**Lecture 1**

Pre Scientific Revolution

Neolithic Revolution (New Stone Age, 11.5k - 5k years ago)

- Human societies began to shift from a lifestyle based on hunting and food chasing to farming and domesticated animals

Early civilizations (like Mesopotamian civilization) had some form of writing, astronomy, calendar, etc

Greek and Hellenistic Science

- Speculation of nature, investigation of the fundamental nature of what exists, questions about the “essence of things”, first to look for general principles beyond observations

Aristotle

- A comprehensive system of philosophy
- A coherent theory of the cosmos
- Wrote systematically about many things
- Cosmos: Terrestrial and Celestial region, Earth at center

Syllogism - Deductive scheme of a formal argument consisting of a major and minor premise and conclusion

Agricultural and Military Revolutions in Europe (800s-the 1500s)

- The agricultural revolution, New military technologies, Dependence on wind and water for the generation of power
- After 9th century, Europe transformed itself to leading in science and industry
- Rise of the population in Europe
- Agricultural revolution due to population increase and land shortage
- Land used for agriculture and food, animals, expanding cities, forests for fuel

Problem: Plowing heavy soil

- Heavy plow: Armed with iron cutter, more friction, needed more traction, pulled by 8 oxes
- Mediterranean scratch plow adapted to light soils
- Heavy plow required neck harness, switched to horse and horse collar
- Horse collar transferred pressure points from neck to shoulders, increasing traction 4-5x, invention was adapted from the Chinese

Three Field rotation system:

- Planting rotated over 3 year cycle, 2 seasonal plantings with 1 fallow

- Development of collective ownership from invention of heavy plow

Three field rotation system: improved diets, improved productivity, more food, more meat, more surplus, more population

Military revolution: Adopted stirrups from Chinese to be able to fight on horseback
- Mounted Shock Combat
- Knight replaced peasant soldier

Manorial System, No need for strong central government, Knight village relation

3 elements of military revolution:
1. Replacing heavily armored cavalry to infantry
2. Introduction of gunpowder weapons, artillery
3. Rise in size of armies

Education in medieval Europe
- Seven Liberal Arts
- Focus on theology and religious affairs
- Weakly organized learning
- Eruption of the European university in 12th century and rapid spread of higher education across Europe

Agricultural Revolution
- Flourishing cities
- Growing economy
- Increase in wealth
- Need for urban institutions
- Modeled after craft guilds
- Secular communities

Standardization of higher education, curriculum, and licensing

Source of Knowledge: Toledo
Period of Translation
Period of Assimilation
Thomas Aquinas
Condemnation of 1277: condemned 219 errors from Aristotle

Medieval scholars interpreted view from theological pov

**Lecture 2**

Copernican Revolution
- Proposed heliocentric cosmology (sun centered)

1450s invention of the printing press

- Communication revolution
- Accurate, inexpensive, standard

Italian renaissance
- Urban and secular phenomenon, aligned with courts but not university
- Development of linear perspective in art
- Anatomical research due to artists needing more detail

Books published in anatomy with more details, lead to discovery of circulation of blood by William Harvey

Aristotle
- Since planets are the same brightness, earth is at the center and distance remains the same
- Universe is finite since we are at the center, infinite areas have no center
- Thought no people could live at equator
- Wrong about comets and supernovae

Models of the Universe
- Eudoxes: concentric model
- Epicycle/Deferent model: Planets moved around around a point named epicycle, with center moving uniformly on a bigger circle called deferent

Copernicus
- Planets move around the sun (annual changes in celestial sphere including retrograde motion)
- Earth rotates on its axis (diurnal motion of celestial sphere)
- Axis of rotation is not perpendicular to the plane of solar system (solved question of seasons having different lengths)

Tyconic model
- Earth is at the center stationary, other planets revolve around earth but around the sun

Keplers Laws
1. Elliptical orbit
2. Line joining planet to Sun sweeps out equal areas in equal times as planet travels around ellipse
3. Ratio of squares of revolutionary periods for 2 planes is equal to ratio of cubes of their semi major axes

**Lecture 3**

Galileo joined medici family, used telescopes
- Telescopic observation of astronomical phenomena
- Surface of moon

- Suns[pots
- Satellites of Jupieter
- Milky way
- Saturn's rings
- Phases of Venus, implies Venus revolves around sun and not earth
- Shook Aristotle's philosophy, found evidence of heliocentric model
- Verification based on observation not authority

Discourse on Two New Sciences
- Math analysis of motion, for e, and strength of materials

Rene Descrates
- Cartesian plane (Mathematics/geometry)
- Matter in motion (Entire universe)
- Mechanistic philosophy

Isaac Newton
- Laws of Gravity, Calculus, 3 laws of motion
- Newton's Principia
- Universal laws, gravity
- Origin of colors
- Reflecting telescope

3 categorically different scientific institutes
- General scientific research institutes
- Modern observatories
- Botanical gardens

**Lecture 4**

Robert Hooke
- Micrographia

Cartography
- Art and applied science of making maps
- Probably first modern scientific technology
- Math geography + Trig + Spherical geometry + astronomy + geodesy + surveying
- Navigation

Experimental Philosophy
New Instruments
- Question about heat

Industrial Revolution

- Many leading figures from UK
- Began in England
- Surplus capital
- Large maritime empire
- Factory system
- Steam Engine

Rise of science as public activity
- Rise of public sphere

Public lectures
Rise in population
Pressure on resources

Steam engineers, iron, coal, need for coal
James Watt's engine
Major shift from agriculture and trade to mechanization of production, elaboration of factory system, development of global market system to support industrial production

Increase in yield, raw materials, food, population
Necessity is the mother of invention

**Lecture 5**

Scientific revolution and industrial revolution were epochal in shaping modern world, many decades for their consequences to unfold
- Francis Bacon
- Rene Descartes

Bacon -> Experimental Science -> Induction

Aftermath of Scientific Revolution
- Classical Sciences - Astronomy, mechanics, mathematics, optics
- Baconian Sciences - Electricity, Magnetism, Heat
    - Started rootless, empirical investigation
    - Depended on instruments

Electricity, Magnetism, Heat
- Investigation into conduction, insulation, attraction, and repulsion
- Static Electricity

Newton's theory of Ether
Baconian sciences extended into other scientific fields
Chemistry did not progress in scientific revolution

Phlogiston theory of combustion
Discovery of new gasses, New elements, Dalton's theory of atoms

Second scientific revolution
- Mathematization of Baconian sciences
- Combination of Baconian sciences with classical sciences

Alessandro Volta
- Battery

First discovery connecting magnetism and electricity
- Hans Christian Oersted

Michael Faraday
- Electrical current by putting magnet through closed coil of wire

Thermoelectricity
- Thomas Johann Seeeck

Carnot Cycle
- Improved steam engine (Sadi Carnot)

Second law of thermodynamics
- Rudolf Clausis

Mawell
- Relationship between electricity, magnetism, and light
- Electromagnetic Radiation

New Scientific Institutes
- Ecole Polytechnique
- University of Berlin
- Humboldtian University

Male dominated character of 19th century science
Only handful of women became directly involved in science

- Professionalization of science
- Hospital became reorganized
- Specialized organizations

- Professionalization of science
- Reorganization of hospital

- Specialized organization
- Specialized journals
- Scientist coined in 1840

Spread of Industrial Civilization
- Belgium, Germany, France, US were first countries outside of England to start industrialization
- Spread of industrialization over European continent was not uniform
- By end of 19th century, science-based industries emerged, with advances in electricity and chemistry

New Era of Colonial development
- English rule in India
- Spread of Russian power eastward
- Western incursions into China
- Scramble for Africa
- Forcible opening of Japan to US

Production of Steel
- British began to produce true steel
- Eiffel Tower, Empire State Building

Petroleum
- Drilling in middle east
- Maritime technology
- Telecommunications

Electrification -> Assembly Line -> Mass Production

## Test 1 Review

### Lecture 1

Neolithic Revolution
- Shift from lifestyle based on hunting and food chasing to a lifestyle based on farming
- Writing, Astronomy, Transportation, etc

Mesopotamian Civilizations
Egyptian Civilizations
Greek and Hellenistic Sciences
Aristotle
- Established a comprehensive system of philosophy
- Wrote systematically about physics, metaphysics, poetry, zoology, music, logic, ethics, politics, rhetoric, government, and even theater

- Established coherent theory of the cosmos wherein categorized objects of the universe are arranged in a distinct configuration
- Philosophy and views on physical sciences shaped medieval scholarship extending into 16th century

Aristotle's Cosmos
- Based on our experience
- Heavenly bodies revolve around earth
- Heavens don't fall or recede
- Upwards and downwards motion on earth
- Terrestrial region
- 4 basic elements in terrestrial region

Syllogism (Logic)

Agricultural Revolution and Military Revolution
- Population increase
- Land shortage
- Heavy Plow
    - Iron cutter
- Three field rotation
    - Collective ownership etc.
- Armored Knight
- Manorial System
- Rise in size of armies
- Introduction of gunpowder weapons
- Water and windmill

## Lecture 2

Cathedral schools for literate priests
Seven Liberal Arts (Trivium and Quadrivium)
- Logic, Grammar, Rhetoric
- Arithmetic, Geometry, Astronomy, Music

Abacus and Armillary Sphere

European University
- Rapid spread of higher education

Flourishing Cities
Growing economy
Increase in wealth
Urban institutions
Standardization of higher education
Toled - Center of translation

Thomas Aquinas
- Provided an intellectual system of rational thought about God, man, and nature

- Scholastic Philosophy

Condemnation of 1277

- Bishop of Paris condemned 219 errors held by Aristoelians

Jean Buridan

Nicole Oresme

Medieval scholars interpreted the world from theological point of view

## Lecture 3

Copernican Revolution

- Copernicus proposed sun centered theory (heliocentric)
- Earth rotates around axis

Printing Press

Italian Renaissance

- Not aligned with universities
- Renaissance Art (Linear Perspective)
- Anatomical Research (Realistic Art)

Andreas Vesalius (De humani corporis fabrica)

William Harvey - Discovery of circulation

Different models for solar system

- Deferent
- Epicycle
- Equant

Tycho Brahe

- Earth center, other planets around the sun

Johannes Kepler

- Platonic Solid
- Kepler's Laws

Galileo

- Telescopic observations
- Sunspots
- Satellites of Jupiter
- Milky Way
- Saturn's rings
- Phases of Venus
- Inertia
- Many books

Rene Descrates

- Matter in motion
- Math/geometry

## Lecture 4

Isaac Newton
- Alchemist
- Principia
- Universal Laws
    - Unification of terrestrial and celestial regions
- Three Laws of Motion
- Gravity as universal force
- Calculus
- Binomial Thm
- Nature of color
- Reflecting telescope

- Optics
    - Light composed of rays

Categorically different scientific institutes
- Modern Observatories
- Botanical Gardens
- General Scientific Research Institutes (The Royal Society)

Robert Hooke
- Micrographia (Microscopy)

Cartography
Barometer
Chronometer
Air pump
Thermometer

## Lecture 5

Industrial Revolution
- Began in UK
- Many leading figures in UK
- Factory System
- Steam Engine

Francis Bacon
- Organization of Science
- Empiricism

Science to solve practical problems
- Science as a public activity
- Public Lectures

Industrial Revolution
- Fundamental Social Change
- Technological Innovation
- Economic Growth

Pre-Industrial Revolution
- Wood, wind, water

Post - Industrial Revolution
- Shift from agriculture and trade to mechanization of production
- Elaboration of factory system
- Development of global market system
- Iron Coal and Steam
- Division of labor
- Mass Migration
- Pressure on Resources
- Population growth
- Shortage of land
- New Farming techniques
- Norfolk system replaced three field system
- Significant rise in meat production

English timber famine
- Man of war ships
- Needed to dig deeper for more coal
- Ground water problem
- Needs effective source of power to remove water
- Steam pump
- Steam engine by Thomas Newcomen (inefficient)
- James Watt Steam Engine
    - Widely adopted
    - Big and stationary
- Richard Trevithick's engine
    - Smaller and movable
    - George Stephenson improved engine

Textile Industry
- Worker productivity in cotton industry increased by factor of 200
- Urban Factory workers
- Locomotives and iron tracks replaced horses and dirt roads
- Iron replaced wood and stone
- Steamship replaced sailing ship

New energy sources
New organization of labor
New means of financing industrial revolution
Ideological changes
Human and animal muscle, sometimes wind and water -> coal and later oil

Formation of new working class
Money replaced traditional exchanges of goods and services
Union activities
Exploitation of labor

- Cotton production quadrupled and profits doubled, no increase in salary

Shift from mercantilism (state controlled) to open markets and free enterprise (laissez-faire)
Romantic movement in poetry, literature, music

Agricultural changes

- Increase in yield, raw materials (cotton, wool, milk, meat), food, population

James Hargreaves jenny for textile

Necessity is the mother of invention

- Spinning machine -> Need to Speed up weaving -> Power loom
- Power loom -> Increased demand for raw cotton -> Cotton gin
- Cotton Gin -> Demand for stronger iron -> Improvements in iron smelting and development of steel
- Factories needed more coal -> Improved mining methods

Recap

- Industrial Revolution: Change from agrarian handicraft economy to one dominated by industry and machine manufacturing
- Mechanization
- New working class
- Iron and steel
- New energy sources
- New Machines
- New organization of works
- Developments in communication and transportation
- Increasing application of science to industry

## Lecture 6

Classical Science
Baconian Science

## Lecture 7

Ecole Polytechnique
University of Berlin

Humboldtian University

- Unity of research and teaching/function of the university as a research center/the freedom of research/centrality of pure sciences

Teaching laboratory
Formal textbook

PHD
Professionalization of science
Reorganization of hospital
Spread of industrial civilization
Advances in electricity and chemistry

New era of colonial development

True steel
- Eiffel Tower, Empire state

Petroleum
- First modern well
- Kerosene for lamps and heaters
- Oil industry
- Internal combustion engines
-

Maritime technology
- Steel ships, propellers, engines, turbines

Telecommunication
- Production and transmission of electricity
- First transatlantic message
- Wireless communication
- Telegraph

Electrification
AC motors

Eddison effect - light bulb

Revolution in communication
Shortening time for production

## Lecture 8

Big Science
- Large scale instruments and facilities
- Government funding
- National interest
- Mass production of scientific discoveries
- Collaboration of specialized scientists from different fields

Atomic Science
- Discovery of radioactivity
- Discovery of electron by JJ thomson
- Discovery of plutonium and radium

- Discovery of proton

Cathode ray
- Michael Faraday
- Negative particles

Thom's plum pudding model
Rutherford's experiments revealed positive particles at center of atoms
James Chadwick - Neutron in 1932
Discovery of chain reaction in U235 fission by a neutron
Einstein Letter to President Roosevelet
Initial methods of Uranium enrichment
- Electromagnetic Method
- Gaseous Diffusion
- Centrifuge
- Liquid Thermal diffusion

Manhattan Project
- Los Alamos
- Oak Ridge
- Richland

Discovery of plutonium
Trinity Site - First atomic explosion

Internationalism in Science
- Theoretical studies / Laws of nature
    - Good cooperation
- Technical/Industrial know-how
    - Good
- Military Science
    - Secret

## PollEverywhere Questions 1

1. Aristotle
    a. Established a comprehensive system of philosophy
    b. Wrote systematically about physics, metaphysics, poetry, zoology, music, logic, ethics, politics, rhetoric, government, and even theater
2. Major innovations in European Agricultural Revolutions were
    a. The introduction of the heavy plow
    b. Substitution of the horse in agriculture
    c. Development of the three field rotation system
3. Spreading learning outside of universities and creating a new lay intelligentsia after the 15th century was because of
    a. Invention of the printing press
4. Tycho Brahe

    a. Discovered the celestial nature of comets and nova
5. Galileo's observation was directly against geocentric model of Ptolemy
    a. Discovery of the phases of Venus
6. Sequence is chronologically correct
    a. Ptolemy, Copernicus, Brahe, Galileo & Kepler, Descartes, Newton
7. Johannes Kepler
    a. Discovered three laws of planetary motion
    b. Put an end to the idea of uniform circular motions in the celestial sphere
8. Newton's major achievements were:
    a. Unifying the terrestrial and celestial physics
    b. introduction of the laws of motion and gravity
    c. discoveries in optics
9. 3 categorically different scientific institutes that appeared during the scientific revolution in Europe were
    a. Learned institutes such as the Royal Society of London, Botanical Gardens, Modern Observatories
10. Philosophical Transactions of the Royal Society was
    a. The first scientific journal in modern sense
11. His book Micrographia was the first important work on microscopy
    a. Robert Hooke
12. Among the major outcomes of the Scientific Revolution, one can refer to
    a. Development of a new approach to understand nature, mathematization of nature, discovery of natural laws
    b. Development of experimental philosophy and devising new scientific instruments
    c. Development of new sciences
13. How did the second Scientific Revolution form
    a. It formed because of the mathematization of the previously more qualitative Baconian sciences and the unification of the Classical and Baconian sciences
14. Phlogiston
    a. Fire like element which contained within combustible bodies and released during combustion
15. Antoine Lavoisier's combustion explanation:
    a. In combustion something was taken out of the air rather than released into it
16. Baconian Sciences
    a. Sciences such as electricity and magnetism - that had no roots in classical sciences but developed during and after th eScientific Revolution
17. Alessandro Volta
    a. Italian physicist who invented battery in early 19th century
18. Michael Faraday
    a. British scientist who generated an electrical current by plunging a magnet through a closed coil of wire
19. Among the most important achievements in physics during the 19th century was
    a. The creation of an entirety new theoretical discipline: thermodynamics
20. The main contribution of Prescott Joule

    a. Worked out the mechanical equivalent of heat
21. Connection between Maxwell's achievements to technology
    a. Understanding of the electromagnetic radiation made wireless transmissions doable
22. With his famous experiment on light, Thomas Young demonstration that light
    a. Propagates like a wave
23. Sequences
    a. Galvani, Volta, Oersted, Faraday, Maxwell
    b. Newton, Faraday, Maxwell, Einstein
24. Humboldtian university
    a. Model of higher education which unites research and teaching, is based on the freedom of research, with centrality of pure sciences
25. In the USA, modern Research Laboratories such as Standard Oil Lab, General Electric, and DuPont were mainly established
    a. By private sector
26. Global Village (McLuhan)
    a. The world feels like a smaller place
27. Telephone was invented in 1876 but it took some time before telephony challenged the telegraph as an effective communications medium
    a. There was no infrastructures to make telephone connections available in houses and workplaces
28. Major invention made flight possible
    a. Internal combustion engines
29. Key elements which made AC power transmission doable
    a. Transformers
30. Why was the discovery of the neutron so important
    a. Because neutrons are neuter and are not repelled by protons in nuclei bombardment
    b. Because they are one of the building blocks of atoms
31. Why was the discovery of plutonium so important for the Manhattan Project
    a. It didn't need very expensive separation and enrichment processes
32. In his letter to President Roosevelt, Einstein
    a. Outlined the importance of research in uranium fission
33. What discovery in atomic physics in 1939 opened the door to utilize atomic energy in both controlled and uncontrolled ways
    a. Discovery of a chain reaction in U235
34. Major theoretical and technical problems in utilizing atomic energy were
    a. Calculation of critical mass, enrichment techniques, and designing the bomb

# Test 2 Review

## Lecture 9

- Newtonian Physics
- Einsteinian Revolution
- Quantum Physics

Newtonian Framework
- Absolute Space and Time
- Time is Real and Uniform
- Space is Real and Distinct
- Space and Time tell matter how to move, but has no effect on space and time
- Universe filled with ether (Medium that light moves through)

Michael Morley Experiment
- Experiment for detection of ether
- Failed to detect

Relative Motion
- Einstein: Space contracts and Time Dilates

Special Theory of Relativity
- Moving object measures shorter in direction of motion as velocity increases
- Moving clocks run slower as velocity increases
- Mass of moving object measures more as velocity increases
- Clocks, watches, satellites

- Satellites in orbit experience 38 microseconds of delay daily

Black Body Radiation

Max Planck
- Quanta
- Father of Quantum theory

Photoelectric effect
- Heinrich Hertz

Einstein
- Light consists of photons whose energy is proportional to frequency
- Higher frequency, higher emission

Rutherford's model
- Problems
    - Why do electrons remain in orbit and not fall
    - Electrons lose energy and produce electromagnetic radiation

Bohr model

- Electrons are only in certain discrete states

Uncertainty Principle

- Heisenberg
- Certain physical properties as pairs cannot be physically measured accurately
- Example: Position and Speed, as one gets more accurate, the other gets less accurate

Quantum Physics is probabilistic

Wave Particle Duality

- Light and Sub Atomic entities like electrons have properties of waves and particles

Newtonian Physics

- Determinism
- All physical processes are continuous
- Separability

Milky Way

- Immanuel Kant argued Milky way was one of number of similar island universe
- Pierre Simon Laplace suggested nebulae were massive clouds of gaseous matter that formed the birthplace of stars and planets

Age of giant telescopes

- William Herschel built large telescope
- William Parson Rosse

Developments in photography and spectroscopy

Shapley - Curtis debate

- Harlow Shapley
    - Milky way is our galaxy, all other nebulae and star clusters are located within galaxy
- Heber Curtis
    - Milky way is small local galaxy and spiral nebulae are distant galaxies outside ours

Cepheid variables

Edwin Hubble

- Studied cepheid variables in nebulae, calculated brightness and estimated distances
- Discovered galaxies are moving away

Einstein/s General Theory of Relativity
- Mass dictates shape of space

Gravitational Lensing

- Einstein and Willem de Sitter: Universe is static
- Galaxies are receding, once were close (Hubble)
- George Gamow: Calculation of background radiation (1940)

Cosmic Background Explorer (COBE)
- Produced map of sky in microwaves and found ambient temperature of universe

New Concepts in Science and Technology
- Data Science and Data Processing
- Machine Computations
- Electronics
- Internet

Medical Technologies
- Antibiotics
- Growth of pharmaceutical industry after WWII
- Introduction of oral contraceptives
- Organ transplant surgeries

Johannes Friedrich Miescher
- Swiss physician and biologist isolate nucleic acid (DNA)

Thomas Hunt Morgan
- Chromosomes

Phoebus Aaron Theodore Levene
- Studied structure and function of nucleic acid
- Etc

Virus Research and discoveries

Erwin Chargaff
- Helped lead to discovery of DNA

Rosalind Franklin
- X ray diffraction studies of DNA molecules
- Double Helix
- James Watson and Francis Crick

## Lecture 10

Atomic Age
- Atomic bombs did not appear immediately to be so different from conventional weapons
- Operational Meetinghouse, single most bombing raid in history
    - 334 B-29
- Atomic bomb required cooperation between scientist, industry, and military

Background:

- 1939: Discovery of chain reaction
- WWII
- Einstein's letter
- US military interest in atomic energy
- Attack on pearl harbor (Dec 7 1941)

Manhattan Project

- Los Alamos, Oak Ridge, Richland
- Clash of military and scientific cultures
- Secrecy vs free flow of scientific info
- James Franck

Different viewpoints against Japan

- Naval blockade and bombing vs massive invasion

Bomb may have been used to intimidate Soviets

Smyth Report

- Within a week of bombs use, basic outlines of scientific and technical details revealed
- Missing plutonium and crucial information

Bills passed

Establishment of AEC (Atomic Energy Commission) - focused on military interest

- Scientist input through GAC but not implement decisions

Breakup of Canadian spy ring for Soviets

Spy Rings

- ¾ of research reports remained classified

Soviets

- Uranium from Eastern Europe
- Info from Smyth Report
- Technical info from spy rings
- Detonated first atomic bomb on Aug 29, 1949

Secrecy and Security

- At least 7.5 billion to 2 trillion pages of info were classified
- House Committee on Un American Activities
- Practice of science and scientific knowledge were classified
- Loyalty investigations of scientists

Edward Teller

Thermonuclear Weapon

- At least 1000x as atomic weapons
- Within 5 years promised
- Scientists thought should not be developed

Computers
- UNIVAC, ENIAC, MANIAC

Office of Naval Research (ONR)
- Relationship between government, scientist, military

Hybrid Institutes

## PollEverywhere Questions 2

1. The scientific medicine - the outcome of revolution in medicine appeared
    a. During the second half of the 19th century and the first half the 20th century
2. The largest part of the US government spending on scientific and technological research is allocated to
    a. Defense
3. Among the major achievements in the 20th-century medicine one can refer to
    a. Discovery of antibiotics, successful organ transplant surgeries, using state of the art technologies in medical procedures
4. The famous Shapley - Curtis debate in the early 1920s was a debate between
    a. Astronomers who believed that all nebula were inside the Milky Way galaxy, and astronomers who believed that our Milky Way was a small galaxy among too many in the universe
5. What was the Michelson Morley experiment
    a. An experiment to verify the existence of ether
6. One of the most important technologies used in finding the double helix structure of the DNA was
    a. X-Ray diffraction (crystalography)
7. How do you define Hybrid Institutes?
    a. Institutes unifying academic, military, and industrial research (in the service of national security)
8. Among the major consequences of the discovery of the Soviet spying circle in the Manhattan Project were:
    a. Classification of billions of pages of information + loyalty investigation of some scientists
9. Besides its budget and outcome, the Manhattan Project was unique because:
    a. It was the first large scale cooperation of scientists and the military
10. The General Advisory Committee (GAC), including Oppenheimer, Fermi, and Conant:
    a. Condemned the use of such a bomb
11. In the 1940s and 1950s, the military investment on American Science:
    a. Changed the path and size of scientific research

12. During the period of the United States nuclear monopoly, the most important task of the government was to:
    a. Continue this monopoly
13. The documentary that we watched made it clear that
    a. They didn't have any idea about implosion and learned about it from spies in the Manhattan Project
14. The documentary that we watched made it clear that:
    a. They were just pro-socialist.communist ideology
15. In August 1946, the Atomic Energy Commission (AEC) was established to transfer the control of atomic energy from military to civilian hands. What happened later?
    a. No Scientists were appointed to its board
    b. AEC received scientists input through the mechanism of a General Advisory Committee (GAC) that could advise but not implement decisions

## Test 3 Review

### Lecture 11

- Launch of Sputnik in 1957

Impact of military investment on American Science

- Path of Scientific Research
- Size and magnitude of scientific activities/projects

Space Age

Military Industrial Complex

- Postwar public debates about
    - Scientific Research
    - Federal Government
    - Military

1945: Congress considering 2 proposals

- Advocating autonomous scientific research
    - Director selected by qualified candidates
- National Scientific Foundation coordinates federal research
    - Director selected by president

1950s: NSF brought together elements of both perspectives

NSF created to promote:

- Progress of Science
- Advance national health, prosperity and welfare
- Secure national defense
- Enhance nation's security

Eisenhower (1954) issued executive order to follow pluralistic approach to basic research, NSF should take over increasing share of basic research, other agencies AEC and DOD continue to fund mission oriented basic research

Press Conference Eisenhower:

- Manufacturing of weapons is theft from hungry people
- Cost of modern bomber =
- Single destroyer =
- Limitation on size of all military forces/practical system of inspection under UN

Hybrid institutes

- Applied Physics Laboratory APL at John Hopkins University + Kellex Company
- High Energy Physics at Brookhaven National Lab
- MIT and Sage
- Problem of security and secrecy

Sputnik

- Rocket was important, not the satellite
- Fear of technological gap between Soviet Union and US
- Soviets had not released images of satellite 5 days after launch
- Back to back achievements of Soviet Union and back to back failures of US created conception of Soviet superiority

Propaganda Advantages

- Capability to send satellite into orbit
- Long range flight capability of Soviet ICBMs

Satellites and Problems associated with Space Flight

- Weight
- Electronic devices
- Power
- Communications
- Functions
- Re-entry
- Recovery
- Carrying Missiles

Military leaders - US needs a Manhattan Project style crash program for rocketry
NSF- Embarrassment was a result of ignoring basic research

Big Science Evolving

Big Science and Space

- New Kind of Science

- Teams of scientists working on same problem
- Collaborative research networks
- New operating structure
- Magnitude of budget
- Etc

Construction of large, capital intensive instruments
Manpower for Science

Impact of general policy

- 1958 Education Bill - National Defense Education Act aimed at both high school and college science education
- PSSC

Lack of general policy in physics

- Only 1 in 4 physics PhDs could expect to find permanent position
- US lacked anything resembling coordinated science policy
- Decentralized structure of scientific research

- Lack of funding from Truman's budget control on rocketry program
- US excelled in long range bombers, not concerned with missiles, they had jet fighters and heavy aircrafts

Reasons

- Need for rigorous economy
- American superiority in aviation
- Scientific pessimism in technical problems of missiles
- US did not need ICBM as much as Soviets

Marshall Plan 1948

- Initiative to help rebuild Western European economies after WWII
- US spent over 12 billion
- Halt spread of communism on European continent

James Killian appointed special assistant for science and technology

- Attended cabinet and other federal agencies
- Establishment of President's Science Advisory Committee (PSCA)

Establishment of NASA
Relationship between scientific research and industrial practice

Maintain scientific superiority

- One of most alarming aspects was potential to inspire populations in unaligned nations
- Newly independent nations destabilized bipolar view of world

Ideology, Modernity, and Third World

- 40 new nations came into existence in Africa, Asia, and Middle East
- Concept of “Third World”
- 9800 million people in the newly freed nations
- European Marshall Plan

Stalin’s view about developing nations:

- Developing nations could not have a transition to Communism without first experiencing industrialization

Leaders of America, Soviet Union, China, and third world countries agreed at global political future depended on development

Clever leader could use the threat of shifting allegiance

- WW Rostow and his anti communist foreign policy based on economic development
- American dollars and experts in developing countries
- Problem of compatibility of Western methods and attitudes with Third World nations traditions and cultures

Eisenhower and Setting of American Space Policy

- Economy was strong in 1959 and budget surplus
- Biggest problem was Sputnik, undermined US credibility in battleground of technological competition
- Eisenhower administration was first to formulate space policy
- Blow to US Prestige
- Propaganda victory

Johnson Hearings

- Political in nature
- Soviets were ahead in missile development, submarines, R&D, and space
- 17 recommendations

Eisenhower

- Downplayed Sputnik
- US launched Explorer, first American satellite into space
    - Detected Van Allen Belts
    - Zones of energetic charged particles, most of which originate from solar wind and captured and held around earth by planet’s magnetic field
- Explorer 2 fails
- Vanguard 1 orbits - Earth is not a perfect sphere

Atlas satellite - Project SCORE

- First communications satellite

Creation of NASA

PSAC

- Urge to explore
- Military Security
- National Prestige
- Science

Space Activities split between DOD and NASA

Slide 44 to the rest (last lecture)

- No notes taken, not covered in test or final

## PollEverywhere Questions 3

1. In the 1940s and 1950s the military investment on American science:
    a. Changed the path and size of scientific research
2. For what reasons President Truman didn't allocate more funds to the rocket program:
    a. He allocated more funds to the domestic economy
    b. Funds allocated to make bigger bombers/jet aircrafts
    c. The United States did not need an ICBM as badly as the Soviets
3. From the American perspective, among the most alarming aspects of Soviet scientific and technical success were
    a. Its potential to inspire the populations of unaligned nations
    b. Its impact on the newly independent nations in the 1950s and 1960s (which could destabilize the bipolar view of the world)
4. The U.S rocketry program was limited by Truman's budget control because of:
    a. Truman allocated more funds to the domestic economy than to the rocket program
5. What is the concept of the "Third World"
    a. Undeveloped countries with colonial pasts in Africa, Aia, and Latin America collectively, which were mainly neutral in the East-West alignment
6. What was the European Marshall Plan?
    a. American initiative to aid Europe and Asia, in economic support to help rebuild their economies after the end of World War Two
7. During the 1950s and 1960s the American scientific research had a
    a. Decentralized structure
8. The 1950 Education Bill (The National Defense Education Act) aimed to:
    a. Reform both high school and college science education
    b. Promote new methods in teaching mathematics, physics, biology, and earth science