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The Necessity to Change the Face of Science

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A broad circle of problems is considered, which science of the future will have to face: rejection of the unconditional bclief into scientific-technological progress as a blessing, changes in the conception of what is scientific in science; possibility of knowledge based on expanding, scientifically sound, ignorancc; formation of a new paradigm as a multidinnensional structure, revealing a holistic vision of the world. (Author)

... a new theory, like all new things, will give a feeling of freedom, excitement and progress. (Feyerabend, 3, p.98)

Professors teaching at universities have always striven to reveal to their audience the face of science, a face which because of its various specific manifestations escapes direct vision. For a long time this seemed to be a manageable if complicated task.

But now the situation has changed. Science and culture as determined by it have reached the maturity level where their further progress has become vague. It is no longer possible to tell the student: "Learn from us and do as we have done". The student must rather be prepared for the possibility of visualizing a new face of science.

But what will this face look like? The future is always unpredictable, which is what makes life interesting and meaningful. And at crucial moments it is altogether absurd to predict anything whatsoever. When trying to look into the future at such moments we must be prepared to see what the new problems will be rather than what solutions they may have.

Some of these problems will be considered below.

Because of the task we have set ourselves this paper looks like a collection of short essays. But this is the only way it could be written at all.

1. Is there any prospect of further scientific-technological progress?

And God blessed them, and God said to them, "Be fruitful and multiply, and fill the earth and subdue it; and have dominion over the fish of the sea and over the birds of the air and over every living thing that moves upon the earth". (Genesis, 1.28)

Scientific-technological progress has long been considered an obvious boon. But now the time has come to doubt this. And the doubts as to the utility of scientific-technological progress increase as this progress continues.

Scientific-technological progress means everincreasing mastery of, alienation from, and subjecting of nature to the increasing needs of mankind. But is it possible to go on endlessly subjecting and conquering life? Will not excessive violence put an end to life?

Let us enumerate, quite roughly, what the continuously increasing mastery of nature brings us: 1) Exponential growth of population – but is that always a boon, and can it go on indefinitely?; 2) Progress in human comfort – but cannot that become a calamity to man, whom nature created to wage a ceaseless, everday battle against the hardships of life?; 3) Scientific cognition of the world – but is not such cognition illusory and does not it bring spiritual life to a dead end?; 4) Intensity of life – we cannot imagine our life outside intensive action, but the urge towards intensity is hardly inherent to man. Rather, it is a peculiarity of our psychic life as produced by Western culture; the East ist more inclined to contemplative perception of the world (at present it is partially switching off to the Western life style, some of whose aspects attract the East, while others provoke fierce resistance).

But the problem in question can also be regarded from another angle. It is important to remember that our ancestor seems to have become a human being as of the moment he started to master nature. The most significant step was, perhaps, the taming of fire. Fire is not merely a tool; it is a system, it has to be controlled, maintained and protected, it can break loose and become dangerous. Man began to learn how to control, and in this process acquired the additional energy he had lacked so far. This was the subject of a brilliant paper read by Goudsblom (1988) at the Congress in Hannover.

In Rustam Roy's book (28) an attempt is made to represent the exponential growth of worldwide population as of the year 5000 B.C. This population growth obviously went hand in hand with an increasing (though difficult to record) mastery of nature. Distinct records of the growth of means to master nature are available as of the middle of the previous century. Correspondingly, the diagrams in Roy's book show the near-exponential growth curves for such indices as speed of transportation, explosive force of substances, and quantity of cement produced. Such a list can easily be continued. The growth of some of these indices will undoubtely come to the saturation level (with exponential increase being replaced by S-shaped logistic curves), but these means of mastering nature will then simply be replaced by other, likewise exponentially increasing ones: lasers and holography, bio-and computer technology (with the latter growing at a terrific rate, some characteristics doubling every two years and others even every single year). It seems relevant to speak now of the exponential growth of the process of mastering nature on the whole – though it can be recorded only with difficulty, since new factors keep entering the game which are hard to compare.

The unrestrained striving for the mastery of nature is giving rise to a number of negative phenomena. Some of them are ecological in nature: pollution of the environment (especially of water resources), destruction of the soil, changes in the atmosphere (ozone holes); judging by the summer of 1988, the greenhouse effect is becoming a reality. Other negative phenomena relate to man: the evolution of some specific diseases, especially mental ones; the increased percentage of retarded babies; the growth of suicide rates and criminality (especially juvenile delinquency); the increased number of alcoholics and drug-addicts; the loss of respect for work and of interest in serious education[1]. These are mainly secondary phenomena, brought about by the mechanization, industrialization, and de-individualization of labor and by the bureaucratization of social and governmental structures. The mastery of nature and the ensuing scientific-technological progress do not seem to have decreased aggressiveness, especially the collective variety, inherent in man from ancient times. It should hardly be correct to say that man has become more intelligent and tolerant, least of all in his social manifestations. If one were to calculate the average number of violent deaths during each century, we would be struck by its impetuous growth.

The aforegoing statements need no detailed comments, since the subject has been discussed at length both in the press and at numerous conferences. It is important to emphasize that the planet Earth, our wonderful cosmic shelter, is in danger, together with all its inhabitants. Suddenly, despite the growing comfort of life, people have begun to lose motivation, the major human existential element. Danger is growing and acquiring sinister, namely exponential proportions. It is becoming quite obvious that scientific – technical-progress is anything but a blessing.

Social-economic problems that for centuries have dominated the Western world are beginning to give way to existential problems. Once more Utopias have begun to appear – now directed at the search for radically new modes of existence. They reject the tendency towards the mastery of nature. They search for ways that would open up the possibility of human existence in friendly cooperation with nature. They reject ceaselessly expanding technology and bureaucracy. They reject hedonism. They search for the spiritual in a holistic vision of the world[2]. We are now on the verge of a new revolution of unprecedented significance. The urge towards the mastery of nature was built into us in ancient times.

Nobody knows what will come true and in what form. Even the nearest future is closed to us. But our subject is the change of the face of nature in the vaguely perceived future. Wishing to come closer to an understanding of this subject we have to formulate the following question: how can science exist if it is not supported by growing technological progress? This question may be formulated in a broader way, too: How can science exist within a culture not oriented to the mastery of nature?

At present there is no one who could answer such questions. But teaching students at universities, as we do, we must keep this problem in mind and communicate it to our students.

2. Is science scientific?

. . . there is not a single interesting theory that agrees with all the known facts in its domain. . . . Science is much closer to myth than a scientific philosophy is prepared to admit. It is one of the many forms of thought that have been developed by man, and not necessarily the best. Feyerabend (3, p.31 and 295)

Our society leads a calm life: it has a shelter. An overwhelming majority believes that science is infallible and certainly objective. This belief is akin to the previously existing convictions of the infallibility of religion and omnipotence of magic. In the Soviet Union, significant decisions are usually accompanied by the incantation: "The proposed decision is scientifically grounded".

But does science itself correpond to the scientific ideal formed around it? Does it become more scientific as science and technology advance? We will examine two aspects of this problem: the predominantly inductive approach, which deals with inferences directly following the experiment (with some theoretical reasoning preceding), and the predominantly deductive approach, which starts out with serious theoretical constructions to be compared later with experimental research.

(1) The predominantly inductive method. In the two cases mentioned we obviously deal with different degrees of scientism. Even if the initial knowledge level is dramatically insufficient, an experiment still answers a distinct question. The scientific character of research is primarily determined by the profoundness and distinctness of this question. Later on the degree of scientism will depend on the data processing technique used. This technique may consist in the reduction of data to standard probabilistic-statistical structures (distribution functions, clusterograms, etc.) yielding readily to object identification. This is the form of inductive inference that is typical of science. Scientometric data testify to the growth of publications containing this sort of inference. A case in point is psychiatry, a branch of knowledge which yields to quantification only with difficulty, causing statistical methods to be still widely used here (cf. DeGroot and Mezzich (4) who scanned three well-known psychiatric journals for 1980).

However, no more than anything else will such inductive analysis of data make for perfect clarity. The use of mathematical statistics allows us to take into consideration (with the help of modern computers) an unprecedented number of independent variables (as many as 100 and more), thus increasing the significance of our research. But in this case the results of the analysis lose their customary clarity, and one will be faced with the increasingly acute problem of selecting the scales of measurement that set the metrics of the space where clusters are searched for. Such selection of metrics, however, means introducing an essentially deductive operation into the inductive procedure. Now is the researcher always prepared to do this? It is certainly possible to search for clusters in spaces of different metrics, which will make us see the experimental data through many different filters arbitrarily given by us. This is an essentially new thing in science. But from the point of view of previous concepts this novelty, for all its attractiveness, seems rather unscientific.

Every question has not only an interrogative component but also an assertive one which makes the question possible in the first place. The assertive part of the question that starts the research concerned may be given by the analytical form of a mathematical model. In that the interrogative component will be concerned with the numerical value of the parameters, with testing the adequacy of the model, with its possible replacement by one of the rival models (if several ones were given a priori) or with the proper interpretation of the model selected. To select a model a priori (i.e. before the experiment) again means introducing a significant deductive element into the essentially inductive research. If this has been done, a priori mathematical experimental design also becomes possible (see e.g. Nalimov, Golikova, and Granovsky, 1985). This results in a sharp decrease of errors in parameter estimation (especially when the number of independent variables is great) and in the elimination of systematic errors. But experimental design, a well-established theoretical discipline, has not – despite all its advantages – attained broad popularity yet. The requirement calling for the a priori selection of a model seems to be difficult to fulfill. But can an experiment be termed scientific if it is not designed in accordance with the mathematically distinct optimality criteria?

Experimental design is especially important in discriminant problems, when we are to choose the best model from several rival ones. In this situation mathematics is used to select the optimal (for the solution of a given problem) distribution of experimental points in the space of variables. However, the success of the solution again depends on the observer – on whether he has included a really good ("true") model in the number of all models tested[3].

Still another very important feature need be taken into account: in order to reveal systematic errors, the experiment must be subjected to intra-laboratory testing. Anyone with experience in this sort of testing knows how unexpectedly great the divergence between results obtained in different laboratories can be. Here the paradox is that technological progress is having a retarding effect. To quote the biochemist Neufeld (23, p.59) on this matter:

> The experiments of today are dependent on high technology, sophisticated equipment and are often performed and analysed with the help of computers. The equipment or technique is expensive and complex, and may represent years of training by one of the coauthors.
> Who can take several years out of their careert to set up and reproduce those experiments?
> . . . The decline in the need, ability and expectation of reproducing results is a major change in how we build the scientific foundations for the hypotheses we construct.

To sum up the main idea of the above section: 1) Even in purely experimental research, no matter what branch of science we take, the part played by the observer carrying out the research is essential. It is impossible to speak of a special scientific, unbiased attitude of some sort. 2) It is impossible to state with certainty that scientific-technological progress increases the degree of scientism of a scientific experiment.

(2) The predominantly deductive method. Major theories are usually produced in a deductive way, whereupon the question arises as to their conformity to experiment. Karl Popper has shown quite unambiguously that as a demarcation criterion falsification must replace verification. Hence it follows that a hypothesis always remains in need of further testing (26, 27). As a matter of fact, the idea of falsification can be found in any better manual of mathematical statistics. The purpose of the statistical analysis of data is to disprove a given hypothesis by the experimental results obtained[4]. But is it possible to call deductive concepts of broad philosophical significance into question? What can be done to Darwin's theory of evolution or Freud's concept of the unconscious?

In our days, even physics is acquiring a non-Popperian character. To quote significant relevant statements by Morris (16, p.112-113):

> I only want to point out that there seems to be a widening gap between theory and experiment. It appears that physicists have advanced the frontiers of science so far that they now run the risk of putting forth questions that are unverifiable and therefore possibly meaningless.
> On the other hand, it is possible to adopt the point of view that even the most far-ranging speculation serves a legitimate scientific purpose. If scientists do not try to imagine what might be true, they will never be able to tell what is true. One could argue that even if we can never determine whether extradimensions of space exist or not, the discovery that they *might* Exist had added to our fund of knowledge. Similarly, if physicists do not attempt to work out the implication of the possible existence of shadow matter we will never know whether the reality of this odd substance is a possible one.
> Perhaps the wisest course would be to suspend judgement and to observe simply that the nature of theoretical speculation has changed. In the early decades of the twentieth century, theoretical speculation had the same "bizzare" character that it possesses today. However, in those days, speculative ideas were either quickly verified in the laboratory or discarded because they had been shown to be untenable. That no longer seems to be the case today. By the 1980s the trend was to heap speculation upon speculation. It may be too early to tell where all this will lead.

In thinking over these interesting remarks I would like to note that speculative constructions fundamental for their epoch (not called into question by experiment) have always been there, but did not create a hubbub, and it was they that, independently of their degree of correctness from the point of view of the scientists of subsequent epochs, made science possible. Without them it would have been impossible to ask questions – there would have been no assertive component[5]. I shall confine myself to one illustration: from the time of Democritus matter was believed to consist of indivisible elementary constituents. This was part of the assertive component of many questions that physicists asked nature. We know by now that the concept of elementary particles was and is illusory: non of matter's basic particles is elementary, for each one is a complex system; it can even be said that each of them consists of all the others, or that all of them are manifestations of one and the same field. But could physics have developed without the fundamental concept of matter existing in the form of elementary particles? The above observation by Morris testifies to the fact that very important things have occurred in the physical sciences: fundamental concepts have lost all sense of shame and are piling up.

On the other hand, the facts described by Morris can also be considered from the point of view of Feyerabend, who proposes to act in a counter-inductive way. To quote one of his pertinent statements (3, p.30):

Some of the most important formal properties of a theory are found by contrast, and not by analysis. A scientist who wishes to maximize the empirical content of the views he holds and who wants to understand them as clearly as he possibly can must therefore introduce other views, that is, he must adopt a pluralistic methodology. He must compare ideas with other ideas rather than with "experience" and he must try to improve rather than discard the views that have failed in the competition... Knowledge so conceived is not a series of self-consistent theories that converges towards an ideal view; it is not a gradual approach to the truth. It is rather an ever increasing ocean of mutually incompatible (and perhaps even in commensurable alternatives), each single theory each fairy tale, each myth that is part of the collection forcing the others into greatest articulation and all of them contributing, via this process of competition, to the development of our conscious ness.

Let us examine one example of conceptual polymorphism. Moscow University president A.A.Logunov (15)[6] has come out against Einstein's general relativity theory (GRT), which he regards as too complicated as well as incomplete. In a brief outline his attitude reads as follows:

... Einstein quite consciously rejected the concept of a gravitational field as a physical field or the Faraday-Maxwell type (p.216)... In GRT it is impossible to infer the law of preservation of energy-impulse of the substance and the field taken together (p.217)... the transfer of gravitational energy in space from one body to another is impossible (p.217)... According to GRT thinking, the relativity principle is inapplicable to gravitational phenomena. It is in this crucial respect (...) that Einstein and Hilbert principally deviated from special relativity theory, which brought them to reject the laws of preservation of energy impulse and angular momentum (p.217) ... Inertial mass as defined in Einstein's theory has no physical meaning (p.218)... At present it is accepted as a proven fact that the gravitational mass of the system consisting of substance and gravitational field is equal to its inertial mass... However, this conclusion is wrong (p.221).

Logunov constructs a relativist gravitation theory (RTG) based

... on the concept of a gravitational field as a physical field of the Faraday-Maxwell type having energy-impulse (p.219). The geometry of the space-time continuum for all physical fields is pseudo-Euclidean (Minkovsky space) (p.219) ... the laws of preservation of energy-impulse and angular momentum are rigorously fulfilled (p.219). RTG explains the entire existing aggregate of observational and experimental data for gravitational effects in the solar system (p.256).

Thus we see that at least within the boundaries of a weak gravitational field as existing within the solar system the two theories, GRT and RTG, cannot be jeopardized by juxtaposition. At the same time their predictions are essentially different. Thus, RTG does not assume the existence of black holes in space-time as predicted by GRT. But black holes have not so far been discovered and if they do exist discovering them is far from simple.

How should one respond to these conflicting hypotheses concerning the foundations of the Universe? Heated discussions are taking place in the Soviet Union. The supporters of both theories are diametrically opposed to each other. The only possible criterion for making a choice seems to be the elegance of the constructions, which is a highly subjective matter. One can come across conciliatory statements, too. For example, the well-known Soviet physicist V.L.Ginzburg writes in his popularizing article (5, p.48)

So, guided by the wise principle of "greatest favourability" RTG should be considered today as an alternative gravitation theory in need of a certain analysis and discussion .... At the same time there is no reason whatsoever to say that GRT is at present in any way shaken... The more I had and have to deal with GRT and the objections raised against it, the more profound an impression do I acquire of its unique profundity and beauty.

I personally would describe the problem in a different way. What has happened testifies to the fact that we have to acknowledge the right for a profound, in-depth relativism within science itself. It should be acknowledged that both GRT and RTG are but metaphors, essential metaphors. From GRT it follows that gravitation is a purely physical phenomenon which, however, can also be interpreted as a purely geometrical one, one which, strange though it may seem, is loading to new unexpected statements on the possible arrangement of the world.

We have examined this example so thoroughly since we are confronted here with an event of possibly historical significance. But there is also a purely sociological aspect to this phenomenon. This stand could be taken only by a high-ranking scientist. What would have happened if an alternative theory of this significance had been proposed by a rank-and-file scientist? Could he have gathered a collective of assistants around himself? Would anyone listen to such a person? Most probably he would simply lose his job. So it turns out that science obeys obviously non-scientific factors.

But let us turn now to such sciences as biology, psychology, sociology. They lack altogether deductive constructions of such power as the physical sciences have. Biology has Darwin's theory which, as a matter of fact, has been radically modified by now. But in this form, too, it cannot be called into question by observation. There are many publications containing criticism of Darwinism – to mention only Berg (1), Chauvin (2), Krasilov (12), Nalimov (20). But Darwinism is still unshakable. Why? --The answer seems very simple: there is no other theory, and not having one at all is uncomfortable.

So what does it mean: to be scientific in science?

To my mind, to be scientific means to be metaphoric, i.e. to be able to produce a fruitful metaphor stirring people's imagination and thus expanding our interaction with the world.

Indeed, as science advances, the metaphoric character of its hypotheses increases. At the same time pluralism in the system of scientific structures grows also. But does it all correspond to the traditional concepts of the scientific nature of science?

3. Does science have forecasting power?

It is commonly accepted that forecasting is one of the prerogatives of science. The word combination "scientifically grounded forecasting" has acquired the flavor of an incantation, though its meaning is far from being always clear, since the term 'forecasting' is polymorphous.

Consider here several possible cases.

1. Forecasting in the physical sciences. Here everything is clear enough: the basis for forecasting is a sub-

stantial deductive construction embodied in a mathematical expression that contains fundamental, i.e. never changing constants. Such forecasting may step beyond the boundaries of what follows from previous experience – this is what happened, for example, in forecasting the possibility of getting an immense amount of energy directly from the atom.

2. Forecasting in biological or social systems. Here the situation is quite different; we have to resort to inductively constructed models based only on part of the independent variables of the system; parameters of such models are not absolutely stable. Certainly, this type of simulation can produce trivial forecasts, i.e. the forecasts of the way a process will evolve in a basically unchanging system. But all efforts will be wasted if we wish to make non-trivial forecasts, to forecast the conduct of the system under a radical change, as for example, under direct anthropogenic influence on an ecosystem. We are unable to control nature scientifically. Any artificial violation of natural systems easily leads to their destruction. It is very important to understand this well[7].

4. Where lies the cognitive power of science?

> *The entire apparatus of knowledge is an apparatus for abstraction and simplification – directed not at knowledge but at taking possession of things. . . (N 503) . . . The world seems logical to us because we made it logical. (N 521) Nietzsche (24)*

Cognition – the acquirement of knowledge about the World – is commonly identified with the cognition of laws acting in nature. But can we accept the thesis that laws determining the existence of the Universe actually exist? Popper, who considers himself a critical realist, says in this connection (27)[8]:

"My answer to this question is 'Yes'."

But if it is Yes, this is to say that we believe unconditionally that the arrangement of the universe is rational. Otherwise, we assume the existence of a grandiose structure that is sufficiently rich logically to collide with Gödel's limiting theorem. In practice, in his everyday research, the scientist does not have to face this difficulty since he deals with local descriptions of the Universe.

Due to the peculiarity of our thinking, we have ascribed to the World the quality of being rational. This was well understood by Nietzsche (24):

Logic is the attempt to comprehend the actual world by means of a scheme of being posited by ourselves; more correctly, to make it formulatable and calculable for us. (N 516)

At present we are witnessing a conspicuous tendency to reject panlogicism: there is a growing relativism towards theories, the right is acknowledged to regard them as metaphors; the basic concepts of space, time, number, and matter can be ascribed the status of a metaphor (Jones in (9)); the idea has been introduced, though only timidly so far, spontaneity being the major fundamental principle of the universe (this subject is considered in detail in my paper (21), as well as in the book by Graham (7).

However, we are and remain positive that science has cognitive power, though, possibly not understood as broadly as it used to be. Our confidence is supported by the following considerations:

(1) No matter how conventional scientific constructions are, they are invariably accompanied by the mastery of the World. There is no doubt as to the reality of the process: everything is quite obvious, and there is no need to formulate any criteria. The mastery of the World is accompanied by our expanded interaction with it. The spectrum of our interaction is constantly broadening. And this process is, without doubt, a cognitive one. As we master the World, we learn more and more about it. This is real knowledge, though it cannot be kept within the boundaries of unambiguous and indisputable hypotheses. In this process of mastering the World hypotheses play rather a subsidiary part[9].

(2) Science has helped people to get rid of primitive views of the World produced by immediate sensual contacts and supported by literal interpretation of religious myths.

(3) Science has revealed to man abstract structures that he was able to understand: spaces of different geometries; time in all conceivable varieties of manifestations; the manifold notions of number and measure; the idea of a probabilistic measure setting the fuzziness of both our concepts and objects themselves observed in the World; the concept of the infinitesimal and the calculus based thereon; the concept of sets; the idea of different possible logics. On the basis of these structures it proved possible to create the variety of languages reflecting in different ways our attitude to the World and to ourselves. It is hardly necessary to say anything on the adequacy of these languages: they will be in active use until something new can be said.

5. Are those sciences that are traditionally regarded as inductive ready to change their course?

> *. . . there is every necessity for number as a foundation. Plato (25) N 977d*
> *. . . I state that in any particular teaching of nature there is only as much science proper as there is mathematics in it. Kant (10, p. VIII)*

It still remains unclear whether sciences that were previously regarded as descriptive ones and alien to theoretization are able to use languages containing abstract notions.

The tornado of computerization sweeps over new territories. My colleagues and I have for more than five years taught biologists what is called computerscience. Actually what we do is not the mathematization of biology but its computerization. There have been definite achievements. Biologists have learned to solve complicated biometrical problems by means of computers – these problems often include a large number of independent variables. But are these biologists ready to evaluate the realism of the initial premises that are to form the basis of any model?[10] And if this is not so, then will not all these activities result in a pollution of our environment? Perhaps, the computerization of biology should be preceded by the mathematization of its fundamental concepts. But this means that biology must become a deductive science at least to the (far from complete) degree that physics has become it. Is this possible?

One might object: what about the immense number of publications[11] related to the mathematization of biology? Well, they are indeed quite meaningful, but nevertheless the predominant ideas are those borrowed from physics and physical chemistry. The peculiar manifestations of living nature are lost.

Let us consider as an illustration what is happening in big ecology. Yu.M. Svirezhev, who can look back on a long experience in mathematical ecology, outlines the following vague problems (30, p.360): "How is one to obtain discrete structures from a set of constantly changing parameters?"; "How is it possible in general to explain the purposeful character of evolution and its – in principle – irreversible course" (30, p.363). Evaluating the situation on the whole he writes:

The problem of selecting an adequate mathematical description in ecology is in general very acute. The methods of description that used to borrow from other, more mathematized sciences have on the whole spent themselves. It is now necessary to look for new, non-traditional approaches, which, however, may be based on well-known mathematical concepts (30, p.360).

But is it possible to look for an adequate mathematical language without formulating biological axiomatics: without defining just what biological space and time are, what changeability is and how it is related to biological stability and, last not least what life itself is?

The present-day mathematization of biological knowledge has achieved its purpose: it has made the mechanistic foundation of modern biology evident and has revealed the adequacy of the mechanistic approach.

In finishing this section I would like to ask: isn't there a danger in that awkward and too hasty mathematization of traditionally non-mathematical fields of knowledge supported by powerful computerization will enhance further loss of the scientific nature of science?

6. Revelation of knowledge through ignorance based on scientific argumentation.

We have to acknowledge that the growth of science is accompanied by a growth of our ignorance – though not a vulgar one but a refined, scientifically embellished ignorance. Scientific relativism as expressed by many equally justified but incompatible hypotheses constantly broadens the spectrum of our consciousness. We begin to view the World through a variety of different images – images we have made up and which are within the reach of our consciousness. Knowledge based on expanding ignorance is a specific kind of knowledge, it lies beyond categories, it cannot be refuted, only expanded. Our knowledge of this kind is now much bigger than in the past, bigger than the knowledge shared by the scholars of earlier generations. For example, now we know a lot about geometries of various spaces, we shall perhaps learn even more, but we shall never learn what space we actually life in. Moreover, from a platform differing from Kant's, we are now prepared to admit that the idea of space is only an image; an image – we have made up, one capable of infinite enrichment, but not assured of a safe landing.

It seems we have to recognize there is Mystery in the World – and we can only make it more profound.

The above speculations are certainly not new. A similar idea is expressed by Harrison (8, p.171) if from a less general position:

No doubt in the future much will be understood that to us is still murky and perplexing. By then almost certainly we shall have uncovered new riddles. The unknown will loom as large as before, possibly more so, and the heart will yearn for refelation which when found will lead inevitably to the discovery of a fresh mystery. The more we know, the more aware we become of what we do not know (p.171).

Later on Harrison comes to dwell on statements by Nicholas Cusa:

In his work "On Learned Ignorance", written in 1440, Nicholas Cusa argued that though the darkness of unlearned ignorance disperses in the light of knowledge, there is another side to ignorance, which he called learned ignorance, that grows with knowledge and wisdom. . . With knowledge comes an awareness of ignorance – learned ignorance – and the more we know, the more aware we become of what we do not know. (8, p.273)

7. Science: is it rational or irrational?

Science is rational in the sense that it (1) does not acknowledge the Mystery of the Universe – it believes in the existence of universal regularity yielding to logical revelation; (2) demands that communication among scholars be logically faultless: (3) is ready to recognize the possibility that a computer can become an analogue of human intelligence.

Science is irrational in the sense that it (1) is based on insight-creating flashes on a pre-logical level of thinking (21); (2) is based on images on its deep levels (where abstract mathematical structures may also become images) (21); (3) opens up the possibility to see the World through scientifically-revealed ignorance, thus bringing us back to contemplation of the Mystery of the Universe.

Scientific activity, as any other human activity, is inherent to man. The rational and irrational are inseparable linked within it, but there may be asymmetry, a bias into one direction. And as any other activity, it can lead man into a blind alley and mankind even into a catastrophe.

8. The problem of man

One has to pay for everything. The dominance of science during the past three centuries was paid for by universal human ignorance, by a lack of comprehension as to what life actually is. What we mean here is not a scientifically-based ignorance, but just plain, vulgar ignorance. No new, essential hypotheses concerning human nature have appeared in science during these three centuries (Nalimov 1988). Nor could they have appeared. To subdue nature, science had to declare that the World was arranged along p-urely mechanistic lines. This resulted in a barrier separating scientific thought from everything alive and, moreover, from thinking. This barrier can be described as follows: (1) An (implicit) prohibition was issued forbidding the World to contain spontaneity (anything not governed by law); (2) The existence of meanings as a separate reality was excluded; (3) The opportunity to study individual, irreproducible events[1 2] typical of life was prohibited, thus excluding from the scientist's sphere of action not only any non-trivial, essentially creative human activity, but also the living World as such, which also exists in its irreproducible changeability.

9. In what way is a holistic vision of the World possible?

We need an external standard of criticism, we need a set of alternative assumptions or, as these assumptions will be quite general, constituting, as it were, an entire alternative world, we need a dream – world in order to discover the feature soft hereal world we think we inhabit (and which may actually be just another dream-world). Feyerabend (3,p.32)

This question has already been formulated in all its poignancy – see e.g. the journal ReVision (29) which is entirely devoted to this topic. I confine myself to explaining my point of view.

I believe that radical, even revolutionary changes are to be expected in the paradigm of our culture.

First we shall have to free ourselves from all doctrinal fetters of any kind: ideological, philosophical, scientific, religious, or aesthetical.

We must acknowledge that the Universe is submerged into Mystery – it cannot be solved, nor should we try to solve it. It must simply be acknowledged as existing. Its image, always discerned by us as fuzzy and vague, must endlessly expand and deepen. We must begin to approach it, strive to be merged into it, while being aware of its evading us the closer we approach it. But to make it happen, the paradigm of culture must become a multidimensional structure.

We must learn to use in correlation everything gained by mankind during its evolution: the rational and the irrational, the aesthetical and the mystical. Let us not be afraid of the latter word, which denotes the technique humanity has been using from time immemorial.

When I start to write a scientific book, I want it to contain scientific, aesthetical, and religious components. I wish it to have a rhythm brought about not only by the intermittent words and phrase structures but also by its meaning. I like to use mathematical structures as images by means of which we can see the World in a new way. I try to support my ideas not only by philosophical conceptions of the past but also by some concepts from contemporary physics. I also like to touch on topics that are traditionally related to the realm of religion.

I am not in a position to decide whether or not I am successful in this. The important thing is to gain the right to do this and the opportunity to be heard. This is how I perceive my participation in the movement aimed at comprending the holistic nature of the Universe – the movement which is now often called Holomovement.

10. Conclusion

I have attempted to sketch an image of science. This image is versatile. It cannot be reduced to a short formulation. It differs from the image we have seen in the past, even in the recent past. We can discern in it the tentative outline of the future. It is closely related to the general state of culture, whose course is still vague.

But before we start to speak of the contours of the future, I would like to quote Kuchinsky, who represents the science of management (14, p.160):

There are certain things we can be sure about regarding any and all man-made systems. They begin to become obsolete as soon as they are created. They create no fewer problems than they solve. Their lifetime is comparatively limited. If they are pursued too long or too vigorously they turn into their opposites. The greater their initial success, the harder their inevitable fall. The stronger and more extensive their foundation of fixed knowledge or position, the greater their threat to man's existence.

The above statements are self-evident, but this subject has never been discussed in so categorical a form. It is equally self-evident that science has long stopped being a thing to enjoy. It has begun to turn into a system. And one of its titles is Scientific-technological progress.

Science breaking into the fetters of its own one-dimensional paradigm, ceasing to be a system, becoming a free and easy occupation again, capable of existence in community with all other aspects of human consciousness, an occupation versatile by nature – this is what I see as being concealed by the curtain of tomorrow.

Notes:

[1] To quote the editorial in the Aug. 15, 1988, issue of the leading Soviet daily "IZVESTIYA": ". . . two thirds of the fifth grade pupils feel a deep aversion to studying.

[2] When reading papers or listening to reports on this topic I invariably remember the Russian Utopian P.Kropotkin, a scholar (geographer), traveller and anarchist revolutionary, very popular before the Russian revolution and in the first years thereafter, but now completely forgotten. (Not even his tombstone indicates that he was a revolutionary, and in the street named after him there is a monument to Engels). His anarchism assumed the existence of an urge towards self-control based on the ethical principle whose source he perceived in nature. One of his books (13) was entitled "Mutual aid as a factor of evolution". His outlook was founded on a deep belief in man and his interrelations with nature. And this is the belief we must revert to if we hope for decentralization, debureaucratization and ecologization. Being a revolutionary, Kropotkin accepted the revolution but tried to soften it. Now it is becoming obvious that a rejection of man's unrestrained power over nature is but a manifestation of the outlook of peaceful anarchism.

[3] An illustration: five models were subjected to investigation in the laboratory. One of them proved to be undoubtedly the best. But in the industrial test another model proved to be the best, that had been found unfitting in the laboratory. Explanation: the models selected were not invariant with respect to scale changes. As a result the laboratory test deceived the researchers, though the experiment was formally irreproachable.

[4] Popper's views on the evolution of science were examined in detail in my 1980 paper (17) and in Chapter I of my 1981 book (18).

[5] In previous publications (see e.g. (18)) I already called attention to the fact that the real progress of alchemy was very slow. The alchemist's mentality was mythological, not hypothetical: he did not have an opportunity to ask questions of nature, lacking as he did meaningful formulations for their assertive components.

[6] Logunov's book is not easy to read, containing as it does over

700 numbered formulas. He wrote it as a challenge.

[7] The difficulties of principle arising in connection with non-trivial forecasts were discussed in detail in my work (19).

[8] This is a quotation from the 1972 edition of the same book.

[9] The notion of cognition as a mastery of the world is far from being new. That was understood in a way by Nietzsche, as is evindent from his words used as a motto to this section. The same idea was for some inexplicable reason shared by Marxism-Leninism. The "Encyclopedia of Philosophy" reads (11, p.562): Cognition, according to Lenin, and therefore knowledge, too, is a process when the mind submerges into reality to submit it to the power of man.

[10] I would like to give two illustrations here: (1) Assume that a biologist wishes to use multidimensional regression analysis. There is a theorem saying that parameter estimates of the regression equation obtained by the least squares method are unbiased and optimal in the class of linear estimates. But this theorem is valid only if all the independent variables are taken into consideration. Is this premise ever fulfilled in biological research? And what is the good of biased estimates especially if the task is the control of the system when its covariance structure is changed? In the second section of the present paper we already asked: how can the result of a classification be regarded as objective if the metric of the space of the classified objects is arbitrary? To be able to discuss this subject in a meaningful way, the biologist will have to reconsider the biological problem in geometrical terms.

[11] Let me indicate here only the series "Lecture Notes in Biomathematics" published by Springer Verlag. By 1988 the series had run to 74 volumes.

[12] Even in Popper (27, p.86) we find the statement: non-reproducible single occurences are of no significance to science.

[13] The first edition of this book was issued in Great Britain, and then in Russia, in 1904. The name of the author was put as P.Kr-in, because of censorship. The second edition of 1906 was confiscated (see Pirumova, N.M.: Pyotr Alexeevich Kropotkin. Moscow: Nauka 1972. 223p.

[14] The dialog may belong to one of Plato's disciples.

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