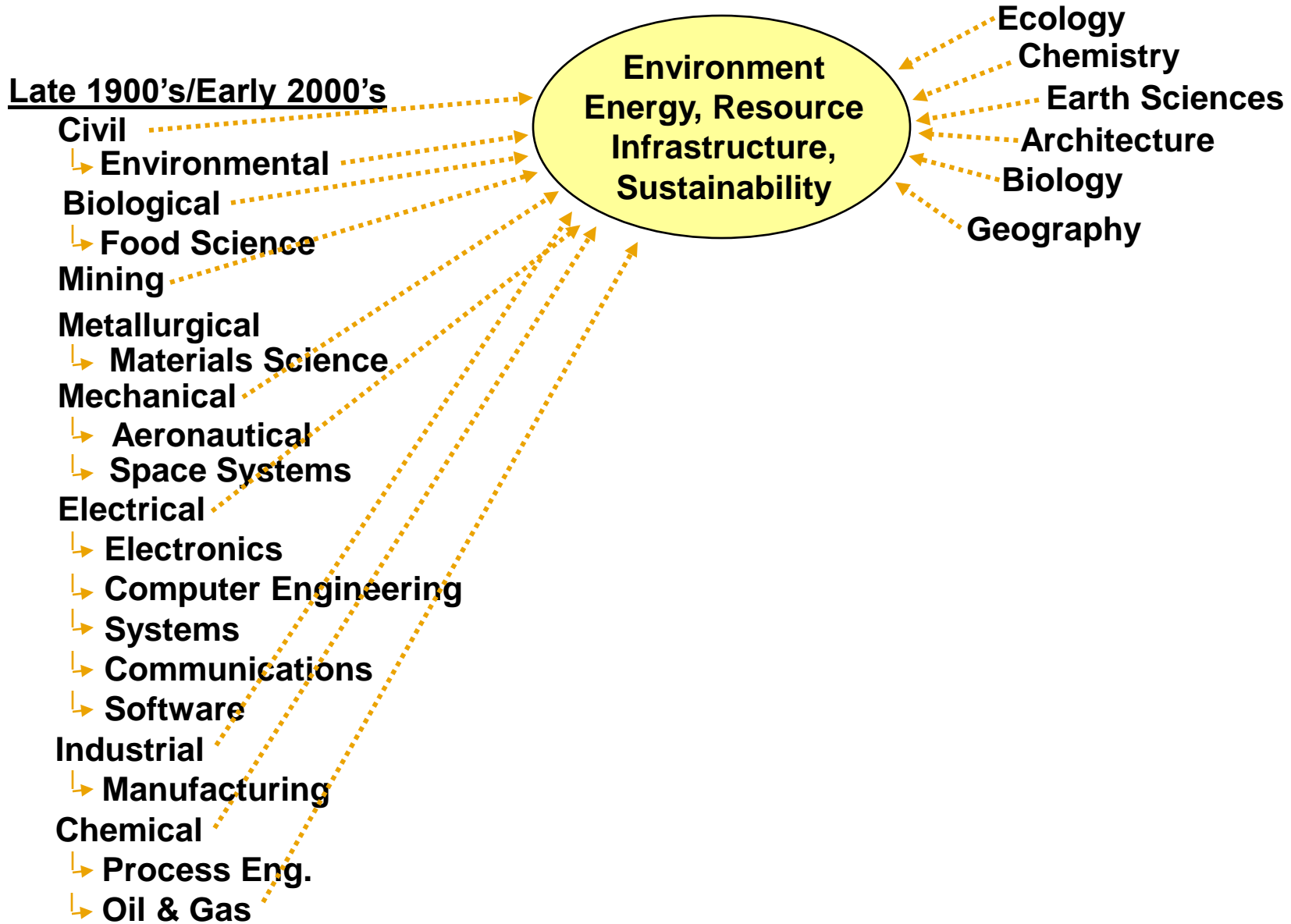
Definition of Engineering

- **Definition of Engineering:** (from American Engineers Council for Professional Development)
 - The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination;
 - or to construct or operate the same with full cognizance of their design;
 - or to forecast their behaviour under specific operating conditions;
 - all as respects an intended function, economics of operation and safety to life and property

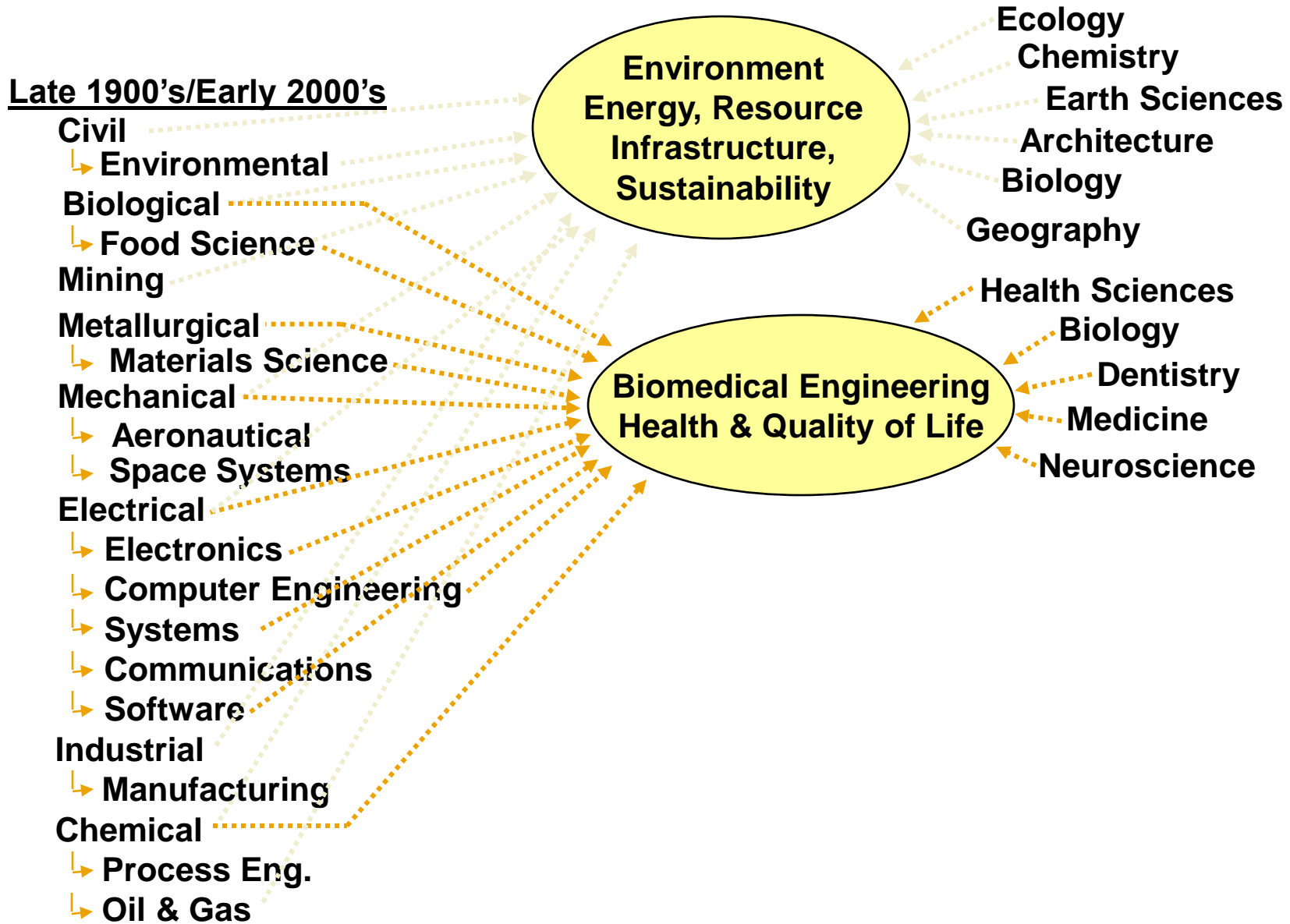
Engineering Disciplines



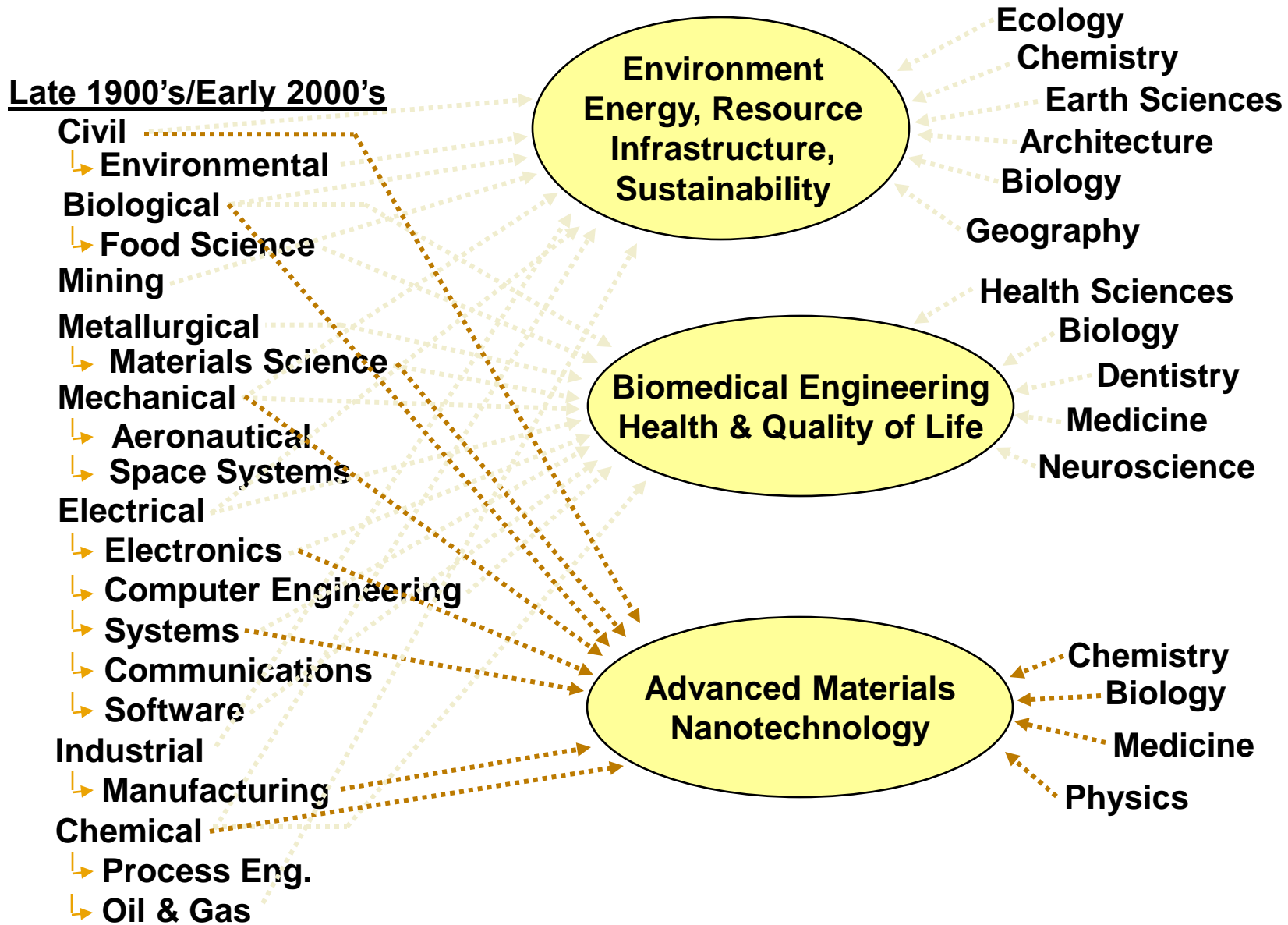
Interdisciplinary Approaches - 1



Interdisciplinary Approaches - 2



Interdisciplinary Approaches - 3



The Role of Engineers

- Engineering is a team activity.
 - Engineering teams involve individuals with widely different abilities, interests and education who cooperate to advance the project.
 - A typical technical team might consist of
 - engineers,
 - scientists,
 - technologists,
 - technicians,
 - social scientists,
 - skilled workers.

Engineer

- Provides the key link between theory and practical applications.
 - Extensive theoretical knowledge,
 - Ability to think creatively,
 - Ability to lead a team towards a common goal.
 - Knack for obtaining practical results,
- Education
 - Basic requirement is a bachelor's degree.
 - Master's or PhD is useful and sometimes preferred.

Professional Engineer

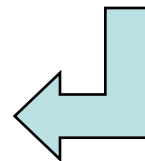
- In Canada, the title “professional engineer” is restricted by law.
 - Only those persons who have
 - Demonstrated competence
 - Been licensed by provincial professional engineering licensing association.



Professional Engineers
Ontario

J. Smith, B.Eng., P.Eng.

In Canada it is against the law to call yourself a “professional engineer” if you are not a licensed Professional Engineer




Canadian Engineering Accreditation Board (CEAB)

- PEO & other provincial/territorial associations rely on CEAB to evaluate & accredit engineering programs in Canada
- CEAB conducts regular & rigorous reviews of engineering programs
- Publishes list of accredited programs in Canada
- All Carleton engineering programs accredited for maximum available time (6 years)

CEAB Academic Requirements

- Mathematics (linear algebra, differential and integral calculus, differential equations, probability and statistics, and numerical analysis)
 - about 1/8th of the program
 - Basic Sciences (physics, chemistry, biology or geoscience)
 - about 1/8th of the program
 - Engineering sciences (ES)
 - minimum of 1/8th the program
 - Engineering design (ED)
 - minimum of 1/8th the program
 - Complementary studies (TSE, etc.) is about 1/8th of the program
- ES plus ED must be $\frac{1}{2}$ of the program

Why Conform to CEAB?

- If you want to become a professional engineer, then one of the principal requirements is that you graduate from an accredited program
 - Other Requirements:
 - Practical Experience (4 years)
 - Professional Practice Examination
 - Character attested to by references
 - Canadian Citizen or Permanent Resident
- 
- Last Year

Technologist

- Works under direction of engineers
 - Applies engineering principles and methods to complex technical problems.
- Education
 - Completion of three year technology program from community college.
- Often supervises work of others and is encouraged to have qualifications recognized by technical society.
- Difference between engineering and technologist education
 - Engineering education typically provides greater theoretical depth
 - Technology diploma usually provides more hands-on experience.

Technician

- Works under the supervision of an engineer or technologist in the practical aspects of engineering,
 - e.g., making tests and maintaining equipment.
- Education
 - Completion of two-year technician program in a community college.
- Association may confer title of Certified Engineering Technician on those qualified.
 - Certification is not necessary to work as a technician.

Skilled Worker

- Skilled in a trade such as electrician, welder, plumber, carpenter, machinist, millwright, etc.
 - Typically carries out the designs and plans of others.
- Has great expertise acquired through formal apprenticeships and/or years of experience.
- Most trades have a trade organization and certification procedure.

Open-Ended Problems

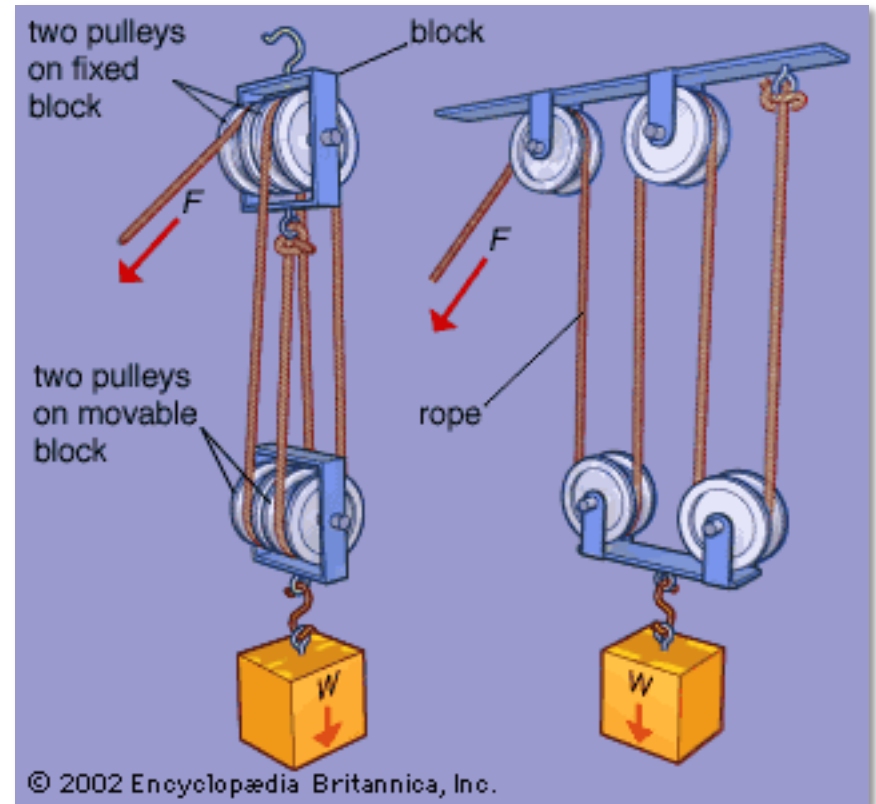
- Most engineering problems are open-ended
 - They don't have a single solution
- Just because there is more than one solution does not mean the problem is easier to solve
 - Actually, it can be the opposite!
 - New students sometimes find open-ended problems frustrating
 - What skills are needed to solve such problems?
 - Broad base of engineering knowledge
 - Critical thinking skills
 - Innovation
 - Perseverance

Engineering Skills

- How to represent a design problem
- How to make assumptions
- How to generate possible ideas for designs
- How to conduct an effective search for a solution
- How to plan and schedule activities
- How to make efficient use of resources
- How to organize the components and activities of a team design project

Ingenuity

- Engineers often find clever ways to “skirt” the laws of nature
 - the “block & tackle”
- Innovation
- Critical thinking
- Problem solving



Canadian Engineering Accomplishments

- Transcontinental Railway
 - Canadian Pacific Railway linked Canada from coast to coast in 1885.



Canadian Engineering Accomplishments

- De Havilland Beaver 1947



Canadian Engineering Accomplishments

- St Lawrence Seaway
 - Series of canals / waterways that opened Great Lakes to ocean going ships in 1959.



Canadian Engineering Accomplishments

- Athabasca Oil Sands
 - Commercial oil sands development showed the feasibility of recovering oil from the oil sands.



Image courtesy of: Suncor

Canadian Engineering Accomplishments

- Very-High-Voltage Transmission
 - Hydro-Québec was first electrical utility to develop transmission lines at very high voltage for long-distance power transmission.



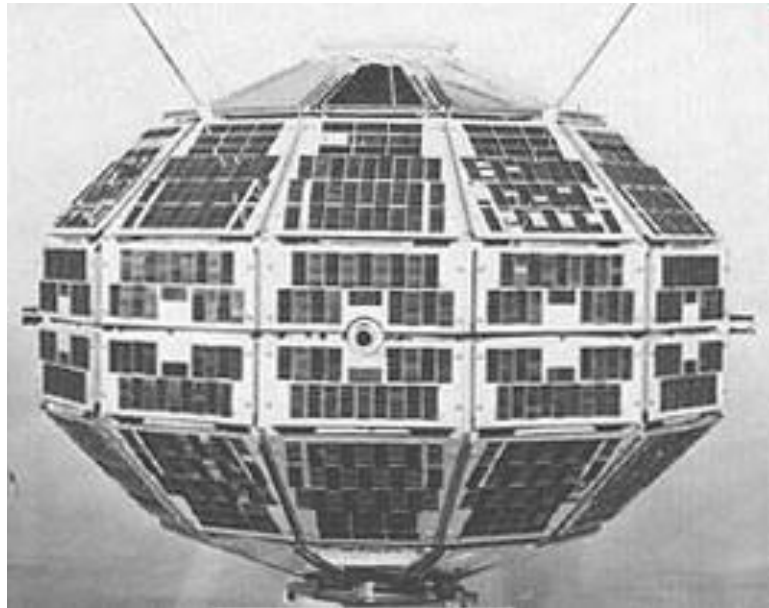
Canadian Engineering Accomplishments

- Nuclear power
 - CANDU nuclear power system produces electric power using natural uranium fuel and heavy-water for moderation and cooling.
 - No need for expensive fuel enrichment.



Canadian Engineering Accomplishments

- Alouette Satellite
 - 3rd country into space – September 1962



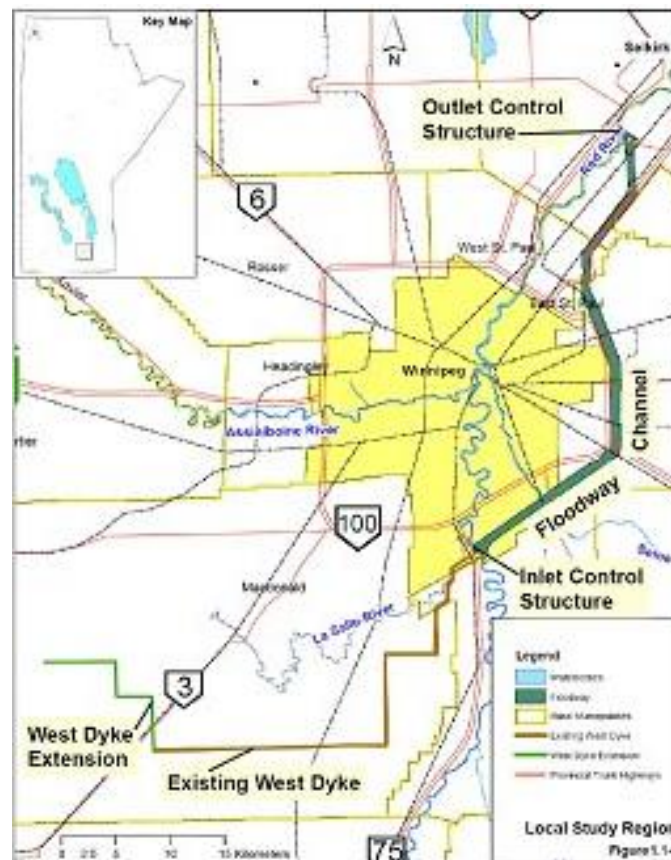
Canadian Engineering Accomplishments

- Trans-Canada Telephone Network
 - Completed in 1958 as world's longest microwave network.



Canadian Engineering Accomplishments

- Winnipeg Floodway – 1963-1968



Canadian Engineering Accomplishments

- The Canadarm



Canadian Engineering Accomplishments

- Confederation Bridge
 - Longest bridge in the world crossing salt water subject to winter ice hazards.



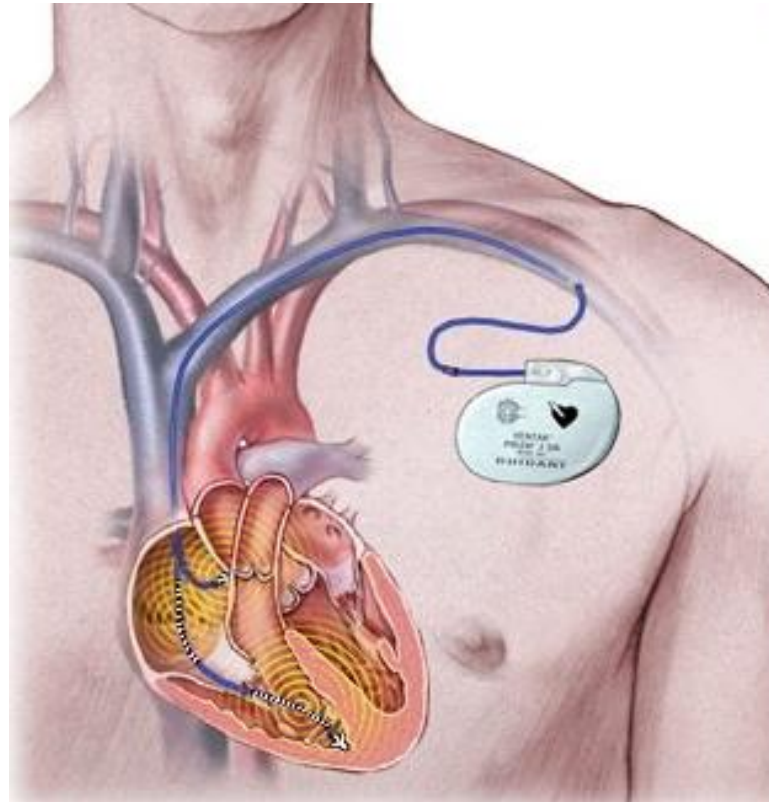
Canadian Engineering Accomplishments

- IMAX



Canadian Engineering Accomplishments

- Pacemaker
 - Developed by John A Hopps in 1949.



Canadian Engineering Accomplishments

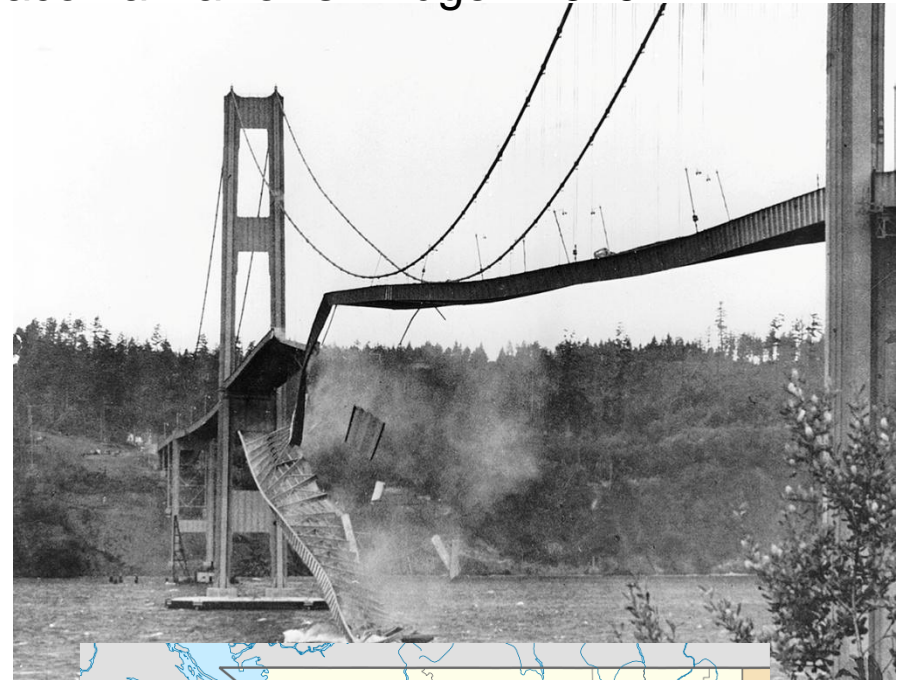
- CN Tower
 - Built in 1976 as world's tallest free-standing structure.
 - American Society of Civil Engineers listed CN Tower as one of seven wonders of modern world.



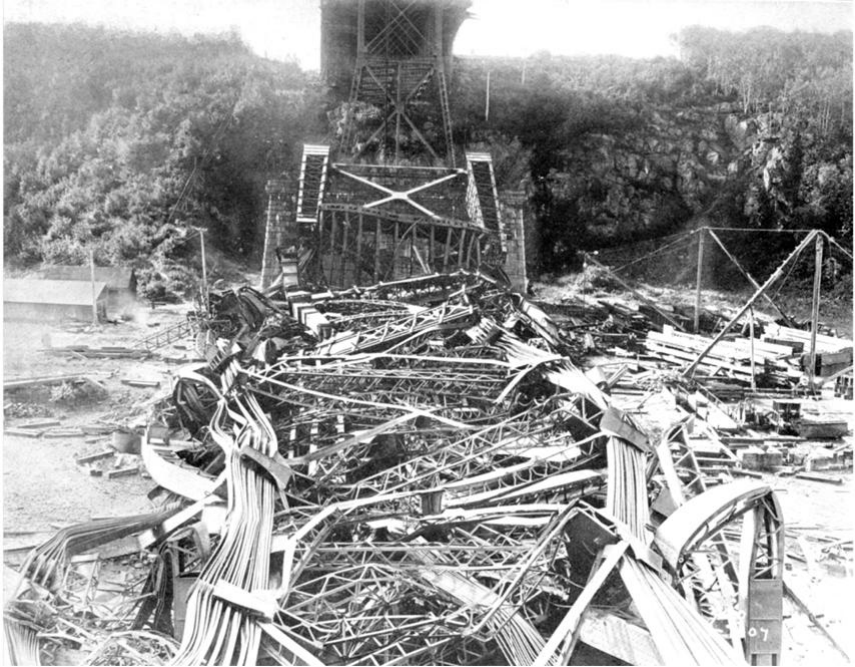
Engineering Requires Diligence



Tacoma Narrows Bridge - 1940



Quebec Bridge 1907



- longest cantilevered span in the world
- collapse during construction killed 75



Space Shuttle

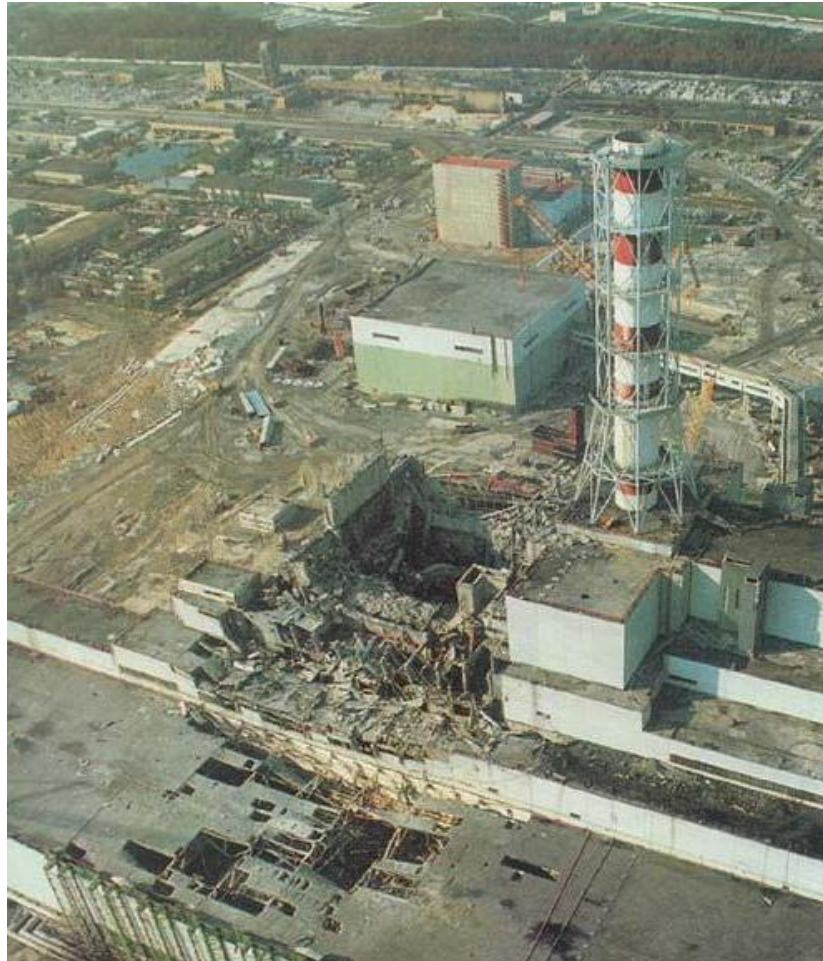


Challenger

Columbia



Chernobyl Nuclear Reactor 1986



All Engineering Is Interdisciplinary

Many engineering disasters are rooted in inadequate interdisciplinary knowledge.

A **FEW** examples:

- No mechanical or civil engineer ever knows enough about electric motors
- Electrical engineers never know enough about heat transfer
- Biomedical engineers will always need more medical knowledge
- Systems engineers need to know more about mechanics
- All engineers need to know more chemistry
- All engineers need to know more about societal reaction to technology
- All engineers need better imaginations !

But ... we only have you here for four years,

So maximize your learning for the next four years !