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George SARTON

Introduction to the History and Philosophy of Science

(Preliminary note)

Extrait d'*ISIS*, n° 10 (vol IV, 1) May 1921.

BRUXELLES

Société anonyme M. WEISSENBRUCH, imprimeur du Roi

(Société typographique: Liège, Bouillon, Paris, 1755-1793)

49, rue du Poinçon.

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Introduction to the History and Philosophy of Science

(Preliminary note)

Before leaving Belgium in October 1914, I had buried all my smaller notes in my garden. The rediscovery of these notes and of a good part of my library and of my larger notes, in August 1919, enabled me to resume at once the realization of an old design, namely, the writing of an introduction to the history and philosophy of science. Many months of the fall and winter of 1920 were almost entirely devoted to the reclassification of my material, and it was only on January 12, 1921 that I could begin the actual writing. I had at first thought that as soon as my material was duly classified, the writing would be relatively easy, for it is a fact that the Introduction exists potentially in my notes. Yet I discovered once more that there is a long, long way from such potentiality to reality. I am now publishing this preliminary paper because : 1. I realize that more time may elapse before the appearance of the Introduction than I had at first reckoned ; 2. To ensure greater completeness and accuracy I propose to submit parts of my work as soon as they are ready, to various specialists : this note will explain my purpose to them more fully than I could do it in a letter.

This preliminary note is divided as follows : (I) Purpose ; (II) Plan ; (III) Tentative Table of Contents ; (IV) Method.

I. — PURPOSE.

The fundamental purpose is to establish the history of science as an independent and organized discipline. The lack of organization of these studies is but too painfully obvious. The number of men professionally engaged in them is so small that it can be counted on both hands, and most of them are concentrating their attention upon a particular science or group of sciences. There are no textbooks above the elementary grade and hardly any of the intellectual tools without which research is necessarily very slow. The greatest number of scientists and scholars have not yet understood, — I do not say the importance of these studies, but their mere possibility ; they have

not yet admitted their very right to exist. Even when courses on the history of science have been organized in a few of our universities or colleges, the very way in which this has been done, suggests an utter misunderstanding of the question. A university president who would invite a professor of botany to teach Greek history would, of course, make a fool of himself, but nobody laughs when he asks the same professor to extemporize a course on the history of science. Yet the latter undertaking, in the absence of the proper tools, is one of great risk and difficulty, while the existence of many excellent textbooks (each being the result of a long, progressive evolution) makes it relatively easy to prepare a course on Greek history. I do not hesitate to say that albeit I have devoted the best part of my life to the study of the history of science, I would find it much easier to give an accurate (if not original) account of Greek political history, than of the development of science. In the first case indeed, I could at once take full advantage of the labour and of the accumulated experience of hundreds of scholars, in the latter case, on the contrary, I would be largely thrown upon my own resources.

Among the scientists and scholars who have become sufficiently interested in our studies, very few seem to have appreciated their special difficulties, which arise from their involving at every step a sound knowledge of two distinct sets of facts : scientific facts and historical facts, and a sufficient familiarity with the methods required to ascertain and interpret these two kinds of facts. The method of the history of science is a combination of the scientific and historical methods. Scientists are apt to underestimate the mere historical difficulties ; historians, to misunderstand the scientific data.

To establish the history of science as an independent discipline, our first step must be to define these studies, to explain carefully the knowledge they imply, the methods which must be used to promote them and finally to take stock of what has already been done and draw attention to that which remains to be done. My Introduction will be such a preliminary survey. It will contain also a summary of the history of science in general and of the history of each science in particular. It will deal chiefly with the development of pure sciences and only subsidiarily with their applications ; for one thing, the number of fundamental principles is limited while the number of applications is unlimited, and we must keep within reasonable bounds. Hence all the most important scientists will be included in the survey, while most educators, administrators, physicians, engi-

neers, inventors will of necessity be neglected. The most important scientists in our eye are those whose discoveries were more original and fundamental, and oriented scientific thought in a new way or enlarged its horizon. It is of course impossible to make a selection upon which all will agree, but I am taking great pains to realize as objective and comprehensive a choice as possible.

The history of science is not simply important in itself, as the history of one of the highest of human activities, but even more because it is the natural basis of the philosophy of science, and indeed of any positive philosophy. To be familiar with the latest stage of knowledge is insufficient for all but merely technical aims : it is impossible to appreciate the pregnancy of that knowledge unless we know its evolution, and unless we be able to place it in its proper historical as well as in its proper scientific background. From that point of view, it is clear that the history of science is even more significant than the history of religion or the history of art, which have long enjoyed full recognition as separate branches of learning and have reached a high degree of organization. For as soon as we realize that our knowledge of nature and of man can not be complete unless we combine historical with scientific information, the history of science becomes, so to say, the keystone of the whole structure. But it is safe to add that the number of scientists and historians who have fully realized that, is exceedingly small.

The aim of the Introduction is to give a complete proof of these assertions, to make a preliminary survey, to provide the student with a synthetic bibliography of the whole field and a master key to its problems.

II. — PLAN.

The Introduction is divided into two main parts, of which the first is devoted to the History and Philosophy of Science as a whole, the second to the History and Philosophy of the special sciences and of their branches.

The First Part in its turn is divided into three main sections : the first deals with generalities ; the second is a survey of the work accomplished at certain epochs or by certain racial or religious provinces of humanity ; the third, a survey of scientific progress, century by century.

The Table of Contents quoted below gives all the information that is needed on the first section. Neither does the second section call for much explanation. Its various chapters are devoted each to one

of the great periods of history (prehistoric times, antiquity, Babylonia, Egypt, Middle Ages) or to one of the great groups of men (primitives, Chinese, Mohammedans, etc.,) whose activity requires independent study, either for philological or for other reasons. For each of these chapters I will try not simply to give the synthetic bibliography but also to explain the specific methodology of the subject. It is plain that one can not undertake a study of, say, Mediaeval or Chinese science without undergoing a certain preparation and becoming acquainted with new methods and points of view. Of course these chapters are written primarily for the historian of science. The one dealing with Islamic science, for example, is not written for the Arabic scholar, and I will assume that the reader either knows the Arabic language or does not wish to know it. Yet it is hoped that the average Arabic scholar, not specially familiar with science, will find in it a sufficient amount of fresh information, and possibly the suggestion of a new point of view. The same remarks would equally apply to the other chapters.

In the third section, by far the most extensive, I survey the development of science century by century. For each century, I first quote the main sources relating to the progress of every science and of science in general, then, taking one by one its main scientists, I give a brief account of their life and work, and name the best editions of their writings and the best biographies and commentaries. The selection will be of necessity more rigorous for the later centuries and especially for the sixteenth century because of the increasing abundance of discoveries. Scientists still living will be included if their main work was done before 1901. Down to the year 1501, all the main scientists of any real importance are included, but beginning with the sixteenth century, I consider only those whose activity was not largely restricted to one special science, the others being dealt with in Part II when I speak of the particular science which they cultivated. For example, PASCAL, NEWTON, GAUSS are considered in Part I, while COPERNICUS, VESALIUS, VIÈTE, HARVEY, ABEL will appear only in Part II. However, cross-references will enable the reader to survey with comparative ease, either the total progress accomplished in each century or the continuous development of each science throughout the ages.

The Second Part contains an introduction in which the great problem of the Classification of Sciences is studied under its historical and philosophic aspects, and then as many main sections as

there are main groups of sciences. I consider seven groups, but I do not attach much importance to this classification and it is quite possible that the editing of my notes will oblige me to change it. While the first part is of greater interest to historians, the second will probably appeal more strongly to scientists and philosophers. The Table of Contents gives its main divisions, and the subdivisions of one of its chapters.

III. — TENTATIVE TABLE OF CONTENTS.

FIRST PART.

The History and Philosophy of Science.

(A) Introduction :

1. Definition of Science. Its signification and limitations.
2. History of Science : definition ; aim and signification ; sources ; methods ; history of these studies ; their relation to other studies ; main sources of auxiliary studies.
3. Organization of Science : external, technical, internal. (cfr. *Isis*, I, 195). National and international organization.
4. Philosophy of Science.

(B) Development of Science at certain periods or by certain peoples.

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|--------------------------------|------------------------------------|
| 1. Introduction. | 10. Middle Ages. |
| 2. Prehistoric times. | 11. Asia. |
| 3. Antiquity. | 12. China. |
| 4. Egypt. | 13. India. |
| 5. Babylonia and Assyria. | 14. Japan. |
| 6. Old Testament Civilization. | 15. Iran. |
| 7. Greece. | 16. Islam. |
| 8. Rome. | 17. Israel. |
| 9. Byzantium. | 18. Primitive and popular Science. |

(C) Development of Science, century by century.

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|-------------------------|----------------------------|
| 1. Ninth century B. C. | 15. Sixth century. |
| 2. Eighth century B. C. | |
| | |
| 9. First century B. C. | 25. (1) Sixteenth century. |
| 10. First century. | 26. Seventeenth century. |
| | 27. Eighteenth century. |
| 14. Fifth century. | 28. Nineteenth century. |

(1) From the xvth century on, only general scientists are considered, but the special scientists dealt with in the Second Part are quoted.

SECOND PART

History and Philosophy of the particular Sciences.

(The subdivision of this second part is not yet entirely determined. The following order is given tentatively.)

Introduction, Classification of the sciences : History and discussion of the attempts to classify the sciences. Vanity but practical necessity of such efforts. The applied sciences are not disconnected from the pure sciences, but, as much as possible, the principles and applications of science are considered successively in the same chapter. However, applications based upon the principles of many sciences are dealt with separately (*ex. gr.* technology, medical sciences).

(A) Formal sciences (Knowledge of forms) :

1. Logic and Theory of Knowledge.
2. Mathematics (including the statistical method).

(B) Physical sciences (Knowledge of inorganic nature) :

1. Mechanics.
2. Astronomy.
3. Physics.
4. Chemistry.
5. Technology.

(C) Biological sciences (Knowledge of organic nature) :

1. Botany.
2. Zoölogy.
3. Anatomy.
4. Physiology.
5. Biology.

(D) Sciences of the Earth (implying a knowledge of both inorganic and organic nature) :

1. Geodesy.
2. Geography and oceanography.
3. Geology, mineralogy, palaeontology.
4. Meteorology and terrestrial physics.

(Nos. 1 and 4 might have been placed in group B; they have been placed here for the sake of completing group D.)

(E) Anthropological and historical sciences (Knowledge of man, past and present) :

1. Physical anthropology.
2. Psychology.

3. Archaeology.
4. Ethnology.
5. Sociology, jurisprudence and positive polity.
6. Economics.
7. History of civilization.
8. History of art.
9. History of language and literature.
10. History of morals.
11. History of religion.
12. History of superstition and occultism.

(In nos. 7 to 12, the word « history » has about the same sense as in the phrase « natural history ». It might be replaced by the word « science ».)

(F) Medical sciences :

1. Medicine (to be subdivided in many separate sections).
2. Pharmacy.

(G) Educational sciences (the methods of imparting and diffusing knowledge) :

1. Pedagogics.
2. Bibliography. Library science.
3. Museology.

(H) Philosophical sciences.

It would be too long to give the contents of each section of this Second Part. I will simply outline one of them, which may be taken as representative.

Mathematics.

(A) Introduction :

1. Definition of mathematics. Its relations to the other sciences and its main subdivisions.
2. History of mathematics. Its main sources and its history.
3. Organization of mathematics (*ex. gr.* : bibliography, encyclopaedias, main textbooks, institutes, teaching, congresses, national and international organizations).
4. Philosophy of mathematics.

(B) History of mathematics century by century.

1. For the early times down to the fifteenth century (incl.) this historical outline will be very brief and will consist chiefly in references to the paragraphs of the First Part dealing with mathematics and mathematicians.

2. The sixteenth century.
 3. The seventeenth century.
 4. The eighteenth century.
 5. The nineteenth century.
- (C) History of special branches or topics.
1. History of various branches and sub-branches, with critical bibliography of the main publications relative to each. For example : Arithmetic; Algebra; Geometry (elementary, analytical, descriptive, synthetic); Trigonometry, etc. Theory of groups, Theory of Numbers, Determinants, Combinatorial Analysis, Theory of Equations, Theory of Probabilities, Statistical methods, etc.
 2. History of particular topics : Quadrature of the circle, special curves, imaginary elements, mathematical instruments and models, etc.

CONCLUSION

- (A) The History of Science, an essential part of education.
- (B) The Encyclopaedic point of view.
History of encyclopaedic endeavours.
- (C) The New Humanism.
History of humanism. Reconciliation of the humanistic and the scientific attitudes. The New Humanism.

Indexes.

IV. — METHOD.

The main substance of the introduction is directly derived from the enormous amount of notes which, being driven by an insatiable curiosity, I have managed to take on practically every topic having any relation, however remote, with the history of science. Unfortunately many of these notes were written when I was still very immature and are, in their present form, of little value. Besides, before the war I had no access to as good a library as the one in which I am now privileged to work. Hence many of my pre-war notes, being either immature or second-hand, have to be corrected completed, rewritten. However, they are very useful to me as finger posts, and my work would be less comprehensive without them.

The information derived from my own collections is completed by the systematic use of three other sources : in the first place, the

Widener library, whose treasures are as accessible to me as if they were my own and whose catalogue is almost perfect; in the second place, a few standard textbooks dealing with the history of particular sciences. However, this second source is distinctly of an auxiliary nature. I use it only to make sure that no item of any importance has been neglected. The total amount of the Widener collections and of mine is so great that the probability of my overlooking any important scientist is very small; moreover the amount of information I have on each of them — obtained so to say at random during many years of study — enables me to measure their relative importance in an objective way, (that being of course only a first approximation.)

Finally I propose to submit various chapters or paragraphs of the Introduction, as soon as they are completed, to experts and to ask for their criticism and advice: this will be my third source.

It will be noted that the simultaneous use of my own collections and of these three other sources must give to my selections a good deal of objective value. This is especially important in the present case, for the size of the subject naturally obliges me not simply to select the topics to be considered, but even for each topic, to select the information to be given. The bibliography to be truly synthetic (see *Isis* III, 159-170) must be critical and selective. I will eliminate the dead wood as much as I can and add critical appreciations as often as possible.

Neither will I hesitate to introduce eventually reflexions of a more personal vein. I will do this for I know by experience how such side remarks can be helpful sometimes even if they be a little adventurous: how often have I not wished that authors whom I was consulting had been less reticent! This can not jeopardize the objectivity of my work for the reader will always know when I am stating a fact and when I am simply expressing an opinion.

It is hardly necessary to add, that however much I may try, the various chapters or paragraphs of such a book are bound to be of very unequal value. I may spend so much time investigating the material pertinent to some of them, that the writing of a new monograph on the subject would cost me but little additional pains. For many others, I must needs rest satisfied with a far more superficial investigation, or else my Introduction would never be ready.

GEORGE SARTON.

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CONTAINING :

G. A. MILLER. — Different types of mathematical history.

J. W. S. JOHNSON. — HENRIK HARPESTRÆNG. A Danish Salernitan.

FLORIAN CAJORI. — Note on the FAHRENHEIT Scale.

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