

GUIDE TO THE READER

The main body of this multilateral Encyclopedic History consists of biographies interspersed with essays, articles and events. The biographies are arranged chronologically, within the domains of six consecutive epochal chapters. There are about 2070 detailed biographies of scientists, thinkers, engineers, explorers, inventors and associated creative minds who, in one way or another, left their mark on the history of science and technology in the fields of: *mathematics, philosophy, logic, physical and environmental sciences* (physics, chemistry, astronomy, earth and space sciences, cosmology), *life sciences* (biology, medicine, physiology, botany, zoology, biochemistry), associated engineering disciplines, and *social sciences* (economics, psychology, sociology, anthropology, linguistics etc.).

The total number of scientists, thinkers and other creative individuals featured in the treatise is about 3000.

The book includes the names of some 1700 *inventors* over a period of 2500 years. Of these, 300 belong to the period 350 BCE – 1900 and the rest to the 20th century alone.

The articles (380 in number) summarize the time-evolution of ideas in the above leading fields of science, technology, mathematics and philosophy. In addition, I have included historical environmental events that impacted civilization and also important politico-historical events that affected science, technology and world-order. The reader will also find many useful tables and some 20 ‘Science Progress Reports’ (SPR) dealing with scientific setbacks.

The biographies and articles of this encyclopedia are interspersed with many *quotations*, gathered from the wit and wisdom of sages, savants and scholars throughout the ages from antiquity to modern times.

These quotations are to be found within the text in chapter 6 and under the heading “worldviews” where they are attached to some fifty selected individuals from Socrates to Feynman.

In these quotations, man reflects on himself, his condition, his times and on science proper through the thoughts of scientists, philosophers, humanists, poets, theologians, statesmen, and other miscellaneous mortals.

Our list of biographies is arranged in strict chronology. We must however remember that history is full of uncertainties. Even when we have managed to arrange our facts in chronological order, we are not sure that the antecedents have influenced the consequents. But at any rate, we are sure that the consequents have not influenced antecedents, and historical certainty is so rare that, when we find it, we must stick to it as closely as possible.

Chapter 6 is dedicated to the second half of the 20th century. Had I included here biographies of contemporary scientists together with proper essays on their respective research achievements (and considering the exponential growth of science during 1950–2005), this chapter alone would have grown into a gigantic size of some 5000 pages. The time needed for the completion of this task would require me to delay the presentation of the encyclopedia by at least five years. To circumvent this difficulty, I have decided to present a general layout of the major research topics and current front-lines, supplemented with tables, timelines and a few key essays.

CREDITS FOR ORIGINALITY OF IDEAS AND INVENTIONS

Observations and measurements provide data that accumulate from epoch to epoch. These form the stuff of hypotheses and theories that in turn suggest new observations. Ultimately we arrive at a major synthesis. These also accumulate, building toward the goal of an ever more inclusive and simple conceptual structure. Connectivity involves the influences of one epoch, one school, one scholar on others, leading to a significant advance in the science. It is a sad but true fact that historical relevance accrues not to the originator of the idea or a fact but to the person providing the connections. e.g. credit for relevance goes not to Aristarchos of Samos, who first proposed, eighteen centuries before Copernicus, that the earth moves around the sun, since that insight was lost. Rather, the connectivity of Copernicus to Galileo, Kepler and Newton was seminal to eventual progress.

It has been said that: “credit in science goes to the man who convinced the world, not to the man to whom the idea first occurs”.

My policy in this treatise has been to give credit wherever credit is due, i.e. also to the originator of an idea or a fact, irrespective of whether he made the connection or not. In fact, I made it my business, as much as I was able, to search for the *true originators*.

CREDITS FOR SOURCES OF INFORMATION

I have borrowed factual information from a vast number of books, articles and encyclopedias, but the creative synthesis of all these sources into a final

mold is mine alone, and the responsibility for accuracy and relevance rests on my shoulders. I believe that in presenting the finished material to my readers, I have saved them the trouble and effort of reading libraries of books.

The cited bibliography is sufficient, although no effort was made to make it complete: first, there is a limit to what a single author can reach and read. Then, even from his chosen sources, not everything is suitable nor available to the common reader. However, in this day and age, when the Internet is within reach of many people, all those who wish to, can update their knowledge on a particular subject, person or event. The length of my reviews of a person's life-work was not intended to be a measure of his or her greatness and importance.

SELECTION OF PERSONS

In a work of this kind, it is not easy to know where to draw the line between inclusions and omissions. While it is relatively easy to determine the most important scientists and thinkers, it is more difficult to agree upon personalities of the second and lower orders. Very often, the inclusion of one scientist entails the admittance of a number of others whose merits were of the same stature. Thus, while it is impossible that I have overlooked any really important personality, it is probable that I have included a few whom it would be better to omit. Clearly, no selection would please everybody. As a rule, however, I have adhered to the following selection criteria:

- Not to mention a person unless there is something special to say of his or her activity (discovery, book, etc.).
- Name people who took the first step in the right direction, however simple it may seem in retrospect.
- Take into consideration the opinion of both contemporaries and later scholars about the contributor.
- Consider the impact and influence of a person's actions, writings and ideas upon the history of science, in both short and long range perspectives.

It was my original intent to deal only with the history of pure science, *but it is often difficult, if not impossible, to draw the line between pure science and the applications.* Sometimes the applications were discovered first and the principles deduced from them; sometimes the converse; but in any case pure and applied science grow together. Yet a line must be drawn somehow, for while the number of pure scientists is relevantly small, that of physicians, teachers, engineers, and other practitioners have always been considerable. My rule is to *speak of a physician, an engineer, or a teacher only if he added something definite to our knowledge*, or if he wrote treatises which were sufficiently original and valuable, or if he did his task in such a masterly way as to introduce new professional standards.

SELECTION OF DATA AND EVALUATION OF SCIENTISTS

Objective material and scientific facts (equations, laws, rules, discoveries, inventions etc.) are relatively easy to choose, formulate and explain. Human facts are not as clear-cut and are often highly capricious and evanescent. It is thus a difficult mission to choose a few of the achievements amongst a great many.

My account of each personality has been as brief as possible but it is sometimes much easier to indicate a great achievement than a much smaller one, and thus some of the notes devoted to second-rate personalities are much longer than one would expect. This does not matter in itself, *but the reader is warned not to try to measure the importance of a person by the length of the note devoted to him or her; there is no relation between the two.*

I may have made accidental errors in my choice, by omission or commission, but I do not believe that I have made systematic errors. Nevertheless, a certain bias may have been introduced by my *linguistic preferences* (English, French, German, Hebrew), my *scientific specialization* (physics, mathematics, chemistry, geophysics, history, philosophy), *education* (Israel, Sweden, USA) and *origins* (Eastern Europe, Germany and Israel).

I have tried to be as concrete as possible, that is to say, to indicate the specific achievements or contribution in the clearest and briefest manner. That was never easy, often difficult, sometimes impossible. Even as in our own day, there were a number of people in the Middle Ages who attained considerable prestige and rendered undeniable services, yet of whom it can not be said positively who did this or that. In such cases, where the influence was of an

indefinite nature, I have been obliged to be vague. In a few other cases I have been reduced to a similar vagueness by my ignorance.

NAMES OF PERSONS

In the transliteration of names not originally written in the Latin alphabet (e.g. Japanese, Persian, Greek, Chinese) I have followed Sarton whose motto was: 'consistency and simplicity', and who wrote foreign names in such a form that the original written form might be easily reconstructed and found in the dictionary.

Permanent Surnames are of relatively modern origin; they did not exist at all in the Middle Ages. There are many ways of naming a person, and much ambiguity is thus caused. I quoted all the names that each person was known under and selected one of these as the best. When mentioning that person I have always used that name.

The Muslim names are especially difficult. I have given, whenever I could, a large part of their names, not necessarily the whole of them, because this involve a genealogy of indefinite length. In general I have tried to select a name which would be convenient and as characteristic as possible. The case of Chinese and Japanese names poses another difficulty, because, according to their customs, names are not only changed during life, but even after death. and many men are best known under a posthumous name. Hebrew names and words were used in accordance with the 'Jewish Encyclopedia'.

Following George Sarton, I have translated the Greek termination *os* and *ov* by *os* and *on*. This has the distinct advantage of distinguishing Greek from Latin writers: Epicuros, Epictetos – Lucretius. Likewise, we write: Miletos, Herodotos, Nicomachos, Eudoxos, Menaichmos, Appolonios, Heironymos, Pappos, Herophilos, Aristarchos, Euhemeros, Aratos, Hipparchos, Ctesibios, Erasistratos, Zenodoros, Diodoros, etc.

ACTIVITY INTERVALS OF SCIENTISTS

The period of activity is centered in the age of peak creative activity, usually between 30–50 years of age. There are however many exceptions to

this rule, especially when the age of greatest prestige is different from that of greatest activity, or because the person's life was cut short. Indeed, it takes a considerable time before the activity of a truly original mind is properly appreciated.

Apart from the class of outstanding persons, whose biographies are known in sufficient detail, the exact period of 'scientific fertility' of most scientists is not accurately known prior to the 17th century. Thus, in the absence of contradictory information, I have considered as a man's prime the year when he became 40 years of age, the nearest to the intellectual climax of most men. It is probable that the greatest scientific discoveries were made, and the most pregnant resolutions taken by men younger than forty, but the accomplishment of their work took considerable time and the maturing of their thought extended over many years.

CLASSIFICATION OF CHRONOLOGY

Every classification has the disadvantage of introducing artificial discontinuities in the flow of life. It must necessarily happen that contemporaries are dealt with in two successive chapters, because one was active at the end of one century and the other at the beginning of the following century; they were flourishing almost at the same time, but at different sides of the cut. This drawback is unavoidable, but is not really objectionable, unless the reader is unaware of it.

The efforts of classification are most disadvantageous in the *Middle Ages*. Not everyone seems to realize that these ages lasted about a 1000 years, and that their development, far from being monotonous, was exceedingly varied. Moreover, brutal political vicissitudes introduced discontinuities in many countries. Under these conditions, any classification of Middle Ages is quite artificial and no natural classification would be applicable to all sciences and all nations. For that reason the Middle Ages were left undivided and unclassified between 529 CE–1583 CE.

It should be kept in mind that no epoch in history begins or ends sharply at a given year and chronological dividing lines are made mostly for the sake of convenience.

BACKGROUND EVENTS
(WARS, REVOLUTIONS, SOCIAL UPHEAVAL AND NATURAL DISASTERS)

Although our center of interest is the evolution of scientific facts and ideas, general history is always in the background. Not only do the different sciences interact among themselves, but there is also a constant interaction between science and all other intellectual developments, as well as social, natural and economic phenomena. These events often interfere with the accomplishment of science but sometimes stimulate or are even stimulated by it.

Wars and revolutions are not essentially different from natural catastrophes such as earthquakes, volcanic eruptions, floods or epidemics; they are almost as impersonal and uncontrollable. For most men these catastrophes are by far the most important events, and this is natural enough, since their welfare is often radically affected by them. Galileo's or Newton's discoveries did not lower the price of food or shelter, at least not with sufficient suddenness to be perceptible. For us, on the contrary, these discoveries which must sooner or later transform man's outlook and, so to say, magnify both the universe and himself, are the cardinal events of the world's history. All the catastrophes and upheavals, caused either by the untamed forces of nature or by the irrepressible folly of men, are nothing but accidents. They interrupt, upset and sometimes enhance man's essential activity but, however formidable, they do not and cannot dominate it.

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To give our history its full heuristic value, it was not sufficient to retrace the progress of the human mind. It was also necessary to record the regressions, the sudden halts, the mishaps of all kinds that have interrupted its course. The history of errors is extremely useful: for one thing, because it helps us to better appreciate the evolution of truth; also because it enables us to avoid similar mistakes in the future; and lastly, because the errors of science are, to some extent, of a relative nature. Some of the accepted and well-established truths of today will perhaps be considered tomorrow as very incomplete truths; and there are even precedents for the perceived errors of yesterday eventually becoming approximate or partial truths of today. Similar rehabilitations frequently occur en route to be the "fixed points" mentioned above, and the results of historical research often oblige us to admire and honor people who have been misunderstood and despised in their own time.

Thus, although we undertook to explain the progress of scientific thought, it is clear that we cannot properly explain that progress without giving at least a brief account of the intellectual delusions which often delayed our advance or threatened to sidetrack it.

Moreover, to correctly appreciate the scientific ideas of any people, we must consider them not only from our point of view, but also from their own, however wrong the latter may seem. Thus it is necessary to outline the development of some pseudo-sciences, such as astrology, alchemy, and physiognomy.

It should be noted that it is not always easy to distinguish a pseudo-science from one which is sound but imperfect; in some cases it is almost impossible; we can do it now with reference to the past, but it is not certain that we can always do it with regard to the present.

For these reasons I have included in my book a condensed history of astrology, alchemy and other delusions. In addition I have included some 20 articles called '*Science Progress Reports*' in which follies of scientific *regression* are expounded.

I have made no attempt to tell that history with any completeness, for the history of error is, of its very nature, infinite. Besides, as I am bent upon explaining the progressive – not the regressive – tendencies of human civilization, I have kept these fallacies in the background where they belong. Indeed, since they never represented the main current of human endeavor, but were rather like undertows, it would be equally wrong to ignore them altogether or to attach too much importance to them.

As the scope of my field of study is immense, both in time and size, errors are unavoidable; in spite of severe precautions taken by myself and the editors, some errors will regretfully still be present. I hope that in time, we shall be able to weed them out.



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Ben-Menahem, A.

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