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AN IMPRESSIONIST PICTURE OF THE HISTORY OF ASTRONOMY

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The chart which follows is a compilation of certain selected "events" in the history of astronomy, presented against a constantly shifting cultural and scientific background. There is a horizontal and a vertical division. "Events" have been grouped into categories (astronomical discoveries, instrumentation, mathematical discoveries, science, society) and into suitable (not necessarily constant time intervals.

A paper in Am.J.Phys. [1] outlines the motivation and structure of this compilation; suffice it to note here that the compilation should not be considered as a complete history; technical jargon creeps in, there is no description or discussion and the material has been selected brutally. It is a tool to be used with more traditional texts, which enables one to "feel" the overall intellectual "climate" of a given epoch and maybe discern trends and patterns of scientific change. In this sense, the compilation bears much the same relation to history as an impressionist painting to a photograph: the information content is less, but one understands the scene better.

Note that the dates given for people correspond (in some cases only approximately) to their birthdates, and that is also the order in which they appear.

To compile this picture, I have drawn heavily on the standard texts given in the bibliography [2]-[10]

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BEFORE -1300

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
Civil year.divided into 365 days (without systematic rules for inserting days) ; seasons determined by first heliacal rising of Sirius ; religious calendar based on moon (Egypt)	Merkhet (Meridian instrument held in the hand)	Sexagesimal positional notation ; arithmetical tables ; arithmetical methods for finding" solutions to 1st and 2nd degree equations ; geometry reduced to arithmetic (Babylon)	Construction of pyramids ; orientation with respect to stars ; Monumental sculpture ; Clepsydre (Egypt)-	Cuneiform writing on clay tablets (Assyria)	- 2800 Cheops
	Primitive linear sundial (Egypt)			Hyeroglyphic writing on papyrus (Egypt)	- 2695 Start of Great Pyramid
Naive, descriptive cosmologies ; interpretation entirely mystical	Precision of angular measurement ≈ degrees	Non-positional decimal notation ; all arithmetical problems solved by use of addition tables ; empirical geometry (Egypt)	Weaving	Egyptian economy based on the annual flooding of the Nile and use of slaves	- 2100 Hammurabi
			Forge bellows		
Stars grouped into constellations ; stellar positions defined with respect to horizon			Loom		
			Steel	Human behaviour strictly directed by religious laws	
			Day divided into 12 "unequal" or "temporary" hours for social activities	Establshment of monolithic empires and "competing" gods	- 1350 Tutankhamen
					- 1300 The Exodus

	Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, technology and Philosophy	Society	Fiducial Points
- 1300			Tables for $X^2 + Y^2 = Z^2$ (Babylon)		Alphabetic writing (Phoenicians)	- 1298 Ramses II - 973 Solomon - 900 Homer - 814 Foundation of Carthage
- 800	Prediction of lunar eclipses --- Recognition of the retrograde movement of certain planets			Compilation of classification schemes (for plants, words, happenings, etc) --- Map of the known world (Babylon)	Rise of state astrology (celestials happenings as signs of social events "to be") (Assyria) --- Rise of divinatory sciences	- 742 Ahaz king of Judah
- 700	Establishment of 12 zodiacal constellations			Welding of metals	Library of Assurbanipal	- 624 Thales - 612 Fall of Ninevah - 611 Anaximander - 604 Nebuchadnezzar - 600 Lao-Tse
600						

	Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, technology and philosophy	Society	Fiducial Points
-600	First greek cosmologies : rational, but naive and not always in agreement with even crude observation	Sights	Irrational numbers	Problem of the "fundamental element" (water, motion, thought, number, atom ?) (Greece)	Greek world fragmented into small, independant trading states ; commercial exchanges "overseas" ; beginnings of Athenian empire	
	Determination of relative positions of the stars		Alphabetic, non-positional arithmetic notation in Greece			- 580 Pythagoras - 576 Heraclitus - 551 Confucius - 539 Fall of Babylon - 530 Parmenides
	"Morning Star" recognised as identical to "evening star"		Rise of geometry	Properties of amber and lodestone		
	Round Earth (Pythagoras)			Building of Doric Temples		
-500				Four fundamental elements (Empedocles)	Athenian democracy based on slaves	- 499 Pericles - 494 Empedocles - 490 Zeno - 484 Herodotus - 480 Euripides - 470 Socrates - 460 Hippocrates - 431 Phidias - 427 Plato, Xenophon - 413 Diogenes - 408 Eudoxus - 405 Fall of Athens
				Atoms (Democritus)	Wars between, for example, Athens and Sparta	
				Sophism		
				Cynicism		
				Fixed pulley		
				Building of Parthenon		

	Astronomical Discoveries	Astronomical Instrumentation.	Mathematical Discoveries (4)	Science, technology and philosophy	Society	Fiducial Points
-400	Stellar positions with respect to celestial equator --- Year of 354 or 384 days according to the appearance of the sky --- Inequality of the 4 seasons --- Retrograde movement of the planets explained by homocentric spheres (Eudoxus, Aristotle)	Sundial based on movement of shadow over inner surface of hemisphere: "hemispherum (Chaldea)	Euclid's geometry --- The world as an exercise in applied mathematics (Plato)	4 first regular solids as fundamental elements (Plato) --- The world as a closed sphere --- Systematic study of nature (Aristotle)	Expansion of Macedonian power; Hellenistic empire from Egypt to the Indus	- 384 Aristotle - 356 Alexander - 341 Epicure - 330 Euclid - 310 Aristarchus
300						

	Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, technology and Philosophy	Society	Fiducial Point
-300	Heliocentric model of solar system with circular orbits (Aristarchus)	First graduated circles	Complete treatment of conic sections (Appolonius)	Vague ideas about refraction of light	Breakup of Alexander's empire	- 287 Archimedes
	Determination of the inclination of the ecliptic		Development of arithmetic	Properties of the lever.	Rise of Alexandria as cultural and scientifics centre of the world	- 275 Eratosthenes - 260 Appolonius
	Estimate of the relative size of the sun			Screw		
	Speculations on the size of the universe (Archimedes)			Hydrostatics	Roman incursions into Greece	17 Hannibal
				Size of the Earth		
				Stoicism	Rise of Budhism in India	
-200				Building of Great Wall in China		

	Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
-200	Solar year divided into $354^{1/4}$ days exactly	Armillary spheres	Beginnings of trigonometry (Hipparchus)	Civilian and military constructions	Mediteranean region, Middle East and Western Europe under Roman rule.	- 162 Hipparchus
	Stellar positions measured with respect to the ecliptic		Sexagesimal notation for fractions	Beginnings of alchemy ; search for the elixir of life (Egypt ?)	Rise of "individual" astrology (Greece)	- 106 Cicero - 101 Julius Caesar
	Precession of the equinoxes					- 98 Lucretius
	Determination of lunar movement and parallax					- 65 Horace - 39 Herod
	Preliminary version of epicyclic theory of solar system					- 31 Victory of Octavio over Cleopatra
0	Civil year divided into 354 days + 1 day every four years (Julien)			Development of geodesy ; simple steam engine (Hero)	Rise of gnosticism and other irrational beliefs	
				Possibility of a vacuum on a microscopic scale in matter		+ 97 Vespasian
100						

	Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
100	Compilation of stellar catalogue with magnitudes (Almagest) --- Definitive version of epicyclic theory - recognised by Ptolemy as mathematical artifice --- Parallax of the sun $\approx$ 3 arcmin	Precision of angular measurement worse than $\approx$ 10 arcmin		Compilations : Strabo (geography) Pliny (history) Galien (medicine)	Rejection by church of all pagan ideas --- Rise of scepticism and dogmatic philosophies	117 Hadrian 120 Ptolemy 121 Marcus-Aurelius
200			Development of an "algebra" of rational numbers ; solutions to 2nd order equations (Diophante - Alexandria)		Barbarian incursions into roman empire ; military and economic anarchy ; rapid succession of emperors ; 1st tetrarchy and rise of bureaucracy	295 1st destruction of Alexandria (Diocletien)
300						

	Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
300					Rise of the eastern empire, essentially christian, and separation from Rome	330 Foundation of Constantinople 389 Library in Alexandria destroyed by Christians
400					Fall of western empire	476 Fall of Rome 482 Justinian
500	Rise of naive cosmologies, flat earth, etc... in christian world - Biblical view of world imposed			Rise of encyclopaedic works --- Systematic translation of greek works in Byzantium	Byzantium dominated by church - rejection of "pagan" ideas	
600	Lunar calendar used by Arabs ; round earth accepted by Arabs			Invention of "greek fire" (Byzantium)	Feudal society in western Europe --- Arab expansion in Asia and Middle East	632 Death of Mahomet 641 2nd destruction of Alexandria by Arabs 672 The Venerable Bede
700						

	Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
700	Round Earth accepted by Venerable Bede (England)	Development of armillary spheres, portable astrolabes ; construction of massive quadrants (Arabs)	Introduction of algebraic ideas into mathematics -classification of various equations (Arabs) --- Trigonometry and trigonometrical tables (Arabs) --- Knowledge sufficient to calculate dates of religious festivals (W. Europe)		Arab incursions into India --- War between Arab and Byzantine world --- Foundation of Bagdad	742 Charlemagne 766 Haroun Al Raschid
800	Struggle between Aristotelian and Ptolemaic ideas in Arab world --- Sky divided into degrees (Baghdad) --- Andromeda nebula seen by naked eye (Persia) --- Penetration of Astrology		Essentially modern mathematical notation with zero taken over by Arab world from India --- Roman numerals used in Europe	Appearance in Arab world of greek works (for ex, Almagest) --- Knowledge of optics, esp. laws of reflexion (Arabs) --- Speculations on origin of starlight, rainbow ...	Essentially feudal society in Christian Europe --- Europe overrun by Arabs, Vikings Magyars --- Rise of Cordoba as cultural centre of Arab world	827 Observatory in Baghdad 850 Al Battani 960 Al Hazen

	Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
				Windmill (Spain) --- Modern horse-riding harness (W. Europe) --- Mechanical clock activated by weight (Europe) --- Plough		
1000	Supernova observed in 1054 in East ; not noted in Europe --- New star observed in 1006 in Europe and in East			Hydraulic works (Byzantium)	End of Barbarian invasions --- Growth of Roman church --- First crusades	
1100						

	Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
1100			"Arab" arithmetical notation known in Europe, but not exploited	Aristotelian philosophy studied in Mohammedan Spain --- Latin translations of many greek works; transfer of Arab knwoledge to Christian Europe --- Distillation of alcohol in Christian Europe --- Canal locks (Bruges)	Universities established in Bologna, Oxford, Paris	1136 Cordoba captured by Fer. III 1170 Omar Khayam 1193 Albertus Magnus
1200	General acceptance of spherical Earth at centre of Universe ; stars, planets, in concentric shells --- Calculation of planetary tables using Ptolemaic methods (Spain)	Large masonary quadrants in Persia		Fusion of christian and aristotelian philosophies Growth of scholasticism --- Mobile limber --- Mechanical clock with "escapement" --- Spectacles	Decline of Arab power --- Voyages of exploration by Europeans --- Growth of ecclesiastical power	1225 Thomas Aquinas 1254 Marco Polo 1258 Baghdad taken by Mongols 1265 Dante 1270 Occam 1291 Establish. of Swiss confederat.
1300						

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
			Firearms (Arabs)	Growth of commerce in Europe ;	1313 Boccacio
			Sandglass	Growth of royal power and bourgeois influence	1340 Chaucer
			Dyeing stimulates chemical research		1347 Great Plague
				100 years war	1400 Gutenberg
European calendar in complete disarray (wrong dates for equinoxes, etc)	Pinules in Europe	"Arab" notation used only by merchants	Greek treatises available in Europe	Turkish invasion of Byzantium	1401 Nic. da Cusa
Penetration of Ptolemaic ideas into Europe	Building of observatory in Samarkand, with large graduated circles		Printing	Universities in Prague, Heidelberg, Vienna, Leipzig	1436 Regiomontanus
Astronomy confused with astrology	Precision of angular measurement $\approx 5'$		Metal engraving		1451 C. Columbus
			Glass-making (Venice)	Voyages toward the "Americas"	1452 L. da Vinci
Speculations about extent of the Universe (Nicolas da Cusa)			Crankshaft	Mercantile spirit	1453 Fall of Constantinople
			Reappearance of animist and vitalist ideas	"a secco" painting ousts "a fresco"	1462 J. Bosch
					1470 Magellan
					1473 Copernicus
					1475 Pizzaro, Michelangelo
					1483 Luther
					1494 Rabelais

	Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
1500	Heliocentric model of solar system ; circular orbits and epicylces (Copernicus)		Spherical Trigonometry Mercator's projection "Handbooks" of calculating procedures Symbolic notation in algebra Solutions to 3rd and 4th order equations	Observational disagreement with Gallen's anatomical ideas Beginnings of modern botanical classification Zoological classification based on Aristotelian ideas Chemistry dominated by theory of 4 elements + quintessence	Internal problems in the Church Rise of the "Universal man" and encyclopaedic knowledge Increasing use of mines and quarries Earth circumnavigated	1509 Calvin 1514 Vasalius 1530 Establishment of the College de France 1540 Wil Gilbert 1546 Tycho Brahe 1550 John Napier
1550	Calendar reformed in Catholic world Zero parallax measured for comet and nova Geocentric model of Tycho Brahe - planets turn around sun which turns around Earth 1st variable star	Tycho Brahe's observatory in Denmark ; best quadrants, sextants and armillary spheres ; corrections for atmospheric refraction ; precision of angular measurement ≈ 1'	Use of decimal fractions	University teaching dominated by Arist. and Ptolemy ; Arist. theory of motion criticised as being inconsistent with observation; Aristotle's finite and hierarchical universe attacked (Bruno) .../...	Rise of Jesuit power wars of religion Development of artillery colonialism	1561 F. Bacon 1564 Galileo Shakespeare 1571 Kepler 1578 W. Harvey 1596 R. Descartes

1600

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
			Theory of the lever inclined plane, and communicating vessels --- Microscope --- Rol ing mill --- Magnetism and electricity distinguished --- Notion of electric and magnetic forces		1599 Cromwell 1600 G. Bruno burnt at the stake
Parallax of a nova estimated at zero (Kepler, Galileo) --- Parallax of Sun estimated < 1' --- Kepler's laws of planetary motion ---	Spy-glass	Modern algebraic notation --- Theory of equations --- Analytic and projective geometry --- Combinatorial analysis ---	Empirism (Bacon) --- Rationalism (Descartes) --- Re-appearance and universal application of Democritus' atomic theory of matter ---	Scientific academies (Italy) --- Ecclesiastical reaction against "new sciences" --- Revolution in England --- 30 years war	1601 Fermat 1623 Pascal 1625 Cassini 1627 Boyle 1629 Huygens 1632 Trial of Galileo Locke Spinoza Wren

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
Confusion between gravity and magnetism		Theory of numbers	Compound movement (Galileo)		1635 Hooke
"Changing shape" of Saturn		Areas of various curves	Pendulum (Galileo)		1642 Newton 1644 Roemer
observation of lunar mountains, planetary discs, Jovian satellites, stars in Milky Way, sunspots and solar rotation, phases of Venus, Andromeda nebula		Logarithms	Steam Pump		1646 Leibnitz Flamsteed
Planetary motion "explained" by theory of vortices (Descartes)		Calculating machine	Barometer ; hydrostatics.		
			Electrostatic generators		
			Laws of refraction		
Age of the world estimate to be ≈ 6000 years (by counting biblical events)			Circulation of the blood		
			Notion of man as a machine ; more gerally, the world "explained" through laws of mechanics + imperceptible matter (Descartes)		

1650

1650

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries (16)	Science, technology and philosophy	Society	Fiducial Points
Observation of : Saturn's rings, 4 satellites of Saturn, Jovian rotation, Orion nebula (first drawing), Martian south polar cap .	Development of very long refracting telescopes	Converging series	Problem of determination of longitude on sea	Colonial trade -rise of the "middle class" in England	1656 Halley
Newton's laws of motion and gravitational attraction	First reflectors	Infinitesimal calculous	Measurement of distance which corresponds to 1° on surface of the Earth	Restoration in England	1662 Establishment of royal society (England)
Measurement of velocity of light using Jovian satellites (Roemer)	Eyepiece with reticule : applications to astrometry		Practical pendulum clock	Exchanges between scientists increasingly popular	1666 Establishment of "Académie des Sciences" (France
Aristotelian world view ousted by Cartesian in European universities	First transit instruments		Theory of mechanical collisions		1667 Swift ; Building Paris Observatory
1st speculations about extra-terrestrial life	precision of angular measurement $\approx$ 15"		Decomposition of "white" light		1676 Building Greenwich Observatory
Solar parallax estimated at $\lesssim$ 10"			Competition b etween corpuscular theory of light (to explain rectilinear propagation) and wave theory (to explain colours)		1682 Hadley 1685 Haendel 1687 Publication of Newton's "Philosophae Naturalis Principia Mathematica"

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries (17)	Science, Technology and Philosophy	Society	Fiducial Points
			Insertion of "aether" into world picture --- Practical pneumatic pump - "nature does not abhor a vacuum" --- Phlogiston - explanation of all chemistry --- Microscopic biology --- Theory of preformed animal in spermatozoïd		1694 Voltaire 1697 J. Harrison 1700 Bernoulli
Measurement of : stellar proper motion, aberration of light, nutation of the Earth --- Confrontation of planetary motion with theory based on Newton's laws ---	Development of naval sextants --- Erroneous belief in impossibility of achromatic lenses (Newton's bad theory of refraction) ---	Differential equations --- Theory of complex numbers and application in trigonometry	Measurements of flattening of the Earth fit Newton's theory --- Observation of lateral attraction of mountains ---	Wars of succession in Spain, Poland, Austria	1706 Franklin 1707 Euler 1712 Rousseau 1713 Clairault 1714 Offer of Royal prize for method to determine longitude at sea (England)

1700

1750

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
Stellar catalogue in "modern"form	First good reflecting telescopes		Enunciation principle of least action		1717 d'Alembert
Speculation that the solar system is at edge of a flattened stellar system (without quantitative support)	Precision of angular measurement 1" - 10"		Electrical experiments - Leyden bottle		1724 Kant 1731 Cavendish 1736 Coulomb; Lagrange 1738 W. Herschel 1743 Lavoisier 1749 Laplace
Development of celestial mechanics	48 and 132 cm reflecting telescops (Herschel)	Rigorous theory of probability and errors	Theory of lenses aberrations	Start of industrial revolution in England	1756 Mozart 1758 Return of Halley's comet agreement with prediction
Discovery of : Uranus, atmosphere of Venus, infra-red solar rays	13 cm achromatic lenses	Partial differential equations	Geodesy of France	Civil revolution in France	1761 Successful test of Harrison' chronometer
Solar parallax estimated to be 8.7" $\pm$ 0.2	chronometers	Calculus of variations	Distinction between temperature & heat - "caloric"	Engineering schools in France	1766 Dalton; Malthus; First editio: nautical almanac
Messier's catalogue of nebulae		Theory of functions	Experimental electrostatics	Popular science fashionable	1768 Fourier
Star counts : suggestion (with quantitative support) that solar system at centre of a stellar system		Theory of numbers	Theory of two electric fluids	Automata	1769 Napoleon I
			Phosphorescence	American War of Independance	
			Electric nature of nerve impulses		

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
Speculations on : formation of world from "primitive nebula" ; hierarchical structure of universe French Academy of Sciences rejects paper on meteorite fall in Gasgony			Discovery of : oxygen, nitrogen, chlorine, composition of water Hydraulic press 1st servomechanism (Watt) Puddling process for manufacture of wrought iron Spinning, nail making, paper making, cable making machines	Cook's voyages Establishment of "East India Co." Theory of free trade and competition	1770 Beethoven ; First editio Encyclopaedia Brittanica 1775 Ampere 1781 Poisson 1784 Bessel ; Paganini 1787 Fraunhofer 1789 Daguerre 1792 Lobatchevsky 1796 Carnot

1800

1800

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
Complete theory of planetary perturbations ; prediction of planet beyond Uranus - discovery of Neptune	Rise of transit circles as high precision instruments	Theory of group s	Emission lines of sodium	Napoleonic wars	1802 Bolyai
Solar parallax determined as 8.6" $\pm$ 0.4	Achromats $\lesssim$ 39cm	Matrices	Photographic process	Opium wars	1805 Hamilton
First stellar parallaxes	91 and 183 cm reflecting telescopes (Ross)	Symbolic logic	Synthesis of urea	Conquest of the West ; annexation of New Mexico, California, Louisiana, Florida	1806 Morgan
Discovery of : asteroïds, binary stars, absorption lines in solar spectrum	Lunar photography	Infinitesimal geometry	Observation of Brownian motion	Abolition of slavery in B Empire	1809 Lincoln
Distinction established between stellar cluster, nebula and spiral nebula	Infra-red "rays" (Herschel)	Elliptic functions	Airy diffraction pattern	"Naturphilosophie" in Germany	1811 Leverrier, Galois, Destruction o machines by Luddites (England)
Density lunar atmosph. density terrest. atm. determined as $< 2 \times 10^{-3}$		Method of least squares	Thermocouple		1815 Boole, Bismarck
Assertion of impossibility of determination of stellar compositions		Beginnings of "mathematical physics"	Electric battery		1818 Marx, Joule
			Induction - Identification of electrical and magnetic phenomena		1819 Adams
			Mechanical theory for origin of electricity		1822 Mendel, Clausius
					1824 Kirchoff, Kelvin
					1826 Riemann
					1831 Maxwell
					1832 Eiffel
					1833 Nobel
					1834 Mendeleev

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial points
Meteoric bombardment suggested as source of solar energy			Thermodynamics : conservation of energy 2nd law, propagation of heat		1835 Schiaparelli, Gibbs, Stefan
Speculation on life on the sun			Laboratory measurement of velocity of light		1838 Jordan, Mach
			Light as transverse waves in "aether"		1840 Monet
			Doppler effect		1842 Lie, Rayleigh
			Cellular theory in biology		1844 Boltzmann, Nietzsche
			Biological evol. by : adaptation (Lamarck), nat. selec. (Darwin)		1845 Cantor, Röentgen
			Atomic theory of chemical reactions		
			Invention of : steam locom., steam ship, tubular boiler, Colt		
			Hegel's philosophy		
			Malthusianism		

1850

1850

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
Observation of emission lines in nebulae : gaseous nature of certain nebulae	Application of photography	Application of group theory	Kirchoff's laws	Franco-prussian war	1851 Great Exhibition (London)
Systematic study of stellar absorption lines ; observation of Doppler shift for certain stars	66cm refracting telescopes	Vector analysis	Kinetic theory of gases - Boltzmann distribution	American civil war	1854 Poincaré
Discovery of helium in sun, Sirius B, "nebulium"	Glass astronomical mirrors	Rise of non-Euclidean geometry	Maxwell's equations - "need" for aether	Impressionism	1856 J.J. Thomson, Freud
First indication that stars have various luminosities	Precision of angular measurement $\approx$ 0.1"	Topology	General theory of elasticity	Rise of German universities	1857 Tsiolkovsky
Gravitational contraction as source of solar energy			Periodic table of elements	Rise of German chemical industry	1858 Planck
Age of the Earth estimated to be at $\approx 3 \times 10^7$ years - agreement with age of Earth estimated by contraction theory			Cathode rays		1859 Popov; Pierre Curie "Origin of Species", Darwin ; First oil well
			Foucault pendulum & gyroscope		1862 Hilbert
			Statistic methods (1st in biology)		1867 Marie Curie
			Laws of heredity		1868 Sommerfeld Hale
			Structure of benzene		1870 Adler; Lenin
			Fermentation studied		1871 Rutherford
			Discovery "fossil" man		1872 B. Russel
			Ind. prep. of Alu.		1873 Schwarzchild
			Proliferation of specialised journals		

1875

1875

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
Discovery of : Phobos & Deimos, spectroscopic binaries, solar motion in the galaxy	Photometry	Tensor analysis	Identification of helium on Earth by spectroscopy	Queen Victoria Emperor of India	1875 Jung
Mercury's rotation measured as 88 d.	Photographic astrometry	Set theory	Seismic exploration of Earth	French colonisation of N. Africa	1879 Einstein
Planetary movements, except for Moon and Mercury, explained by celestial mechanics	Spectro-heliograph	Transfinite numbers	Study of propagation in continuous media	Russo-Turkish war	1880 Spengler
Equilibrium structure of gaseous spheres	Bolometer		Stefan's, Wien's law	Essentially feudal society in China and Russia ; industrial exploitation in England and U.S.A.	1881 Picasso ; Fleming ; Michelson-Morley experiments
Formation of the Moon by fission from Earth	Refracting telescopes $\lesssim$ 1 m		Balmer series		1882 Eddington ; Stravinsky
Speculations about extra-terrestrial life ; observation of canals on Mars			X-rays		1885 Bohr
			Radio-activity of Uranium		1886 Trumpler ; Last impressionist exhibition in Paris
			Identification and theory of electrons		1887 Schrödinger Founding of Esperanto
			Transmission of radio-waves		1889 Hitler ; Chaplin
			Failure of all attempts to measure velocity of Earth through aether - explained by Lorentz.		1892 L. de Broglie "La Planète Mars et ses conditions d'habitabilité", Flammarion

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, technology and Philosophy	Society	Fiducial Points
			Impossible to ignore effect of Universe in mechanics (Mach)		1893 Invention Zip-fastner 1894 Lemaître 1895 "The Time Machine" H.G. Wells
			Subjective nature of classical mechanics (Poincaré)		
			Prehistoric time scale tied to stati-graphy		
			Discovery chromosomes and microbes		
			commercial synthesis of indigo		
			Liquefaction of oxy-gen and nitrogen		
			Hydroelectric plant		
			Internal combustion engine		
			Maxim gun		

1900

1900

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
Martian canals disproved	2.5 m telescope	Algebric topology	Quantum theory	Colonialisation of Indochina	1900 Pauli,
Solar parallax determined as $8''.806 \pm 0.004$	Photographic photometry	Hilbert spaces	Special theory of relativity: $E = mc^2$	Exploration of N. and S. poles	1901 Heisenberg; Fermi; Disney
Magnetic storms on Earth linked to sunspot frequency	Bolometry	Functions of real and complex variables	General theory of relativity : geometrical description of gravity ; Mercury's motion explained	Russo-Japanese war	1902 Dirac
Theories of stellar convection	Stellar interferometry	Summation of divergent series	Atomic nucleus identified experimentally ; Bohr atom ; world made of electrons and protons	1st world war (1914)	1903 "Conduction of electricity through gases" by Thomson ; "Problems in Astrophysics" by Clerke
Radial velocities of galaxies measured	Precision of angular measurement $\approx 0.01''$	Partial differential equations	Electronic theory of magnetism	Russian revolution (1917)	1905 First neon signs
Cepheid period-luminosity law		Theory of functions	Atomic structure of solids ; X-ray crystallography	Suffrage for women in England	1909 Model "T" car
Novae observed in Galaxies			Low temperatures	League of Nations	1914 "Stellar Movement & Structure of the Universe" by Eddington ; "Report on radiation & quantum theory" by Jeans
H-R diagram for nearby stars ; stellar evolution conceived as red giants $\longrightarrow$ white dwarfs			Theory of radio-activity ; artificial transmutation	Symbolism, surrealism in art and literature	

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries (26)	Science, Technology and Philosophy	Society	Fiducial Points
Solar eclipse measurements in agreement with general theory of relativity			Theory of Brownian motion		1920 "Outline of History" H.G. Wells
Star counts : sun at centre of Galaxy ; Cluster counts sun at edge of galaxy ?			Invention of : electronic valves, Wilson cloud chamber, Geiger counter ; Bakelite		
Radioactivity proposed as source of solar energy			Transatlantic radio transmission - theory of ionosphere		
Catastrophic cosmogonies : idea of rarity of extraterrestrial life			Plastic surgery		
			Conditioned reflexes		
			Psychoanalysis		
			Reappearance of Lamarckism in France		
			Continental drift		
			Internal combustion engine powered aircraft ; transatlantic flight		

1920

1920

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
Discovery of interstellar gas, and dust $\Rightarrow$ self consistent model of Galaxy	Development of Schmidt Camera	Hermitian operators	Wave & quantum mechanics	Economic upheavals	1923 USSR established ; "R.U.R" Capek
Internal structure of stars radiative equilibrium + thermo-nuclear reactions	Photocells, photomultipliers used in photometry	Compact Lie groups	Discovery of ν , $\mu^{\pm}$, n, e^{+}	Electrification, development of heavy industry in USSR	1926 General strike (England)
Dynamics of Galaxy	Coronograph	Gödel's theorem	Theory of electrical conduction in solids	Rising importance of U.S.A. in fundamental research	1929 Wall St. crash ; 2nd Surrealist manifesto
White dwarfs identified with degenerate matter		Axiomatisation of calculus of probabilities	Electron. microscope	Notion that dialectical materialism must apply in science (USSR)	1933 Hitler chancellor of the Reich ; German "brain drain" to U.S.A.
Calculation from first principles of total number of particles in Universe		Estimation theory	Molecular spectra		
Lunar photometry $\Rightarrow$ microstructure of lunar surface		Theory of population dynamics	Superfluidity		
Photospheric opacity identified		Information theory : relation to entropy	Saha equation		
		Theory of logical machines	Invention of : photomultiplier, quartz crystal clock, television, bathyscaphe, stratospheric balloon acrylic plastics, jet engine		
			Discovery of deuterium		

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology and Philosophy	Society	Fiducial Points
Discovery of Pluto			1st particle accelerators ; study of nuclear forces ; nuclear models transuranic elements, nuclear fission, induced radioactivity, artificial transmutation		1939 "The Philosophy of Physical Science", by Eddington. 2nd world war
Chemical composition of globular clusters					
Identification methane, ammonia in giant planets ; CO_2 in Venusian atmosphere					
"Nebulium" identified as O^{++}			Age and internal structure of the Earth		
Distances of nearby galaxies: Hubble's law ; theory of expanding universe			Non-uniform rotation of Earth - explanation of anomalous movements of moon		
Thermodynamics of expanding universe : speculations about heavy element production ; controversy about age of universe			Direct observation of chromosomes		
Discovery of cosmic rays			amino acid structure of proteins		
Cosmic radio waves					

1940

1940

Astronomical Discoveries	Astronomical Instrumentation	Mathematical Discoveries	Science, Technology & Philo.	Society
Observation of solar radio emission ; first extra-glactic source	5m reflector	Monte-Carlo methods	Development of rockets	2nd World War ; atomic bombs dropped on Hiroshima and Nagasaki
Prediction that neutral interstellar hydrogen should emit at 21 cm	Infra-red spectrograph	Production control systems	Rapid development of radar	Independance of India and Pakistan
Notion of 2 stellar populations	Ultra-violet spectrograph launched in V2 rockets	Economic and demographic prediction theory	Nuclear reactors ; Nuclear bombs	"The Kon-Tiki"Expedition" - Heyerdahl
"Coronium" identified as highly ionised Fe		Theory of self replicating machines	Failure of unitary field theory	
Radar reflection from moon			$\pi^{+,0}$, Λ observed in cosmic rays	
Measurement of atmospheric pressure on Mars			Construction of synchrotron	
Solar parallax determined as 8.79" $\pm$ 0.001			First electronic computers	
Properties and composition of primary cosmic rays			Invention of transistor	
			Cybernetic ideas used in biology	

Astronomical Discoveries	Astronomical Instrumentation	Science, Technology & Philo.	Society
Nebular cosmogonic theories fashionable - many planetary systems forseen		Chronology of life ; hypothesis on origin of life	
Speculation about light element production in big-bang (problems with heavy elements production) : prediction of diffuse background radiation		Antibiotics Synthesis of vitamins	
Astronomical ephemeris calculated by electronic computer	Systematic application of linear detectors (ex. electronic camera	"Intelligent" electronic "animals"	Cold war
H-R diagrams for globular clusters : basis for stellar evolution theory ; methods for finding stellar ages ; prediction of observable solar neutrino flux	Construction of large disk radio-telescopes	Research in elementary particle physics grouped into teams ; growth of international collaborations	Korean war Hungarian uprising
Numerical modelling of stellar structure	Instruments flown on board satellites ; solar photos in U.V.; interplanetary probes (in situ measurements of solar wind) ; probes towards the moon ;	Discovery of hyperons, K-mesons anti-proton ; classification of elementary particle by empirically assigned "quantum" numbers"	Morrocan independance Place of "Science in Society" Non-representational art and music fashionable

1950

Astronomical Discoveries	Astronomical Instrumentation	Science, Technology & Philo.	Society
Discovery of galactic radio emission at 21 cm : search for spiral structure	First photos of Earth from orbit	Invention of : Laser ; reliable atomic frequency standard	
recalibration of fundamental cosmic distance scale		Artificial synthesis of diamonds	
Hubble's law $\Rightarrow$ age of the Universe $\approx 2 \times 10^{10}$ years		Construction of nuclear power stations	
Theory of stellar nuclear-synthesis - possibility of stellar creation of all elements except H ; problems with light elements		Thermo-nuclear weapons	
		Intercontinental ballistic missile : growth of space technology	
		structure of proteins	
		Genetic code	
1960			
1st radio-observation of interstellar molecules	Automatic experiments on lunar surface	Meteorological, geodesic and spy satellites	Growing importance of "third world"
Quasars	Aperture synthesis radio-telescopes	Anti-missile missiles	
Background γ-radiation	Radar echoes from Venus, Mercury and Mars	Rapid development of chemical & biological warfare techniques	
Infra-red sources			

	Astronomical Discoveries	(3V) Astronomical Instrumentation	Science, Technology & Philo.	Society
1965	2-stage nucleosynthesis theory: stars ⟶ heavy elements ; big bang ⟹ He, D	Air-borne infra-red instrumentation	Observation of elementary particles "resonances"	
	Micro-wave observation of 3° background radiation	Man on Moon (1st landing 1969)	Rising numbers of elementary particles	Vietnam war
	Observation of pulsars : neutron star model			Increasing fear about effects of technology on environment
	Matter-antimatter cosmologies to explain background δ-radiation			Popular misconception of the effects of computers on social structures
1970	Systematic study of galactic and extragalactic radio-sources	Last Apollo mission (1972)	Super particle accelerators - 83 known "elementary" particles	Global economic crisis
	Growing number of complex interstellar molecules	I-R, U-V, X and γ-rays instruments in orbit	Search for a unified theory of weak and e-m forces	Raw materials crisis
	Cosmic X & γ-ray sources	Astronomical "neutrino-telesc."		Rise of individual terrorism as a mean of applying polit. pressure
1975	Dev. & failure of matter-antimat. cosmologies	2,50 m optical space telescope projected		World divided into several polit. blocks with competing ideologies

1975	Astronomical Discoveries	Astronomical Instrumentation	Science, Technology & Philo.	Society
	Zoology of variable optical, X and γ-ray sources	Automatic instruments on Venus, Mars	Laboratory synthesis of genes	
	Failure of all attempts to observe solar neutrinos	Probes to giant planets	4-colour problem solved with help of computer	
	Anomalies in Hubble's law : speculations about massive photons, neutrinos, etc...	6m optical telescope	Rapid growth of micro-electronics	
	Anisotropy of 3° radiation	multiple mirror telescopes	Construction of space shuttle	
	Speculations about extra-terrestrial life : - no life on Mars (Viking) - programs to "listen in" on nearby stars	Projects for optical aperture synthesis telescopes	Projects for "space colonies" at level of engineering studies	
	Discovery of rings around Uranus and Jupiter	Development of "electronic photography"		
1980	Discovery of diversified nature of Galilean satellites of Jupiter (volcanoes on Io, etc...)			