Alexei A. Pokrovski

NOURISHMENT AND THE BIOSPHERE

"The world of life which is comprised of the lithosphere, the hydrosphere and the atmosphere": this definition of the biosphere is not complete since it does not express the determining influence of living organisms on its composition, on its structure and on the processes of its continuing evolution. The part of living matter in the biosphere is relatively small (about 0.25%), but this part has a considerable influence on its structure.

The biosphere should be considered as the universal source of all food products without exception. Mankind's ability to feed itself depends on the productivity of this biosphere in the first place. Moreover, its condition determines not only the quantity but also the quality of nourishment. The problem is a critical one today because of the increasing pollution of the biosphere by products poured into it by various human activities.

Frequently the total productivity of the biosphere is expressed either by the tons of organic substances produced annually or in the amount of carbon assimilated in the course of the process of synthesis. But it is the latter formulation, which measures energy assimilated and preserved in chemical bonds, which interests most our research. We are then most concerned with that part of energy which can be assimilated in turn by man from his food.

The productivity of the biosphere as a whole should obviously

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exceed by a great deal the global needs of mankind for nutritive substances. Thus the problem of providing nourishment for man depends broadly speaking on the relation between the total productivity of the biosphere and mankind's need for nourishment on the one hand, and, on the other, on the relation between the productivity and the amount humanity is capable of using as food at a given point of scientific and technical progress.

To evaluate exactly the food needs of the human population we can consider the following formula:

Total productive capacity of the biosphere (in kilocalories)	>	Global needs of mankind for nourishment (in kilocalories)

This inequality is particularly determined by the level or the percentage of organic substances formed in the biosphere used in the nourishment of man. We will call that part of the total biosynthetic productivity used by man as food the "coefficient of food use" (CFU). The simplest manner to calculate it is in terms of the amount of energy consumed. For this we must express in joules or in calories the total productivity of the biosphere (TPB) and the global consumption of energy by the population (GCEP) and then evaluate the percentage of energy used with the formula:

$$\text{CFU cal.} = \frac{\text{GCEP cal.}}{\text{TPB cal.}} \times 100\%$$

The coefficient of food use of the biosphere can serve as an important criterion for measuring scientific and technical progress.

With regard to agricultural production it must be emphasized that barely one tenth of the earth's land surface is used today for the production of edible plants. This area furnishes about 9 billion tons of organic substances of which 15-20% at the most is used for feeding man. This equals $2-2.5\times10^{15}$ kcal., from which we derive the formula:

$$\text{CFU} = \frac{2-2.5\times10^{15}}{4\times10^{17}} \times 100\% = 0.5\%$$

This means that the value of the coefficient of food use in today's world conditions is about 0.5% of the total productive capacity of the biosphere.

The value of the coefficient can change according to the different regions of the globe. It is relatively high in those regions of intensive agricultural activity aided by fertilizing; it falls to around zero in the deserts, the tundra and the jungle. For the increase in CFU an important role is played not only by the extension of the area of seeding, but also by the "green revolution" which is developing today and which transforms agriculture radically thanks especially to discoveries in genetics and selection. The green revolution will no doubt increase notably the world harvest of grain as well as its quality.

According to calculations of the Food and Agriculture Organization (FAO) we can hope that towards the year 2000 a relatively satisfying solution will be brought to bear on the problem of the energy value of human nutrition. But in these kinds of calculations the energy needs of the population are not the sole concern; man's daily ration is constituted of a rather large number of irreplaceable substances, among which protein plays a key role.

Today the qualitative and quantitative aspects of the process of the assimilation of nourishment is part of the concept of a balanced diet. This means that man cannot have a normal, active life without receiving adequate amounts of energy and proteins and without receiving various irreplaceable products in determined proportions, each of which products plays a specific role in his metabolism.

The idea of a balanced diet is crucial not only for the theoretical study of the means of assimilation of nourishment but also for resolving the principal practical problems of the calculation of the minimal human needs for energy and food products. It is correct to consider it as the scientific basis of modern strategies of food production and world nutrition. It also allows us to determine the distribution of food resources. The following table brings out the considerable differences in protein consumption between developed and developing countries. These differences are not only quantitative but also and especially qualitative.

Comparative Indices of Daily Rations (by inhabitant):

Indices	Developed Country	Developing Country
Amount of calories (kilocalories)	3.060	2.150
Proteins (grams)	90	58
Animal proteins (grams)	44	9

According to data of the UN, inhabitants of developing countries receive one third less calories, almost two times less proteins and about five times less animal proteins than inhabitants of developed countries. Of course each country has its own nutrition customs, but in most cases the rations are made up of vegetable products, especially grain. Thus in many places the principal food is rice, in others corn or wheat, etc. Unfortunately the biological value of proteins furnished by the various types of grain is relatively low for they are lacking in the amino acids necessary to the human organism such as lysin, tryptophan, theonine and methionine. The multiplication of certain diet-related diseases in the developing countries is a consequence of a diet weak in protein and of the inferior quality of these proteins.

An important study of the syndrome of under-nourishment and protein deficiency, realized under the auspices of the World Health Organization (WHO), UNICEF and UNESCO, has shown the severity of the problem for a considerable part of the population of several countries. The problem of protein supply for their inhabitants was examined by the group of Advisors on Protein Matters of the FAO, by WHO, UNICEF and the UN Committee of Consultants for Applying Scientific and Technical Gains for Development, the Economic and Social Council of the UN (ECOSOC) and finally by the UN General Assembly.

If we analyze the reasons for the lack of nutritive substances in the world, naturally the first factors are social and historic such as the economic collapse of developing countries for which the colonialists are responsible, the urbanizing process now underway and, to a certain extent, a relatively rapid demographic increase.

As we approach this problem we must keep in mind the approximate figures available for evaluating the total volume of food proteins produced today. We must remember as well that in the total mass of organic substances produced by the biosphere, the proportion of protein is relatively small. The total productivity of the biosphere is evaluated today at about 75 million tons of protein per year, of which about 24 million tons are animal proteins.

Global population today is about four billion people. Moreover, we are witnessing an exceptional demographic explosion. By the year 2000 the population of the planet will exceed six billion, and therefore we will need more than 130 million tons of protein to ensure even the minimal dietary norms established by the FAO, (60 grams per person per day). According to the estimates of this organization, it is extremely difficult to obtain such an amount of protein using traditional agricultural methods. But there are various possibilities for notably increasing the yield of the biosphere and, even more important, for improving its coefficient of use.

The first possibility is to stimulate the development of all forms of agricultural production by favoring the introduction of new varieties of plants chosen not only for their better yield, but also for their greater nutritive value, such as certain kinds of corn rich in lysin (OPAK-2, for example) and new kinds of grain and rice particularly rich in protein.

Let us emphasize that it is exactly this direction that the USSR has taken in its efforts to plan the continuing accumulation of food resources. The decisions of the XXV Congress of the Communist Party of the Soviet Union foresee among other things a significant increase in agricultural production thanks to mechanization, to improvement of the soil and to chemical processes. It is no less important to seek new sources of protein, to elaborate methods of reasonable nourishment for domestic animals and to choose new races with a higher yield.

To evaluate the efficiency of agricultural production one must therefore consider not only the coefficient of the use as food of organic substances produced by the biosphere but also the increase of the biological value of products destined to nourish man and beast.

A second possibility is the more extensive use of the seas and oceans since this aquatic part of the biosphere occupies almost two thirds of the surface of our planet. There too it is becoming urgent to proceed with the active selection of the most productive species of fish and marine animals which means to arrive at a broader and more rational use of the alimentary resources of the ocean. In the course of the next century the oceans of the world will be the scene of a technical-scientific revolution which we propose to call the "blue revolution."

The third possibility, finally, is to turn to the microcosm for solutions to the problems of nourishment and of fodder. Recently interest in the world of micro-organisms has been limited to their pathogenic action. The development of technical micro-biology in the middle of the 20th century has made it a promising sector for the production on an industrial scale of numerous substances, proteins among others.

Micro-organisms have the property of growing rapidly and of containing a large number of proteins; the average content of the dried biological mass of numerous microorganisms exceeds 50-60%. One-celled organisms are thus by their very nature high protein entities, rich in lysin and relatively poor in methionine.

Nevertheless, even though the use of micro-organisms offers an attractive source of protein, their use as a food product presents serious difficulties. There is not only the fact of the high cost of their production and the complicated technology which this implies, but also and above all there is the need for expert doctors who can determine if their inclusion in the food ration of humans is useful and without danger.

In all countries, agricultural production is the principal source of proteins. Fishing and fish hatcheries play an important role as does hunting, although more restrained in our times. A particular place must be reserved for proteins from oleaginous plants, of increasingly widespread use for human nourishment. The eventual production of protein from one-celled organisms is a new and important means of increasing the general protein reserve.

Statistical research reveals that in the overwhelming majority of developed countries today, at the most half of all protein produced is used for human nourishment; the rest is used for raising animals and a small part for fish production and for research. It is not unreasonable to think that the production of concentrations of monocellular protein will produce interesting results, particularly in the area of animal and fish production. We are firmly convinced that in the near future the principal source of required protein will be animal production and also that it is by giving a maximum development to agricultural production that we will be able to furnish the world's population with the food products it needs.

This concept is the one adopted in the USSR for the use of proteins derived from monocellular organisms in the immediate future. A strong microbiological industry already furnishes the country's agriculture with hundreds of thousands of tons of protein substances and progress of the order of 100-110% can be expected in the course of the tenth Five Year Plan (1976-80).

Research into methods which allow a better use of the resources of the biosphere and the perfection of procedures biologically and economically justified for increasing the coefficient of food use are naturally among the most important tasks facing the food industry. Nevertheless experience shows that in this domain a hasty application of procedures which are seemingly reasonable but which have not yet received scientific approval can provoke as a result ecological disorders which can imperil not only certain biological species but even entire sectors of food production. The harmful consequences of an uncontrolled action by man on the biosphere are well known. There is a wide divergence of opinions concerning the possibilities of the use of chemistry and its concrete applications in the area of consumable nourishment. Certain scholars affirm that agriculture has been outmoded by the considerable labor it requires, its limited financial return, its dependence on the whims of nature, and that it should yield its place to chemistry to produce industrially nutritive substances and the food the world needs.

Contrary to this point of view, the majority of agricultural specialists and nutritionists, notably the Soviets, see particularly in chemistry an important means of increasing agricultural yields through a large-scale use of mineral fertilizers, pesticides, proteic substances and growth stimulants.

Finally there is a third opinion group which would deny in a general manner the bases for the application of chemistry to the industrial and even agricultural production of food. Citing the harmful influence of certain pesticides on the biocenosis and on the chemical composition of food products whose alteration could harm human health, this group advocates if not a complete ban at least a notable limit on the use of chemistry in agriculture. This wide difference of opinions leads us naturally to examine the problem from the point of view of the science of human nutrition.

As a nutritionist and one who sees an important role for chemistry in agricultural production, the present writer esteems that reason obliges us to proceed with prudence when introducing directly or indirectly any new substance into the domain of food and to execute prior biological research permitting a verification and observance of its safety factor.

Medical experts are especially interested in the increasingly numerous exterior factors which accompany the unharnessed technical progress of our times to which we cannot remain indifferent. Notably there is the question of the action of a number of new chemical and physical agents on the human organism and on nature. A casual relation has been established between the increasing chemical pollution of the soil, water and the atmosphere, and the disappearance of a large part of certain biological species (birds, fish, mammals and useful insects) which has brought about certain changes in the biocenosis of our planet. The mutagenous and even carcinogenic effects of many chemical and physical agents have been revealed. In recent years cases of genetic anomalies have become particularly frequent.

There are many reasons to think that food constitutes one of the most important means of transmitting ecological damage to the human organism. The chemical composition of food is very unstable and the use of chemical fertilizers on plants can, to a certain extent, modify their mineral content. Chemical products used on plants can leave residues not only in products of vegetable origin, but also in animal products and even in mother's milk.

Thus it is impossible to foresee the present tasks of the science of nutrition independently from the repercussions on the biosphere by scientific and technical progress which will perhaps bring nutritional abundance in man's next millenium on earth.

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