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Philosophical Problems of Biosphere Control

The appearance of life on the Earth signified the origin of the planet's biosphere. Having originated the biosphere of the Earth simultaneously expanded and grew more complex. Progressing in forms of organisation the living organisms spread to the seas and oceans, inhabited the atmosphere and converted the upper layer of the lithosphere into soil. But even now, when the living things on the Earth number 1.5 million species and the weight of the biomass exceeds 300,000 million tons of dry substance, the biosphere is still a thin film spread all over the Earth surface and is, therefore, spherical.

Man is a product of historical development and a constituent part of the biosphere, but at the same time somewhat different from it, interacting with it and opposing it. In the course of man's historical progress the dialectical *interaction* between society and the biosphere gradually changes to *control* at first of separate elements of the biosphere, then its parts and, lastly, of all the biosphere on a world scale. Man is still far from solving the latter problem in practice, but theoretically this problem is urgent already today. In this article we shall briefly examine but a few of its philosophical aspects.

THE SCIENTIFIC AND TECHNOLOGICAL REVOLUTION AND THE BIOSPHERE

Man's entrance into the epoch of the scientific and technological revolution in the second half of the 20th century has resulted not only in a change of the scope, but also in a fundamental *qualitative* change of the very character of society's influence of nature. In former epochs the scope and results of this influence were comparatively limited. In the 19th century both advocates and bourgeois opponents of Malthusianism regarded overpopulation of the Earth and provision of food for the increasing population as the main problem of interaction between society and nature: But today this type of exchange of substance between society and the biosphere, despite the "demographic explosion" caused by decrease in mortality and simultaneously a high birth-rate in the developing countries, is being clearly relegated to the background. According to ecologists, the present 3,500 million people are equivalent, by the extent of their influence on nature, to about 30,000-40,000 million people of the Stone Age, although the food consumption per person is about the

same as it was thousands years ago. The main thing today is the *technical influence* of the people on nature, one of its results being pollution of the environment with the waste products of production and everyday activity.

The main factors influencing the biosphere today are not so much the increase in population and agricultural production, cultivation of new territories, etc., as industrial, technical production activity which leads to poisoning of the atmosphere and the water of the rivers, lakes and oceans with dust, gases and harmful chemical and radioactive substances.

It is particularly important to take into account that the scientific and technological revolution began under conditions of a split of the world into two opposing socio-economic systems. The war danger originating from the imperialist countries determines the rocket-nuclear arms race. The already accumulated reserves of nuclear weapons are quite enough to exterminate a large part of mankind and seriously harm the reproduction of the human race by perniciously influencing the genetic material throughout the biosphere. The reserves of chemical and biological weapons are fraught with no less danger than the nuclear bombs.

The well-founded anxiety of the people forces the governments of the capitalist countries to take some measures of nature protection. But these measures are absolutely inadequate. The rivers, seas and atmosphere are being increasingly polluted and the soil poisoned with chemicals, while the forests and animal kingdom are being exterminated as a result of monopoly rule, the situation in the dependent countries and colonies being in many respects even more alarming than in the USA, Western Europe and Japan. The American imperialists are exterminating the population, as well as the animal and vegetable kingdoms in Vietnam. Not very long ago a new concept—"ecocide"—meaning deliberate extermination of everything living and destruction of the ecological balance came into existence.

When the threat to the biosphere increases declarations on nature protection become almost an obligatory "side dish" in the speeches of capitalist politicians and the programmes of bourgeois political parties. Moreover, in the USA and Japan the problem of conservation of the environment is shamelessly used by the ruling circles as a kind of lightning-rod to switch the people's attention from the critical social problems, like the extremely low wages in Japan, racial discrimination, the antiwar movement, inflation and increasing unemployment in the USA, to such a common problem as nature protection that is of equal concern to all the citizens.

A true basis for solving the problem of controlling the biosphere on a world scale can be provided only by planned socialist economy. An idea of the necessity of taking international measures to protect nature is already making its way because the problems of biosphere control cannot be solved in a single country since the biosphere is truly indivisible. That is why in the Report of the CC CPSU to the 24th Congress of the CPSU nature protection was referred to as both our internal and international problem. In taking measures to expedite the scientific and technological progress in the USSR "we must see to it that it should combine with rational treatment of the natural resources and should not cause dangerous air and water pollution or exhaust the soil". The Report emphasises the readiness of the Soviet state "to participate in col-

lective international schemes for nature protection and rational use of the natural resources", "in settling problems like conservation of the environment" ¹

Control of biosphere is one of the greatest problems facing man today. And this is where capitalism's total incompatibility with the requirements of historical progress manifests itself particularly clearly. F. Engels referred to it as far back as 100 years ago. Noting the lack of coincidence between our aims and the results of our activities Engels held the domination of private interest to be the fundamental cause of it.

For Engels freedom as regulation of the natural processes is inseparable from the freedom as regulation of the development of society. Hence, to subdue nature man must subdue the social forces, and this requires "something more than mere knowledge. It requires a complete revolution in our hitherto existing mode of production, and simultaneously a revolution in our whole contemporary social order" ²

Despite the truly tremendous difficulties which the first socialist state encountered it was the first in history to consider the more remote social consequences of the most important technical projects. If it were not for Russia's backwardness under tsarism and the need to overcome it at all costs and in the shortest possible time, if it were not for the unprecedented ravages inflicted on our country by imperialists during the foreign intervention and Civil War and, especially, during the war against nazi Germany, and if it were not for the necessity of spending a large part of our means on defence even today, our natural resources could be used incomparably more rationally and with greater regard for the requirements of the future.

A good deal has been and is being done but the Soviet people are quite naturally concerned about the purity of the Baikal water, the excessive felling of forests in the European part of the Soviet Union, the soil erosion in the steppes, the ill-considered use of DDT and other chemicals, the flooding of large areas during the construction of hydro-electric power stations, the unpunished destruction of the fauna by poachers, the pollution of rivers with sewage, etc. Such facts are daily discussed in the central and local Soviet press. Like any other aggregates of facts they admit of various generalisations.

It is well known that in cases of one-sided generalisation "the forest may not be seen for the trees". Of course, one-sided conclusions are based on certain facts. But facts should not be taken "at random", but in their aggregate, their totality, their objective relationship. It is precisely one-sided generalisations that underlie the controversies between "optimists" and "pessimists" about the future of the biosphere and, whereas at one time the voices of "optimists" clearly prevailed in the Soviet Union, today, on the contrary, the voices of their opponents sound louder.

The "pessimists" most commonly appeal to the emotions. They refer to the numerous facts of real damage done to nature and the health of the people, are justly indignant at these facts, urge the people to struggle against the factory directors at whose instructions impure water is drained into rivers,

¹ *24th Congress of the CPSU, Documents*, Moscow, 1971, pp. 69, 70, 38.

² K. Marx and F. Engels, *Selected Works*, Moscow, 1970, Vol. 3. p. 76.

against the dam builders who fail to take into account that fish must spawn, against the timber industry workers who continue to fell forests where they should be planted, against all manner of poachers, against hikers who leave fires in forests, etc. This indignation is legitimate, although it is not at all the privilege of "pessimists" But it is characteristic of them that the attention is fixed only on the unfavourable changes in living nature and, hence, the far-reaching conclusions.

The "pessimists" go into raptures over "unpolluted" nature and assert that the conditions of human existence are steadily deteriorating. Extrapolation of this tendency into the future leads to the most unpleasant predictions that even without a thermonuclear war, if the industrialisation of the planet continues, man will "drown" in his own waste products.

The "pessimists" are opposed by "optimists" whose position we shall also describe with a certain degree of poignancy to emphasise its essence. The basis of "optimism" is most commonly a blind faith in human progress and the omnipotence of technology or a devil-may-care attitude towards everything expressed in the words: after me the deluge. Characteristic of this trend of thinking is an underestimation of the consequences of technological progress, especially in capitalist countries. The "optimists" rest upon no less important facts of a different kind proving that man's production activities transform the environment so that an "orderly" nature adapted to our needs is created. To be sure, the planted and cultivated meadows and fields and in a number of countries (for example, the GDR) forests, as well as park zones, rivers regulated by dams and other elements of cultivated landscapes, like the completely exterminated causative agents of many human, animal and plant diseases evidence that man can control the development of the biosphere in his own interests with due regard for the future.

Of themselves these facts can be used not only by "optimists" Credulous optimism, to which we are here referring, begins when *only* this tendency is considered, while the former is not noticed or ignored, and not all the consequences of the scientific and technological revolution are taken into account. For example, an opinion was expressed that the most essential reason for the disturbance in natural cenoses is primarily the rapid increase in the number of people. We are the least inclined to belittle the importance of this factor. To provide food for the rapidly growing population of our planet will require quite some efforts, especially since in a number of areas (South-East Asia, Africa and Latin America) hundreds of millions of people are undercreating and even starving. Nevertheless, the main thing for the biosphere today is not the increase in population, but the "technisation" of nature.

About 20-30 years ago superficial "optimism" usually took refuge in I. Michurin's aphorism: "We cannot wait for favours from nature". Michurin is not at all to blame that his statement concerning the possibilities of breeding new varieties of plants has been given such broad interpretation. As a matter of fact, we do not need to wait for favours from nature, but in remaking nature we must act with circumspection, taking into consideration not only the immediate, but also the more remote changes we are making in it.

Some Soviet authors still resort to dialectical materialism for aid when they want to substantiate their superficial attitude towards the most complicated

problem of biosphere control. Dialectical materialism is indeed a philosophy of a revolutionary remaking of the world. But it is alien both to the passive-contemplative attitude towards the world, as a philosophical basis of "pessimism" and the voluntarists' attitude to the world, as the basis of "optimism" in the sense of these terms referred to above. Voluntarism emphasises the influence of society on nature but interprets this influence in a simplified manner, underestimating the "resistance" offered by nature. On the contrary, the passive-contemplative attitude towards nature ignores in its admiration for "mother nature" the fact that in the dialectics of interaction between society and nature the leading factor is society and that nature is remade in social practice.

Dialectical materialism, as the philosophical basis of the struggle of the communist parties and the people headed by them in fundamentally remaking society, also serves as the philosophical basis of the people's purposeful activities in remaking nature. The philosophy of Marxism is guided by historical optimism in both cases. However, this is not passive, but militant optimism, based on knowledge of the real contradictions and therefore cautious in its predictions, and the least inclined to underestimate the dangers to the biosphere resulting from the industrialisation of the planet. We have reasons to assume that the consequences of the scientific and technological revolution unfavourable to the biosphere can be overcome, and not by flight from technological progress and the more so by attempts to return to "untouched" nature, but as a result of accelerated and comprehensive scientific and technological progress accompanied by a social revolution which will create conditions for utilising the present and future achievements of the human genius in the interests of the working people.

BIOSPHERE AND "NOOSPHERE"

One of the main ideas of Marxist philosophy is that the higher forms of motion arising under certain conditions from lower forms "superpose themselves", as it were, over the latter without destroying their action. Thus the physico-chemical forms of motion characteristic of the "foundation of matter" not only surround the biosphere and are conditions of its existence, but also fully retain their force in living organisms. However, the *active* role in their interaction is played by the higher form of motion. The interaction of the biosphere with inorganic nature is, on the one hand, interaction with inorganic nature that surrounds it from "below and above" and, on the other hand, interaction between physiological and physico-chemical regularities in the vital activities of organisms.

Still more complex is the interaction between society and living nature. The human society that has come into existence as a result of the self-development of living matter and that may be called "the social form of the motion of matter" does not, on the one hand, do away with the action of biological laws in the organism of each representative of mankind and, on the other hand, interacts with the biosphere of which it is a part. Here, too, the *active* role in both forms of interaction is played by the higher, i.e., social principle.

Leaving aside the first part of the question (interaction between the social and biological in man) we shall devote our attention to the second aspect, taking into account the fact that in society there is also interaction between the spiritual and material, between theory and practice.

Control of the biosphere should be regarded as conscious activity of society aimed at changing it in accordance with practical purposes. Like subduing nature in general, the biosphere may be controlled only in accordance with its known objective laws. In keeping with the aforesaid the problem of controlling living nature has two aspects: controlling the vital processes in the human organism, including health protection and biological improvement of the species *Homo sapiens*, and controlling the biogeocenoses in agriculture and forestry, in the zones of industrial planting of greenery, in town, etc., all the way to the biosphere as a whole. The connection between these two aspects of the problem is incontestable. The slogans of "nature protection", "environment conservation", etc., which have become so popular in the last decades are first of all actually appeals for protecting the health of the present and future generations of people from the harmful consequences of their own activities.

Control of the biosphere should be understood as *material, practical* mastery of it. The general formula of freedom as recognition of necessity with regards to the interrelationship between society and nature was disclosed by F. Engels in the following words: "We by no means rule over nature like a conqueror over a foreign people, like someone standing outside nature—but that we, with flesh, blood and brain, belong to nature, and exist in its midst, and that all our mastery of it consists in the fact that we have the advantage over all other creatures of being able to learn its laws and apply them correctly."³

In remote past the rule of nature over man made itself felt in a comparatively narrow sphere. The vast expansion of the latter as a result of the development of science and engineering has as its seamy side the increased possibilities of this peculiar boomerang, i.e., manifestation of elemental forces within the "humanised" nature seemingly subject to our rule. It is particularly important to take this factor into account in the biosphere. And it is no less important for further considerations to emphasise the dual meaning of the concept "freedom" as *cognition* of natural necessity and as its *practical subdual*. Cognition is conditioned by practice, is called into being by it, but it possesses a certain independence with respect to it. Cognition comes forward as a necessary prerequisite for taking a correct decision which, to be successful, must be taken with knowledge of the matter and must contribute to the subsequent practical action. But real mastery of nature is established in the process of material influence on it, and, first of all, in social production, in the labour activities of the masses changing the face of the planet. In other words, society as the subject of biosphere control is not only the *subject of cognition*, but also the *subject of action*.

These Marxist truths are such philosophical truths which cannot grow antiquated. We have to make a point of this in connection with the problem of biosphere control because inexact and simply incorrect assertions sometimes ap-

³ K. Marx and F. Engels, *Selected Works*, Moscow, 1970, Vol. 3, pp. 74-75.

pear in our scientific literature and periodical press. This is in some measure connected with the increasingly greater use of the term "noosphere" which in ancient Greek means the "sphere of the mind". In itself this term is philosophically neutral and depends on the connotation that is attached to it.

This term was introduced by Pierre Teilhard de Chardin and E. Leroy in the 1920s. As is well known, both these French philosophers inclined towards idealism, E. Leroy to Bergsonism and P. Teilhard de Chardin to a peculiar system of objective idealism in which he endeavoured to combine neo-Thomism with the idea of evolution.

Teilhard's reasoning for bringing this concept to the foreground is briefly as follows. Life, the psychic, the rational exist in inorganic nature in "pre-forms" "If we examine matter from the very bottom, we find that this primary matter is something more than a teeming of particles. . . Under this primary mechanical layer we must conceive an extremely thin 'biological' layer which is absolutely necessary to explaining the state of the cosmos in the subsequent times." ⁴ Geogenesis passes into biogenesis which, in the final analysis, is none other than psychogenesis. Psychogenesis leads to the appearance of man with the result that it is superseded by a higher function, firstly, by emergence and then by a subsequent development of the spirit-noogenesis. That is why from the living membrane—the biosphere—"we must single out in the majestic aggregation of the terrestrial films one more support, i.e., one more membrane, proportional to the given process. Only one interpretation, only one name is capable of expressing this great phenomenon—the noosphere. It is really a new coating, a 'thinking layer', which, engendered at the end of the Tertiary period, has since then unfolded over the vegetable and animal kingdoms, *outside* the biosphere and *above* it [Italics ours.—M. R., S. Sh.]" ⁵

Thus the noosphere or, what is the same, the sphere of the mind unfolds, according to Teilhard, *outside* the biosphere and *above* it—and this is the essence of his objective idealism. But in his own way he is consistent. The material is, from his standpoint, the secondary characteristic of each "layer", especially of the highest of these layers—the noosphere. If already the lower stages of matter are allegedly endowed with a psychic principle, humanised nature on Earth must be regarded as the embodiment of mind, as "its" sphere and only its sphere. Precisely for this reason some Soviet philosophers prefer to speak of the "technosphere" which emphasises the material character of humanised nature. But this term also has its minuses since control of the living world is not directly associated with technology.

The term "noosphere" was accepted by the great Russian scientist V. Vernadsky, and the Soviet philosophers of our day, who use this term, usually cite him. And this is natural because, unlike the idealist Teilhard, the materialist Vernadsky put an entirely different meaning into this concept. In the last chapter of his work *The Chemical Structure of the Biosphere of the Earth and Its Surroundings*, the chapter entitled "A Few Words About the Noosphere" he wrote: "Humanity taken as a whole is becoming a potent geological force, and today man, his *thought and labour* are faced with the problem of remak-

⁴ Pierre Teilhard de Chardin, *Le phénomène humain*, Paris, 1955, p. 53.

⁵ *Ibid.*, p. 201.

ing the biosphere in the interests of free-thinking humanity as a single whole [Italics ours.—*M. R., S. Sh.*]"⁶

Vernadsky repeatedly emphasised that the noosphere is a material mantle of the Earth that has experienced the influence of man. "The noosphere," he wrote, "is a new geological phenomenon on our planet. In it man is for the first time becoming a major geological force." "The noosphere is the latest of the many stages of evolution of the biosphere in geological history, the stage of our days." So far the human mind does not in any way rule over the noosphere. "The face of the planet, the biosphere, is being chemically sharply changed by man *consciously* and mainly *unconsciously* [Italics ours.—*M. R., S. Sh.*]"⁷

Thus Vernadsky, unlike Teilhard, held that, firstly, the noosphere is not *above* the geological mantle and the biosphere, nor, especially, *outside* of them but is historically the latest stage of a part of them transformed by man's activity. Vernadsky undoubtedly dialectically approached the conception of the connection between the higher and lower forms of motion in the course of historical development.

Secondly, the noosphere is a sphere not only of the *mind*, but also of *mind* and *labour*; in another place Vernadsky expresses this idea even more clearly by emphasising that man's power is connected "with his mind as well as his labour directed by his mind"⁸ Vernadsky, the brilliant natural scientist, does not separate mind from labour, and theory from practice, for he has no doubts that the changes in the biosphere, the chemical processes in it, are a result of the material activity of society.

Thirdly, like Engels, Vernadsky distinguishes between the changes made by man *consciously* and *unconsciously*, i.e., spontaneously, the latter so far prevailing. And fourthly and lastly, Vernadsky associates the making of the noosphere with social conditions: establishment of peace on earth, emancipation of the masses of working people, advance and utilisation of science in their interests.⁹ In this form the theory of the noosphere—despite the debatableness of this term—corresponds in essence to the spirit of dialectical materialism and considerably enriches the latter.

ECOLOGY AND CONTROL OF THE DEVELOPMENT OF THE BIOSPHERE

Without knowledge of the laws governing the functioning and development of the biosphere a transition from man's spontaneous influence on the biosphere to conscious control of it is impossible. Of the aggregate of sciences of the biological cycle this problem should undoubtedly be dealt with by *ecology*.

Each biogeocenosis, while it is an element of the biosphere, is at the same

⁶ V. Vernadsky, *The Chemical Structure of the Biosphere of the Earth and Its Surroundings*, Moscow, 1965, p. 328 (in Russian).

⁷ *Ibid.*, pp. 328, 329.

⁸ *Ibid.*, p. 327.

⁹ See I. Mochalov, *V. I. Vernadsky—Man and Thinker*, Moscow, 1970 (in Russian).

time a most complicated system whose elements are the populations of certain species of animals, plants and microorganisms which form part of it. According to V. Sukachov's conception, biogeocenoses are biological macrosystems that must be regarded as peculiar natural laboratories whose law of life is unity of living and inert components. The basic "division of labour" within them is as follows: plants create the primary organic products, animals feed on plants, and microorganisms decompose the organic substance created by both plants and animals and thereby create conditions for the circulation of substance and energy. Biogeocenoses simultaneously possess certain stability under given environmental conditions and variability. The stability of biogeocenoses (and often also their productivity) increases together with the complication of their structure. In complex systems the energy is used more economically, the food chains are longer and many of them are parallel. In special cases this makes possible interchangeability; the plants, suppliers of primary products can feed a larger number of animals, and the biomass of the system increases by addition of natural products most valuable to man. Such biogeocenoses are usually also characterised by the greatest stability, the system spending relatively less energy to maintain this stability.

This can be demonstrated by comparing the biogeocenoses of different agricultural lands. Forests amid fields are characterised by a rich fauna which often consists of about 1,500 different species of animals with quite a few potential pests. However, their mass reproduction is seldom observed and lasts but a short time, the well-balanced system soon coping with the "disturbers of the peace". On natural meadows there are usually fewer species of animals than in forests, but here, too, the pests do not, as a rule, cause serious damage because this system is also well balanced and any pest encounters numerous enemies, competitors and parasites. On grasslands the number of species decreases to a few hundred, the stability of the system diminishes, an increase in the number of separate species is observed more often, lasts longer and does appreciable damage. Lastly, on ploughed fields there are still fewer species of animals, and the stability of the system must be maintained by man. It is often generally impossible to keep the crops in a normal condition without a special struggle against the harmful species of animals.

The foregoing regularity can also be clearly observed in forests. Fruit orchards are destroyed in a few years, if they are not protected from harmful insects. The obligatory measures of protecting cultured forests must include control of insects, while natural forests (like the taiga) cope with their own pests. Even outbreaks of mass reproduction of the most dangerous pests cannot disturb the dynamic equilibrium of the natural system, biogeocenosis regulates itself.

Control of biogeocenoses with the aim of enhancing their productivity and stability is the problem biological science has to solve together with agricultural practice. And in this respect we must not only use the most effective measures to increase the crop capacity, making up with our activity for the instability of the cultured biogeocenosis, but also take its internal regularities into account.

This is important primarily because the changes we make in one of the links of the causal chain may lead to unforeseen results. The following con-

crete example will serve as an illustration. A model population of a specialised species of moth developing on wheat (inexhaustible food base) was created and it was found that in the absence of enemies the moth produces overpopulations and most of the larvae are destroyed. This explains the paradoxical results of the subsequent experiments: during bacterial epizootics (destroying up to 90% of the larvae) the total number of the pests not only failed to decrease, but even sharply increased. A predatory mite that reduced separate populations to 0.1-0.05 of their former density proved to be an effective regulator of the numbers of moths. However, the joint action of the parasites and mites not only fails to cause the dying-out of the "victim", but may even lead to an increase in its numbers. The sharp decrease in the density of the "victim's" population leads to the dying-out of the predator, and the number of the "victims" increases. This result may be biologically comprehended. The character of the dynamics of the numbers and the rate of reproduction of the moth "take the predators into account" The absence of predators disturbs the type of reproduction natural to the species and overpopulation develops with all the ensuing consequences.

Even if the simplest artificial communities are very complex biological phenomena whose development is strictly governed by law we can easily imagine the diversity of the events occurring in systems consisting of hundreds of species. Regulation of the internal connections means that under the very same conditions (with the very same influx of energy) the productivity of biogeocenoses may sharply differ. This creates a basis for optimism. Man cannot regulate the supply of energy in the different geographic areas. Here science is as yet helpless. But we can already regulate the composition of the communities and can consequently regulate the productivity of living systems.

The other basic trend that offers ecology a practical way out is neutralisation of the harmful influences on the natural and cultured biogeocenoses exerted by industrial activity, growth of towns and motor transport, pollution of seas and internal water reservoirs, changes in the atmosphere, etc. Here it is particularly important to emphasise the dangers resulting from underestimation of the laws governing the life of the biogeocenosis. It is usually a case of the obvious dangers which lead to essential changes in the number of one or several of its dominant components, i.e., when the disturbance in the structure of the biogeocenosis which ensures its stability is a direct result of anthropogenic influence (change in the chemism of water leads to destruction of fish, insecticides or herbicides destroy representatives of useful flora and fauna, etc.). Such facts strike the eye and this offers an opportunity relatively quickly to take measures aimed at saving the valuable species or community threatened with destruction.

No less dangerous, however, are the situations where a change in the habitat of the living organisms does not directly lead to destruction or decrease in the numbers of any of the species forming part of the biocenosis, but alters the energy of their vital activity.

Thus industrial exploitation of an area leads to a slight rise in the climatic temperature which influences the development of plants and animals. But different species react to the disturbance in the environment differently, and this results in discoordination of the work of the biocenosis. The degree of its

stability decreases and the dynamic equilibrium that ensures the potential immortality of the established ecologic systems is disturbed. The consequences to which this sometimes leads can be seen from the unprecedented increase in the numbers of starfish ("crown of thorns") which must be regarded as a catastrophe if not on a planetary, then at least on a continental scale since it threatens the shores of Australia. The essence of the catastrophe lies precisely in the disturbance of the natural equilibrium—the destruction of the biocenoses of the coral reefs.

Many biogeocenoses are so stable that their age is commensurate with that of objects of inanimate nature; this is interpreted as "eternity" of the forests, steppes and prairies. But the stability of living systems is based on greatest sensitivity of its elements to changes in the external environment. The more sensitively a living component of a biogeocenosis reacts to changes in the conditions of its existence, the more perfect the reaction of the population homeostasis and the less probable an irreversible change in the biogeocenosis as a whole; hence, the greater its stability. However, the mechanisms of maintaining the stability of a living system work flawlessly only in a historically conditioned range of external conditions. If these conditions change, the destruction of the biogeocenosis is but a question of time.

Modern biology regards biogeocenoses as functional units of the biosphere. It may therefore be asserted that an anthropogenic change in the environment that causes discoordination of functions of biogeocenoses is much more dangerous than direct destruction of separate species of plants and animals. The key to understanding and, consequently, preventing this danger is in regarding biogeocenoses as systems whose dynamic equilibrium can be maintained in a wide, but not an unlimited range of the external environment.

The connections of biogeocenoses in the biosphere are connections of elements of a single system for which reason cenoses must be regarded as *open* systems. The interconnections of biogeocenoses manifest themselves in various aspects, two of them—the spatial and functional—being particularly important. The periodical and non-periodical migrations of animals connect the biogeocenoses divided by vast spaces in a single ecologic system. Thus changes in the wintering conditions of birds in the tropics determine the number of the most important components of the arctic cenoses, changes in the conditions of the overflow lands of southern rivers determine the number of migrating forms of locusts and may cause a catastrophe in distant northern cenoses; appearance of epizootics of rabies among bats in South America may essentially affect the biocenoses in the Far North; nuclear fall-outs resulting from an atomic explosion at the equator and subject to the laws governing the movement of air masses on the boundary of the troposphere and stratosphere lead to an increase in the radioactive background of the Arctic with all the ensuing biological consequences. These and similar examples clearly show that the independence of the biogeocenoses is relative and the biosphere is a single whole. From this it follows that the hope of localising essential disturbances in the biosphere is naive, to say the least, and control of the biosphere therefore requires unification of the efforts of all the nations.

The other aspect of the same problem is the interrelationship of the biogeocenoses developing in different environments—aqueous and ground. Despite the

fact that the conditions of existence in the water and on land are entirely different the freshwater and ground cenoses constitute a single whole. For example, many species of insects, whose larval phases of development take place in water, carry out of the water reservoir, after completing their metamorphosis, and enormous amount of living protoplasm amounting, on a landscape zone scale, to millions of tons. It is therefore natural that any change in the environmental conditions on land should cause a corresponding change in the structure of freshwater cenoses. Usually this does not result in substantial changes in the cenotic equilibrium because the population mechanisms regulate the "coming in" and the "going out" of the biomass. If, however, the changes in the environment go beyond the historically established limits, a disturbance in the cenotic equilibrium becomes inevitable. To appreciate the scale of such a "discoordination of functions" of a biological system, suffice it to point out that swarms of some insects weigh close to scores of thousands of tons.

Thus the optimism in evaluating our influence on nature should be based on a clear cognizance of all the dangers—direct and indirect—with which this influence is fraught and on a consideration of all the means that science can offer in neutralising the undesirable consequences.

The biological proper or, to be exact, the ecologic levers of living nature control were briefly described above. Knowing the regularities of the interconnections of the populations in biogeocenosis we can add to it new species which will favour the productivity and stability of the cenoses, will regulate its composition by influencing the numbers of the separate populations, will oppose to the factors, inevitably resulting from the growth of industry, other factors, etc.

Ecology may be defined as the science of the structure of living nature on Earth, the structure of the biosphere. That is precisely why it is also potentially the science of controlling the development of the biosphere. Of course, ecology cannot neutralise the predatory, imprudent acts ensuing from the nature of capitalism and doing damage to the biosphere. Nevertheless, it can predict many consequences of these acts that escape the attention and are underrated, and thereby contribute to the struggle for nature protection. But its truly positive role will be fully revealed under social conditions which presuppose a purposeful and consistent struggle for creating optimal conditions of human existence on a world scale. We see the key to the solution of this problem in the socialist transformation of society and the basis for true optimism which correctly appraises the gravity and extent of the dangers ensuing from the scientific and technological revolution in the initial stages of its historical development.