Kedrov, Bonifati M.

Problem of periodization in the history of natural science

Organon 1, 207-218

1964

B. M. Kedrov

PROBLEM OF PERIODIZATION IN THE HISTORY OF NATURAL SCIENCE

FORMULATION OF THE PROBLEM

1.

The problem of periodization is, strictly speaking, a problem of the internal structure of historical process, that is of the structure of its presentation, too. Hence follows the theoretical importance and practical significance of that problem for the whole historical science and for all of its divisions, including the history of natural science.

2.

The period in the history of science is called a determined stage or phase of its development characterized by the whole complex of stable specific indications appearing at its rise and disappearing at its completion, owing to which the historical boundaries of each period are showing up more or less clearly.

3.

Such indications of each period are first of all: universal method of cognition or of approach to the investigation in nature's phenomena, that is existence of determined research methods characteristic of a given period and playing a decisive role during the whole of that period; general tasks confronting the natural science as a whole, and its particular branches during a given period; general technological and industrial needs determining the main directions of nature's cognition.

THE TWO APPROACHES TO PERIODIZATION

4.

The formal approach to the problem of periodization is founded on a superficial consideration of most simple and striking signs and connections, which do not reflect, however, the essential regularities

and the internal contents of the process being analysed. Of formal character is the periodization: according to purely chronological indications, for instance according to centuries (science of the XVIIth, XVIIIth, XIXth, XXth centuries) or according to historical epochs (Antiquity, Middle Ages, Renaissance and so forth); according to socioeconomic structures only (science of slave-owning society, of feudal society and so on) without inquiring into the peculiarities of the development of science itself in every structure; according to the particular prominent discoveries, snatched from the whole process of development (science of steam age, electricity age, atomic age etc.); according to persons, with whom great discoveries are connected (Copernicus's epoch, Newton's epoch, Darwin's epoch etc.).

5.

A substantial approach does not confine itself to external, formal indications (for instance, by referring science to one or another historical epoch), but requires a penetration into the essence of the process being analysed, into the profound, fundamental ties and interdependencies that, in the final analysis, determine the changes of the individual stages and phases of the development of science, and consequently its periodization. Only such an approach is Marxist.

THE FACTORS DETERMINING PERIODIZATION

6.

There are three main factors determining the division of the history of natural science into periods: regularity of the process itself of nature's cognition (its internal logic); its direct dependence on technology, on industrial and agricultural production, and on medicine; its dependence on the general development of socioeconomic relations and on the character of the class struggle, especially in the domain of ideology — which exert an influence upon the natural science both directly and through the domains contiguous to it (philosophy and technology).

7.

Science may not be reduced to a pure cognition of nature, for it is organically interwoven with practice which stimulates its development, serves as a criterion for it, and constitutes the ultimate end of the cognition. In a broad sense of the word, the way of nature's cognition conducts from the empiric observations and experimental inquiries, through theoretic (logical) comprehension and generalization of what has been observed, to the practical activity and utilization in technology, in production, of what has been disclosed and discovered by

science. Natural science, therefore, is inseparably connected with philosophy and technology, and through them — with life and development of the whole society.

8.

In spite, however, of the very importance of connections of natural science with technology (and through it — with the industrial production) and philosophy (and through it — first of all with the ideological class struggle), those connections do not fully determine yet the concrete content of the particular periods of science development. Being a cognition of a determined object (nature), science as a specific phenomenon and its stages (periods) are characterized above all by two factors: by general traits of the stages of every cognition and by the degree of cognizing a determined object, that is by the degree of revealing the regularities of nature. The first factor is expressed by the movement of every cognition from the phenomena to the essence and from the less profound essence to the more profound one; the other is expressed by the specificity of the manifold essence being disclosed, and of its manifestations. Both factors together determine the internal logic of the development of natural science itself.

9.

Accordingly, the characteristic of particular periods is to be founded upon the contemplation of the mutual bond existing between the internal logic and the external conditions of science development.

THE THREE PHASES OF NATURE'S COGNITION (SCHEME ABC)

10.

From the point of view of the internal logic, the cognition of nature is characterized by the general course of development, which conducts: 1) from the direct contemplation of nature's phenomena, 2) through the analysis of nature, 3) to the synthetical reconstitution — on the basis of the particulars cognized — of the picture of nature as a whole.

11.

To the three stages of every cognition (lively contemplation, analysis, synthesis based on the previous analysis) correspond three phases of development of the entire natural science:

A. Phase of contemplation: nature is regarded as a whole direct and not dismembered into parts; the general overshadows the particulars.

B. Phase of analysis: nature is sharply divided into particular domains; its objects are being anatomically dissected, and to this effect, immobilized, isolated and deprived of life; the reverse joining of the

division elements does not take place or has a superficial character only; the particulars overshadow the general.

C. Phase of synthesis: nature is being once more regarded as a whole, yet not simply as something undivided, but as something originated by way of an internal interaction of its parts; the whole is being reconstituted out of the parts by setting them into movement and by reviving the objects formerly immobilized and deprived of life — that is to say by binding together what was disunited before; it is for the first time that the general and the particulars appear in an organic unity.

In the typical case, phase A is being represented by the ancient science, phase B — by the science of the XVIIth century and of the first half of the XVIIIth century, phase C — by the contemporary science.

TRANSITIONS BETWEEN THE FUNDAMENTAL PHASES OF COGNITION

12.

The scheme ABC has an extremely general but at the same time one-sided character, because it does not take into account the connections of science with practice. As a matter of fact, such phases as A, B, C do not appear in a pure form. They have been singled out abstractly, by means of a logical analysis only. Moreover, the scheme under consideration does not embrace, strictly speaking, many important epochs of the history of science (Middle Ages, Renaissance, the second half of the XVIIIth and the whole of the XIXth century a.s.o.). That is why the scheme ABC requires a further elaboration and concrete definition through explaining the dependence existing between the formation of new periods within natural science and the external conditions of science development as well as needs of technology and production.

13.

The progressive movement of cognition is proceeding under the direct influence of practice. The causes determining the very progress of science — requirements of technology and production — determine at the same time the historical terms of the natural science passing from one period to another. As a result of that, the transition from one phase of cognition development to another may last many decades and even centuries, unless the motive forces of science development attain an appropriate level.

14.

The sociopolitical conditions may now stimulate, now hamper the science development; they may occasion within it new contradictions or favour their solution. In consequence of the influence exerted by

the impeding external conditions, the imminent transition of cognition from one phase to another, in accordance with the scheme ABC, may be hampered or even temporarily receive a wrong direction.

FULL SCHEME OF PHASES OF SCIENCE DEVELOPMENT AND OF TRANSITIONS BETWEEN THEM

15.

Under the influence of non-scientific causes impeding the transitions of cognition from one stage to another, the above transitions had been hampered, in course of history, and transformed into more or less independent and prolonged intermediate periods:

a. The transition from contemplation to analysis was hampered in the age of feudalism by the prevalence of religious ideology and by the absence of sufficient stimuli of technological progress — which led to the formation of a special intermediate period.

b. The transition from the analysis of nature to its synthetical comprehension became complicated in the XIXth century, in the era of capitalist domination, by the ideological-political and philosophical reaction of the bourgeoisie, which equally then contributed to the formation of a really special intermediate period.

Accordingly, the scheme ABC is being transformed into a more detailed scheme A*a*B*b*C, where two intermediate, transitory periods *a*, *b* have been included.

16.

Thus we received altogether five periods with specific marks: I period, phase A; II — transition *a* from A to B; III — phase B; IV — transition *b* from B to C; V — phase C. Since natural science, as a science in the true sense of the word, appeared not before the Age of Renaissance, the two first periods have for the whole natural science (but not for some of its branches) a pre-scientific, embrional character, and only the three following ones — a scientific, in fact, a developed character.

17.

Owing to the dependence of science development on the development of the entire society, all the above periods must, in the end, correspond (more or less exactly of course) to the fundamental periods of general history. Each period in its own developed form corresponds either to a determined socioeconomic system, or to its special phase, to a separate stage. Chronologically, however, the revolutions in the views on nature, while constituting in fact the bounds between the periods of the history of science, do not completely correspond to social revolutions nor to other great turning-points in the history of the entire society.

EMERGENCE OF A LEADING SCIENCE

18.

The internal logic of science gets determined more in detail by the course of the development of cognition from more simple objects (movement forms and their regularities) to more complex ones. The notion of simplicity has in this case both an objective meaning (as a correspondence to the lower stages of nature development), and a subjective one (in the sense of its greater accessibility to cognition and utilization by man). In conformity with that, the development of natural science began from the most simple and easily cognizable forms of the moving matter, and proceeded towards inquiring into forms more and more complex, less and less accessible to cognition and utilization. It is just what determined the successive development of various branches of science and the application of their achievements in technology. The fact that in the course of science development such or other scientific branches or problems are coming to the fore, is to be explained by technological needs of society.

19.

Accordingly, the dominating role of a leading science in the particular periods of natural science was being acquired successively by its one or another developing branch: mechanics in the 3rd period (hence one of its denominations: "mechanistic science"); chemistry of compound substances and physics at the beginning of the 4th period and biology — at its end (hence one of its names "steam and Darwin century"); atom physics, then quantum and nuclear (subatom) physics at the beginning of the 5th period (hence the name: "century of nuclear energy") and lately, at the contemporary stage of the 5th period, physics of elementary particles, cybernetics, cosmonautics, macrochemistry and molecular biology. The development of science, with that, takes place in the following way: all the branches of science, which had arisen before, keep on developing, but to the forefront are advancing the branches that have just come into being in the course of nature cognition as a new, a higher stage of the development of natural science as a whole.

CONCRETE PERIODIZATION

20.

In order to determine more concretely the characteristic peculiarities of the particular periods of the history of science, it is necessary to explain the general features of each of them from the viewpoint of: general approach to the study of natural phenomena (scientific method

or way of thinking); authority of one or another philosophy, fostering or hampering the process of knowledge; level and character of the development of the technology and of its inquiries; basic contradiction of the natural science remaining in force during a given period. In conformity with that, a more concrete name and definition may be given to each period underlying the scheme A*a*BbC.

FIRST PERIOD (A)

21.

The basic period A was characterized by a general natural-philosophic way of thinking and an adequate approach to natural phenomena, since the rudiments of nature's knowledge formed part of one and indivisible philosophic science. That way of thinking was, in its foundations, naively dialectic and at the same time naively materialist. Technology was still very little developed, and accordingly could not visibly stimulate the development of nature study nor create conditions for an inevitable appearance of a systematic-experimental and all the more theoretical natural science. The fundamental contradiction of that period was a deep chasm between broad natural-philosophic conceptions and extremely primitive experiment and production habits, giving no possibility of hoarding facts exactly established and checked.

SECOND PERIOD (*a*)

22.

The intermediate period between the phases A and B, especially in the conditions of the feudal West, was characterized by the scholastic way of thinking, which eliminated or strongly restricted and distorted the experimental approach to natural phenomena. The dominating religious ideology reduced science to a servant of its own; as a result of religious conceptions penetrating into science, which already before began differentiating into particular branches, it degenerated into peculiar, semi-scientific and semi-religious hybrids (astrology, alchemy, cabalism, magic etc.).

Technology still developed so slowly that its influence could not protect science against the pernicious effect of religion and scholasticism. The main contradiction of that period was an unnatural combination of the not yet shaped science with the world outlook and way of thinking completely inimical to it. Sporadic sprouts of science appeared and were cultivated in the East (Arabs, Central Asia, Transcaucasus etc.).

THIRD PERIOD (B)

23.

The fundamental period B was — at its beginning — characterized by: rapidly proceeding and profound differentiation of the formerly united science into particular branches (mechanics, astronomy, physics a.s.f.); violent (revolutionary) departure from religion and scholasticism; development of experimental investigations enabling the accumulation of empirical data, the collection of facts indispensable for their subsequent generalization, that is for building the foundation of the science itself. The natural phenomena were cognized by means of an analysis without considering their general connections ad their development. Formal (artificial) classifications came into being. All that constituted a cognitive premise for the subsequent cognition of nature in its connections and changes. Such an analytic approach, however, being one-sidedly immobilized and made absolute, led to a metaphysical way of thinking which supplanted the original naive dialectics. But every metaphysics, as a matter of fact, is a gnosiological source of idealism and theology ("initial impulse", "creative acts") in spite of the prevailing general materialist world outlook. Here is the fundamental contradiction of that period to be sought: natural science, at first revolutionary and breaking with religion (discoveries of Copernicus), later on proved to be logically incapable of overcoming theology, nature being regarded by it as conservative throughout. Technology, industry (just having arisen) exerted a very stimulating influence upon science, putting before it the task of studying the mechanical form of movement as a fundamental one in the conditions of manufactory.

FOURTH PERIOD (*b*)

24.

The intermediate period *b* between the phases B and C was characterized by the overcoming of the metaphysical world outlook that was endowing nature with an absolute invariability. Spontaneously, without scientists' knowledge and in spite of themselves, natural science was being penetrated by an essentially dialectical view upon natural processes. It is in the evolutionary conceptions that were reflected the ideas of development and of general connections in nature. Those ideas intruded into science at first in some particular points (discoveries of Lomonossov, Kant, K. Wolf, Boscovich), making breaches in the previous fossilized view on nature. In the evolutionary conceptions, successively penetrating into astronomy, chemistry, geology, physics, biology, was reflected a new method of nature study (comparative method in anatomy, physical geography, chemistry; historical method

in cosmogony, geology, biology a.s.o.); it permitted to realize the theoretical synthesis within the particular branches of natural science by embracing the whole of the stored experimental material from the viewpoint of a unified theory and natural classification, and equally between various branches of science thanks to the fact that they had been penetrated by the general ideas of development and of mutual connections. That synthesis, however, was not yet complete since the particular branches of science remained disunited and the ideas of development and of mutual connections did not penetrate into the most general forms of being and the most elementary objects of nature constituting the foundation of natural science. The empirical task relative to the collection of materials being in the main fulfilled, the transition to the next task — to a theoretical generalization — was performed. In view of that, the hypothesis became a form of science development, a purely empirical thought proved to be contracted and inadequate, the importance of theoretical thought was visibly increasing. At the same time, the connections of science with practice, technology and production were extending and consolidating. The main scientific trend was determined by the first technological revolution (replacement of the human hand by the machine, utilization of steam in the steam-engine). This involved the necessity of solving the problem of energy conversion, etc. The introduction of the dialectical method, as adequate to the new contents of science, proved to be an urgent necessity. The scientists, however, were hindered from shifting to that method by the reactionary ideology of bourgeoisie which had grown a ruling class. This gave rise to a fundamental contradiction of that period — to a contradiction between the new objective (dialectical) content of scientific discoveries and the former subjective (metaphysical) way of thinking. It is just what accounts for the numerous particular difficulties of the XIXth century science.

FIFTH PERIOD (C)

25.

The fundamental period C is characterized by the marks of a fully developed theoretical synthesis: penetration of the idea of connection and development into the domain of elementary objects of nature and general forms of being; interpenetration of formerly isolated branches of science and simultaneous formation of new, intermediate and transitory branches (cybernetics included), which realize the general integration of science; extension of nature study in both directions — towards micro-objects and macro-objects. The attainment of the phase C was connected with the most recent revolution in science opened with the discovery of Roentgen rays, radio-activity (H. Becquerel), electron (J. J. Thomson), radium (P. Curie and M. Curie-Skłodowska). In the XXth

century the revolution in physics was represented, among others, by Planck, Rutherford, Einstein, Bohr. The connection of science with production grew even closer. The second technological revolution has put new tasks linked with the transmission of human brain functions to a steering machine (a cybernetical device). The power base of production has widened considerably: it was at first electricity (dynamo) and chemistry (combustion engines) that got ahead, later on — atomic energy (reactors). Cosmonautics came into being. There began the penetration into the chemism of life, bringing us nearer to the solution of the problem of biosynthesis.

26.

Although dialectics grows more and more indispensable, the conditions of imperialism give rise to additional difficulties in the matter of scientists' transition to it, the growing activeness of the reactionary (idealistic) world outlook being one of those difficulties. That is why science is seized with crisis which may be regarded as a separate, parallel period C, coming into play in the countries of the contemporary capitalism. Its fundamental contradiction is a further development and aggravation of the contradiction of the preceding period *b*: owing to the spontaneous (unconscious) character of dialectics, the commenced transition from metaphysics to dialectics is being exploited by the reactionary ideology with a view to oust materialism from science and replace it by idealism. Consequently, the reactionary encroachments are being engendered by the revolutionary remaking of science, the backward motions — by its rapid progress.

27.

That contradiction (the reaction sponging on revolution, regress on progress) is being solved in the conditions of socialism; it is for the first time that an accordance is being attained here between the form (way) of scientists' thought and the objective contents of the scientific discoveries themselves. Dialectics becomes a research method, consciously recognized by the scientists; science gets free from the former antagonism existing in capitalism between science and production, and (in the course of the building of communism) turns, in full measure, into a direct productive force.

GENERAL RESULT OF PERIODIZATION

28.

On the basis of the whole complex of general marks, each period may be characterized as follows:

I. A. Natural-philosophic (from Antiquity to the IVth century A.D.)
II. *a*. Scholastic (Vth—XVth century)

III. B. Collecting or empirical (XVIth—XVIIIth century)
IV. *b*. Evolutional or theoretical (XIXth century)
V. C. Of newest revolution or contemporary (XXth century).

29.

When approaching the same periods in a purely methodological manner, each of them may be characterized from the viewpoint of the predominant way of thinking and of the influence of philosophy on science. In doing so, there are two parallel periods to be distinguished within the fifth period:

I. A. Naively dialectical
II. *a*. Scholastic
III. B. Metaphysical (mechanistic)
IV. *b*. Spontaneously (inconsequently) dialectical
V. C. Of crisis in science
Consciously (consequently) dialectical.

THE DIVISION OF PERIODS INTO STAGES

30.

At a more detailed periodization of the history of science, each of its periods may be generally divided into three stages: early (pre-classical), where the essential marks and contradictions of the preceding period did not yet fully disappear and those of the beginning one did not yet fully take shape nor manifest themselves; middle or principal (classical), where the essential marks and contradictions of the given period developed in full; late (post-classical), where apart from the essential marks and contradictions of the given period, the marks of the next period begin coming to light (arising). In certain cases the number of stages may be greater or smaller. The existence of those stages shows the absence of any sharp bounds between the periods and the gradual change (development) from one period to another.

CONTRACTION OF THE PROBLEM: PARTICULAR BRANCHES OF SCIENCE AND PARTICULAR COUNTRIES

31.

The general theses and principles of periodization of the world science as a whole may be adopted for the periodization of its individual branches, divisions and trends as well as for the development of science in the particular countries. With that, the following marks are coming to light: the more detailed, the more narrow is the character of a branch or of a trend within the science, the more profound is — at the determination of the appropriate periods — the influence exerted by the internal

logic of the development of cognition and by the specificity of the object under examination; the periodization of the history of science in particular countries is, on the contrary, characterized by the periods being dependent on external, socioeconomic conditions — so that the periodization approximates to the general-historical periodization.

32.

Although the periodization within the particular branches of natural science is, in the end, being determined by the periodization of the natural science as a whole, the bounds of periods in general may not coincide. Thus for instance the transition from the third period to the fourth started in astronomy in the middle of the XVIIIth century (Kant's cosmogonical theory), in chemistry of compound substances — at the beginning of the XIXth century (atomism), in geology — in the thirties of the XIXth century (theory of gradual development of the Earth), in physics — in the forties (theory of energy conversion), in biology — in the thirties and fifties (cellular theory, Darwinism), in chemistry of atoms and molecules — in the last third of the XIXth century (periodic table); toward the end of the XIXth century, the sharp boundary between physics and chemistry began to be effaced and the contemporary physical chemistry came into being, as a foundation for the further development of both disciplines in the XXth century. Finally, a radical breaking of the former fundamental notions of mechanics (mass, space and time) and of physical-chemical disciplines (atom, molecule) set in only at the turn of the XIXth and XXth centuries. The general succession, however, of the alternating periods in the history of particular branches is the same as within the natural science as a whole.

33.

The principles of periodization of the history of natural science and its concrete scheme, put forward in this monography, represent the personal views of the author and are proposed for discussion with the view of elaborating a base for a Marxist solution of the question under consideration.