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.

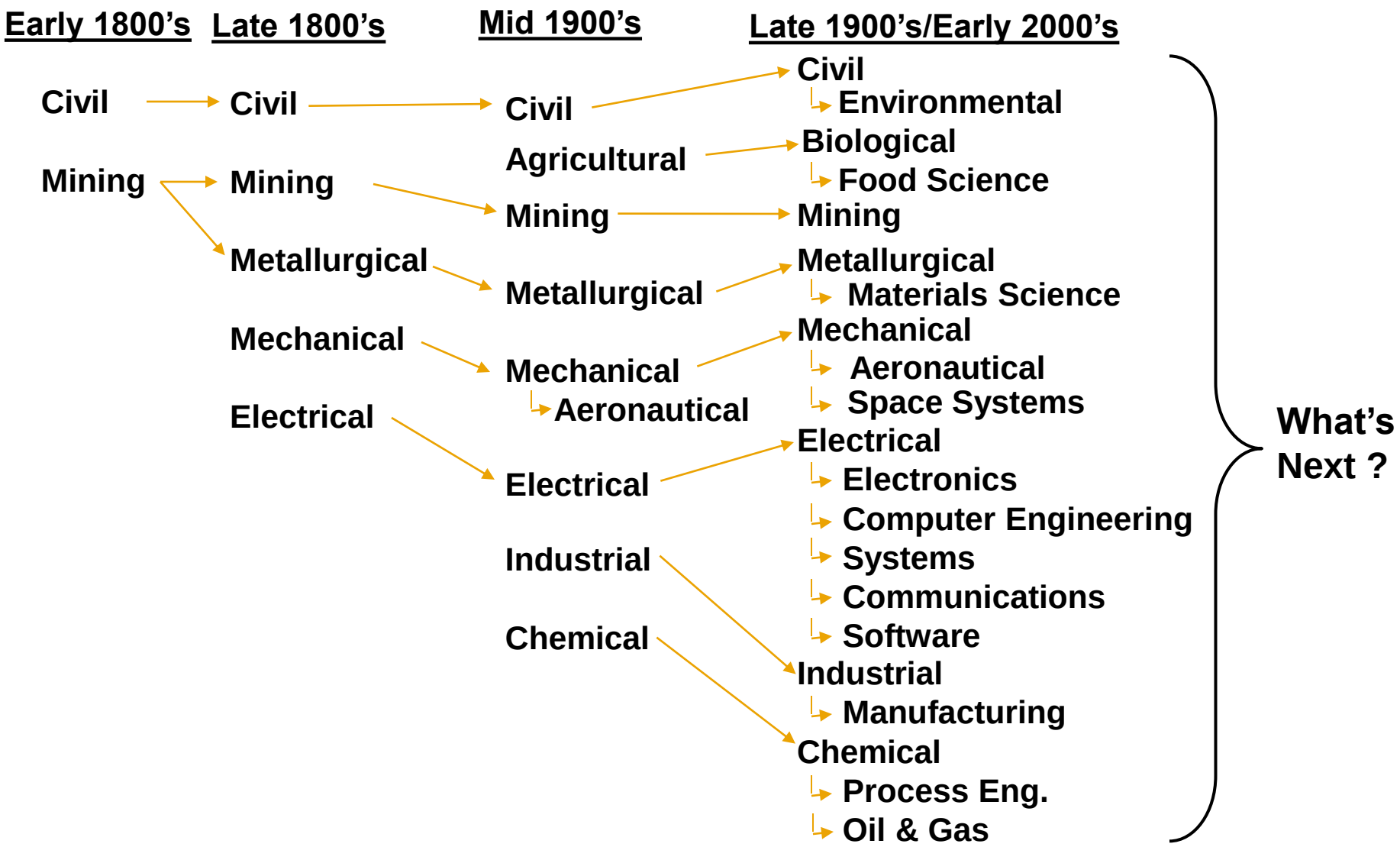
Definition of an Engineer

- 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.

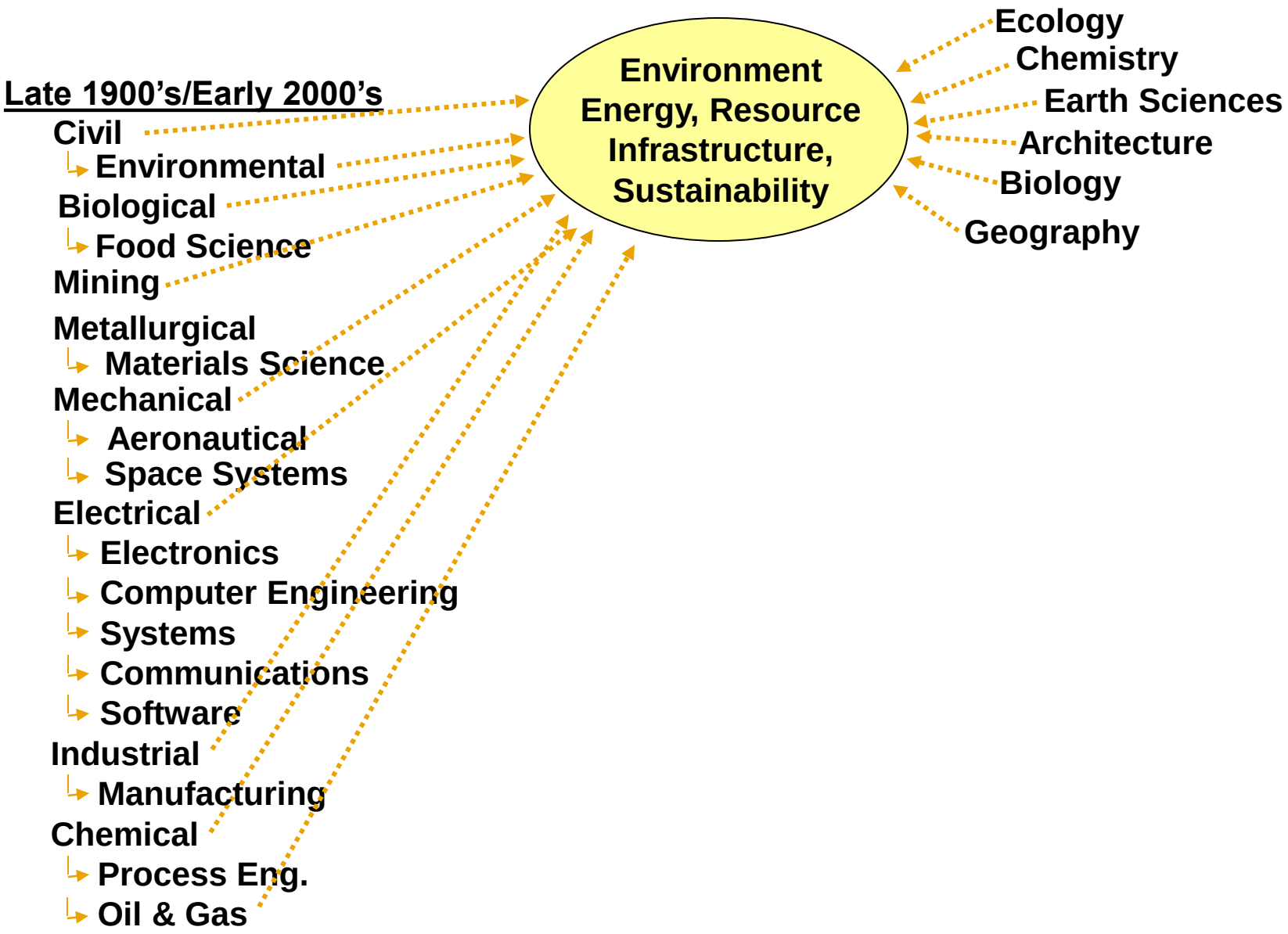
Definition of Engineering

- 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

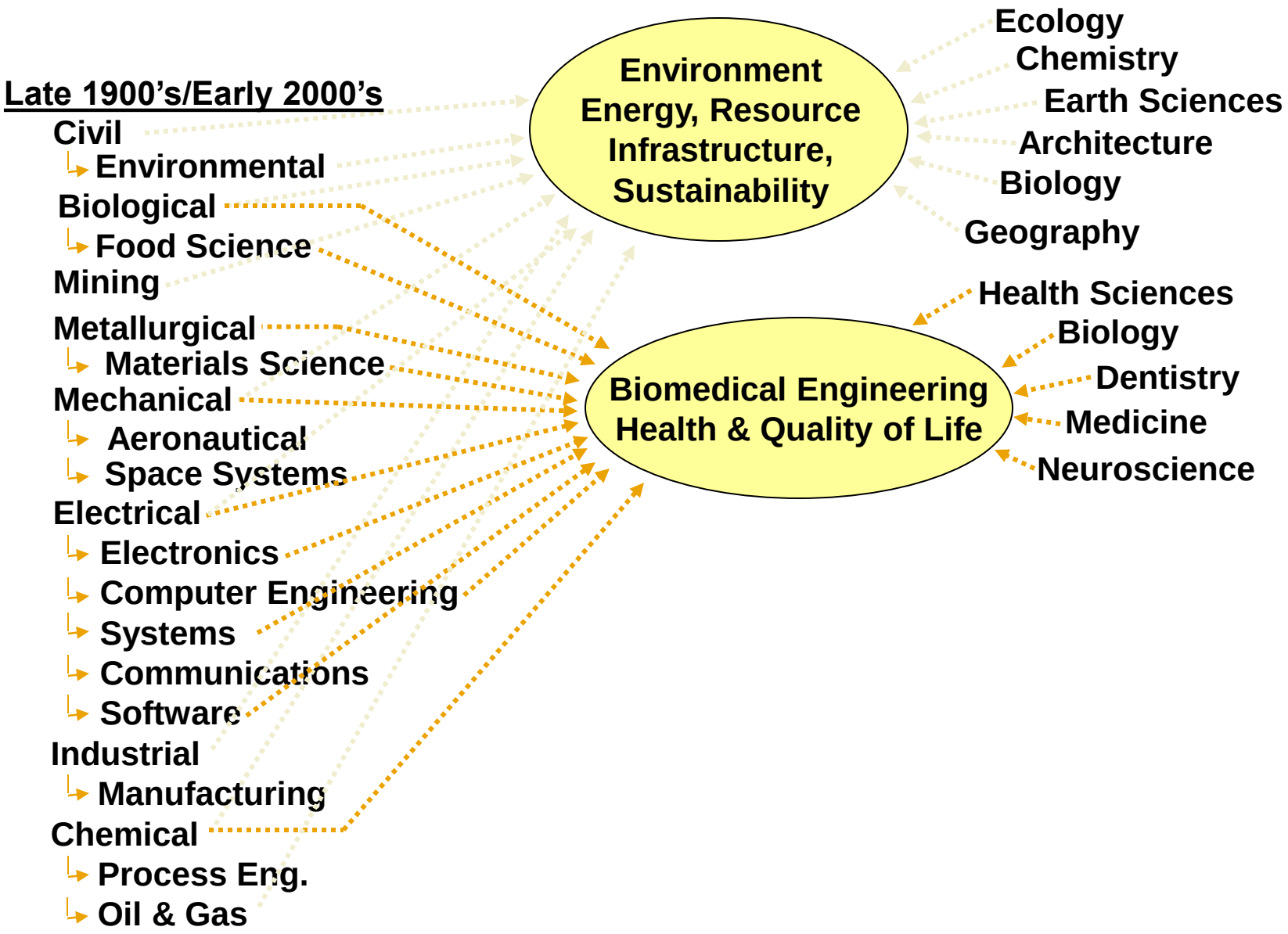
Engineering Disciplines



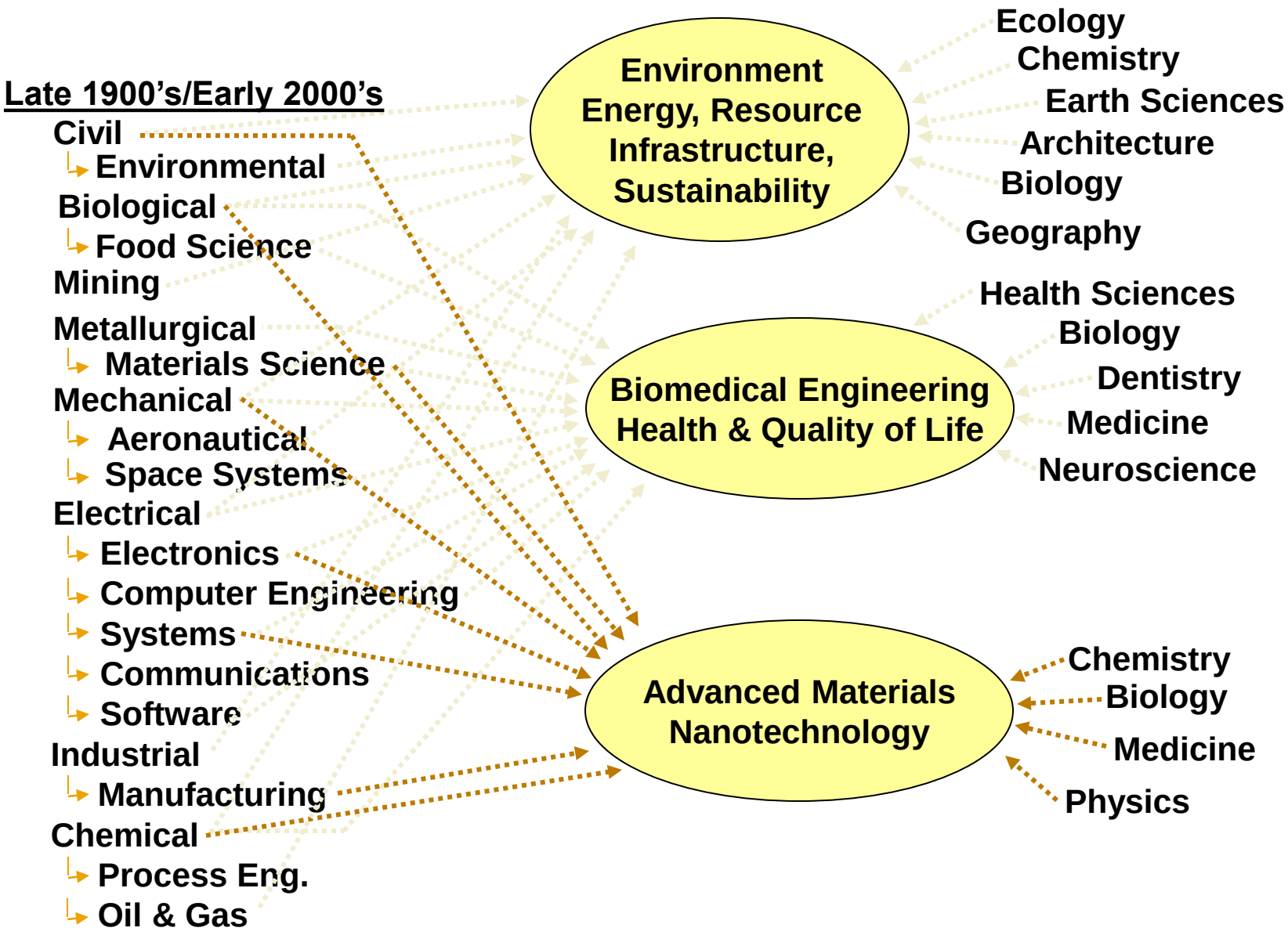
Interdisciplinary Approaches - 1



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,

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- Provides the key link between theory and practical applications.
  - Extensive theoretical knowledge,
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  - Knack for obtaining practical results,
- Education
  - Basic requirement is a bachelor’s degree.
  - Master’s or PhD is useful and sometimes preferred.

Engineers are in demand

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.

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.)
  - about 1/8th of the program

ES plus ED must be ½ 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

Two years ago

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Two years ago

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

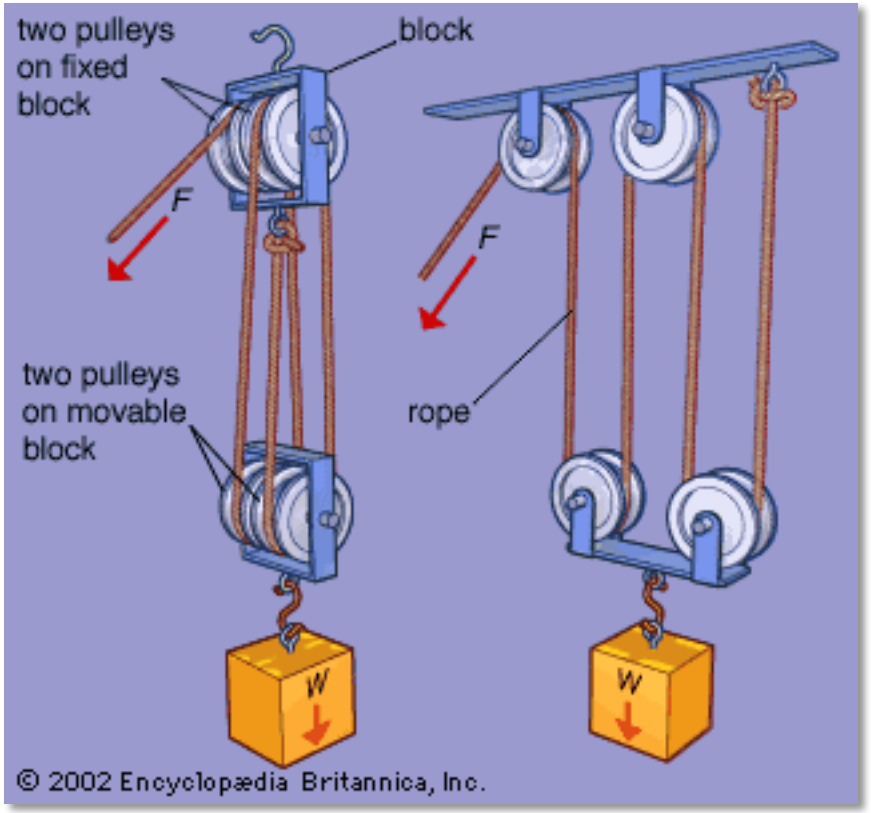
- Most engineering problems are open-ended
  - They don't have a single solution
- Just because there is more than one solution does not mean the problem is easier to solve
  - Actually, it can be the opposite!
  - New students sometimes find open-ended problems frustrating
  - What skills are needed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

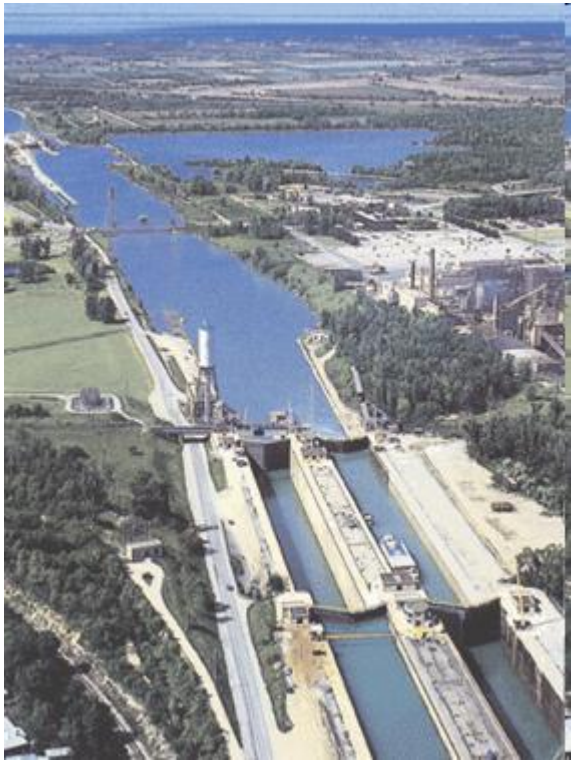
- Transcontinental Railway
  - Canadian Pacific Railway linked Canada from coast to coast in 1885.

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.

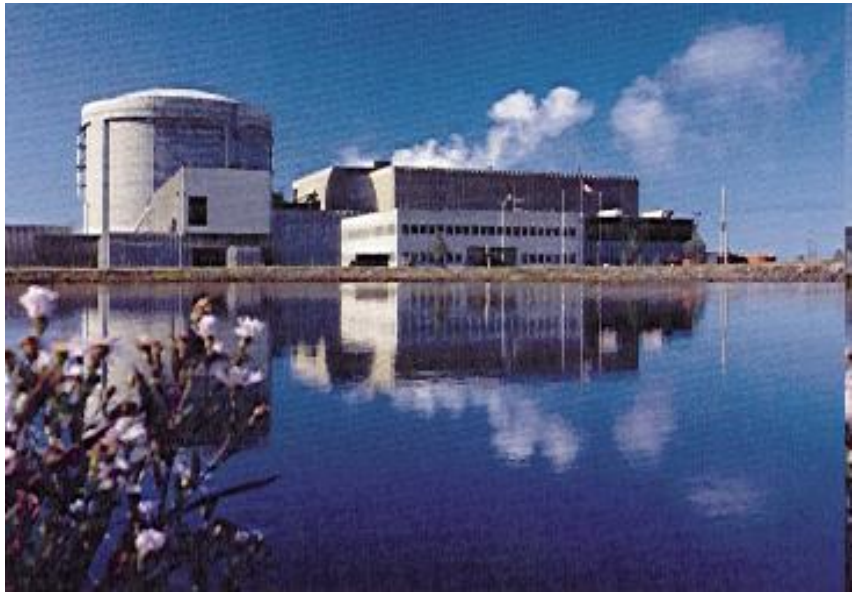
Canadian Engineering Accomplishments

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

Hydro-Québec is the largest electricity generator in Canada and the world's largest hydroelectric producer

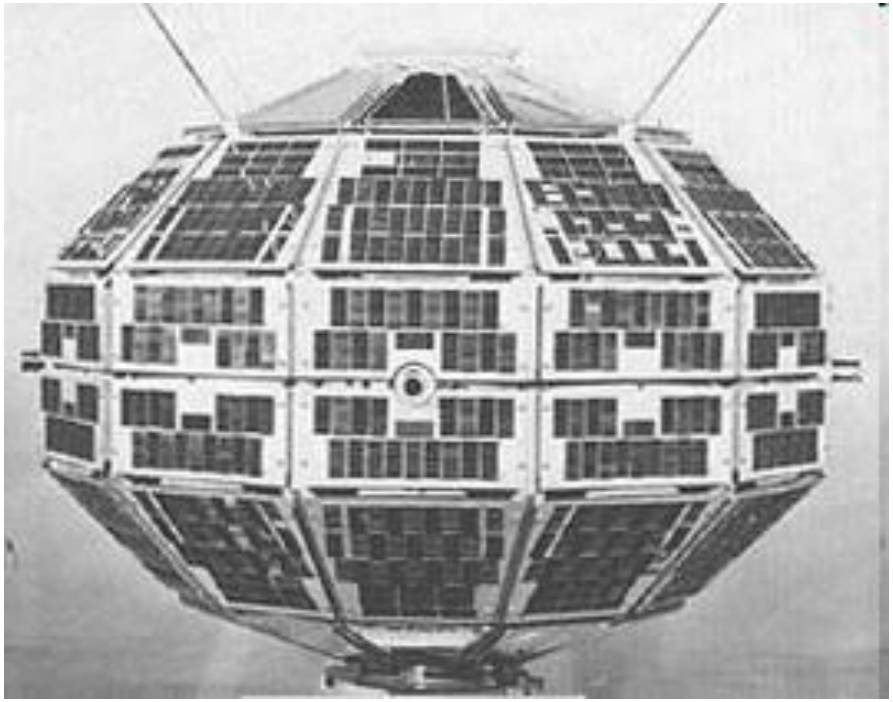
Canadian Engineering Accomplishments

- Nuclear power
  - CANDU (short for CANada Deuterium Uranium) reactor is a Canadian-invented pressurized heavy water reactor. Nuclear power system produces electric power using natural uranium fuel and heavy-water (deuterium oxide) 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 - mechanical arm that was used on the Space Shuttle orbiters to maneuver a payload from the payload bay of the orbiter to its deployment position and then release it.

Canadian Engineering Accomplishments

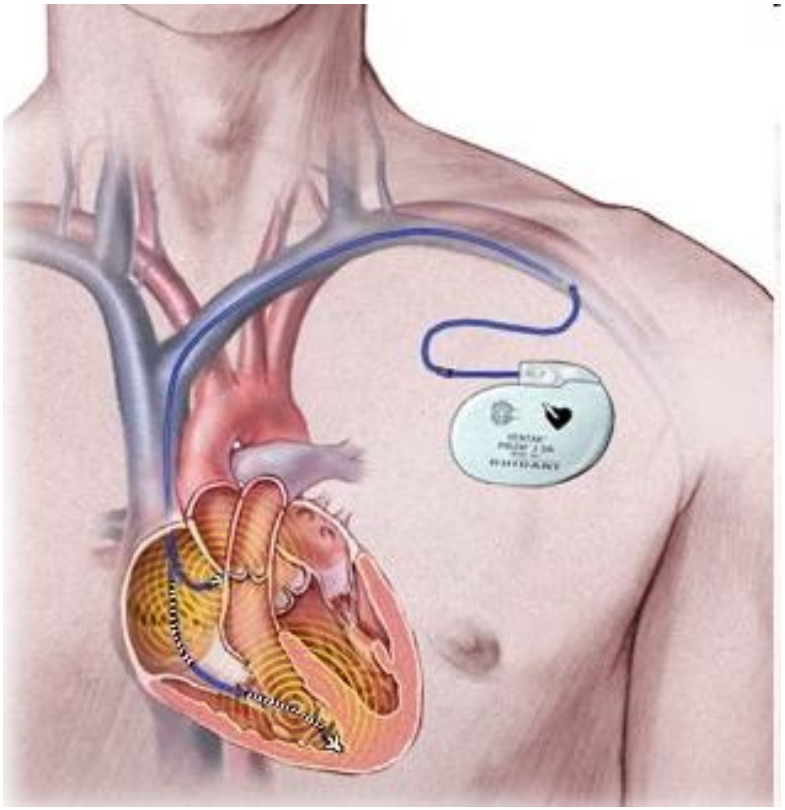
- Confederation Bridge (links Price Edward Island with mainland New Brunswick)
  - Longest bridge in the world crossing salt water subject to winter ice hazards.

Canadian Engineering Accomplishments

- IMAX (**Ima**ge **Max**imum) - motion picture film format which has the capacity to record and display images of greater size and resolution than conventional film systems.

Canadian Engineering Accomplishments

- Pacemaker
  - Developed by John A Hopps in 1949.

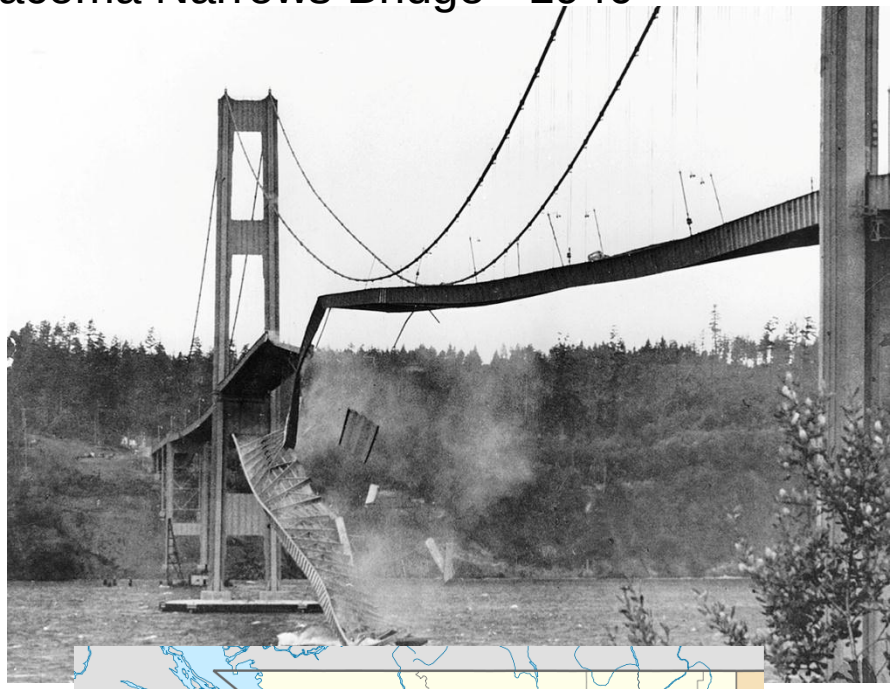


Canadian Engineering Accomplishments

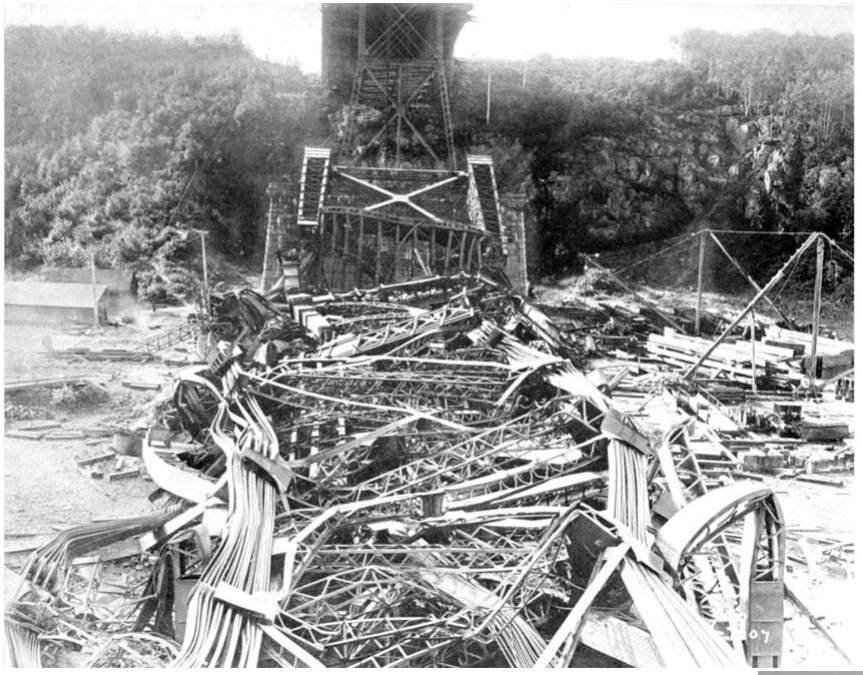
- CN Tower
  - Built in 1976 as world's tallest free-standing structure.
  - American Society of Civil Engineers listed CN Tower as one of seven wonders of modern world.

Engineering Requires Diligence

Tacoma Narrows Bridge - 1940



Quebec Bridge 1907



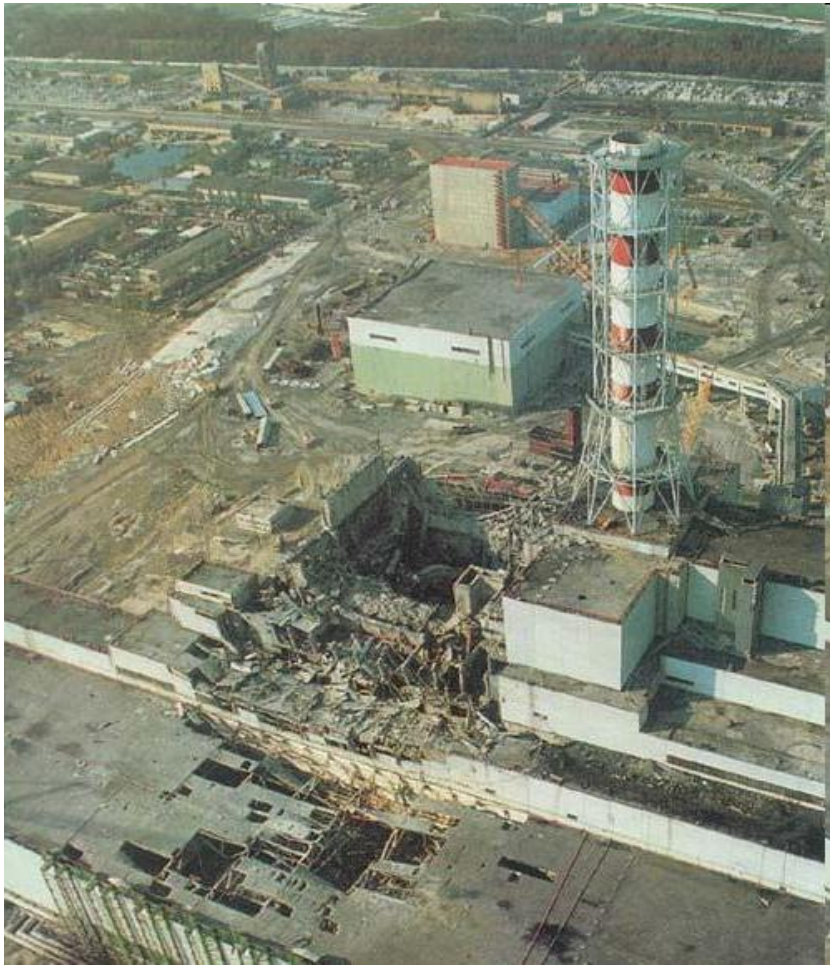
- longest cantilevered span in the world
- collapse during construction killed 75

Space Shuttle

Challenger (1986)

Columbia (2003)

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 !