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CONTENTS

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SOCIAL COGNITION AS A VARIETY OF RATIONALITY

Academician Mark MITIN

Problems of rationalism and irrationalism have played an important part both in the history of philosophy and in present-day intellectual life. In its various forms,rationalism is directed towards science, towards a cognition of the law-governed patterns in the development of the material world and spiritual phenomena. On the contrary, irrationalism denies, in general, or at least belittles scientific knowledge, and addresses itself to some immediate intuitive and instructive premises which are allegedly beyond the reach of reason.

Present-day irrationalist conceptions are fed by the spiritual crisis in capitalist society. By fatalising and fetishising the contradictions in scientific and technological progress, its ideologists are out to prove that Nature, society, and cognition are essentially irrational or chaotic.

Views and assertions are becoming ever more widespread in the Western world that our times are marked by ineradicable paradoxes, and that scientific and technological progress has destroyed faith in reason and in man's ability to arrange his life in a rational way. A sense of fatigue and pessimism has penetrated into man's world-perception today, many philosophers and sociologists assert. There is no longer any confidence or hope in the future of mankind. Some call it the "twilight of reason", others "the eclipse of culture", and yet others "the demise of the spiritual"; what in fact we hear is a "requiem for reason".

What is the explanation of this loss of faith so characteristic of many Western philosophers? The cause does not lie in the bankruptcy of reason. The situation is in no way linked to reason in general, but to historically definite social relations.

A complex and many-faceted ideological struggle is under way in the world today. It has involved all forms and levels of social and individual consciousness, finding a certain specificity in each of them. Forced to take account of the changed situation in the world, the ideologists of capitalism are skillfully camouflaging the devices and methods they use to bring ideological and political pressure to bear on the intelligentsia and the masses of working people. Through the mass media, they are inculcating all kinds of myths in people. By fatalising and fetishising the capitalist variants of the solution to the problems of scientific and technological development, these ideologists play on the fear instilled in socially disunited individuals by the institutionalised system of social pressure. Through the information media, a vague fear is moulded into irrationalist, mystical and religious models of life and reality, this leading to the disoriented individual clutching at superstitions, mystical religious revelations, and widely publicised formulas of bourgeois ideology. A negation of scientific methodology and objective dialectics serves the ideological aims of capitalism: the distortion and suppression of political consciousness in the masses. "In its rational form it is a scandal and abomination to bourgeoisdom and its doctrinaire professors, because it includes in its comprehension and affirmative recognition of the existint state of things, at the same time also, the recognition of the negation of that state, of its inevitable breaking up; because it regards every historically developed social form as in fluid movement, and therefore takes

5435

into account its transient nature not less than its momentary existence; because it lets nothing impose upon it, and is in its essence critical and revolutionary."[1]

The extreme trends in anti-rationalist philosophical views are represented, on the one hand, by irrationalism, which stems from "life-philosophy" and Nietzsheism that appeals to the immediate and intuitive obviousness of existence, and, on the other hand, by a pragmatised rationalism which a number of bourgeois scholars (in the first place by Max Weber in his Wirtschaft und Gesellschaft) have identified with the social organisation of capitalist reality, and the principles of hard cash and utility.

On the threshold of the new times, reason was called "natural light" (lumen naturale). Irrationalist philosophising stood opposed to bourgeois enlightenment from the positions of feudal and romantic reaction, and a criticism of capitalism from the Right. By the middle of the 19th century, irrationalism had become a widespread form of bourgeois consciousness and a philosophical expression of the crisis of bourgeois ideology.

The development of bourgeois society has toppled the ideals and values of traditional culture, oriented towards rationalism à la Hegel, the identity of being and consciousness, and towards the "rationality of reality". Idealistic rationalism, which reduces all problems of human activities to those of cognition, is losing its socially oriented value, since capitalism's blatant inhumanity and immorality cannot be glossed over with the aid of metaphysical and abstract arguments.

The discrediting of the fundamental postulate of idealistic rationalism regarding the identity of being and thinking has given rise to a number of speculations on the theme of the "crisis of rationality" in general. The revision of the rationalist world-view has proceeded along at least five lines:

Firstly, positive technocratic revision (Raymond Aron and N.Luhmann) regards rationality as an ability to systematise and bring order into all spheres of social life, irrespective of subjective yardsticks of value. In the long run, this trend leads to rationality being identified with the norms of the technocratic model of society's organisation.

Historically speaking, scientific consciousness was associated in bourgeois philosophy with the prestige and rights of Reason. At the dawn of bourgeois society, philosophers synthetised an understanding of science as a universal form of man's cultural life out of a spirit of science's form and love of freedom. The ensuing development of capitalist society, and the ascertainment and exacerbation of social antagonisms, as well as the utilisation of all forms of human consciousness in the interests of exploitative society in fact stripped science of its great cultural function, yet the tradition of idealising the form of science conditioned the latter's ambiguous status in the social system. On the one hand, science promoted the rationalisation of all spheres of human activities by performing its cultural function. On the other hand, the ruling bourgeois class, through its ideologists, proclaimed, in the name of science and reason, its programmes which expressed its aims and interests and, using the prestige of reason, hallowed the existing social system.

The above-mentioned technocratic conceptions of science and the scientific and technological revolution have, as a rule, now assumed the form of a frank apologia for the "supremacy of technology" and have joined up with various conceptions both of de-ideologisation, and re-ideologisation, convergence and de-politicisation. Research into the "techniques and mechanisms of rule" has become the content of such conceptions. All kinds of varieties and modes of manipulating people and their consciousness come in for detailed analysis; all sorts of new "theories" have been put forward, such as socio-techniques, humanotechniques,

communication techniques and the like. All such technocratic theories see the people as a mass to be manipulated and, with the aid of various techniques, to be integrated into the social system of state-monopoly capitalism. The theory advanced by E.Forsthoff[2] is a typical attempt to arrive at such a solution of questions of social organisation.

The theory of "technocracy" is out to ideologically justify the state's mounting bureaucratic centralisation and the coalescence of the rule of the monopolies with that of the state; they are also out to justify and substantiate the abolition of some elements of bourgeois democracy. Thus, technocratic ideology is aimed at perfecting the machinery of the monopoly bourgeoisie's rule through methods of suppression, coercion and deception. Technocratic theories are ultimately spearheaded against the theory of class struggle and the revolutionary transformation of the world; they falsify the interconnection and interconditionality of scientific, technological and social progress.

Another line of the revision of rationalist worldview is the subjectivist-irrational one (E.Husserl, M.Heidegger), which reduces reason, the capacity of rational cognition, to "phenomenological vision", immediate knowledge, and mystical insight. With its total disregard of social processes, this approach reduces to nil any possibility of understanding and explaining actual social practice and its definite trend. Thus, an analysis of concrete socio-economic relations, the objective regularities of social development, and class antagonisms remains, as a rule, beyond the irrationalists' purview.

The irrationalists, who elevate social illusions of reality (institutionalisation, depersonalisation, non-spirituality, and mythologisation), refuse to recognise the spirituality and rationality of human existence in general. Actual cognition is an arbitrary, unpredictable and unplanned action. Depersonalised man (M.Heidegger), who at times finds himself in a "boundary situation", dispels, as it were, the gloom of social chaos, but the absence of communication between man and man does not make it possible to register the meaning achieved in cultural forms of universal significance.

The third line along which the rationalist tradition is in a kind of way negated is "critical rationalism" (K.Popper, I.Lakatos, W.Bartley and H.Albert), whose spokesmen try to renovate the old traditions of rationalism. Though manifesting a certain interest in the methodology of scientific cognition, "critical rationalism" in fact limits the tasks of philosophy to an analysis of scientific knowledge as such. Popper has attempted to construct his philosophy, proceeding, as it were, from the general theory of rationality, but his postulates are in no way overall characteristics of man and his mind, expressing, as they do, only some particular features of logical thinking.

It is not knowledge of the world's reality but only knowledge about knowledge that is the main target of the philosophy of "critical rationalism". That target is formulated in Popper's initial methodological principles. The absence of any attention to reality (physical and mental) leads him, within the framework of critical rationalism, either to a radical scepticism of the Feyerabend type or else to an ontologisation of the cognitive content and rules of science in the spirit of the Platonic "realm of ideas" (in Popper's later writings). Popper regards cognition as a certain play of cognitive forces, as a "game for its own sake".[3]

According to Popper, the transposition of philosophico-rational elements into the sphere of social historical phenomena is untenable, since as a rule it leads to an apology for the existing social order and may become the theoretical foundation of any totalitarianism.

It is on that scheme that Popper's critique of Hegel's "reactionary philosophy" is built. To him, Hegel was primarily "the first official philosopher of Prussianism"[4], a

man who prepared philosophy to enter the service of authority and reaction. This view emphasises and brings into the foreground the "applied" essence of Hegelian philosophy, and an interpretation which lays stress on its conservative and reactionary aspect and denies its dialectical method, which is an outstanding product of reason and the traditions of rationalism. Popper regards social cognition and historism as methodological devices in an "apology for Prussianism",[5] as a means of restricting the individual's freedom, and as the rigid determination of human activities and, moreover, something "designed to pervert the ideas of 1789".[6] In Hegel's historism, Popper sees a bulwark of present-day totalitarianism.[7] Since Popper himself has no intention of analysing the possibilities contained in such concretely historical interpretations and parallels, but merely grapples with them and negates historism, social cognition and dialectics, such a stand becomes, in its turn, a theoretical justification of naked nihilism, petty-bourgeois individualism and anarchism.

There is nothing fortuitous in the antipathy displayed by Popper's "critical rationalism" for German classical philosophy. It convincingly exposes positivism's anti-philosophical stand, and its striving to abandon world-outlook problems and to transpose the range of problems dealt with in classical realism exclusively to the sphere of the logico-epistemological.

The Hegelian understanding of dialectics and reason, and the process of world history as a whole are seen by Popper as a kind of totality responsible for the appearance of totalitarian social systems and, on the social plane, implementing the idea of the restriction and even eradication of individual freedom and of its fusion with total necessity.

As already pointed out, philosophical tradition, with its rationalistic understanding of reason and human activities in application to social reality, leads, according to Popper, to the formation of totalitarian regimes. Since totalitarianism and the de-humanisation of life and patently regressive elements, Popper is of the opinion that the philosophical tradition of Cartesian-Hegelian rationalism promotes social regress and theoretically sanctions political and social despotism, giving it the form of historical necessity. As a result, "critical rationalism" sweeps aside the historical optimism of classical philosophy, its faith in the future of mankind, the might and practical purpose of reason, the objectivity of social cognition, the reality of human values and the existence of justice and human liberty.

A similar one-sided and negative attitude towards Hegel's philosophy is, characteristically enough, also being displayed by Herbert Marcuse, who, too, considers that the actual historical process, social progress and social cognition do not enter the province of philosophy. "It is no longer the task of philosophy to transpose the ideas of reason into reality," Marcuse has written in his Reason and Revolution.[8] According to Marcuse, Hegel's philosophy reflected the efflorescence of the mind's power. The task pursued by 19th-century philosophy consisted in learning and understanding that power. According to Marcuse, the 20th century is confronted by a quite different task, i.e. the achievement of a "genuine state order",[9] which can be achieved only through spontaneous action by unorganised social forces. Philosophy's conservatism is explained by Marcuse as follows: in its nature, philosophy is out to cancel distinctions between mind and reality and to reconcile them in the consciousness. That is why, according to Marcuse, philosophy is unable in principle to promote social progress. Philosophy's first step towards social knowledge should be directed against itself: philosophy should abolish itself as a form of methodological consciousness. Marcuse holds that since the Enlightenment philosophy has defined and brought forward reasonable ideals and aims of the historical movement. However, the course of history has

shown, Marcuse asserts, that the rationalist methodology of philosophy counteracts the realisation of humanist ideals, and that the rational stands outside of social practice. Proceeding from his anti-rationalist principles, Marcuse in fact diffuses philosophy in the spontaneous revolutionism of petty-bourgeois movements, placing it in the service of petty-bourgeois anarchism and individualism.

Another widespread variant in the negation of rationalism in terms of social cognition is the "socio-critical" trend (T.Adorno, M.Horkheimer, J.Habermas, E.Fromm), which proceeds from a recognition of only "technical rationality", and identifies reason only with technical and instrumental thinking which, in their opinion, has compromised itself by having participated in the bureaucratic organisation of bourgeois society's spiritual life, following the model of the "culture industry". "Reason is sick and it will be most reasonable to cure oneself of it"[10] is the assertion made by these petty-bourgeois pseudo-critics of capitalism, who identify the fate of spiritual life under capitalism with the fate of spirituality in general, and also identify the "rational" with the bourgeois means of mass culture in general.

Note should be taken of a certain external terminological similarity between these critical conceptions about capitalism, and Marxist philosophy. The former theories make frequent use of such notions as "property", "ideology", "economic structure", "exploitation", and the like. This has provided a number of bourgeois researchers with a pretext for the false assertion that there exists a trend towards convergence between historical materialism and such "critical" statements about capitalism. In reality, however, all this is limited to a purely terminological resemblance, with a radical difference in essence. In the abovementioned "critical" theories, such categories have been built into an abstract and anthropological interpretation of the history of society, outside of any analysis of actual socio-economic reality. By substituting for an analysis of concrete socio-economic phenomena a study of their notional forms, such "critics of bourgeois society," as T.Adorno and H.Marcuse strip historical reality of its material and objective basis and return it in roundabout fashion to the sphere of abstract panlogism, which they have in word rejected. The fundamental vice of such theories lies in a consideration of the historical process chiefly as the movement of notional forms, this running counter to the dialectico-materialist understanding of history as a consistent succession of socio-economic formations marked by a certain level in the development of the productive forces and production relations, and reflected in the development of notional forms.

The law-governed patterns of social development are rejected by the representatives of the Frankfort School, as is the objective dialectics of nature and society. These people carry over a socio-economic and class analysis of social phenomena into the sphere of abstract notions such as "rationality", "sociality", and "enlightenment". In that case, human history appears as a succession of forms of "self-destructive enlightenment"[11] and as a movement towards the downfall of traditional social and ethical ideals. A "critique of capitalist reality" is turned by them into a "critique of false consciousness", a critique of "ideology" (T.Adorno, M.Horkheimer and J.Habermas) and into "technological rationality" and "one-dimensional consciousness" (H.Marcuse).

Further, there is taking place, in present-day Western philosophy, a growth of the intuitivist trend, which is following two directions: first, a "descent to the grass roots", a biologisation of man's cognitive capacity; in the second place, there is the opposite process of the deification and mystification of man's reason, and interpretation of intuition as God-given insight.

The first trend is marked by a recognition of man's

immediate and instinctive reactions as actions of cognition, for an understanding of which any rationalist methodology should be eschewed and forgotten. "The German philosopher and anthropologist Gelen is perfectly right," writes the German philosopher Hengstenberg, "when he says that man's 'nature' should be seen, not only in his reason but in its being reflected absolutely in all structures of behaviour."[12] Of course, if man's instinct is grounded in "reason" and is capable of immediate cognition, then any rigorous theory proves superfluous—such is the theme of the anthropological trend in intuitivism. Moreover, instinctive "cognition" is non-social, interprets bourgeois reality in supra-class terms, and justifies violence,hostility, social injustice and exploitation, which it absolutises and calls inherent in human "nature".

The second trend reflects the way in which philosophy and theology are drawing closer together in present-day bourgeois society. The intuitivist aspect is gaining ground in all irrationalist trends in bourgeois philosophy: existentialism, phenomenology, hermeneutics, personalism and anthropology. The profound crisis in bourgeois liberalism and abstract bourgeois humanism, the non-understanding of the actual alignment of forces in capitalist society, and a fear of concrete social action as well as of the revolutionary movement of the masses have led many bourgeois thinkers into the camp of intuitivism. There is nothing surprising in the heightened demand for intuitivistically "interpreted" theology in bourgeois ideology since the mass disturbances of 1968 in France. Such is the evolution of the philosophical views held by M.Horkheimer[13], representative of the Frankfort School, who has convincingly shown that a negation of the role of reason, of practice, and the contraposition of the world and "life", of intellect and spiritually intuitive potentialities lead straight to Christian theology. Intuitivism leads directly to the religious world-outlook.

At the present stage, intuitivist philosophy has become widespread in Western Europe. The replacement of a religious logical apparatus of proof by pretentious and vague declarations, in intuitivism, regarding freedom of the spirit, the necessity of creativity, the barrenness of the intellect and the value of intuitive and ecstatic states are all to the advantage of mass propaganda, which distracts interest from actute social problems and an awareness of the need to radically change capitalist reality.

The alliance between idealist philosophy and theology is re-appearing in new forms and gaining strength in the conditions of the ever deeper spiritual crisis in bourgeois society. Such trends are meeting each other half way in new searches for "absolute being". A special closeness is revealing itself between irrationalist trends and theological views. "Man is dead; only organisations and machines are alive," the technocrats assert; if that is the case, then the "worldly" has shed its possible Absolute. Christian theology has a tradition of asserting the sanctity of the existing world order, both in nature and society. The exacerbation of the contradictions within capitalism has laid bare its inherent irrationality and inhumanity and destroyed faith in a "divinely ordained order". In the footsteps of the "crisis philosophy" there inevitably arises the "crisis theology" originated by K.Barth. Theology, which has joined in the general criticism of science's rationality and the "non-genuineness"of capitalist reality, implying by this the non-genuineness of everything that is "worldly",has contrasted to the reality of history the sphere of the transcedental, to reason—the miraculous, and to social revolution—divine "salvation".

Irrationalist trends have displayed themselves historically as bulwark of mysticism and religious beliefs. As a rule, they have gained strength in critical situations which have confronted human cognition with unsolved problems. Irrationalism has always been an expression of the impotence of man's mind.

We have considered five types or forms of anti-rationalist thinking. However, these philosophical and sociological theories do not always fit into the typology we have suggested. At times, it is not some single programmatical principle that is predominant, but several. To such non-traditional manifestations of irrationalism in socio-political and sociological theory pertains the conception advanced by P.Pareto, the Italian sociologist. Since his ideas have again come to the fore in present-day Western thinking and are a basis for a theoretical interpretation of contemporary social and political life in the bourgeois world and for an "apologia" for the irrationality of social life and social practice, attention should be paid to the role paid by Pareto's ideas in present-day bourgeois thought.

R.Aron's interpretation of Pareto[14] in the spirit of technocratism is characteristic, revealing as it does the socio-political and logical-methodological principles which endow any traditional conception of irrationalism with "new life".

According to Pareto, logico-experimental truth is the only truth, the search for truth calling for the construction of an object by means of certain concepts, by means of building a simplified model of the world, abstracted from the concrete world which we perceive. Scientific truth takes no account of essences of this kind; it does not go beyond uniformities or regularities. Limited though it is, scientific truth none the less offers the only logical instrument of behaviour, since the latter presupposes an accord between a sum of means of achieving a predetermined purpose, and the actual unfolding of events. Thus, R.Aron points out, meta-theory serves as a reference point in the interpretation of human behaviour and establishes the distinction between logical and illogical behaviour. In its turn, the sociological theory arising from the Paretian meta-theory thus adds up to an apparently systematic whole

5435

2-I

as a result of two processes: an analysis of illogical actions with the aid of the concepts of residues and derivations, and the reconstruction of a general equilibrium thanks to the mutual dependence of four variables (residues, derivations, social heterogeneity, and interest).

What the analysis of illogical actions leads to when applied to politics, R.Aron goes on to ask and replies that, in examining this problem, Pareto departs from the distinction between form and substance, from the essence of phenomena. It is in this light that the Italian sociologist has explained the "similarity" between political and religious faith. Carrying on his arguments in the "Pareto vein", Aron goes on to say that the affinity between mediaeval witch trials and political trials of the times of McCarthyism, for example, has been hit upon spontaneously by the public. This affinity, in his opinion, lies not in the arguments used in both cases but in the "substance", the sentiment that a maleficent power is embodied in such and such an individual, the tendency to seek in a confused reality or in an abstract entity (imperialism instead of the Devil) the origin of the ills which afflict a society. In other words, the distinction between the religious and the political ideologies is, according to Pareto, a distinction in form; the affinity between them is one of essences.

Pareto, the author goes on to say, has brought forward one of the fundamental philosophico-methodological postulates in present-day sociology, namely, the individual's "interiorisation" of the system of values of imperatives characteristic of a society or a religion, the denial of any distinction of principle between the interiorised convictions of one or the other, between religions and moral convictions. In this sense, Aron thinks, Weber and Durkheim were close to Pareto, but they expressed their views more flexibly, whereas Pareto was at pains to shock his rationalist reader, and, while emphasising that the illogical is the alogical, constantly pointed out the violations of logic committed by all "believers".

It is apparent that Pareto belonged to the same generation as Durkheim and Weber, the author continues. If one is to consider as the fundamental postulate of all sociology an acknowledgment of the socialisation of men by their background, the existence in each of them of prejudices, or beliefs, or affirmations of values which cement society by giving it the minimum of coherence without which no social system could exist, then Pareto is a sociologist no less than Durkheim or Weber. However, Pareto's "sociologism" has a different ring from that of Durkheim or Weber. The critique of religion characteristic of the Enlightenment opens up the road to reason. The Paretian critique of religion opens up the way to a "science" which confirms the right of religion to its non-rationality.

What marks Pareto's political and sociological theories is that they lay claim to being scientific and not simply to being a guide to action. They give no advice or recommendations, and draw no distinction between good and evil. As a consequence, R.Aron thinks, the Italian sociologist's Treatise lends itself to various interpretations. Aron has emphasised the existence of four interpretations of Pareto's ideas: the fascist or Darwinian; the Machiavellian or authoritarian; the liberal Machiavellian, and the sceptical or cynical.

Let us leave to R.Aron's consciousness his characteristic of the four types of "interpretation" of Pareto's ideas. It should be noted, however, that they all testify to a totally erroneous and anti-scientific approach, an instance of which is the equating of the fascist interpretation with the Darwinian one. This is typical of the scientific weakness and spiritual poverty of present-day bourgeois ideologists.

The above-mentioned trends in present-day irrationalist thought have been totally disproved by historical experience and the entire course of the development of scientific knowledge.

2-2

Contemporary historical experience (social, political, ethical, and moral-psychological) gives a social ring to the idea of rationality. What is brought into the foreground is the demand for a clear-cut understanding of the social significance of theoretical concepts. Marxism-Leninism is the complete unity of science and ideology, of objective knowledge and the theoretical expression of the main trend of social development.

As a world-view and a scientific methodology, Marxist-Leninist philosophy helps us to understand the law-governed link between scientific and technological development and concrete historical conditions, and the prospects of social transformations and political decisions in the life of society.

The revolutionary changes of our times have involved all spheres of life: social systems, the productive forces, science, technology, politics and spiritual life. But what are the causes of these revolutions, which have affected the whole world and entire aspects of man's life? Where do their motive forces spring from? What social consequences is the scientific and technological revolution leading to? Answers to these and other most complex questions of our highly dynamic times are provided by genuine social science, genuine rational knowledge and by Marxism-Leninism, which is a genuinely scientific and philosophical world-outlook.

The role of social cognition is important today as never before. In the conditions in which "disenchantment with progress" reigns in Western philosophy, and the general crisis of the outmoded bourgeois system and the ecological crisis are making themselves ever more felt, the future of the world, mankind and civilisation hinges on the measure in which social activity is linked with the genuine scientific cognition of social reality.

The role of genuine, scientific social cognition has become enhanced to the utmost in the bourgeois world, which is rent by an economic, social and spiritual crisis, a

world in which man comes up against the irrationality of capitalist reality, social inequality reigns, and extremes of wealth and luxury meet with grinding poverty, satiety and despair, a world in which the triumph of reason in science, and the fantastic achievements of technology live cheek by jowl with mediaeval superstitions and prejudices.

Refuge in irrationalism, phenomenology, intuitivism and existentialism actually proves a flight from the real and vital problems of social life.

In this situation of chaos in the bourgeois world's social life, the philosophy of Marxism, which proceeds from the methodology of dialectical materialism, stands for scientific social cognition, for an objective knowledge of the law-governed patterns of social development. Basing itself on the rich experience of human cognition and the practice of the world's working-class movement, the philosophy of Marxism reveals the social and class essence of capitalist society, in which the entire ideological social machinery is out to employ irrationalism, theology and similar trends to play down the historical doom of capitalism and its inescapable downfall.

Man's rationality in social cognition rises to a new and higher level of development, his activities consciously proceeding within the framework of social and historical practice, the mainstream of the world revolutionary movement. Proceeding from the dialectico-materialist understanding of the rational as a capacity to reflect the surrounding world objectively and in adequate terms, Marxism-Leninism analyses conflict situations in the economy, politics, and spiritual life, and ascertains their deep-lying social roots. The logic of social development in the world today has borne out the truth of Marxism's social theory.

As an expression and theoretical generalisation of the revolutionary practice of the working class, social cognition ascertains in adequate terms the concrete socio-historical processes and phenomena in social life. Guided by reason and by materialist dialectics and class consciousness, social cognition reveals the need for historical advance along the road of social progress towards the triumph of the forces of socialism and communism. Embodied in social consciousness, the rational provides the basis for changes in reality and serves the progressive aspirations of the advanced class, the working class of today, which is the creator of all the material and spiritual values in the world.

The dialectico-materialist conception of rationality contains within itself the substantiation of the most important criteria of scientific rationality, criteria which cannot be established through an anti-historical approach to scientific cognition. It is on the basis of materialist dialectics that cognition can be understood in its contradictory but progressive development, which contains within itself negation and the sublation of negation as their essential features. These problems engage the attention of a large number of scholars specialising in the philosophical substantiation of science; these problems are widely discussed in the philosophical literature of a number of Western countries. However, in the absence of a consistent scientific methodology they are not able, despite careful and rigorous analysis, to find a proper solution to vital problems of scientific rationality.

Marxism holds that a cognition of social objects—despite all their complexity and contradictory nature—is not only possible but necessary to resolve the contradictions engendered by present-day social development. Marxism holds that social life possesses its own specific regularities, the task of cognition lying in the discovery of these regularities.

Marxism has proved the only social theory to scientifically reveal society's law-governed patterns and indicate the practical road towards the rational and revolutionary restructuring of social relations. The more than 130 years

5435

5435

of the existence of Marxism have proved both the possibility and necessity of cognising social phenomena and also the fact that the cognition of social reality is the highest form of rationality.

Marxism understands cognition dialectically, as a complex and contradictory process of interaction between the subject and the object in the course of a rational mastering of the world,leading up to theoretical knowledge through empirical cognition. As the foundation of such rational and cognitive activities, practice then becomes its supreme stage thanks to its merging with theoretical knowledge.

Social cognition is an emergence from the narrow-minded, abstract and metaphisical nature of the understanding of cognitive activities as subject-object relations; it means a resolute rejection of individualism and subjectivism. Social scientific cognition opens up broad vistas of social creativity and social activity for the individual, who obtains in it the necessary guidance for socially transforming activities and spiritual self-perfection.

Social cognition is a most important component of present-day knowledge. It is directed towards an understanding of the most complex phenomenon of cognition-social phenomena and processes in which class society, the individual, social progress and regress are the objects of research.

Social cognition pertains to the most complex kinds of cognition, revealing as it does, with special force, the tremendous variety of phenomena and trends in present-day social life. It is here that a scientific prevision of the future is essential. The Marxist theory of the scientific cognition of social processes is irrefutable proof of the genuine power of rationality, the power of materialistic and dialectical rationalism.

In contrast with the adventurist and metaphysical "theory of critical rationalism", Marxism brings scientific rationalism into the foreground. The task of the scientific

2-4

cognition of social phenomena has never been so acute as it is today. Never before has the future of the world, civilisation and mankind depended so greatly on a correct understanding of present-day social processes.

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Marxist philosophy approaches the problem of cognition and knowledge as a whole, social cognition inclusive, from positions that are radically different from the irrational philosophical conceptions. The distinction lies, first and foremost, in the basic criterion of the correctness and scientific nature of the cognition of the objective world consisting not in formal criteria of the authenticity or unauthenticity of knowledge, but in practice, both in the area of the sciences of nature and in the sciences of social life.

On the contrary, the essence of all kinds and forms of irrationalism is a denial of a scientific and rational understanding of the objective world, the law-governed patterns of the development of nature and society.

The victorious advance of capitalist civilisation destroyed the harmony between man and his environment, and changed the traditional value orientations. In bourgeois thinking, "technological intellect" has proved incapable of solving the radical problems of human history. Under the guise of a struggle against the "technological intellect", irrationalist trends in the world of today have come to the fore and have launched an attack on reason and human rationality in general. In this situation, an ever greater role belongs to social cognition, which is the embodiment of dialectical materialist rationality, the highest rationality, which promotes social progress.

It is not reason, or "technological intellect", or "technological rationality" that has been compromised in present-day society but a social system that restricts rationality, its historically outmoded capitalist form. Such

5435

rationality is a variety of that intellect of which Hegel wrote that, while engaging in "trivial things", it imagines that "it is in the sphere of the interests of philosophical science".[15]

To cast off the cold-blooded rationality of "technological intellect", reason must go through the experience of social cognition and comprehend the logic of social development. Historical development has called for a concretisation of the major function of human cognition, that is to say, social cognition. Therein lies the genuine purpose of human rationality: to serve and promote social progress.

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THE RATIONAL AND THE IRRATIONAL

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The primary prerequisite for a philosophical understanding of intelligence is not to absolutise or universalise it. Contrary to rationalist idealism, intelligence is not the essence of things. Even the essence of man cannot be reduced to intelligence, though, of course, it has a direct bearing on it. Like consciousness, intelligence is a social product, a social quality, a species characteristic of man.

Intelligence presupposes the existence not only of the human mind, but also of human, social relations. We should, therefore, distinguish between intelligence and the mental activity of the higher animals who, the zoopsychologists tell us, have their own, primitive thought process which, however, plays an insignificant part in their purposive behaviour. One cannot accept Montaigne's view that "the behaviour of the tuna fish testifies to their acquaintance with the three departments of mathematics. As to astronomy, it can be said that they teach it to humans: they stop at the winter solstice and wait for the next equinox. This led Aristotle to concede their knowledge of astronomy. As for geometry and arithmetic, their shoals always form a cube."[1]

Darwin demonstrated that purposiveness was a characteristic physiological function of animals, enabling them to adapt to circumstances, learn, etc. Marx and Engels considered this an outstanding contribution to science. In our day, when bionics, biochemistry, cybernetics, ecology and other sciences have broadened and deepened our understanding of the spontaneous purposiveness characteristic of all living beings, it is becoming even more obvious that this feature of animals and plants cannot be considered intelligent mental activity. More, the spontaneous purposive physiological processes occurring in the human organism are not only independent of man's conscious and mental activity, but are often incomprehensible or even unknown to him.

Intelligence is a specifically human trait. To regard other natural phenomena (both in inanimate nature and in animals) as irrational is a simplistic approach. For only a being endowed with intelligence can be either rational or irrational. This paradox was noted by Hobbes who wrote: "Stones and inanimate things cannot err only because they do not possess the ability to reason and imagine."

Intelligence is cognitive thought. Or, more generally, coherent, consistent and proof-based thought founded on experience, practice and acquired knowledge. Intelligence differentiates and generalises sense-perceptions and, with the help of logical deduction, passes from ignorance to knowledge, from one level of knowledge to another, higher one. It apprehends, controls and appraises actions and their results, overcomes delusions, which are inevitable if only because knowledge never rises above its development level.

Engels pointed out that intelligence exists "only as the individual thought of many milliards of past, present and future men".[2] But as distinct from external, inimitable, chance differences between one individual and another, intelligence is a kind of mental activity of individuals that is integrated in the process of their interaction, is enriched, developed, records the cognitive results achieved, is objectivised in things and institutions created by society, thus providing a common patrimony of mankind that finds expression not only in production, science and art, but also in the multiform phenomena of social life. This

qualitative characteristic of human intelligence as not only an individual, but also social phenomenon, one that raises above the level of cognition and objectivisation, was discovered, and also mystified, by classical German idealism.[3]

The de-mystification of speculative-idealist ontology of intelligence and the positive solution of the problem presented by dialectical idealism is an outstanding historic service rendered by the founders of Marxism who demonstrated that "it is in the measure that man has learned to change nature that his intelligence has increased".[4]

Intelligence and reason are synonyms. Attempts to divide the two, or to draw a distinction between reason and rationality, lead, wittingly or unwittingly, to acceptance of a kind of "unconscious" intelligence, a "vital force", etc., where scientific investigation reveals only objective regularities independent of intelligence. Rationalist idealism is idealism precisely because it seeks to prove that intelligence, the rational, exists outside and independent of rational human activity and its objectivisation. This conception is no more than subtle, immanent teleology. A genuine scientific understanding of purposiveness in living nature is impossible without drawing a fundamental distinction between rationality and spontaneous purposiveness, though in common usage both are often regarded as synonymous. However, even in <u>conscious</u> human activity, the two are not always identical. Failure to draw a distinction between them is typical of rationalist idealism, consistent adherence to which leads to the Leibniz conception of pre-established harmony. And according to this conception the laws of nature are purposive, rational and, furthermore, moral. Indeed, if we accept this teleological view, we can only admire the orderly laws of nature—at any rate on our planet—and the way they assure man's existence, even "serve" him—provide water when he is thirsty, food when he is hungry. Wolf's metaphysics clearly demonstrated the hollow "profundity" of conclusions drawn from this philosophical doctrine. Engels characterised it as the conception of "purposive order in nature" which logically leads to the conclusion that "cats were created to eat mice, mice to be eaten by cats and the whole of nature to testify to the wisdom of the creation".[5]

Hegel and his immediate predecessors (from Kant to Schelling) were aware of the fallacy of this vulgar teleology. To it Hegel opposed immanent teleology, the doctrine of the rationality of the laws of nature, of development as the revelation of the rational and realisation of the rational aims inherent in every developing thing. In this way rationalist idealism could not explain the phenomenon of purposiveness in living nature precisely because it equated purposiveness with rationality. It regarded the natural conditions of human existence as rational inasmuch as they provided for purposive human activity. And though idealism, unlike mechanistic materialism, correctly pointed to the existence of an inner purpose in living nature, it mystified this phenomenon, thereby blocking the road to its scientific understanding. And yet a real investigation of purposiveness within the framework of biology will demonstrate the qualitative difference between the purposiveness intrinsic in the human organism and independent of man's consciousness and will, on the one hand, and man's conscious, purposive, and purposive-formulating activity, on the other, which presupposes the presence of a subject of rational activity. Intelligence without the thinking subject, abstract intelligence is an idealistic myth, despite the fact that we are here dealing with a real, highly important phenomenon of nature that specifically characterises the very essence of living nature.

And so, rational activity is not only purposive, but above all purpose-formulating. It presupposes the existence of a subject, consciousness, thought, cognition, meaningful choice of aim, and of thought-out actions to achieve it. Hence, not only actions consonant with these conditions,

but also their results, their objectivisation, are rational within definite bounds (a question to which we shall return). And yet purpose-formulating, purposive activity, taken in the abstract, is not always rational. Its aims and the means of their achievement are important criteria of rationality. The actions of criminals, no matter how well thought out and how successfully accomplished, are irrational because they clash with the purposive activity of individuals and of society, not to mention the fact that they are incompatible with the long-range interests of the criminal himself. And this applies not only to the behaviour of individuals. Hitler's carefully prepared predatory war against the peoples of the USSR and other countries was from the very start criminal and irrational. Consequently, the rationality of any act must be judged by its concrete and not merely general features.

The rational assumes many different forms. It is not only cognitive thought, science and art, but also social organisation and social practice, everyday experience and human behaviour, to the extent that it meets definite standards. The determining basis and form of rational human activity is material production, the main features of which, mutatis mutandis, apply also to other branches of human activity.

In the process of labour, Marx states, man "realises a purpose of his own that gives the law to his modus operandi, and to which he must subordinate his will"[6], his rationally motivated "purposive will". As a conscious and rational activity, labour has its own inner plan, which regulates, mediates and controls the metabolism between man and nature, creates mental models of intended actions and their results. If we add to this that by its very nature labour is socially necessary activity, then it should be perfectly obvious that it can be regarded as the paradigm of everything rational.

Of course, not all forms and stages of rational activity contain all the above-mentioned features. For human activity can be highly rational even when it does not, for a number of objective reasons, achieve its set purpose. Man often undertakes rational actions the aim of which is manifestly inachievable.

As all cognitive and practical activity, the rational is historically determined, is relative and contradictory. Forms of rationality that have ceased to correspond to the new historical conditions are overcome by continuing development. Thus, there are not only rational, but also non-rational phenomena. And we should not absolutise these opposites, for they are just as relative as the opposites of truth and delusion, knowledge and ignorance. This does not, however, obliterate the qualitative difference between them. Our forefathers burned down forests to grow crops. Nowadays rational agriculture includes safeguarding and extending forest lands.

Social production, i.e., the rational organisation of conscious and purposive human activity, has led to progressive deterioration of the natural conditions of man's existence. This negation of the rational by his own spontaneous results is not, of course, fortuitous but law-governed. But even this negation is itself subject to negation. In other words, disturbance of the ecological balance is not an absolute law of rational activity. Regeneration of the human habitat (and even its improvement) is a fully feasible social task, but only within a definite historical perspective that presupposes—contrary to all the theorists of latter-day "technical pessimism"—continued comprehensive development of the productive forces within the framework of appropriate production relations based on public property of the means of production. This is not a subjective, but a scientifically grounded conclusion. It is borne out by rationally organised technological processes, which include recycling or completely deneutralising waste materials. On principle, there are no unknowable, unforseeable or unremovable negative consequences of technological progress. Nonetheless, constant efforts to overcome the non-rational have never yielded absolute results.

Production rationalisation, in a broad sense, implies not only advances in technology, but also rational social organisation of the productive forces. It is from this standpoint that one should regard the succession of socio-economic formations, these epochal landmarks of mankind's progress. The transition from capitalism to socialism entails the rationalisation of social production on a world scale, as the forerunner and accelerator of the vast future changes in science, technology and social relations.

And so, Marxist philosophy regards rationality not as a static condition of human activity and social organisation, but rather as social progress and development. And an essential element of this is the dialectical negation of every historically-determined form of rationality by its own further development. Engels writes: "In the place of moribund reality comes a new, viable reality—peacefully if the old has enough intelligence to go to its death without a struggle; forcibly if it resists this necessity."[7] This dialectic of rationality is unacceptable to conservatives, who cling to the past, oppose the present and fear the future. And this applies not only to individual thinkers, philosophers and sociologists, but also to social classes and groups whose attitude is expressed (unwittingly perhaps), in their theoretical constructions. One such reactionary metaphysical interpretation of the dialectical contradiction of the rational as of all natural and social reality, is philosophical irrationalism. Its exponents include, on the one hand, ideologists of the imperialist bourgeoisie, and on the other, petty-bourgeois spokesmen of romantic anti-capitalism.

Philosophical irrationalism tends to absolutise the qualitative difference between the rational and the non-rational, regarding it as an absolute contradiction. The historically transient character of each form of rationality is interpreted as evidence of its primordial non-rationality, its illusory, sham rationality. The non-rational is elevated to an absolute and is defined as the irrational.

Philosophical irrationalism refuses to define, let alone systematically describe, the irrational, which however, it regards as the original, substantive realm of everything existing. To systematic analysis and conceptual definitions the irrationalists prefer metaphors, subjectivist interpretations and fantastic conjectures. For Schopenhauer the irrational is a blind, all-destructive cosmic will; for Nietzche it is "the will for power", for Bergson, the "vital thrust", the disintegration of which is the source of both of matter and of human intelligence. Heidegger, in his "fundamental ontology", uses irrationalism to explain being, which in turn is characterised negatively, as something undefinable, unknowable and in no way related to the "existing", the subject of scientific investigation.

The irrational, its theorists claim, is the direct perception of reality. Individual facts, inasmuch as they cannot be deduced from general premises, are likewise irrational. The sensous, emotional life is likewise irrational, for it is entirely independent of the mind. Common to all irrationalist theories is the ontological conception of premordial chaos, to which is ascribed absolute power. The laws discovered and studied by science, the forms of orderliness in nature, rational social structures, intelligent, notably cognitive, activity—they are all disparaged as an illusory form of being, as appearance artificially created by the human intellect which, we are told, does not venture directly to approach reality and fears its own irrational basis. It need hardly be proved that this concept of all-embracing chaos has no supporting evidence in science. The irrationalists are, of course, fully aware of that but, then, they reject science as the foundation of a world-outlook, acceding to it only pragmatic value which, it is claimed, does not accord with authentic knowledge.

5435

Hence, irrationalist criticism of rationalistic absolutisation and universalisation of intelligence becomes a more refined, compared with rationalist idealism, substantiation of a new variety of idealist philosophy, despite its frequent claims of having broken with idealism. This has been noted by F.Müller, a Swiss critic of irrationalism. He points to the characteristic irrationalist claim to "oppose to the spirit the reality of human life".[8] This tendency is conspicuously present in Schopenhauer and Nietzche, both of whom claim to have refuted and repudiated idealism, which, however, did not prevent them from elaborating its irrational variant.

Irrationalism proclaims total rejection of teleology, demonstrating that, in effect, it is at the heart of idealism, However its real purpose is to denigrate scientific understanding of the laws that govern natural and social processes. Furthermore, the irrationalists, for all their hostility to rationalism, fall prey to one of its illusions— they equate the law-governed with the rational.

It is not the purpose of this article to give a detailed analysis of irrationalism. I touched on this philosophical trend inasmuch as it directly or indirectly negates the reality of the rational, and metaphysically interprets the dialectical nature of rationality, that is, its relative oppositeness to the non-rational. In this context,it is only natural to raise a question that has a direct bearing on the dialectical-materialistic understanding of rationality: Does the irrational exist? Irrationalist philosophy, the arguments of its supporters notwithstanding, is just as inadequate in proving the irrationality of the spiritual as religion is in proving the existence of the divine. Irrationalist philosophy, despite its critique of logic, and its differences with it, often resorts to fine-spun reasoning, using logical arguments to prove the existence of the alogical!

Their disquisitions about the "intrinsic chaos" of na-

3-2

ture and the allegedly fortuitous character of its laws, are no more than rhetoric. For the laws of nature are not something superficial operating on the surface of phenomena, but essential, necessary, universal laws that set the course of natural processes. Irrationalist references to spontaneous cataclysms over which man has no control do not, of course, corroborate the anti-scientific conception of an omnipotent chaos. One must have no sense of humour to believe in the irrationality of earthquakes, typhoons, etc.

The irrationalist is fond of discussing the irrationality of feelings, emotions, behaviour motivations, etc. And his line of reasoning is always the same: first, he "proves" that everything outside intelligence is irrational and then denies that intelligence is intelligence. Of course, sensuous impulses, passions, etc., are often irrational, though they are part of rational beings and to a certain extent lend themselves to human, not to mention social, control. However, no matter how irrational, even senseless, they may be, human actions and impulses, e.g. infatuation, affectation, action, etc., are always determined by definite motives, circumstances, conditions of life; in short, by laws the study of which is the subject of psychology and other sciences dealing with man.

The sum-total of arguments exposing the fallacy of the irrational interpretation of natural and social realities, suggest —or so it would seem at first glance—that there is no such thing as the irrationality, in the sense in which it is understood by its theorists. But it would be oversimplification to believe that its dialectical-materialist criticism can be reduced to negation of the irrationalist conception of reality. Marxist philosophy studies the inherent "irrational" intentionality of some existing phenomena. Marx, as we shall see further on, does this in his *Capital*, and running ahead somewhat, we can say that the irrational does not exist as a universality, as an essence, as a regularity of natural and social processes. But under

certain conditions it does emerge as a form of their manifestation, notably as an appearance.

Appearance is often understood superficially, subjectively, as something that does not really exist, though it appears to. This reduction of appearance to illusion, or in other words, ignoring its objective basis, its real content, runs counter to the material facts. And yet illusion is *generated* by appearance. Usually it finds expression in the fact that appearance is mistaken for essence, for development laws. Appearance should, therefore, be considered not as something that is only *seen*, but does not really exist, but as something intrinsic to objective reality though inadequately expressing the substantive processes to which it owes its origin. To believe that essence is expressed directly, in all its "nakedness", so to say, is to fall prey to naive and anti-scientific illusions. For if essence and its manifestation coincided, there would be no need for science.

Of course, not every appearance is irrational. Irrational appearance is a specific form of the manifestation of the contradictions between phenomenon and essence, contradictions which, within a certain framework, become absolute opposites, absolute incompatibles. Appearance exists everywhere and consequently is a form of universality which, however, differs from development laws in the same way as the accidental differs from the necessary.

Appearance, for instance, finds expression in the *dominance of the accidental*, which, however, is a manifestation of the necessary. The obvious, a specific mental phenomenon, is often likewise appearance—one could call it the "appearance of appearance".

Identification of appearance and its investigation as an expression of essence are important, a closer study will reveal that appearance is objective and essential and that it is a specific feature of essence. Lenin wrote: "The essence appears; the appearance is essential."[9] Let us cite a convincing example of how appearance exerts a powerful influence on all biological processes and on everyday life. Everyone knows, of course, that contrary to appearance it is not the Sun that revolves around the earth, but on the contrary the earth revolves around the sun, following an exact orbit. The heliocentric hypothesis was proven not only in theory, but also in practice. But the appearance, exposed as such both by science and practice, remains and has retained its sensuous authenticity. We begin the day after sunrise and retire after sunset. The biological rhythms that regulate life on our planet reflect this appearance, adapt to it and, to a certain degree, are determined by it. Of course, all this is possible only because this appearance reflects a definite regularity: the relativity of movement within the Solar system. The theory of relativity has shown that physical laws apply equally to inertial systems.

Where appearance denotes total negation of essence, of laws, it is irrational, but it should not be equated with philosophical irrationalism. For such appearance, albeit indirectly, reflects essence. It is subordinate to definite objective regularities and represents a specific form of interaction of phenomena. Superficially, the dialectical-materialist recognition of the objective existence of irrational appearance might seem to be a concession to philosophical irrationalism, though actually it implies its consistent and substantiated negation.

The brilliant analysis of irrational appearance in capitalist social relations, given by Marx in his Capital, testifies to the great effectiveness of dialectical-materialist methodology. Marx explains that commodity fetishism under capitalism creates the appearance that production of things and of commodities is one and the same process. The product of labour is so closely coalesced with its commodity form that the latter appears not as an historically determined (and transitory) social relation, but as an intrinsic feature of every product of labour. This appearance

5435

5435

of identity of product and commodity, Marx says, is irrational. The value of a product—likewise an historically-determined social relation and not the natural property of things that have become commodities—appears as the natural measure of labour and its product. Yet no chemical analysis can reveal in the product of labour its value, for the latter, as every social relation, does not contain a single grain of matter. Bourgeois economists are enrapped by this appearance, inasmuch as they define commodity simply as a product of labour, despite the fact that commodity production acquires universality only under capitalism.

As soon as it becomes a commodity, the product of labour is converted, to use Marx's expression, into a supersensuous thing, since the basic form of economic contacts is the relation between things, commodities. This gives relations between people a fantastic character. In precapitalist formations, Marx points out, labour and its product did not assume "a fantastic form different from their reality".[10] And the reality is that value—the amount of labour invested in a product—is an historically-formed social relation. But in a society in which the social essence of labour is realised not through productive cooperation of individuals, but rather through its materialisation and estrangement, value appears as a natural property of the product of labour. In other words, the historicity of value does not externally manifest itself, and value converts every product of labour into a social hieroglyph. Hence the interaction of producers exchanging the products of their labour appears as "material relations between persons and social relations between things".[11]

Such is the irrational appearance of capitalist relations: the expression of their antagonistic essence. Nor is it merely a mental vision, a fiction that can be scientifically resolved. But research can only expose it; it cannot destroy it. And this mental vision is anything but harmless, for not only does it deceive, and dupe, but re-

3-4

presents, also, an objective, logical expression of the dominance of the spontaneous forces of social development over men, the dominance of the product of labour over its producer. And the most striking manifestation of this is the obvious power of money.

In religion, figments of the human fantasy —the logical expression of the irrational appearance of social antagonisms—dominate over people and in many ways shape their behaviour. In the capitalist economy such a spontaneous dominating force, one that shapes human destinies, is the movement of value realised through social relations. The quantities of value, Marx writes, "vary continually, independently of the will, foresight and action of the producers. To them, their own social action takes the form of the action of objects, which rule the producers instead of being ruled by them."[12]

Marx's study of the irrational manifestations of capitalist relations is carried further in his analysis of the celebrated Trinity Formula, a concoction of vulgar political economy which fully accords with the external appearance of capitalist production (and, naturally, with capitalist interests). According to this formula, the three principal types of income—profit, rent, wages—derive from capital, land and labour power.

Marx had a high appreciation of classical bourgeois political economy, noting that it demolished this illusionary notion and proved that value is created only by labour. Nonetheless, even the finest representatives of bourgeois political economy absolutised the capitalist mode of production and therefore remained entrapped, Marx remarks, in the world of appearances they had demolished by their criticism. The fact that the capitalist's profit is proportionable to the size of advanced capital and not to the number of proletarians he exploits, turns out to be a more convincing argument than the scientific conclusions drawn from the theory of value which, moreover, do not suit the capitalist.

Equally obvious is the fact that the owner of land receives rent according to the quantity and quality of the rented land. And it is even more obvious that the worker, who according to the theory of value is the only creator of value, receives only his wages. What we get, therefore, is that the participants in capitalist production not only live in a world of appearances, but that appearances directly determine their behaviour.

No capitalist, of course, is guided by the scientific theory of value, which is absolutely unknown to most of them. The capitalist is guided by the vulgar notion that the amount of profit is proportional to the amount of effectively functioning capital. He sees no proportion between profit and the portion of capital that goes into wages. But in that case the capitalist's profit—for such is the objective appearance of capitalist production—is not related to the number of workers employed. The classical bourgeois economists could not resolve this contradiction between appearance and essence, a contradiction that is at the very bottom of the irrational Trinity Formula. It was explained and theoretically resolved only by Marx, and primarily because he was free of the prejudices that are constantly imposed and nurtured by capitalist reality.

Marx demonstrated that the level of surplus value is dependent on the organic composition of capital. Where the variable capital (expenditure on labour power) exceeds constant capital (means of production), surplus value is greater than in industries with a reverse ratio. However, the pattern differs from industry to industry due to the influx of capital into the more profitable spheres of production, so that in the final analysis competition cancels out the difference and surplus value is redistributed. As a result of this competitive struggle there emerges an average norm of profit, roughly proportional to the relation between the total of invested capital and profit. And so the irrational appearance, that the amount of profit is determined not by the amount of materialised living labour, but by the size of effectively functioning capital, is produced by the mechanism of capitalist production.

Like other means of production in a bourgeois society, land is capital and it can be converted into money capital, which, loaned out, earns entrepreneur interest. Understandably, ground rent received by the landowner must be at least equal to interest derived from money capital equivalent to the price of the land. But land has no value inasmuch as it is not a product of labour. Consequently, the price of land, which fixes the size of ground rent, is an irrationality. For it is the price of something that has no value despite the fact that the price of a commodity is the money-expression of its value. The land, on the other hand, is a natural phenomenon and rent derived from it is a social relation. This means, to quote Marx, that "a social relation conceived as a thing is made proportional to Nature, i.e., two incommensurable magnitudes are supposed to stand in a given ratio to one another".[13] Actually ground rent is part of the surplus value created by labour power, part of the profit the capitalist is obliged to pass on to the owner of the rented land, and rent thus assumes the irrational form of a natural product of the land.

The capitalist entrepreneur knows that his capital can, and moreover independently of his own enterprising effort, yield profit in the form of interest. Whatever he earns over and above interest is the result of the productive functioning of capital. And this result, Marx says, assumes the irrational form of "profit of enterprise", derived, it would seem, not from the exploitation of workers, but as the product "of the capitalist's own labour".[14]

Equally irrational, in their direct manifestation, are wages, paid by capitalists to exploited workers, since they represent outwardly the price of labour spontaneously formed on the labour market. But labour has no value; it itself creates value. And value is determined by the amount of socially necessary labour (considering the given level of capitalist production) materialised in a commodity. But not labour in general—that is just as much an abstraction as matter in general, but historically-determined ("abstract" in Marx's definition) labour that produces values, and not merely needed things produced by the concrete labour of, say, the carpenter or tailor. Consequently, Marx explains, "the 'price of labour' is just as irrational as a yellow logarithm".[15] However (and this should always be borne in mind) the irrational is but the appearance (albeit objective) of definite realities, in this case the antagonistic production relations, which are by no means irrational: they function and develop in accordance with their intrinsic economic laws, discovered, studied and explained by the founder of scientific communism.

The capitalist argues that he pays the worker as much as his labour is worth. That reflects the appearance that arises on the capitalist labour market. Actually, the "price of labour" is not a fair remuneration, as the capitalist affirms, but merely the money expression of the value of labour power, i.e.,the value of the means required for the worker's existence and re-production. And that labour power produces incomparably more than the values required for its existence and re-production is concealed by the objective mechanism of capitalist production and exchange, by the appearance of a "free" agreement between the capitalist and the worker who "voluntarily" enters his employment. The reality, Marx states, is "that wages of labour, or price of labour power" are but an irrational expression of the value or cost of labour power.[16]

And so, mystification of the economic structure of bourgeois society is not simply the result of subtle sophistry by apologists of capitalism: these pastmasters at mystification are themselves a specific product of the capitalist mode of production, their intellectual activity—the ideological form of spiritual production in capitalist conditions,their consciousness—reflection of the society they live in. And like other agents of capitalist production, these ideologists "feel completely at home in these estranged and irrational forms of capital—interest, land-rent, labour wages, since these are precisely the forms of illusion in which they move about and find their daily occupation".[17]

The actual interconnection of qualitatively different types of profit, their unity, their relation to labour, the creator of surplus value, the real basis of all capitalist profit, present themselves to the vulgar economist as something entirely contrary to the obvious. His understanding reflects the estranged, alienated economic relations of his society. That is why the perversion of real relations, the irrational appearance of capital's self-growth irrespective of the exploitation of labour, is interpreted by capitalist ideologists as something taken for granted. "As soon as the vulgar economist arrives at this incommensurable relation, everything becomes clear to him, and he no longer feels the need for further thought."[18]

These comments of Marx, as his entire analysis of the direct manifestation of the essence of capitalist production, are of immense epistemological value, notably for the study of the phenomenon of the obvious which often turns out to be a delusive appearance that hinders scientific investigation. And yet this appearance should not be dismissed, once it has been identified as appearance. The task is not simply to see the reality behind it, but to establish how and why a certain reality generates a certain appearance. This Marx does in Volume III of Capital. Only such a genetic analysis of appearance is dialectical, as distinct from the reductionist methodology employed by the classical bourgeois economists.

The most convincing example of the irrational appearance of capitalist relations (and the mystification of their antagonistic essence) is the capital-interest relation. Loan capital is not sold, but loaned. Interest is what the recipient of the loan pays the lender; it is the specific price

of loan capital which, however, differs fundamentally from the value embodied in it. This price is not the money expression of value. But in that case the price is not price but interest and, like price, cannot be identified with value. In the words of Marx, "interest, signifying the price of capital, is from the outset quite an irrational expression".[19] And at the basis of this irrational appearance is the law of surplus value, part of which goes into interest. And interest is possible only because loaned money, in the final analysis, finances capitalist enterprise, i.e., the production of surplus value. This, it would seem, is the obvious essence of profit derived from interest. But this obvious essence is obscured by the functioning of loan capital, the owner of which receives a fixed interest irrespective of whether the loan is employed for production or for personal consumption. And since both parties are capitalists, interest is "a relationship between two capitalists, not between capitalist and labourer".[20] Hence, the link between interest and exploitation is further obscured. Interest-yielding capital thus appears not as capital, but as some mysterious property of money. This produces the illusion of the self-growth of capital as "the relation of a thing, of money, to itself".[21] Money breeds money—such is the appearance of loan capital, the circulation of which, expressed in the formula $M—M^1$, represents "the meaningless form of capital, the perversion and objectification of production relations in their highest degree, the interest-bearing form".[22]

Apples grow on apple trees and pears on pear trees—that is a natural process that does not breed irrational appearances. And this led some ancient philosophers to conclude that likeness always breeds likeness. But, of course, it never occurred to them that money possesses some mystical ability to breed money. That irrationality originated only with the capitalist mode of production, and to the bourgeois it seems entirely natural, rational and, what is more, an eternal ability of money.

Marx cites Richard Price, the 18th-century British economist: "Money bearing compound interests increases at first slowly. But, the rate of increase being continually accelerated, it becomes in some time so rapid, as to mock all the powers of the imagination. One penny, put out at our Saviour's birth to 5 per cent compound interest, would, before this time, have increased to a greater sum than would be contained in a hundred and fifty millions of earths, all solid gold."[23] That is more than a historical curiosity discovered by Marx in economic archives. Price's contention was shared by many of his contemporaries. Pitt, the then Prime Minister, was so carried away by this piece of mystification that he actually put before Parliament a bill providing for a new tax, the proceeds from which would be deposited and produce compound interest, thereby guaranteeing Britain a constant non-deficit budget. Like the vulgar economists of later days Pitt did not realise that the amount of surplus value is determined by the amount of surplus labour and this restricts the accumulation of money or any other form of capital.

Marx explains that the irrational appearance of capitalist relations rests not in the existence of the surplus product, but in the antagonistic nature of capitalist production. With the abolition of exploitation, of alienation of production and its product, there will disappear the domination of the spontaneous forces of social development and the irrational appearance of economic relations that distorts the way of life. However, the abolition of antagonistic relations will not signify removal of all the contradictions of social development. Scientific and technological progress and social and economic development are restricted by their current level. Man's rule over nature will generate changes in natural processes—sometimes contrary to his intentions—comparable to geological changes in magnitude. Of course, people will learn to better manage the spontaneous consequences of their conscious activities, but this will not imply the elimination of these consequences. If

there can be contradistinction of the rational and non-rational, by the same token there can be no metaphysical division between the non-rational and irrational appearance. We must, therefore, take into account the relativity, the historical limitations and the contradictions of the rational. The dialectic of the rational and non-rational is just as universal as is development, for the non-rational is, in the end count, the inevitable historical limitation of the rational.

Marxism-Leninism has proved the possibility of reconstructing society along rational lines. The communist government is carrying out this reconstruction in practice.

The fundamental characteristic of this new historical process is planned, rational social development in all spheres, with the result that the development of the individual and of mankind as a whole becomes the supreme social goal.

And so, we reject rationalist absolutisation of thought and irrational absolutisation of its opposite, and are substantiating, through scientific and philosophical investigations, the need for rationally organised struggle against irrational manifestations of the spontaneous consequences of man's activity. This struggle, the forms of which are being constantly improved, is a humanistic aspect of the entire future history of mankind.

NOTES

1 Montaigne, Essais, Book II, Paris, 1964, p.211.

2 F.Engels, Anti-Dühring, Moscow, 1969, p.105.

3 The young Feuerbach, who shared the views of Hegel, his teacher, wrote in his thesis "On the Single, Universal, Infinite Intelligence" that the intelligence inherent in each individual differs substantially from his other traits. Every person has a nose. "But the nose, as such, does not exist; it is an abstraction. There exist many different noses...." Intelligence is quite another matter: it is the same in different individuals, despite the fact that each person has his own head and, therefore, his own mind. But this intelligence is, at the same time, a form

of universality and, therefore, intersubjective. Feuerbach writes that "in thinking as an act of exercising my intelligence, as a thinking person, I am not one or another individual, nor am I one of many... I am simply a man: not outside others, not differing or separating from them; in that capacity I appear only as a sensuous being. I am at one with all individuals,—all people, precisely because intelligence, representing the unity and absolute identity of oneself, is the unity of all, for its essence and very existence form a unity." (L.Feuerbach, Selected Philosophical Works, Vol.1, Moscow, 1959, pp.245-246. In Russian.) This unorthodox interpretation of Hegel's doctrine to a certain extent reveals the rational kernel in Hegel's conception of intelligence.

4 F.Engels, Dialectics of Nature, Moscow, 1954, p.306.

5 Ibid., p.36.

6 K.Marx, Capital, Vol.I, Moscow, p.174.

7 K.Marx and F.Engels, Selected Works in Three Volumes, Vol.III, Moscow, 1970, p.328.

8 F.L.Müller, L'irrationalisme contemporain, Paris, 1970, p.141.

9 V.I.Lenin, Collected Works, Moscow, Vol.38, p.253.

10 K.Marx, Capital, Vol.I, p.81.

11 Ibid., p.78.

12 Ibid., p.79.

13 Ibid., Vol.III, p.817.

14 Ibid., p.829.

15 Ibid., p.818.

16 Ibid., p.823.

17 Ibid., p.830.

18 Ibid., p.818.

19 Ibid., p.354.

20 Ibid., p.382.

21 Ibid., p.392.

22 Ibidem.

23 Ibid., p.395.

5435

AXIOMATICS AND THE SEARCH FOR THE FUNDAMENTAL PRINCIPLES AND CONCEPTS IN PHYSICS

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With all its wide variety, Nature is single and consists of matter in the process of development—this idea, advanced by dialectical materialism, has become a generally accepted view in present-day physics, finding reflection, not only in its content but also in its methodology and logic. The principle of development and that of the singleness of Nature have been put to use in present-day physics in the search for new phenomena and laws. To show that is one of the primary aims of the present article.

Generally accepted in physics at the various stages of its historical development, a definite overall view of Nature (a problem of world-outlook) has always been linked with the logic of research (a problem of methodology) typical of it during the epoch in question. Such was the situation prior to classical physics, when physical knowledge, grounded in day-by-day observation and, with rare exceptions[1], with no systematic methods of research, was in full keeping with the highly generalised and indefinite views held by the philosophers of the times, even with their, at times, mastery (relative to the philosophy of antiquity) surmises in the spirit of Naturphilosophie. Such was also the case in classical physics when the research method proclaimed by Newton and later known as the

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method of principles, constituting, as it did, a kind of modification of Euclid's axiomatics, was in one way or another in accord with the atomistic view of Nature (which Newton also shared).

The unity of Nature is reflected in the unity of cognition. The latter found its initial form in axiomatics, while geometrical knowledge, the first kind of knowledge to emerge in its time, became a science on being axiomatically constructed by Euclid.

A complete or, conventionally speaking, closed system in any physical theory (classical mechanics being the first to establish itself along that road) consists of fundamental concepts and principles (called axioms, in the language of geometry) which bind those concepts in definite relationships, as well as corollaries derived from the latter through logical deduction. Such corollaries must be in agreement with experimental data, be tested empirically. Otherwise, physical theory cannot be a theory in <u>physics</u>; in other words, experiments and only experiments can be the criterion of truth in physical theories. That is to say, experiments alone ultimately confirm that a theory is a reflection of objective reality and consequently certifies that the mathematical apparatus (formalism) is in keeping with that theory.

In physics, any system of concepts and principles corresponds to its mathematical apparatus (formalism); it describes a definite area of physical phenomena indicated by experience. The boundaries of the applicability of the concepts of a system in the aspect of their correspondence to Nature are again established empirically.

Since the times of Euclid, the axiomatic method has undergone change and become equipped with fresh possibilities of explaining and forecasting phenomena under study. While one can speak of this method, in its initial or, so to speak, Euclidean form, as "informal" or "material axiomatics", as S.Kleene has put it,[2] the research into mathem-

atical logic by D.Hilbert, the celebrated mathematician, has brought axiomatics into the fore both as "formal" and as "formalised" axiomatics. The two latter are distinct from material axiomatics in their concepts and inter-relations operating, as it were, in a pure form, with no empirical content, the language of symbols (formalism) being employed in formalised axiomatics instead of verbal language; while deduction is not actually separated from the empirical and the visual in material axiomatics.

With all the necessary changes, this also refers to axiomatic constructions in physics. The axiom or principles of Newtonian mechanics (these are also called its fundamental laws) deal with inert mass and force, acceleration, space and time, as well as the relations between those concepts. Such relations and concepts are points of departure within Newton's mechanics and are, in themselves, idealised expressions of empirical data. Set forth for the first time in Newton's <u>Principia</u>, they provide a model of material axiomatics in classical physics. In the main, the development of the axiomatic method in physics has repeated the development of that method in geometry. We have reason to speak of the existence, in present-day physics—with its highly complex and ramified mathematical apparatus—of formal and especially formalised axiomatics (these being, in a sense the acme in the development of the axiomatic method). Properly speaking, this has taken full shape since the establishment and construction of the theories of non-classical physics. A rigorous or, in some measure, exhaustive analysis of the pertinent problems would take us far beyond the confines of this paper, so we shall try to present no more than a general idea of the gist of the matter.

Let us take the equation: $F=\frac{d(mv)}{dt}$

It expresses the second law of Newtonian mechanics, which assumes that the mass of a body is a constant magnitude. This equation, however, can also be regarded as an expression of the law of the special theory of relativity, in which case m denotes the following:

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

where m_0 is the mass of a motionless body ("rest mass"), v—the body's velocity, and c—the velocity of light.

Thus, the equation expresses the law of relativistic mechanics, which assumes that a body's mass changes with its velocity.

The above equation can also express the law of motion in quantum mechanics. It is common knowledge that, in quantum and in classical mechanics, magnitudes are associated in one and the same equations, while, in quantum mechanics, operators figure in these equations, i.e., they contain magnitudes of a different mathematical nature than those in classical mechanics.

The reader is entitled to ask the following question: on what grounds are such "substitutions" made in the equations (i.e., the substitution of operators for numbers, of a more complex expression for m, and so on), and also what is their logical significance in general? Replying to this question means speaking of the very content of classical relativistic and quantum mechanics, and the transition of a special theory, with all its concepts, to a more general and profound theory, with concepts more meaningful than those of the special theory. That means that we shall have to speak of the way mass is understood in relativistic mechanics and how that understanding has come into being; moreover, we shall have to speak of how, in quantum mechanics, operators are mathematical depictions of physical facts that are never met in classical theory, and, besides, it would mean dealing with the very logic in the inception of the special theory of relativity, quantum mechanics, and so on and so forth.

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All this has been said to underscore that the formal and formalised axiomatic construction of physical science embraces the development of its content, thereby fostering an ever deeper knowledge of Nature. It should be noted here that, in physics, special importance attaches to the question of how its formalisms should be interpreted as compared with the same question in mathematics. That is something we shall dwell on later.

What is the importance of the axiomatic method to physics? Both in the logical and the methodological aspects, the importance of this method to physics—both in the form of material axiomatic and in its higher forms; the formal and the formalised—is not merely great, but, as we shall try to prove, is so essential as to be difficult to overestimate. Its comparison with other methods of analysis must inevitably lead us to agree with Hilbert, who has said the following regarding the axiomatic method:

"Despite the high pedagogical and heuristic value of the genetic method, the axiomatic method is preferable for a final representation and complete logical substantiation of the content of our knowledge."[3]

We shall repeat that what Hilbert has said of the axiomatic method in mathematics also applies, as we see it, to physical axiomatics. It goes without saying, that, in this case, as always, one should not fall into extremes and exaggerate Hilbert's profound thought.

Let us begin with the genetic method Hilbert speaks of and take a look at its content, though we shall speak of it in a somewhat different way than Hilbert has (see page 316 in the book referred to). We would like to speak of the part played by the genetic method in cognition, while at the same time stressing (unlike Hilbert) that this method in a way fits into the axiomatic method.

How is the concept of number introduced? Proceeding from the assumption that zero does exist and from the

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proposition that when increasing a number by unity gives us the following number, we get a natural series of numbers and through them develop the laws of counting. If we take a natural number a and add to it a unity b times, we shall obtain the number a + b, thereby determining (introducing) the operation of addition of natural numbers (together with its result, which is called the sum).

By adding the numbers a, whose number is b, we shall thus determine (introduce) the operation of multiplication of natural numbers, and shall call the result of that operation the product of a by b, which we shall designate as ab. Similarly (we shall omit a description of the appropriate exposition), we shall determine the operation of raising to a power and the exponent itself.

Let us now take what are known as inverse operations in respect of addition, multiplication and raising to a power. We shall assume that we have the numbers a and b, and have to find a number x to satisfy the equations $a + x = b$, $ax = b$, $x^a = b$. If $a + x = b$, then x is found through the operation of substraction: $x = b - a$ (whose result is called the difference). In the same way are introduced the operations of division, the extraction of a root and the taking of a logarithm (the latter two being inverse operation in respect of the raising to a power).

On the basis of these definitions, we can construct the axiomatics of natural numbers, the appropriate axioms being arranged in groups: a) the axioms of connection, b) the axioms of computation, c) the axiom of order and d) the axioms of continuity.

We have now reached the focal point of our reasoning. The practice of a search for the solution of equations containing the numbers considered above shows that the inverse operations—substraction, division and the extraction of a root—cannot be performed in all cases. However, let us now assume that inverse operations are performed in all instances. Properly speaking, that is an assumption arith-

metic has accepted throughout its historical development; as a kind of logical summary of that development, it has seen the appearance of positive and negative numbers, integers and fraction, and rational and irrational numbers.

This bifurcation of a natural number into the above-mentioned opposites, and the inter-relations between the latter have led to the appearance of the concepts of a relative number, of number as a relation, and a real number; consequently, the latter has developed from the simple concept of a natural number through consecutive generalisations. The concept of real number has been further developed in present-day arithmetic, but what has been said is enough for our present purpose.

The application of the axiomatic method has, in essence, emphasised that axiomatics in no way precludes any recognition of the variability of fundamental concepts and logically closed theories; on the contrary, it presupposes the need for new fundamental concepts and principles. In this kind of application of axiomatics, all that makes the axiomatic method so useful to the logical formulation and full logical substantiation of scientific theories is given its genuine (and not formally logical) completeness and an expression that is equivalent to reality.

This was excellently expressed in mathematics by Nicolas Bourbaki, when he wrote: "It is only in this sense of the word form that one can say that the axiomatic method is a formalism; the unity which that method confers on mathematics is not the armour of formal logic, the unity of a lifeless skeleton; it is the nutritive fluid of an organism in full development, a supply and fertile research instrument which all great mathematical thinkers since Gauss have consciously worked with, all those who, in the words of Lejeune-Dirichlet, have always worked to 'substitute ideas for calculations'."[4]

The situation in physics is actually the same. Thus, the principle of relativity, which is a corollary of the principles of Newtonian physics, i.e., the principle of relativity in its Galilean form, did not operate in respect of the propagation of light, a phenomenon grounded in the principles of the theory of electromagnetism. That led up to the task of extending the area of application of the principles of mechanics, including electromagnetic phenomena. It also meant that the principles of Newtonian mechanics had to form a single and integrated system, together with the principles of electromagnetism. This blending led to the appearance of new concepts, broader and more meaningful than those of classical mechanics. The first to be modified were the concepts of space and time, with the disappearance of the concepts of absolute space and absolute time. There appeared the concepts of relative space and relative time, which proved to be aspects of a single four-dimensional spatial-temporal continuum. Accordingly, the Galilean transformation, which, in Newtonian mechanics, linked the inertial systems of reference together and presupposed the existence of absolute space and time, was replaced by the Lorentz transformation (which, by linking together the inertial systems of reference, presupposes the existence of relative space and time). The principle of relativity now emerged in its generalised Einsteinian form, and relativist mechanics appeared.

A second example is provided by quantum mechanics. In this theory (we are referring to it here inasmuch as we have its logically closed form in view), there exists a fundamental postulate: to any physical magnitude (dynamic variable) in classical mechanics there corresponds, in quantum mechanics, a definite linear operator which affects the wave function, it being assumed that there exist, between such linear operators, the relations to be seen in classical mechanics between the respective magnitudes. The fundamental role in quantum mechanics also belongs to the postulate that establishes the link between the operator and the magnitude's value characterising the reading from

the measuring device (which provides knowledge of the microobject).

Our two examples are a kind of logical summary of the state of affairs that developed in the theory of relativity and quantum mechanics at the time these theories were being evolved. Like any summary, it cannot convey the variety of logical and actual situations that had come into being when these theories were being born; neither do they convey the details of the blend of thought and experiment that brought forth the principles of these leading theories in present-day physics. To preclude any possible misunderstanding in ascertaining the method used to discover new concepts by means of axiomatics, as mentioned above, special note should be taken of the fact that, once they have been deduced during the definition of certain definite fundamental concepts, axioms, in their turn, become a foundation for the deduction of new fundamental concepts, broader and more meaningful than the original ones. At present, the equations that express axioms contain symbols with no actual values. The gist of the matter consists in the discovery of those actual values, i.e., the discoveries of new concepts (and, consequently, the construction of a new theory). As is common knowledge, that task is accomplished through the method of mathematical hypothesis, the method of observability in principle, and other theoretical methods applied in modern physics.

Circumstances of this type make clear that although (and we shall cite a well-known example) the structure of axioms of relative or real numbers is the same as that of natural numbers, that isomorphy cannot, of itself, help us to learn, for instance, how negative numbers are added or multiplied. In the same way, the identity of structure in the principles of classical, relativist and quantum mechanics does not of itself guarantee a knowledge of the fundamental laws of relativist and quantum mechanics, once the laws of classical mechanics are known. It would be useful at this point to recall Engels' remark on the law of the negation of negation. The knowledge alone that this law of dialectics applies to the development of a grain or the calculation of infinitely small numbers "does not enable me either to grow barely successfully or to differentiate and integrate".[5] As we have seen, the situation is the same in the realm of axiomatics, but that does not reduce the positive methodological role either of the laws of dialectics or of axiomatics.

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It is with good reason considered that the possibility of expressing a theory through a system of axioms is indicative of its logical completeness (closedness); however, the history of knowledge and science has most frequently looked upon a theory's logical completeness as a kind of synonym for its universality and invariability. The latter was historically justified, so to speak, during the two millennia Euclidian geometry reigned as the only geometrical system (i.e., until the middle of the nineteenth century), or by the two hundred years of the supremacy of Newtonian mechanics (down to the twentieth century) as the ultimate and indisputable theoretical system in physics. We have tried to show the illusoriness of this notion when axiomatic ideas are examined on the plane of logic. The logical consistency of a theory does not preclude its development but, on the contrary, presupposes that development.

The ideal of a classical understanding of the axiomatic construction in physics was dealt its first blow by Maxwell's electromagnetic theory, but there was no change in the essence of that understanding of axiomatics: during the efflorescence of the electromagnetic picture of the world, many physicists substituted the electromagnetic field, with Maxwell's equations, for the bodies of mechanics with Newton's axioms (Newtonian mechanics itself seeming to be refuted as irrelevant to the foundations of the Universe, and so on). Lenin expressed at the time the viewpoints of dialectical materialism on this matter. When the

electromagnetic picture of the world was taking shape, Lenin pointed out that the view was untenable which asserted that materialism "necessarily professed a 'mechanical', and not an electromagnetic or some other immeasurably more complex picture of the world of moving matter".[6]

The final blow at the classical understanding of axiomatics in physics was dealt by the theory of relativity, and especially by the development of quantum mechanics when it assumed its present-day form.

It transpired—a circumstance noted above in a different context—that Newtonian mechanics has its limits in the area of the phenomena it is called upon to explain and anticipate; that is to say, its limits of applicability: electromagnetic phenomena on moving bodies, as well as phenomena that are atomic in scale can be neither described or explained with the aid of the concepts and principles of Newtonian mechenics. Experimental research into such phenomena, together with an analysis of the theoretical situations arising in classical physics, led up to the theory of relativity on the one hand, and to quantum mechanics on the other. Today, as is common knowledge, physicists have grown accustomed to the idea that no closed physical theory is absolute, and that each has its limits of application and is, in that sense, an approximation, and so on.

But how is one to find the limits of a theory's applicability, and what is that limit? We shall begin with the latter question. There exist phenomena that cannot be described with the aid of the concepts of a definite theory; while they can be described, they cannot be explained in it. Such a theory disregards the sphere of such phenomena, the range of its applicability being the area of phenomena which it can or does explain. In other words, another theory that is different in principle must function(i.e. describe, explain and consequently predict) beyond the limits of a given theory's applicability.

We have no intention of delving deeper into the question of the limits of a theory's applicability, but there is an aspect it is worth while dwelling on. There exists an expression that is in frequent use, apparently with logical reason: the limit of a theory's development. What is the meaning of that expression, and in what relation does it stand to the expression "the limit of a theory's applicability" that we have just spoken of?

This question may seem artificially contrived. It is usually asserted that there is no point in speaking of the development of an axiomatic system. Indeed, all the theorems in an axiomatic system may be regarded as implicit in the axioms and rules of deduction; only the activities of the mathematician (or some appropriate device) can make any theorem contained in it explicit, and an axiomatic system contains an infinite number of such theorems of different degrees of ordering. At the same time, it is common knowledge that, in reality, deduction from axioms is no standard procedure, so that the derivation of, say, a geometrical (or mechanical) fact and proposition from a corresponding system of axioms is, as everywhere in the field of cognition, a solution of the problem of seeking something unknown on the strength of known data! As Engels once said, even formal logic is a method of search for new results.

Like any other method that uses the propositions of formal and dialectical logic, the deductive method (which includes the axiomatic system proper), cannot dispense with the imagination. It should be again recalled that, as Lenin once put it, "... even in the simplest generalisation... there is a certain bit of fantasy".[7] Of course, the role of the imagination greatly increases with the ever greater scale and depth of the generalisations that science engages in and without which it ceases from being a science. A closer look at that role is a grateful task.

Thus, inasmuch as the deductive method (or, its highest form, the axiomatic method) leads from the known to the unknown and increases scientific knowledge, the axiomatic

system should be regarded as a theoretical system capable of developing and as developing in the appropriate conditions. The development of an axiomatised theory means the obtaining of formerly unknown assertions and propositions, within the limits of that theory's applicability. As follows from its definition, that development of theory proceeds, so to speak, within itself; in its development, a theory does not go beyond its limits; from the viewpoint of its fundamentals (as a system of axioms) it remains unchanged. In that case, how is one to find the limit of the applicability, or the development, of an axiomatised theory?

It goes without saying that the reply is not to be found in showing that one constructive theory contains another constructive theory within itself, the former finding, in its own way, the limits of the second theory's applicability, thus demonstrating that the latter is its extreme instance. This is no solution of the problem, but rather the assumption of that solution's existence.

Can the limits of a theory's applicability or the limits of the area of phenomenon it explains be discovered empirically?

It all depends. The phenomena established by Michelson's experiments of the so-called "ultra-violet catastrophe" have indeed become the extreme points of the applicability of classical mechanics: it is from these two "cloudlets" in the clear skies of classical physics—as they were once called—that the (special) theory of relativity, and quantum mechanics arose. However, the relatively long-known fact of the movement of Mercury's perihelion, which was not covered by Newton's theory of gravitation, in no way became an extreme point of that theory's applicability. It was not along the methodological road on which the theory of relativity and quantum mechanics arose that Einstein's theory of gravitation was discovered, a theory which determined the limits of the applicability of Newton's theory of gravitation. A decisive part in the creation of Einstein's theory of gravitation was played by the principle of equivalence, which presupposed the identity of inertia and gravitation, i.e., in essence an experimental fact showing that all bodies falling in a vacuum have one and the same acceleration, something that was known to Newton, who did not, however, include it in the theoretical contents of his theory of gravitation, but merely accepted empirically.

Thus it may happen that an established theory does not explain certain well known empirical facts. People get used to that but, as it transpires, their interpretation or explanation (substantiation) goes beyond the limits of established theory, something that only a genius can at times discern. It was in that way that the general theory of relativity, or Einstein's theory of gravitation, was established, a theory that, during its creation, was based on the same empirical material (or basis) as Newton's theory of gravitation, but added to the latter a group of fresh ideas that were alien to the classical concepts.

A logically built theory, or an axiomatised theoretical system, one that functions correctly within the limits of its applicability,should be non-contradictory and complete. As shown by K.Goedel, a system's non-contradictoriness and completeness cannot be proved by the theoretical instruments of that system. When it comes to physical theories, the fact that a theory is non-contradictory and complete is usually accepted without proof, unless the contrary is especially required, just as a theory is accepted without the proof, that it is universal, of course when the facts do not stand in the way.

From the latter assertion it follows that if a phenomenon that, so to say, is to be proved by a given theory is not proved by that theory but that, on the contrary, contradictions (paradoxes) appear in the process of that explanation,paradoxes which cannot be resolved by that theory, we are entitled to regard the presence of such paradoxes

as a sign that the theory in question is approaching its limits.

It is, of course, quite possible that the thinking engendered by the contradiction will lead to individual propositions and concepts in the theory being made specific, and to the contradiction being resolved on the foundation of the theory in question. In that case, the contradiction and its resolution merely promote the logical improvement of the theory on the basis of its own principles. With all the necessary changes, the same refers also to the question of the completeness of a theory. In their time, Einstein, Rosen,and Podolsky formulated propositions from which ostensibly followed the incompleteness of quantum mechanics in Bohr's understanding of probability. It emerged, however, as was proved by Bohr, that Einstein was mistaken: as applied to problems of quantum mechanics, his initial proposition in the paradox is not unambiguous[8].

We shall not deal here with instances of this kind, which refer to the problem of the logical improvement of a given theory in accordance with its axiomatics, and does not relate to the question of the boundaries of its applicability.

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The advance from classical to present-day physics took place as a consequence of the appearance, in (classical) theory, of a number of paradoxes mentioned above. This feature is, in certain measure, also characteristic of Maxwell's electromagnetic theory, which immediately preceded non-classical theories. Maxwell brought together all the experimental data Faraday had found on electricity and magnetism, and then expressed them in the language of mathematical concepts, this leading him to see a kind of contradiction between the equations he had obtained. To remedy the situation, he added a single expression to the equation, this without any experimental substantiation (which came later), and it was thus the theory of electromagnetism was born. The method of mathematical hypothesis as applied by Maxwell[9] also proved highly productive subsequently.

Another example is provided by Einstein's (special) theory of relativity, which appeared at the conjunction of classical mechanics and classical electrodynamics as a result of the resolution of the paradox, the contradiction, between Galileo's principle of relativity and the principle that the velocity of light in a vacuum is independent of the movement of the source of emission, the two being examined together. M.Podgoretsky and Ya.Smorodinsky called such borderline paradoxes "contradictions of encounter"[10]. The method of observability, in principle, played a very important part in the resolution of this paradox, i.e., in the creation of the theory of relativity.

Quantum mechanics also appeared, in some measure, as an outcome of the resolution of a "contradiction of encounter", in this case between classical corpuscular mechanics (i.e., Newtonian mechanics) and the classical wave theory. However, the role of the wave theory was played here, not by the corresponding theory of matter but by the electromagnetic theory, which was why the "encounter" was far from being as "simple" as in the case of the inception of the (special) theory of relativity. Quantum mechanics appeared as the result of the resolution, not only of a "contradiction of encounter" but also of a number of other contradictions. It should be noted that, in respect of the original theories (this referring also to the theory of relativity), a theory that has already appeared is, in the language of present-day logic, a kind of meta-theory in respect of those theories.

Of primary importance for an understanding of the emergence of quantum mechanics was a problem which may be termed that of the stability of the structure of ordinary bodies, molecules, corpuscles or those atoms which, from the viewpoint of Newtonian mechanics, from the foundation of matter and whose motion ultimately determines all changes

in the world. Newton found a way out by postulating the infinite firmness of the divine origin of the initial atoms and so on.[11] The same problem appeared, so to speak, in all its tangibility when it turned out that the "primitive" atom was now a system consisting of electrically charged particles (a positive nucleus and negative electrons), so that it became necessary to tackle the problem of its stability from the angle of the classical theory of electromagnetism. It is common knowledge that the "Rutherford atom" owed its stability, not so much to the physical laws of the time as to the optimism of Rutherford and his adherents, their confidence that a positive solution of the problem would eventually be found. And found it was, in 1913, by the young Danish physicist Niels Bohr, who built a nuclear model by applying to the Rutherford atom what was then still Planck's quantum hypothesis. The "Bohr atom" did indeed prove stable, a property that was explained by the laws of Nature; in other words, the ancient atom at last "acquired"stability, not because someone has assured himself and others of that in his own name or in the name of the Almighty, but because it had been established by the quantum laws of the motion of matter.

Incidentally, if one gives deeper thought to the way the problem of the stability of the structure of atomic particles of matter was solved, one may even consider strange the idea of its possible solution in any other way. In essence, the properties and motion of macro-objects can be explained by the laws of motion and properties of their component micro-objects—that to avoid falling into regressus ad infinitum—only when the properties and the motion of macro-objects are not ascribed to the micro-objects. That is accomplished by quantum mechanics, which has shown beyond dispute that micro-objects obey quite different laws than macro-objects do. But in that case, the hardness of macrobodies, and the constancy of the standards of length and time, etc., i.e., all the physical characteristics of macro-objects without which measurements and, consequently, physical knowledge are impossible, have to, and do, find substantiation in quantum mechanics as the mechanics of objects at the atomic level.

On the other hand, man—if I may be permitted to say so,—is a macroscopic creature; he learns of the micro-world only when micro-objects affect the macro-objects that man attaches to his sense organs. Such macro-objects (which become man's instruments) enable him to gain a mediated knowledge of the micro-world. Thus, in his cognition of micro-objects, man cannot but use the classical concepts because it is through them alone that he can describe the readings of his instruments, i.e., inasmuch as he cannot dispense with the use of classical theories when making his measurements.

Such, in short, is the relation between quantum and classical mechanics, this leading us to an understanding of that relationship between the fundamentals in the theories of physics which is, in our opinion, characteristic of twentieth century physics.

In the first place, we should note that the mechanics of the atomic world (quantum mechanics), far from being reducible to the mechanics of macrobodies (classical mechanics) in the same way that the theory of electromagnetism cannot be reduced to classical mechanics (which it does not absorb), actually contains something far greater than that relationship. As mentioned above, quantum mechanics provides, in a certain sense, the foundation of classical mechanics; it substantiates some of the fundamental concepts that reflect the properties of macroscopic objects. Consequently, it behaves towards those concepts in the same way as it does towards classical mechanics, in which the derivative concepts are grounded in axioms.

The system of axioms in a theory contains the fundamental concepts in their links, which, however, are not logically substantiated within that system, but are postulated

on the basis of various convincing considerations that are taken into consideration when the system is being built up. In that aspect, a theory is called <u>incomplete</u> (and non-closed), but that incompleteness is of a different nature, in principle, than, say, the incompleteness of quantum mechanics which Einstein had in view in his above-mentioned discussion with Bohr. The fundamental concepts in their interlinks, which form the axiomatic system of a theory, can be substantiated by a theory that is deeper and broader than the one under consideration, and with a new axiomatics, etc. On the plane of logic, the status of the degree of "substantiation" of fundamental concepts in their interlinks in the axiomatics of a theory resembles the status of "non-contradictiveness", "completeness", etc., of an axiomatic system, which, as Goedel has proved, "cannot be substantiated with the means of that system" or, in a more general form, the fundamental propositions of a theoretical system cannot be obtained through its <u>logical means</u>, but they can be found by the logical means of a broader and deeper theory.[12] Using the same logical terminology, one may say that quantum mechanics is a kind of meta-theory of classical mechanics. Thus, for instance, Newton's theory of gravitation, like classical mechanics, gave no thought to the proportionality or (given the proper choice of units) the equality of the gravitational and inertial mass of a body: classical mechanics merely recorded and accepted as an experimental fact that the acceleration of various bodies in a gravitational field is the same. The finding of the substantiation of the equality of gravitational and inertial mass, or rather, the substantiation of the proposition that the gravitational and the inertial mass of a body are equal meant emerging beyond the confines of Newton's theory and the construction of a theory that would have been a kind of meta-theory in respect of that theory of gravitation. It was the latter that Einstein did by creating a new theory of gravitation or, as he called it, the general theory of relativity. We shall set that forth in Einstein's words by quoting several exerpts from his writings. It will be sufficient for our purpose to limit ourselves to hints.

With reference to the proposition that "the gravitational mass of a body is equal to its inertial mass," Einstein says that "this important law had hitherto been recorded in mechanics, but it had not been interpreted" (in this case we have used expression: classical mechanics did not substantiate, found no grounds, etc.). "A satisfactory interpretation", says Einstein in conclusion, "can be obtained if we recognise the following fact: the same quality of a body manifests itself, according to circumstances, as 'inertia' or as 'weight' (lit. 'heaviness')"[13]. By formulating this idea, Einstein gave a substantiation of the equality of gravitational and inertial mass as recorded empirically in classical theory, and initiated his theory of gravitation. The following excerpt from his book What Is the Theory of Relativity? can serve as an illustration of his fundamental idea: "Imagine a coordinate system which is rotating uniformly with respect to an inertial system in the Newtonian manner. The centrifugal forces which manifest themselves in relation to this system must, according to Newton's teaching, be regarded as effects of inertia. But these centrifugal forces are, exactly like the forces of gravity, proportional to the masses of the bodies. Ought it not to be possible in this case to regard the coordinate system as stationary and the centrifugal forces as gravitational forces? This seems the obvious view, but classical mechanics forbid it."[14]

If we bring together everything mentioned above, so to speak, regarding theory and its meta-theory, then the following conclusion suggests itself: the paradoxes which arise in a theory and cannot be resolved by its logical means indicate that the theory in question stands at the limits of its meaningfulness, and that its axiomatics (its axiomatic construction) has achieved the supreme logical completeness possible from the viewpoint of that theory's actual content and its axiomatic form. Such paradoxes are distinct, in principle, from those that arise in a theory and are resolvable by its logical means, i.e. from paradoxes that speak of the logical incompleteness of a theory (or of its incorrectness in its reasoning or imprecision in its premises). The presence of paradoxes in a theory, such that cannot be resolved by its logical means, testifies to the necessity of seeking for more general and more profound theories through whose means such paradoxes can be resolved (the resolution of such paradoxes usually coinciding with the construction of a general theory that is being sought).

Thus, the existence of paradoxes of this type means, in essence, that the physical cognition of objects is not held up at the level of some particular theory, but develops, involving new aspects of material reality, without rejecting the knowledge already achieved by that theory. The existence of paradoxes of this type also means that the theory which contains them but does not resolve them through its means potentially includes a theory that is more general and deeper than it itself is. From this viewpoint, any axiomatised theory necessarily contains such knowledge that cannot be substantiated by the means of that theory, for otherwise cognition would come to a standstill at a definite point, and what has been achieved would turn into a metaphysical absolute.

The development of the theory of present-day physics is ensured by the genetic series of theoretical systems which are closed or logically developing axiomatic structures linked together in definite relationships, structures from which, in the genetic series, a more general theoretical system evolves out of a more special system. Thus, the further development of physical science dealt the death blow at a single axiomatic system of physics, as a whole, in the spirit of the mechanical ideas of the eighteenth and the nineteenth centuries. As proved, in essence, by Goedel's theorems, such a system also proved impossible from the viewpoint of logic: the logical development of theory and of physical science as a whole is expressed in a genetic hierarchy of axiomatic systems, a hierarchy which combines both the trends towards stability and the trend towards variability, both of which are inherent in individual axiomatic systems and in their aggregate.

Although a single axiomatic system (structure) in the spirit of classical physics is now defunct, it is in the realm of ideas more than in any other area that the outmoded and the dead tries to drag down what is alive and progressive. A single axiomatic system is also being revived in present-day physics, true, in a form that would seem far removed from its "classical" model. The following notion of physical science is to be met in present-day literature: physics is developing as an axiomatic system that is, in principle, rigorous and non-contradictory, a system that involves all its departments, and one in which the historically earlier theory (together with its axiomatics) is an extreme particular instance of the historically later theory, inasmuch as it proves to be broader than the earlier one. With the passage of time the same takes place with the latter theory and so on and so forth.

When a theory is generalised, i.e.,when a transition takes place from a special theory to a general one, the former does not completely disappear in the latter, while the general theory does not become the sole true theoretical system in physics, as would follow from the idea of a single axiomatics in physical science. In fact, a special theory is preserved within the general one, and in a modified form (this also referring to definite concepts of the special theory): it remains within the general theory as an approximated theory, its concepts also remaining as approximated ones. From this point of view, one can speak of absolute simultaneity in Einstein's theory of relativity as well. Thus, a theory is not cast off with its transition

to a general theory but remains as a relative truth, i.e., an absolute truth within certain limits.

Connected with all this is the finding of answers to the following questions some of which have been considered above: why is it necessary, in the search for the "non-Euclidity" of some spatial form, to make use of Euclidean geometry? Why is it that we learn about the properties of the spatio-temporal continuum from measurements of local space and time? Why are concepts of classical mechanics used to describe experiments that are the empirical basis of quantum mechanics? The list might be continued.

We thus see that dialectical contradiction—the source of any development and vitality—operates in axiomatics as well.

NOTES

1 We are referring to statics as created by Archimedes.

2 Stephen C.Kleene, Introduction to Metamathematics, New York, 1952, p.28.

3 D.Hilbert, Grundlagen der Geometrie, Leipzig-Berlin, 1930, p.242.

4 N.Bourbaki, "L'Architecture des mathématiques", Les grands courants de la pensée mathematique, Paris, 1962.

5 Frederick Engels, Anti-Dühring, Moscow, 1969, p.169.

6 V.I.Lenin, Collected Works, Moscow, Vol.14, p.280.

7 Ibid., Vol.38, p.372.

8 Albert Einstein (with B.Podolsky and N.Rosen), "Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?", The Physical Review, 1935, Vol.47,p.777.

9 Maxwell himself assumed that he had been guided by the mechanical model of the ether but in certain conditions illusions often seem something real.

10 M.I.Podgoretsky and Ya.A.Smorodinsky, "On the Axiomatic Structure of Physical Theories", Questions of the Theory of Knowledge, Book 1, Moscow, 1969, p.74 (in Russian).

11 Issac Newton, Optics, Third Book of Optics, Part I, New York, 1952.

12 Excellent material in this instance is contained in V.A.Fok's article "The Significance in Principle of Approximated Methods in Theoretical Physics" published in the journal Uspekhi fizicheskikh nauk, 1936, Vol.XVI, Issue 8.

13 Albert Einstein, Relativity. The Special and General Theory, New York, 1947, p.77.

14 Ideas and Opinions by Albert Einstein, London, 1956, p.231.

CYBERNETICS AND THE SYSTEM OF NEW SCIENTIFIC PRINCIPLES

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Cybernetics is a relatively new science, but it already has a history of successes and as yet unfulfilled hopes, its own traditions, an impressive volume of literature, its own admirers and sceptics, enthusiastic adherents and sober-minded researchers, as well as scientific popularisers and mythologisers. The explosion of cybernetic enthusiasm that stirred the imagination of many scientists and the broad mass of science-lovers is now being replaced by a calm and businesslike attitude towards cybernetics, by an analysis of the realistic possibilities it provides for solving actual problems in any particular science. Sometimes individual disappointed voices and reproaches are heard to the effect that cybernetics has not provided a quick solution to the problems that have faced research workers for many a decade. They even cast doubt on the scientific status of cybernetics on the plea that it cannot enumerate "its own" laws.

We believe that, in the final analysis, there is some foundation for both a businesslike enthusiasm and some scepticism. This is to be found in the special nature and place of cybernetics in the system of scientific knowledge, in the character of its scientific concepts and principles, its approach to the object of research and, finally, the tremendous demands made on this new field of science.

At first glance, the emergence of cybernetics constituted another step towards the further differentiation of science, since a new discipline appeared with its own subject-matter and its new problems. Is this really the case?

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The first question must be about the status of cybernetics: can it be considered a particular science, such as quantum physics, molecular biology or the theory of law? We believe that the reasons behind and the history of the emergence of cybernetics, as well as its scientific content, indicate that it is not yet another particular discipline, but a scientific field tying together in a certain scientific region the general ideas and principles of a number of disciplines that study the various classes of self-controlling systems. This idea was expressed, though in insufficient detail, by Norbert Wiener, one of the founders of cybernetics, in his well-known work Cybernetics or Control and Communication in the Animal and the Machine.

As a scientific field embracing various particular sciences with its conclusions, principles, and generalising concepts, cybernetics has certain inherent methodological functions of a regional significance. In this sense, cybernetics is similar to branches of knowledge, such as physics or biology as a whole, etc. Indeed, with its fundamental principles, concepts and laws (for instance, the law of the conservation of matter and energy) physics as a branch of knowledge fulfils a methodological function for individual physical disciplines. The same applies to biology and other branches of knowledge.

Generalising scientific ideas, the general scientific principles and scientific concepts usually constitute the theoretical basis for the method employed to solve particular scientific problems. For this reason, cybernetics has some methodological functions of a regional significance

for a number of particular sciences. In this sense it is similar to the head disciplines of branches of knowledge, the ones that supply the other disciplines with their general concepts and principles of a methodological significance. But this is where the similarity seems to end, for cybernetics is not a particular science and has not become the head discipline of some branch of knowledge, as general physics has to the other physical disciplines.

The general principles and concepts of cybernetics are of great importance for biology, and of some importance for individual social sciences and a number of technical sciences. But these principles and concepts are not the basic ones for biology, sociology or any other branch of science, which have their own fundamental principles and concepts. Cybernetic ideas are of auxiliary and subsidiary, though great importance to them, so cybernetics does not and cannot fulfil the functions of a head science in relation to biology, sociology or any other branch of knowledge. Cybernetics has another task, that of bringing several branches of knowledge together in one scientific region according to certain features common to their objects of study.

Possibly the formation is under way of a cybernetic branch of knowledge embracing such particular discipline as information theory, control theory, games theory and a number of others. If this is so, it should be remembered that the way such a branch forms is in great contrast to the emergence of other branches of knowledge. First, almost all cybernetic disciplines appeared before the cybernetic scientific field itself, and for some time developed relatively independently. Second, there is as yet no justification for claiming that the branch has a head discipline—cybernetics as such. For now there is only cybernetics as a scientific field, and the cybernetic branch (if it really exists) can be headed alternately by, first, one, then another cybernetic discipline. At one time the leading one was information theory. In the future, another discipline will possibly take over, depending on the conditions and logic of the development of the cybernetic field as a whole.

The specific nature of cybernetics as a regional scientific field predetermines both the successes and failures in its application, depending on the demands made on it and the skill employed in utilising its potential. Applied in its natural role of regional scientific field, cybernetics undoubtedly has a heuristic significance in research in the particular sciences. It helps resolve complex problems in these areas, and in this sense its contribution cannot be overestimated. And, on the contrary, the potential of cybernetics is reduced to a minimum as soon as attempts are made to substitute the principles of cybernetics for the content of some particular science and cybernetics is expected to produce an exhaustive solution (primarily by cybernetic means) to the problems of biology, sociology and certain other sciences.

Just like particular sciences, scientific fields have their own subject-matter. The idea is widespread that, in contrast to sciences studying the various forms of the motion of matter (physics, chemistry, biology, sociology), cybernetics abstracts from the substratum and the actual forms of the organisation of matter, and from the actual bearers of motion. Its inherent approach is a functional one—a study of the self-motion of some classes of material systems, regardless of their specific matter.

The subject-matter of cybernetics is in some sense abstract, and this is where the similarity lies between cybernetics and mathematics. Cyberneticians are interested in the general principles of the self-motion not of all material systems, but only of functional, or, in other words, self-controlling systems, including living, social and certain technical systems which differ with respect to their substratum, level of organisation, and form of self-motion, but function in accordance with principles and laws that are common to all of them. Considering all this, a short

definition of the subject-matter of cybernetics might be as follows: cybernetics is a regional scientific field whose task is to put forward the general principles and to investigate the general laws of the self-motion of self-controlling systems by means of the inter-connected "cybernetic" particular sciences (information theory, automation theory, games theory, and so on). This definition naturally has no pretensions to being a complete one, if only because cybernetics is only in its early stages, so it is as yet impossible to foresee either the volume or the nature of the problems that this promising scientific field will put forward.

The subject-matter of cybernetics determines the nature of its method, the means by which its problems are formulated and resolved, and the results implemented in practice. As a rule, the fundamental problems of cybernetics are engendered by the requirements of the particular sciences investigating specific classes of functional systems. The theoretical solution of these problems by cybernetic means cannot be directly realised in practice. It is the means and methods of the particular sciences studying not functional systems in general, but functional systems "in flesh", i.e., living, social or technical systems that exist and function in their own specific material embodiment, that are required to turn schemes of abstract cybernetic systems into actually operating principles of real systems.

The emergence of a new scientific field in some way reflects science's growing demand for a differentiation of knowledge. The birth of the cybernetic scientific field constituted yet another step towards satisfying this demand. But this is not what determines the importance and role of cybernetics in modern science, whose demand for a synthesis of knowledge is just as great, if not greater. Without such a synthesis science is no more than a collection of isolated ideas. To a considerable extent cybernetics reflects the second demand, for its main function is to synthesise knowledge, something that is particularly necessary due to the acceleration of its breakdown into particular discipline. Such is the objective dialectic: the tendency towards a synthesis of knowledge carves its way in the form of a further differentiation of science.

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The principles of cybernetics. The establishment of cybernetics, a process that is still continuing, is the formation of a system of new scientific principles and concepts reflecting the functional unity of all classes of self-controlling system, from living ones to social ones. We are talking about a system of principles and concepts, bearing in mind their inseparable link and intercondition-ality within the framework of the integral scientific field. This does not, of course, mean that certain principles and general concepts of cybernetics cannot be introduced into and investigated by the particular "cybernetic" sciences as relatively independent phenomena. Thus, for instance, the theory of information communication can abstract from the concept of "control" and even from the content of the signals transmitted along the channel, and operate with the concept of "information" in considering certain engineering problems connected with telegraph, telephone and other forms of communication. Long before the emergence of cybernetics, the principle of feedback was used and studied theoretically in radio engineering and biology.

Wiener focused considerable attention on the principle of feedback and studied it on the overall theoretical plane as a general principle of all control processes. This gave rise to the appearance in cybernetics literature of a tendency to equate the content of cybernetics with feedback theory.[1] In our opinion, this impoverishes the content of this scientific field and does not help in revealing the integral system of its new principles and concepts.

As already noted, the basic principles and concepts of cybernetics are those of the self-motion of self-controlling systems in general, regardless of the actual substratum of

each individual system. Without pretending to strict genetic or logical consistency, we shall enumerate some of these principles that have been elucidated in some way or mentioned in works on cybernetics.

We think that the basic principle of the existence and functioning of self-controlling systems should be considered as the principle of active self-motion on the basis of regular reproduction of improbable states of the elements, subsystems or the self-controlling system as a whole through the use of the energy of the environment.

Any self-control process constitutes a "weak" action by the controlling "element" on the controlled one—the executive element for achieving a specific result which cannot be obtained by the self-controlling system's controlling "element" alone. In order that this action might be repeated in a further act, rather than be one-off, the self-controlling system as a whole must possess a regularly renewed and sufficient number of degrees of freedom, i.e., its elements or subsystems must have the capability or the possibility of transferring from a more probable to a less probable state, in the physical sense of the word, by using the energy of the environment.[2] This transition, in contrast to reactive changes in the state of the physical system under the influence of the environment, is characterised by a high degree of activity expressed in the ability of the self-controlling system to select its behaviour irrespective of the physical principle of the least action, or that of the greatest probability, without upsetting the second principle of thermodynamics or any other law of physics.

The latter concerns individual cases of amplification when the weak actions of some physical objects on others lead to large-scale physical events. These amplification processes, however, are not control processes, since the physical system always passes from the less probable to the more probable state, and the amplification process is not regenerated spontaneously. Cybernetics studies spontaneous and regularly renewed impact by the controlling on the controlled in living, social and certain technical self-controlling systems, which are carried out by using the energy of the environment.

Although cybernetics abstracts from the substratum of the self-control processes, it does not go so far as to take no account, in its basic principle, of the source of the self-controlling system's high activity. In its constructions it cannot completely eliminate energy processes, for these are the physical basis of self-control processes, processes of impact by the controlling on the controlled. From the standpoint of the general systems theory, this principle of cybernetics is considered from the point of view of so-called "open systems" which are capable of taking part in the exchange of substances and energy with the environment.

The process of control presumes a certain unity of the controlling and the controlled "elements" of the self-controlling system, the controlling element's ability to impact on the given controlled element and the ability of the latter to subordinate itself to and accept the action of the controlling element. In brief, the controlling and the controlled must be conjugate, otherwise there can be no regularly regenerated process of control.

The conjugation of the controlling and the controlled is characterised by the relative primacy of the controlling "elements" over the controlled, by a certain subordination of the executive elements to the supremacy of the controlling "elements". In other words, a relation of hierarchy or subordination is thus established between the controlling and the controlled.

Such a relation or the hierarchical principle (principle of subordination) is one of the basic principles of cybernetics. This does not mean that the executive elements are completely removed from the functions of control. The hierarchy of controlling and executive elements is not ab-

solute, but relative. Depending on the conditions of control and the level of organisation of the self-controlling system, the executive elements operate within the process of control to exert an active and substantial influence on the controlling elements (for instance, through feedback).

Physics and other sciences dealing with inanimate nature do not come across the phenomena of the balanced functioning of physical systems, when each of their actions must be preceded by account being taken of the specific features of the environment and the internal possibilities of the system itself. This is why physics does not need to study active forms of reflection, but confines itself to the physical (reactive) forms of reflection, which are used in experiments to study physical phenomena that cannot be directly observed.

In contrast to this, biology, some technical sciences, the social sciences and the cybernetic scientific field cannot avoid the active forms of reflection inherent in all self-controlling systems. The functioning of self-controlling systems is determined by the coordination of the self-control processes with the environment and with the possibilities of the system itself. If there is no correspondence between the system's planned actions and the internal and external conditions under which it functions, eventually the system is bound to collapse. For the self-controlling system to function normally, it must take account of its own possibilities and the specific features of the environment as a condition for and, simultaneously, as an impediment to its existence. This is achieved through active reflection of the environment and self-reflection of the system's own states, mainly by specialised adaptive organs (the sense organs in animals, the mechanisms of irritability in plants, sensing elements in artificial self-controlling systems).

These forms of reflection are, in some form or another, a manifestation of their common essence: everywhere the reflection process is reproduction of the specific features of the original by other means and in another form as changes in the processes of the reflecting system under the action of the original. Reflection becomes active when it selectively reproduces in another form the specific features and trends in the changes in the environment that are vitally important for the reflecting (self-controlling system, when it is simultaneously self-reflection of the system and reflection of the course and results of its interaction with the environment, and, something of considerable importance, when it acts as one of the internal causes behind the self-controlling system's choice of behaviour.

Reflection can be called active inasmuch as it interacts with the other processes of the self-controlling system that make up the energy, force and material basis of self-control, and directs them in conformity with the requirements of the system's survival and development under the external and internal conditions of its functioning.

Foreign literature on cybernetics does not consider specially the role of the reflection processes in the functioning of self-controlling systems, though all the authors' reasonings concerning the feedback principle essentially originate from the proposition that the self-controlling system receives "information" about the characteristics of the outer world and the results of its behaviour. It was Soviet authors who first focussed attention on the role of reflection in the processes of control and communication.[3] They put forward the principle of active reflection and self-reflection as one of the basic principles in the functioning of self-controlling systems.[4]

Communication between the elements of physical systems is accomplished by means of physical interactions, as a result of which material, field, energetic and structural changes occur in the interacting objects. Only through physical interactions do the elements of physical systems combine into an integral formation. For this reason, phys-

ics, being the generally recognised leader of the natural sciences even today, does not require the concepts of "information", "information causality", or "information communication" to describe physical reality. This is if the application of the ideas of information communication theory is not considered in creating the technical means for processing the results of physical experiments and the word "information" is not taken in its everyday sense to indicate knowledge received by a physisist from investigation of a physical object.

Biological, many social and technical sciences study material systems whose elements, apart from physical, chemical and physiological interactions, are also connected with an information communication, which is fundamentally new in comparison with physical communication systems. At the same time, this new form of communication is so important for preserving the integrity of the self-controlling systems that it may be considered decisive for them.

Without regularly accomplished information communication, the self-controlling system cannot function nor can its integrity be preserved. A weakening or complete loss of communication between the elements of the self-controlling system inevitably leads to the destruction of all other communication, to a halt in the physical and other interactions within the framework of the system as an integral formation, and to the collapse of the system.

If the principle of active reflection and self-reflection expresses the way the self-controlling system coordinates its actions with external conditions and its own possibilities, information causality and the principle of information communication reveal the form which lends the content of reflection communicability and helps it become a real factor in controlling the actions of the self-controlling system.

A considerable number of works have been devoted to the problems of information communication (usually called simply communication). Many authors study the metric aspect of information transmission along a communication channel in the form of a signal, solving problems of the maximum channel carrying capacity, given minimum distortion of the signals. Unfortunately, little research has been published so far on a quantitative analysis of information content, although this problem is of fundamental significance for control theory, since this theory is always linked with the self-controlling system's value relationship to the factors of the environment.

In the world of physical phenomena there is no value criterion pertaining to the results of the interactions of objects, which are indifferent to interacting physical systems, and before the beginning of interaction not one system predetermines its results depending on the task of preserving its own integrity. Such a task simply does not exist in the world of physical systems.

Self-controlling systems differ fundamentally from simple physical systems in the way their functioning is directed towards achieving a specific result, within certain limits, regardless of changes in external conditions. The functioning of self-controlling systems is always a process by which they preserve their integrity and qualitative definiteness. For this reason, internal changes in self-controlling systems are, as a rule, functionally invariant in the sense that they are directed towards achieving a strictly specific result necessary for the survival of the system and its further development. This is if the self-controlling system is sufficiently highly organised for self-development. Such a functional invariance is accomplished as a process of target-setting and target-achievement, which is an objective functional phenomenon, regardless of whether it is recognised in the case of conscious human activity or takes place without the participation of consciousness as in all other cases of the activities of self-controlling systems. 5435

<u>The principle of target-setting</u> is inseparably linked

with the principles of active reflection and information communication, since the formation target—the functional invariant—is accomplished by a generalisation of the content of previous reflection of the environment, self-reflection of the system and representation of its requirements, and by a generalisation of the elements of the system in space and their states in time, achieved with the help of information communication.

On the whole the process of target-setting and target-achievement is one of the main forms of active reflection of reality, during which the generalised content of previous reflections in the form of the experience of the system becomes an inherent reason for the purposeful activities of the self-controlling system in the environment.

Target-achievement is not possible without comparison of the results obtained by the system and the set targets and, on this basis, correction of the actions of the self-controlling system to minimise the discrepancy between the set, i.e., initial, targets and those realised. All this is achieved through the feedback between the executive elements and the controlling elements.

We shall not consider the feedback principle in detail, since it has been thoroughly elucidated in works on control. Let us note only that the feedback is realised through reflection by the executive and controlling elements of the results of the system's interaction with the environment and, as a rule, on the basis of information communication between the elements of the system or self-controlling systems together.

The principles of self-control considered above are united and tied by the <u>principle of adaptation</u> of the system to the internal and external conditions under which it functions. Adaptation can take the form of simple adjustments by the self-controlling system to the specifics of
5435 its environment, as a result of changes in certain parameters of the system, in such a way that they conjugate with

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the corresponding parameters of the environment without destroying the integrity and qualitative definiteness of the system. Such a form of adaptation is inherent in all self-controlling systems. It is limited by the possibility of changes of the system's state and is useless when the changes in external conditions are of considerable amplitude.

Highly organised self-controlling systems are capable of a more sophisticated, active form of adaptation when simple adjustment to the environment is supplemented by transformation of this environment by the self-controlling system in accordance with its tasks of survival and further development.

Not one of the enumerated principles of the functioning of the self-controlling system can be realised in isolation from the other principles or contrary to them. The system of these principles expresses the general features of all the processes of self-control independently of their material and energetic substratum. At the same time, it is distinguished by a certain degree of abstractness, inseparable from the basic laws of the motion of matter, and cannot be considered in complete isolation from the material and energetic substratum of the processes of self-control.

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<u>On the system of cybernetic principles and concepts</u>. The system of the basic principles of the processes of self-control in general, or the principles of cybernetics, that has not an overall but a regional significance within biological, some social and technical sciences, is the foundation for creating a system of new, generally scientific but more exactly regional concepts.

Many of these concepts have a long history of being unconnected in the system of particular concepts intended for describing certain aspects of conscious, and only con- 5435

5435 scious, human activity. These include the concepts of "control", "information", "programme", "model", "requirement", "value", "target", "target-orientation", "memory", "experience", and a number of others. Some of these concepts were not, strictly speaking, scientific concepts before the emergence of cybernetics, though, like many others, they were used in science to indicate the respective phenomena.

Cybernetics as a branch of knowledge (and its disciplines) laid the foundations for turning the concepts "information", "control", "target", "programme" and several others into scientific ones, helped towards their objectification and release from any anthropomorphism, and combined them into a system of interrelated concepts.

This basically progressive process of the establishment of a system of new scientific concepts by a certain generalisation of old particular concepts comes across several difficulties of subjective origin. These result from the one-sided application of a method of analysis, when an individual phenomenon is artificially isolated from the system of phenomena, without account being taken of the links between them, as well as by force of tradition, persistent habits, certain dogmas taken on trust and acquiring the force of the absolute.

The difficulties also arise from the opposite tendency to expand the new approach beyond the objective boundaries of its applicability, when the process of reasonable objectification of the concepts is replaced by thoughtless, excessive generalisation of them, which leads to their devaluation.

It should be added that the first successes in objectifying and formalising a concept such as "information" engendered difficulties resulting from the one-sided approach to this important matter.

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First let us consider the last issue. In retrospect it becomes increasingly clear that the first attempt at quantitative analysis of the processes of information communication and at formalisation of the concept of information was connected with only one of its aspects, certainly not the main one from the standpoint of control processes. This was the question of the optimal transmission of information signals along the communication channel with the minimum loss and distortion.

The statistical "information theory" created by a number of authors was essentially from the very beginning a statistical theory of signal communication for which the significance of the signals transmitted along the communication channel was not important, but for which the conditions for transmitting the maximum number of signals along the given channel without distortion were very important. This, however, means that the actual information, i.e., the significance of the signal for which artificial channels of information communication are set up and natural ones arise in self-controlling systems, is of no importance for the statistical "information theory".

Claude Shannon, one of the leading founders of the statistical information theory, warned that it is inadmissible to transform the concept of information specific to engineering communication into a universal means for describing phenomena beyond the limits of signal communication. In spite of these warnings the signal interpretation of information threatened to predominate.[5] At one time attempts to analyse the content of information, i.e., that which constitutes its essence and the main purpose in control processes, were rejected.

In actual fact, the concept of information proved more complex and much richer than it appeared in the statistical theory. The phenomenon of information has many specific features resulting from its inseparable link with the phenomenon of control: these are its syntactical, semantic, value, causal, communicative, theoretico-reflective, metric and several other aspects. Not one of these aspects has yet been subjected to a sufficiently thorough study. Many of the characteristics of information have not yet been successfully formalised in theory. Suffice it to say that neither the content and value of information, nor the link between these qualities of information and the form and level of control, its target and the nature of any class of self-controlling systems can yet be measured or evaluated in quantitative terms.

It should be noted, however, that certain successes have been achieved in describing information qualitatively. In this sense much has been done by Soviet philosophers who have established the genetic link between the phenomenon of information and that of reflection, revealed the derivative character of information in relation to reflection and shown the inseparable link between information and the phenomenon of control.

The concept of information, which is fundamental for cybernetics, has evidently not yet been sufficiently revealed, and considerable painstaking work still lies ahead to create a general theory of information including quantitative analysis and qualitative description of all the main qualities and aspects of information in its inseparable connection with the processes of self-control. It might be presumed that existing mathematical information theories will become partial instances of the general theory according to the principle of correspondence.

Another concept fundamental to cybernetics is that of control, which is also in the formation stage. We believe that one of the basic methodological difficulties facing research into this concept arose as a result of attempts by certain authors to characterise control as simple action by some systems on the parameters of others. This approach produced nothing new in comparison with the description of physical interactions and was based on the assumption of the separate existence of the "controlling" and the "controlled", linked by a spontaneous and single act of physical interaction. No attention was paid to the special link between the "controlling" and the "controlled" as inseparable aspects of a single integral material formation.

It is incorrect to confine control to some transformation of one system by another system. Such transformations are common in nature and do not constitute a specific feature of control. There is no doubt that any control action constitutes some transformation of the controlled under the influence of the controlling element.

Not every transformation, however, is the result of an act of control which must be considered not as the external relation between two systems, but as the internal relation between the controlling and controlled subsystems within the integral active system. In this sense the controlling and the controlled condition each other in the overall functioning of the integral system, which might justifiably be called self-controlling.

A correct definition of the concept of control (to be more precise—self-control) evidently requires that account be taken of aspects specific to the phenomenon of control, as well as the qualities of the self-controlling system and its links with the outside world. Such a definition must be based on the system of the basic principles of self-control and the system of the general concepts of cybernetics.

The concepts of "target-setting", "target" and "target-achievement" occupy a special place in the definition of the control concept. The process of control is always directed towards the achievement of predetermined results. The con-

cepts "information", "programme", "control" and certain others were accepted and included into the scientific apparatus of cybernetics fairly quickly, whereas the transformation of the concept "target" and its derivative concepts "target-setting", "target-achievement", "target cause" (describing the objective functional phenomenon, inherent only in self-control, of the orientation of action towards achieving a specific necessary result) into scientific concepts meets with difficulties due to a prejudice originally engendered by the incongruities of essentially idealistic teleology.

In the distant past the teleological dogma arose according to which target-setting was an act manifesting the conscious, and only the conscious, will of man and of the spirit in general (God). It is now difficult to understand why this dogma was uncritically borrowed by the critics of teleology as the initial and basic assumption for their criticism.

The dogma concerning target-setting as the prerogative of the conscious, and only the conscious, activities of man is in no way justified either theoretically or practically, and is essentially conventional. Moreover, there is an unlimited number of irrefutable facts testifying that all living systems are focussed on achieving a specific result necessary for their vital activity. These facts do not fit into the framework of old conceptions of target and must be interpreted from the standpoint of the regional scientific concept "target", which reflects the objective functional phenomena inherent in all self-controlling systems, regardless of whether they function consciously or unconsciously.

A certain objectification in modern science of the concepts "target-setting", "target" and "target-achievement" has become possible thanks to research into the properties of reflection in all matter, priority reflection and the activity of reflection, research into the phenomenon of information and information communication, information causality and the phenomenon of memory, reflection of imprints and a number of others. All this confirms once more the usefulness of the systems approach in studying the new scientific concepts that cybernetics has brought into currency.

In conclusion, let us stress that the system of scientific concepts of self-control and the system of scientific concepts of cybernetics are regional, general principles and concepts that help in describing and understanding the phenomena of self-control, but only where they exist.

NOTES

[1] See Colin Cherry, On Human Communication, New York, 1957, pp.21-22.

[2] See Albert Szent-Györgyi, Introduction to a Submolecular Biology, New York-London, 1960.

[3] See, for instance, the works of I.B.Novik, Cybernetics, Philosophical and Sociological Problems, Moscow, 1963; V.S.Tyukhtin, On the Nature of the Image (Psychic Reflection in the Light of the Ideas of Cybernetics), Moscow, 1963; B.S.Ukraintsev,"Information and Reflection", Voprosy filosofii, No.2, 1963; A.D.Ursul, The Nature of Information, Moscow, 1968 (all in Russian).

[4] B.S.Ukraintsev, Self-controlling Systems and Causality, Moscow, 1972, p.47 (in Russian).

[5] See Claude Shannon, The Bandwagon, Trans. IRE, IT-2, No.1, 1956.

THE ECOLOGICAL SITUATION TODAY AND THE FUTURE OF MANKIND

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An analysis of recent scholarly discussions shows that all of them, be it a symposium of physicists or a conference of philosophers, in one way or another touch upon the problem of man and his environment, which has become a crucial issue of global significance. It should also be noted that most of the discussants challenge the conclusions of the Club of Rome on this issue.

The Club of Rome is not an accidental phenomenon in the life of bourgeois society. It is a characteristic reflection of the state of capitalism in the 20th century. Already at the beginning of the century Oswald Spengler spoke with apprehension about the "decline of Europe"; now in the second half of the century apprehension itself has become an object of research in existentialism. It has reached beyond the bounds of philosophy, history and journalism to become an unpleasant fact of everyday bourgeois life. Not only factory and clerical workers, engineers and scholars view the future with anxiety; neither the petty and middle owners who go bankrupt are confident of the morrow because of inflation, economic depression and the reduced purchasing power of the mass consumer.

Here is how Aurelio Peccei, an Italian economist (FIAT director) and public figure, and founder of the

Club of Rome, explains how it came into existence. In his second programmatic article entitled "The Predicament of Mankind"[1], he writes that, in the face of impending catastrophe, civilised people in all countries realise that they cannot remain apathetic. Therefore, in 1968, a number of European scientists and intellectuals holding different views and beliefs came to a certain agreement. At a meeting held in the Academia Nazionale dei Lincei in Rome they discussed new approaches to possible solutions of ecological problems. At the end of the discussion some 30 men representing the natural and social sciences, the business world and government decided, after recording the fact of the dislocation of the social organism that became evident as the wealth multiplied and technology was used in a rash and chaotic manner, to pool their efforts and form the Club of Rome, named after the city they had gathered in.

In the said article, as in others, Peccei tries to systematise the basic global issues of the day which he calls "world macroproblems". It was suggested that in their entirety the practical difficulties should be called "world problems", which some scholars regard as a key to dealing with a system of "world macroproblems". We are unable to make a detailed analysis of this question here because of lack of space, but we can note that the main goal the Club of Rome has set itself is to start an integral study of global problems. Unlike many experts in the West, they do not set off some problems against others, which is to a great extent due to their collective efforts.

Pointing to some of the specific features of the Club's activities, Peccei writes: "Having opted against formal structures and procedures, it operates as an 'invisible college' whose members individually or in small work groups accomplish specific tasks as the occasion may require."[2] He goes on to say that although the groups work independently, they do not lose sight either of their common goal or the basic problems formulated in other researches of the Club. Its aim is to look for a way out of the

situation in which mankind finds itself as a result of the unplanned character of present-day social development and the improvidence of its leaders. The main problems which have to be solved to reach this aim are: 1) population and the Earth's ability to ensure its further growth; 2) vital resources; 3) the environment; 4) psychological evolution of human society and its institutions; 5) creation of a new philosophy linked with the quest for the purpose of human life.

The Club of Rome, it might be noted, is famous not for the works by the author cited above. It became widely known in 1972 with the publication of <u>The Limits to Growth</u>, a collective monograph produced by D.H. and D.L.Meadows, J.Randers and W.Behrens III of the Massachusetts Institute of Technology on the basis of the Club's fundamental elaborations, Peccei's original conceptions, and the method worked out by the well-known American systems-analyst Jay Forrester whose <u>Urban Dynamics</u> was recently published in the USSR. The authors used the said method to construct a universal "world system" model of the year 2000, which, in their view, takes due account of the basic trends of modern development. Their report on the limits to growth was presented at two international conferences, in Moscow and in Rio de Janeiro, in the summer of 1971.

Commenting on <u>The Limits to Growth</u>, the Club of Rome leaders stated that they had set two tasks before the MIT people: to determine the limits of our world system and the various factors which condition its numerical indicators; and to bring out the dominant elements which exert the major influence on the behaviour of the world system in its interaction. The main conclusions of <u>The Limits to Growth</u> met these requirements. The comments suggest that the MIT study is a very bold attempt at an exhaustive analysis of the world situation. For all that, however, the MIT study is only the first step and it will take years to work it out in detail. It considers the limits to growth only as uppermost physical limits imposed by the finiteness of the world system.[3]

But it pursues other objectives as well. Its authors stress that it advances tentative suggestions regarding the future state of the world and opens up new perspectives for continued intellectual and practical endeavour to shape that future.[4] The authors of the comments note that although the study gave rise to many questions and critical remarks it did not meet with any serious objections.

We, nevertheless, believe that the conclusions of The Limits to Growth and also, incidentally, the stand taken by the Club call for criticism, not sweeping, indiscriminate criticism, but effective, unbiased and constructive criticism. To begin with, one should not identify the constructions by Forrester with those by the Meadows group. Secondly, one should distinguish between the stand of the MIT group and the views of Peccei, because they differ in many respects. Thirdly, attention should be paid to the fact that the flow of criticism caused by the paper written by Meadows and others has a major methodological defect: as a rule, only one of the five ecogenic factors is analysed critically, while the problem as such still awaits its comprehensive and integral solution. To a certain extent, M.Mesarović and E.Pestel have managed to come nearer to it.

In reply to the criticism on the part of Sussex University[5] and proceeding from the Meadows group's recognition of the possibility that the model can be improved upon, Pestel and Mesarović elaborated a new universal hierarchical world model consisting of ten blocks, or "regions". Regional divisions were to help built a more improved model which would take into account the socio-economic aspect of the "world system", proceed from the distinctions between planned and free-market economies, and record the specifics of the economic structures of the developing countries. To a certain extent, the model proposed by Pestel and Mesarović which they themselves called "A Strategy of Survival"

is an alternative to the "Blueprint for Survival"[6] proposed by a group of English scholars.

The need to distinguish the stands taken by the abovementioned scholars, including members of the Club of Rome, was emphasised by Academician E.Fyodorov in his afterword to the Russian 1974 edition of The Closing Circle by B.Commoner, the noted American ecologist. It should be remembered that the Club of Rome is a rather representative international organisation uniting people of different countries and different mental attitudes. Unlike the Meadows group, Peccei, for instance, believes that the goal is not to limit or hold back economic growth but to achieve social stability. He speaks about passing to a planned and planning society. Under capitalism, such a proposition is utopian, of course. On the other hand, it reflects his new form of criticism testifying to the fact that a considerable part of the influential and thinking intelligentsia has abandoned the narrow, pragmatic ideals of the consumer society.

In Peccei's opinion, instead of discussing and propagating the hypothesis of zero growth rate one should "think seriously about achieving a 'stable society', that is, a continuous, dynamic, optimal or sub-optimal condition of equilibrium both with its external environment and, necessarily, with its internal one. Obviously, such a society, in harmony with nature and with itself, can only be a long-term goal, a goal, however, to be carefully studied and prepared now."[7] The Club of Rome pays considerable attention to social stability and dynamic equilibrium. In the conditions of existing class contradictions, however, all this remains nothing but wishful thinking.

Academician E.Fyodorov justly notes in this context: "Who in the West will strive to implement the ideas of the Club of Rome and their like? And what immediate concrete goals should one start with? The members of the Club of Rome would do well to give thought to that."[8]

Other "world problems" also call for criticism; this

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has already been expressed in a number of papers. First, the main sectors of the "world system" do not evidently reflect the diverse links of living and developing reality which is hard to fit into the Procrustean bed of such "global" schemes. It is hardly possible that all world balances are accounted for and adequately assessed. Secondly, new inventions in science and technology (the nature of which we still cannot fully imagine but which are quite probable) can help surmount difficulties that seem unsurmountable today.

The authors of The Limits to Growth, however, do not take these "technical" premises into account. Meadows and others hold that the world model does not contain only one variable which is called "achievements of science and technology". "We have not found it possible to aggregate and generalise the dynamic implications of technological development because different technologies arise from and influence quite different sectors of the model."[9]

This variable is indeed extremely multidimensional. Nevertheless, it is precisely this state that can be regarded the most vulnerable point in the conceptual basis of the model, though Meadows and others, contrary to their own statements, make attempts to consider the technological achievements of today. The same is true in relation to the socio-political factor which should be present in any model if it is to be scientifically authentic and universal. The model neither takes into consideration the influence of various value systems, views, ideas and convictions, while the ideological opponents of the Communists find that they have to take ever greater account of the attractiveness of the ideas of communism and its humanist ideals. The latter are so attractive that they themselves become a powerful accelerator of social development.

Though the advocates of "global ecology" subjectively show what, in Academician Fyodorov's view, might be unconscious socialist tendencies[10], objectively the "global

5435

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equilibrium" blueprint would in fact mean perpetuation (in spite of a number of reservations) of the status quo, that is, bourgeois property relations.

The political indifference of the Club of Rome, its desire to stay above the struggle of the two opposite social systems and its disregard of the interests and needs of the developing countries—all that comes in for sharp criticism by progressively-minded Western scientists as well. B.Commoner, for instance, who still quite recently hesitated in his evaluation of the political aspect of the ecological situation, is now ever more definite in his choice. In his speech at the festival to mark the 50th anniversary of Unita, he criticised the Club of Rome for its indifference to politics, which plays into the hands of the ruling forces, and stressed that the moment these forces proved incapable of meeting the needs of the people would become a turning point in history.

A book entitled Ecology: Can We Survive under Capitalism? by Gus Hall, General Secretary of the Communist Party of the USA, was published in New York in 1972. Drawing upon numerous facts, the author proves convincingly that the threat of an ecological crisis is determined by the aggravating contradiction between the scientific and technological revolution and the capitalist means of its development and is a manifestation of the general crisis of capitalism today. He writes that in the long run, there is only one alternative: capitalism or continuation of life on our planet.

A new attitude to nature insistently dictated by scientific and technological progress, presupposes new relations among people. The problem of nature and society is inseparably linked with the problem of liberating mankind from all forms of social oppression. It is inseparable from the main content of the present epoch—the epoch of transition from capitalism to socialism. All attempts to find other ways of radically resolving the problem ultimately lead to nothing but social illusions.

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While recognising the gravity of the warnings by the Club of Rome about the pernicious consequences of the present negative tendencies in the interaction between society and nature one cannot but note that the Club's idea of "global equilibrium" is utopian. The key to the solution of this problem is to be found, not in limited industrial development or universally enforced birth control but in radical social changes, the abolition of private property in the means of production, and in the organic combination of the achievements of the scientific and technological revolution and the advantages of the socialist economic system.

Today, ecological problems have acquired a strongly pronounced political colouring, as was emphasised by the international symposium "Marxism-Leninism and the Protection of the Environment", held in Prague in 1972. In the capitalist countries, the efforts to protect the environment are becoming a part of the struggle for a democratic renovation of the state, for anti-monopoly democracy. Another trend in the struggle for an anti-monopoly front is emerging under the leadership of the working class, as well as new stimuli in the struggle for communism (see <u>Ecology and Politics (Problems of Environmental Protection). An International Discussion by Marxists</u>, Prague, 1972).

However, the gravity of the situation—the real and serious threat to life on Earth—demands that immediate international agreements and concrete measures to protect the environment be taken, already now, in the conditions of the peaceful coexistence of two opposed social systems. Nature protection is a major point in the Soviet Peace Programme elaborated by the 24th and further developed by the 25th Congresses of the CPSU. Leonid Brezhnev said: "We are also prepared to participate in collective international schemes for nature protection and the rational use of natural resources."[11] In our epoch, there is all reason to consider natural protection to be second in importance only to the preservation and consolidation of peace.

A generalisation of the main trends in the resolution of this particular problem leads to a conclusion of great theoretical importance. In previous epochs, production and reproduction of social life included two spheres—production of the means of subsistence, and production of social individuals. In the present epoch, there is a pressing need for another type of production—production and reproduction of the natural environment itself. Hence the great methodological importance of the theory of the noosphere elaborated by Vernadsky, the founder of geobiochemistry. The theory is a summary of Vernadsky's long and fruitful study of the biosphere of the Earth contained in the last, and unfortunately unfinished, chapter of his monograph <u>The Chemical Structure of the Biosphere of the Earth and Its Surrounding</u> (Moscow, 1965). The theory was also expounded in his paper <u>Some Remarks about the Noosphere</u>.

Vernadsky assumed such a level of material production development possible as would ensure the autotrophy of mankind, its independence of the biosphere. He wrote: "In this way the human mind would not only create a new great social achievements, but also introduce a new great noological phenomenon in the mechanism of the biosphere."[12]

The idea of mankind being autotrophic gives rise to the following question: will not scientific and technological progress in the long run lead to a replacement of the biosphere by a technosphere which would synthesise foodstuffs, purify water, regulate the gas content of the atmosphere, in a word, produce for people everything that they are getting from the biosphere today? The answer to this question should evidently be in the negative. Living nature in all its variety will always have enduring aesthetic, educative and recreative significance for man, to say nothing of the fact that technical devices performing the functions of the biosphere would most probably be more complicated and less efficient systems than the biosphere. There are also other arguments worth considering. Pursuing his objectives, man could, in principle, replace forests, fields, meadows and highly organised animals and plants with cassettes of artificial photosynthesis, power installations, factories and works. However the most sophisticated equipment would hardly be able to destroy all the micro-organisms. Left alone with bacteria and viruses with their exceptional genetic abilities, man would be running the risk of becoming extinct because of infections. "To replace the biosphere with the technosphere," M.Kamshilov writes, "would mean the creation of Molochs, which could lead us nowhere."[13]

Man has always changed nature and will continue to do so, but the technosphere should not destroy but preserve the principles of the organisation of the biosphere, supplement the biosphere and interact with it as part of a single dynamic system. Such a symbiosis of technosphere and biosphere (biotechnosphere) makes it possible to speak of a radically new planetary phenomenon and at the same time of a new stage in scientific and technological progress. While the current stage of scientific and technological progress turns natural processes into industrial ones, the new stage is meant to adapt industrial processes to natural ones by ever more harmoniously linking them up with "the natural processes, and to create on this basis a new natural rotation of matter and energy in the society-nature system".[14] This particular stage of scientific and technological progress has in fact started. Its immediate manifestation is the elaboration and application in production of closed-cycle technology. And accordingly, we believe, the problem of the noosphere arises.

The term "noosphere" (Gk. *nous*—mind) was first used in 1927 by the French mathematician and philosopher E. Le Roy, who was a follower of Henri Bergson (see E. Le Roy, *L'Exigence idealist et le fait de l'évolution*, Paris, 1927). Proceeding from the biogeochemical basis of the biosphere noted by Vernadsky in his Sorbonne lectures of

1922-1923. E. Le Roy together with P. Teilhard de Chardin considered the noosphere to be the contemporary planetary stage of the development of the Earth's crust. The term was first used by Vernadsky in the 1930s in his article "The Study of the Phenomena of Life and Contemporary Physics". But the ideas about the noosphere had been expressed by him much earlier, in his paper *The Autotrophy of Mankind* published in French in 1925.

Unlike P.Teilhard de Chardin who ultimately reduced the noosphere to some supramaterial basis which is directly connected with the centre of mental concentration (God), Vernadsky approaches the problem exclusively from natural scientific positions, from the positions of a naturalist who studies geological, planetary processes. To Vernadsky, the noosphere, just like the biosphere, is a material formation. "As soon as a living being endowed with intellect appears on our planet, the planet enters a new stage of its history. The biosphere turns into the noosphere,"[15] he stressed.

Mankind by itself is only a negligible part of the mass of the planet's matter. Intellect makes man powerful. Thought (ideal) is not, however, a form of energy. It can change nature only through the activities of men "who dispose of a certain practical force".[16] Therefore, it is not intellect alone but intellect and work combined that make man a major geological factor. The material processes generated by man's productive activities are commensurable with natural geological processes if we speak about the amount of replaced chemical elements and the changes in the planet's crust. Man, however, cannot and should not turn his activities into an elemental geological force. In his subsequent works and particularly in his paper *Some Remarks about the Noosphere* (1944), Vernadsky further developed his understanding of the noosphere and considered, not only its natural (biogeochemical) but also its social aspects.

Man's intellect and work have the task of consciously and radically changing the biosphere for the benefit of all mankind. "This new state of the biosphere, to which we are drawing ever closer without noticing it, is the noosphere,"[17] Vernadsky noted. The immediate prerequisites for the noosphere consequently appear not when an intelligent being appears on the Earth, as was assumed originally, but when "man's geological role begins to dominate in the biosphere and broad horizons open for his future development (ibid., p.270). With profound optimism and confidence in the future Vernadsky pointed out that the ideals of our society "are in unison ... with the laws of nature and consonant with the noosphere".[18] He referred directly to Marx when noting that "the concept of noosphere ... is fully consonant with the basic idea underlying 'scientific socialism'".[19] The noosphere is a result of a planned and conscious transformation of nature. While from the geological point of view the noosphere is formed incomparably quicker than the biosphere, from the point of view of social history it is a long process the completion of which is connected with the establishment and development of communist society. Emerging as a planetary phenomenon, the noosphere becomes a cosmic phenomenon owing to the specifics of the development of the social form of movement, which fully corresponds to Vernadsky's conception. In this respect, one can agree with Yu.Trusov when he says: "The noosphere is not a planetary but a constantly expanding cosmic sphere: on this planet it has only its beginning."[20]

The term "noosphere" is gaining ever wider currency in Soviet scientific and popular literature in recent years. Inadequate analysis of Vernadsky's works, however, leads to sweeping statements that the noosphere already exists alongside the biosphere and technosphere. Underestimation of his ideas gives rise also to an erroneous, in our view, interpretation of the noosphere as simply a manifestation of man's purposeful activities in respect to nature, in which connection the idea is aired that the formation of the noosphere occurred "about the time when civilisation start-

ed". The social aspect of the problem remains undefined also when, with the help of the concept of "noosphere", the fact of man becoming the main geochemical force on the Earth's surface is only started.

In the future, not separate elements of the natural environment, but the entire natural environment will become a single complex, dependent on man, of natural conditions and technical means preserving those conditions. Such a unity of man and nature can be achieved only if and when the alienation of nature from man has been overcome and private property abolished. It is that state of nature and society that will mean that the noosphere has come into existence. An organised state of nature in the conditions of the noosphere is inseparable from communist relations.

To sum up. An analysis of the connection between the existing ecological situation and understanding of man's future shows convincingly the theoretical depth and the philosophical and natural scientific validity of Vernadsky's theory about the noosphere as well as the utopianism and, in a certain aspect,the reactionary character of the ideas propounded by scholars who are trying to find the solution to ecological problems independently of the basic social problems of our day.

Forecast and prediction are two different things, of course. Unlike prediction, forecast is not always true: some forecasts are self-destructive. Negative forecasts can also be of importance for understanding the future if they stimulate the development of scientific thought, arouse and mobilise social forces capable not only of opposing but also neutralising undesirable tendencies. A forecast, however, becomes scientific only if and when it rests on a firm methodological foundation, on a theory that shows the real ways of human development. In this respect, the forecasting of the interaction of society and nature requires above all comprehensive elaboration of a general theory of that interaction.

When speaking about the future, we must not forget about the present. Not tomorrow but today the destruction of nature must be stopped and a careful and really humane attitude to its wealth established as simple norms of morality and justice. So far as people's attitudes towards nature in the process of material production are established through their relations to one another, genuine unity of man and nature presupposes first of all genuine unity of mankind itself. Public, or to be more exact, communist property is the only permissible, also in this sense natural, basis of a society, which, according to Marx, will harmoniously combine "the realised naturalism of man and the realised humanism of nature".[21]

NOTES

1 A.Peccei, "The Predicament of Mankind", Successo, Milan, June 1970.

2 A.Peccei, "How to Survive on the Planet Earth", Successo, February 1971, p.138.

3 D.H.Meadows et al, The Limits to Growth, New York, 1972, p.186.

4 Ibidem.

5 "Limits to Growth? The Club of Rome Replies to the Main Criticism of the MIT Studies", The Ecologist, 1973, No.8, pp.298-302.

6 "A Blueprint for Survival", The Ecologist, 1972, No.1.

7 A.Peccei, "Zero Growth Rate?", Successo, October 1973, p.120.

8 E.K.Fyodorov, Interaction of Society and Nature, Leningrad, 1972, p.84 (in Russian).

9 D.H.Meadows et al, op.cit., p.130.

10 E.K.Fyodorov, op.cit., p.76.

11 24th Congress of the CPSU. Documents, 1971, Moscow, p.70.

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PHILOSOPHY AND INTEGRATIVE AND PAN-SCIENTIFIC TRENDS IN COGNITION

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Already in the 19th century, the development of science showed that new knowledge accumulated most rapidly at points of contact between various disciplines, as a result of their interaction. However, it was only in the second half of the 20th century that the interaction between various groups of sciences, a process achieved through the conduct of inter-disciplinary research and the accomplishment of comprehensive tasks, acquired a most extensive nature.

We shall recall that the 25th Congress of the CPSU set Soviet scientists the task of fully utilising the fact that "fresh opportunities for fruitful general theoretical, fundamental and applied research arise at the conjunction of various sciences, notably the natural and the social".[1] That also means that profound and specialised research, including the area of philosophy and methodology, is required into the ways, the prospects and the mechanisms of the augmentation of scientific knowledge and its utilisation, which already exists or can appear as a result of the purposeful and tapping of reserves within science itself, such that escaped the attention of scientists in the conditions of the prevalence of specialisation, of a narrow and "departmental" approach to the tackling of various problems, i.e., in conditions of differentiation dominating integration processes.

Today, too, the differentiation of science seems to be prevalent over integration, though the further acceleration of scientific and technological progress calls for interaction between scientific disciplines to be markedly stepped up and for integrative processes in cognition to be expanded. Speaking of the mounting trend towards integration, a synthesis of knowledge, Academician B.Kedrov has pointed out that "the main significance is now being attached to those lines of advance in science which presuppose the interaction of various sciences between themselves, the emergence of comprehensive groups of sciences, and a 'link-up' between sciences which but recently seemed far removed from each other".[2]

The growing attention being paid to a synthesis of the natural sciences and the humanities, and the involvement of the technical and applied sciences in that integrative movement are linked with the sharply enhanced role of science in social development in the conditions of the present-day scientific and technological revolution. Side by side with the introduction of scientific knowledge in industry, i.e., together with its function in industrial processing, science is acquiring other socially significant functions, revealing its ever greater possibilities and means of accomplishing fundamental social and economic tasks.

In the conditions of the intensification and higher efficacy of the scientific and technological revolution, success in the solution of urgent and cardinal economic problems can be achieved only through the optimum blending of scientific, technological and social progress.[3] Moreover, economic achievements now depend, not so much on successes in individual branches of sciences as on positive results in science as a whole. That is why strengthening the links between various groups of sciences has acquired such importance.

The task of "strengthening the relationship between the social and the natural and technical sciences"[4], a task set in the <u>Guidelines for the Development of the National</u>

Economy of the USSR for 1976-1980, is a major line of advance, the kernel of the integrative movement in science, on which depends the efficacy both of its basic and applied branches.

The integration of science in the broad context may be regarded as the interaction between the various aspects and components of scientific activities. If science is regarded as activities in the production of new knowledge, and its utilisation in a wide variety of practical spheres; then science as a system of knowledge operates as a component of scientific activities, i.e., as its outcome (or one of its outcomes). Besides the latter, one can discern among the components of scientific activities such things as the subject, the object, the means, the aims and the conditions of activities, the processes of interaction taking place both within each of these components or else between them. From this point of view, the integration of science is seen as a system-forming interaction between various kinds and components of scientific activities, while the synthesis of knowledge is merely a synthesis of the results of these activities.

The synthesis of knowledge according to the object of scientific activities (research) stems, first and foremost, from the unity of the entire material world, the overall links between phenomena, that leading to the integrative interaction between the subject-matter of the individual sciences and scientific theories, and the appearance of problems common to them all. In this connection, there takes place the further consolidating of the association between scientists working in the natural, the social and the technical sciences, an association achieved through the establishment of systemic-comprehensive and inter-disciplinary institutions and organisations operating as collective subjects of cognition.

Both the technical means and the operations of cognition, as well as the theoretical devices, methods and procedures in research, are marked by integrative trends giving rise to new forms and kinds of scientific activities, such as, for instance, scientific information work. The emergence of single aims of scientific research, especially under the influence of social practice, markedly encourages the synthesis of knowledge in the process of target achievement, and leads up to generalising results, both in the form of adequate conceptual and theoretical systems and as scientific achievements reified in material productive forces.

The growing interaction between the three main groups of sciences follows different roads, first and foremost in the course of what is known as inter-disciplinary research.[5] Alongside inter-disciplinary research within a single group of sciences, in which the objects, methods, and scientific language of individual disciplines prove similar to a certain degree, inter-disciplinary research is conducted through various groups of sciences, for instance, individual scientific disciplines forming part of the socio-humanitarian group of branches of knowledge, and through the group of the natural sciences; in particular, a trend towards the drawing together of biological and ethical knowledge is emerging.[6] Integrative processes, a link-up between the social and the natural sciences, are distinctly expressed in research into processes of social information and administration.[7]

The interconnection between the social and natural sciences can also be effected in a mediated fashion, through the technical sciences.[8] Technical knowledge itself operates as a kind of synthesis of social and natural science. From the social sciences technical knowledge borrows information on the purposes and the law-governed patterns in the development of society, and its industrial and technical needs which are called upon to meet the demands of the technical sciences, which, in their turn, borrow from natural science a knowledge of the fundamental laws of living and non-living nature.

Partial processes in strengthening the links between the social and the technical sciences (along this road, in particular, such areas as technical aesthetics, ergonomics and the like have appeared) also take place; besides, the natural and the technical sciences are drawing ever closer to each other[9] through the introduction of fundamental discoveries into industry. A number of relevant examples were quoted by Academician Alexandrov, President of the USSR Academy of Sciences, in his address to the 25th Congress of the CPSU.[10] Such examples included the development of basic theories in the physics of the atomic nucleus and the appearance, on that basis, of applied sciences promoting the creation of nuclear technology (nuclear power plants, atomic icebreakers, and the like) and its extensive use in industry and other practical spheres.

A close interaction between the natural and the technical sciences is also to be seen today, when the tasks of the exploration and conquest of space have to be dealt with. It is the basic work conducted in this area that has made it possible to expand the possibilities of TV and other communications, and to place space achievements in the service of the economy: in sea navigation, geological prospecting, forestry studies and, in the foreseeable future, in agriculture.[11]

The relatively independent interaction between the two different groups of sciences naturally is a part of the more general process of establishing stronger links between all the fundamental departments of present-day science. The greatest prospects for the development of integration and consolidation are held out by the joint participation of a number of sciences in dealing with comprehensive, global, overall scientific and major economic problems.[12] To such problems, as engendered by the scientific and technological revolution of today, pertain the conquest of space, the study and utilisation of the World Ocean, nature protection, the rational exploitation of nature and a number of others, which all call for the efficacious blending of the efforts

of representatives of natural and socio-humanitarian knowledge.

The appearance of new trends in the integration of science has fostered the coordination of styles of thinking specific to representatives of various groups of sciences. Works have begun to appear of late which deal with research into the styles of thinking of scientists, examples being mainly borrowed from the natural sciences.[13] Within the framework of the style of thinking inherent in natural science, more narrow "styles" have already been identified: ecological, cosmic, cybernetic, probability and other styles, while a study is being made of the succession of "paradigms", the modes of thinking within the same science, and so on.

At the same time, studies into the humanitarian style and also the technological mode of thinking are becoming topical in the conditions of today. The existence of styles of thinking specific to natural scientists, scholars in the humanities, and representatives of the technical sciences is common knowledge and reveals itself with sufficient clarity when comprehensive problems are being jointly dealt with, this often giving rise to heated arguments and sometimes to a total lack of mutual understanding. The features of the style of thinking in representatives of the three groups of scientists mentioned above are, of course, the outcome of objective and actual distinctions in the subject-matter of the sciences, which, in considerable degree, mould the specifics of the cognitive means and procedures, the approach, and the style in scientists' creative thinking.

When we take note of the specifics and, consequently, the distinctions in the style of thinking of experts engaged in these three groups of present-day sciences, it is important for us to discern and study what is common to them, unites them and makes up the foundation of the drawing together and link-up of various styles of thinking. This means addressing oneself to those aspects and charac-

5435

8-I

teristics of the mode of thinking which make for such link-ups, and not merely for a simple translation from the language of one science into that of another (although that is very important in the conditions of ever greater specialisation and sharp differentiation), and can also serve as a source, a "generator" of new scientific knowledge.

The increase of interconnection between the social, the natural, and the technical sciences, and the link-up between the style and mode of thinking of their representatives is merely a task located within science and forming part of the more general task of uniting science with industry, the results of the scientific and technological revolution with the advantages of the socialist system of the economy. The style of thinking in scientists as a whole should be linked up with the style of thinking in representatives and leaders of the economy, for which purpose scientists should proceed from the needs of the practice of communist construction and should introduce scientific knowledge into industry with more boldness and efficacy. "Much remains to be done," Leonid Brezhnev emphasised in his report to the 25th Congress of the CPSU, "to embody scientific achievements quickly not only in individual, albeit the most brilliant, experiments and exhibit models but also in thousands upon thousands of new kinds of products, from unique machines to everything that contributes towards improving the working and living conditions of people. The practical application of new scientific ideas is today as important as their development."[14]

It is the needs of social practice, as well as the integrative processes in the economy and in the socio-political sphere which, together with the objectively existing unity of the world, provides the foundation on which integrative trends are developing in science. It is indicative that integration makes the greatest impact wherever science introduces its achievements into industry, wherever science more and more tangibly becomes a direct productive force, and the results of the scientific and technological revolu-

tion blend with organisational and economic activities, thereby fostering the solution of fundamental problems of scientific, technological, and social development.

The development of space research and space rocketry, and the exploitation of achievements in this area to meet the needs of the economy can well bear out this proposition. This has been specially emphasised by Academician V.Glushko, a pioneer in rocketry and a leading expert in space travel: "The road travelled by present-day science is the extensive and comprehensive utilisation of many scientific and technological avenues, and their synthesis in a single and constantly improving system. Space travel is a highly important testing ground where that synthesis is effected in practice. Therein lies an explanation of its successes and a guarantee of future victories."[15]

In its turn, research into the synthesis of scientific knowledge and the interaction between the three main branches or groups of sciences calls for a special methodological understanding of what may be called the implemental function of science. It is no secret that the vast majority of researches into the methodology of science, the epistemological problems of natural science and even the general theory of knowledge are overtly or covertly oriented towards basic science, in general, towards the production of new scientific knowledge. Here it should be noted that there are very few writings on the philosophical problems of the applied and technical sciences. Thus, the philosophico-methodological, the epistemological, substantiation of the introduction of scientific achievements leaves much to be desired. This direction of philosophical research is directly linked with the enhanced role of Marxist-Leninist philosophy in the further consolidation of the alliance between the social, the natural, and the technical sciences, the interaction between fundamental and the applied sciences, and between science as a whole and industry.

The integrative and synthesising processes in science are tangibly intensified by philosophy. It is instructive to note that the integrative movement in natural science, which has in part proceeded outside and independently of philosophical knowledge, has made a considerable study forward since genuinely scientific philosophy formulated as one of its focal tasks the institution and the consolidation of the alliance of philosophy and natural science. Today this alliance has made considerable strides in the USSR, despite the existence of temporary difficulties, and is maintained by the activities of Soviet philosophers and natural scientists.[16]

The alliance of philosophy and natural science has made it possible to "take in" and foresee, from a single methodological standpoint and on the basis of Marxist-Leninist theory, the processes of the synthesis of knowledge in the sciences of nature. It is not fortuitous that generalising writings on this problem[17] could have appeared only in the conditions of effective contacts and joint fruitful participation of Marxist philosophers and natural scientists in the synthesis of knowledge. The intensification and the coordination of the integrative processes in natural science, which have been the outcome of joint research by philosophers and natural scientists, have extended their frontiers, emerged from within the sciences of nature, and manifested themselves at an ever greater rate in the sciences of society and technology. In essence, Lenin's idea of the alliance between philosophy and natural science has, as noted in the article "The Supreme Duty of Soviet Philosophers"[18] acquired new forms and scale: we have an alliance of Marxist philosophers and representatives of knowledge in concrete sciences, in all social, natural and technical sciences. The expanded alliance of philosophy and particular sciences operates as an objectively essential trend, a law-governed pattern of cognition, which has notably enhanced the role of philosophy in the synthesis of all three fundamental groups of present-day sciences.

Marxist philosophy's integrative function is not, of course, something independent of, or divorced from, its methodological, world-view and other functions and subfunctions[19]; it is merely another aspect of it. What should be emphasised is that the integrative function of philosophy can manifest itself in full only when the strengthening of the interaction between the social, natural and technical sciences becomes a cardinal task in the development of science. In these conditions, philosophy's integrative potential can be utilised in full, but the extension of its field of activities imposes on philosophers a high responsibility to representatives of specialised sciences.

The implementation of philosophy's integrative function calls for active organisational and practical activities by philosophers, parallel with the elaboration of theoretical propositions. In fact, this bears upon philosophy's initiative in the integrative processes in present-day science, which, as pointed out in the journal Voprosy filosofii in an editorial entitled "From Party Positions", "presents new demands to those working in the field of philosophy, namely, to their qualification and their ability to discern new problems and to unite scholars to elaborate such problems on the Marxist-Leninist methodological basis, from Party positions".[20]

While the alliance of philosophy and the specialised sciences was in a certain measure restricted to the link with natural science, it often appeared as an alliance of social and natural sciences. In these conditions the overall methodological role of philosophy proved in considerable degree merely potential in the broad scientific aspect, since it was manifested mainly in respect of the natural sciences. At present, the integrative processes in present-day cognition as the purposefully and systematically organised and coordinated strengthening of the interconnection between the three fundamental departments of science, are creating favourable conditions for the full manifestation,

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in respect of science as a whole, of the integrative and methodological function of the theory of materialist dialectics.

This has had a considerable corrective influence on the opinion, widespread mainly in everyday consciousness but also in part among scientists with insufficient philosophical background, that philosophy is an exclusively social science. However, that opinion (just as the opinion that mathematics is a natural science) does not quite adequately reflect the actual situation. In reality, Marxist-Leninist philosophy is a science of the universal laws of the movement and the development of nature, human society, and thinking.[21] From this definition it is clear that philosophy bears upon science as a whole, and that its propositions refer to absolutely all objective areas, including nature.

While taking note of the universal scientific nature of Marxist-Leninist philosophy, we should not forget either that it operates as a form of social consciousness, in which the Party spirit and the scientific approach are blended. This feature of philosophy, the reflection in it of ideological class and social factors, also brings it closer to the social sciences and, at the same time, distinguishes it from the other branches of scientific knowledge, as well as from phenomena pertaining to general science, something we shall deal with below. Thus, in Marxist-Leninist philosophy as the unity of dialectical and historical materialism, there takes place a dialectical synthesis of the "universally scientific" and the "socially scientific", their joint participation in the present-day integrative processes of scientific activities. The universally scientific character of philosophical knowledge manifests itself, not only in the subject-matter and method of dialectical materialism but also in philosophy's fundamental functions and sub-functions in the areas of world-outlook, methodology, criticism, ideology, axiology, management and government, and the like.[22] However, the overall scientific

5435

nature of philosophical knowledge expresses itself most fully through its integrative-synthesising function, as a result of which philosophy operates as a "methodological centre in the interlinks between various scientific disciplines and their mutual influence."[23]

The universal scientific character of philosophy has its various forms and manifestations, wherein lies one of the criteria of philosophy's efficacy and of its utilisation in the particular sciences. The efficacy of philosophy should not be seen in a purely utilitarian light or be reduced merely to its methodological impact on the particular sciences, however fruitful that influence may be. "The criterion of the appraisal of the quality and efficacy of scientific work in the area of philosophy," S.Trapeznikov has emphasised, "is wholly linked with a correct understanding of its important place in the life of society, and in the moulding of social consciousness, which is continuously replenished with new ideas and values."[24] The efficacy of Marxist-Leninist philosophy is linked with the development of all its functions and connections both with present-day science and with all social processes.

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The tasks set by the Communist Party in the area of scientific research are directed towards the harmonious and proportional development of science as a whole, since therein lies a guarantee of the integral development of technology, industry, and the entire economy of the USSR, the enhancement of their effectiveness, the smooth and accelerated development of the productive forces, and other social processes.

Of course, the proportional development of science as a whole, far from precluding, presupposes the advancement to the forefront of those problems on which the successful development of the economy, culture, and science itself hinges in the greatest degree. The 25th Congress of the CPSU

5435

8-4

called upon Soviet scientists to focus their attention on these main problems in scientific, technological and social progress, and to provide for the further development of research aimed at opening up opportunities and roads, new in principle, for the transformation of the country's forces, and the creation of technology and industrial processes of the future, all of which call for a pan-scientific approach. These include problems, already mentioned by us, of the conquest of space, and environmental protection, as well as the task, set by the 25th Congress of the CPSU, of improving work in the area of scientific and patent information.[25] While the need for a pan-scientific substantiation in the solving of the ecological problem and in space research stems from social factors which, in principle, lie beyond the province of science and in the interaction between man and terrestrial and extra-terrestrial nature, the availability of scientific and technological information is mainly determined by requirements located within science. Improvements in the supply of information for science, and the introduction of scientific achievements in industry are aimed at eliminating those results of the "information crisis" in scientific activities which are a cause of losses, both in science and the economy.

A proper solution of the pan-scientific problems that have appeared at the juncture of social, natural and technical knowledge now calls for the mobilisation of efforts and the strengthening of links between practically all the fundamental groups and branches in present-day science. This has also led to the appearance of new integrative methods, trends, approaches and notions bearing upon science as a whole. The emergence of these new trends in science as a whole serves to enhance the theoretical potential and methodological arsenal of science, and to its acquiring greater integrity and effectiveness in the introduction of new scientific ideas into practice.

Since the onset of the scientific and technological revolution, new and fundamental phenomena have appeared in

scientific cognition, which have become recognised as referring to science as a whole: new notions, methods and problems.[26] To illustrate this new class (type) of notions, methods and problems, some examples might be cited. Many authors include in pan-scientific notions algorithms, probability, supplementariness, signs, meaning, isomorphism, information, models, systems, structure, management, formalisation, and the like. The following are considered methods (approaches) of a pan-scientific (but not philosophical) character: the logico-mathematical, the statistically probable, systemic and structural, cybernetic, theoretical and information, and simulated methods, as well as methods which have taken shape in semiotics, the science of science, information science, prognostication, and others.

Four areas of non-philosophical and pan-scientific concepts and disciplines are mentioned in the book by Blauberg and Yudin (pp.32-39), namely: 1) theories dealing with problems and content (of the cybernetic type); 2) universal conceptual systems (e.g., A.A.Bogdanov's tectology); 3) pan-scientific methodological concepts (e.g., the theory of information); 4) universal formalised concepts. Among pan-scientific problems one can only name such as that of the scientific and technological revolution, and its components; besides, mention might be made of problems as those of man, automation and cybernetisation, the origin and development of life and mind in our world and in the Universe, the harnessing of the World Ocean, the forecasting of science and an adequate supply of information to serve it, and the like.

The "pan-scientific" concept is used in various meanings, the most widespread of which is the one employed in any particular science. With reference to notions, it may be a category common to all or most of the particular sciences. However, this understanding permits a fragmentation of the meaning of "pan-scientific" to involve notions which reflect properties both of objects of cognition, and of the particular sciences that study such objects. What is implemented here is a unity of the ontological and the logico-epistemological aspects, of the foundations of that notion which can be called a universal pan-scientific notion. Another class of notions, methods and problems consists of such which refer only to the particular sciences themselves, and not to the objects cognised by such sciences. Such pan-scientific phenomena have only an epistemological, or logical status (e.g., the notion of prognosis, the methods of prognostication, and so on).

Some pan-scientific phenomena can be grounded only in scientific activities themselves and, in this respect, characterise the development of absolutely all sciences, and science as a whole (including philosophy) as, for instance, certain notions in the science of science, the information science, etc. Though their principles and notions are utilised not in all particular sciences, but only in several or else even in a single discipline, these can also be considered, in a definite sense, either as pan-scientific or else in the process of becoming so. All this shows that the "pan-scientific" concept has a variety of meanings, which should be identified and studied.

What is characteristic of pan-scientific trends and phenomena is that they first appeared within the framework of some particular branch of science and then acquired an interdisciplinary nature and are at present not only becoming comprehensive but refer to science as a whole or else reveal a trend to acquire that quality. Most of them have appeared within the particular sciences and in mathematics, but not in philosophy; in acquiring an application to all science, they embrace their traditional philosophical categories, while, at the same time, differing from them. In speaking of the distinction between pan-scientific and philosophical notions and methods, we shall be referring only to Marxist philosophy.

In the first place, the pan-scientific nature of the

categories and methods of the theory of materialist dialectics is something already established and operative (which does not preclude their further development), whereas in respect of "pan-scientific" forms and means of cognition they are only a trend and a possibility, so that one can always find a branch of knowledge in which they have not as yet functioned. (To avoid any misunderstanding we should emphasise one important circumstance: philosophy, which we consider a discipline bearing upon science as a whole, contains special parts and departments which do not bear upon science as a whole, for instance, the history of philosophy, historical materialism, and a number of departments which have branched off from philosophical knowledge (ethics, aesthetics, etc.). In the main, it is the theory of materialist dialectics which has a pan-scientific character. A similar remark might be made with reference to mathematics, which contains both specialised and pan-scientific components of knowledge .

Secondly, the pan-scientific nature of the latter notions and methods is limited in principle. This has been emphasised with sufficient clarity by E.Yudin, who has written that "unlike dialectics and philosophical methodology in general, the systems approach and similar methodological trends are, even with due account of their pan-scientific nature, applicable, not to all scientific cognition but only to definite types of scientific tasks within, so to speak, the jurisdiction of the corresponding approach".[27]

Thirdly, as pointed out by E.Yudin, pan-scientific approaches, especially the systems approach, while remaining a form of reflection within science, wholly depend, in their philosophical foundations, on philosophical methodology and its level.[28] In other words, pan-scientific phenomena develop on the basis of philosophical methodology, in which process they experience a far more fundamental influence of philosophy than does the philosophy that makes a study of these integrative and pan-scientific trends.

In the fourth place, philosophical categories and methods are not, as a rule, linked, in particular, with the corresponding mathematical and logico-symbolic means, whereas pan-scientific methods and notions are intimately linked with their logico-mathematical "accompaniment".

Fifthly, and most important, philosophy focusses its main attention on the problem of the relation between social being and thinking, between matter and consciousness, this being the fundamental philosophical problem, whereas universal and pan-scientific notions abstract themselves from that aspect of the relation between being and consciousness which characterises them in the unity of identity and distinction. In cases when this relationship is expressed by pan-scientific notions, what is brought out is only a definite aspect or some part which has neither universally philosophical nor ideological significance. Pan-scientific phenomena are abstracted in considerable measure from the nature of objects and of the consciousness that reflects them (namely as social consciousness) and from the relationship between being and consciousness both in the formal aspect and in that of content, therein lying another feature (alongside the potential character) of their pan-scientific nature.

With regard to the pan-scientific phenomena under examination here, philosophical knowledge operates as a system which, in the main, studies the general laws of the relation between the components of the "being-thinking" system,[29] their identity and distinction, their interlink and interrelation in the process of development. To philosophers, the pan-scientific and integrating relation between matter and consciousness, and the socio-ideological factors have proved necessary, but not the main ones, since knowledge that registers in its notions only what is common to all sciences is unable to ascertain the plentitude in the relation between being and thinking; it abstracts itself from the differences between them and studies only one aspect of their actual relationship.

With due note of the distinction between the categories and methods of philosophy and those of science as a whole, one should at the same time note the special role played by scientific and philosophical methodology in the shaping of phenomena pertaining to science as a whole, phenomena which, in considerable measure, acquire their overall character thanks to their inclusion in the field of philosophical research and appraisal as a result of their close interaction with the philosophical categories and methods which reveal, in the notions and methods of particular sciences, the "pan-scientific" content immanent in them and fostering their movement from one area of scientific knowledge to another.

While distinguishing between the philosophical and the pan-scientific levels of methodology, we nevertheless emphasise their interlinks and their pan-scientific foundation. Identifying philosophical and pan-scientific methodology, and making an apology for pan-scientific approaches cannot be tenable, because they actually link up with the neo-positivist trend to substitute particular scientific or pan-scientific methods for the philosophical method (side by side with the logico-symbolic means, the role of such particular scientific or pan-scientific methods has of late been assumed by the systems approach and by methods connected with the theory of information and with cybernetics). The sharp contraposition of philosophical to non-philosophical, pan-scientific methodology, this as a reaction to their identification, is also unjustifiable, since it leads to the isolation, the divorcement of pan-scientific approaches from the theory of dialectics, to an absolutisation of the methodology of philosophy in the overall "arsenal" of science's methodological means.

The pan-scientific nature of the new integrative forms and means of cognition also consists—apart from what has already been said—in their performing a number of general logico-epistemological functions in science: methodological, meta-theoretical, formalisation and mathematical modelling, the synthesis of knowledge, its systematisation, the transfer, communication and translation from one specialised scientific language to another, etc.

We have enumerated a number of distinctive features in philosophical and pan-scientific categories, yet their mutual transition from philosophical categories to pan-scientific notions and vice versa cannot be precluded. That is why the task arises of more detailed research into the relation between philosophical and pan-scientific knowledge, a task linked with the ascertainment of the nature and the development of the pan-scientific forms and means of cognition under discussion here.

The previously advanced criteria of philosophical knowledge, which were grounded in the principle of universality and the like, have proved inoperable in respect of pan-scientific notions. It would seem that what is necessary here is further search for the specifics of scientific knowledge. And, as we see it, this search should be directed towards ascertaining the role and the significance to philosophy of its fundamental problem—that of the relation between being and thinking. (This matter has been dealt with by T.Pavlov in the above-mentioned "The Philosophy of Dialectical Materialism and the Particular Sciences", in respect of knowledge in the particular sciences. The conclusions drawn by him also bear upon the pan-scientific phenomena under study here). It would seem that only those notions expressing the most general characteristics of the relation between being and thinking can rise to the higher level of philosophical abstraction, while others which, even if they do have the status of universality and universal content, will remain pan-scientific.

Pan-scientific problems, notions and methods are new integrative phenomena characteristic of present-day scientific cognition. At the same time they comprise a new discovery in that area of philosophy which gives effect to a generalised reflection on science, a discovery which no doubt stands in need of further profound and comprehensive study.

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The pan-scientific and integrative processes in present-day science dealt with in this article, processes in which an actively creative and fundamental role belongs to Marxist-Leninist philosophy, comprise a characteristic feature of the science of society whose aspirations and efforts are directed towards creating a communist future.

The implementation of integrative pan-scientific trends hinges on the conditions of scientific activities and, in the first place on socio-economic as well as political, legal and other factors. The synthesis of the sciences of nature and those of man and society, as well as their unity, of which Marx wrote,[30] fully manifests itself only under socialism and communism, since, as pointed out in the Report of the CPSU Central Committee to the Party's 25th Congress, "... the scientific and technological revolution acquires a true orientation consistent with the interests of man and society only under socialism. In turn, the ultimate objectives of the social revolution, the building of a communist society, can only be attained on the basis of accelerated scientific and technological progress."[31]

NOTES

1 L.I.Brezhnev, Report of the CPSU Central Committee and the Immediate Tasks of the Party in Home and Foreign Policy. 25th Congress of the CPSU, Moscow, 1976, p.128.

2 B.M.Kedrov, "Marx and the Unity of Natural Science and the Humanities", Voprosy filosofii, 1968, No.5, p.6.

3 P.N.Fedoseyev, "The 25th Congress of the CPSU and the Tasks of the Social Sciences", Voprosy filosofii, 1976, No.5, p.13.

4 Guidelines for the Development of the National Economy of of the USSR for 1976-1980, Moscow, 1976, p.77.

5 E.M.Mirsky, "Inter-Disciplinary Research as an Object of Scientific Study", Systems Research. A Yearbook for 1972, Moscow, 1972 (in Russian). For a detailed discussion of the synthesis of knowledge between the two different groups of sciences, see the article by B.M.Kedrov on the synthesis of sciences, Voprosy filosofii, No.3, 1973.

6 I.T.Frolov, Present-Day Science and Humanism, Moscow, 1974; Progress in Science and the Future of Mankind, Moscow, 1975 (both in Russian).

7 V.G.Afanasyev, Social Information and Administration of Society, Moscow, 1975, pp.104-110 (in Russian).

8 B.M.Kedrov, "On the Synthesis of Sciences", Voprosy filosofii, 1973, No.3; B.M.Kedrov, "The Dialectical Road of Theoretical Synthesis in Present-Day Natural Science", in the collection: The Synthesis of Present-Day Scientific Knowledge, Moscow, 1973 (in Russian); B.S.Ukraintsev, "The Link Between the Natural and the Social Sciences in Technical Knowledge" (Ibid.).

9 For philosophical and methodological research into these processes, see the book Methodological and Social Problems in Technology and the Technical Sciences. The Specifics of the Technical Sciences, Moscow, 1974, Issue 2; The Interconnection Between the Natural and the Technical Sciences, Moscow, 1976, Issue 3 (both in Russian).

10 Pravda, February 27, 1976.

11 Ibidem.

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13 M.F.Vedenov and Yu.V.Sachkov, The Problem of Styles of Thinking in Natural Science, Moscow, 1971; I.B.Novik, Questions of the Style of Thinking in Natural Science, Moscow, 1975 (both in Russian).

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20 Voprosy filosofii, 1974, No.1, p.51. See also "Dialectics and Present-Day Scientific Cognition", Voprosy filosofii, 1973, No.3, pp.75, 76, and elsewhere.

21 F.Engels, Anti-Dühring, Moscow, 1969, p.169.

22 On these functions see the above-mentioned article by V.Dobriyanov and its discussion in Voprosy filosofii, 1976, No.3, pp.124-145.

23 P.N.Fedoseyev, "The Philosophical Interpretation of the Scientific and Technological Revolution", Voprosy filosofii, 1976, No.10, p.5.

24 S.P.Trapeznikov, "The Marxist-Leninist Philosophy of Science and Our Times", Voprosy filosofii, 1973, No.8, p.20.

25 Guidelines for the Development of the National Economy of the USSR for 1976-1980, p.77.

26 Studies in this area are already under way. See I.V.Blauberg and E.G.Yudin, The Development and Essence of the Systems Approach, Moscow, 1973; V.A.Lektorsky and V.S.Shvyrev, "Methodological Analysis in Sciences (Types and Levels)", Philosophy, Methodology, Science, Moscow, 1972; V.S.Gott and A.D.Ursul, Pan-Scientific Notions and Their Role in Cognition, Moscow, 1975 (all in Russian).

27 I.V.Blauberg and E.G.Yudin, The Development and Essence of a Systems Approach, p.98.

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5435

9-I

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PHILOSOPHICAL PROBLEMS OF NATURAL SCIENCE IN THE WORKS OF ENGELS

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Problems of dialectics of nature and the dialectics of cognition had always attracted Frederick Engels' attention. They were dealt with by him not only in Dialectics of Nature but also in The Condition of England. The 18th Century, Anti-Dühring, Ludwig Feuerbach and the End of Classical German Philosophy, in letters,and other works.

Engels began working on Dialectics of Nature in 1873 and continued it (with an interval of two years) until Marx's death in 1883. Some material was added to the manuscript in 1885-1886. Initially, Engels intended to write a critique of the vulgar-materialistic views of L.Büchner and others. Later he decided on a more comprehensive analysis and a philosophical generalisation of the achievements of natural science and a systematic critique of metaphisical and idealistic interpretations of these achievements. He wrote of this idea in a letter to Karl Marx on May 30, 1873. The need for a study of this kind, in which the dialectics of nature and the dialectics of cognition would be considered from the standpoint of new materialism, was warmly approved by Marx, and also by K.Schorlemmer, a noted chemist who was the first Marxist naturalist. The objective conditions and needs of the class struggle, namely, the moulding of a working-class outlook, made Engels interested in natural science.

Due to various circumstances, Engels was unable to complete his plan, but Dialectics of Nature is a systematic dialectico-materialist examination of the fundamental results and methodological lessons of natural science taught in Engels' day. He showed the dialectical character of the laws of nature, enunciated a number of underlying ideas on key propositions of philosophy, and enriched the content of the categorial foundations of dialectical materialism.

1. Change of the Subject-Matter of Philosophy and Dialectics of Nature

Karl Marx and Frederick Engels did not regard philosophy as a consummated system of knowledge, as a "science of sciences" that, as the highest authority, dictated truths to other, "less fundamental sciences". In Anti-Dühring, under the heading "Dialectics. Negation of the Negation", Engels noted the new significance of the philosophy he was developing, writing: "This modern materialism, the negation of the negation, is not the mere re-establishment of the old, but adds to the permanent foundations of this old materialism the whole thought-content of two thousand years of development of philosophy and natural science, as well as of the history of these two thousand years." "It is in fact," he added, "no longer a philosophy, but a simple world outlook which has to establish its validity and be applied not in a science of sciences standing apart, but within the positive sciences."[1] Engels' proposition is basic for understanding the new significance of philosophy in the Marxist world outlook, and for a scientific solution of the problem of the relationship between philosophy and natural science. First, Engels points out that the materialism propounded by him is a "new materialism" that cannot be regarded as the re-establisment of the old materialism. Further, he notes the unity between the old and the new materialism precisely in their points of departure, i.e., the permanent foundation of materialism that must be deepened, developed, and enriched with the ideological content of the history of

science, the history of philosophy, and history itself. As a result, philosophy is sublated; that is "both overcome and preserved; overcome as regards its form and preserved as regards its real content".[2] Thus, in Engels' view, philosophy does not have a special reality distinct from the reality studied by the natural and social sciences. He stresses that philosophy is sublated dialectically, and not metaphysically, for that form is removed which is acquired in the minds of philosophers of the reviewed period, particularly Hegel. The real significance of philosophy is preserved, but it must show itself through real sciences, and not as a special science about sciences.

As a science about sciences, as an absolute system resting on pure thought, philosophy has thus been overcome. But it is preserved in its real content. The need arises of defining the subject-matter of philosophy as a science about the most general laws of the development of nature, society and thought. Speculativeness and shallow empiricism are the two extremes that are not implicit in real philosophy. One thus cannot generally discuss the world without studying the data of the sciences striving to understand the world.

A close analysis of all of Engels' pronouncements about the subject-matter of the new materialism and the conceptual understanding of the method of study used in Dialectics of Nature, show that the subject-matter of dialectical materialism was never interpreted by him as solely a science about thought. He wrote that dialectical materialism is a science of the general laws "of motion and development of nature, human society and thought".[3]

The genuine nature of the new philosophy, as any other science, is proved by the entire sum of results achieved by the natural and social sciences, by natural scientific and socio-historical practice. The actual significance of philosophical propositions is substantiated in the philosophy of Marxism not independently and not in isolation of the achievements of science and actual practice but, on the contrary, in close, organic relationship with practice and with all sciences. In *Theses on Feuerbach* Marx proclaimed that practical activity is drawn naturally into its own sphere by Marxist epistemology.

Engels made it clear that dialectical materialism differed not only from such schools of former philosophy as narrow empiricism and speculative rationalism, but also from metaphysical materialism. As early as the 1840s, in *The Holy Family*, Marx and Engels had drawn attention to the fundamental shortcomings of the old materialism, which did not understand the real role of socio-historical practice in the process of cognition, and the active nature of the social subject. Criticising the materialism of the English philosopher Thomas Hobbes, they wrote: "*Physical* motion was sacrificed to the *mechanical* or *mathematical*, *geometry* was proclaimed the principal science. Materialism became *hostile* to *humanity*. In order to overcome the *anti-human incorporeal* spirit in its own field, materialism itself was obliged to mortify its flesh and become an *ascetic*. It appeared as a *being of reason*, but it also developed the implacable logic of reason."[4] By its methodological orientation and basic content this passage harmonises with Marx's first well-known thesis about Feuerbach. The absolute counterpositioning of the objective and the subjective is precisely what made the "object of reality, of sensitiveness" regarded "solely in the form of an object", of "contemplation" and not as human sensual activity, not subjectively.

2. *Problem of the Relationship Between Philosophy and the Natural Sciences*

The advances in the natural sciences made it imperative to ascertain the general features and trends of philosophical generalisation, to surmount alienation between the natural sciences themselves, and between them and philosophy. In *The Economic and Philosophical Manuscripts of 1844*, Marx wrote that "the *natural sciences* have unfolded colos-

sal activity and accumulated steadily growing material. But philosophy has remained as alien to them, as they have remained alien to philosophy."[5]

Hegel's analysis of the development of natural scientific knowledge in his *Philosophy of Nature* fell short of the methodological requirements of science, first, because of his mistaken primary philosophical principle and, second, because Hegel did not have an intimate knowledge of fundamental scientific discoveries. Further, it must be borne in mind that *Philosophy of Nature* was Hegel's most metaphysical work, and that the shortcomings and limitations of his philosophy were seen most glaringly in it. Hegel's Naturphilosophie, Engels wrote, "erred because it did not concede to nature any development in time, any 'succession', but only 'coexistence'. In this Hegel fell far behind Kant, whose nebular theory had already indicated the origins of the solar system, and whose discovery of the retardation of the earth's rotation by the tides also had proclaimed the doom of that system."[6]

Lastly, the integrity of dialectical materialism's philosophical system itself required an analysis of the dialectics of nature. The task that faced Engels in this connection was formulated by him as follows: "... to convince myself also in detail—of what in general I was not in doubt—that in nature, amid the welter of innumerable changes, the same dialectical laws of motion force their way through as those which in history govern the apparent fortuitousness of events".[7]

There was thus a pressing theoretical and practical need for a consecutive and systematic philosophical analysis of natural scientific data. In tackling this task, Engels considered, from the standpoint of Marxist philosophy, important problems such as the relationship between philosophy and the natural sciences, the relationship between dialectics and the natural sciences, the classification of the forms of motion of matter, the dialectics of necessity

9-4

and fortuity, and so on. While philosophically summing up the achievements of mathematics and the natural sciences, he showed that there had to be organic unity between philosophy and the natural sciences, systematically criticising the one-sidedness both of narrow, shallow empiricism and of speculative rationalism and dogmatism. He directed much of his criticism at philosophical empiricism, which in his day came forward as positivism. His criticism of the limitations of metaphysical materialism, of positivist absolutisation of sense data, of the misconceived speculative construction of a special reality, rested on his dialectical materialistic interpretation of data of science and the history of philosophy.

The need for understanding the achievements of empirical natural science dialectically is dictated, first, by the development of science, which requires the systematisation of available material "in accordance with its inner bonds", and, second, the problem of the organic link between different areas of knowledge becomes unavoidable. The data of the natural and social sciences can be generalised dialectically only if account is taken of the law of developed theoretical thought resting on knowledge of all preceding philosophy. These two factors were particularly important in the period we are considering. That period saw the emergence of new scientific disciplines, and the transition of existing sciences from description, systematisation and classification to explanation. Engels proved that the metaphysical method with its immobile, fossilised categories was narrow, and showed that dialectics was vital. He demonstrated the force of the dialectical method, proving that an "exact representation of the universe, of its evolution, of the development of mankind, and of the reflection of this evolution in the minds of men, can therefore only be obtained by the methods of dialectics".[8]

He showed convincingly that no scientific work can be successful without knowledge of the laws of philosophy, for

without thought there can be no cognition, no rational understanding of reality. Naturalists, he wrote, had to know the history of science, the history of philosophy, stressing that the natural philosophy attacked by some metaphysically-thinking philosophers and naturalists indeed "contains a great deal of nonsense and fantasy, but not more than the unphilosophical theories of the empirical natural scientists contemporary with that philosophy."[9]

In criticising shallow empiricism for its underestimation of the part played by theoretical thought in cognition, Engels showed that a fact is relatively "indisputable", that it is dependent on the interpretation model within which the given fact is understood. In this work he notes for the first time that there can be no "decisive experiment", for any single fact is a unity of the subjective and the objective, and only socio-historical practice can in its movement as a process serve as an indisputable argument in favour of the authenticity of a hypothesis or theory.

In his criticism of the extremes of dogmatic rationalism and a priorism, and of empiricism, Engels took the dialectics of the subjective and objective into account. The attention that he gave to criticising empiricism was due to the fact that most of the naturalists of that period were either indifferent to philosophical analyses of the foundations of their science or were proponents of the empirical tradition in philosophy.

All this is evident of how revisionist philosophers were wrong when they interpreted Engels' philosophy in the spirit of the orthodox Machist, phenomenological theory of knowledge. One of them, F.Adler endeavoured to prove that as used by Marx and Engels the terms "materialism" and "dialectics" were synonymous with the terms "experiment" and "development" used in contemporary natural science.[10]

Engels not only showed that it was wrong to absolutise directly sense data but criticised the speculative deduction of the universe from reason with the aid of categories of pure thought. Thus, in his analysis of the objective foundation of dialectical laws he criticised Hegel, who did not deduce dialectical laws from nature and history, but imposed them from above as laws of thought. "This," he wrote, "is the source of the whole forced and often outrageous treatment; the universe, willy-nilly, has to conform to a system of thought which itself is only the product of a definite stage of evolution of human thought."[11]

In deciding the question of the relationship between the new, dialectical form of materialism and the natural sciences, Engels proceeded from the contention that the science of nature was a social phenomenon. Because of the social character of the process of cognition, of the historicity of reflection, it is impossible entirely to rule out elements of theoretical generalisation from cognition. Hence the need for conscious guidance by a definite philosophical premise, and, provided this philosophy is genuine, the possibility is created for avoiding innumerable methodological and philosophical errors springing from ignorance of the history of science and the history of philosophy, or from ignorance of genuinely scientific methodological principles. The lessons of the history of knowledge cannot be ignored "with impunity", and "empirical contempt for dialectics is punished by some of the most sober empiricists being led into the most barren of all superstitions, into modern spiritualism".[12]

The process of cognition is thus intrinsically linked with philosophical thought and cannot dispense with it. Proving this, Engels drew the conclusion that whatever attitude naturalists adopt "they are still under the domination of philosophy. It is only a question whether they want to be dominated by a bad, fashionable philosophy or by a form of theoretical thought which rests on acquaintance with the history of thought and its achievements.

"'Physics, beware of metaphysics", is quite right, but in a different sense."[13]

The term "dominate" means that natural scientists have consciously or unconsciously always been guided by definite methodological and philosophical principles. Therefore, as a methodological programme the assertion "Physics, beware of metaphysics" is basically wrong when metaphysics is taken to mean philosophy in general. Engels says that it "is quite right, but in a different sense", namely when metaphysics is taken to mean a method of thought, a method of study opposed to dialectics. In other words, the assertion "Physics, beware of metaphysics" has the implication that while it was not dialectico-materialistic one, organically linked with the requirements of scientific cognition, and while it rested on metaphysics and mechanicism in constructing its speculative patterns, the former philosophy, too, endeavoured to impose these patterns on physics and thereby hindered its development. It was therefore only the conscious transition of naturalists to materialistic dialectics that could remove "fabricated, artificial interconnections by the discovery of the real ones",[14] and help avoid not only philosophical but also natural scientific errors.

3. Dialectics of Natural Scientific Cognition

The keynote of Engels' Dialectics of Nature is that dialectico-materialistic thought is vital for the development of the natural sciences. He combined the positive solution of this problem with a consistent, systematic criticism of the predominant metaphysical method of thought. The metaphysical method of studying objective reality, characterised by its fragmentation into individual unconnected parts, processes and objects, and their systematisation and classification, took shape with the emergence and development of special natural sciences. This method was justified and necessary at a definite stage of the development of scientific study. But, as Engels noted, "this method has also left us as legacy the habit of observing natural objects and processes in isolation, apart from their connection with the vast whole; of observing them in repose, not in motion; as constants, not as essentially variables; in their death, not in their life".[15]

At the close of the 18th and early 19th centuries the development of empirical natural science had produced considerable factual material that bespoke of links and interactions, and showed the obvious incompatibility between existing philosophical concepts of the natural sciences and their objective need for a general method that could focus the attention of researchers on looking for the links of phenomena, for modifications, movement and development in the dialectico-materialistic approach to the objects of study, for recognition of nature's existence independently of the subject of study. The development of natural science, as of knowledge of society, insistently required the development of dialectico-materialistic philosophy and the sweeping away of metaphysical notions that were predominant chiefly among naturalists.

The history of science shows that the transition of naturalists from metaphysical notions about nature to dialectical ones was a long and difficult process. Due to the metaphysical narrowness of their mechanistic approach the naturalists found themselves in theoretico-cognitive impasses. At the close of the 19th century, the naturalists who sought to dispense with a theoretical, philosophical understanding of the empirical results in their field proved to be captive to various irrational, religious notions, for example, spiritualism and mysticism. This was noted by Engels in Natural Science in the Spirit World, written in 1878. In his analysis of the "experimental foundations" of spiritism, he indicated "the most certain path from natural science to mysticism". This was "the shallowest empiricism that spurns all theory and distrusts all thought."[16]

In the chapter headed "Electricity", Engels wrote in Dialectics of Nature that for empirically-minded naturalists "even the experimentally established facts have gradually become inseparable from their traditional interpretations".[17] Scorn for theoretical thought thus does not deliver the researcher from theoretical generalisations. It only leads him along the path of the old, traditional method of thought, compelling him to tailor new facts to old patterns. On the example of his analysis of Wiedemann's Teaching of Galvanism, Engels proves that "the simplest electric phenomenon is presented falsely", for "this empiricism cannot any longer describe the facts correctly, because traditional interpretation is woven into the description".[18]

Here Engels demonstrated that the latest results of natural scientific study, the discovery of facts hitherto unknown to science, and the theoretical conclusions drawn from these facts were mercilessly battering down the old traditions, with the result that the champions of traditional patterns of thought were finding themselves in difficulties.

In Dialectics of Nature Engels gave considerable attention to how to teach the dialectical method of thought to naturalists. For this, he wrote, naturalists must be acquainted with the history of the development of human thought, for in "every epoch, and therefore also in ours, theoretical thought is a historical product, which at different times assumes very different forms and, therewith, very different contents. The science of thought is therefore, like every other, a historical science, the science of the historical development of human thought."[19]

Acquaintanceship with the history of the development of scientific knowledge is a convincing argument in favour of dialectics, for, first, it shows that "the theory of the laws of thought is by no means an 'eternal truth' established once and for all" and, second, it furnishes "a criterion of the theories propounded by this science itself".[20]

Ignorance of how philosophical problems were set and resolved, and of the results achieved by philosophical science in its development led many naturalists to methodological errors in assessing theories. Thus, "propositions which were advanced in philosophy centuries ago," Engels wrote, "...are frequently put forward by theorising natural scientists as brand-new wisdom and even become fashionable for a while."[21]

Study of the pattern of the process of cognition makes it possible to ascertain its empirical and theoretical levels. Engels dialectically reformulated the old epistemological dilemma over the priority of the sensual over the rational or, on the contrary, of the rational over the sensual. In effect, he proved that this was a wrong, undialectical way of putting the question, and that empiricism and rationalism erred in their arguments to show the authenticity of knowledge. The methodology of scientific knowledge was confronted with the important problems of, first, the origin of the primary principles of theory and, second, the appearance of new knowledge and, in this connection, the role of induction in the process of cognition.

In analysing the dialectics of the empirical and the theoretical, the correlation of the facts underlying a theory and the principles of this theory, Engels wrote in part: "The empiricism of observation alone can never adequately prove necessity."[22] The fact that a theory's principles cannot be deduced in principle solely from empirical data alone became increasingly obvious in the 20th century and had been stressed by Engels in the latter half of the 19th century. Moreover, he was opposed to isolating theoretical premises from practice, from experimentation, criticising natural philosophical and a priori patterns of the universe. This is most clearly seen in his attitude to Kantian idealistic a priorism. "The principles," he wrote in this connection, "are not the starting-point of the investigation, but its final result; they are not applied to natural and human history, but abstracted from them; it is not nature

and the realm of humanity which conform to these principles, but the principles are only valid in so far as they are in conformity with nature and history. That is the only materialistic conception of the matter."[23]

He underscored the a posteriori character of the principles of knowledge, their origin from experimentation. But the principles that take shape and are tested in practice become important methodological instruments of cognition. Such principles come forward as a leading and guiding idea. Engels anticipated many ideas of the hypothetical-deductive method of cognition, their modern construction. In each new theoretico-cognitive situation, principles may be transformed, complemented with new principles and generally prove to be inapplicable in the new sphere. Socio-historical, scientific-experimental practice thus remains the decisive criterion of the authenticity of the primary principles of cognition. However, the principles that are repeatedly confirmed in practice and allow obtaining new results often acquire the nature of a bias. While facilitating the study of new aspects of reality, such principles in many cases themselves become the object of scientific analysis. As time passes they become the points of departure of knowledge, a priori and set up against reality itself. Attention was drawn to this by Engels when he analysed the specifics of mathematical knowledge, in particular, its laws. In mathematics, he wrote, "as in every department of thought, at a certain stage of development the laws, which were abstracted from the real world, become divorced from the real world, and are set up against it as something independent, as laws coming from outside, to which the world has to conform".[24]

With the development of knowledge the character of mathematics has become so abstract that today it is hard to indicate the objective prototype of modern abstract mathematical notions. This results in an increased apparent independence of mathematical knowledge from the real world, from its links and relationships. Engels' conclusion that "pure mathematics was subsequently applied to the world, although it is borrowed from this same world and represents only one part of its forms of interconnection—and it is only because of this that it can be applied at all"[25] has been borne out by the practice of scientific knowledge, by the development of technology and social production, and is evidence that the dependence, the connection of mathematical structures, propositions and relationships, reflects by specific means what exists in the real world. Engels emphasised the "terrestrial" character of mathematical truths, in particular, of mathematical axioms, and moved to the solution of the problem genetically. If, he wrote, "among us the mathematical axioms seem self-evident to every eight-year-old child, and in no need of proof from experience, this is solely the result of 'accumulated inheritance'".[26] Subsequently, Lenin was to write in his Philosophical Notebooks: "... the practical activity of man had to lead his cosciousness to the repetition of the various logical figures thousands of millions of times in order that these figures could obtain the significance of axioms. This nota bene."[27]

The role of induction, deduction, analysis, synthesis and other methods of scientific cognition was prominent among the problems of scientific study that attracted Engels' attention. He justifiably condemned the absolutisation of individual methods of approach in the practice of investigation and proved that the most diverse methods had to be used in studying phenomena of nature, society and thought: "... progression from the individual to the particular and from the particular to the universal takes place not in one but in many modalities."[28] His underlying idea is that there must be a dialectico-logical approach to the methodology of scientific study. In characterising the attitude of scientists who metaphysically applied formal-logical methods of cognition, Engels wrote: "These people have got into such a deadlock over the opposition between induction and deduction that they reduce all logical forms

of conclusion to these two, and in so doing do not notice that they (1) unconsciously employ quite different forms of conclusion under those names, (2) deprive themselves of the whole wealth of forms of conclusion in so far as it cannot be forced under these two, and (3) thereby convert both forms, induction and deduction, into sheer nonsense."[29]

He was particularly sharp in his criticism of the attitude of scientists who absolutely divorced induction and deduction, hypertrophied induction, and preached "universal induction". This heavy criticism of "universal induction" was due to the role that was accorded to the induction method in that period. Resting on the primary principles of dialectico-materialistic methodology, Engels sweepingly criticised the inductive interpretation of obtaining and advancing scientific knowledge generally and of British "universal inductivism" in particular. He drew upon the history of the natural sciences to show that the absolute truth of the scientific results obtained by induction were illusory. He wrote: "According to the inductionists, induction is an infallible method. It is so little so that its apparently surest results are every day overthrown by new discoveries."[30] A comprehensive analysis of historico-scientific material brings out the narrowness of the induction method of cognition, which in those years was seen by many scientists as the only sure method of cognition. Engels was not against the method of induction generally, but proved the methodological hollowness of the attempts to depict that method as the only or best method of cognition. As all other theoretico-cognitive procedures, induction has its own, narrow sphere of application; in particular, the application solely of that method cannot explain aspects of cognition such as the emergence of new theories and of new knowledge generally. "With all the induction in the world," Engels wrote, "we would never have got to the point of becoming clear about the process of induction. Only the analysis of this process could accomplish this."[31]

5435

IO-I

Criticism of the absolutisation of the possibilities of one method of cognition or another bore a programmatic nature and pursued the general aim of proving the need for, and heuristic character of, materialistic dialectics, which is incompatible with the absolutisation of any single method of cognition and, generally, with preset patterns of thought, as well as with negations of the productive role of thought implicit in positivism at its early stage of development.

In his analysis of the process of cognition, Engels drew attention to the dialectically contradictory character of the creation of theories, stressing the transient nature of existing theoretical systems, which some naturalists regarded as complete and absolute, bringing to light the enormous heuristic role of hypotheses in cognition, and so on, noting that the "form of development of natural science, in so far as it thinks, is the hypothesis".[32] In the most developed natural scientific disciplines—astronomy, mechanics, physics, and chemistry—"we are swamped by hypotheses as if attacked by a swarm of bees. And it must of necessity be so".[33]

The existence of an element of hypotheticity in the structure of knowledge is thus an attribute of the development of science. The scientific value of the position upheld by Engels in the question of the role of hypotheses in cognition lies in its methodology, which correctly oriented naturalists studying the unknown. This was a timely philosophical proposition, for in those years there was a fairly widespread positivist attitude to the hypothesis, which at that stage of its development endeavoured to eliminate elements of the hypothetical from the structure of knowledge.

The creation of a systematised scientific theory was linked not only with the existence of elements of hypotheticity, which were subject to experimental verification, but also with the use of many other methods in addition to

induction, deduction, analysis, and synthesis. In particular, in combating the widespread narrow empirical interpretation of the process of obtaining new knowledge and evolving theories, Engels analysed categories such as reason and intelligence, the abstract and the concrete, the whole and the part, and so forth. Of the greatest interest to us is his profound logico-methodological analysis of the place and function of an idealised object in knowledge on the example of Sadi Carnot's ideal steam-engine. Writing of the role of methodological procedures such as induction and synthesis in knowledge, he noted that Sadi Carnot "studied the steam-engine, analysed it, and found that in it the process which mattered does not appear in pure form but is concealed by all sorts of subsidiary processes. He did away with these subsidiary circumstances that have no bearing on the essential process, and constructed an ideal steam-engine (or gas engine), which it is true is as little capable of being realised as, for instance, a geometrical line or surface."[34] But this cognitive procedure "in its way performs the same service as these mathematical abstractions: it presents the process in a pure, independent, and unadulterated form".[35]

The heuristic character of the process of idealisation is thus based on a theoretically constructed mental object, which is widely applied in modern research. The most developed branches of scientific knowledge (physics, mathematics, chemistry, biology, and so on) have always used the method of idealisation, albeit to a varying extent. "Mathematical space," "absolutely black body", "uncompressible liquid", and so on are natural elements of modern scientific knowledge. Generally speaking, idealisation is a vital attribute of the process of cognition, for, as Engels showed, the creation of an uncontradictory scientific theory is organically linked with generalisation, with the abstraction of various properties of the studied object, which are unessential for the given problem. Thus, in order to operate successfully with the phenomena studied in science, these phenomena need deputies formed by idealisation. Engels held that although idealisation was a purely thought process and its application depended entirely on the subject that studies reality, it had an objective foundation.

The growing role of the abstract-theoretical element in modern science, which is internally linked with a high level of generalisation—idealisation, mathematisation, cybernetisation, and so forth—shows Engels' keen scientific insight. He appreciated the great methodological and heuristic significance of idealisation as an important method of scientifically studying reality.

He closely linked the study of the methods of scientific cognition, such as analysis and synthesis, induction and deduction, idealisation, and so on, with the elaboration of the basic laws and categories of materialistic dialectics. His study of the actual process of cognition in the natural and social sciences led him to the conclusion that the laws of dialectics formulated by Hegel had to be reconsidered from the materialistic point of view, and that the categorial foundation of Marxist philosophy had to be further developed. In particular, he gave much of his attention to the elaboration of key categories of philosophy such as matter, motion, space, time, necessity, fortuity, cause and effect, interaction, and so on.

4. Elaboration of Laws and Categories of Materialistic Dialectics by Engels

In studying the objective foundation of dialectical laws, Engels wrote: "It is, therefore, from the history of nature and human society that the laws of dialectics are abstracted. For they are nothing but the most general laws of these two aspects of historical development, as well as of thought itself."[36] He held that as the actual laws of the development of nature, dialectical laws are valid not only for history but also for theoretical natural science.

He analysed objective dialectical laws of nature, the transformation of quantity into quality and vice versa,

5435

and the reciprocal penetration of opposites, the negation of the negation, noting their universality for theoretical natural science as laws of so-called subjective dialectics. The subjective dialectics of thought mirrors the objective dialectics of the material world. In showing the content of the law of transformation of quantitative changes into qualitative and vice versa on the example of the division of any material object, he noted "that the purely quantitative operation of division has a limit at which it becomes transformed into a qualitative difference: the mass consists solely of molecules, but it is something essentially different from the molecule, just as the latter is different from the atom".[37] A great materialist and dialectician, Engels was able, on the basis of the level reached by scientific knowledge in his day, to propound an idea that was far in advance of the development of science. Thus, by stressing that the mass differed from the molecules of which it consisted, he drew the attention of researchers to studying the substance of the mass, and warned them against any mechanistic notion that properties of the whole were determined by the properties of its component parts. He correctly noted the complexity of understanding the substance of the mass, which is still far from being understood in modern physics as well.

The dialectical approach enabled Engels to show the significance of physical constants in cognition, their methodological function: "... the so-called physical constants are for the most part nothing but designations of the nodal points at which quantitative addition or substraction of motion produces qualitative change in the state of the body concerned, at which, therefore, quantity is transformed into quality."[38] He drew the conclusion that as nodals constants in science express the unity of definite quantitative and qualitative changes, violations of which signify the removal of the old level and the transition to a new level of reality, and the need for a transition to a new theoretical system.

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Engels' systematic analysis of the mechanism of the transformation of quantitative changes into qualitative and vice versa rests on the recognition of the struggle of opposites as the mainspring of the development of all phenomena. His point of departure was that any scientific investigation showed "that the two poles of an antithesis, positive and negative, e.g., are as inseparable as they are opposed, and that despite all their opposition, they mutually interpenetrate".[39] Using concrete natural scientific data he demonstrated the universality of the dialectical contradiction and showed the essence of the unity and struggle of opposites, pointing out the relativity of the demarcation between opposites, and, lastly, drew attention to the diversity of forms of contradiction. In this situation the fundamental theoretical task is not only to record opposites, for this is the first, initial phase of investigation, but also to find the interrelation, interaction, mutual transformation, and interpenetration of opposites.

The methodological idea underlying all of Engels' arguments is that, first, the unity and struggle of opposites are the fundamental principle of being and cognition and, second, that cognition should not, as in the case of metaphysically-thinking investigators, stop at a rigid, absolute counterposing of opposites, for "identity and difference—necessity and chance—cause and effect—the two main opposites which, treated separately, become transformed into one another".[40]

In his works on the dialectics of nature, Engels analyses the categories "matter" and "forms of its existence". In his view, the concept "matter" expresses what is common to all objects of the external world, namely, the fact that they exist independently of the subject perceiving them. "We leave out of account," he wrote, "the qualitative differences of things in lumping them together as corporeally existing things under the concept 'matter'."[41] Since the period we are considering was thus characterised by the

elaboration of "a peculiar general outlook, the central point of which is the view of the absolute immutability of nature",[42] he concentrated on proving that being and cognition were dialectical, and this led him to a comprehensive analysis of the category of "motion", and also of "space" and "time". In his critique of Dühring's natural philosophical assertions, he wrote: "... the basic forms of all being are space and time, and being out of time is just as gross an absurdity as being out of space."[43] This philosophical proposition derives its methodological value not only from its content but also from the fact that it was propounded when classical, Newtonian notions of space and time were predominant, and were regarded outside their link with and dependence on each other and matter itself.

In proving the attributive character of space and time, Engels later noted in Dialectics of Nature that space and time "are naturally nothing without matter, empty concepts, abstractions which exist only in our minds".[44] The link of space, time, and moving matter, brought to light by relativistic mechanics, bore out the propositions put forward by Engels.

5. Engels' Classification of Forms of Motion of Matter

In Dialectics of Nature Engels gave considerable attention to classifying forms of motion of matter. The ideas stated by him on this problem are fundamental, and they predetermined the orientation of subsequent Marxist methodological investigation.

In his analysis of this problem he underscored, first, the interrelation of different forms of motion of matter, second, the fact that the higher forms of motion of matter contain lower forms and, last and third, that displacement by no means exhausts the essence of the higher forms of motion of matter. Methodologically, his point of departure was that in nature there are no "pure" forms of motion of matter and that the "whole of nature accessible to us forms a system, an interconnected totality of bodies, and by bodies we understand here all material existences extending from stars to atoms, indeed right to other particles, in so far as one grants the existing of the last named".[45] He stressed two important circumstances, which became objects of special investigation in the 20th century: 1) the systematic character of objects of reality, which is also mirrored by the systematic character of scientific knowledge, and 2) the existence of a universal link outside which both the being of matter and its cognition are inconceivable.

While proving that there is an internal link between diverse forms of motion of matter, and their mutual transformation and interpenetration, Engels categorically opposed any levelling of the qualitative distinctions between forms of motion of matter. The question of the qualitative distinctions between forms of motion of matter and their non-reduction to each other is discussed by him exhaustively in Dialectics of Nature.

Engels' study of different forms of motion of matter in their interaction, and the specific ways by which the forms of motion of matter that directly follow one another pass into one another, allowed him to classify the forms of motion of matter and, at the same time, define each individual form more strictly on the basis of its links with other forms. Lastly, his approach to the problem of classifying forms of motion of matter created the methodological prerequisites for distinguishing and investigating new, unknown forms. Of course, the classification proposed by Engels bears a certain imprint of historicism. However, no new classification embracing all forms of motion of matter presently known to science has been created, although attempts have been made in that direction.

An analysis of the correlation of the different levels of matter distinguished in the structural and genetic aspects of the forms of motion of matter led Engels to yet another problem of the classification of sciences that is

5435

interesting from both the theoretical and practical angles. On the basis of his classification he formulated principles for the classification of sciences which hold the attention of scientists to this day. He wrote: "Classification of the sciences, each of which analyses a single form of motion, or a series of forms of motion that belong together and pass into one another, is therefore the classification, the arrangement, of these forms of motion themselves according to their inherent sequence, and herein lies its importance."[46]

In speaking of the classification of the sciences, he stressed, first, what distinguished one science from another, second, the interrelation of different sciences, and, most importantly, he gave the philosophical foundation for using methods of investigation evolved in one branch of science in another. This foundation bears on material, structural unity of the universe, which underlies the interpenetration of sciences,and is also seen in the common mathematical formalism, in the possibility of using the methods of some sciences, for example, physics or chemistry, in another science, for example, biology. The various forms of motion of matter differ qualitatively from each other, and this makes reductionist trends in the methodology of cognition philosophically wrong; moreover, the qualitative specifics, the impossibility of reducing one forms of motion to others, their autonomous character cannot be absolutised. The interrelation of the different forms of motion of matter must be borne in mind.

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Dialectics of Nature holds a special place among the works of Marx and Engels devoted to methodological problems of developing natural scientific knowledge. It is the first philosophical analysis of scientific data about nature made from the standpoint of dialectico-materialistic philosophy.

Engels' Dialectics of Nature is important methodologically, for it convincingly shows the role of dialectico-materialistic philosophy in the methodological orientation of naturalists working on urgent problems of natural scientific knowledge.

The theoretical core of Dialectics of Nature includes a consistent dialectico-materialistic view of nature and an essential contribution to the categorial basis of materialistic dialectics.

In this work Engels made his first profound and all-round analysis of contemporary natural scientific knowledge in terms of materialistic dialectics. He showed that nature, society and thought are governed by the same common laws of development. His analysis and generalisation of the achievements of natural science enriched the philosophy of dialectical materialism, making it possible not only to regard the science of nature as a single whole but also to make important forecasts about the course of its further development.

Dialectics of Nature is not a product of philosophising in the old, pre-Marxist sense, for all its propositions spring from the data of contemporary science and do not stem from a priori theorisation. Moreover, it is not an empirical work, which only follows in the wake of the natural sciences, classifying and systematising sensory-empirical material concerning nature into a single system. Engels' attitude was sharply negative to this style of individual empirically-minded naturalists and philosophers. Dialectics of Nature is a Marxist philosophical work in the true sense of the word.

If we analyse the revolutionary changes that have taken place in science since Dialectics of Nature was written, we shall see that in some areas Engels was far ahead of the development level of the natural science contemporary to him. The science of the 20th century has borne out the ideas propounded by him in this work.

NOTES

1 F.Engels, Anti-Dühring, Moscow, 1969, p.166.

2 Ibidem.

3 Ibid., pp.167-169.

4 K.Marx and F.Engels, The Holy Family, Moscow, 1956, p.173.

5 K.Marx and F.Engels, From Early Works, Moscow, 1956, p.595 (in Russian).

6 F.Engels, Anti-Dühring, p.17

7 Ibid., p.16.

8 Ibid., p.33.

9 Ibid., p.16.

10 F.Adler, "Dialectical Materialism and Empirio-criticism. Frederick Engels and Natural Science", Historical Materialism, St.Petersburg, 1908, p.354 (in Russian).

11 F.Engels, Dialectics of Nature, Moscow, 1964, p.63.

12 Ibid., p.61.

13 Ibid., p.213.

14 K.Marx and F.Engels, Selected Works, Vol.III, Moscow, 1970, p.365.

15 F.Engels, Anti-Dühring, p.31.

16 F.Engels, Dialectics of Nature, p.60.

17 Ibid., p.140.

18 Ibidem.

19 Ibid., p.44.

20 Ibidem.

21 Ibid., pp.44-45.

22 Ibid., p.233.

23 F.Engels, Anti-Dühring, p.48.

24 Ibid., p.52.

25 Ibidem.
26 F.Engels, Dialectics of Nature, p.271.
27 V.I.Lenin, Collected Works, Moscow, Vol.38, p.190.
28 F.Engels, Dialectics of Nature, p.229.
29 Ibid., p.230.
30 Ibid., p.232.
31 Ibid., p.231.
32 Ibid., p.244.
33 F.Engels, Anti-Dühring, p.107.
34 F.Engels, Dialectics of Nature, pp.232-233.
35 Ibidem.
36 Ibid., p.63.
37 Ibid., p.65.
38 Ibid., p.66.
39 F.Engels, Anti-Dühring, p.32.
40 F.Engels, Dialectics of Nature, p.219.
41 Ibid., p.258.
42 Ibid., p.24.
43 F.Engels, Anti-Dühring, p.67.
44 F.Engels, Dialectics of Nature, p.239.
45 Ibid., p.71.
46 Ibid., p.252.

PROBABILITY IN CLASSICAL AND QUANTUM PHYSICS

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The fundamental character of probability ideas and research methods is widely recognised in modern science. Also widely recognised is that probability notions give flexibility and mobility to the theoretical forms of expressing knowledge and thereby reflect the inner dialectics of nature, the character and style of contemporary scientific thought. Decisive in the evolution of these views of probability was the development of physics (classical statistical physics and quantum theory), biology (genetics), and also cybernetics (information theory) and sociological research.

At the same time, there still exist considerable differences and blank spots in problems of substantiating probability and its scientific applications. In analysing the philosophical foundations of probability, attention is primarily focused on physical conditions and corresponding theories. Physics was the first to employ strict probability methods for investigating and expressing the laws of nature, for studying the structure of matter, and to this day its data continue to serve as a basis for revealing the nature of probability, for revealing the bases of the intensive applications of probability in contemporary science. Attention here is concentrated on a comparative analysis of the bases of probability in classical and quantum physics. It is natural to assume that the development of physics and its transition from classical to quantum physics also makes it possible to establish more fully the bases for the use of probability methods, insofar as that transition (the elaboration of quantum theory) was based on probability notions. However, when it comes to comparing probability in classical and in quantum physics very different views become apparent. "The concept of probability is not altered in quantum mechanics," write Richard P.Feynman and A.R.Hibbs. "When we say the probability of a certain outcome of an experiment is P, we mean the conventional thing, i.e., that if the experiment is repeated many times, one expects that the fraction of those which give the outcome in question is roughly P. We shall not be at all concerned with analysing or defining this concept in more detail; for no departure from the concept used in classical statistics is required. What is changed, and changed radically, is the method of calculating probabilities."[1]

V.Fok and M.Omelyanovsky express other views. "The concept of probability was also treated in classical physics," writes Fok. "But there the meaning was entirely different. In classical physics probabilities were introduced when the conditions of the problem were not fully known and it was necessary to average over the unknown parameters....

"In quantum physics,probabilities are of an entirely different nature. Here they are essential,and their introduction reflects, not an incompleteness of conditions but objective potential possibilities existing in the given conditions."[2] In this statement it is important to note an obvious contraposition of the "meaning" of probability in classical and quantum physics. This view is shared by Omelyanovsky: "Probabilities in quantum mechanics differ fundamentally from probabilities in classical theories. In the latter they express the existence of chance circumstances in the investigated phenomena and therefore are not directly involved in the laws governing those phenomena. In quantum mechanics,matters are quite different: in it probabilities are treated as a component of the fundamental laws of nature (Schroedinger's equation) and their introduction

is a reflection of a potential possibility objectively existing in definite real conditions."[3]

C.Weizsäcker expresses the radical idea that quantum theory is nothing but the general theory of probabilities.[4]

A widespread point of view is reflected in the following statement of J.M.Jauch: "The probabilities which occur in classical physics are interpreted as being due to an incomplete specification of the systems under consideration, caused by the limitations of our knowledge of the detailed structure and development of these systems. Thus these probabilities should be interpreted as being of a subjective nature.

"In quantum mechanics this interpretation of the probability statements has failed to yield any useful insight, because it has not been possible to define an infrastructure whose knowledge would yield an explanation for the occurrence of probabilities on the observational level. Although such theories with 'hidden variables' have been envisaged by many physicists, no useful result has come from such attempts. We therefore take here the opposite point of view which holds that the probabilities in quantum mechanics are of a fundamental nature deeply rooted in the objective structure of the real world. We may therefore call them objective probabilities."[5]

We thus have widely diverging assessments of the role and significance of probability in classical and quantum physics. It is widely accepted that there are substantial differences between the substantiations of probability in classical and quantum physics. Let us examine the relevant questions in greater detail.

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What are the bases for the inclusion of probability in classical physics? How can one understand and explain the significance of probability ideas in classical physics from the most general positions, from the point of view of the notions of the nature of existence and knowledge?

To answer these questions it is necessary to examine the general structure of classical statistical physics, the fundamental statements of the problems solved by its methods.

The ideas of statistical physics evolved in the course of investigations of the nature of heat phenomena, in the first place in gases. Here atomistic notions were the point of departure. General considerations regarding the molecular structure of matter, especially gases, were expressed scientifically quite some time ago. Their development can be traced in the works of Robert Boyle, Isaac Newton, Daniel Bernoulli, Mikhail Lomonosov, and other scientists of the period when classical physics was being elaborated. However, the emergence of statistical notions in physics as "working" physical ideas is linked first of all with the names of R.Clausius, James Clerk Maxwell, L.Boltzmann, and J.W.Gibbs.

In his elaboration of the kinetic theory of gases, in which he treated gas as a system comprising a vast number of particles, Clausius in effect realised that changed methods were required for these investigations. This is seen in the concept of "means" introduced by him in defining the states of motion of gas molecules. This made it possible to go over from the mechanics of a system of particles to the investigation of the physical state of systems formed of huge number of molecules. In Maxwell's words, the main fact is that Clausius "opened up a new field of mathematical physics by showing how to deal mathematically with moving systems of innumerable molecules."[6] But it was Maxwell who clearly realised that in the elaboration of the molecular kinetic theory of gases a transition occurs from the dynamical methods of mechanics to methods of probability theory. He went over from the notion of mean values of quantities characterising molecular motion in macrosystems to the concept of probability distributions of the values of those quantities. The concept of probability

distribution was introduced to reflect the properties and laws of material systems, and it is pivotal in numerous diverse applications of probability theory. It was after Maxwell's work that the intensive development of the theory of the internal structure of substances began.

Classical statistical physics attained relative completion and wholeness in the works of L.Boltzmann and J.W.Gibbs. The statistical interpretation of the fundamental law of thermodynamics—the Second Law—is due to the works of Boltzmann (his celebrated H-theorem). As a consequence, statistical mechanics acquired a generalised form of expression suitable for the investigation of systems of a highly varied physical nature.

The advance of classical statistical physics was accompanied by an investigation of its bases and significance. Notions immediately appeared that science was forced to turn to the ideas and methods of probability theory only because of the impossibility of developing strict solutions of complex problems, i.e., that probability in physics is a consequence of the inadequacy of our knowledge. There was a justification of such an interpretation in that historically (genetically) statistical physics was elaborated as the mechanics of a vast number of particles. Insofar as in this case direct solution of the corresponding equations of mechanics was abandoned in favour of notions of the mean values of quantities characterising the motion of particles, it was claimed that probability methods are a consequence of loss of refinement, simplification, etc., in stating the tasks of investigation.

At the same time, however, such assertions were also provided with more substantial philosophical explanations. The specifics of statistical systems was associated with, and characterised in terms of, the category of chance. Naturally, the broad philosophical interpretation of probability methods depended upon the interpretation of this category. In the classical period of the development of natural science, the category of chance was understood purely subjectively, as a characterisation of phenomena and processes whose causes and necessary connections are simply unknown. "Nothing in nature," wrote Paul Holbach, "can occur fortuitously: everything obeys certain laws; these laws are but a necessary connection between certain effects and their causes... To speak of a fortuitous coupling of atoms, or to attribute certain effects to chance means to speak of ignorance of the laws according to which bodies act, meet, combine, or separate."[7] Accordingly, probability methods were justified solely by the adequacy of knowledge: we involve probability methods in those cases when the investigated processes are intricate and we are simply incapable of tracing the interconnection of all the causes, or simply do not know them. These methods were ascribed temporarily, second-class, inferior status.

However, with the development of the applications of probability methods, especially in physics, their objective nature and independent value became increasingly apparent. Such was the interpretation of materialist philosophers and of natural scientists resorting to probability methods. "Insofar as it is a question of the application in theoretical physics," wrote M.Smolukhovsky, for example, "all probability theories which treat chance as an undiscovered partial cause a priori be declared unsatisfactory. The physical probability of an event can depend only on the conditions affecting its appearance, not on the extent of our knowledge."[8] By now the insolvency of views which justify the use of probability in science, natural science in the first place, by the inadequacy of our knowledge have been amply shown.[9]

The category of chance is of great importance for the interpretation of probability methods. Chance and probability have become virtually inseparable in the views of scientists. The specific nature of probability methods and relevant scientific theories is substantiated and revealed

on the basis of the category of chance. This approach is extremely widespread and is employed in virtually all cases of applications of probability methods, with the exception of quantum theory, where its inadequacy is recognised. At the same time there are still very many unclear points, and in some cases simply absurdities, in the very understanding of the category of chance, that prime category of dialectics, which makes more difficult an understanding of the essence of the methods of probability theory and have a negative effect on the development of their applications.

In Soviet philosophical literature, the view has gained root that the category of chance in the first place characterises a definite class, a definite type of connections existing in the material world. The principal meaning and principal difficulty lie in the question: what are the specifics, the peculiarities of the given class of connections? If we take the Soviet Philosophical Encyclopaedia we find in it the following: "Chance is a type of connection determined by causes extraneous and incidental to the given phenomenon or process."[10] And further: "At the root of the dialectical materialist understanding of chance lies an analysis of the character of the causes of this or that phenomenon. The cause of a necessary process is internal; the cause of a chance process is extraneous to it."[11]

It is apparent from these statements that the specifics of those connections which are treated as chance are defined as extraneous, incidental, secondary, incompatible with the inner essence of the investigated process. And, contrariwise, internal connections defining the essence of a process are always expressed solely in terms of the category of necessity. Such an approach to the category of chance and its relationship to necessity is characterised by many reference books on philosophy and scientific papers. It is tantamount to claims of the inadequacy and passing character of the ideas and methods of probability theory. But this is totally erroneous, for probability theory lies on the main road of development of the general ideas and notions of contemporary natural science.

What are the shortcomings of the examined definition of chance? Is it erroneous? Such judgements must be approached cautiously. In science, and especially in our daily language, we often employ the concepts of chance in precisely this sense. However, already in the simplest applications of classical statistical physics—in analysing the properties and laws of gases—the concepts of chance are involved to characterise relations between molecules, i.e., the internal structure of gases. The case is analogous in other applications of probability theory, for example, in genetics, where the concept of chance is used to characterise relations between mutations in certain systems, i.e., the internal structure of the mutation process, its essence.

The enrichment of the content of the category of chance in contemporary science can be traced in the elaboration of the general teaching (notions) of complex control systems. It is, of course, still too early to speak of it as a fully formed teaching. But at the same time it is obvious that we have here a comprehensive programme of research stimulating the posing of numerous problems. Elaboration of this programme contributes to the generalisation and development of a number of propositions of great importance for world outlook and methodology, in particular, for the contemporary understanding of chance, for example, the idea of relative independence (autonomy) in the behaviour of material systems, or the idea of levels in their structure and organisation. Also significant is that the understanding of chance is inseparably linked with the interpretation of probability distributions as a basic concept in the structure of probability theory and its applications.

To reveal the nature of chance it is in the first place necessary to turn to an analysis of the notions of independence. Relations between objects, events or elements

of a multitude are said to be of a chance nature when direct, mutually conditioned connections and dependences between the elements are virtually absent or play an insignificant part. Independence means that the state or behaviour of an investigated object is not dependent on or determined by, the state or behaviour of other, "related" or surrounding entities. But how is such independence possible in a world where the very origin and existence of every entity or phenomenon is unthinkable in isolation from their interactions and connections with the material environment?

The concept of independence is applicable primarily to certain mass phenomena and specific systems formed by a very large number of entities. It expresses a certain structure of these systems. However, these mass phenomena themselves depend upon the conditions of their existence or origin. In other words, independence itself has meaning only given certain integral characteristics of the system expressing their unity. It is important to stress that in speaking of the unity of investigated systems we actually characterise a certain new level in their structure and organisation. The consideration of independence and notions of levels is an indication of the profound dialectical content of the category of chance.

The examined interpretation of the category of chance provides a better understanding of the role and significance of probability in classical physics. In this connection let us consider the basic task performed in it by statistical theory. Often, in defining this task, the extreme complexity and involvement of the corresponding physical systems comprising a vast number of individual particles—atoms and molecules--are emphasised explicitly of implicitly. Furthermore, the impossibility of a "strict" solution and the need for simplifications are noted, which is done on the basis of probability methods. As a consequence, we find that the main function of statistical theories is an approximate, averaged description of the properties and laws of physical systems. But there is much more to the "purpose" and meaning of probability methods than the role of a mere "scaffolding". This is reflected in one way or another in the very formulation of the basic problems of statistical physics. In our view, this was done most forcefully by G.E.Uhlenbeck. In his works on fundamental problems of statistical mechanics he specifically emphasises that "the basic task of statistical mechanics ... is, in my opinion, the elucidation of the relation between the microscopic, molecular description and the macroscopic description of the physical phenomena."[12] The question of this relation is also the analysis of the role of probability in classical physics.

Statistical physics studies macroscopic bodies consisting of a huge number of particles, i.e., macrobodies as specific material systems. We repeat that statistical physics achieved significant results first of all in the study of gases and similar systems. Statistical methods began to play an important role in the study of liquids and solids fairly recently.

Historically the statistical theory of gases was preceded, on the one hand, by the formulation of the foundations of gas thermodynamics, that is, a macroscopic theory of gases (not dependent upon atomistic notions), and, on the other hand, by the elaboration of the theory of mechanical motion of simple entities—classical mechanics. The development of atomistic ideas in the science of gases posed the question of a kind of "synthesis" of the macroscopic laws of gas and classical mechanics, i.e., the task of studying the properties and laws of gases taking into account their internal differentiation and integration. Fundamental to an understanding of the essence of this synthesis is the fact that it became possible only when probability methods were employed. Probability represented the scientific concept which for the first time made it possible to link on a strict mathematical basis two main and independent trends in the study of the relevant systems—the one proceeding from the properties of the system as a whole

to the properties of its elements, the other proceeding from the properties of elements to the general properties of the system.

A key place in the cognition of statistical systems belongs to the concepts of probability distributions used to express their physical characteristics and regularities: "A property," writes Michel Loève, "is pr.-theoretical if, and only if, it is describable in terms of a distribution."[13]

Distributions are used to describe elements, their interactions and systems as a whole. They express the unity of discreteness and continuity, the synthesis of the integral and differential aspects of the structure of statistical systems.

Thus the significance of probability in classical physics consists above all in that it is a structural characteristic of physical systems. But every object of research is, in the final analysis, a system. That is why it is important to stress the specifics of systems whose laws and regularities are expressed in terms of probability.

The systems of entities investigation of which launched the elaboration of statistical mechanics possess one extremely important feature: the interactions between the entities that ensure their coupling in a system are comparatively negligible in magnitude, and they are neglected in the apparatus of the theory. That is why it is said that statistical physics proceeds from the investigation of systems of non-interacting (unconnected, "free") particles. This made for a certain methodological paradox: in statistical mechanics the existence of interactions between the elements of investigated systems is at one and the same time recognised and not recognised.[14]

Recognition of interactions between elements is necessary for the fundamental substantiation of statistical physics; they are neglected in mathematical descriptions, while the existence of common features in the behaviour of particles, which is, essentially, what is important in these interactions, is characterised in terms of macroparameters of the system and the external conditions of its existence. In other words, the structure of statistical systems is such that the states and behaviour of individual particles are independent and do not affect each other. It is precisely this type of structure, this type of interaction between elements that is defined as chance. The contemporary understanding of chance resting on notions of independence supplements and substantiates the basic research problems in classical statistical physics.

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Unlike the case of classical physics, in quantum physics the fundamental nature of probability concepts was recognised virtually at once. Whereas in classical physics, probability could still be treated as a secondary, alien element in the structure of the physical theory, in quantum mechanics, probability is from the outset one of the main bases of its very structure. The latter is associated with changes in formulating the principal task of investigation: in quantum theory, probability methods are used, in the first place, to investigate the laws and properties of individual quantum particles, or microentities. The transition from the study of systems formed of vast numbers of particles to investigations of individual particles, is an indication of the extreme flexibility and usefulness of probability methods. This transition became possible thanks to important changes in the methods of defining probability notions. In classical physics, the properties and laws of physical systems are expressed directly in terms of probability distributions. In quantum physics, the states of microparticles are expressed primarily in terms of wave functions.

The transition from direct application of probability distributions to wave functions is of fundamental significance in quantum theory. If characterisation of statisti-

cal systems is based on concepts of probability distributions, it is natural to assume that the equations of each such statistical theory should be mathematically defined and the problems solved in terms of probability distributions. Indeed, such was the state of affairs in early statistical theories. However, in quantum mechanics, the basic equations of systems and problems are formulated in the first place on the basis of the concept of wave functions. The latter are of a fairly abstract mathematical character and it is often held that, in general, they have no immediate physical meaning. Historically, wave functions were introduced into quantum theory in a purely formal manner and they became established in physics only after they were linked with probability distributions: the square of the module of a wave function in a certain representation defines the probability of the corresponding physical quantity. The connection of wave functions with probability is in general the justification of their use in quantum theory; it was only the establishment of this connection that made it possible to fill the whole mathematical apparatus of quantum mechanics with profound real meaning, which was done after the elaboration of this apparatus.

It should also be noted that there exist quantum systems ("mixed") the states of which cannot be defined in terms of wave functions. In such cases so-called density matrices are employed. Probability is also crucial for an understanding of their physical meaning, and the density matrices are in effect a special, mathematically expanded form of expressing probability distributions.

It was only the introduction of wave functions that made it possible to theoretically reveal the wave-corpuscular nature of macroentities and reflect their other internal properties. Here direct application of probability distributions cannot be successful, if only because their superposition cannot explain the appearance of interference minima, since they have positive values everywhere.

The concepts of wave functions proved more flexible than the earlier elaborated direct characteristics of probability distributions, and by virtue of that more suitable for expressing the natural interconnections between the very probability distributions of quantities in quantum theory.

But the question arises: how is it possible to study the properties and laws of individual particles with the help of probability methods? After all, probability theory is, by definition, a theory of mass (chance) phenomena.

Probability methods in quantum theory are also substantiated on the basic of mass phenomena. However, this mass character is quite different than in classical physics. In quantum physics, investigators proceed from the statistics (mass nature) of observations, from manifestations of the properties of an investigated micro-entity in certain standardised conditions. Conclusions regarding the properties of the corresponding entity are drawn from the existence of a stable diversity in the results of observations. "A macro-entity," writes Fok, "manifests itself in interaction with the instrument... The result of the interaction of an atomic entity with a classically described instrument is the basic experimental element, systematisation of which on the basis of various assumptions concerning the property of the entity constitutes the task of theory: the properties of the atomic entity are deduced from an examination of these interactions, and the predictions of theory are formulated as expected results of interactions."[15] He goes on: "In given external conditions the result of the interaction of the entity and the instrument is not, generally speaking, uniquely predetermined; it merely possesses a certain probability. A series of such interactions results in statistics corresponding to a definite probability distribution. This probability distribution reflects the objectively existing potential possibilities in the given conditions.... It is the probability distribution that is subjected to experimental verification."[16]

Speaking of series (assemblies) of observations (manifestations of the properties of micro-entities), it should be stressed that they possess basic features inherent in the probability systems of classical physics. First of all, the results of individual observations are independent of each other: the result of one observation does not predetermine the result of another (subsequent) observation. In other words, the internal structure of mass phenomena developed from observation results is determined in terms of the category of chance.

Furthermore, in classical physics, any statistical assembly (probability system) also possessed integral characteristics, otherwise probability methods could not be applied to those systems. Series (assemblies) of observation in quantum theory also possess such integral characteristics. "Wave mechanics," noted L.Mandelshtam, "is a statistical theory. But it is possible to speak of its statistical and probabilistic character only when we have a certain assembly of elements... In wave mechanics, it is the assembly of repeated experiments (each individual experiment being an element of it), provided that the repetition occurs in the same conditions...

"Let us call this assembly, which is being statistically processed, a collective. The collective must be in some way isolated, otherwise the posing of any question about it is meaningless. So it is said that $|\Psi|^2$ is a probability. But in what collective? If this is not stated, various ambiguities and paradoxes are possible...

"Of course, we encounter the same question in classics, as well. We can speak of the Maxwellian velocity distribution only at a constant temperature. If the temperature changes the distribution will be quite different. The same is true in classical problems, which do not involve collectives... Thus, in any theoretical investigation, the conditions of the experiment must be defined, and this definition can always be reduced to the statement of certain parameters.

"We have come to what I regard as the most significant and important. Namely, wave mechanics asserts that to define a micromechanical collective to which the Ψ= function refers, it is sufficient to state (denote) macroscopic parameters."[17]

Directly linked with the existence of integral characteristics of micromechanical collectives (assemblies of repeated experiments) is the existence of natural boundary conditions imposed on wave functions. These conditions include: the possibility of normalising wave functions (the possibility of integrating the square of the module of the wave function in the event the energy levels of the system are discrete), their finiteness, unambiguity, and continuity throughout all space. Satisfaction of these boundary conditions is essential for the apparatus of quantum mechanics.

Thus the substantiation of probability characteristic of classical physics retains its meaning in the case of statistical collectives of observations (experiments) in quantum mechanics. However, in quantum theory, it is not the results of such observations themselves that are investigated. On the basis of such observations, conclusions are drawn concerning the properties, structure and laws governing microparticles. Accordingly, the categories of necessity and chance are no longer adequate for substantiating probability in quantum theory: the category of the potentially possible is additionally invoked. The properties of micro-entities are determined from observational data. The wave function characterises their physical state. But this is a characteristic which makes it possible also to define all possible manifestations of those properties that can be observed in various permissible conditions. That is why it is said that the wave function (and quantum mechanics in general) describes the potential possibilities of the behaviour of an entity in some or other conditions. The category of possibility makes it possible in many ways to

view and substantiate the use of probability terms in quantum physics.

However, to say that quantum mechanics (as a theory of microprocesses) simply expresses the possible behaviour of micro-entities falls short of the full truth. In examining the range of possible behaviour of micro-entities, quantum mechanics makes it possible to reflect the existence of definite regularities in the "mass" of these possibilities, and its fundamental propositions are in fact based on the existence of such regularities. It is found that the regularities themselves, in the range of possibilities, are due to deeper properties of micro-entities, and it is they that are primarily of concern of quantum theory. Importantly, in theory these inner characteristics are defined not as potential possibilities, when observation results are not unambiguously predetermined, and depend not only on the entity but also on its macroscopic environment. Formulation of the quantum-mechanical problem, notes Fok, "fully allows for the introduction of quantities characterising the entity itself independently of the instrument (charge, mass, spin, as well as other properties described in terms of quantum operators), while at the same time allowing for a diversified approach to the entity: it can be characterised from that aspect (corpuscular or wave) the appearance of which is due to the design of the instrument and the external conditions created by it".[18]

For analysing quantum-mechanical knowledge it is most important that its concepts fall into different levels, different classes: the first class comprises as it were "directly observable" concepts (for example, coordinates and momentum), which in theory are treated as typical chance quantities (in the probability theory sense); the second class comprises quantum numbers (of the type of spin). The difference between these classes of concepts consists, first of all, in the "approximation" to what is directly given by the physical experiment. The former express the more superficial characteristics of micro-entities, the latter the deeper, inner ones. The former make it possible to individualise quantum processes, the latter are of a generalised nature. The former tend by their nature to classical concepts, the latter primarily express the specifics of quantum phenomena. The former vary continuously, the latter are more stable. The former are more closely associated with the phenomenological, the latter with the essence, although there can be no doubt that essence appears and appearance is essential. Naturally, completeness in the theoretical expression of quantum processes is achieved when both classes of concepts referring to different logical levels are employed.

The interconnection and synthesis of these two classes of quantities, with due account of their different nature, within the framework of a single theory proved possible on the basis of probability concepts. Here the methods of characterising the states of microparticles change significantly. In defining these states, prime significance is attached to concepts of the second class (quantum numbers) as expressing the deeper essence of micro-entities. Depending upon their numerical values, they quite strictly, unambiguously define each type of elementary particle, and it is primarily according to them that various types of particles are identified in experimental studies. However, statement of these parameters (quantities) does not unambiguously define the values of parameters of the first class; on the contrary, this defines the whole sphere of possible manifestations of the latter.

It is now generally accepted that the possibilities of this or that behaviour of certain material entities are conditioned above all by their inner structure. The inner structure always defines a mass of possibilities, and the deeper the properties are characterised the broader the corresponding field of possibilities. Realisation of one possibility or another depends upon the internal state of the corresponding entity and the conditions of its external

existence. In the most general case the transition from possibility to reality contains certain irrational features in a way similar to the transition between two points on a number-scale axis.

The latter also finds reflection in the types of interconnection between concepts of different classes in quantum theory. Concepts expressing the deeper essence of entities (actually the specifics of quantum processes) could be called integrally generalised. The significance of these concepts is revealed depending on their role in comparatively closed theoretical systems: they are not simply added to other, primary, concepts of the same system, but express a definite regularity in relations between such "initial" concepts. Elaboration of such concepts began already in the theoretical systems of classical physics (centre-of-mass and moment-of-inertia in simple mechanical systems; the curl α of a vectorfield in electrodynamics). The essence of abstractly generalised concepts is directly linked with the nature of the general; the general does not represent a mechanical conglomerate of individuals; rather, it expresses the structural organisation in terms of which each individual is incorporated in the system. In other words, the dependence between these two classes of concepts is revealed not in the coordination aspect but in the subordination aspect. Subordination includes a certain "independence", "autonomy": characteristics of the higher level do not unambiguously define the characteristics of the "lower", initial level, but only the range of their permissible values.

All the foregoing enables us to draw the conclusion that the meaning of probability in quantum physics consists above all in that it makes it possible to investigate and reflect in theory the regularities of entities possessing a complex, "two-level" structure, including certain features of independence, of "autonomy". It is in this connection with structure and the methods of its expression that the fundamental meaning of probability lies. This required the further development of probability concepts: the transition from probability distributions as basic characteristics to wave functions. Thereby it is possible to synthesise the continuous and the discrete, stability and changeability, rigid conditionality and independence, elementariness and wholeness, that is, to reveal and express the profound internal dialectics of the world of atomic processes. It is in this development of the flexibility and breadth of physical thinking that the prime philosophical and methodological function of probability in quantum theory lies.

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Let us again refer to the statements concerning the role and meaning of probability methods in physics cited at the beginning of this paper. When Richard Feynman and A.Hibbs say that the concept of probability did not change in going over from classical to quantum physics, they have in mind the interpretation of probability at the initial empirical level. At the level of "direct observations", the frequency interpretation of probability operates, and in this sense the transition from classical statistical physics to quantum physics introduced no significant change in the interpretation of probability. However, the significance of theoretical notions consists not simply in describing and correlating direct experimental data, as claimed by the positivistic programme of the analysis of knowledge. General concepts and categories of science which constitute the "kernel" of theoretical notions must serve the cognition of the inner essence of entities of material reality. And, as our analysis shows, the concept of probability is precisely linked with the revelation and expression of the structure and internal essence of investigated physical systems. The complexity of the situation and main difficulties and discussions concerning the nature of probability appear first of all at this theoretical level. It is clearly in-

sufficient to restrict oneself to analysis of probability at the empirical level, which is in effect recognised by most participants in the debate.

Analysis of probability on its theoretical level is most interesting and complex, and here considerable shifts are observed in going over from classical to quantum physics, as stated in the comments of Fok and Omelyanovsky quoted before. In classical physics,probability is linked with analysis of the structure of systems formed of a huge number of "non-interacting" particles. At the basis of the expression of the properties and regularities of these systems lies the concept of probability distribution. In quantum physics,the probability concept is already linked with analysis and expression of the structure of individual microparticles, which is what made for physics' breakthrough to the level of the atom and elementary particles. In the process significant changes in the language took place: the laws of microprocesses are no longer described with the help of probability distribution, but by means of wave functions. A fundamental feature of probability in quantum theory is "interference of probabilities" which has resulted in the fact that its laws are expressed in terms of "probability amplitudes". Quantum theory has vividly demonstrated that the strength and significance of probability lies in its connection with such generalising ideas and concepts of contemporary natural science as systems and structure, levels of internal structure and organisation of material systems, independence (autonomy) and the binding of elements within integral systems.

The point of view of C.Weizsäcker, as well as the work of Jauch, are interesting in that they draw attention to the importance of feedback in the relations between probability and its applications. It is frequently tacitly assumed that the development of probability methods of research and the expansion of the sphere of "applications" of probability does not significantly affect the interpre-

5435

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tation of probability. However, the development of applications necessarily affects the understanding of the very nature of probability. With regard to the applications of probability to information theory this state of affairs is sufficiently well realised.[19] Probability enters most natural and immanently into quantum physics. However, the data of quantum physics and analysis of its structure are practically not used to reveal the meaning of probability. Yet the dialectical view of the nature of cognition means that more developed cases of application of probability correspond to a deeper penetration into and expression of the essence of probability. Further development of the interpretation of probability in physics lies through mastery of the situation in quantum theory.

Assertions that probabilities in classical physics are of a subjective nature have already become a kind of prejudice, accepted only as a matter of faith. However, assertions that probabilities in quantum mechanics are of an objective nature and deeply rooted in the very structure of the material world possess tremendous heuristic force. We sought in this paper to reveal the present stage of this question; in the process we found that revelation of the nature of probability is connected with an analysis of the leading problems of materialist dialectics.

NOTES

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MAN AND THE ENVIRONMENT. METHODOLOGICAL ASPECTS OF THE PROBLEM

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The growing interest in the problem of nature conservation has two main causes: the intensifying and growing contradictions between society's demand for natural resources and the limited possibilities for satisfying it in the traditional ways, and the need to preserve human habitat.

This is a problem that concerns all mankind, and as such it is central to scientific understanding and transformation of the world. If it is to be solved, the old forms of society's activities must be improved and changed, as well as new and more rational ones found in order to improve and multiply resources of Nature and preserve its beauty for the present and future generations.

From the methodological point of view, it is such general questions as, for instance, defining the very concept or nature conservation, elucidating its place and significance in human activity to transform the world, and classifying the forms of nature conservation, that are of particular interest in solving the problem.

Nature conservation is a specific form of society's activities towards limiting or putting an end to all

5435

environmental pollution and preventing natural resources from being exhausted, as well as towards precluding any permanent disturbance to the balance of nature and the relatively stable relationship that has developed during evolution between nature's subsystems and component parts. Society's nature conservation activities are ultimately intended to maintain the "society--nature" equilibrium.

These of society's activities are trained on nature as a whole, but primarily on those subsystems and component parts that are most valuable for practical ends and for scientific research: irreplaceable mineral resources, pure water, clean air, arable land, industrial or endangered species of plant and animal, and so on.

The concept "nature conservation" includes many types of activities, differing in terms of their goals (maintaining the balance of nature at all its diverse levels, preserving rare animals and plants, making economical use of irreplaceable resources, etc.); of their nature (planned or spontaneous, careful or wasteful); of effectiveness (effective, little effective or ineffective); of socio-economic characteristics(of the whole people or private entrepreneurial), and so on. All this testifies to the many planes of the concept, and indicates the need for an integrated approach to defining it.

Nature conservation should not be regarded in isolation, but in connection with the overall problem of harmonising man's relationships with the environment, which means that the task should be integrated as closely as possible with the prospects for scientific and technological progress. One particularly undesirable dilemma is that between the conservation of nature, with cessation of all human influence on it, and providing nature with as much technical equipment as possible. On the one hand, there are calls to return to the ancient conception of nature as sacrosanct, and consequently of any influence on it as immoral, i.e., "Nature knows better than Man himself what Man needs". This

5435

is, of course, an incorrect approach. History has shown that technical progress has always contributed considerably to nature protection.

On the other hand, purely technical approaches are also evidently incapable of providing a complete solution to the problem, since technological progress has not only favourable consequences (at each stage eliminating many of the unfavourable ones of the previous period) but also new and, what is more, ever increasing undesirable ones. Not without cause is reliance on technology's ability to solve the problems posed by the development of technology itself called "technological optimism", an attitude that was common enough in the West during the first half of the 20th century, but which is now losing its currency. The new methodological trends characteristic of present-day Western science are of interest.

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The works considered in this article belong to the third wave of Western literature on environmental problems. Boasts of Man's might and his increasing domination of nature that were heard during the scientific and technological revolution of the 1960s were replaced by alarming prophecies of an impending ecological catastrophe for mankind and for the Earth as a whole.

Biologists, journalists, politicians and public figures have produced a multitude of examples to show the detrimental effects of scientific and technological progress: environmental pollution, the shortage of material and energy resources, the disappearance of many species of plant and animal, unfavourable changes in the nature of Man himself, and so on.

In the early 1970s, however, works began to appear that tried to carefully weigh both the favourable and unfavourable consequences of current human activity. They

5435

seek ways of transforming the biosphere that would ensure further technological progress without disturbing the basic ecological factors for human existence and the Earth as a whole (acceptable levels for various types of pollutant, radiation, noise, etc.).

In the opinion of many Western scholars, the interaction between society and nature is already at a critical stage, requiring urgent scientific and social solutions. It must be said in favour of many Western scientists that, rather than confining themselves to simple declarations, they seek methodological means and principles for conducting research into human ecology, the science studying the interrelation between man and the environment.

The most interesting works in this field are J. Forrester's <u>World Dynamics</u> (Cambridge, Massachusets, 1971) and the research done by the Denis Meadows group, which is written in popular language and intended for the layman. Their book <u>The Limits to Growth</u> (New York, 1972) provoked a particular response.

To some extent the success of this last book is due to its futurological approach, and to the fact that this was the first attempt to collect material on the most diverse aspects of human activity into a formal world model for computer study.

Previously, formal models had been built of only individual aspects, such as economic development, population growth, etc. It is just as important, however, to reveal the interconnection between these trends as to study them in isolation, and this is what Forrester and Meadows have tried to do through the computer. Their world models contain five major world development trends: accelerated rates of industrialisation, rapid population growth, wide expansion of the zone of undernourishment, exhaustion of irreplaceable resources and deterioration of the environment. These are studied in a realistic interrelation with each other. The

5435

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group's first book, The Limits to Growth, met with an unending flow of critical literature.

The arguments against the world model itself are indeed numerous. At a discussion of the book sponsored by the European Council the various criticisms were summed up.[1]

The majority of these stressed that the degree of unity between the variables is too high if the average values of very diverse magnitudes are taken, which might lead to error. Population growth rates in different countries. for instance. vary by 500%, while the model uses only the average. To make the model realistic, it was proposed that it should include at least two categories of countries: developed and developing.

The model's weakest point, the discussion emphasised, is that it takes no account of the actual mechanisms by which man adapts to the environment, the main one being price formation, which plays a major role, especially in the economy. The number of loops in the social feedback was not large at all in the world model, thus precluding the possibility of including the system's defence mechanisms against ecological catastrophe.[2]

Fairly serious objections were raised to the fact that the model's mathematical functions are reversible. Since the Meadows group studied virtually all the features of human behaviour in only one direction, they made a serious mistake in assuming symmetry of human behaviour. The data show, for instance, that as soon as the standard of living rises, the rate of population growth falls. Even if the standard of living falls, however, the population growth rate might be expected to remain very low for a long time and possibly only to start rising again once the standard of living reaches an extreme low, or the low standard of living has existed long enough for the customs attached to a high one to have died out.

Thus the model's functional dependence between the standard of living and the population growth must not be

considered reversible. Aurelio Peccei, leader of the Club of Rome and a participant in the discussion, stated that there would be some sense in improving the model in this respect. As for the actual example of the population growth as a function of the standard of living, he considered that there were sufficient data indicating that such factors as customs and upbringing were less important than those of personal satisfaction, which were usually connected with the standard of living. Thus, the problem is to determine the factors whose influence on social behaviour is not sufficiently known.[3]

One other objection refers to the model's extreme sensitivity to such changes as the inclusion of a small exponential growth in the discovery of natural resources and the development of the technology used in the fight against environmental pollution. There is also an unevenness in the level at which the data are included in the various subsystems of the model, which are fragmentary and incomplete. The sector simulating environmental pollution has come in for particular criticism.[4]

We should like to look in more detail at one of the fullest critical analyses of The Limits to Growth. This was carried out by a research group in the Science Policy Research Unit of the University of Sussex and published in the February to April 1973 issues of the magazine Futures. The value of the Sussex group's criticism compared with previous ones lies in the following points. First, it was a comprehensive group with a variety of specialists, though no medical experts were included, which meant that the group did not consider the important medical aspects of the interrelation between Man and nature.

The Sussex group had access to the initial versions of the technical calculations made by Meadows and his colleagues, though these were not included in the book and had not been published previously. It was therefore possible for the group to base their criticism on a thorough knowledge of all stages in the building of the world model, rather than on the final assumptions and results alone. Finally, the Sussex group used the computer, Meadow's own weapon, in their criticism.

The most important question, a subject of animated polemics, was the extent to which the results of simulation in general and the Meadows group's model in particular reflect reality. Any model, however close to the original, cannot be identical to it. Furthermore, the more complex the original, the greater the difficulty in building a satisfactory model. The model built by Meadows and his colleagues is a formal world model in mathematical form. In comparison with a descriptive model it has both certain advantages and disadvantages. The authors of The Limits to Growth focussed on the positive aspects of this type of model, noting that, in quantitative models, each assumption is recorded in exact mathematical form and is accessible for general consideration, and that a computer carries out all operations much faster than the human brain, and without error. They disregard, however, the disadvantages of computer simulation.

The Sussex group, on the contrary, stresses the latter. Dr.R.Golub noted that unquantifiable factors, such as social changes, are totally ignored, making the model biased. Quantitative models are oversimplified to make them suitable for processing by current computer technology. Certain parameters that in fact are changing, are assumed invariable by the model. Computer simulation gives the impression of precise quantitative evaluation of a relationship between variables, which is, in fact, not clear.[5]

The Sussex group were not all agreed in their evaluation of computer simulation. Some of them, stressing the negative aspects of simulation, see this method as no more than an attempt to replace the concept of complex calculation processes. The majority, however, compare the positive and negative aspects of computer simulation, concluding

that this method constitutes a useful addition to the process of mental simulation.

C.Freeman underlines[6] that attempts at simulating complex systems in general are still at a primitive level, but the aim should be to build quantitative models that will closely reflect reality. He continues that it remains true that a cybernetic model cannot be any better than the mental model on which it is based. Such a model is not an impartial oracle, but an argument in the political struggle.[7] Thus formal models, and here one cannot but agree with Freeman, supplement mental ones but cannot, of course, replace them.

While giving a basically positive assessment of the possibilities of cybernetic simulation, but also criticising computer fetishism, the members of the Sussex group go directly to criticism of the main assumptions of the world model. These include exponential growth of the population, industrial production, the production of foodstuffs, environmental pollution and consumption of irreplaceable natural resources.

The second assumption is that exponential growth cannot go on indefinitely, if only because the Earth is limited in size, as are the deposits of irreplaceable natural resources, arable land, ability of the biosphere to absorb pollutants, and so on.

The Sussex group objects to these assumptions too. In their opinion, it is incorrect to assume constant exponential growth, and there are no fixed physical limits to the Earth, such as deposits of minerals, yield of the land, and so on. The concept of "deposits of resources", Freeman writes, agreeing with Page, is rather a technico-economic one that is a function of society's degree of development.[8]

The assumptions made by the authors of The Limits to Growth result, in the opinion of the Sussex group, in pessimistic, neo-Malthusian conclusions. Even without a computer it is clear, as Cole points out, that exponential growth of the consumption of resources, for instance (if deposits are assumed to be sufficient for 250 years, as they are in some experiments with the world model) must stop fairly soon.[9]

The simplicity of individual conclusions, however, does not mean that a thorough analysis of the world model is useless, for in most instances the result is not so obvious.

The computer simulation carried out at the Massachussetts Institute of Technology (MIT) indicates that, if there are no changes in the technical, economic and social foundations of society, the rapid exhaustion of resources will produce a slowing down in the growth of industry and agriculture, as early as next century, a rapid fall in the population and finally a catastrophe. If the achievements of science and technology ensure an unlimited supply of resources, the catastrophe will arise from environmental pollution. If it is assumed that society will be able to protect nature effectively, the population and industrial output growth will continue until all reserves of arable land are exhausted and then, as in all the previous versions, a catastrophe will set in.

The last chapter of The Limits to Growth contains the authors' recommendations for averting the threat. They proposed halting the Earth's population growth even before 1975, with births kept from exceeding the death rate, and simultaneously stabilising industrial production at the current level so that invested capital did not exceed resources for the depreciation of equipment.

Such a global equilibrium would not, in the opinion of Meadows and his colleagues, indicate stagnation. Any human activity not requiring large quantities of irreplaceable resources and not harming the environment (in particular, art, science, education, sport) would develop unhindered.

MIT's model is criticised on two planes: the structure of the model and the input data. Like most of the model's opponents, the Sussex group notes its considerable importance. Freeman writes that he calls the authors of The Limits to Growth neo-Malthusians not only because of their pessimistic conclusions, but also because, like Malthus, they have focussed the public attention on the complexity of environmental problems and started up an extremely important debate.[10]

No member of the Sussex group disputes the results of the experiments with the model, experiments which completely ignore technical, economic and social changes in the world. Apparently the conclusion that a catastrophe is inevitable should be seen as one of the undoubted advantages of Meadows' model.

Differences of opinion begin with respect to the influence of future technological achievements on the behaviour of the model. The Sussex group propose that the model does not take sufficient account of the potential strength of modern science and technology. The disagreement between the two groups is, in Freeman's opinion, rooted in their attitude towards technological progress.[11] The MIT model includes no variable for technological changes, the argument being that we have no precise quantitative information concerning the science and technology of the future. As was well noted by Nature magazine's reviewer, however, no one can foresee exactly which scientific and technological discoveries will be made even during the coming decades, but history makes it absurd to doubt them.[12]

It might be added that man's adaptation to the environment has always required technological improvements, and will continue to do so in the future. The very use of computers in the study of the interaction between society and nature is itself a manifestation of the truly inexhaustible possibilities of the scientific and technological revolution. In Meadows' conception there is thus a sharp incompatibility between computer fetishism and underestimation of science and technology.

As the Sussex group's experiments with the computer demonstrated, the inclusion of an assumption of technological discoveries in those sectors of Meadows' model that had been without it put off the onset of catastrophe. To us this conclusion is clear confirmation of the Marxist-Leninist thesis of the importance of science and technology in the development of society. True, the Sussex group say nothing of the fact that technological progress is inseparably linked with social progress and is, to a significant degree, determined by it.

As if anticipating criticism, The Limits to Growth authors admit that their model is incomplete, but say there is nothing to prevent it being improved and expanded, and in this the Sussex group are in agreement with them.

The dividing line between the two groups runs with respect to whether the given model can be used in its present form as a basis for political decisions. Meadows believed that, since his group's model was essentially the only one of its type (apart from its prototype, the earlier Forrester world model), while the situation required undelayed global solutions before 1975, these must be based on the given model (Meadows naturally has in mind a transition to a global equilibrium). The Sussex group consider this to be a mistaken attitude.

As for the structure of the world model, the Sussex group's three main arguments should be noted here. The behaviour of society is included in the programme as a constant, while in the real world, this is determined by changing circumstances. The increase in environmental pollution, for instance, must cause additional resources to be pumped into nature conservation. In the world model, there is no such social feedback, a fact which inevitably affects the results.[13]

The computer experiments carried out by the Amsterdam group of T.Oerlemans, M.Tellings and H.De Vries have shown that if a social feedback function is introduced into two sectors of the Forrester model--these of environmental pollution and of natural resources--the ecological crisis no longer appears inevitable.[14]

The second objection concerns the fact that the model gives a single forecast in each experiment. In the real world, processes are subject to random changes, writes Cole, which cannot be taken into account. Consequently, any prediction must consist of a range of future states for the world with different degrees of probability.[15]

Finally, there is another mention of the high degree of unity of the variables. The world model does present population in general, rather than that of individual countries, and pollution in general rather than the actual pollution level in the different parts of the world, and so on. Here the seemingly purely methodological problem unexpectedly manifests itself on another social plane. Both groups fall into a common error: they both ignore the fundamental differences between the capitalist and the socialist systems in the influence on the environment, and take certain common features of industrial development as absolute. This is all the more regrettable since, as the Sussex group are aware, it is primarily socio-political factors that offer the greatest threat to humanity at the present time, rather than the Earth's physical limits.

This last argument put forward by the Sussex group is undoubtedly their strongest, and the members of the Club of Rome, who had initiated the building of the world model, were forced to recognise it. According to Dennis Gabor, the Club of Rome realises that such a primitive model is unsatisfactory,[16] which is why, among other proposals, the Club has supported the draft world model elaborated by Professors Mesarovič and Pestel.

Their world model is divided into ten regions distinguished by socio-political and economic factors. Such a model is, of course, more realistic and capable of making more accurate forecasts of mankind's future. There is no doubt that even more detailed world models will be built to include all individual states. It should be remembered, however, no matter what the model, it cannot, as Freeman notes, replace theory. The creation of a theory of the interaction between society and nature is only possible, in our opinion, if comprehensive use is made of the most diverse research methods (including, of course, computer simulation) based on the principles of dialectics and historical materialism.

The main advantage of the cybernetic model, as seen by Meadows and his colleagues, is that the results always follow logically from the conditions.[17] They claim that global simulation on the basis of systems dynamics, the method used by them, is less susceptible to the shortcomings of simulation than are modern economic and econometric models based on regression and matrix analysis. The method of systems dynamics, in their opinion, suffers less than all other available methods from mathematical oversimplification, and therefore gives a closer representation of reality. Meadows and his co-researchers admit the incompleteness and subjectiveness of their model, but still claim for it the distinction of being the best model available for criticism and utilisation, and state that the quality of global solutions might progress as subsequent models are improved.[18]

While defending the basic assumptions of the model, however, its authors are in agreement with the subjectivity. The Limits to Growth, they write, investigates the fundamental characteristics of the world system. These characteristics must be understood and discussed independently of the precise quantitative data and functions of the model. In answer to criticisms of these basic assumptions, the authors of the model admit that human knowledge might grow exponentially, along with the population and economy of the world.

It does not follow from this, however, that the technological application of this knowledge will also grow exponentially. For instance, the doubling of a harvest does not increase the possibilities for doubling it again. Meadows and his colleagues believe that to propose that technological progress will also grow exponentially and to include this assumption in the formal model would be to misunderstand the nature of exponential growth.[19] They do not believe that technological progress will come to a halt, but affirm that technological progress cannot in itself solve the vital problems, since it has both favourable and unfavourable consequences.

All the mechanisms of the social feedback, the authors of The Limits to Growth explain, do not immediately react to changes in the world system, but operate with lags, and therefore, given exponential population and economic growth, they will be unable to give sufficient warning of the onset of the imminent ecological catastrophe. This also applies to such social adjustment mechanisms as technological progress, and human values, and to such economic mechanisms as price formation.[20]

The Meadows group could not, however, come up with weighty enough arguments against the avalanche of criticism from journalists and members of international governmental and unofficial organisations (the World Bank, the Resources for the Future organisation, the European Council, and others).

After exhausting their arguments, the authors of The Limits to Growth resorted to counterposing the Western and Eastern concepts of Man's purpose. In their opinion, the Western concept of Man, arising from Christian traditions and corroborated by rapid technological achievements, leads to technological optimism.

The opposite concept of man, they continue, is closely connected with the Eastern religions. Accordingly, Man is just one of the species which are equally subject to the natural laws that limit the behaviour of all life forms. Technological optimists have always called this view pessimistic; Malthusians simply call it accepting fate.

In conclusion the authors of The Limits to Growth recognise that there is no objective way of proving either of the two concepts of Man and his role in the world. The advocates of each view can find arguments from environmental reality to support their case. Technological optimism predicts the fulfilment of human hopes, more comfortable living conditions and achievements of the human intellect. The Malthusians foresee only population growth, the destruction of the soil, the extinction of animal and plant species, a dangerous growth of towns and a widening chasm between the rich and the poor. They will say that Malthus was right both then and now, write the Meadows group at the end of their answer.[21]

Thus it should be noted that, though they use the most advanced computers, Western scientists cannot find suitable solutions to the complex ecological problems, and resort ultimately to Malthusianism or technological optimism.

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The definition of Man's place in nature is a major philosophical problem, on which to a large extent policies concerning the transformation of the environment depend. The basic precondition in solving this problem is often to counterpose Man to nature.

This false position is overcome in dialectical materialist philosophy. Nature is understood not only as an object, but also as a human emotional activity. In turn, the change wrought in nature by Man acts as the most fundamental and closest foundation for thought.[22] This approach makes it possible to consider Man in inseparable unity with nature. "Man lives through nature. This means that nature is his body, with which Man must remain in constant contact in order not to die."[23]

5435

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Man's relationship with nature is the process by which nature is transformed into his living environment. Parallel to this process, concepts of those parts of nature with which Man interacts are separated out from the concept of nature itself. Thus, the concepts of the environment, the biosphere and the noosphere are formed. As a result of the transformation of nature, two spheres emerge for Man to protect: the internal (his own body) and the external (which is constantly expanding)--that part of nature which acts directly on Man.

A fundamental feature uniting the internal and external environments of mankind is the fact that neither of them can develop through degradation and destruction of the other. If Man's external environment begins to deteriorate, this will sooner or later affect the internal one. There is no shortage of examples of this. A clear link has been revealed between pollution of the external environment and the growing number of disease (cardiovascular, cancers and others). Moreover, social evolution is undoubtedly a decisive factor in Man's development, but it also inevitably causes the environment to evolve. In the long run the latter engenders biological evolution of Man, thus creating a feedback circuit which coordinates the evolution of the Earth as a whole.

To deny the existence of such a feedback would be to isolate the spirit from the material, the social from the biological in Man. The biological and the ecological are included in the social not in a mechanical way, and not always in one and the same form. Their inclusion is very contradictory and active. The biological and the ecological sublated by the social are modified by it, and in turn exert a certain influence on its development. The biological, like the ecological, can provide either a favourable or an unfavourable foundation for the formation of Man's social essence.

Unfortunately, the only way of establishing the statistical dependence between changes in nature and in the biology of Man is still, in many instances empirical, and there is as yet no way of revealing the structure of the cause and effect links.

The interconnection between the social, biological and ecological factors (climatic, geographical, soil, physico-chemical, and so on) has specific features depending on the age stages in the development of the individual. Consideration of these features plays a definite methodological and practical role. From the methodological point of view, it is important to elucidate the place and role of each of the factors under review in isolation from the various stages of ontogenesis.

It has been established that, during childhood and old-age, there is a steady disequilibrium in the exchange of substances, energy and information between the human organism and his social and ecological environment. Any society based on humane principles must, therefore, show special concern for children and old people, assuming many of the functions concerned with ensuring their normal vital activity and development. This concern takes the form of laws prohibiting child and adolescent labour, ensuring social provision for the aged, and setting up children's institutions and homes for the aged.

Recognition of the leading role of social factors in a man's biological development does not imply any imbalance between them at all ages. In the post-natal period, a child's life is concerned in the main with satisfying its biological requirements for food, air, warmth, and so on. The role of social factors at the initial stages consists in creating the normal microsocial conditions required for the child to survive.

It is within the family and the nursery that a person's physical features form and develop. The function of society and the family at this stage is to ensure procreation. The

role of ecological (natural) factors is not great in ontogenesis. The child assimilates everything given him by the socio-ecological world around him. Favourable factors of the external environment promote his normal, natural development, while unfavourable ones hinder the establishment and formation of natural features.

At later ages the significance of the micro-environment (the family) does not decrease, but is added up by other social and ecological factors: the kindergarten, then school, pioneer, young communist and other organisations. Not discarding, but dialectically sublating that which left its imprint on the individual at an early age, we see that the significance of the social and ecological environment is somewhat different in maturity from that in childhood.

In early life, the child is a relatively passive party in its interrelationship with the social and ecological environment, but once a person reaches maturity he actively interacts with the conditions surrounding him, transforming and modifying them in his own way. Social and ecological factors have another meaning for the thinking man. These not only form personality characteristics, but also focus their development in a particular direction. Surrounding nature occupies a different position in a mature person's activities than in childhood. It has a certain educative significance for him, helping to develop his aesthetic abilities. At the same time, nature's importance as a factor in physical development does not decrease.

In old age, with the general unification of social contacts, the role of biological and ecological factors increases. Existing a long time within nature, doing socially important work according to his specific biological features, and recognising his significance for society and the people around him, all stimulate Man in his activities, increase his lifespan, help him to realise his plans and ideas more fully, and so on. The falling biological and physiological potential of older people makes society responsible for improving the scientific organisation of the labour and every-day life of older people, and for creating more favourable ecological conditions for their activities.

Analysis of the current stage in the interrelationship between society and nature prompt the conclusion that the period when society exerted a random influence on the environment and Man's own nature is now past. Recognition of the need to control society's influence on the environment and for Man to improve his own body are characteristic features of the current stage in scientific comprehension.

Man's progress in managing his external environment is, in essence, and indirectly, control of his own biological evolution.

Assuming the possibility of Man's biological evolution, we must also note the relative nature of such concepts as "the norm", "health", "sickness". Discussions on the theory of pathology reveal the difficulties of drawing a line between health and sickness. The absence of realiable methodological criteria for distinguishing between these two states makes it extremely hard to justify the concepts of "the norm" and "sickness", as well as the understanding of many aspects and problems.

In our opinion, health might be defined as the human body's ability to function optimally, with each organ helping in the fulfilment of the entire organism's comprehensive functions. It is from the extent to which a particular organ assists in these integral functions that its state of health can be judged. Otherwise an optimally functioning, but parasitic system might be considered as normal. But the human body as a whole also functions as an element of society, so this particular feature of human behaviour must also be settled when defining a Man's health. The socially healthy individual is the person who promotes the development of society. In turn, human society as a whole functions as a subsystem of the biosphere, of

the single society--nature system. For this reason, a medical definition of the concept of health must also include an idea of the optimal functioning of the biosphere as a whole. Health, under this approach, is not only a biological concept, but also a socio-ecological one.

At the present stage in the interaction between society and nature, it is becoming essential for new ecological ethics to be elaborated for controlling the interrelations between Man and his environment. It seems to us that it would be helpful to focus attention on medical ethics in elucidating the question of ecological ethics.

The actions of a doctor and the demands of medical morality are based on the overall moral principles of the given society. Interpreted through the activities of doctors, however, these overall moral principles appear in a specific way in the given sphere, taking the form of medical rules and norms of behaviour. In the opinion of some Western scientists, scientific and technological progress entails a crisis of medical ethics due to the excessive popularisation of medical knowledge and, above all, the introduction of medical technology. This claim is, of course, unfounded. On the contrary, the significance of ethics grows during the scientific and technological revolution, with new ethical norms beginning to develop.

It is equally incorrect to speak of Man losing his understanding of nature's values while he is intensively transforming it. Above all, values should not be considered as a system of absolutes, for they change as human activities develop. Before the appearance of medicine there could be no such thing as medical ethics. It is while Man operates on and transforms nature that he recognises it as a value. Each new stage in this transformation brings a change in the system of human values, and as the possibility of changing the world grows, so does man's feeling of responsibility for the environment. Those fragments of reality that are drawn into the sphere of human activity become subject to the moral norms of the given society.

During the scientific and technological revolution, when the Earth as a united whole is drawn into Man's sphere of influence, it is quite reasonable to speak of the need for ecological ethics. This should not, of course, imply some superclass morality. Ecological ethics, determining Man's relationship with the environment, as well as medical ethics, are both a part of the overall moral norms and principles of any society, and a sphere in which they are manifested.

And of course, in a society ruled by the pursuit of profit, ecological ethics will remain at best no more than a declared desire. Only dialectical-materialist philosophy, based on recognition of Man's unity with nature, can support new ecological ethics, and only in a socialist society are ecological moral principles embodied in the moral rules of behaviour of the working people. Ecological ethics determine the rules governing not only Man's attitude to nature, but also that of man to man, mediated by their attitude to nature.

Man's transformation of the environment, as already noted, often entails unfavourable consequences which ultimately threaten the survival of mankind and the Earth as a whole. There are both social and gnosiological reasons for this. The gnosiological roots of the ecological crisis are found in the rift between the sciences and the suppression of one science by another, ultimately in the division of labour. The feedback between social, natural changes and changes in the human body correspondingly presumes a close link between the sciences. On the one hand, an interconnection is essential between the natural and technical sciences with those of the environment (geology, geography, biology), while on the other, the latter must be closely linked with medicine in order that the effect of changes in the external environment on Man's internal environment might be studied.

In other words, science must contain an outline of a feedback similar to one that exists in nature. Science must be integral, just as nature is. Only recently, however, has it become possible to speak of the development of such boundary sciences as medical geography, and the appearance of new ones—geohygiene and medical geology, that study the influence of rocks on human health.

A synthesis of environmental sciences with medicine might be realised on the methodological plane. Medicine is an ancient science in which methodological principles have been elaborated that might be usefully applied in nature conservation.

The basis of this methodological expansion is the unity of Man's internal and external environment, and the tasks common to the protection of both nature and human health. In particular, the focussing of the Soviet health service on prophylaxis is a basic principle that might be successfully applied in environmental protection. This approach would prevent nature conservation from turning into a science that only establishes the detrimental effects of the scientific and technological revolution and treats nature's wounds. On the contrary, forecasts of the direction of scientific and technological progress would make it possible to develop "ecological prophylaxis".

The sciences of the biosphere must not become sciences concerned only with the diseases of nature. All this prompts the conclusion that, just as the problem of health cannot be confined to the spheres of biology and medicine because it is inseparably linked with the specific features of the social system, nature conservation is not only a natural scientific problem but also a socio-political one.

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Since the world today is represented by different social systems, the approaches to solving the nature-conservation problem adopted in each of them differ fundamentally.

The global approach to nature protection and the necessity for international cooperation in this sphere presumes, rather than excludes, a consideration of the specific nature of the problem in each country or group of countries with a common type of social system.

This must be stated clearly, for some philosophers attempt to prove that both bourgeois and socialist societies are faced with virtually the same problems in the nature conservation sphere. For this reason, they claim, the "irreconcilable ideologies" at present in existence must give way to a "single ecological philosophy" if an ecological catastrophe is to be averted. This is an attempt to use the one or two similar features in the nature conservation sphere as an argument for the theory of a single industrial society long-since disseminated by anti-Communists.

Thus, the battle between the forces of socialism and capitalism has now been transferred to the sphere of nature conservation. The state of the environment is determined primarily by the nature of the social attitude towards it.

The level of pollution in the various parts of the world is determined more by the fundamental differences between the capitalist and the socialist systems in the sphere of influence on the environment, than by the state of industrial development or the Earth's physical possibilities (although these factors are also important in themselves).

The critical state of the natural environment in the industrially developed capitalist countries is primarily a consequence of the random, private property exploitation of natural resources. Thus, the "Cooperation in Environmental Protection" Commission at the World Congress of Peace Forces was provided with information on soil and water pollution brought about by the monopolies' predatory attitude to nature.

There is particular concern about one aspect of the natural environment's complex structure--the state of the atmosphere.

Specific criteria must be established for evaluating the sociological approach to solving the problem of environmental protection.

The first and main criterion for judging the attitude of a society to nature is Man's state of health. In the final analysis, the advantages of any social system with respect to environmental protection must be judged from Man himself, from his state of health and fitness for work.

The socio-class approach to environmental protection requires account to be taken of the fact that it is mainly the working class who suffer from environmental pollution in the capitalist countries, for it is these people who, for obvious reasons, have less opportunity to avail themselves of better housing, rest homes and sanatoria, and new technology for purifying the air and water. The socio-class approach to the problem of Man's ecology shows that, in this sphere too, an intense struggle is being waged between the forces of progress and regression, between socialism and capitalism.

Another criterion for assessing capitalist society's attitude to nature is the exploitation of the natural resources of other, usually less developed, countries. Thus, the USA alone accounts for 50% of all environmental pollution.[24] In spite of this, the US Government allocates only a small part of its national income for cleaning up and preserving nature. Making use of the fact that some natural values (clean air, the waters of the World Ocean) are in unlimited supply, the capitalist countries satisfy their constantly growing industrial demands essentially at the expense of the developing countries.

The flora of many industrial countries provides less oxygen than does that of the developing countries, while the former use up far more of it. This is consumption through a special sort of exploitation of the developing countries. "Ecological" exploitation can be seen as a form of neocolonialism.

It should be noted that the Western press makes frequent attempts to transfer the guilt and blame the less developed countries for the threat of ecological catastrophe! The argument runs as follows. First, in line with Malthus, overpopulation is given as the reason for all Man's difficulties. Then the quantity of natural resources and foodstuffs, as well as the extent of environmental pollution, is calculated, assuming a population growth rate equal to the present one in the developing countries, the preservation of capitalist society and the current technical base. This prompts the corresponding conclusion.

At the 38th North American Wildlife and Natural Resources Conference in March 1973, Lesley Glazgo complained that the population of India was rising at a rate of 13 million a year. If the developing countries did not find a rational solution to the population problem, he lamented, it would constitute a threat to all the states of the world.

One more trick employed by the Western press is to make science and technology the scapegoat. The facts, however, do not confirm the idea that they are responsible for the ecological crisis. No one can deny that technological progress plays a major role in the capitalist countries too but, first of all, the difficulty is to make enterprises replace old technology with new one. This is often unreal, for it would bring a drop in profits. Under free competition, private companies cannot take measures to protect resources if this reduces their profits. In turn, the state cannot force private entrepreneurs to do so without itself assuming the costs entailed. If private entrepreneurs have to make too high outlays on protecting resources, this may be against their interests and result in a slowing down of or a complete halt to production.[25]

Even if nature conservation measures are introduced, however, they are reduced to nothing by economic crises. R.Parson presents a most graphic example. The volatile substances that result in the processing of coal into coke were previously released to pollute the atmosphere. Modern coke ovens can catch these substances, which can now be used to make a variety of useful products. Due to oversaturation of the market, however, these volatile substances are still often lost "up the chimney". This shows how the ecological crisis is beginning to accompany the economic crisis in bourgeois states.

The fuel and energy crises are new phenomena in the capitalist world. These also set off a chain reaction and are aggravated by environmental pollution. During the 1973 fuel crisis in New York, for instance, urban power stations were permitted to use oil with a high sulphur content. This could only result in a sharp rise in the sulphur dioxide content in the air, which is polluted enough already.

Thus, the ecological crisis is no longer simply a dire warning by foresighted scientists and politicians in the West; in the form of the energy crisis it has now become a grim reality. In turn, the energy crisis combines with the pollution crisis to produce the economic crisis. As stated by eminent American public figures, the shortage of energy resources in the United States creates the danger of a major economic depression. The USA is faced with serious dangers, difficulties and uncertainties. A vicious circle is formed. The economic crises lead to ecological crises, which further aggravate the economic situation of the countries of the West.

The economic, energy and raw-material crises and the pollution crisis club together, thus precipitating a catastrophe in capitalist society.

5435

In socialist society the Marxist-Leninist understanding of the interrelationship between society and nature is the

~~general philosophical~~ and social foundation for nature conservation as an integral part of concern for the people's health. A thrifty attitude to the natural environment emerges from the very essence of the socialist state. In the Soviet Union and other socialist countries, in spite of the primary task of developing productive forces, considerable attention is focussed on the construction of purification plants and the improvement of production technology in order to reduce the unfavourable consequences of technogenic influence on nature to a minimum. In the socialist countries, ~~there is no reason for a catastrophic pollution of the~~ natural environment.

A study of Lenin's decrees on nature conservation, the foundations of Soviet land and water legislation, the documents of the 25th Congress of the CPSU, the State Five-Year Plan of national economic development for 1976–1980, and especially of the documents of the USSR Supreme Soviet's Fourth Session which in particular discussed the question "On Measures to Improve Nature Conservation and Rational Use of National Resources", as well as of the USSR Constitution makes it possible to formulate the main features of the USSR's nature-conservation policy.

In the Soviet Union, nature conservation is a task for all the people, and numerous research, state and public organisations are engaged in solving it.

In the Soviet Union, nature conservation is a major task for the state, which coordinates and directs the nature-conservation activities of many public organisations through the Soviets of People's Deputies. The recommendations of standing commissions on nature conservation under the Soviets of People's Deputies are set out most fully in the documents of the USSR Supreme Soviet's Fourth Session and the Resolution "On Measures to Improve Nature Conservation and Rational Use of Natural Resources" adopted on September 20, 1972 by that Session.

5435

The resolution envisages a set of measures to step up nature conservation in the country: a greater responsibility of various organisations and establishments for improving nature conservation and rational use of resources; a better system for planning nature-conservation measures; a whole complex of technical measures to prevent harmful substances being released into the atmosphere or fresh water; timely construction of purification plant; the creation of new and improvement of existing technological processes; economical use of water; improved sanitation of ~~population centres; and so on~~.

State capital investment in special measures for nature conservation between 1976 and 1980 will amount to 11,000 million rubles, more than during the previous five-year period.[26]

The socialist type of social relations opens up favourable prospects for rapidly solving the problem of environmental protection on the basis of the latest achievements of the scientific and technological revolution. The fact that scientific and technological progress is, in individual instances, accompanied by negative consequences does not justify rejecting science and technology altogether. It only justifies rejecting an expansion of production on the old, obsolete technological basis. The smoking up of towns and pollution of water by industrial waste take place primarily where insufficient use is made of the latest means for purifying this waste. Modern technology creates favourable conditions for organising closed production cycles.

In the final count, technological progress cannot in itself solve the problem of protecting the environment, since it has both positive and negative consequences. The ultimate solution to these problems lies in a combination of technological, scientific and social progress.

5435

The fact that, in the Soviet Union, the land, minerals, water and forest are all public property provides the economic foundation for a planned organisation of nature

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conservation. Under socialism, the planning of measures for the comprehensive use of natural resources, innovation of technological processes that prevent harmful waste, the more widespread application of the latest means for purifying bodies of water and fighting agricultural pests, afforestation and land improvement work, plus much more, can and must ensure preservation of the natural environment. "The programme for the further development of the USSR economy as a whole and its separate branches", runs the above-mentioned resolution, "must be implemented on the basis of thorough and comprehensive research, accompanied by scientific forecasts of the possible consequences and definitely by a system of measures preventing a harmful influence on the environment".

The system of nature conservation in the USSR as a whole is focussed on creating optimal conditions for people's health, a goal which is served in particular by systematic study of the necessary sanitary and hygiene conditions and by obligatory sanitary control over industrial and housing construction.

One distinguishing feature of the USSR's activities in nature conservation is the concern shown by the Soviet state for improving the general education in secondary, technical and higher schools on nature study, as well as training, on a wider scale, highly qualified specialists in this field, who will be capable of finding a solution to the nature-conservation problem. The state's activities in this sphere are inseparably linked with inculcating into Soviet people a feeling of personal responsibility for the integrity of nature and a thrifty attitude towards its resources.

It is important to draw attention once more to the need for a comprehensive approach to describing the specific features of nature conservation in the USSR. This will provide a fuller impression of the character, tasks and lines of development of the USSR's nature-conservation

policy, and its methodological and social significance for a global solution to the problem. Concern for nature conservation in the USSR is combined with concern for improving the people's health and living conditions.

The USSR's nature-conservation policy is focussed on active cooperation with other countries and international organisations. At the USSR Supreme Soviet's Fourth Session (1972), it was stressed that the Soviet state, however effective the measures it takes, cannot ensure a solution to the entire complex of problems involved in protecting the atmosphere, open seas and the World Ocean from pollution. The global consequences of environmental pollution can only be eliminated by a common effort on the part of all countries and peoples. A change in the socio-political climate in the world will help to overcome the threat of an ecological crisis. The actual balance of forces testifies that pollution of the natural environment is not inevitable, but all mankind must fight to keep it clean.

NOTES

1 See Ecologist, 1973, Vol.3, No.8, pp.298-302.

2 See ibid., p.301.

3 See ibid., pp.301-302.

4 See ibid., p.302.

5 See Futures, 1973, Vol.5, No.1, p.12.

6 Ibid., p.13.

7 Ibid., p.7.

8 Ibid., p.11.

9 Ibid., p.22.

10 Ibid., p.10.

11 Ibidem.

12 See Nature, March 16, 1973, Vol.242, No.5394, p.148.

13 See *Futures*, 1973, Vol.5, No.1, p.27.

14 See T.W.,Oerlemans, M.J.Tellings, H.De Vries, "World Dynamics: Social Feedback May Give Hope for the Future", *Nature*, August 4, 1972, Vol.238, No.5362, pp.251-255.

15 See *Futures*, 1973, Vol.5, No.1, p.27.

16 *Nature*, May 25, 1973, Vol.243, No.5404, p.249.

17 *Futures*, 1973, Vol.5, No.1, p.142.

18 Ibid., p.150.

19 See ibid., p.142.

20 Ibid., p.144.

21 See *Futures*, 1973, Vol.5, No.1, p.151.

22 See F.Engels, *Dialectics of Nature*, Moscow, 1964, pp.233-234.

23 K.Marx and F.Engels, *From Early Works*, Moscow, 1956, p.565 (in Russian).

24 *Za Rubezhom*, 1974, No.20, p.8.

25 See R.Parson, *Nature Presents Its Bill*, Moscow, 1968, p. 256 (in Russian).

26 L.I.Brezhnev, *Report of the CPSU Central Committee and the Immediate Tasks of the Party in Home and Foreign Policy. 25th Congress of the CPSU*, Moscow, 1976, p.75.

5435

5435

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