PROTEIN, NUTRITIONAL HAZARD, AND CULTURAL EVOLUTION: SOME THEORETICAL COMMENTS

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INTRODUCTION

It has recently been suggested that the availability of animal protein in human diets may have been a factor of great importance in determining the pattern of cultural evolution. According to the protein hypothesis, meat is a critical nutrient usually in short supply, and the need to acquire meat has thus had an important shaping effect upon all civilizations. In perhaps the most spectacular statement of this position, Harner (1977: 119) attributes Aztec warfare and cannibalism to the need for meat: "... for the necessary satisfaction of essential protein requirements, cannibalism was the only possible solution."

It is our contention that the protein hypothesis is wrong for two reasons. First, there is no essential protein requirement which demands that Homo sapiens consume flesh foods, human or otherwise. Although nutritional scientists did set high levels for recommended protein intake during the 1950's and 1960's, more recent research has resulted in a drastic lowering of protein-intake standards (Waterlow and Payne 1975). As Hegsted (1978: 62) puts it, "Considerable evidence is now available that refutes the 'protein hypothesis'." Second, ecological conditions never determine cultural patterns; rather, the evolving complex of cultural "control constraints" (Pattee 1972, 1977; Polanyi 1968; Diener, Nonini, and Robkin 1980; Robkin and Diener N.D.) selects and harnesses environmental resources. Thus, no biological factor ever generates a single, "only possible" cultural response; rather, "features of the natural environment become significant only when and as they are introduced into cultural systems and become incorporated as cultural elements" (White 1959: 51).

A recent critique of ecological theory and the protein focused upon some general features of human nutrition and the cultural biases which have led to an overemphasis on the role of animal protein (Diener, Moore, and Mutaw 1980). In this paper, we will expand upon that general critique and develop an alternative, evolutionary perspective upon problems of human nutrition. In so doing, we will employ the relative importance of plant and animal foods in Mesoamerica as a useful example.

PROTEIN IN MESOAMERICA

The emergence of neolithic economies over the last 10,000 years or so has been the cause, according to some, of a near-universal animal protein shortage in Homo sapiens: "... a diet that contained a fairly high proportion of meat would be basically a diet most suitable for human animals ... Widespread nutritional diseases such as protein deficiency (the commonest nutritional dificiency) ... stem largely from the dietary change brought about by the neolithic revolution" (Yudkin 1969: 548-549). Some time ago, Linton (1940: 34-35) suggested that protein shortage may have been a critical factor in the culture history of Middle America and the American Southwest:

"An inland people who had no domestic food animals and who raised only starch crops would have great difficulty in developing and maintaining a dense population... To hunt and gather wild foods successfully the people would have to live in small and widely spaced communities. In time such farmers-food gatherers might develop considerable skill in cultivation but a mere increase in the quantity of starch foods raised would not solve their problem. There would be a definite ceiling, set by the supply of wild proteins, beyond which their population could not increase without encountering dietary deficiencies. This, in turn, would set a limit to the level of culture which they could maintain."

Linton argued that protein-yielding plants (e.g. beans, peanuts) might suffice to overcome the limits set by nutritional factors upon civilizational advance, but others have argued that it is <u>animal</u> protein which is critical. Stini (1971:1023) suggests that in agricultural regions such as Mesoamerica, where reliance is upon a limited assemblage of vegetable nutrients, "nutritional imbalances" develop as a result of a "shortage of one or more of the essential amino acids"; such imbalances are said to be "frequently disastrous." Smith (1976: 19) suggests that under such circumstances protein shortages would be the primary limitation upon population size. Commenting upon the protein available from corn-bean combinations at Tehuacan, Kaplan (1967: 202) concludes that it "appears to be adequate for some members of the population, such as working males, [but] it is inadequate for the more protein sensitive members such as lactating mothers and recently weaned children."

Haviland (J967) felt that the effects of such dietary stress could account for variation in skeletal size at Tikal. Schoeninger (1979) found differences in bone composition in skeletons from Chalcatzingo, and attributed the differences to differential meat intake. Shimkin (1973: 278) argues that, " the supply of animal protein must be viewed as a critical factor historically." In a recent review of central Mexican culture history, Santley and Rose (1979: 192-201) remark:

> "Dietclry proteins are perhaps the single most important nutrient in the food supply. . • Animal sources .of dietary protein supply the proper assortment and proportion of amino acids and are thus high quality proteins. Vegetable sources of protein, however, wjth the exception of nuts, are usually lacking in one or more of the essential amino acids and are thus low quality protein...The greater consumption of calorie-rich foods like maize, if not supplemented with some meat, should create not only shortages in protein and undesirable leucine/isoleucine ratios but also greater susceptibility to disease... Scarcity of animal meat and other high quality protein would appear to be the key to understanding the reduction in population growth during MH-2I2 times."

The most controversial application of the protein hypothesis to Mesoamerican history has been Harner's (1977) analysis of Aztec cannibalism. According to Harner, the Aztecs shared with all other human populations a need for dietary animal protein. Since domestic animals were limited in pre-Columbian Middle America, cannibalism was the "only possible solution":

> ". . . domesticated animal production was limited by the lack of a suitable herbivore. This made the ecological situation of the Aztecs and their neighbors unique among the world's major civilizations . . . cannibalism, disguised as sacrifice, was the natural consequence of this situation . . . From the perspective of cultural ecology and population pressure theory, it is possible to understand and respect the Aztec emphasis on human sacrifice as the natural and rational response to the material conditions of human existence". (Harner 1977: 118-119, 132).

Harris (1977: 162) credits Harner with "solving the riddle of Aztec sacrifice"; elsewhere, Harris (1979: 34) suggests that the "preference for animal protein dominates the human quest for food." Ironically, a recent review of the anthropological literature written for nutritionists argues that ethnographic materials demonstrate the protein hypothesis (Abrahms 1979). The hypothesis thus becomes circular , with anthropological evidence used to convince nutritional scientists and nutritional evidence used to convince anthropologists. Although the protein hypothesis continues to be widely supported in anthropology, however, it has now been largely discredited in the nutritional sciences.

THE PROTEIN MYTH

Harner's protein explanation of Aztec cannibalism, and other accounts that accord a determinative priority to protein in Mesoamerican culture history, are based upon two assumptions. First, it is assumed that animal protein is an essential constituent of all naturally-occurring human diets. Second, it is assumed that environments "cause" and cultures "respond". Here, we will reject the special role accorded to meat in human nutrition by reference to recent research in nutritional science. Later, we will argue that cultures are active and evolutionary systems which shape their environments, rather than merely responding to them.

Although protein determinism did dominate nutritional thinking during the decades immediately following World War II, it is now recognized that such simplistic assessments of human nutritional needs as that presented by Harner are untenable and that the "meat hypothesis" is marred by severe cultural bias (e.g., Diener, Moore, and Mutaw 1980). As Waterlow and Payne (1975: 113-117) note:

> "In 1968 the U.N. Advisory Committee on the Application of Science and Technology to Development

presented a report to UNESCO with the title "International Action to Avert the Impending Protein Crises." Numerous recommendations were made about methods of increasing protein supplies, the production of high protein foods and the exploitation of unconventional sources of protein to fill the 'protein gap'. Seven years later there is a strong body of opinion that this is an incorrect statement of the problem: that what the world with its expanding population has to face is primarily a food gap or an energy gap and not a protein gap. . . perhaps the story of the protein gap shows the arrogance of supposing that we know the answers and illustrates the need for a continuing critical examination of the premises on which action is based."

Pellet (1978: 60, also 1976) notes that," . . the concept of a worldwide protein gap is no longer tenable." Crawford and Rivers (1975: 235) call the protein hypothesis a "myth": ". . . the emphasis on protein is misplaced. . Nutritionists have been hypnotized by the protein myth." McLaren (1974: 95) argues that an overemphasis upon protein resulted in a major misuse of resources in the post-World War II period: "It is common for the cost/benefit analysis of a given measure to be computed. Perhaps someone should try to work out a cost/detriment analysis of the protein fiasco."

Sukhatme (1975: 53, 57) remarks, "There is no evidence to support the thesis that diets common in the developing countries are deficient in protein...Clearly, protein needs are very low compared to what is eaten in the rich countries." Hegsted (1976: 318) notes that the protein content of traditional diets around the world "is almost invariably more concentrated than in human milk," a point also emphasized by Trowell (1977: 7). De Gavine (1978: 416) argues that, " man can subsist as well on either a meat and fat diet. or on a diet which is practically devoid of animal protein and fats. .." According to Manning (1977: 28), "protein deficiency is probably not the major cause of malnutrition."

One reason for the mistaken emphasis upon protein is that primary protein deficiency has been confused with secondary protein deficiency. Clinical symptoms of protein deficiency may appear when adequate dietary protein is available, but when inadequate calories are available to metabolize the available protein. Gopalan (1975a: 341) stresses that "calorie deficiency is the real bottleneck and any protein deficiency that may be present is incidental to such calorie deficiency." Miller (1974: 948) contends that, "No diets customarily consumed by children, and properly measured, have been shown to be adequate in calories and deficient in protein." Austin (1976: 88) comments that, "Protein fortification is an expensive way to solve a calorie problem." The primacy of calories has led McLaren (1975) to suggest that "protein-calorie malnutrition" should be renamed as, simply, "energy malnutrition."

Even when children suffering from clinical symptoms of malnutrition are considered, no evidence exists that feeding high protein diets is helpful. Arroyave (1975: 8) argues that the treatment of malnourished children does "not have to depend on the so-called 'high-protein sources'." Ifekwunigwe (1975: 393) agrees, pointing out that, "The importance of this is that the savings made by avoidance of excessive amounts of protein may help to relieve the financial strain on treatment that is necessarily carried out on a very limited budget." Rao (1974: 709) found no evidence of primary protein malnutrition among poorly nourished children in India: "Significantly, in the great majority of these children, in terms of the latest recommendations on the protein requirements, actual protein intakes are adequate on a body-weight basis." Nnanyeluge (1978: 108) concludes, "There is no evidence that high-protein supplements are in any way beneficial. . ." Even under famine conditions in Ethiopia, Rivers, Seaman, and Holt (1974: 947) could find no evidence of protein malnutrition.

The claim that most plant foods lack essential amino acids is false. Most plant foods contain all the essential amino acids. While Zein (in corn) and gelatin (an animal protein) are examples of totally incomplete proteins - each lacks an essential amino acid - such cases are rare. The question about most foods is not whether they <u>contain</u> the essential amino acids, but whether they contain them in amounts and proportions adequate to support normal human growth and functioning. It was once believed that the Protein/Energy ratios of only "high quality" proteins (e.g. meat) fell within the safe range for Homo sapiens; more recent research, however, indicates that "the pIE ratios of cereals fall within the likely range of the safe level" (Waterlow and Payne 1975: 116). Indeed, Begum, Radhakrishnan, and Pereia (1970) have shown that normal growth could be sustained in 2-3 year old children by diets in which wheat or rice were the only sources of protein. DeWaard (1976: 100; also Arroyave and Lee 1976) remarks:

> "In the feeding practice for healthy adults and older children, protein quality does not seem to be significant... The insignificance mentioned even holds for maize, the protein of which is deficient in trypthophan. This amino acid was not limlting in the diets of men consuming maize as their only staple... My impression is that protein quality is often over-emphasized."

Gopalan (1975b: 350, also 1975a) remarks that, "... the protein requirement can be completely met by ... cereal-legume based diets." Indeed, animal products in most diets "may be more important for their lipid content that for their protein content" Crawford and Rivers (1975: 242). While cereals alone may provide adequate protein for older children and adults, infants have higher protein needs. But cereal-legume mixes are fully adequate even for infants, and even under exposure to infectious disease (Gopalan 1968, 1975a, b). After all, "human breast milk, an unexcelled food for human infants, is in fact a 'low protein' food" (Hegsted 1978: 62).

The supposed "poor quality" of vegetable proteins was justified by reference to short-term nitrogen balance studies. These studies failed to allow for a period of dietary adaptation after a change from a high-protein to a low-protein diet, or for the extreme efficiency of amino acid recycling when dietary protein intake is low. In fact, "... men and animals, after a period of adaptation, achieve nitrogen balances with low protein intakes" (Harper 1975: 148). Waterlow (1975: 33) notes that, "In man on a normal protein diet ... 75% of all amino acid entering the pool is normally recycled or reutilized for protein synthesis. When protein intake is reduced this proportion may rise to 90-95% ... the extreme efficiency of the mechanism of adaptation and economy reinforces the confidence I have in the safe levels of protein intake proposed by FAO and WHO [as revised downward in 1973]."

In the United States, huge amounts of animal protein are consumed; thus," .. much protein is burned as fuel, a process comparable to heating a house by burning beefsteaks in the furnace - adequate but expensive" (Brues 1977: 193). Elsewhere, the economic, social, and cultural biases leading to overemphasis upon animal protein have been discussed (Diener, Moore, and Mutaw 1980). Here, it is merely necessary to note that present opinion in nutritional science refutes a fundamental assumption of protein determinism.

NUTRITIONAL HAZARD AND CULTURAL EVOLUTION

White (1959: 51) has remarked that features of the natural environment become important only when and as they are introduced into cultural systems. Resources are "introduced" into cultural systems when symbolically-encoded "control constraints" are devised to pattern their use. (For a discussion of control constraints, see Pattee 1972, 1977; Diener, Nonini, and Robkin 1980). Rather than seeding imaginary biological determinants for culture, we need to focus upon the flow of cultural forms down through time and note how culture controls biological and ecological activities. Culture is not <u>determined</u> by protein needs; rather, culture <u>determines</u> what kinds of materials serve as human foods.

As noted, human protein needs are very low, and all traditional grain-legume combinations have been found to provide sufficient protein (Crawford and Rivers 1975: 238). Although Harner and Harris suggest that the 15,000 or so victims sacrificed each year by the Aztecs were required as a meat supply, they also admit that much of the human flesh obtained by sacrifice was not eaten. Further, they ignore the massive amounts of protein-rich legumes imported each year by the Aztecs. Legumes rarely contain less than 20% crude protein, and they may contain 30% or more; by comparison, dried whole milk contains from 22% to 25% crude protein (Altschul 1965: 24). Since the tribute lists indicate that the Aztecs received at least 168,000 bushels of dried legumes each year (Kaplan

1967: 203), and since even larger amounts of leguminous protein may have been grown locally, the protein contribution of cannibalism to the Aztec diet is totally insignificant.

Although grain-legume diets can supply all of the protein necessary for human growth and development, they can do so only when properly prepared. While animal products contain toxic substances (Liener 1974), or in other ways may endanger the health of those who ingest them (Diener, Moore and Mutaw 1980), it is the vegetable component of the human diet that requires the more extensive processing prior to ingestion. But food processing methods - broadly, "recipes" - are not determined by the ingredients they call for; rather, the symbolic evolution of man's technological skills determines what can be, and what cannot be, processed into human food. Further:

> ". . . it is continuity on the subjective side rather than on the objective, or overt, that is essential. As we have shown, it is the symbol, particularly in word form, which provides this element of continuity in the tool experience of man . . . it is this factor of continuity in man's tool experience that has made accumulation, and progress, in short, a material culture possible"(White 1949: 48).

It is seldom recognized just how great has been the accomplishmentof processing vegetable sources to serve as human food. Thus, "out of the enormous variety of higher plants in the world, mankind has over millenia selected only a limited number for food purposes . . . most can be eaten only if the quantities are moderate or small or the food has been processed to remove toxic factors" (Scrimshaw 1978: 174). The evolution of food processing knowledge and technology represents "the first major advance in alimentation in 200 million years or more in the line that led to man, the first essential change in digestive economy since the premammalsstopped swallowing their prey whole and began to chew and predigest it in the mouth" (Hockett 1973: 407).

Roberts (1975) points out that nearly all of the dietary. protein for the poorer populations in the developing world is supplied by vegetable foods, especially grain legumes, and this was undoubtedly the case in pre-columbian Mexico as well. The food legumes represent the most diverse assemblage of any group of plants used as human food, and one or more of them is consumed regularly in nearly every country of the world (Adams, Milner, Montifort, and Rockland 1978: 302). Common genera among the food legumes include Phaseolus, Vigna, Cicer, Pisum, Lens, and others. The genus Phaseolus, which includes about 160 species, has been particularly important in New World dietaries. P. vulgaris, P. acutifblius, P. lunatus, and P. coccineus are species of New World origin important as food crops. There is a great deal of variety within species; for example, Kaplan (1967: 201) has described P.vulgaris as a "polymorphic, poorly understood species" containing "hundreds of varieties."

In spite of their present importance in human diets, "the nutritive value and protein digestibility of legumes are very poor unless subjected to cooking or some other form of heat treatment" (Liener 1976: 1076). Even after being heated, legumes may not be safe for human consumption unless further treated or unless consumed in limited amounts or in specific food combinations. Serious outbreaks of poisoning have been reported from the ingestion of cooked beans (e.g. Rothenasinkkam 1947), for example, and peasant communities may observe strict taboos upon the amount of beans eaten and the combination of foods with which beans are consumed (Diener 1979). Thus, with beans as with many other food items, the process of introducing a potential resource into the cultural system is a prolonged one, dependent upon the accumulation of symbolically-encoded information and symbolically-mediated technical systems. The symbolic evolution of human dietary patterns continues in the present, and even today the toxic factors in legumes and other foods may result in health hazards:

> "Through long experience, man has learned to adopt safe foods and to eliminate unsafe materials from foods. But it is not always true to say that foods do not contain any toxic substances or, so called, anti-nutrients at all, and that these substances are completely inactivated in foods or removed from them" (Miyoshi, Hamaguchi, Matsumoto, and Misuno 1978: 195).

The toxic factors in the leguminous plants eaten by man are various. Perhaps the best understood are the protease inhibitors. "Substances which have the ability to inhibit the proteolytic activity of certain enzymes are found throughout the plant kingdom, particularly among the legumes" (Liener and Kakade 1969: 8). It has been suggested that the inhibitors function in plants to regulate proteolytic processes, to store protein, or even to operate as defense mechanisms against predatory insects (Vogel, Trautschold, and Werle 1968: Whitaker and Feeney 1973; Liener 1976). A great variety of inhibitors (against trypsin, chymotrypsin, subtilisin, elastase, plasmin, kallikrein, papain, various amylases, etc.) have been noted (Whitaker and Feeney 1973). Protease inhibitors occur in diverse biological systems, exist in many structural forms, and inhibit different proteolytic enzymes. Their specificities for inhibiting different proteinases also vary widely. Hence, it is frequently difficult to predict the results of ingesting any particular inhibitor. Toxicological effects, however, include growth impairment, pancreatic hypertrophy, interference with the inflammation response, interference with immune reactions, etc. (Whitaker and Feeney 1973).

A second class of toxic factors found in most plants are the hemagglutinins. Hemagglutinins are proteins that have the ability to clump or agglutinate red blood cells in a fashion similar to antibodies. Although potatoes, bananas, mangoes, wheat germ, and many other edible plant products contain agglutinins, the most studied hemagglutinins have been those derived from legumes. The toxic effects of hemagglutinins may be severe. For example, kidney bean and black bean hemagglutinins fed to rats at the 0.5% and 1.0% level for a two week period resulted in complete mortality (Liener 1976). Growth reduction and diarrhea are also commonly observed.

A third toxic constituent of legumes is phytate.Phytate is a strong acid that forms a wide variety of salts with several heavy metals. Whether a particular salt is formed is dependent on pH as well as on the presence of secondary cautions. A great deal of attention has been given to the effect of phytate in decreasing calciumabsorbtion in the gut; decreased iron availability has also received attention. "The results indicate that a compound such as phytate that complexes with such a broad spectrum of metals may produce a wide variety of deficiencies depending on which element first becomes limiting under specified dietary conditions" (Oberleas 1973: 369). Although phytate occurs in a variety of plant products, from carrots to sweet potatoes, "cereals, nuts, and legumes contain larger portions of phytate" (Ibid.: 364). Parenthetically, dietary reconstructions based upon the calcium/strontium ratio in bone (e.g., Schoeninger 1979) may be influenced by the presence of phytate in the diet. As far as we are aware, this complication has never been controlled for in past studies.

Many other toxic factors occur in legumes and other plant foods: saponins, antivitamins, cyanogenetic glucosides, etc. Most of the antinutritional or toxic effects can be partially or wholly eliminated by proper cooking or other processing techniques, by limiting the amounts ingested, and by combining a variety of items ina single meal (1FT Expert Panel/CPI1975:

69). However, "some of the intermediary stages of toxicity may not be easily detected" (Jaffe 1973: 113).

The evolution of modern man is bound up with the processing of plant foods. The "sudden spread of hearths that occurred about 40,000 years ago" (Leopold and Ardrey 1972: 513) indicates, in our opinion, rapid advancement in food processing knowledge and technology. From that time until the present, humanity has thought about, talked about, and experimented with the potential food sources in the environment. Some materials are obviously toxic and have been avoided. "The more dangerous toxicants . . . are those that act in a slower, more subtle fashion and therefore may not be recognized as being dangerous" (Strong 1973: 2). Indeed, in a very real sense, almost <u>all</u> plant foods are toxic unless their ingestion is culturally regulated and/or their form altered by processing.

Complex rules exist for processing and ingesting legumes and other plant foods. In eastern Guatemala, for example, Chorti peasants in the small community of Tuticopote Arriba commonly consume seven varieties of legume and nine varieties of corn. Cooking instructions differ for different food items, and include boiling, pre-soaking, post-soaking and rinsing, grinding, refrying, resteaming, etc. Further, specific combinations of foods are combined in traditional recipes and a variety of taboos limit ingestion of specific foods by particular individuals. For example, pregnant women are prohibited from eating black beans, perhaps as a precaution against phytate intake and possible deficiency disease during this period (Diener 1978, 1979, n.d.).

The processing of legumes can be quite complex. Protease inhibitors and hemagglutinins are largely inactivated when cooked in boiling water at lOOoe. Dry heat is much less effective with some varieties of legume, as is a lower cooking temperature. This poses a problem in highland areas where the boiling temperature of water is lower. Other toxic factors are heat resistant and require additional processing, as with gram production from Phaseolus in India:

> "The seeds are cooked more easily if they are split. They allowed to soak and are mashed into a thin paste, strained by squeezing in a cloth bag, and partly dried, boiled for half an hour, squeezed again, kneaded with hot and cold water, and finally dried completely. . . In some places it is usual to soak the gram (in its husk) and some beans in water for 12 to 24 hours and to tie them in a wet cloth. The bundle is allowed to stand for a day or two, and most of the seeds germinate" (Dean 1958: 215-216).

Such complex methods of food product selection, processing and ingestion-regulation are not directly determined by environmental factors; there is no "only possible" way for man to obtain his food from the natural environment. Further, the cultural materialist strategy, which places its emphasis upon the behavioral and "etic", underestimates the creative capacity of symbolic evolution. More than anything else, the evolution of human nutritional patterns is the evolution of "recipes" -

symbolically-encocted ideas about proper food handling and consumption passed down from one generation to the next. To emphasize a single element. such as animal protein. and to assume that this element mechanically elicits a solitary cultural response. is thus to misconstrue the very essence of cultural change. The ecological theatre is only the setting in which cultural development occurs; it is the creative process of cultural evolution itself which provides the substance of the play:

> "Much of sociocultural development seems to proceed very largely on its own terms, including some important aspects of ecological adjustment. Societal growth is a continuously creating process, conditioned far more by past history than by directly felt environmental forces. On the whole . . . the natural environment serves as no more than a backdrop" (Adams 1960: 292).

CONCLUSION

Harner, Harris and other cultural materialists have suggested that animal flesh constitutes an absolutely essential element in the human diet. They have also argued that, given the need for meat. the behavioral responses of human populations are often nutritionally determined. From this viewpoint. the "ernie" or symbolic activities of human beings appear as ideological afterthoughts with little practical importance.

An example of the application of this paradigm is Harner's explanation of Aztec cannibalism, whjch he interprets as the "only possible" behavioral solution to human protein needs.

The position of the protein determinists is faulty for two reasons. First, recent research in the nutritional sciences has resulted in a drastic, downward revision of the estimated protein needs of human populations. As Crawford and Rivers (1975: 238) note, "no diet in the world with a concentration of protein below the minimum has been identified." Because human protein needs are so very low, it is highly unlikely that any cultural trait has ever evolved to insure the protein intake of a human population.

Second, the cultural materialist perspective leads to a faulty intrepretation of the relationship between environmental elements and cultural traits. From the cultural materialist viewpoint, factors such as biological protein needs and environmental protein reserves <u>determine</u> cultural behavior, and the symbolic interpretations men form of their world are merely emic afterthoughts. A classic example of such an interpretation is Harner's explanation of Aztec cannibalism as the "only possible" solution to the dietary need for animal flesh.

From a "new evolutionary" position (White 1949, 1959; Diener, Nonini, and Robkin 1978, 1980; Diener 1974, 1980), such a mechanical portrayal of cultural dynamics is invalid. For example, considering human nutritional needs, the environment provides a wide variety of materials which may be either hazards or potential food resources. Legumes in their natural state are highly toxic, and they thus "become significant only when and as they are introduced into cultural systems and become incorporated as cultural elements" (White 1959: 51). The "incorporation" of resources into cultural systems occurs as human beings think about, talk about, and experiment with the environment about the them; that is, cultural systems transform the natural environment by bestowing upon it a symbolic meaning. As Marx (1963: 217) remarks, "nature, taken abstractly, for itself, rigidly separated from man, is nothing for man." It is the symbolic capacity of man which is the origin and basis of human technical adaptation.

An evolutionary approach to problems of human nutrition will not focus upon symbols as divorced from the natural world, but neither will it seek an escape from the symbolic essence of man by assigning determinative priority to the physical environment through mechanical materialism. Rather, we need to focus upon the process of "unceasing labour and creation" (Marx 1868: 63) of cultural evolution, which proceeds as real, living human beings impose symbolic order upon the mechanical world of physics and chemistry. Indeed, "The basic positions of the modern theory of knowledge are reflected in this practical intertwining of objectivism and subjectivism, as it is seen in the dialectics of labour. . ." (Schmidt 1971: 115). From this viewpoint, human technical systems control the world, they are not controlled by it; man makes himself, he is not a passive product of the environment; and while the technical adaptation, including the nutritional adaptation, of culture to environment is crucial - the most important aspect of technology is the information contained in the minds of people as they struggle to understand, and to change, the world in which they live:

> "The fact that we design machines that can, for a time, operate as physically separate and informationally autonomous systems does not in their present stage make them less biological or less dependent for their design, construction, repair, adaptation, and evolution on their ultimate interactions with humans and on the languages of the brain. In other words, if we wish to consider the origin, function, and evolution of the complex machines that now exist, then the brain of man must be recognized as part of the complex system. ... Or to put the problem another way, the artificial components - the man-made works - are really the simple part of what I call the complex system in which the description of the system is in the brain" (Pattee 1977: 260).

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