

N O T I C E

THIS DOCUMENT HAS BEEN REPRODUCED FROM
MICROFICHE. ALTHOUGH IT IS RECOGNIZED THAT
CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED
IN THE INTEREST OF MAKING AVAILABLE AS MUCH
INFORMATION AS POSSIBLE

SOME PROBLEMS OF HUMAN ADAPTATION AND ECOLOGY
UNDER THE ASPECT OF GENERAL PATHOLOGY

V. P. Kaznachev

(NASA-TM-76095) SOME PROBLEMS OF HUMAN
ADAPTATION AND ECOLOGY UNDER THE ASPECT OF
GENERAL PATHOLOGY (National Aeronautics and
Space Administration) 15 p HC A02/MF A01

M80-27076

Unclass

CSSL 06S G5/52 27930

Translation of "Nekotoryye problemy adaptatsii i ekologii v aspekte
obshchey patologii," Vestnik Akademii Meditsinskikh Nauk SSSR, No. 11,
Nov. 1979, pp 51-57.



SOME PROBLEMS OF HUMAN ADAPTATION AND ECOLOGY
UNDER THE ASPECT OF GENERAL PATHOLOGY

V. P. Kaznachev

All the various forms of pathological processes and illnesses occurring in the diversity of nature cannot be attributed to one mechanism or expressed by one concept. However, human thinking, in its attempt to accumulate knowledge about the clinical symptoms of illnesses, the mechanisms of their origin and those of their development, has always attempted to find some kind of universal set of principles that may unify this diversity.

/51*

Among contemporary causes of morbidity in the population two important points attract our attention. In the first place the relative importance of acute illnesses, to which clinical medicine has directed the most attention, does not exceed 20% in the structure of overall morbidity and mortality of the population (if we do not take into account traumatism). In the second place, if we abstract from the nosological diversity of chronic diseases and include their total number in the morbidity and mortality of the population, it becomes clear that humanity is currently living through a pandemic of chronic pathology, and this is most apparent in developed countries with a fairly high standard of living, well developed medical science and a good system of health care. A comprehensive idea of the importance of chronic pathology may be found in Fifth Survey of the State of Health in the World: 1969-1972 (VOZ, 1977). In the Soviet Union during the period 1960-1970 cardiovascular diseases and malignant neoplasms, when taken together, were the cause of death in 62.3% of the cases in 1970 compared with 50.9% in 1960 (V. Ts. Uralis, 1947).

For males at the present time the danger of death from ischemia may be compared with the mortality risk at the time of one of the great infectious epidemics (I. Ye. Ganelina, 1975; MacMahon, 1965).

It is becoming constantly more apparent that the overwhelming majority of fre-

* Numbers in the margin indicate pagination in the foreign text.

quently occurring diseases and reasons why people feel bad may be summed up in the words "just plain" poor health, functional disorders with no clearly perceptible organic background or, as it would seem, pathological processes that may be diagnosed but are rather innocuous in respect to human life. Patients present some slightly restricted physiological functions of the organism, a disturbance in their feeling of psychosocial well being, reduced work capacity, but medicine, which has traditionally concerned itself with the determination of developing or already developed diseases, may suggest a comparatively small quota of patients in the category indicated who resort to the doctor's office ever more frequently. Less and less frequently can their ailments be put into the generally accepted classifications of health and disease (Sokolowska, 1978).

Keeping in mind what has been said about the current importance of the problem of chronic diseases in the first place and conditions of psychophysical discomfort accompanied by limitations on work activity in society, we feel it should be emphasized, that scientific thinking about these problems is the moral mandate" given to contemporary medical science. The successful execution of this "mandate" depends upon the level of knowledge of the most general principles of human vital activity. It was quite natural that the XXV Congress of the Soviet Communist Party selected from numerous actual scientific problems and gave high priority to the need for intensifying research in the area of the principles governing vital activity of the human organism.

It is specifically in the context of the practical problems connected with the preservation of health that we obviously should give first priority to the importance of studying the adaptation and ecology of humans from the point of view of general pathology. In a further presentation we will concentrate preferentially on those fundamental characteristics of the adaptation process, that are most important in the study of the human being subjected to conditions caused over a long period of time by a complex of inadequate discomfort factors in the external environment.

Process of Adaptation as a Phenomenon of General Pathology

The results of research (Z. I. Barbashova, 1960; Selye, 1961; A. I. Strukov, 1961; A. D. Slonim, 1964; S. S. Shvarts, 1967; I. I. Shmal'gauzen, 1968; I. S. Kand-

ror, 1968; A. M. Chernukh, 1972; A. P. Avtsyn, 1972; F. Z. Meyerson, 1973; D. S. Sarkisov, 19 [lacuna] etc.) indicate that the process of adjustment is determined /52 by a complex specific restructuring of all regulatory and homeostatic systems, i. e. a new condition is set up in the vital activity of the human organism.

Is this condition the same as health? Earlier we researched the ideas of "health" and "illness" (V. P. Kaznacheyev, 1963; V. P. Kaznacheyev and M. Ya. Subbotin, 1971; V. P. Kaznacheyev and V. M. Strigin, 1978) and came to the conclusion, that a comprehensive definition of these concepts is possible only after a complete study of the full value of realizing basic biosocial functions and goals for living in the individual. The individual's health is taken as a dynamic condition (process) for maintaining and developing biological, physiological and psychic functions, optimal work capacity and social activity over a maximal lifespan. Illness is a special form of vital activity on the part of the organism in which it is impossible or difficult to carry out biosocial functions that are important in life. In this context adaptation is a dynamic condition (process) of maintaining and developing optimal (i. e. appropriate to the genophenotype) interactions of the organism with an inadequate environment in such a way as to guarantee the attainment of vital goals.

As a condition, adaptation arises on a basis of functional reconstruction in line with genetic or epigenic programs of the organism and includes a redefinition of levels of realization of physiological functions, use of the plastic and energetic resources of the organism, a change in metabolic processes, reorganization in the structure of tissues, cells and molecules. This aspect of adaptation has now been studied rather thoroughly. Though a great deal remains to be done, fundamental characteristics have been established for quite a few individual adaptive mechanisms and reactions.

It must be noted, that in the light of an ever more profound understanding of the processes of adaptation, we are beginning to see how limited has been the study of acute and chronic stress. Stress itself, in the sense in which it is widely accepted today, is only a particular type of more complicated principles of adaptation. [lacuna] We have reason to believe that in any example of acute or chronic stress the human organism sets up heuristically ("visceral behavior" according to I. M. Sechenov) a longterm prognosis of conditions and, when adverse pressure is being exerted and it is impossible to maintain fully those functional levels required by

health, the organism selects a behavior that minimizes the functions. This is reflected in some metabolotrophic processes, which in turn results in the weakening of some functions and the impairment of some structures. Such behavior, being adaptive in its nature, is associated with minimization of the vital activity of the organism, i. e. with illness. However, this is some sort of organized and previously foreseen adaptive action ("adaptation through illness" according to I. V. Davydovskiy), "...physiological relationships change to pathological ones so that, when the illness is over, the original or approximately original relationships will be set up" (I. V. Davydovskiy, 1956). One must make a clear distinction between these special conditions and actual breakdown in adaptation as the result of disturbances in the functioning of regulatory systems, the breakdown of homeostatic mechanisms and other manifestatiois that lead to the interruption of adaptation and the rise of a pathological conditions ("dysadaptation disease"). If in the first group of processes we find true adaptation syndromes, a sort of "pathological norm" without which there is no realization of adaptation processes under extreme conditions, the second group includes diseases in the ordinary traditional sense of the word.

The conditions of adaptation and dysadaptation must be assessed by their final outcome: the dynamics and duration of the so-called vital cycle (V. P. Kaznacheyev and V. M. Strigin, 1978). In our opinion the vital cycle as distinguished from ordinary processes of ontogenesis covers the entire period of human active vital functioning. It comes into play on the basis of specialized genetic and epigenic programs, mechanisms, as well as neurovisceral and immunological memory. New informa- /53
tion and approaches to the study of the organism's adaptation have encouraged us to reevaluate a number of old and by now traditional general pathological conceptions, so as to change established ideas about the role of some phenomena in human pathology. Some processes, previously accepted as normal, reveal their pathogenetic significance, whereas other processes, that had been considered pathological, are explained and evaluated as normal conditions in given new situations. A great number of examples might be cited.

A group of adaptive reactions came to our attention while we were doing research with a laboratory team of the Institute of Clinical and Experimental Medicine of the Siberian Branch of the Academy of Medical Sciences of the Soviet Union on the process of human adaptation under conditions in the Far North. The materials gathered in this research were evaluated at the IV International Symposium on Circum-

polar Medicine (Novosibirsk, 1978). Here we will note only some characteristics of this unique "polar stress syndrome". Under prolonged action by a complex of ecological factors experienced by humans at high latitudes there is a change (L. Ye. Panin et al.) in all forms of metabolism: carbohydrates, fat, protein, and there is a change in the metabolism of vitamins and microelements. The energetic metabolism switches over from the "carbohydrate" type to the adipose. In the blood there is an increase in the amount of transport forms of fat: free triglyceride fatty acids, lipoproteins of very low density, etc. Sugar content remains at the lowest normal level and not infrequently goes beyond it. In individuals it may reach 45-50 mg% without any signs of hypoglycemia. The formation of new standards for indices of the internal environment ("northern metabolic type") with restructuring of the metabolic "loop" is accompanied by a reduction in the renal barrier for a number of compounds in the blood, such as sugar, some water-soluble vitamins and probably microelements. The introduction into the organism of carbohydrates or vitamins (thiamine) leads to their excretion in the urine and their return to the original level in the blood.

Increase in the blood content of such a transport form of fat as low density lipoproteins (atherogenic fraction) is accompanied by a simultaneous rise in the level of lipoproteins of high density (nonatherogenic), so that the correlation of atherogenic and nonatherogenic fractions of lipoproteins is maintained at an optimal level. When urbanization occurs in the North, the transformation of low density lipoproteins and high density lipoproteins is disturbed, which leads to a steady increase in the blood of the atherogenic fraction of lipoproteins and to the development further on of atherosclerosis and cardiac ischemia.

The study of the processes of free radical acidification of lipids in humans who have experienced the prolonged effect of a complex of ecological factors in the Far North revealed (V. Yu. Kulikov et al.) a regular restructuring of the regulation of free radical acidification of unsaturated fatty acids and of the antioxidation defense system. The metabolic changes noted are adaptive in character. At the same time the results of disturbances in the system of free radical acidification and antacid activity is an accumulation of qualitative changes in cell structures and, when the critical point is reached, this finds its reflection in some pathological processes (hemolytic anemia in the North, pneumopathy, etc.).

A study of the adaptive reactions of the immunological system makes it possible to identify a group of signs that characterize the inclusion of universal mechanisms that are common to any specific or nonspecific effect. When humans adapt in the Far North there occurs a change in the reciprocal functional activity of the subpopulation of lymphocytes of the peripheral blood with an increase in the quota of young T-cells and nondifferentiated lymphocytes (O-cells) and likewise the activation of B-lymphocytes. There is a change in interrelationships between classes of serum immunoglobins, there is an appearance of autoimmune phenomena, there is an increase in the amount of a number of acute phase proteins and a demand for complement components. There is a disturbance of the seasonal and circadian rhythms regulating the entrance into the circulatory bed of various subpopulation lymphocytes, and in some cases they show increased sensitivity to glucocorticoid hormones. One discovers a similar group of signs when humans are affected by various nonspecific stress factors and /54 also in a number of diseases. All of this points to a stereotypic restructuring of the functions of the immunological system during the period of adaptation, a restructuring which is associated with the condition of stress linked in its turn with the heightened risk of the development of some immunopathological phenomena.

According to the data M. A. Yakimenko, a reduction in the kinetic energy of the muscles, including the heart muscle, when low temperatures affect the organism, reflects an essentially adaptive phenomenon, a necessary link in adaptation to cold just as are the accompanying changes in external respiration.

It becomes evident that a study of the process of adaptation takes on the importance of a new methodological approach in research on the bases of vital organic activity and the organ's functional systems.

For example, with the use of this approach a previously unknown function has been discovered: the function of the histiocytic apparatus of the connective tissue. It has been shown that under conditions of a water deficit the histocytes provide for osmotic homeostasis by producing "metabolic water" and by releasing water bound up with the structures of connective tissue.

Human Ecology and Processes of Adaptation

Granted the importance of studying the internal organ (physiological, tis-

sue, cellular, molecular) mechanisms of adaptation and the necessity for further progress in this direction, one must keep in mind that adaptive restructuring in the individual is the result of processes that occur in a more complex system of which each individual is a part, i. e. in a population.

In interaction with the environment when living in a biosystem the deciding organizational level is population, that lives in a concrete biogeocenosis (V. N. Sukachev, 1949), where, within the limits of concrete populations, practically all evolutionary processes arise and take shape (N. V. Timofeyev-Resovskiy et al., 1973). In our definition of human population we have recourse to accepted criteria (N. V. Timofeyev-Resovskiy et al., 1973; Odum, 1975) as a biosocially organized group, always inhabiting a definite area.

The key principles that determine health, adaptation and the pathology of the human individual cannot be understood outside a population-ecological category. The human being as a biosocial entity continues to be a part of the biosphere upon which he depends in view of a substance-energy cycle and which (even as a social entity) he transforms ever more actively by accomplishing a gigantic biochemical task that is the basis for formation of the noosphere (V. I. Vernadskiy, 1974).

The tempo of man's conquest of new environments in which to live, that answer the daily requirements of society, is increasing relentlessly. A striking example of this is the current national economic development of the of the eastern and northern regions of the Soviet Union. Everyone knows the degree to which anthropogenic changes in the external environment are occurring in association with human economic activity (Ye. K. Fedorov, 1977). This type of change is important for biologists not only from the point of view of environmental pollution or the depletion of natural resources important for life but also as a process of active formation of a qualitatively new and more complex environment in respect to which humans as a biological species do not possess inherited stereotypic mechanisms of adaptation.

We cannot regard existing human populations as conservatively stable groups constantly isolated over generations in an area they have taken possession of. We are dealing rather with continuous streams of people migrating across geographical space in a complicated interweaving of social, industrial and natural conditions. The high rate of migration mobility of the population (Ye. D. Malinin and A. K. Usha-

kov, 1976; D. I. Valentey, 1976; N. P. Fedorenko, 1976; L. L. Rybakovskiy, 1976 et al.) is becoming a regular phenomenon that characterizes one of the most important aspects of adaptation in contemporary populations. It is especially extensive today in Siberia, in the Far North and in the Far East, i. e. in territories where there is vigorous growth in the density of the zone taken over by humans.

A combination of the circumstances referred to — the rapid rate of modification in living environment, the constantly increasing mosaic of the heterogeneity of biotic and physicochemical properties of the biosphere especially in association with urbanization and likewise with the industrialization of agriculture, migration mobility (longterm and shortterm) connected with the new industrial conquest of previously uninhabited regions, the intensification of microevolutionary changes in people themselves — make it practically impossible to establish fairly stable relations between humans and the external environment. /55

Using the terminology of E. S. Bauer (1936), we may say, that today the interactions of man with his environment are characterized by an ever increasing degree of steady imbalance which is supported by the constant pressure of the adaptation process.

One of the scientific directions which would make it possible to take into account all of the phenomena mentioned without neglecting processes and factors essential to human health is currently human population ecology, i. e. a new scientific direction proceeding essentially from the framework of demography, hygiene, medical geography, geographical pathology, etc.

The condition of health of the individual and of the population is a derived socioanthropoecological interchange. Today the term "human ecology" embraces the development of an interdisciplinary scientific approach in respect to the principles of interchange between human populations and the surrounding environment, the development of national population, the maintenance and the development of health, the improvement of the species homo sapiens in the process of this interchange. Specifically from the viewpoint of anthropoecological principles we can arrive at a deeper and more accurate understanding of the process of adaptogenesis in the multiplicity of its individual-organismic manifestations.

Clinical observations (A. D. Makaricheva et al.) clearly show that under extreme conditions in nature we note phasic changes in the types of response reaction of the mother organism to the progeny in the course of pregnancy. In addition, there is a change in the frequency of pregnancy complications over the course of the first three or four years in the life of a woman living under conditions of the Far North. Research carried out by N. I. Tsirel'nikov et al. has shown that, due to the effect of factors in the Far North, significant morphofunctional changes are occurring in the human fetoplacental system. A study of the shortterm effects of cold on the organism in early postnatal ontogenesis (Yu. P. Shorin et al.) leads to steady change in the activity of the number of enzymes at later stages of development. These data are evidence of the fact that the sensitivity of the organism to extreme effects depends in great part on the periods of individual development.

We must emphasize, that events in the external environment, i. e. exoecological processes, are directly linked with the condition of the internal environment of the organism, the bacterioviral picture it presents, its chemical makeup and its antigenic structure. Apparently one must distinguish "endoecological processes", keeping in view most of all the interaction of the organism with xenobiotics, i. e. with factors foreign to the organism (microorganisms, antigens, chemical compounds), that penetrate into the internal environment.

The tissues of the internal environment responsible for maintaining homeostasis are inescapably drawn into the adaptation process but the underlying principles are not yet clearly understood.

In this connection there is a certain importance in the data obtained from a study of the reactivity of blood polynuclears (D. P. Mayanskiy et al.) to a bacterial stimulator in clinically healthy persons living at high latitudes. Persons who spent from 6 to 12 months in the Far North presented leucocyte hypoergy (reaction with nitrous tetrazole). As people stayed longer in the Far North the average indices for polynuclear stimulation remained at a low level, but side by side with persons who showed low reactivity there was also a highly reactive group. Such index dissociation reflects a different degree of adaptation in the antimicrobe systems of effector cells which cause infectious inflammatory reactions to the complex of ecology-specific factors in high latitudes and expressed variously in the population.

It seems rather well founded, that morphological and metabolic restructuring of the connective tissue system manifested in the process of adaptation in the organism⁵⁶ is accompanied by real changes in reactivity and this may be reflected in the dynamics of the inflammation process and condition its tendency toward becoming chronic (V. V. Vinogradov et al.).

We know that the type of restorative processes in a parenchymatic organ is largely determined by the functional condition of its connective tissue stroma. In this sense the facts discovered by V. N. Mayanskiy et al. are indicative. Depression of the functions of hepatic macrophages or the Kupffer cells led to a regular inhibition of the recovery rate for the hepatic structure. However, when the Kupffer cells were stimulated with bacterial polysaccharides there was a notable acceleration in the process of restorative regeneration.

When the organism is trained to physical overload (Yu. P. Shorin et al.) there occurs a series of regulatory and metabolic displacements of an adaptive nature which taken together provide for increased static and dynamic work capacity. However, at the same time there is a sharp drop in the resistance of the organism being trained in respect to the toxic effect of pharmacological preparations in connection with the repression of microsomal enzymes in the metabolism of xenobiotics. It is interesting, that physical training likewise leads to a notable repression of the processes of restorative regeneration. An important aspect of endoecology is "deficit conditions" of the internal environment in connection with the impoverishment of the bacterioviral picture, the dissipation of chemical elements and the loss of antigenic diversity. Thus, numerous data on illnesses conditioned by specific biogeochemical areas (Reports of the Biogeochemical Laboratory, Moscow, Nauka, 1968, Vol. XVI; 1976, Vol. XIV; 1978, Vol. XV) present only particular manifestations of the overall connection between exoecological and endoecological phenomena. A study of the mechanisms of these interrelations, their positive and negative aspects, brings us closer to a deeper of the problems of etiology and, more precisely, the etiology of the conditions of adaptation, dysadaptation and pathology.

An analysis of population-ecological aspects of adaptation in humans leads us to an understanding of the health of populations as a process of sociohistorical development of the vitality — biological and psychosocial — of the population over a number of generations, an increased capacity for work and greater productivity in

collective work, the growth of ecological dominance and the perfection of the species homo sapiens.

The criteria for the health of a particular human population together with the individual qualities making up its organisms include the birthrate level, the health of descendants, genetic diversity, adaptivity of the population to climatic-geographic conditions, readiness to fulfill various social roles, age distribution, etc. (A. M. Markov et al., 1973; M. S. Bednyy, 1972; B. Ts. Urianis, 1974; Fil'roze, 1975, etc.).

Such are the current aspects of the ecology and adaptation of humans in the light of general pathology or, more exactly, general pathological problems of population anthropoecology and human adaptation. It is difficult to overestimate the scientific and practical importance of these problems.

REFERENCES

1. Anugin, V. A., Osnovy prirodopol'zovaniya [Principles of Nature Usage], Moscow, 1978.
2. Anokhin, P. K., Teoriya otrazheniya i sovremennaya nauka o mozge [Theory of Reflection and Contemporary Brain Science], Moscow, 1970.
3. Avtsyn, A. P., Vvedeniye v geograficheskuyu patologiyu [Introduction to Geographic Pathology], Moscow, 1972.
4. Barbashova, Z. I., Akklimatizatsiya k gipoksii i yeye fiziologicheskiye mekhanizmy [Acclimation to Hypoxia and Its Physiological Mechanisms], Moscow-Leningrad, 1960.
5. Bauer, E. S., Teoreticheskaya biologiya [Theoretical Biology], Moscow-Leningrad, 1935.
6. Bednyy, M. S., Demograficheskiye protsessy i prognozy zdorov'ya naseleniya [Demographic Processes and Population Health Prognosis], Moscow, 1972.
7. Chernukh, A. M., Pat. fiziol., 2, 9 (1970).
8. Fedorenko, N. P., ed., Vosproizvodstvo naseleniya i trudovykh resursov [Productivity of the Population and of Labor Resources], Moscow, 1976.
9. Fil'roze, E., Ocherk potentsial'noy demografii [Outline of Potential Demography], Moscow, 1975.
10. Davydovskiy, I. V., Ucheniye ob infektsii [Infection Science], Moscow, 1956.
11. Ganelina, I. Ye., Ishemicheskaya bolezni' serdtsa i individual'nyye osobennosti organizma [Cardiac Ischemia and Individual Characteristics of the Organism], Leningrad, 1975.
12. Kandror, I. S., Ocherki po fiziologii i gigiena cheloveka na Kraynem Severe [Outline of Human Physiology and Hygiene in the Far North], Moscow, 1968.
13. Kaznachev, V. P., Biosistema i adaptatsiya [The Biosystem and Adaptation], Novosibirsk, 1973.
14. idem and M. Ya. Subbotin, Etyudy k teorii obshchey patologii [Studies on the Theory of General Pathology], Novosibirsk, 1971.
15. idem and V. M. Strigin, Problema adaptatsii cheloveka [The Problem of Human Adaptation], Novosibirsk, 1978.
16. Kucherin, N. A., Zabolevayemost' i ekonomika [Morbidity and Economics], Leningrad, 1973.
17. Malinin, Ye. D. and A. K. Ushakov, Naseleniye Sibiri [The Population of Siberia], Moscow, 1976.

18. Merkov, A. M., M. S. Bednyy and A. T. Shatalov, v kn. Obshchestvo i zdorov'ye cheloveka [in Society and Health], ed. by G. I. Tsaregorodtsev, Moscow, 1973, pp 132-149.
19. Meyerson, F. Z., Obshchiy mekhanizm adaptatsii i profilaktiki [General Mechanism of Adaptation and Prophylaxis], Moscow, 1973. /57
20. Odum, Yu., Osnovy ekologii [Principles of Ecology], Moscow, 1975.
21. Rybakovskiy, L. L., ed., Territorial'nyye osobennosti narodonaseleniya RSFSR [Territorial Characteristics of the National Population of the RSFSR], Moscow, 1976.
22. Sarkisov, D. S., Ocherki po strukturnym osnovam gomeostaza [Outline of the Principles of Homeostasis], Moscow, 1977.
23. Selye, H., Ocherki ob adaptatsionnom sindrome [Outline of the Adaptation Syndrome], Moscow, 1960.
24. Shmal'gauzen, I. I., Faktory evolyutsii [Factors in Evolution], Moscow, 1968.
25. Shvarts, S. S., Ekologicheskiye osnovy adaptatsii zhivotnykh [Ecological Bases of Animal Adaptation], Moscow, 1967.
26. Slonim, A. D., O fiziologicheskikh mekhanizмах prirodnykh adaptatsiy zhivotnykh i cheloveka [Physiological Mechanisms of Natural Adaptation in Humans and Animals], Moscow-Leningrad, 1964.
27. Strukov, A. I., v kn. Kompensatorno-prisposobitel'nyye protsessy [in Compensatory-Adaptive Processes], Kuybyshev, 1961, pp 8-15.
28. Sukachev, V. M., Vopr. geografii 16, 45-60 (1949).
29. Timofeev-Resovskiy, N. V., A. V. Yablokov and N. V. Glotov, Ocherki ucheniya o populyatsii [Outline of Population Science], Moscow, 1973.
30. Ulanis, B. Ts., Problemy dinamiki naseleniya SSSR [Problems of Population Dynamics in the Soviet Union], Moscow, 1974.
31. Valentey, D. I. et al., Sistema znaniy o narodonaselenii [Information System on National Population], Moscow, 1976.
32. Vernadskiy, V. I. Biogeokhimicheskiye ocherki [Outlines of Biogeochemistry], Moscow-Leningrad, 1940.