Towards an impressionist picture of the history of astronomy

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A description and short extract are given of a tabulated history of astronomy, in which particular emphasis is placed on the interaction of astronomy with various disicilplines.

In an earlier paper[1] I suggested that the time was ripe for a new approach to the teaching of astronomy; I proposed what amounts to a series of multidisciplinary courses in which particular physics topics would be analyzed from many different points of view.

The history of astronomy also requires a considerable facelift; most traditional elementary courses and texts tend to highlight how terribly clever "we" are, and how obtuse (though ingenious) were our predecessors (with of course, such notable exceptions as Aristarchus, Copernicus, Galileo, Newton, etc.). A basic defect which one finds depressingly often in the history chapters of most introductory texts is the presentation of astronomy as a subject developing on its own in total isolation from the scientific and social context of its time. One finds, for example, inumerable and tiresome discussions on the absurdity, beauty, and complexity of the Ptolemaic model of planetary orbits, but virtualy no mention of the reason why Greek philosophers were so obsessed with circular motion—the obsession, of course, had virtually no relation to astronomy but was rooted in certain perfectly reasonable assumptions (within the context of the time) about the nature of motion, and astronomy merely "proved" that these ideas were right. Since we have no hindsight on our own epoch, it is difficult to make reasonable judgements about it; however, it is a salutary lession to see how another civilization reacted to complicated and conflicting sense impressions. Do many students (or even their teachers) appreciate in a rational (rather than purely gratuitous and mystical) way the physical hypotheses underlying such standard operations as the assignment of quantum numbers to elementary particles or the decomposition of complex waveforms into harmonic components (the Ptolemaic world system is in some sense an early equivalent of these operations)? In our own infinitely more sophisticated way, we too often construct models with much the same disregard as the Greeks for tiresome "details" which do not fit the "grand scheme."

Another defect which springs to mind is to ignore the interplay between technological capability, its effect on scientific instrumentation, and the resulting (though often delayed) consequences for astronomy—modern astronomy so often emerges as a triumph of the intellect and one forgets about the technical triumph which led to it.

I have found that my students are keenly interested in the evolution of astronomy when presented within a wider cultural and social background, and this has motivated me to find a way of supplementing the usual one chapter summary which just gives a blow-by-blow account of how different, apparently arbitrary models succeeded one another.

The essential problem is how to reduce the information contained in a library full of books into a form which occupies about a dozen pages, without destroying the essence of the message one wishes to transmit. One way is to give an ordered enumeration of all scientific and astronomical "happenings." However, as S. Lem has so nicely pointed out in his short story "The sixth crusade, or how Trurl and Claupaucius built a demon of the second kind," too much information is as bad as none at all (maybe worse), since one simply cannot digest it.

The solution I chose was to construct a two-dimensional table of very carefully selected "events." The horizontal division is into categories (astronomical discoveries, instrumentation, mathematical discoveries, science, society); the vertical is a time scale. Associated with the time scale is an ordered list of "fiducial points"—dates of critical "happenings," births of prominent or important or "typical" persons, etc. The aim of all this is not so much to enumerate facts (although facts there must be) as to evoke the intellectual climate of an epoch by association with events or names one already knows about (even if only vaguely).

The compilation covers the period 1300 BC to AD 1980; even with the most savage editing it would have been too long for publication in this Journal and so has been published by the Physics Auxiliary Publishing Service (PAPS).[2] However, to give an idea of the usefulness of the approach chosen, Table I shows an extract, which covers the critical period AD 1100–1650.

One sees immediately that the table cannot be used alone and is not in itself a history; technical jargon inevitably creeps in, there is no description or discussion, and the material has been selected brutally. It is a *tool* to be used with a more traditional course or book—one should think of it as a means of placing astronomy in perspective against a constantly shifting scientific, cultural and social background.

In this sense, the compilatlion bears much the same relation to history as an impressionist painting to a photograph; looked at very closely, it disintegrates into a collection of apparently unrelated point events, but seen from a distance, shapes and patterns start to emerge. Compare an impressionist painting of a crowd with a photograph: in the former, distorted and incomplete image though it is, one can almost hear what each person is saying and even guess why the crowd is there—in the photograph, exact in every detail, one can discern nothing. The reason is simple: the impressionist painter uses fragments of familiar images to suggest subconciously the caracteristics of an entire world. The history chart has been constructed in the same spirit: fragmented but familiar events are used to evoke an entire period and the reader, suitably stimulated, actually supplies most of the missing information. Not all of the events will necessarily be familiar to everyone; however, many events

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Table I. Extract of the history chart for the period AD 1100–1650.

	Astronomical discovery	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	Universities established in Bologna, Oxford, Paris	1136 Cordoba captured by Ferdinand III
				Latin translations of many Greek works; transfer of Arab knowledge of Christian Europe		1170 Omar Khayam
				Distillation of alcohol in Christian Europe		1193 Albertus Magnus
				Canal locks (Bruges)		
1200						
	General acceptance of spherical Earth at center of the universe; stars, planets, in concentric shells	Large masonary quadrants in Persia		Fusion of christian and Aristotelian philosophies—growth of scholasticism	Decline of Arab power	1225 Thomas Aquinas 1254 Marco Polo 1258 Baghdad taken by Mongols
	Calculation of planetary tables using Ptolemaic methods (Spain)			Mobile limber	Voyages of exploration by Europeans	1265 Dante
				Mechanical clock with "escapement"	Growth of ecclesiastical power	1270 Occam
				Spectacles		1291 Establishment of Swiss confederation
1300						
				Firearms (Arabs)	Growth of commerce in Europe; Growth of royal power and bourgeois influence	1313 Boccacio 1340 Chaucer 1347 Great Plague
				Sandglass	100 years war	1400 Gutenberg
				Dyeing stimulates chemical research		
1400						
	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 Nicolas de 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	Voyages toward the "Americas"	1451 C. Columbus 1452 L. da Vinci 1453 Fall of Constantinople
	Speculations about extent of the universe (Nicolas da Cusa)			Glass making (Venice)	Mercantile spirit	1462 J. Bosch
				Crankshaft	*a secco* painting ousts *a fresco*	1470 Magellan 1473 Copernicus 1475 Pizzaro, Michelangelo
				Reappearance of animist and vitalist ideas		1483 Luther 1494 Rabelais
1500						
	Heliocentric model of solar system; circular orbits and epicylces (Copernicus)		Spherical trigonometry	Observational disagreement with Gallen's anatomical ideas	Internal problems in the Church	1509 Calvin 1514 Vasalius

Astronomical discovery	Astronomical instrumentation	Mathematical discoveries	Science, technology, and philosophy	Society	Fiducial points
		Mercator's projection	Beginnings of modern botanical classification	Rise of the "Universal man" and encyclopaedic knowledge	1530 Establishment of the College de France
		"Handbooks" of calculating procedures	Zoological classification based on Aristotelian ideas	Increasing use of mines and quarries	1540 William Gilbert 1546 Tycho Brahe
		Symbolic notation in algebra	Chemistry dominated by theory of 4 elements + quintessence	Earth circum-navigated	1550 John Napier
		Solutions to 3rd- and 4th-order equations			
1550					
Calendar reformed in Catholic world	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 Aristotle and Ptolemy; Aristotelian theory of motion criticized as being inconsistent with observation; Aristotle's finite and hierarchial universe attacked (Bruno)	Rise of Jesuit power	1561 F. Bacon 1564 Galileo, Shakespeare
Zero parallax measured for comet and nova			Theory of lever, inclined plane, and communicating vessels	Wars of religion	1571 Kepler
Geocentric model of Tycho Brahe—planets turn around sun which turns around Earth			Microscope	Development of artillery	1578 W. Harvey
1st variable star			Rolling mill Magnetism and electricity distinguished Notion of electric and magnetic forces	Colonialism	1596 R. Descartes 1599 Cromwell 1600 G. Bruno burnt at the stake
1600					
Parallax of a nova estimated at zero (Kepler, Galileo)	Spy glass	Modern algebraic notation	Empiricism (Bacon)	Scientific academies (Italy)	1601 Fermat
Parallax of sun estimated < 1′		Theory of equations	Rationalism (Descartes)	Ecclesiastical reaction against "new sciences"	1623 Pascal 1625 Cassini 1627 Boyle
Kepler's laws of planetary motion		Analytic and projective geometry	Reappearance and universal application of Democritus's atomic theory of matter	Revolution in England	1629 Huygens 1632 Trial of Galileo; Locke, Spinoza, Wren
		Combinatorial analysis		30 years war	
Confusion between gravity and magnetism		Theory of numbers	Compound movement (Galileo)		1635 Hooke

Table I. *Continued*

	Astronomical discovery	Astronomical instrumentation	Mathematical discoveries	Science, technology, and philosophy	Society	Fiducial points
1650	"Changing shape" of Saturn		Areas of various curves	Pendulum (Galileo)		1642 Newton
	Observation of lunar mountains, planetary discs, Jovian satellites, stars in Milky Way, sunspots and solar rotation, phases of Venus, Andromeda nebula		Logarithms	Steam Pump		1644 Roemer
	Planetary motion "explained" by theory of vortices (Descartes)		Calculating machine	Barometer; hydrostatics		1646 Leibnitz, Flamsteed
	Age of the world estimated to be ≈ 6000 years (by counting biblical events)			Electrostatic generators		
				Laws of refraction		
				Circulation of the blood		
				Notion of man as a machine; more generally, the world "explained" through laws of mechanics + imperceptible matter (Descartes)		

should be sufficiently familiar to the average scientist to make this a useful tool, and maybe stimulate him to seek out details on the less familiar contents.

One final word of . . . warning. Any historical compilation of this kind which tries to evoke ideas and not just to enumerate facts must to some extent be biased and even idiosyncratic. I have tried to be honest, but a compilation done by someone else might well look more or less different, in much the same way that two paintings of the same scene are not always identical, although good photographs are. Note in particular that oriental astronomy is virtually absent; fascinating in its own right, its contribution to our present world picture is too limited to justify a possible doubling of the size of the table. Moreover, since Western knowledge of oriental culture is very limited, it would be well-nigh impossible to present it in the "impressionist" form.

[1]L. M. Celnikier, Am. J. Phys. **46**, 994 (1978).

[2]See AIP document no. PAPS AJPIA-49-473-36 for 36 pages of the entire table for the period 1300 BC–AD 1980. Order by PAPS number and journal reference from American Institute of Physics, 335 E. 45 Street, New York, NY 10017. The price is $1.50 for each microfiche (98 pages), or $5 for photocopies up to 30 pages with $0.15 for each additional page over 30 pages. Airmail additional. Make checks payable to the American Institute of Physics.