東京工業大学
Tokyo Institute of Technology

Science and Engineering Ethics

Week 1: Why Is Science and Engineering Ethics Now?

A Hypothetical Case

- You are an engineer for a company that has received a contract regarding a structural design for a high-rise building. This building will be constructed in the central part of the capital of Country A. According to the building codes of Country A, you need only consider the effect of perpendicular winds, which blow perpendicularly on each side of the building. Your team has created a design that would fully satisfy the requisite standards, and the owner is pleased with such design.

Hypothetical Case Study

- When the construction is about to commence, you, who returned to your home country, discover that an enormous typhoon is slated to occur in areas surrounding Country A of a magnitude that only takes place once every 1000 years. Therefore, you calculate the maximum wind speed of this large typhoon that could potentially hit the building. As a result, you noticed that there would be no problem in the case of the perpendicular winds, however, it is possible that the building would collapse if the wind were to impact the building at an oblique angle. (The effects of quartering winds were not taken into consideration when the design was made.)

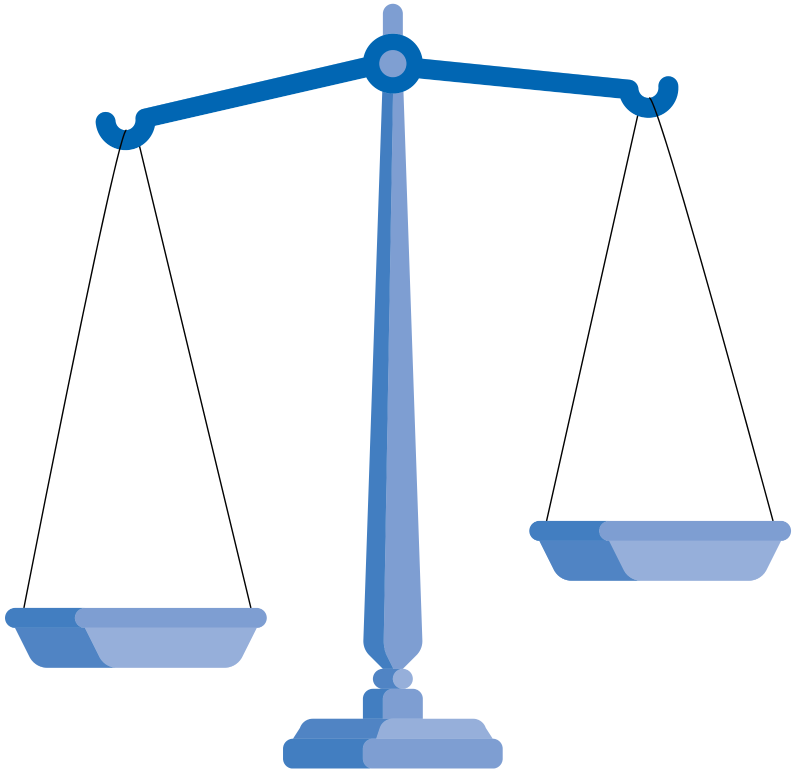
Hypothetical Case Study

- You report your findings to your boss and attempt to convince him to change the structural design of the building. However, your boss does not listen to you based on the assertion that "our design has satisfied the laws and regulations of Country A, and there is no need to change the design to prepare for the probability of something that might occur only once every 1000 years."
- What would you do if you were the engineer?

Yanosuke Hirai
(1902-1986)

Important Balance of Values

- Social Contribution
- Advancement of expertise
- Organizational development
- Loyalty
- Facts
- Environment



- Schedule
- Information transparency
- Compliance
- Integrity
- Cost
- Technological innovation

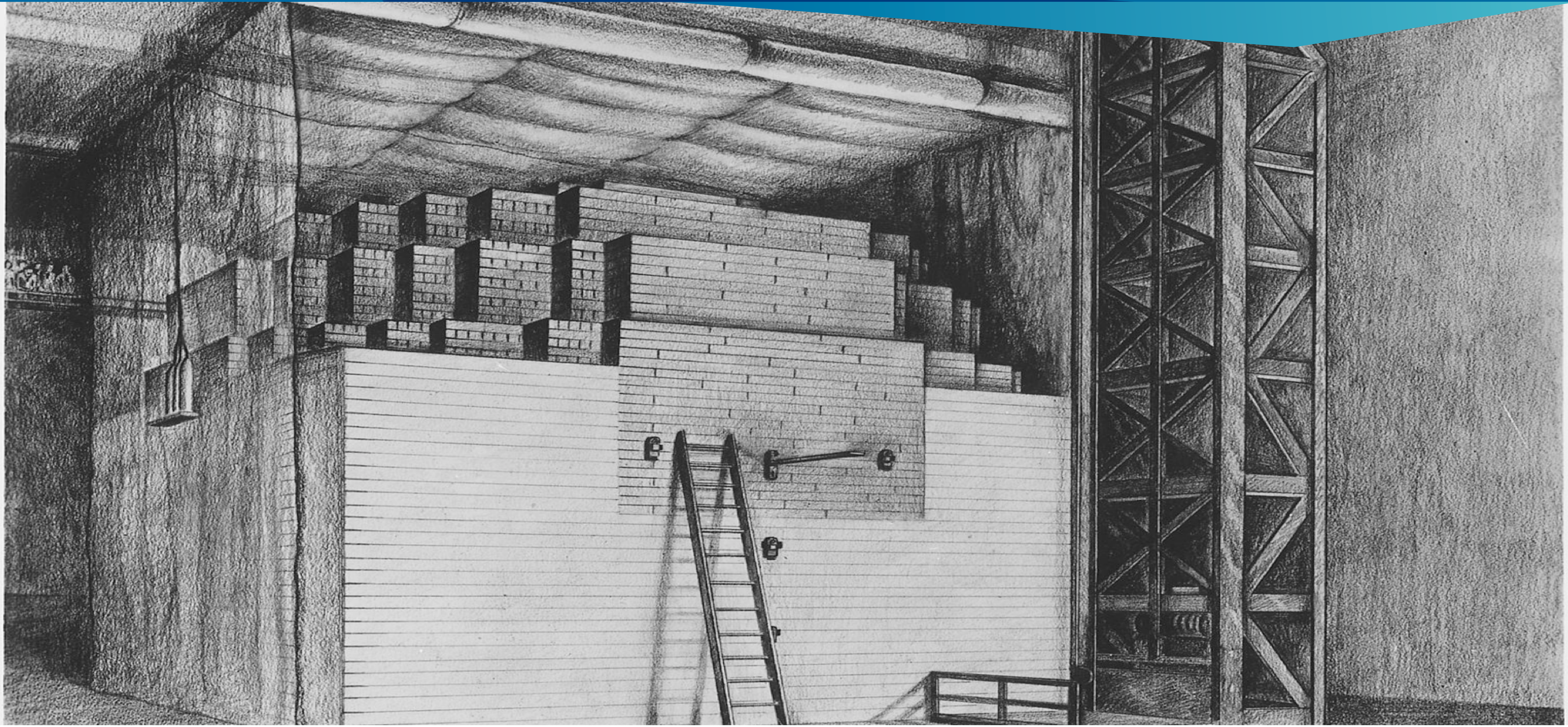
The Safety, Health, and Well-being of the Public

Four Levels of Science and Engineering Ethics

Levels	Objectives
Meta	Nature of science/engineering
Macro	Relationship between science/technology and society
Meso	Organizational and institutional issues relating to science/engineering practice and to scientists/engineers and organization
Micro	Conducts of Individuals (i.e., scientists and engineers) and organizations

Dates of Drastic Changes in Science and Technology in Relation to Society

- December 2, 1942
- September 11, 2001
- June 13, 2010
- March 11, 2011

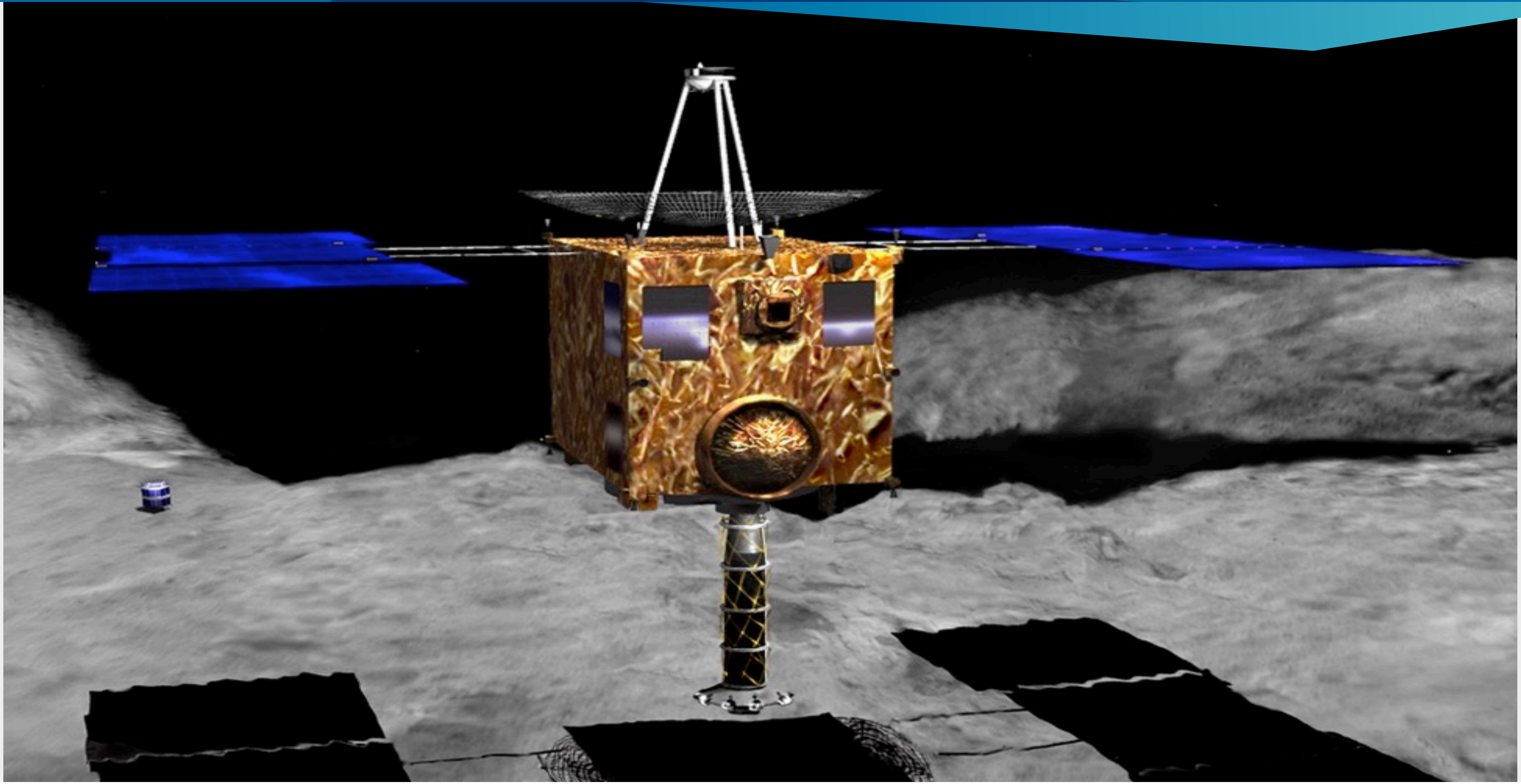


December 2, 1942

Control of nuclear chain reaction

"Stagg Field reactor" by Melvin A. Miller of the Argonne National Laboratory https://commons.wikimedia.org/wiki/File:Stagg_Field_reactor.jpg

September 11, 2001
terrorist attacks in the United States



June 13, 2010
Japan's Hayabusa Asteroid Probe comes back to Earth

"Hayabusa hover" is by JGarry at English Wikipedia
https://commons.wikimedia.org/wiki/File:Hayabusa_hover.jpg

March 11, 2011
Great East Japan Earthquake and Fukushima Daiichi Nuclear Power Plant accident

"US Navy 110318-M-HU778-007 An aerial view of Minato, Japan, a week after a 9.0 magnitude earthquake and subsequent tsunami devastated the area" by U.S. Marine Corps photo by Lance Cpl. Ethan Johnson.
https://commons.wikimedia.org/wiki/File:US_Navy_110318-M-HU778-007_An_aerial_view_of_Minato,_Japan,_a_week_after_a_9.0_magnitude_earthquake_and_subsequent_tsunami_devastated_the_area.jpg

The World in Transition Because of the Advancement of Science and Technology

In this era, science and technology has tremendously broad, large and profound on human society.

This is an era in which decisions made by specialists and organizations involved in science and technology can have enormous influence on **society and the environment.**

The **responsibilities and ethics** of engineers are being questioned.

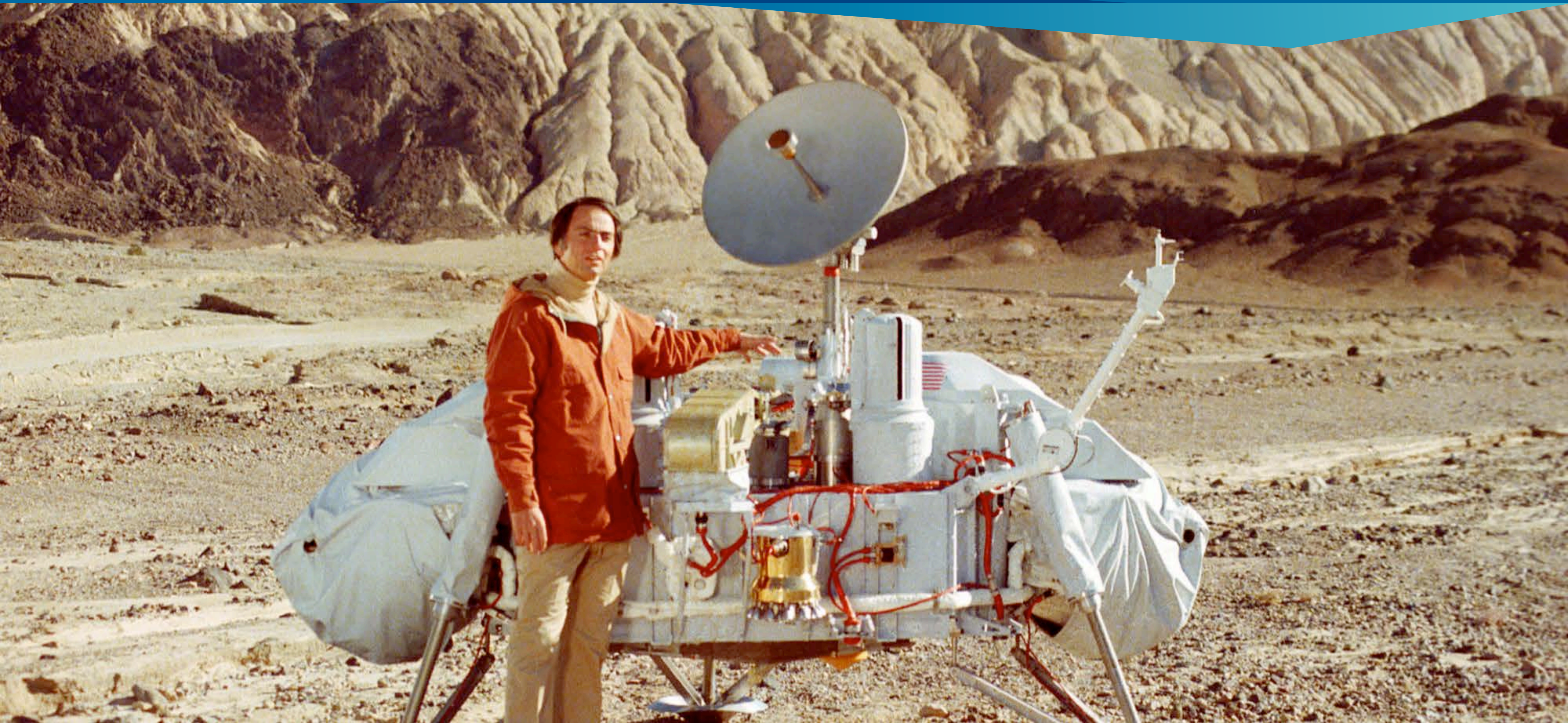
Fudano's Principles for Ethical Issues

In making ethical decisions, enlarge your frame of reference and relativize your thoughts in terms of:

Timeframe

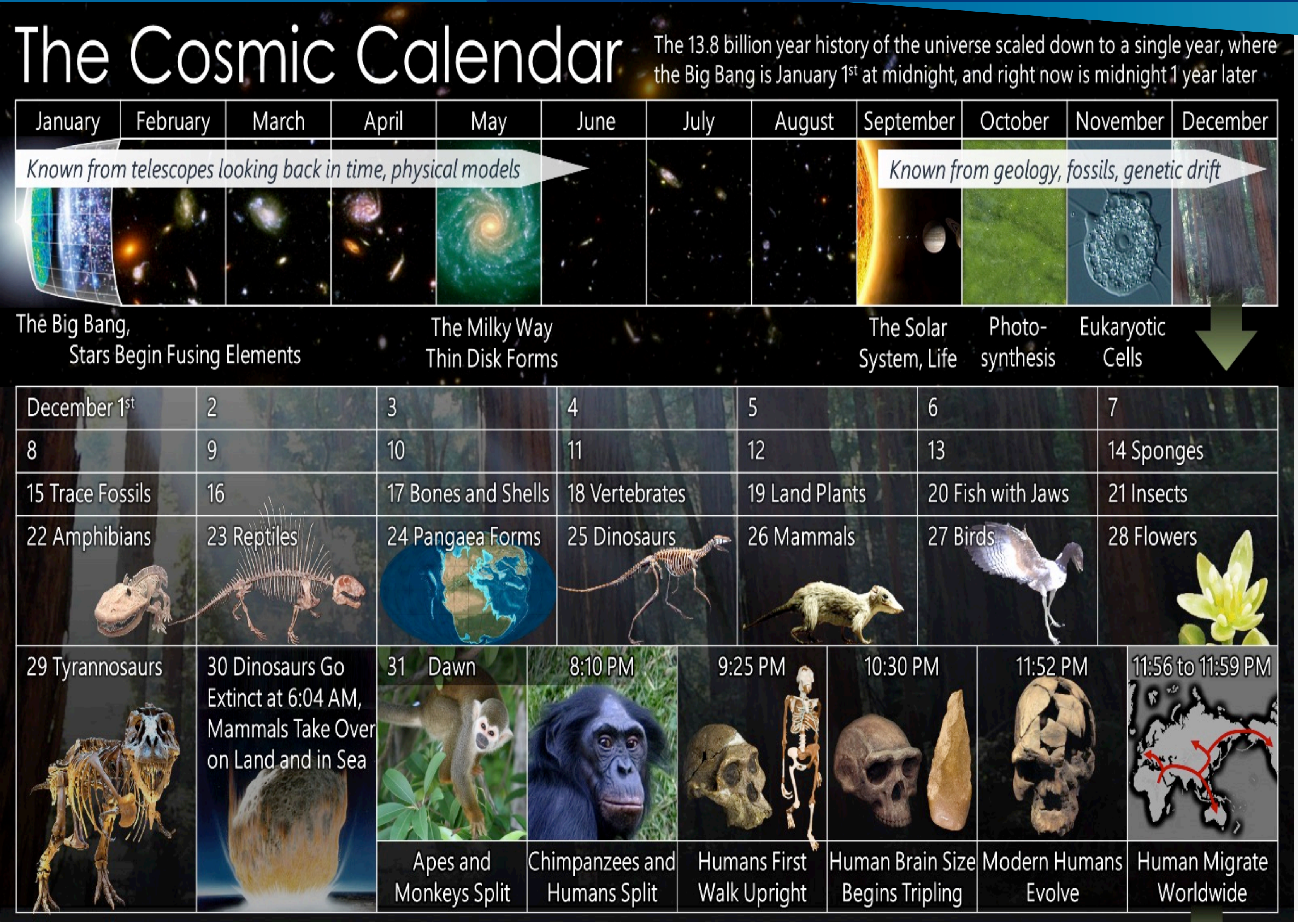
Space

Relationship



Carl Edward Sagan (1934-1996)

"Sagan Viking" by JPL
https://commons.wikimedia.org/wiki/File:Sagan_Viking.jpg



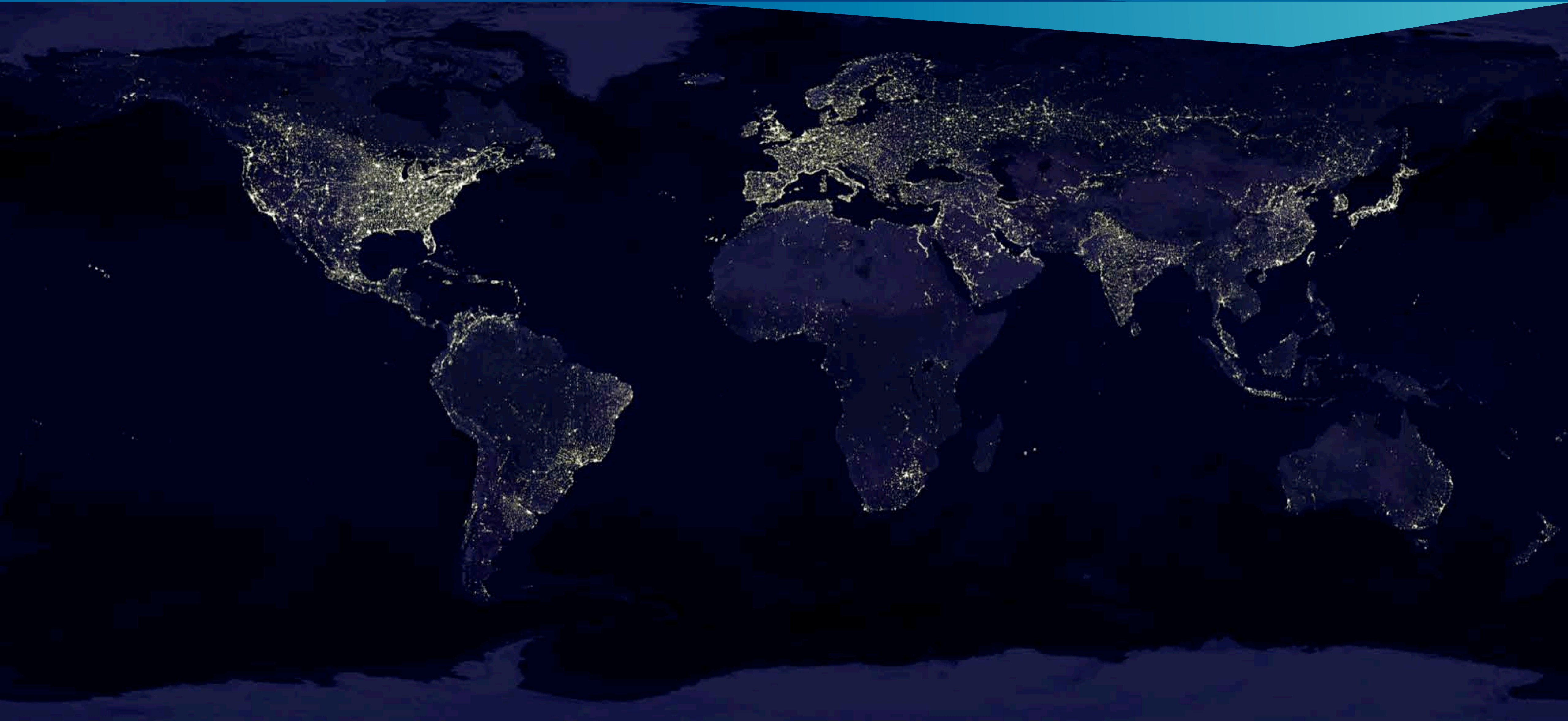
- January 1: Big Bang
- September 9: Birth of the solar system
- September 14: Formation of the Earth
- September 25: Birth of life
- December 31 at 10:30 p.m.: Emergence of humanity
- December 31 at 11:59:56 p.m.: Greek philosophy
- December 31 at 11:59:59 p.m.: Birth of modern science

Cosmic Calendar - Carl Edward Sagan
13.5 billion years compressed into a single calendar year

20 Great Achievements by Engineers during the 20th Century

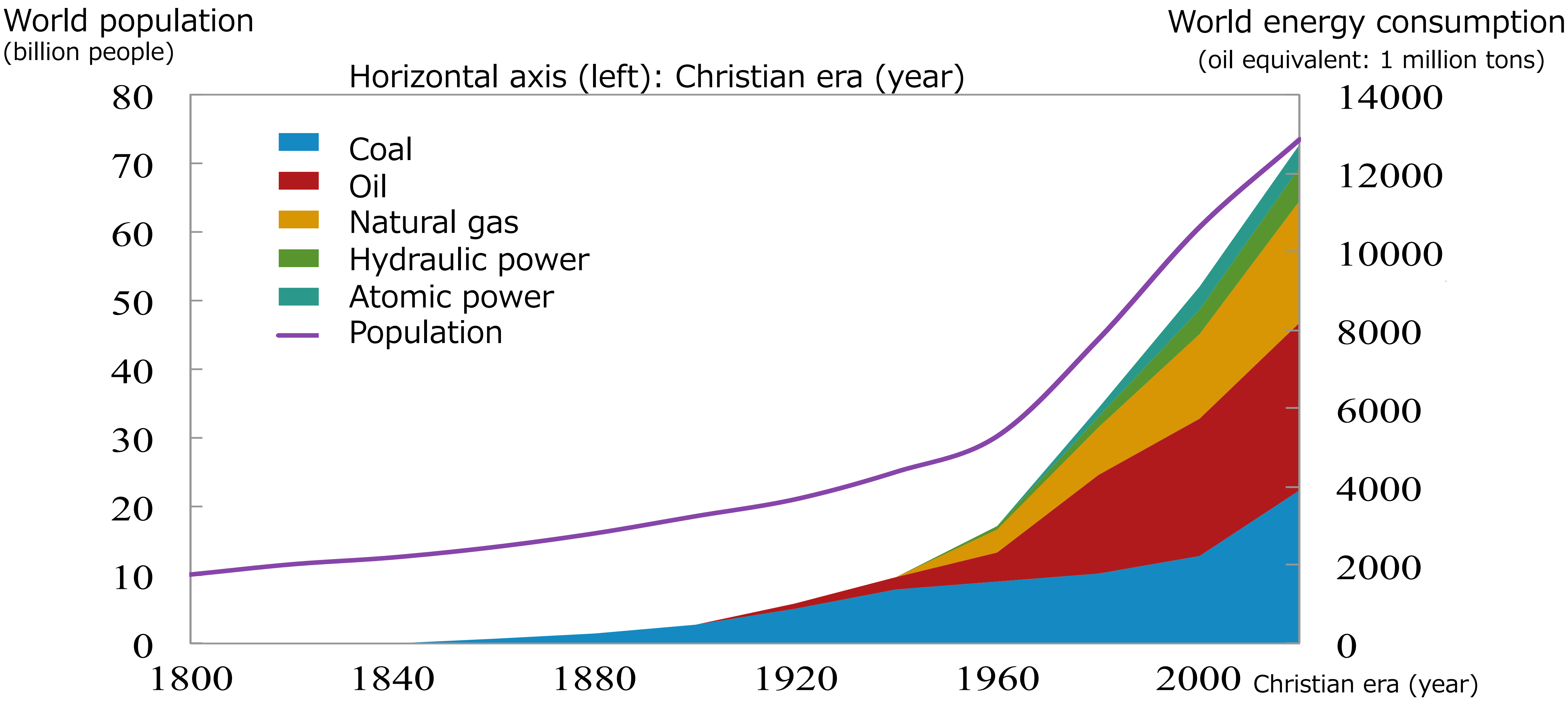
1. Electrification
2. Automobiles
3. Airplanes
4. Water supply and distribution
5. Electronics
6. Radio and television
7. Agricultural mechanization
8. Computers
9. Telephones
10. Air-conditioning and refrigeration
11. Highways
12. Spacecraft
13. The Internet
14. Imaging technology
15. Household appliances
16. Medical and health technologies
17. Petroleum and petrochemical technologies
18. Laser and fiber optics
19. Nuclear technology
20. High-performance materials

National Academy of Engineering, 2009, http://www.greatachievements.org/



Earth’s city lights as viewed from space

http://eoimages.gsfc.nasa.gov/images/imagerecords/55000/55167/earth_lights_lrg.jpg



Human Achievements Represented as a Quarter of a Second

Source: State of World Population, data from the Ministry of Economy, Trade and Industry (Ministry of International Trade and Industry) and others.

Can humanity fully utilize the advancements of science and technology?

There have been many important human achievements over the last 100 years (a blip of only 0.25 seconds on the compressed cosmic calendar).

What will the future bring?

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21st Century Engineers and Ethics

Global standards of engineering competencies
Engineers with internationally acceptable competencies
Local training and global practice

- International agreement between bodies responsible for accrediting engineering degree programs to mutually recognize the substantial equivalence of engineering
  Washington Accord (1989)

- International mutual approval of engineering qualification
  CPD (Continuing Professional Development: training for continuing professional development for specialists)

Engineering in a Fast-changing World

Engineering responsibilities will be expanded, the quantity of information will sharply increase, and opportunities for engineers will spread throughout the world.

↓

A new image of engineering is emerging.

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There is a need to reform engineering education.

Necessity of Internationally Available Engineers

International mutual approval of a substantial equivalent for engineering education

- Washington Accord (with a central focus on English-speaking countries, 1989)
- The "Eug Ing" European Federation of National Engineering Associations (1993)
- Quality assurance for trade in services (WTO) (1995)
- APEC Engineer (creation of system for 1995 through 1997)
- International strategies of ABET (evaluation of engineer education programs outside the US)

IEA: Required Qualifications and Abilities for Graduates of Engineering Departments

1. Knowledge of engineering
2. Problem analysis
3. Designing and developing of solutions
4. Investigation
5. Use of the newest tools
6. Engineers and society
7. Environment and sustainability
8. Ethics
9. Individual activities and teamwork
10. Communication
11. Project management and finance
12. Continuing education and lifelong learning

International Engineering Alliance, "Graduate Attributes and Professional Competencies Version 2, "18 June 2009
http://www.jabee.org/international_relations/iea/

6. Engineers and society

7. Environment and sustainability

8. Ethics

- Evaluate problems regarding society, health and safety, law, and culture arising from engineering activities and responsibilities for the best results using inferences based on associated knowledge.
- Apply fundamental ethical principles, observe ethical developments as a specialist, carry out relevant responsibilities, and comply with the proper codes of behavior for engineers.
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Micro Level: Recent Incidents in Japan (Individuals and Organizations Involved in Science and Technology)

1995 Tokyo Subway Sarin attack
1995 Sodium leak at the Monju fast-breeder reactor
1999 JCO Tokaimura criticality accident
2000 Concealed knowledge of recalls at Mitsubishi Motors
2001 Yukijirushi food label replacement scandal
2002 TEPCO (Hitachi) issue
2004 Scandal of concealment of recalls by Mitsubishi Fuso Truck and Bus Corporation
2004 Pipe rupture accident in the secondary system of Unit 3 of the Mihama Power Station
2004 Falsification of data by Kansai Electric Power Co.
2005 Falsification of drainage data by JFE Steel Corporation
2005 JR Fukuchiyama line train derailment accident
2005 Falsified quake-resistance data for condominium designs
2005 Paloma gas water heater accident
2006-7 Electric power company concealment scandal
2011 Fukushima Daiichi Nuclear Power Station accident
2015 Asahi Kasei Construction Materials Corporation piling data fabrication scandal

Two Aspects of Ethics

	Aspirational Ethics	Preventive Ethics
Aspect	Want to do/should be done	Ought not to
Goal	Good decision making and good work	Prevent what should not be done
Direction	Contribution to well-being	Avoiding harms and protect safety and health
Orientation	Extroversion-oriented	Introversion-oriented
Effect	Encouraging/Inspiring	Withering

NAE Grand Challenges for Engineering

- Advance Personalized Learning
- Make Solar Energy Economical
- Enhance Virtual Reality
- Reverse-Engineer the Brain
- Engineer Better Medicines
- Advance Health Informatics
- Restore and Improve Urban Infrastructure

National Academy of Engineering, http://www.engineeringchallenges.org/

NAE Grand Challenges for Engineering

- Secure Cyberspace
- Provide Access to Clean Water
- Provide Energy from Fusion
- Prevent Nuclear Terror
- Manage the Nitrogen Cycle
- Develop Carbon Sequestration Methods
- Engineer the Tools of Scientific Discovery

National Academy of Engineering, http://www.engineeringchallenges.org/