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# A Methodological Model of a Scientific Discipline

## Introduction

The aim of this article is to present a model of a scientific discipline seen in an activist and pragmatic perspective. In this approach a characterization of a model of a scientific discipline must contain those elements that are crucial for its development. Hence, a scientific discipline must be considered in its complexity, which involves a broadly understood methodological analysis.

The very notion of a scientific discipline is an object of controversy. While I am not going to relate it, I would like to emphasize that a scientific discipline should not be identified with a domain of science, i.e. a set of objects and their properties that are a subject of research or reference. A scientific domain is only one of the elements characterizing a scientific discipline. It is only in the case of interdisciplinary studies that its scope exceeds that of a scientific discipline.

My characterization of a methodological model of a scientific discipline rests on a systems approach to science, and it is in this approach that the character and main aspects of a scientific discipline will be presented. Hence, the work embraces: 1) the systems approach to science, and 2) the main aspects of a scientific discipline.

## 1. The systems approach to science

So far, the definitions of science and a scientific discipline have emphasized either logical or pragmatic aspects. These two aspects, however, are not mutually exclusive and can be treated as complementary. This is what the systems approach does in its attempt to grasp science in all its complexity. The systems approach to science makes it possible to grasp and integrate its various complementary aspects and to overcome controversies concerning its character. As Gorochow (1972: 370) states,

> the systems approach should be the means to build complex theoretical studies of science. Only then can all the ambiguity of the concepts of science be preserved in the context of uniform theoretical investigation.

The systems conception of science was formulated by Czeżowski (1936: 3) in the following way:

> ...all this, scientists, their libraries and laboratories, scientific books and journals, precision instruments, preparations and museum collections, constitute a whole, a system, an organism whose parts are connected by means of various relationships...

The understanding of science as a socio-cognitive system that I am going to propose is broader and more holistic, however, because it embraces all its basic aspects.

The systems approach to science should be based on a real conception of a system. In the real sense, a system is a concrete object composed of other objects which are its components, and which are interconnected in such a way that they form a whole distinct from the environment. A minimal definition of a system requires three aspects to be described: 1) its composition, 2) its environment, and 3) its structure. The composition of a system is a set of its parts or components, its environment is a set of things that are not its components, but with which it is connected, and its structure is a set of real relations, especially connections holding among the system components and between them and the environment (cf. Bunge 1979: 4).

On this understanding of a system, both science and a scientific discipline can be treated as socio-cognitive systems. This is so because science is not only a cognitive activity, but also a mode of social action and its product, shaped by a scientific community in a specific social environment (cf. Ziman 1968).

The conception of a socio-cognitive system can be presented as follows. A socio-cognitive system, as any real system, is defined by its three aspects: its composition, environment and structure.

The **composition** of a socio-cognitive system includes the totality of persons engaged in research activity, viz. a scientific community. Its **environment** includes the natural environment as well as a technical-cultural one, i.e. means and facilities used by researchers, and a social one, i.e. the society within which the researchers conduct their studies. Its **structure**, or more precisely, its relational structure, embraces both internal and external relations. Internal relations include primarily research activities as well as communication and criticism, which together produce scientific knowledge, and also other social relations, like co-operation, competition, etc. External relations include interaction between the socio-cognitive system and society, that is, the influence of science on society and practice, and of society, hence of the economy, politics and culture, on science. Here are some remarks on this matter.

1) The scientific community is a specific social, or more precisely cultural, subsystem. It is functionally diversified according to the character of activity. Thus, by function, it can be described as composed of researchers, or creators of knowledge, technical workers, organizers, etc. There are a number of divisions in this respect. The community is also diversified according to the scientific position and importance, hence authority, of its members (cf. Rybicki, Goćkowski 1980). It is also highly institutionalized, both legally and customarily, as reflected in the principles of scientific advancement (degrees and titles) and forms of

organization (universities, scientific institutes, academies of sciences, committees, societies, etc.). A big role in the scientific community may also be played by informal organizational structures and monopolization.

2) Society as an environment has a decisive role in the operation and shaping of science. This especially refers to the State, its system and official ideologies, particularly in totalitarian countries, ways of financing, etc.

3) Both research activities and their results, i.e. scientific knowledge, have properties fundamentally different from other kinds of people's cultural activities and their products.

The specificity of research activities derives from that of their aims and the ways and means they employ. The aims are the adequacy of cognition and improvement of practical activity on this basis. And while the notion of truth is not effective, it is inseparable from scientific cognition and constitutes its primary value. The ways of research activity are scientific methods, i.e. principles of research procedure defining the process of solving scientific problems and allowing information about the fragment of reality under study to be obtained. This requires the application of various instrumental means and research techniques which in some cases involve enormous costs. Significant from a social point of view is not only the cognitive effectiveness of research methods, but also their "economy".

The distinctness of science as a product consists first of all in the fact that scientific knowledge takes the form of conceptual systems. They are composed of notional constructs (concepts, theses) with specific reference among which obtain logical relations ordering them, and the environment of which is knowledge not contained in the systems. Theoretical systems (theories) are their special cases.

Without going into a discussion on the ontological status of scientific knowledge, it should be emphasized that the recognition of its conceptual character does not imply the acceptance of the claim that it constitutes a separate world, like Popper's "third world".

Science as a socio-cognitive system has various scales of complexity: at a global scale it is "world science", at a regional one, the science of a given country, e.g. "Polish science", and at a local one, the science of a centre or university. It should be noted that the overall structure of such a system is a nested, not hierarchical, one, as is sometimes claimed, although in some centres or even countries science may have a dominant role.

## 2. The main aspects of a scientific discipline

A scientific discipline is a subsystem of science specializing in the study of a specific domain. It is a functional socio-cognitive system and has various scales of complexity.

In order to present its character, however, it is not enough to define its composition, environment and relational structure, but it is necessary to take into consideration the domain of inquiry and the specificity of the research activity and the character of the scientific knowledge referring to it.

Thus, the following elements distinguish a scientific discipline from other ones (cf. Gasparski 1982: 182, Mazur 1982: 256, Bunge 1983b: 197, Zamecki 1988: 128, Chojnicki 1989: 6):

1) the scientific community,
2) the domain of inquiry,
3) the research activity including:
   3.1. the philosophical background of research,
   3.2. aims,
   3.3. the problematics,
   3.4. methods of the research procedure,
   3.5. communication and scientific criticism,
4) the fund of scientific knowledge,
5) links with other disciplines, and
6) the social environment and external links.

## 2.1. The scientific community

Each scientific discipline is in principle represented by a different community of researchers. According to Bunge (1983b: 198), the research community of a research field

> is a system composed of persons who have received a specialized training, hold strong information links amongst them, and initiate or continue a tradition of inquiry.

The role and importance of a discipline depends first of all on the human factor, i.e. on the size and character of this community. Its formation is conditioned by a number of internal factors of science as well as by external ones: social, political, cultural and economic.

When analysing the scientific community of a given discipline, attention should be paid to those of its properties that shape the effectiveness and innovativeness of research activity. These include primarily: science-creating qualities of researchers, correct social relations holding among them, and an adequate organization and institutions regulating research activity.

The basic science-creating qualities of researchers include: abilities, skills, qualifications, ambition and a creative talent. However, they are only potential and require favourable social, organizational and institutional conditions to surface.

Of much importance are the relations and interactions taking place in the scientific community. According to Ziman (1968: 10),

> ...to understand the nature of science we must look at the way in which scientists behave towards one another, how they are organized, and how information passes between them.

As in any social system, the most important role is played by co-operation and competition (Bunge 1983: 110).

> Co-operation includes (...) help in transmitting skills and information, formulating or reformulating problems, devising hypotheses or methods, offering

> constructive advice or criticism and, in general, sharing knowledge. Competition includes making destructive criticism, proposing rival theories, methods or data, and fighting over the support of third parties, such as assistants, colleagues, and funding agencies. Cooperation gives individual workers the necessary support, and competition keeps them at their toes; competition helps find out error, and co-operation corrects it.

The interactions holding in a scientific community also influence the position and scientific authority of scientists as well as informal structures to which scientific schools belong.

Of no little significance is the internal organization and institutions, which are closely interrelated.

The internal organization is of a highly institutionalized nature. This manifests itself on the one hand in the hierarchical structure of a scientific community, not only factual but first of all institutional, taking the form of requirements that the profession of researcher must meet, especially in the sphere of academic activity (scientific degrees and titles), differing according to the discipline. On the other hand, there is a complex system of institutions within which research activity is divided into scientific and academic and within which its quality is supervised, and which takes the form of universities, institutes, departments, scientific committees, etc.

## 2.2. The domain of inquiry

The domain of an empirical scientific discipline in the real sense is a set of certain components of reality, i.e. of those concrete objects and their properties that constitute its reference. The same objects can be investigated by different disciplines, each dealing with their different properties. Thus, real domains of scientific disciplines may differ as to the kinds of objects and the classes of their properties.

It is difficult to characterize a real domain of a scientific discipline directly, that is, through a description of the concrete objects and their properties that are its reference. It can be done indirectly, however, through the conceptualization of the selected fragment of reality, or, in other words, through the formulation of conceptual reference models for the given set of objects and/or their properties.

Conceptual reference models of the domain of a given scientific discipline are sets of key theoretical predicates of the objects and their properties that are components of this discipline. They play a twofold role. On the one hand, they restrict the area of interest of the discipline and make it defined, on the other hand, they suggest certain ways of conceiving the objects. These models assume different characters depending on the theoretical level of the discipline.

In disciplines with a high theoretical level conceptual reference models are built in the framework of a theory with a high degree of generality, or as their assumptions. Hence the problematics of the domain of these disciplines are contained within the basic theories. In turn, in disciplines with a low level of theoretical development conceptual reference models are built in the form of pre-theories that define main research aspects and theoretical predicates of key importance. They are formulated in such a way as to represent a possibly broadest scope of reference. Several competitive models are formulated for one and the same discipline. The pre-theories that present them are different orientations in the given discipline.

The domain is the basis for distinguishing a scientific discipline, because the latter's problematics and methods depend on it. This is not a unidirectional dependence, however, as there can be feedback. Changes in the problematics and methods as well as the adoption of new aims of the research may lead to a modification of the character and scope of the domain. Thus, the domain of a discipline does not possess an unalterable scope and changes with its development. It is a necessary, but not sufficient, condition for characterizing a scientific discipline.

## 2.3. The research activity

The research activity carried out in the framework of a scientific discipline embraces a research procedure aiming to solve problems arising within its domain, and efforts to give scientific knowledge the form of a final result. To characterize the activity, it is necessary to consider its main elements, i.e.: 1) its philosophical background, or general outlook, 2) the aims or goals of research, 3) its problematics, 4) methods of inquiry, and 5) communication and scientific criticism.

### 2.3.1. The philosophical background

Starting the characterization of the research activity of a discipline with its philosophical background may raise doubt, as many scientists deny the importance of philosophical assumptions in research activity. However, the fact that one does not voice philosophical opinions does not mean that one has not got any. Such opinions are assumed not only openly, but also tacitly and can be reconstructed on the basis of the mode of research activity. To quote Myrdal (1969: 51), before there can be a view there must be a viewpoint.

Research activity must rest on philosophical assumptions because it concerns cognition, which has an essentially philosophical character, and is controlled by it. The philosophical assumptions of a scientific discipline consist of: 1) ontological assumptions concerning the structure of the world, usually expressed as the basic conceptual apparatus. 2) epistemological assumptions about the character and methods of scientific cognition, and 3) ethical principles or rules regulating researcher's behaviour.

According to Bunge (1983b: 204):

> There is no science without some ontology and some epistemology. To begin with, all the fundamental concepts of science, such as those of thing and property, state and change of state, possibility and actuality, space and time, life and mind, artifact and society, are ontological. Secondly, when exploring some uncharted territory the scientist is tacitly guided by a number of ontological and epistemologies principles. For one thing he presupposes that the most general laws hold in the new territory, and that the most general methodological principles will help him to explore it. (...) If he believes in objective possibility he will investigate things-in-their-environment instead of trying to account for

their behavior exclusively in terms of environmental agencies. If he believes in randomness he will try stochastic models, otherwise he will limit himself to 'deterministic' ones. If he is an inductivist he will collect as many facts as possible before hazarding any hypotheses. If he is a deductivist he will prefer exploring the logical consequences of hypotheses proposed by others.

Within particular disciplines there is, of course, a considerable diversity of philosophical opinions manifesting itself in the form of various philosophical-methodological orientations. These orientations are ideals or models of the rationality of scientific thinking and acting. The models present conceptions of reference, basic principles of the research procedure, the character of knowledge, and their cognitive and practical functions (cf. Chojnicki 1986). They have been influenced by various philosophical debates and, in turn, have played an important role in the conscious shaping of the aims and standards of the research procedure. Another approach to a discipline's general outlook, problematics and research methods, the change of which takes place via revolution, is Kuhn's conception of a paradigm.

Ethical principles are of no less importance for the research activity than the epistemological ones. They are those principles that help attain the primary cognitive value, that is, truth. According to Czeżowski (1989: 225), they include the principles of honesty, objectivity, and impartiality. Without analysing them further, let us remark that they are implemented in the conditions controlled by both, individual motives and mechanisms of action in a scientific community, and external factors.

### 2.3.2. Aims of the research activity

As any conscious and rational activity of man, the research activity aims to achieve definite cognitive and practical goals. They assume a different character on an individual and a collective level.

On the individual level these aims are expressed through research tasks that scientists set themselves or others, in the form of research problems and proposed solutions that are a contribution to the growing fund of knowledge of the given discipline.

A distinction should be made between a researcher's motives and purposes. According to Kaplan (1964: 374),

> ...motives concern the relation between the scientific activity and the whole stream of conduct of which it is a part; purposes relate the activities on inquiry to the particular scientific problems which they are intended to solve. (...) Thus a scientist's motives may include the love of country, or of money, or of glory; his purposes must be specified in terms of the particularities of the problem in which he is engaged: to show that a given phenomenon is subject to certain laws, or that a given explanation can be extended to a certain other class of cases, or the like. Various purposes may serve any motive, and various motives may be involved in the decision to fulfil a particular purpose.

On the collective level the aims of inquiry involve the shaping of the scope, cognitive character, quality and function of scientific knowledge within a given discipline. They are presented in the form of research programmes and are the main component of the formation of scientific schools.

### 2.3.3. The problematics

The problematics of a discipline is a set of scientific problems (actual and potential) posed and solved by researchers on the basis of the body of knowledge of this discipline. The scope of the problematics constitutes the discipline's thematic field. The problematics of a discipline changes with the adoption of new research aims and the introduction of new or improvement of old methods.

Scientific problems are inseparable from ways of solving them. Hence it is important to divide them into: 1) substantive problems concerning various aspects (states of things and their change) of a selected fragment of reality falling within the domain of inquiry, and 2) procedure problems referring to finding solutions, i.e. to research methods. Mutual relations between these two groups of problems play an important role in the advance of science.

Scientific advance requires cognitively and practically worthwhile problems to be posed and solved. The fundamental difficulty lies in the fact that it is hardly possible to determine in advance the cognitive value of a problem and its significance. Bunge (1983a: 245) emphasizes three aspects of this issue:

> One is that all research proposals are evaluated both as *a priori* and *a posteriori*, and prior evaluation rests on some more or less tacit idea of problem worth. Second, if these ideas of problem worth were rendered explicit and discussed in the open, project evaluation would be more rational and objective, and therefore more fair. Third, very few researchers have a knack for 'spotting' important problems, even fewer the ability and drive needed to solve them.

Another important element in the shaping of the problematics of a discipline, apart from worthwhile detailed problems, is the formulation of wide-scope problems, which are the basic component of development programmes of scientific disciplines. They seek to fill the gaps in the body of knowledge and to improve the understanding of the regularities and structures within the domain of a discipline. According to Bunge (1983a: 283),

> Those wide-scope problems are the very *raison d'être* of entire disciplines, and they are unlikely to receive final solutions even though they are being investigated and progress is being made in solving them. All grand problems are like hydras: as one head is cut another sprouts.

The formation of the problematics of a discipline does not, however, take place in a social void. This especially concerns those problems whose solutions improve practical activity. For the basic sciences to undertake them, however, it is usually necessary to secure special material conditions for this type of research, especially the economic motivation.

### 2.3.4. Methods of inquiry

The most important characteristic of a scientific discipline, besides the problematics, is the scientific methods it uses, i.e. the procedures (sequences of steps) that are the ways of solving scientific problems. They are presented in the form of principles or rules defining activities that form the process of problem solution. The research procedure, however, cannot be fully characterized by means of such principles, especially in the case of activities in which skills can only be acquired via research apprenticeship.

While not all research activities rest on scientific methods, the latter play a decisive role in the research procedure, because they regulate and control it. Scientific methods have a creative function in acquiring knowledge and they also legitimize it through the justification of results obtained on their basis. This latter role is especially important, because they contain criteria which determine the recognition of theses arrived at with their help. The satisfaction of these criteria is some guarantee of the truth or certainly of these theses.

Scientific methods contain two main components: 1) operational, and 2) logical. The **operational** component embraces the principles or rules of the application of suitable techniques, i.e. ways of using research tools. In methodological analyses too little attention is paid to the role of these tools in research activities, even though the progress in the creation and use of instrumental means is crucial for the development of empirical sciences. To realize this, it is enough to consider the role of computers in research. The range of means and tools used is very wide (instruments, apparatuses, but also algorithms, computer programmes, codes, etc.) and serves science and practice. The use of research techniques requires not only the knowledge of the rules of their application, but also practical skills acquired through personal experience during apprenticeship. This is true of various activities: experimenting, field observations, historical analysis of sources, and even mathematical analysis.

The **logical** component includes the principles of logic (in a broad sense, together with mathematics) used in the process of argumentation. The means of argumentation are the logical correctness of inference and the adequacy of empirical information. With respect to the logical means applied, argumentation can embrace various kinds of inference: deductive and probabilistic, or reductionist, inductive, statistical, and by analogy. However, as is stated by Wójcicki (1974: 42),

> neither opinions of specialists nor those of methodologists of empirical sciences on what logical means are necessary to establish the scientific disciplines being developed, can never have an ultimate character.

Thus, the application of scientific methods is a necessary but not sufficient condition of the efficiency of research. They must be combined with good scientific craftsmanship (cf. Ravetz 1971: 75).

The influence that scientific methods have on the development of a discipline is exerted by the introduction of new or improvement of old ones, thus enabling scientists to obtain new and/or well justified research results. According to Nowakowska (1977: 239), this influence can be presented in the form of the following hypotheses:

(1) There is a relationship between the precision of method characteristics and the level of organization of a discipline. It can be formulated as a claim

that *the more codified the procedures, the less margin of freedom they allow, the more organized the discipline.*

(2) There is an inversely proportional relationship between the lifetime of methods and the rate of development of a discipline. It can be formulated as a claim that *the shorter the lifetime of methods, the more rapid the development of a discipline.*

(3) The lack of new methods over a longer period of time slows down the increment of the factual component, and hence hampers the development of a discipline as a whole. In this situation the main aim of research may be the search for new methods. This may cause going back to the methods already discarded, which is described as the formation of a methodological loop.

(4) Thus, one may put forward the hypothesis that *the poorer the development of a discipline, the more methodological loops.*

The above statements show that there is a clear connection between the development and application of scientific methods and the development of scientific discipline, but this issue has only just to be recognized.

### 2.3.5. Communication and scientific criticism

Communication and scientific criticism are the main activities transforming the results obtained by researchers into scientific knowledge which is their effect. To quote Ziman (1978: 3 and 6),

> ...scientific knowledge is a product of a collective human enterprise to which scientists make individual contributions which are purified and extended by mutual criticism and intellectual co-operation. (...) Each scientist makes observations, performs experiments, proposes hypotheses, carries out calculations, etc. whose results he communicates to his colleagues. (...) But when we talk of scientific knowledge, we refer to the content of the message that accumulate and are available in the public domain, rather than to the memories and thoughts of each person.

The principal means of communication and scientific criticism are scientific journals and publication series specializing in particular problems or disciplines, as well as conferences of researchers.

Scientific results are mainly communicated via their publication, which is closely associated with their scientific appraisal and criticism. The latter takes place twice: before and after the publication of a work.

Before publication the scientific appraisal and criticism of a work takes the form of an internal review. This type of criticism poses some dangers, because it may be conservative, made from the perspective of the current body of knowledge. After publication scientific appraisal and criticism is both explicit and tacit. The appraisal and criticism is expressed explicitly via published reviews, and tacitly in the process of testing and absorbing the results. The latter consists in conducting similar or analogical studies, in continuing the research, and in the adoption of its results as elements of syntheses or theories. A total lack of interest in published results on the part of the scientific community of a given discipline is a negative test of their value.

## 4. The fund of scientific knowledge

The fund of knowledge of a discipline may be understood in two ways: 1) historically, as the body of knowledge accumulated in its research field during its development, and 2) currently, as a set of research problems and results which provide a basis for further inquiry.

In the current sense, to which I shall restrict my remarks, knowledge is a present state of the given discipline. Thus conceived, knowledge can be considered in various aspects: according to its content, methodological structure, and function.

As to its **content**, the knowledge of a discipline is a set of thematic groups systematizing it according to subject and problems. The set can be divided into sub-disciplines or sections. This kind of systematization allows the determination of gaps in knowledge and the weight of topics in the implementation of goals researchers set themselves.

In the aspect of the **methodological structure**, two basic components are distinguished in an empirical discipline: factual and theoretical. Whithout going into their characteristics, let us note their different significance for the cognitive character of knowledge.

The factual component occurs in two roles: 1) as the result of the stage in the research procedure devoted to establishing facts which will tentatively verify a theory, and 2) as the final result of the research procedure which seeks, or stops at, descriptive knowledge not exceeding facts or their generalizations.

The theoretical component, which the theory of science identifies with a conceptual system composed of general statements referring to a specific domain, in particular of factually justified scientific laws linked thematically and logically, plays an especially important cognitive role, because it provides a basis for the explanation of phenomena and processes taking place within this domain.

The disciplines that confine themselves to description as a final kind of knowledge are treated as pre-theoretical sciences, because they can provide little, if any, explanation of those fragments of reality they deal with.

In disciplines with well developed theory, however, there is interaction between these two components. On the one hand, the discovery of new facts may eliminate some theories as inadequate and necessitate the building of a new ones; on the other, attempts at a reduction of competing theories through the elimination of some of them as empirically inadequate help determine the directions of experimental studies (cf. Nowakowska 1977: 216).

The **functional** aspect of the knowledge of a discipline refers to what it can help achieve in the area of cognition and transformation of the world, hence to its cognitive and practical role (cf. Sztompka 1973: 71).

The cognitive role of knowledge includes three functions: 1) informative, i.e. supplying bits of information that help reduce the indeterminancy of objects, events and processes, 2) explanatory, i.e. providing explanation for reality, and 3) prognostic, i.e. anticipating future states of things and events. The practical role of scientific knowledge consists in its being used to control and transform reality.

The contribution of these functions may be different in each discipline and thus determines its character: basic, applied, or technological. The main aim of basic science is to explain the world and predict its changes; that of applied science is to use this explanation and predicition to make further research that may be practically useful; and that of technology is to control and transform reality through the design and production of artificial systems and plans of action based on scientific knowledge (Bunge 1983b: 215).

## 5. Links with other disciplines

Each scientific discipline is connected with other ones. The research activity carried out in one cannot be isolated from that conducted in others. The link is mutual: a discipline is affected by other ones and in turn acts on them itself.

A discipline is acted upon primarily via: a) the application of mathematical methods and models, and b) the use of the knowledge and methods of more basic disciplines.

The application of mathematical methods and models is taken to be an indicator of the degree of development of an empirical discipline although in some, especially social, sciences it may not always lead to actual advance. The use of the knowledge and methods of more basic disciplines is indispensable, especially when they provide general theories and scientific laws. However, in the words of Bunge (1983b: 205), *no science borrows all of the knowledge in the sciences it presupposes, but a science with few doubts is either very fundamental or very backward*.

The impact on other disciplines has little significance for the development of the knowledge of the discipline that exerts it, but it can be treated as a measure of the discipline's prestige and provide a clue as to what research problems are worth undertaking.

## 6. The social environment and external links

Science is an autonomous, self-regulating socio-cognitive system. It does not operate in a social void, however, but in some social surroundings. The links of science as a whole and its particular disciplines with the social environment are bilateral and interactive. On the one hand, science acts upon society, its culture, economy and politics; on the other, society influences the formation of science. I shall limit my remarks to this second kind of interaction.

The substantial role that science plays in today's culture and economy makes it an important means of acheving economic and political goals. Hence the principal manifestation, and also a tool, of society's influence on the nature and development of scientific activity is scientific policy (cf. Kukliński 1991). It is a set of targets that are achieved with the help of material and human means.

Society's science policy can be 1) interventionist, or 2) non-interventionist. A non-interventionist policy leaves science mainly to private initiative or social organizations. It is implemented through action rather than programmes and is tacit rather than explicit. Public institutions, especially government and official programmes, little affect the shape of scientific activity. Research is carried out mainly at private universities and institutes, and financed by foundations and industry. The State only finances huge projects of a clearly public nature (military matters, the natural environment).

An interventionist policy, in turn, rests on the State's active involvement in the shaping of scientific activity through government institutions and big public projects which it finances. The influence the State has crucially depends on its goals and role. Two types of science planning and management can be distinguished here: 1) authoritarian and 2) democratic (cf. Bunge 1983b: 248).

**Autoritarian** planning and management fully regulates and shapes the whole of the socio-cognitive system of science through central government institutions. The control covers both aims and means of scientific activity, including the character of the scientific community, the content of scientific thought, and the scope of research in the framework of the official ideology. This leads to the monopolization of scholarly life and giving preference to low-level studies. Naturally, in practice there are several levels of authoritarian planning and management, but their results are usually similar: a low level of exploratory proves and innovativeness. This is aptly characterised by Parkinson (1965: 116) in his Parkinson's Law:

> Nowadays, when one country lags scientifically behind another equally prosperous country, the most probable reason is that the government has been telling its scientists what they are to discover. This means, in other words, that too much money has been allocated to specific projects and too little to abstract science. The more resources have been devoted to projects the politicians can understand — that is, to the development of discoveries already made and publicized — the fewer resources are available for discoveries which are now inconceivable in so much as they have not yet been made.

**Democratic** planning and management is characterized by freedom of research and an equilibrium between various centres influencing scientific activity. To achieve it, it is necessary to reconcile the interests of science itself and those of the consumers of its results. While an essential element of this approach is the necessity to finance from public, especially government, resources, there is no authoritarian imposition of closed projects and research is permitted to develop on a competitive basis. Naturally, the research must accomodate social needs, and the mechanisms of social scholarly life should include the possibility of their public presentation, confrontation and recognition.

The significance and role of particular disciplines in these approaches are different. In the authoritarian system the internal structure of science was defined from above, and some disciplines were even eliminated, mostly on ideological grounds. The rank and developmental possibilities of each discipline, especially in the external aspect, should depend on its actual and potential research contribution and worthwhile programmes. It should be emphasized that only a balanced development of the whole of science, hence of a variety of disciplines, can ensure cognitive progress.

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