Biological Correlates of Development:

Nutrition and Learning

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Nutrition and Educational Planning

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THE PHILOSOPHICAL BASIS of the ANISA Model, which unequivocally affirms the spiritual nature of man, serves as a powerful integrator of the vast body of information about human growth and development and enables one to generate a coherent body of theory for educational planning.[1] The theory of development derived from this philosophy defines the nature of human potentialities and the processes by which they are translated into actuality. Thus education as defined by the ANISA Model refers to the process of interacting with the environment in a manner which enables the human organism to grow, develop, and function, thereby actualizing its genetic potential.[2] Such actualization depends upon maintaining the biological integrity of the interacting organism and this in turn depends upon its nutritional status. Educational planning, therefore, is incomplete without a full knowledge of the role of nutrition in the release of human potential.

Geneticists constantly remind us that what is inherited is not this or that particular "trait" or "character" but a genotypic potentiality for an organism's developmental response to its environment. Given a certain genotype and a certain sequence of environmental situations, the development of the organism's potential follows a certain path. The selection and preparation of the environment and the guiding of the human organism's interaction with it should no longer be left to chance. In the future, the evolution of man will be directed largely by his knowledge of growth and development and his view of his own destiny. Physical adaptation and natural selection, which generally characterize biological evolution, will be heavily influenced by man's collective and individual efforts to improve the quality of life by providing for himself a suitable environment and orchestrating the kinds of interactions needed.

Sociologists, developmental psychologists, cultural anthropologists, and behavioral scientists have contributed to modern man's understanding of the underlying processes of these interactions which enable the child to actualize his genetic potential. Present-day educational systems are beginning to draw upon the vast body of knowledge from many disciplines which will enable them to develop a better understanding of the causes of educational failures sustained by "disadvantaged"

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1. See Daniel C. Jordan and Donald T. Streets, "The ANISA Model: A New Educational System for Developing Human Potential," *World Order,* 6, no. 3 (Spring 1972), 21-30.
2. See Daniel C. Jordan and Raymond P. Shepard, "The Philosophy of the ANISA Model," *World Order,* 7, no. 1 (Fall 1972), 23-31.

students and to define more clearly the action necessary to assist them. An educational system which merely concentrates on such matters as curriculum innovation, motivation, cultural factors of language acquisition, or enriching preschool experiences, without providing for the maintenance of the biological integrity of the organism, will be inadequate. The actualization of genotypic potential depends upon the biological integrity—both its structure and functioning—of the interacting organism. There is an intimate relationship between the integrity of the child as a biological organism and the characteristics of his mind and personality. In the words of Herbert Birch and Joan Dye Gussow:

> As an organism, the child is not only a mind and a personality capable of being unmotivated, unprepared, hostile, frustrated, understimulated, inattentive, distracted, or bored; he is also a body which can be tired, hungry, sick, feverish, parasitized, brain-damaged, or otherwise organically impaired.[3]

Furthermore, there is a close relationship between the quality of the environment and the physical and mental health of the person who lives in it.

The ANISA educational model is based on the synthesis and application of a vast body of scientific research from many disciplines, including extensive information which defines a critical role played by nutrition in the release of the potentialities of the child.

The contributions of biochemistry, human physiology, and other biomedical sciences to our understanding of the growth and functioning of the human organism have been phenomenal during the last two decades. The identification and chemical synthesis of many vitamins and their rational use in the treatment of many nutritional deficiency diseases like scurvy, beri-beri, rickets, pellagra, pernicious anaemia; the identification and mode of action of steroid hormones and other hormones like thyroxine and insulin and their applications to body dysfunctions; the estimation of minimum daily requirement of body building and nutritional biochemicals and essential minerals during all the stages of growth of the human organism; and the study of protein and enzyme functions at cellular level and the knowledge of intermediary metabolism and regulation of amino acids, fats, and carbohydrates are common knowledge in biochemical circles. Further advances have been made in our understanding of the biochemical basis of genes, fetal and neonatal physiology, and morphogenesis of the neuromuscular system. These advances have thrown considerable light on the organizing principles underlying the "molecular logic" of cells connected with human growth, development, and functioning.

The electron microscope, the ultracentrifuge, microchemical techniques, and the use of radioactive isotopes have made it possible to study the metabolism and nutritional needs of the individual cells and even of the subcellular component, or organelles of the cell. At the present time an impressive body of information is accumulating which is leading to a more complete understanding of the intricacies of cell structure and the complex and vital role nutrients play in the growth,

3. Herbert G. Birch and Joan Dye Gussow, *Disadvantaged Children: Health, Nutrition & School Failure* (New York: Harcourt, 1970), p. 7.

development, and function of the cell. Nourishment of the cell is basic to the nourishment of the collection of cells—tissues, and this in turn is basic to the nourishment of the different organs of the body and ultimately the entire body. Thus, a defect in nutrition at cellular level may adversely affect the functioning of the whole body.

Although it has been twenty-three years since the discovery of the last vitamin, new information on nutrition continues to pour in at a phenomenal rate. In 1971 alone over four thousand papers relevant to nutrition were presented at a single scientific meeting. Understanding the complexity of the process of nourishing the body is indeed a challenging frontier of science that is only beginning to be explored in depth. As the biochemist becomes more and more concerned with the fine points of metabolism at the cellular level and less and less with the total organism, it will become the role of nutritionists to integrate the theoretical knowledge from many fields of study and to apply this information to the maintenance of health and the prevention of disease. The fact that scurvy, rickets, beri-beri, pellagra, and kwashiorkor, all nutritional deficiency diseases, can be found in affluent and developing countries alike is stark evidence of our failure to apply the knowledge we already possess. Understanding these advances in the biomedical sciences provides the basis for improving the quality of human life; the knowledge it represents must be incorporated into an educational system that emphasizes the significance of nutrition and its relation to the release of man's potentialities.

Although articles and reports of all kinds abound concerning the nutritive requirements of the expectant mother and the new-born infant, no one has extracted and integrated the findings as they pertain to education and introduced them into systematic educational planning for schools and communities. It usually takes about a generation for new discoveries and techniques of one science to become a part of the regular working tools of other sciences. It takes considerably longer time for such findings to become familiar to the layman and to exert any significant influence upon his life and way of thinking. Within the ANISA Model, it is the role of educational specialists and related community agencies to bridge the gap between discoveries and their application, especially when these discoveries directly influence child growth and development.

In spite of the rapid advances made in the science of nutrition during the past fifty years, the annual toll taken in human lives due to malnutrition has still to be reckoned in the millions. Above and beyond this mortality, account has to be taken of the vastly greater number of children who, subjected to periods of undernutrition during the early years of their development, survive with physical inadequacy or some form of mental retardation. The damaging effects of malnutrition on the physical development of young children have long been obvious and recognized. Research evidence on the relation of nutritional factors to intellectual performance and learning is fast accumulating and the implications of these findings and challenges for the total educational program are too evident to be ignored. These research findings are of paramount importance because, according to estimates by the consultants of the Food and Agriculture Organization, almost 70% of the world's population may suffer from sub-chronic undernutrition and an estimated three hundred million children living in underdeveloped areas of the world have low

protein diets. Although the significance of these findings is not fully understood in terms of human well-being and the release of the potentialities of man, the evidence is sufficient to demand attention and action on the basis of present knowledge. The absence of a definite, unequivocal, and empirically proven correlation between malnutrition and impaired learning potential, as Birch put it, "does not reflect absence of the problem but only the lack of attention devoted to it."[4] "To wait till all the answers are in," says Francis Keppel, "to delay until all negative conditions are identified and solved, to ignore the apparent connection between diet and intellectual development would be only to invite society's suicide."[5]

Since malnutrition is always found with poverty and since poverty is associated with a number of other factors which have depressive effects on learning ability, it is difficult, if not impossible, to design studies which would unequivocally establish the precise role of human malnutrition in the impairment of learning competency and useful adaptive behavior. From a purely pragmatic standpoint this probably makes little difference. Learning capacity depends not only on the maturity of the nervous system but also on the nature of the stimulus provided by the environment and on the circumstances that evoke the interaction of the organism with its environment. Birch was right to point out "that there is no human organism existing without a social environment containing a culture, and a background of explicit experience as well as a breast, a bottle and a bowl of porridge."[6] In addition, he points out that "we must not permit our thinking to be clouded by an inappropriate anxiety about social conditions but rather to have our studies illumined by an awareness of them."[7] Programs should be carried out now, whether or not we have complete factual data on which they can be based. For educational planners, this is important psychologically and morally; for, if the evidence we have today about the relation between malnutrition and mental development increases and becomes definitively established as the scientific facts of tomorrow, they must face a generation of infants coming into the school system who are ill-equipped mentally for learning, because, through no fault of their own, they were fed improperly.

OUR INTENT here is to analyze the problem, demonstrate the need for better nutrition and adequate nutrition education in communities throughout the world, and explain the role of nutrition in the ANISA educational system. Our analysis of the problem therefore seeks to define the particular role played by nutritional factors in maintaining the biological integrity of the human organism as it interacts with the social and cultural environments for the optimum release of the genotypic potential. Consideration of the ways in which available research permits us to achieve this objective will be the substance of the rest of this article.

Of all the factors that inhibit or retard the growth, development, and functioning

4. Herbert G. Birch, "Designs and Proposal for Early Childhood Research: A New Look—Malnutrition, Learning and Intelligence," ed. Edith H. Grotberg, Document from Office of Economic Opportunity, ED 053 811 (Washington, D. C.: Superintendent of Documents, Government Printing Office, 1971), p. 1.
5. Francis Keppel, "Food for Thought," in *Malnutrition, Learning and Behavior,* ed. Nevin S. Scrimshaw and John E. Gordon (Cambridge, Mass.: MIT Press, 1968), p. 4.
6. Herbert G. Birch, "Field Measurement in Nutrition, Learning and Behavior," ibid., p. 498.
7. Ibid.

of the human organism as a whole, the most detrimental is malnutrition.[8] It is well known that there are certain periods of vulnerability in the development of organisms during which the presence or the lack of a developmental modifier causes a significant alteration in the course of the normal development. These periods are called "sensitive periods." If the presence or lack of certain modifiers during a sensitive period results in permanent damage or change, it is called a "critical period." From the standpoint of release of the genotypic potentialities of the human organism, the periods of rapid growth are periods of special vulnerability to nutritional injury. In fact, there are strong evidences that the critical periods which ultimately determine the full expression of the genotypic potential in the case of humans extend over a time continuum starting at conception and going well beyond preschool years. The effects of inadequate nutrition on growth and mental development depend to a large extent on the point in the continuum at which the deprivation occurs, the severity and duration of the deprivation, and the nutrient of which the organism is deprived.

From a practical standpoint it is important to determine whether the effects of malnutrition are transitory or permanent—i.e., whether there exists a critical period during which the damages are irreparable. Our present knowledge of the nature and growth of organisms at the cellular level sheds some more light on these concerns. Growth occurs by two processes: cell division, or *hyperplasia,* and cell enlargement, or *hypertrophy.* For every organ, the process of hyperplasia precedes that of hypertrophy. In other words, cell division characterizes the early stages of growth in any organ and stops before growth in size and weight of the organ is complete. Myron Winick and his collaborators have defined three phases of growth of all organs: cell division alone; cell division and cell enlargement; and cell enlargement alone.[9] The structural component of these cells, their metabolism, and their functional integrity are ultimately connected to their nutritive supply.

Malnutrition interferes with both types of cellular processes. However *it appears* that when malnutrition occurs after the transition to growth (cell enlargement alone), recovery is possible by refeeding. When malnutrition interferes with the cell division stage of growth, the injury may be irreparable. Thus any developing organism is more vulnerable to deprivation—a reduced supply of building materials —than the one that has attained its full growth. The more rapidly it is growing the more vulnerable it is to deprivation. The more severe the deprivation the greater will be the damage to the ultimate development. Any interference during the critical periods with the normal development, maturation, and function of the organs, be

8. In North America the term malnutrition signifies a "crisis model" with images of pot-bellied children of Biafra, or the Oxfam commercials showing children of famished Bangladesh, flashing in our mind. As Birch put it (in "Designs and Proposal for Early Childhood Research," p. 4) these "images reflect only a highly visible tip of a huge iceberg." We shall confine ourselves to the general definition of malnutrition as a state of acute or chronic undernutrition involving a total or partial lack of a nutrient or nutrients in the food intake of the human organism during its life cycle as a result of which a functional deficiency of the body system occurs. This impairment can be either permanent or temporary.

9. Myron Winick, "Nutrition and Cell Growth," *Nutrition Review,* 26 (1968), 195-97.

they of the central nervous system or viscera, has a serious effect on the release of the potentialities of the child in later years. In this framework, the mother-to-be, the fetus, the infant, and the preschool child assume central positions in the overall scheme of nutritional programing.

Considerable evidence indicates that women who are malnourished as children are more likely to have disturbed pregnancies and bear children of low birth weight with increased risk of neuro-integrative abnormality. Inadequate or faulty nutrition during pregnancy can affect both the mother and the developing fetus.[10]

Growth and development of the fetus is dependent on a healthy placenta, which acts as the infant's lungs, kidneys, and liver. During the first few weeks of embryonic life, the cells of the fertilized ovum undergo a high degree of specialization and differentiation and by the eighth week after conception the brain is recognizable as such and a well-formed spinal cord is evident. At the end of the first trimester, embryogenesis is almost complete and most of the further development of the fetus is by growth only. During the rest of the pregnancy, the rate of growth of the human organism is faster than at any time during the rest of its life cycle. It has been estimated that if this rapid growth were to be continued into later life, by fifteen years the child would be seventy-five feet tall and would weigh several tons.

The period when the growth rate is maximum is, therefore, critical from the standpoint of vulnerability to nutritional defects. It has been demonstrated that the brain, which grows and differentiates at a very rapid rate during intrauterine life and the period closely following birth, is one of the organs most vulnerable to malnutrition or subnutrition. Animal investigations carried out by Alan N. Davison and John Dobbing show that myelination (formation of a fatty protective sheath around nerve fibers) may be impaired by reduced cell replication and delayed biochemical maturation when malnutrition coincides with the periods of rapid brain growth.[11] Stephen Zamenhof and his colleagues and Myron Winick have demonstrated that nutritional deprivation is also accompanied by a reduction in brain cell number.[12] This effect has also been demonstrated in human infants who died of severe early malnutrition.[13] In addition defective enzyme organization in the brains of malnutritioned organisms has been well established.[14]

10. It has been generally found that there is no better time in which to attempt the education of a community than during the prenatal and postnatal periods of the female members of the community. During these times, especially when it is the first pregnancy, women are vitally interested in knowing what goes on inside their system; and with the excitement at the prospect of reproducing another life they are very receptive to ideas and willing to do what is required for the welfare of the new creation. The need to establish good communication at this juncture is of paramount importance.
11. Alan N. Davison and John Dobbing, "Myelination as a Vulnerable Period in Brain Development," *British Medical Bulletin,* 22, no. 1 (1966), 40-44.
12. Stephen Zamenhof, Edith Van Marthens, and Frank L. Margolis, "DNA (Cell Number) and Protein in Neonatal Brain: Alteration by Maternal Dietary Protein Restriction," *Science,* 160 (1968), 322-23; and Myron Winick, "Nutrition and Cell Growth," pp. 195-97.
13. Myron Winick and Pedro Rosso, "The Effect of Severe Early Malnutrition in Cellular Growth of Human Brain," *Pediatric Research,* 3 (1969), 181-84.
14. H. Peter Chase, James Dorsey, and Guy M. McKhann, "The Effect of Malnutrition on the Synthesis of Myelin Lipid," *Pediatrics,* 40 (1967), 551-59; and H. Peter Chase, and Harold P. Martin, "Undernutrition and Child Development," *New England Journal of Medicine,* 282 (1970), 933-76.

In the human organism, the period of most rapid brain growth extends from about the beginning of the last trimester of pregnancy to about six months after birth. The human brain adds about two milligrams per minute at birth and grows from 25% of its adult weight at birth to 70% of its adult weight at the end of one year; 90% of the total postnatal brain growth occurs in the first three years. The number of neuronal cells is more or less fixed at birth. During the next nine months, cell replication in the brain is that of only the glial cells. Other aspects of growth and differentiation in the nervous system such as myelination, proliferation of the dendrites, and synapse formation, which are critical for neuro-integrative organization, continue to develop at a very rapid rate throughout early childhood. It is safe to conclude that the period of vulnerability extends beyond the first year of life well into the preschool age.

There is unequivocal evidence to show that protein-calorie malnutrition[15] during any of the stages of the formation, growth, and development of the infant's brain is reflected in retarded growth and smaller head circumference.[16] Severe protein-calorie deficiency may not only result in smaller head size but also a disproportion between skull size and brain size. Using skull transillumination techniques it has been shown that there is an increased volume of cerebrospinal fluid in the cranial cavity which can be interpreted as secondary to brain atrophy. Early protein-calorie deprivation may slow the rate of cell differentiation and multiplication whereas restriction at a later stage may only affect cell size (growth). If the degree of deprivation is sufficiently prolonged, changes in function may be permanent. Thus, malnutrition may directly affect intellectual performance or learning capacity by temporarily or permanently damaging the central nervous system.

Studies on various animals have conclusively demonstrated the irreversible effects of early malnutrition on later behavior patterns and learning abilities.[17] Over the past decade longitudinal studies have been carried out in naturally occurring clinical settings in countries where malnutrition is endemic.[18] A critical review of eight such

15. We shall examine here only protein-calorie deprivation during this vulnerable period to show as a case in point how this affects the learning competence of the developing child. In fact, any one or a combination of the essential nutrients (e.g., vitamins and minerals) lacking in the diet during this period or later years will lead to improper functioning of the human organism.

16. Mavis B. Stoch and P. M. Smythe, "The Effect of Undernutrition during Infancy on Subsequent Brain Growth and Intellectual Development," *South African Medical Journal,* 41 (1967), 1027-32; and Fernando Monckeberg, "Effect of Early Marasmic Malnutrition on Subsequent Physical and Psychological Developments," in *Malnutrition, Learning and Behavior,* p. 269.

17. Richard H. Barnes, A. Ulric Moore, Ian M. Reid, and Wilson G. Pond, "Effect of Food Deprivation on Behavioural Patterns," ibid., p. 203.

18. In North America malnutrition is a word used only in reference to underdeveloped countries. The affluence of the West may be leading us to a false sense of security about the adequacy of our nutrition and the assumption that everyone is well fed and malnutrition and starvation are not our worries. Recent reports indicate that segments of the population of the United States have demonstrable malnutrition. See, for example, the report of the Council on Foods and Nutrition, American Medical Association, "Malnutrition and Hunger in the United States," *Journal of American Medical Association,* 213 (1970), 272. Although differing in nature, severity, and extent, the effect of malnutrition on child development and adult performance is still a critical issue in the United States.

studies reported in the last six years, in which children hospitalized with severe protein-calorie malnutrition were followed after recovery, shows that the greater the degree of malnutrition, the more severe the intellectual handicap.[19] As early as 1960, it was reported that severe nutritional deprivation in the early months led to marked delays in language acquisition. Early malnutrition also has a detrimental effect on the auditory-visual integrative function and on neuro-integrative behavior in general.[20]

Even after an adequate structure of the central nervous system has been established, poor nutrition during the following years can severely impair the neurophysiological bases of learning and behavior. Moreover, an adequate state of nutrition is an essential prerequisite for good attention and for sensitive responses to the environment. One of the most palpable clinical manifestations of serious malnutrition in children is a striking combination of apathy, irritability, extreme nervous tension, and listlessness. This apathy inhibits volitional competence as the child does very little as a result of his own will or intention. Apathy itself is a sign of lack of motivation. Unresponsiveness on the part of the child characterizes his relation to people as well as objects. When his relationship with other people is affected, his development of moral competence may also be inhibited. This ultimately leads to impairment of all other competencies which are then reflected in the child's attitudes and value systems at a later age. If the child is unresponsive to the surroundings, little or no learning takes place. The ability to integrate visual with tactile, tactile with kinesthetic, and visual with kinesthetic stimuli—all essential for developing learning competence—was relatively lacking in malnourished children studied by Joaquin Cravioto and his colleagues, and the rate of their recovery was appallingly slow.[21]

There is a synergetic relation between infection and malnutrition in humans. Malnutrition has deleterious effects on the body's nitrogen balance, thus lowering significantly the levels of certain essential serum proteins (complement and circulating gamma globulins), levels which are critical to the organism's defense mechanisms or immunological response to infection. Malnutrition and infection act synergistically to produce chronically or recurrently sick children who are unresponsive to sensory stimuli.

All these studies support the view that the earliest period of infancy is one of the most critical for the developing brain and central nervous system. If learning competence is the ability to differentiate and integrate experience which is necessarily mediated through the central nervous system, impaired functioning of this system because of malnutrition will impair the development of learning ability.

No doubt a vast array of scientific questions remain unanswered in this area.

19. Ernesto Pollitt, "Behavioral Correlates of Severe Malnutrition in Man," in *Nutrition, Growth and Development of North American Indian Children,* ed. W. M. Moore, M. M. Silverberg, and M. S. Read, DHEW Publication No. (NIH) 76-26 (1972), pp. 151-66.
20. Joaquin Cravioto, and Elsa R. De Licardie, "Intersensory Development of School-age Children," in *Malnutrition, Learning and Behavior,* p. 252.
21. Joaquin Cravioto, Elsa R. De Licardie, and Herbert G. Birch, "Nutrition, Growth and Neurointegrative Development: An Experimental and Ecologic Study," *Pediatrics* (suppl.), 38 (1966), 319-72.

However, it would be disastrous if the recognition of limitations of scientific understanding were to be used as a cover or excuse for inaction. Science is a fabric of information and theory being continually woven, and both our knowledge and concepts are always limited by the reality of time. It is our function to use science as a tool for the technological, social, and spiritual progress of man; and we can use it effectively to identify our greatest needs at any point in time and to satisfy them by restructuring our priorities, policies, and procedures.

THOUGH MANY QUESTIONS are still to be answered on the relation of malnutrition to mental development, the available body of knowledge makes it abundantly clear that the association between nutrition and physical as well as functional development is very strong. In view of this, we have little choice but to advocate improved nutrition as one essential for the growth and development of healthy and intelligent children.

Simply providing food is not the answer to the problem, since tradition and superstition have convinced many people that the foods nutritional science considers important to child-bearing mothers and young children are harmful to health or taboo on some other account. Where tradition and superstition, rather than proper knowledge, determines dietary habits, the forces behind these traditions must be understood before positive approaches toward re-education in nutrition can be undertaken. If it is to have long-term impact, the intervention must also have as one of its major components a program of instruction for parents, children, and community members as a whole. Clearly, the child is not an independent or isolated agent and a considerable portion of his life takes place in his home with his family. It is obvious that gains, both with respect to food intake and with attitudes and preferences toward food, made while the child is in a school or some similar environment may be undone if the home and the school function at cross purposes with one another.

Consequently, an essential part of any program of child education must be the establishment of the cooperation and positive participation of the parent in the achievement of the goals and objectives which the program sets for itself. This means that a program of parent education with respect to nutrition and the physical needs for children is an essential component of educational planning. The enlistment of cooperation and the education of the parent can have effects which are beneficial not only to the child who is in the educational system but to all children in the families, born and unborn. It is imperative that we acquaint the mother not only with the needs of the child after his birth but also with his needs when he is still in the womb.

For the human organism to house a sound mind it must build and maintain a healthy body. Thus the critical role played by proper nutrition must be understood, appreciated, and supported by the administration, teaching staff, and the community. This can be done only by active parent and community involvement in school planning. The ANISA system envisages beginning work with prospective parents a year before conception so that a superior nutritional status of the mother-to-be can be guaranteed and the best possible environments, both prenatal and postnatal, for producing a healthy organism maintained. Good nutrition is requisite to the full release of the potentialities of the child.

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