History of Thought:
4. Modern Knowledge: Renaissance, Enlightenment, Scientific/Industrial Revolution

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Europe 1500

http://www.euratlas.com/big/big1500.htm
What the Renaissance knew

1453: The Ottomans conquer Constantinople and rename it Istanbul
1492: Christian Castilla reconquers Spain from the Arabs
1492: Columbus in America
1521: Spanish conquistadores in Mexico, then Peru
1557: Portugal establishes a trading post in Macao (first European settlement in the Far East)
1618-1648 Thirty Years' war: France, England, Sweden win against Austria and Spain
1620: English pilgrims board the "Mayflower"
1648: at the end of the war the population of Europe has declined from 30 to 20 million
What the Renaissance knew

• Western Europe
  – 1494-1618 Spanish supremacy
    • 1618-1648 30 Years' war: France, England, Sweden win against Austria and Spain
  – 1648-1815 French supremacy
    • 1795-1815: Napoleonic wars: England, Russia, Austria, Prussia, Sweden defeat France and Spain

• Eastern Europe
  – 1354-1683: Ottoman expansion
    • 1683: Poland-Lithuania and Austria defeat the Ottomans
  – 1682-1774: 100 Year War between Austria and the Ottoman empire
  – 1721-1991: Russian expansion
Gunpowder Empires
What the Renaissance knew

• The gunpowder empires
  – Ottoman Empire (1301-1827)
    • 14 million people in 1520 (Spain: 5 million, England: 2.5 million)
    • Constantinople largest city in Europe (500,000)
    • Melting pot of races, languages and religions
    • Tolerance of other races/religions
    • Janissaries (gun-carrying infantry recruited from Christian families)
What the Renaissance knew

- The gunpowder empires
  - Ottoman Empire (1301-1827)
    - Islamic world technologically and culturally ahead of Europe
    - Sophisticated urban society
    - Universities and libraries
    - Mathematics
    - Medicine
    - Industry
What the Renaissance knew

• The gunpowder empires
  – Russian Empire (1552-1917)
    • Origin: Novgorod, Kiev, Moscow
    • Merging of Rus Vikings (loose federation of warlords and traders) and Slavs
    • Multiple races, languages and religions (Christians, Jews, Muslims, Buddhists, Pagans)
    • Christian Orthodox state: heir to Byzantium after 1453, successor to Roma and Byzantium
What the Renaissance knew

• The gunpowder empires
  – Russian Empire before Pyotr
    • A quasi-theocracy (the "Third Rome" of Orthodox Christianity)
    • Russia cut off from Reformation, Renaissance, scientific revolution
  • No universities
  • No literature, art and music outside religion
  • Foreigners quarantined in the "German quarters" of Moscow
What the Renaissance knew

• Ming China
  – Technologically and culturally advanced
  – Canal system
  – Naval superpower (1350 combat vessels in 1420)
  – Exploration (Cheng Ho, 1405-1433)
  – but…
  – steady decline
What the Renaissance knew

• Ming China
  – Seven voyages of Zheng He/ Cheng Ho (1405-33)
    • A Chinese Muslim eunuch
    • Largest wooden ship ever built
    • Vietnam, Java, Sumatra, Malaysia, Thailand
    • SriLanka, India, Bangladesh
    • Persia, Yemen, Mecca
    • Somalia, Kenya
What the Renaissance knew

• The miracle of Europe
  – A dis-united Europe
    • Political fragmentation
    • Endless intestine wars
    • Technologically, religiously and culturally backwards
    • Science, philosophy and technology imported from the Muslims
    • Fewer people and resources than the Asian empires
What the Renaissance knew

• The miracle of Europe
  – A dis-united Europe
    • ...but even a small country like Portugal could achieve conquest on a scale that China never achieved
What the Renaissance knew

• The miracle of Europe
  – The far-flung European empires are established initially by private initiative
  – Most of the capital comes from the very fragmented lands of Italy and the Netherlands
What the Renaissance knew

• The miracle of Europe
  – What kept the miracle going: continued competition among European powers for supremacy, anywhere anytime
Portugal: Europe’s Unlikely Pioneer

(From “A People And A Nation”, Houghton Mifflin, 1998)
What the Renaissance knew

• The miracle of Europe
  – Habsburg Empire
• Continuous wars:
  – 1494-1529 Italy
  – 1521-1739 Ottomans
  – 1530-1555 Germany
  – 1568-1648 Netherlands
  – 1588-1659 England
• 1648: the "Peace of Westphalia" reduces the Germanic empire to a loose confederation of hundreds of independent entities, and replaces Spanish supremacy with French supremacy
What the Renaissance knew

Habsburg Empire circa 1700
What the Renaissance knew

- The Spanish Empire/ Ferdinando
  - The church is the main driver of national unity
  - Inquisition, created by Tomas de Torquemada in 1479 to convert Jews and Muslims
  - 1516: Archduke Carlos of Habsburg inherits Spain, the "Low Countries", the “New World” and southern Italy
  - 1520: Elected Holy Roman Emperor by dynastic right (union of Spain and Austria-Hungary)
What the Renaissance knew

- The Spanish Empire/ Carlos
  - 1519-21: Cortes conquers the Aztecs in Mexico (only 2 million survive war, disease and famine, out of a population of 25 million)
  - 1531-36: Pizarro conquers the Incas in Peru
  - Missionaries: Franciscans (1524), Dominicans (1526), Jesuits (1550)
  - Gold, God and Glory
  - Enormous loss of population in the Americas due to diseases
What the Renaissance knew

- Richelieu’s terror in France (1624-42)
  - Founder of the absolute monarchy
  - Creation of the nation state
  - Establishment of France as the greatest military power of Europe
  - Practical application of Machiavelli’s theories
What the Renaissance knew

- Richelieu’s terror (1624-42)
  - Vision of a technocratic state (Grandes Ecoles)
    - “Rational Reorganization of Government” (1627)
    - Reorganization of the educational system to favor the sciences
    - Founding of the French Academy (1635)
What the Renaissance knew

• The Dutch renaissance
  – 1568: Williams of Orange leads an uprising against Spain in the "Low Countries" ("Eighty Years' War")
  – 1597: the Dutch found the colony of Batavia in Java
  – 1602: the Dutch East India Company is established in Holland
  – 1625: Dutch colons found a trading post in America, Nieuwe Amsterdam (New York)
  – 1648: End of the Thirty Years' War: Spain recognizes the independence of the United Seven Provinces
What the Renaissance knew

• England/ Revolution (17th c)
  – The “glorious” English revolution (1688) that installs a Dutch king shifts power towards the capitalistic landowners
  – Dutch-style market economy vs state-driven economies of France, Spain, etc
  – Rise of private capital markets in England vs centralized monarchical finances of France, Spain, etc
What the Renaissance knew

• The century of women
  – Caterina Cornaro, queen of Cyprus (1468)
  – Lucrezia Borgia, duchess of Este (1501)
  – Margaret of Austria, regent of the Netherlands (1507)
  – Louise of Savoy, regent of France (1515)
  – Margaret, queen of Navarre (1527)
  – Caterina de Medici, queen of France (1547)
  – Elizabeth I, queen of England and Ireland (1558)
  – Christina Wasa, queen of Sweden (1640)
  – Anna Maria van Schurman, linguist: "Dissertatio de ingenii mulieribus ad doctrinam et meliores litteras aptitudine" (1639)
What the Renaissance knew

• The age of exploration/ Asian expansion
  – Islamic conquest of Constantinople cripples the trade routes of Venice and Genoa
  – Islamic conquest of Constantinople motivates Christian kings to look for a different route to the Indies
What the Renaissance knew

- The age of exploration
  - 1488: Bartolomeu Dias rounds the Cape of Good Hope
  - 1492: Cristoforo Colombo/Colon/Columbus accidentally discovers America (for Spain)
  - 1497: Italian seaman Giovanni Caboto/Cabot discovers the spring wind to travel from Britain to Canada
  - 1497-99 Vasco de Gama discovers how to travel from Portugal to India via the Cape of Africa (winds and currents of the South Atlantic)
  - 1522: Ferdinand Magellan's expedition circumnavigates the globe
What the Renaissance knew

• The age of exploration/ Asian expansion
  – Rise of Portugal, best placed Christian kingdom to bypass the Islamic lands and to reach south India
  – Portugal has nothing to offer to the Indies in exchange for spices hence it has to use firepower and colonize
  – Portugal becomes the first invader of India to come from the sea, not from the northeastern route
  – Decline of Venice and Genoa
  – Decline of Alexandria
What the Renaissance knew

• The age of exploration/ Asian expansion
  – The Dutch empire of the spices
    • Malaysia: tin and later rubber (1877)
    • China: silk and porcelain
    • Arakan (west Burma): slaves
    • Siam (Thailand): hides
    • Sumatra: Pepper and later tobacco (1858)
    • Java: textiles and later coffee (1791) and sugar
    • Borneo: camphor
    • Moluccas: nutmeg, mace, cloves
    • Celebes (Sulawesi): rice
• Cloves and nutmeg trees grew only on a few small volcanic islands...
What the Renaissance knew

• The age of exploration
  – Birth of the “corporation” in England (East India Company, 1599; Virginia Company, 1606; Massachusetts Bay Company, 1628; Hudson’s Bay Company, 1670) and the Netherlands (Dutch East India Company, 1602; Dutch West India Company, 1621) to fund long-distance trade
  – Netherlands in 1600
    • Most sophisticated capitalism
    • Greatest trading nation of Europe
    • Most efficient shipping technology (one third of British costs)
What the Renaissance knew

• The age of exploration
  – Spanish and Portuguese explorers colonize in the name of their monarchs (thus the interior too)
  – British and Dutch explorers colonize in the name of profit (thus mainly the coasts)
  – Future territory of the USA ignored by all powers for 150 years
What the Renaissance knew

• American colonies
  – Spain
    • Does not develop agriculture and commerce
    • Does not populate the colonies
    • Most of the colonists sent from Spain are male
      (racially mixed population)
    • Wealth depends on exploitation of native and slave
      population
  – England
    • Develops agriculture and commerce
    • Populates the colonies
    • Colonists are families (racially divided population)
    • Wealth depends on the work of immigrants
What the Renaissance knew

- Printing Press/ Before
  - Boom of universities and commerce has greatly increased demand for books
  - Copying manuscripts is time-consuming and error-prone
  - 1422: The library of Cambridge Univ has only 122 manuscripts
  - Gutenberg (1456): movable type (impractical for Chinese characters)
What the Renaissance knew

• Printing Press
  – First book: 210 copies of a 1282-page Bible (1456)
  – Culture shock: all copies are absolutely identical!

Huntington Library, San Marino, California
What the Renaissance knew

• Printing Press
  – Before the press: 50,000 books in all of Europe, mostly controlled by the Church
  – By 1501 there are 1000 printing shops in Europe, which had produced 35,000 titles and 20 million copies.
What the Renaissance knew

• Printing Press
  – Spreading of humanism throughout Europe
  – Spreading of Lutheran ideas (Luther’s protest used the new technology)
  – Spreading of bourgeois ideas
  – Spreading of vulgar languages (Latin remains for church and officials)
  – Spreading of national identity (the printing press as the voice and the consciousness of the people who speak the same language)
  – Destruction of the unified Latin culture of Europe
What the Renaissance knew

• Culture leaves the monastery - profession of the father
  - Thomas More lawyer
  - Mikolaj Kopernik merchant
  - Michel Montaigne merchant
  - Tycho Brahe aristocrat
  - Giordano Bruno poor soldier
  - Johannes Kepler poor soldier
  - Francis Bacon aristocrat
  - Galileo Galilei musician
  - Blaise Pascal judge
  - René Descartes politician
  - Thomas Hobbes priest
  - Robert Boyle aristocrat
  - Athanasius Kircher teacher
  - Baruch Spinoza merchant
  - Isaac Newton farmer
  - John Locke lawyer
  - George Berkeley aristocrat
  - Gottfried Leibniz teacher
  - Carl von Linne priest
  - David Hume aristocrat
What the Renaissance knew

• Leonardo (b1452)
  – Perspective
  – Art and Science
What the Renaissance knew

• Leonardo (b1452)
  – Systematic experimentation (not just speculation)
  – Not interested in tradition
  – Forces shape nature
  – Inductive method
  – The Earth rotates on its axis, the Sun does not move (pre-Copernican)
  – Manuscripts "lost" until the 18th century but widely circulated in his lifetime
What the Renaissance knew

- Leonardo (b1452)
  - Mechanical engineering
What the Renaissance knew

- Leonardo (b1452)
  - Mechanical engineering
    - Before Leonardo: military and architecture
    - After Leonardo: industrial applications and link with science
What the Renaissance knew

- Technological progress
  - Engineering literature written by engineers for engineers
    - Mariano Taccola's "De Machinis" (1449)
    - Hyeronimus Bruschwig's "Liber de Arti Distillandi" (1500)
    - Jacques Besson's "Theatrum Instrumentorum et Machinarum" (1569)
    - Vittorio Zonca's "Novo Teatro di Machine et Edificii" (1607)
What the Renaissance knew

• Technological progress
  – Technological progress still largely independent of scientific progress
  – Not only knowledge of nature but also control of nature
  – No major inventions but continuous widespread improvements
  – A side-effect of a new rationalist approach, but constrained by the guilds (no attempt to automate production)
What the Renaissance knew

• Science
  – Most scientific discoveries take place outside the universities
  – Academies and societies are private or royal
What the Renaissance knew

• Reformation (1517)
  – The Church owns one third of German land
  – Corruption of the Church (e.g., sale of indulgences)
  – Political rivalry between Pope and princes
  – Martin Luther
    • Sola fede: Salvation from faith alone
    • Sola scriptum: Faith comes from knowledge of God’s scriptures
    • The Bible rather than the Church as the source of religious authority
    • German nationalist sentiment
What the Renaissance knew

- Mikolaj Kopernik/ Nicolaus Copernicus (1530, Poland)
  - Heliocentric theory
    - The earth, spinning on its axis once daily, revolves annually around the sun
    - The planets too circle the sun
    - The Earth is one of the planets
    - The stars are very far
What the Renaissance knew

• Mikolaj Kopernik/ Nicolaus Copernicus
  – Heliocentric theory
    • A side effect of the discovery of America: if Ptolemy was wrong about the continents, and the Bible was missing America, then they might as well be wrong about the Earth’s movement
  – Very little help from technology: Copernicus uses the same instruments used by Ptolemy
What the Renaissance knew

- Tycho Brahe (1573, Sweden)
  - Discovered a nova (a new star)
  - Aristotelian/Christian view:
    - The world below the moon is imperfect and dynamic
    - The world above the moon is perfect and static
  - Brahe’s view:
    - The world above the moon is not as perfect as we think
What the Renaissance knew

• Johannes Kepler (1619, Germany)
  – Laws of planetary motion
    • Planets move in ellipses (motion is not uniformly circular)
    • The square of a planet’s periodic time is proportional to the cube of its mean distance from the sun
  – The heavens are a machine
Trivia

• What happened in
  – Italy, Spain and Poland between 4 Oct 1582 and 15 Oct 1582,
  – France between 9 Dec 1582 and 20 Dec 1582
  – Hungary between 21 Oct 1587 and 1 Nov 1587
  – Prussia between 22 Aug 1610 and 2 Sept 1610
  – Denmark between 18 Feb 1700 and 1 Mar 1700
  – Britain between 2 Sep 1752 and 14 Sep 1752
  – Greece between 9 Mar 1924 and 23 Mar 1924
  – Russia between 31 Jan 1918 and 14 Feb 1918
  – Turkey between 18 Dec 1926 and 1 Jan 1927?
What the Renaissance knew

- Francis Bacon (1620)
  - Truth must be found via objective, unbiased, empirical observation, and inductive accumulation of evidence
  - Induction vs deduction
  - Goal of science is to control the world ("how to command nature itself"), i.e. technology
What the Renaissance knew

• Galileo Galilei (1632)
  – A body in free motion does not need any force to continue moving
  – Linear uniform motion as the natural motion of all objects
  – If a force is applied, then what will change is the acceleration, not the velocity
  – Acceleration is the same for all free-falling objects
What the Renaissance knew

- Galileo Galilei (1632)
  - Celestial objects are not perfect spherical bodies
  - The Heavens are not static and perfect, but subject to forces and continuously changing
  - The same natural laws apply on Earth and in the Heavens
  - Matter is the same everywhere
What the Renaissance knew

- Galileo Galilei (1632)
  - Relativity: All physical laws are the same regardless of the observer’s state of motion as long as the velocity of the observer does not change (there is no local way of telling uniform motion from rest)
  - We do not perceive the speed of the Earth around the Sun because of Galileo’s relativity
What the Renaissance knew

• Galileo Galilei (1632)
  – Conservation of energy: energy changes in quality (from potential to kinetic) but is always conserved
What the Renaissance knew

• Science
  – Very fast: Olaus Roemer determines the speed of light (1676) - the speed of light is finite
  – Very small: Anton van Leeuwenhock proves the existence of microorganisms (1674)
  – Very far and very big: Galileo (1610) documents the mountains of the Moon and the moons of other planets (Jupiter)
What the Renaissance knew

- Telescope
  - Probably invented in 1600 in Holland
  - Transition from naked-eyed observation to device-mediated observation
  - 1610: Galileo points a telescope to the heavens (he peeks into God’s realm)
  - The Church had no problem with Copernicus’ mathematical theory but has a problem with Galileo spying God
  - The telescope reveals many more stars that the human eye cannot see
What the Renaissance knew

• Microscope
  – Probably invented in Germany
  – Robert Hooke’s “Micrographia” (1665): the cell
  – Leeuwenhoek sees microorganisms (1674)
What the Renaissance knew

- René Descartes (1644)
  - Rationalism
  - Dualism
  - Mechanicism
  - Reductionism
What the Renaissance knew

• René Descartes (1644)
  – Doubt as the foundation of philosophy
  – All our beliefs based on our sensations can be doubted
  – Everything can be doubted except my own existence: “Cogito ergo sum”
What the Renaissance knew

• Descartes (1644)
  – Two substances: matter has extension, mind has thought, each has its laws, they communicate via the pineal gland (Dualism)
  – Descartes indirectly brokered a truce between religion and science, by assigning sentient life to religion and matter to science.
What the Renaissance knew

• René Descartes (1644)
  – Equivalence between living and non-living matter
  – Animals are machines
  – Everything material can be reduced to mechanics
  – Human bodies are machines too but the soul is not
  – The universe is a mechanism
  – God is the clockmaker (determines the law that drive the mechanism)
What the Renaissance knew

• Descartes (1644)
  – Reductionism
    • The scientific method is to analyze a problem, decompose it into component parts, explain each component and then rebuild the whole
    • The whole is the sum of its parts
    • One can simplify a problem (reduce the complexity) by dividing the system into its parts
    • Civilizations were mostly holistic for thousands of years before the Cartesian revolution
What the Renaissance knew

- Descartes (1644)
  - Analytic geometry: isomorphism between algebra and geometry i.e. use algebra to solve geometry
  - Cartesian coordinates
What the Renaissance knew

• Thomas Hobbes (1651)
  – Materialism
    • Only matter exists
    • All knowledge comes from the senses
    • Nature is a mechanism
    • Human behavior is caused by material phenomena, and is controlled by the competing motivations of appetite and aversion: no free will
What the Renaissance knew

• Baruch Spinoza (1677)
  – There is only one substance: God
  – Monism instead of dualism: only one substance and it is God/Nature
  – God is all that exists (he is what is), there is nothing that is not God ("pantheism")
  – Things and souls are (finite) aspects (modes) of that one (infinite) substance
  – Spinoza got rid of the mind
What the Renaissance knew

• Baruch Spinoza (1677)
  – Immortality is becoming one with God/Nature, realizing the eternity of everything
  – Salvation is living in harmony with Nature (love of God)
  – Knowledge and meditation lead to a superior form of salvation: a direct intuition of reality and of the human condition
What the Renaissance knew

- Isaac Newton (1687)
  - The same physical laws apply to the entire universe
  - Physical laws can be formulated in terms of mathematical equations
  - Natural state: uniform straight motion
  - Absolute time and space
  - Force as cause of change of motion (acceleration)
  - Conservation of energy
What the Renaissance knew

• Isaac Newton (1687)
  – Principle of universal gravitation: every particle of matter in the universe attracts every other particle with a force varying inversely as the square of the distance between them and directly proportional to the product of their masses
  – Gravitational force as cause of planetary motion
  – Gravitational force as the reason that objects fall
  – Unification of terrestrial and celestial mechanics
  – Action at distance: bodies exert forces on one another through empty space
What the Renaissance knew

• Newton (1687)
  – Old view of the world
    • The universe is static. Stars have been placed by God in their place and will always occupy that location.
    • There is a fundamental difference between the Human world of the Earth and the Divine world of the Heavens
    • Galileo peaked into the Heavens and didn’t find the Divine but more Earths and Moons
What the Renaissance knew

• John Locke (1690)
  – Perceptions are mechanical interactions with objects, that cause mechanical interactions within the nervous system and ultimately the brain, where “sensations” arise (“causal” theory of perception)
  – These sensations produce ideas in our minds
  – Simple ideas are then combined by Reason to become complex ideas
  – All knowledge derives from experience ("empiricism")
  – Knowledge is acquired, not innate
What the Renaissance knew

• John Locke (1690)
  – The sensations are caused by the objects, but all we know is the sensations, not necessarily the real objects
  – The world is not necessarily what appears to us
  – Our theories of the world are only hypotheses, based on sensations that may not represent the truth and based on experiences that represent only a fraction of the “experienceable” world
  – Human knowledge is limited
What the Renaissance knew

- John Locke (1690)
  - Birth of psychology: Locke replaces “soul” with “mind”
  - The “I” is created by experience
What the Renaissance knew

- John Locke (1690)
  - People have rights (condemn of absolutism)
  - Three branches of government for "checks and balances"
  - Separation of church and state
  - Rule of the majority ("liberalism")
What the Renaissance knew

• George Berkeley (1710)
  – Idealism
    • Critique of Newtonian world: matter does not even exist
    • All we know is our perceptions
    • We cannot directly know that there is an external world ("esse est percipi")
    • There is only one substance: mind
What the Renaissance knew

- Gottfried Leibniz (1714)
  - Panpsychism
    - Only minds exist
    - There are infinite minds
    - Humans are not the only ones to have minds
    - Everything has a mind
    - Matter is made of minds (Leibniz got rid of the body!)
    - Minds come in degrees, starting with matter (whose minds are very simple) and ending with God (whose mind is infinite)
    - Reality is the set of all finite minds (or "monads") that God has created
What the Renaissance knew

• Leibniz (1714)
  – "Lingua characteristica": universal language based on the laws of Logic
    • The disparate disciplines of human knowledge can be unified by translating them into a universal language: a small set of primitive signs and a set of combinatorial rules to operate on them
    • The answer to any question can be obtained by a mechanical procedure of applying the rules to the signs
What the Renaissance knew

- David Hume (1740)
  - All ideas come from perception
  - "Mind" is a set of "perceptions" or ideas created from perceptions
  - The mind is a theater where perceptions play their parts in rapid succession
  - Mental life is a series of thoughts, feelings, sensations: “I am nothing but a bundle of perceptions”
  - The self is an illusion
What the Renaissance knew

- David Hume (1740)
  - Skepticism: critique of causation
  - Induction is not always right: Bacon’s scientific method does not always lead to truth
  - From what “is” we cannot infer what “will be”
  - No absolute truth: any belief is as justified as any other
  - Science is nothing but a set of beliefs shared by the scientific community
Body-mind debate

• Dualism: mind and body are made of two different substances
  – Substance dualism: the mind is a different (nonphysical) substance altogether from the brain

• Descartes
  – a substance is characterized by that property that it cannot lack and still be the same substance (extension and “cogito”)

• Hume:
  – The mind is a theater where perceptions play their part in rapid succession

– How do mind and body interact?
Body-mind debate

• Monism: only one substance exists
  – Materialism: only matter exists
    • Hobbes
      – Everything is a mechanism
  – Idealism: only mind exists
    • Berkeley
      – The only thing that exists is our mind
  • Pantheism: only God exists
    • Spinoza
  • Panpsychism: everything has a mind
    – Leibniz
  – How does one substance originate from the other?
What the Renaissance knew

• Prelude to industrialization
  – 1709: Abraham Darby pioneers the use of coke instead of coal to fuel the blast furnace
  – 1712: Thomas Newcomen invents the steam engine to pump water from a coal mine
What the Renaissance knew

• Prelude to industrialization
  – Metal revolution of the late 18th century
  – Most machinery still made of wood until 1800
  – Abraham Darby's iron foundry (1708)
  – John Wilkinson's boring machine (1774) that makes Watt's steam engine practical
  – Henry Maudslay's all-metal lathe (1794), a precision machine for screw cutting
  – Metalworking mostly confined to England
What the Renaissance knew

• Evolution of the Earth
  – Microscopy and geology introduce new species
    • Robert Hooke, "father of microscopy"(1665)
      – First detailed portraits of insects
      – Identification of the living “cell”
    • Nicolas Steno: "Prodromus/ Preliminary discourse to a dissertation on a solid body naturally contained within a solid" (1669)
      – Fossils are remnants of living beings of the past
      – The landscape of the Earth was created by rising seabeds
What the Renaissance knew

• Evolution of the Earth
  – Thomas Burnet: "Sacred Theory of the Earth" (1691)
    • Physical explanation for the events related in the Bible
  – Robert Hooke: "Discourse on Earthquakes" (1705)
    • The landscape of the Earth was created by catastrophic earthquakes over the Biblical time scale
  – Anton-Lazzaro Moro: "De' Crostacei e degli altri Marini Corpi" (1740)
    • The landscape of the Earth was created by volcanic eruptions
What the Renaissance knew

- Evolution of the Earth
  - Benoit de Maillet: "Telliamiad" (1718)
    - Physical explanation for the genesis of the Earth unrelated to the Bible
    - The landscape of the Earth was caused by retreating oceans
    - Time scale way beyond the Biblical time scale
What the Renaissance knew

- Renaissance Music
  - Polyphony of independence voices
  - Instrumental accompaniment
    - harpsichord (1450, Italy)
    - violin (1520, Italy)
    - pipe organ (16th c)
    - pianoforte (1720, Bartolomeo Cristofori, Italy)
What the Renaissance knew

• Baroque Music
  – Antonio Vivaldi (1678): "Cimento dell'Armonia e dell'Invenzione" (1725)
  – George-Frideric Handel (1685): "Concerti Grossi" (1740)
  – Johann Sebastian Bach (1685): "Die Kunst der Fuge" (1750)
What the Rinascimento knew

• Firenze 1420-1450
  – Brunelleschi
    • Dome for the cathedral (1418-38)
Sandro Botticelli: "Allegoria della Primavera" (1478)

Raffaello: "Marriage of the virgin" (1504)
Raffaello Sanzio: "Stanza della Segnatura" (1511)
Michelangelo Buonarroti: "Il Giudizio Universale" (1541)
Leonardo da Vinci: "Cenacolo" (1497)
Hieronymous Bosch: "The Garden of Delights" (1504)
Hieronymous Bosch: "The Garden of Delights" (1504)
Pieter Bruegel: "Triumph of Death" (1562)
El Greco

"Toledo" (1599)

“Burial of Count Orgaz" (1586)
Pieter Rubens: "Debarquement de Marie de Medicis" (1625)

Rembrandt: "Nightwatch" (1642)
What the Rinascimento knew

- Poetry, Theater, Novel
  - Gil Vicente (1465, Portugal): "Auto da Barca do Inferno" (1516)
  - Ludovico Ariosto (1474, Italy): "Orlando Furioso" (1532)
  - Francois Rabelais (1494, France): "Gargantua et Pantagruel" (1552)
  - Luiz Vas de Camoes (1524, Portugal): "Os Lusiadas" (1572)
  - Christopher Marlowe (1564, Britain): "Faust" (1592)
  - Edmund Spenser (1552): "The Faerie Queene" (1596)
  - William Shakespeare (1564, Britain): "Hamlet" (1601)
  - Lope de Vega Carpio (1562, Spain): "Fuente Ovejuna" (1614)
  - Miguel Cervantes (1547, Spain): "Don Quijote" (1615)
  - John Donne (1572, Britain): "Holy Sonnets" (1615)
  - Pedro Calderon (1600, Spain): "El Gran Teatro del Mundo" (1633)
  - Moliere (1622, France): "Le Misanthrope" (1666)
  - John Milton (1608, Britain): "Paradise Lost" (1667)
  - JeanBaptiste Racine (1639, France): "Athalie" (1691)
The Industrial Age

1750: There are about 300 states in Germany
1756: Britain and Prussia declare war against France, Austria and Russia ("Seven Years' War")
1776: the American colonies ratify the Declaration of Independence
1789: A popular uprising in Paris starts the French Revolution
1797-1815: Napoleonic wars
1812-24: Independence movement in Hispanic America
California’s population is 5,000
The Multi-national European Wars

- 1756-1763: Seven Years' war: Prussia and Britain win against France, Austria, Russia, Saxony, Sweden and Spain
- 1795-1815 Napoleonic wars: Austria, England, Russia, Spain, Sweden, Prussia win against France
- Ottomanic wars
  - 1768-74: Russia defeats the Ottomans
  - 1787-92: Russia and Austria defeat the Ottomans
  - 1806-12: Russia defeats the Ottomans
  - 1828-29: Russia, France and England defeat the Ottomans
  - 1853-56: Ottomans, England and France defeat Russia
Europe 1815

http://www.uni-potsdam.de/u/slavistik/diverses/maps/1815.htm
World 1813

After Napoleon’s victory

What the Industrial Age knew

- Textile inventions
  - James Hargreaves’ spinning jenny for the cotton industry (Lancashire, 1767)
  - Richard Arkwright’s power-driven machinery (spinning frame, 1769) and factory system of production (the world's first water-powered mill at Cromford, Derbyshire, 1771)
  - Samuel Crompton’s spinning mule (Lancashire, 1779), that combines the moving carriage of the spinning jenny with the rollers of Arkwright’s water frame
What the Industrial Age knew

- Textile inventions
  - Joseph Marie Jacquard’s weaving machine (France, 1804), using “punch cards” to program the loom

(Usher: A History of Mechanical Inventions)
The Industrial Revolution

- Britain

First stage: cotton textile factories of Lancashire (first powered by waterwheels, then by steam)

Second stage: cast-iron factories of Shropshire (powered by steam)
The Industrial Revolution

- Birmingham
  - Lunar Society, the most influential scientific academy, promotes the importance of machines
    - Joseph Priestly
    - James Watt’s steam engine
    - William Murdoch’s gaslight
    - John Wilkinson’s cast-iron boat
The Industrial Revolution

- Manchester
  - Water mills + coal mines + Liverpool's port + technology
  - Middle class runs most of the enterprises
  - 200 years of clock-making (cotton mechanics were clock-makers)
  - First polytechnic schools
  - Cotton: 0.6% of British industrial output in 1770, 9.2% in 1801, 25.3% in 1831 (more than 50% of the exports in 1830)
The Industrial Revolution

- Steam engine
  - Boom of factories causes high demand for iron
  - Iron has to be smelt with coal
  - The demand for coke (coal ridden of its gases that enables higher temperatures) increases exponentially to smelt iron
  - Problem: pumping water out of coal mines
  - 1776: James Watt improves the steam engine
  - 1782: the first steamboat sails the Clyde (Glasgow)
What the Industrial Age knew

- James Watt (1776)
  - Fuel crisis due to deforestation
  - Coal is the substitute fuel but difficult to extract because of water in the mines
  - Steam engine needed to pump floodwater from coal mines
  - Watt perfects Thomas Newcomen’s inefficient steam engine (1712)
What the Industrial Age knew

• James Watt’s steam engine
  – Transition from waterwheel to steam-power multiplies the output of textile mills
  – The textile industry moves from the riverside to the industrial city
  – Steam-power multiplies coke furnaces for cast iron
  – Freshwater more easily pumped to cities improving health
  – Steam-power revolutionizes transportation (train, steamship)
The Industrial Revolution

• Steam engine
  – Consequence: high demand for iron to build steam engines
  – And in turn steam engines facilitate the mass production of iron
  – Collapsing price of cast iron makes it popular as a building material
  – John Wilkinson builds iron parts for Watt’s engine and uses Watt’s engine to make iron
The Industrial Revolution

• The Factory
  – 1771: Richard Arkwright opens the first factory powered by water power (Nottingham, for cotton spinning)
  – Labor force: mostly women and children and a few male supervisors
  – 1785: Arkwright installs Wall’s steam engine and created the first steam-powered cotton mill
  – 1800: Boulton & Watt have sold 500 steam engines mostly to mines but also to blast furnaces and to factories and to pump freshwater to cities (Paris, 1782)
The Industrial Revolution

• The inventors
  – Inventors are ordinary people, not academics and not nobles
    • Hargreaves (poor weaver), Arkwright (barber, the 13th child of a poor family), etc
  – The automation of manufacturing begins in Lancashire, not at a royal court or at a university
The Industrial Revolution

- Labor force
  - Workers need little or no skills (ever younger children get employed by factories)
  - Machines to build ever better machines that require ever fewer skills
  - Artisans who lost their source of livelihood
  - Peasants who migrate to industrial cities
  - Wealth gap between capitalists and workers
  - Transition from rural poverty to urban poverty
  - A new social class: the proletariat
The Industrial Revolution

• The workers
  – Overcrowded factory towns beget new diseases (cholera epidemics of 1832, 1848, 1853)
  – Working conditions (long hours, dangerous machinery, pollution) shorten life expectancy
  – James Kay’s “The moral and physical condition of the working-class employed in the cotton manufacture in Manchester” (1832)
  – Edwin Chadwick’s “The Sanitary Condition of the Labouring Population” (1842)
  – Friedrich Engels’ “Condition of the Working Class in England” (1844)
  – Public Health Act (1848)
  – Great Stink of London (1855)
The Industrial Revolution

• The bourgeoisie
  – Factory owners
  – Railroad builders and shipbuilders
  – Bankers and insurers
  – Lawyers
  – Importers of raw materials
  – Exporters of finished goods
  – Engineers
The Industrial Revolution

- The north/south cold/warm divide: temperature or religion?
  - Civilization had always thrived in the warm regions of the planet (Egypt, Greece, Mesopotamia, southern Italy, Indus Valley, Yellow River Valley, Islamic world) whereas the cold regions were the regions of the "barbarians" (agriculture/trade vs nomads)
  - By the age of the industrial revolution the pattern had reversed: northern (colder) countries were richer than southern (warmer) countries
The Industrial Revolution

• Transportation revolution
  – 1761: Francis Egerton finances the Bridgewater Canal
  – England’s private sector creates a national network of canals to transport fuel and goods
  – 1800: Robert Fulton builds the first steam paddleship, the Clermont (propelled by Watt’s steam engine) launching the era of steamships
  – 1804: Richard Trevithick builds the world’s first locomotive (“Iron Horse”), launching the era of trains
The Industrial Revolution

- **Transportation revolution**
  - 1812: Henry Bell starts the first commercial steamboat service in Glasgow
  - 1819: The "Savannah" (New York shipyard of Fickett & Crockett) completes the first transatlantic crossing by a steamboat (in 28 days)
  - 1820: The first iron steamship, the “Ann Manby”
  - 1830: The world’s first commercial railroad opens (George Stephenson’s Liverpool-Manchester)
  - 1838: Regular transatlantic ship service begins
What the Industrial Age Knew

• Electrical revolution
  – William Gilbert (1600): coins the term "electricity" (from “elektron”, the Greek word for amber: amber becomes charged by rubbing)
  – Stephen Gray (1729): conductors and nonconductors, positive and negative charge (electricity flows from one place to another)
  – Benjamin Franklin (1752): lightning is a form of electricity
  – Charles Coulomb (1791): law of attraction and repulsion
  – Alessandro Volta (1800): battery that transforms chemical energy into electricity
  – Humphry Davy (1806): identity of electrical and chemical forces
What the Industrial Age Knew

- Electrical revolution
  - Hans-Christian Oersted (1820): an electrical current has magnetic properties
  - Michael Faraday (1830s) invents the transformer and the dynamo (electricity and magnetism together can produce motion)
  - Faraday proves that all electricities (Franklin’s, Galvani’s, Volta’s) are the same and views space as full of electromagnetic fields (but does not use mathematical proofs, only intuition)
What the Industrial Age Knew

- Chemistry
  - Joseph Black (1755): carbon dioxide
  - Henry Cavendish (1766): hydrogen
  - Joseph Priestly (1774): oxygen
  - Henry Cavendish (1785): water and air are not elements but compounds (oxygen+hydrogen, oxygen+nitrogen)
  - Antoine Lavoisier (1777): combustion is a form of oxidation (combination with oxygen), water contains oxygen and hydrogen
  - Antoine Lavoisier (1789): conservation of mass (the quantity of matter is the same at the end as at the beginning of every chemical reaction)
  - John Dalton (1803): matter is composed of atoms of differing weights
What the Industrial Age Knew

Lighting revolution

1792: William Murdoch invents gas lighting
1812: The London and Westminster Chartered Gas-Light and Coke Company is established
What the Industrial Age knew

- Adam Smith (1776)
  - The production and distribution of wealth
  - Free enterprise system
  - Free competition and free trade
  - Competition works for the common good ("invisible hand")
What the Industrial Age knew

• Adam Smith
  – The American colonies are a cost (money and blood)
  – They only benefit the capitalists but not Britain as a whole
  – Weakens the theoretical foundations of the British Empire
The Atlantic Slave Trade

• Sugar consumption in Europe
  – 1400: exotic rarity
  – 1700: a necessity, but an expensive one
  – 1800: 4 kgs/year per person
  – 1900: 50 kgs/year per person
  – (2000 in USA: 30 kgs per person)
The Atlantic Slave Trade

• History of Sugar Plantations till 1700
  – Arabs acquired sugar when they invade Iran and spread it all over the southern Mediterranean in large scale operations
  – Crusaders discovered sugar in Palestine/Lebanon and Italians managed sugar operations
  – Mongol expansion and loss of Palestine (1291) force the Italians to move operations elsewhere
    • Cyprus, Crete, Sicily
    • Labor-intensive
    • Capital-intensive
The Atlantic Slave Trade

• History of Sugar Plantations 1200-1700
  – Portuguese possessions
    • Madeira (1480s): Italian techniques and capital (Sicilian technology and marketing by Lomellino family of Genoa), indigenous labor force (biggest exporter of sugar in the world in 1500)
    • Sao Tome` (1500s): exclusively slave labor, faster-growing operations (between 1501-1550 it imports more African slaves than Europe or America)
    • Brazil (1540s): Amerindian and African slaves
    • The combination of sugar and slaves brings imperial wealth
    • Sugar becomes as important as Asian spices
The Atlantic Slave Trade

• History of Sugar Plantations 1700-1900
  – Caribbean islands, 1700s
    • Barbados, Jamaica (English): Estates over 200 acres, over 100 slaves
    • Martinique, Guadelupe, Saint Domingue (French): Estates over 1000 acres, over 200 slaves
  • From 1713 to 1822 the West Indies lead Asia, Africa and North America in commodities exported to Britain
The Atlantic Slave Trade

- History of Sugar Plantations 1700-1900
  - USA Plantations, 1800s
    - Population not self-sustaining, required constant flow of new slaves
    - Diversification: tobacco, cotton
    - Cotton fueled industrial revolution
    - Large-scale, capitalist operations
    - Specialization and mass production
The Atlantic Slave Trade

• History of Sugar Plantations 1700-1900
  – Britain
    • Sugar has become a necessity by 1800
    • Britain: 9 kgs per person per year
    • France: not even 1 kg
    • Imported sugar indispensable for drinking imported tea, imported coffee and imported chocolate from imported porcelain
What the Industrial Age knew

• British Empire
  – Self-appointed mission to redeem the world, being the first democratic country (Magna Carta) and a Christian country
  – A liberal empire, pretending to enslave in the name of freedom
  – The seeds of its demise were planted by the original colonists: explorers, adventurers, traders, hunters, preachers, criminals (they all cherish freedom above all else)
What the Industrial Age knew

- British Empire
  - Global communications
    - steamships
    - railroads
    - telegraph
    - undersea cable (Dover-Calais 1851, North America 1866, Australia 1871)
  - they unified colonies as "nations"
  - they fostered global trade
  - they created a worldwide logistical system
What the Industrial Age knew

• Enlightenment/ “Les Lumieres”
  – Materialism: the world is ruled by physical laws
  – Reason: only reason is necessary to understand the world
  – Knowledge: everything reason has understood can be organized in encyclopedias for use by other humans
  – Atheism/deism: religion is superstition
  – Progress: understanding the (natural) world is the key to improving the (human) world
What the Industrial Age knew

• Enlightenment/ Causes
  – Why France?
  • No political freedom compensated by relative freedom of speech (e.g., salons) and of customs (e.g., sexual)
  • Jesuit schools (Voltaire and Diderot both educated by the Jesuits)
  • Legacy of Richelieu’s technocratic state and French Academy
  • Envy of Britain’s political freedom (Voltaire’s exile in Britain, 1726)
What the Industrial Age knew

- Julien Offray de LaMettrie (1748):
  - The mind is a machine
  - Thought is the physical processes of the brain
  - Perception and learning are changes in the physical structure of the brain
  - Organisms are machines
  - Anatomical correspondence and behavioral correspondence between animals and humans
  - Man is an animal
  - Animals have feelings too
  - Life arose from a primordial soup and then evolved
What the Industrial Age knew

• Georges Buffon (1749)
  – A history of life and of the Earth that is not based on the Bible
  – Fossils are past animals
  – The Earth must be a lot older than 6,000 years
  – The Earth went through a number of stages that changed its environment
  – Some animals became extinct
What the Industrial Age knew

- Enlightenment/ “Philosophes”
  - Voltaire (1756)
    - Deism, a purely rational religion
      - God created the universe and the physical laws that govern it
      - God has nothing to do with the affairs of the universe
      - God cannot be bribed by humans (prayers, rites)
      - Humans can choose good or evil
      - Humans shall be punished or rewarded accordingly
What the Industrial Age knew

- Enlightenment/ “Philosophes”
  - Voltaire (1756)
    - Moral crusade against intolerance, tyranny, superstition
      - The Church as a monster
      - The State as a mass murderer (“all murderers are punished unless they kill in large numbers”)
      - But also contempt for the masses
What the Industrial Age knew

• Enlightenment/ “Philosophes”
  – Voltaire (1756)
    • Freedom of thought ("Je ne suis pas d'accord avec ce que vous dites, mais je défendrai jusqu'à la mort le droit que vous avez de le dire")
    • Invention of public opinion (he addresses the masses, not the elite)
What the Industrial Age knew

• Enlightenment/ “Philosophes”
  – The Enlightenment
    • discredited revealed religion (Voltaire, Diderot)
    • discredited the ancient regime (Rousseau)
    • emergence of a critical spirit
What the Industrial Age knew

• Enlightenment/ “Philosophes”
  – France becomes the cultural dictator of Europe, determining taste in literature and art
  – French replaces Latin as the language of the European aristocracy
What the Industrial Age knew

• Enlightenment in Europe
  – General optimism about the human mission, grounded in science and reason (will last till the world wars)
  – Scientific determinism gradually replaces religious faith
  – Realism
What the Industrial Age knew

- Enlightenment in Europe
  - The public sphere where new ideas circulate
    - The novel
    - The newspaper
    - The concert
  - Books replace music as the main entertainment
  - The ideas of the intelligentsia spread to the middle class
  - Emancipation of middle-class taste from the dogmas of the aristocracy
  - The literary critic
What the Industrial Age knew

- Deism in the USA
  - George Washington
  - Thomas Jefferson
  - Benjamin Franklin
  - Tom Paine (“The Age of Reason”)

- The US revolution is a practical application of the Enlightenment
What the Industrial Age knew

• Loss of credibility by the Bible
  – 1492: America is not mentioned in the Bible
  – 1572: A new star appears in the sky (a nova)
  – The other continents never heard of Jesus and have different prophets
  – Contradictions between Old and New Testaments
  – Church dogmas not justified by the scriptures
  – Edward Gibbon: Christianity caused the fall of the Roman Empire
What the Industrial Age knew

• French Revolution (1789-94)
  – Frustrated citizens of France’s “ancient regime”:
    • Rising bourgeoisie
    • Seven Years War
    • Aggrieved peasants
    • Intellectuals (of all classes) influenced by Philosophes
    • Mobs angered by famine in the countryside and shortage of bread in Paris
What the Industrial Age knew

• French Revolution (1789-94)
  – New political discourse
    • Salons organized by women in Paris
    • The philosophes of Diderot's encyclopedia
    • Rise of the press
    • The monarchy lost control of what its subjects were reading
    • Creation of a "public sphere" outside the control of the state
What the Industrial Age knew

• French Revolution
  – Sep 1792: National Convention - End of monarchy
  – Jan 1793- Nov 1794: Robespierre's Terror
  – Jan 1793: War on Britain, Netherlands and Spain
  – Aggressive attitude against the other powers
  – The other powers feel threatened by the revolution
  – 1799-1815: Napoleon
What the Industrial Age knew

- French Revolution (1789)
  - Guillotine (first used in April 1792)
What the Industrial Age knew

• French Revolution (1789-94)
  – Dismantling of feudalism: a casteless society
  – Losers: aristocracy (loses land to the peasants) and Church (loses most of its wealth but retains some power because people still believe in the Catholic dogma)
  – Beneficiaries: bourgeoisie (money buys power) and peasantry (gets the land of the aristocracy)
What the Industrial Age knew

- French Revolution (1789-94)
  - Not a class war between bourgeoisie and aristocracy (85% of people executed were commoners)
  - The "nation" replaced "God" and "King" (birth of nationalism)
  - The future is good, the past is bad
  - The political discourse dominates in France while the literary and scientific discourses dominate in Britain
What the Industrial Age knew

• Napoleon’s experiment (1795-1815)
  – Enlightened leader
  – Vision of a federation of free European peoples
  – Code Napoleon:
    • Abolition of serfdom
    • Freedom of religion
    • National constitutions
    • Universal male suffrage
    • Parliament/ bill of rights
    • Free public schools
    • Academies for arts and sciences
    • French scholars to Egypt (1798)
What the Industrial Age knew

• Napoleon’s experiment (1795-1815)
  – Consequences
    • National spirit
      – Aspiration to unification by people who speak the same language but are fragmented into several states (Italy, Germany)
      – Aspiration to independence by people who speak the same language and are subjects of an empire that speaks a different language (Austro-Hungarian subjects, Italians)
What the Renaissance knew

• Prussia
  – Education
    • Inspired by Athens and Renaissance (the German nation is a federation of nations just like ancient Greece and Italy)
    • Greek revival in universities
What the Renaissance knew

- Prussia
  - Education
    - Wilhelm von Humboldt (1792)
      - Reform of education in Germany
      - Establishment of Technische Hochschulen and Gymnasien (classical school based on Greek civilization)
      - Abitur examination
      - Berlin Univ (1810): the first university founded on research
      - Depth of knowledge, not breadth
      - The PhD
What the Renaissance knew

- Prussia
  - Education
    - Before the PhD:
      - Engineers and doctors learn on the job
      - Science is a hobby
      - Research depends on patronage from nobility and gentry or the scientist is financially independent (Darwin)
      - Ecole Polytechnique in Paris (1794) invents the science/engineering student but Napoleon turns into a military school
      - Science lagging behind technology
What the Renaissance knew

• Prussia
  – Education
    • After the PhD:
      – Formal courses in science and engineering taught by researchers
      – Competitive examinations
      – The model spreads to Britain and the USA
      – 1870: the better educated country (Germany) wins the war (against France)
      – Science overtakes technology
What the Renaissance knew

• Prussia
  – Education
    • French science is centered upon Paris,
    • but Germany is not a state and does not have a center: science is distributed across many capitals (Berlin, Munich, Dresden, Weimar, Hamburg….)
What the Industrial Age knew

• Thomas Bayes (1761)
  – Probabilities
  – Our knowledge is mainly probabilistic
  – As we learn more facts, we update our “confidence” in our beliefs
  – Learning is an incremental process of getting closer and closer to the truth
  – Trivia: unpublished manuscript discovered after his death
What the Industrial Age knew

- Joseph Fourier (1827)
  - Any periodic function can be decomposed into sine and cosine functions
  - Everything that is continuous can be represented as a sum of waves

\[
f(x) = \frac{A_0}{2} + \sum_{m=1}^{\infty} A_m \cos(mkx) + \sum_{m=1}^{\infty} B_m \sin(mkx),
\]

where \( k \) is the function’s frequency and is related to the period via \( k = 2\pi/\lambda \). The coefficients \( A_m \) and \( B_m \) are given by

\[
A_m = \frac{k}{\pi} \int_{-\lambda/2}^{\lambda/2} f(x) \cos(mkx) dx, \quad m \geq 0,
\]

\[
B_m = \frac{k}{\pi} \int_{-\lambda/2}^{\lambda/2} f(x) \sin(mkx) dx, \quad m \geq 1.
\]
What the Industrial Age knew

- Evolutionism
  - Jean-Baptiste Lamarck (1809)
    - Biology founded on the concept of evolution
    - All living beings were formed through evolution
    - Inherent tendency of life towards complexity
    - Irregularity in evolution due to environmental circumstances
    - Changes in the environment cause changes in living beings, both body and habits
    - Bodily changes are inherited
    - Habits are inherited
What the Industrial Age knew

- Immanuel Kant (1781)
  - Reaction to Descartes’ dualism: the world is itself a product of our mind
  - We are not passive experiencers of the world; we are the creators of the world we experience.
  - Time and space themselves are not inherent qualities of the physical world but tools of the mind.
What the Industrial Age knew

• Immanuel Kant (1781)
  – The ultimate reality (the thing-in-itself, "ding an sich") cannot be experienced by the human mind
  – We experience the world as we perceive it through our (human) nature
  – We cannot know how things are in themselves
  – We cannot know the objects of the world, but only our perceptions of such objects
What the Industrial Age knew

• Kant (1781)
  – Not all our knowledge is derived from experience
  – Some basic knowledge is built into the human mind at birth
  – These “categories” (such as space and time) are basically organs of perception
  – Newton had introduced an absolute space and time “outside” the mind. Kant located them inside the mind.
What the Industrial Age knew

• Kant (1781)
  – Kant’s Ethics:
    • Reaction to the utilitarianism of the Enlightenment: a morality that determines duty regardless of pleasure and pain
    • There is an absolute good
    • The existence of morality is as evident as the existence of physical objects
    • Categorical imperative: good actions are those that one would want as universal laws
What the Industrial Age knew

- German Idealism
  - A reaction to the new authority of science
  - There is a limit to human knowledge/reason
  - There is a reality that the human mind cannot know
What the Industrial Age knew

- Peter Schilling (1800)
  - The phenomena of the world vary in degree of self-consciousness, from the rocks (will is completely unconscious) to humans (will is conscious)
  - Consciousness emerges from unconscious matter through stages of self-organization
  - All that exists is continuously being redefined by the process of self-organization
  - The universe is moving towards a higher consciousness of itself
What the Industrial Age knew

• Georg-Wilhelm-Friedrich Hegel (1807)
  – Only the Absolute exists, everything else is an illusion (eg space and time, objects, any division of the Absolute)
  – The Absolute is both the infinite universe and infinite pure mind
What the Industrial Age knew

• Hegel (1807)
  – Dialectical method (progress is the result of the conflict of opposites)
  – Any attempt to state the reality of something (thesis) results in a contradiction (antithesis) that can only be resolved (synthesis) at a higher level, where both are true, which yields a new thesis, for which there exists an anti-thesis, which can be resolved in a synthesis, etc. All the way to the highest level, the absolute
  – Reality (nature as well as human history) is the dialectical unfolding of the absolute
What the Industrial Age knew

• Hegel (1807)
  – History is due to the conflict of forces/nations
  – An entity lays down a challenge, which becomes a thesis
  – An antithesis arises
  – A synthesis resolves the two on a higher plane
  – (eg, “revolution” is opposed by “reaction” and the synthesis is a new social order)
  – History is the unfolding of the world spirit
What the Industrial Age knew

• Arthur Schopenhauer (1819)
  – A human being is both knowing and willing
    • As knowers, humans experience the world in terms of space, time and causality (the “view from without”, the world as representation, cognitive view)
    • As free-willing beings, humans are also provided with a “view from within” (the world as will, conative view)
    • The knowing intellect only knows the surface, while the will is able to grasp the ultimate meaning
What the Industrial Age knew

• Arthur Schopenhauer (1819)
  – We can know reality in itself, but only from within, via self-knowledge, via the realization that we are “will” (striving nature of conscious beings)
  – Mind (conscious and unconscious) is will
  – Will is the inner force of human life
  – “Will and acting are one”
  – Will is the true substance of the body
What the Industrial Age knew

- Schopenhauer (1819)
  - The will's constant urge for achievement of ever more ambitious goals causes human unhappiness
  - We are victims of our insatiable will
  - The will is the origin of our sufferings: the less you "will", the less you suffer
  - The endless cycle of willing and suffering can be broken only by ceasing the striving, i.e. Buddhist-like resignation/contemplation
  - Salvation requires an “euthanasia of the will”
What the Industrial Age knew

• Carl Friedrich Gauss (1824)
  – The study of numbers as a science in itself
  – Prime numbers
  – Imaginary numbers
  – Non-Euclidean geometry
What the Industrial Age knew

• Sadi Carnot (1824)
  – Study of heat
  – Foundations of Thermodynamics
  – Perpetual motion is impossible
  – Second law of Thermodynamics
What the Industrial Age knew

• Auguste Comte (1826):
  – Sociology: Science of society
  – Society undergoes the same three stages as Science
  – Scientists will rule countries in the last stage
  – Study the future, not the past
What the Industrial Age knew

• John Stuart Mill (1836)
  – Ethics
  – The moral value of an action depends on its outcome: a good action is one that has a good outcome
  – The best action is the one that pleases the greatest number of people
What the Industrial Age knew

• Charles Darwin (1839 although published in 1859)
  – Animals evolved
    • New species evolved from pre-existing species
  – Evolution = variation + selection
    • Variation is ubiquitous
    • Natural selection is the driving force of evolution
    • New species are created by the action of natural selection on variation
  – Adaptation
    • New species are caused by the need to adapt to environmental changes
What the Industrial Age knew:

- Charles Darwin (1839 although published in 1859)
  - Mystery of variation, that appears to be random
  - Variation can only be treated as a statistical quantity and described statistically
  - Populations, not individuals
What the Industrial Age knew

• Soren Kierkegaard (1846)
  – The philosopher cannot be a detached, objective, external observer: the philosopher is someone who exists and is part of what is observed (an “existing subjective thinker”)
  – Existence is both the thinker’s object and condition
  – The truth that matters is the pathos of existing, not the truth of Logic
  – Logic is defined by necessity, but existence is dominated by possibility
What the Industrial Age knew

- Utopian socialism
  - Charles Fourier (1808)
    - Reorganization of society around phalanxes
  - Claude Rouvroy de Saint-Simon (1825)
    - Scientists to lead society ("positivism")
    - Christianity to inspire industrialization
    - Industrialization to improve lives
  - Pierre Proudhon (1843)
    - Anarchy: elimination of government
    - Property is theft
    - Educate people so that government and police would become unnecessary
What the Industrial Age knew

• Karl Marx (1847)
  – What is the value of a product
    • time/cost of producing it vs price people are willing to pay for it
  – The capitalist class (bourgeoisie) exploits the working class (proletariat) by keeping the "surplus value" produced by the working class
  – By reinvesting the “surplus value” the capitalist class increases its control of society
What the Industrial Age knew

• Karl Marx (1847)
  – The working class is “alienated” because producer and product are separated
  – Private property is the result of the process of alienation, and vice versa
  – Workers do not own the product of their work
  – The working class is further alienated because the capitalists own the production system
What the Industrial Age knew

• Karl Marx (1847)
  – Socialism: all citizens own the means of production
    • Just distribution of wealth and services
    • Human needs, not profits
  – Communism: full equality, class-less society
What the Industrial Age knew

• Karl Marx (1847)
  – All nations go through five economic stages, whose character is determined by the relations of production: slavery, feudalism, capitalism, socialism (collective ownership of property), communism (rule of the people)
  – The ultimate goal of history is a class-less society of peers (Hegelian synthesis = communism)
  – Society with government (as a separate institution) will evolve into communism
  – The working-class shall overthrow the capitalist class
What the Industrial Age knew

• Birth of Mass Media
  – The serialized romance (Richardson's "Pamela", 1740)
  – Sentimental novel (Goldsmith’s “The Vicar of Wakefield”, 1766)
  – Domestic tragedies (Goerge Lillo, 1730s)
  – The gothic novel (Walpole’s “Castle of Otranto”, 1764; Lewis’ “The Monk”, 1796)
  – Juvenile books (booming in the 1780s)
  – Theatrical "spectacles" (pantomime, ballet opera)
What the Industrial Age knew

• Birth of Mass Media
  – Being a writer becomes a profession (no need for aristocratic sponsors)
  – Anybody can be a writer (even housewives)
  – Publishing and selling books becomes a lucrative business (notably Lackington, 1774)
  – Women become a major class of readers, and later of writers (replacing card games with bluestocking clubs)
  – The writer becomes an observer of real life
What the Industrial Age knew

• George Boole (1854)
  – Applying algebraic methods to a variety of fields (Leibniz’s project)
  – Logical propositions denoted by symbols
  – Laws of logic denoted by operators
  – “All humans are mortal” translates into “All y are some x” or $y = vx$, and can be further derived: $y - vx = 0$, “Non-mortal humans do not exist”
  – Systematic use of symbols eliminates the ambiguities of natural language
  – Logic becomes as rigorous as Mathematics
What the Industrial Age knew

• Non-Euclidean geometries
  – Carl-Friedrich Gauss (1824, Germany): Euclid's postulate of the unique parallel can be replaced by the postulate that through any point there are an infinite number of parallels)
  – Nikolaj Lobachevsky (1826, Russia)
  – Janos Bolyai (1829, Hungary)
  – All of them: the sum of the angles of a triangle is less than 180 degrees
What the Industrial Age knew

- Bernhard Riemann (1854 lecture at Gottingen)
  - General class of geometries (any number of dimensions in any kind of space), that comprises the classical Euclidean geometry as a special case
  - The geometry of the surface of a sphere in which all straight lines are great circles (no parallel lines at all, unless space is flat)
  - Spaces with any number of dimensions
  - Space can be curved instead of flat
  - The curvature of space is measured by a “curvature tensor”
  - The sum of the angles of a triangle is greater than 180 degrees
What the Industrial Age knew

• Charles Babbage: "Difference Engine" (1859), manufactured by Edvard Scheutz
What the Industrial Age knew

• Poetry
  – William Blake (1757, Britain): "Jerusalem" (1820)
  – Anti-rationalist: “Science is the tree of death”
  – Friedrich Hoelderlin (1770, Germany): “Der Archipelagus” (1800)
  – William Wordsworth (1770, Britain): “Prelude” (1805)
  – Johann Wolfgang Goethe (1749, Germany): "Faust" (1832)
  – Heinrich Heine (1797, Germany): "Das Buch der Lieder" (1827)
  – Giacomo Leopardi (1798, Italy): “Canti” (1835)
What the Industrial Age knew

• Music
  – 18th c: the symphony orchestra is born with its four sections (strings, winds, brass and percussion)
  – 1720s: a new genre emerges, the symphony, that becomes the main form in Germany, where it becomes the musical manifestation of Idealism (music = philosophy)
What the Industrial Age knew

• Music
  – Wolfgang-Amadeus Mozart (Austria, 1756): Concerto 21 in C K467 (1785)
  – Mozart (Austria, 1756): “Don Juan” (1787)
  – Franz-Peter Schubert (Germany, 1797): “Unfinished Symphony” (1822)
  – Beethoven (Germany, 1770): “Symphony No 9” (1824)
  – Berlioz (France, 1803): “Symphonie Fantastique” (1830)