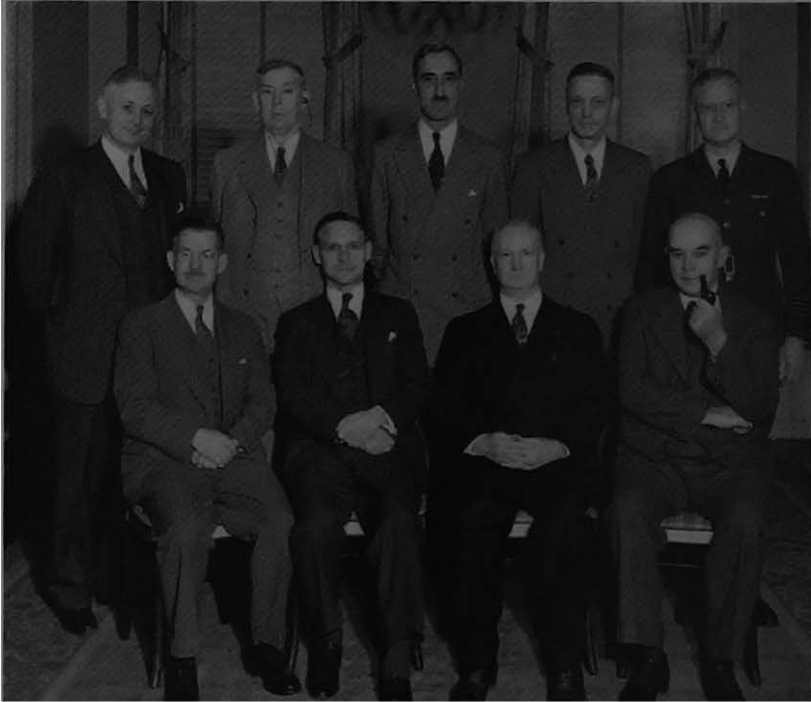


NUTRITION AND PUBLIC HEALTH  
IN THE POSTWAR PERIOD



SPEAKERS ON NUTRITION AND PUBLIC HEALTH

Sitting: L. A. Maynard, Ph.D., Charles G. King, Ph.D., Paul R. Cannon, M.D.,  
Frank G. Boudreau, M.D.

Standing: Roy C. Newton, Ph.D., E. V. McCollum, Ph.D., Harold C. Stuart, M.D.,  
Philip C. Jeans, M.D., Frederick F. Tisdall, M.D.



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# CHILDREN'S FUND OF MICHIGAN

*A Charitable Trust Created by the Late  
Senator James Couzens*

TO PROMOTE THE HEALTH, WELFARE,  
HAPPINESS AND DEVELOPMENT OF THE  
CHILDREN OF THE STATE OF MICHIGAN  
PRIMARILY, AND ELSEWHERE IN THE WORLD

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**CONFERENCE OPENING**

**WILLIAM J. NORTON, Sc.D.**  
*Executive Vice-President and Secretary*  
*Children's Fund of Michigan*

**T**HIS CONFERENCE on nutrition has been summoned by the Children's Fund of Michigan to discuss a matter of the greatest importance to every man, woman, and child in the world.

Since its establishment by the late James Couzens in 1929, the Fund, through its Research Division, has had as one of its major undertakings, study in the chemistry of nutrition. That food and drink have a vital influence upon health and sickness has always been apparent to all. But until recently next to nothing has been known about the mysterious processes by means of which the substances taken into the human body are converted into bone, tissue, and fluid, or why some foods are generally more efficient as body builders than others, or why some that are efficient in most bodies lack efficiency when eaten by particular persons.

Within the last few years, biological chemistry has come into its own, and one of the deep forests it has begun to clear and penetrate is the forest of ignorance on these matters. Many inquiries into the chemistry of nutrition have been launched, among them those of the Children's Fund, and much knowledge has been uncovered highly useful to mankind.

Now we need to apply this knowledge more capably than hitherto. A long lag frequently exists between scientific discovery and its utilization by the multitudes of common people, and that lag is great in the area of nutrition. Unusual difficulties exist in putting this knowledge to work, bad habits that have the sanction of encrusted tradition, cultivated fads and unwholesome tastes, and the clear inability of millions of submerged people all over the world to get the items needed for a balanced diet. But those obstacles do not excuse those who are in possession of the knowledge from making all reasonable efforts to disseminate it widely. Indeed, they are a challenge that must be met and in due time overcome.

With that thought in mind, the Research Laboratory of the Children's Fund of Michigan has invited ten distin-



gushed specialists in various phases of nutrition to share a little of their learning with this audience. We are of course proud that the heads of our Laboratory, Dr. Icie Macy Hoobler and Dr. Harold H. Williams, are themselves recognized as eminent authorities in the field of nutrition. They conceived the conference and made all the arrangements. Dr. Macy Hoobler will act as chairman of the meetings, and I take pleasure in presenting her to you.

### ICIE MACY HOOBLER, PH.D.

*Director, Research Laboratory, Children's Fund of Michigan*

Dr. Norton, Distinguished Guests, and Friends: We are sorry to announce that there will be a slight change in our program. Doctor Holt telegraphed us that it would be impossible for him to be here today, but we hope to be able to include his paper in the printed proceedings of the conference. (Page 191).

At the end of each unit of our program, we have provided for a discussion period. You may submit questions to our distinguished speakers and they will be glad to answer those questions.

We have motion pictures scheduled during a part of the noon hour, later this afternoon, and preceding the evening session. I hope that all of you will be able to see them. We have brought them here because we thought that they would make a splendid contribution to this conference, and that, for those of you who have come from a distance, it would be comfortable in this lovely auditorium, and you could at the same time enjoy the films. Group Captain Tisdall has been good enough to bring from Toronto the film titled "The Training Table."

FOOD PRODUCTION FOR BETTER HEALTH  
AND LONGER LIFE

L. A. MAYNARD, Ph.D.

*Director, School of Nutrition, Cornell University*

Member, Food and Nutrition Board and the Agricultural Board,  
National Research Council; National Academy of Sciences

**I**T IS WELL recognized that malnutrition is caused to a much greater extent by a diet which is inadequate in nutritional quality rather than in amount as measured by calories. Our nutrition education program has thus stressed the use of more of the foods which are the better sources of the specific nutrients needed. More recently it has come to be realized that much can and should be done to improve the nutritional quality of individual foods as actually consumed. It has been demonstrated that much can be accomplished through the conservation of nutrients in processing, storing, and cooking. The enrichment of flour and bread, and the alternative United Kingdom and Canadian practice of retaining more of the nutrients of the wheat in milling, are examples of another general procedure for improving the nutritive value of specific foods. There is a third general method which has large possibilities, and which particularly deserves consideration in a food and nutrition program for the post-war world. Here I refer to the improvement of the nutritional quality of our basic food supply as produced. This is the aspect which I am going to discuss.

When one examines the data in the literature for the nutrient content of a given basic food, be it a seed, a fruit, a vegetable, or an animal product, he finds wide variations. Some of these variations are the result of faulty sampling and analytical procedures. But they are owing in large part to more basic causes inherent in the methods and conditions of production. For example, tomatoes, upon which we rely for vitamin C, may range from 5 to 45 mg. of the vitamin in the fresh fruit. Butter may range from 5,000 to 25,000 I. U. of vitamin A per pound.

Such wide variations may be interpreted by some to mean that little dependence can be placed on the vitamin values actually obtainable from these sources. But this is a wrong interpretation, for the bulk of the products as marketed exhibit much narrower ranges, and the supplies from different sources eaten by the individual over any extended period tend to average up. The much more import-

ant significance of these wide ranges lies in the possibilities thus indicated of producing more of the products having the higher values, and thus of stepping up the average content of the general supply through an understanding and control of the factors responsible for the variations.

With the development of the newer knowledge of nutrition, beginning early in this century, and with the discoveries of the diseases resulting from dietary deficiencies of the vitamins, mineral elements and certain amino acids, the need for the so-called protective foods to avert these deficiencies became recognized. In the case of the foods of plant origin there thus resulted largely increased production and consumption of vegetables and fruits. In producing these foods the goals of horticultural practice have been increased yields and market quality. Varieties have been selected for high yield, disease resistance, drought resistance, and cold or heat resistance. Yields have been increased by fertilization and other cultural practices. Ability to withstand shipment to market and to appear attractive to the consumer has been held in view from seed-time to harvest. These things are important, but in all of these developments comparatively little attention has been given to the real reason why protective foods are needed, namely, to supply the nutrients in which the diet is otherwise deficient. From this standpoint we need a consideration of yields of nutrients as well as of tons or bushels per acre. Yields may be restored on depleted soils by appropriate measures, and yet the food crops produced may have a low nutritive value. There is ample evidence that some of our protective foods have become less protective through neglect of these considerations. Market quality is important but it is not enough. Very tardily, nutritional quality is now coming in for attention.

The starting point of good crops is good seed. This has long been a subject of research in terms of yield. There are also genetic differences in nutrient content which should

be considered. This has become evident from variety comparisons with many different crops. Studies at the U. S. Vegetable Breeding Laboratory at Charleston, S. C., for example, have shown that the vitamin C content of 28 commercial varieties of tomatoes, grown side by side in the same soil ranged from 11 to 22 mg. per 100 grams. Thus, it would take twice as much of the poorest as of the best tomatoes to meet dietary requirements for vitamin C.

VITAMIN C CONTENTS OF COMMERCIAL VARIETIES OF TOMATOES

milligrams per 100 grams

Summerset	22	John Baer	16
Rutgers	18	Early Shipper	14
Marglobe	16	Bonny Best	11

(U. S. Vegetable Breeding Laboratory)

But of much greater significance is the probability that new varieties can be developed with values markedly above the top limit of the range. The table gives the mean ascorbic acid content of commercial varieties in comparison with the small-fruited varieties, *L. peruvianum* and *L. pimpinellifolium*.

MEAN ASCORBIC ACID CONTENTS OF COMMERCIAL AND SMALL-FRUITED VARIETIES OF TOMATOES

VARIETIES	NUMBER OF LINES	MEAN VITAMIN C mg./100 gm.	MEAN FRUIT VOLUME ml.
<i>L. peruvianum</i>	21	62.7	2.5
<i>L. pimpinellifolium</i>	50	46.5	1.3
Commercial varieties	30	15.2	96.7

(Reynard and Kanapaux, Proc. Am. Soc. Hort. Sci. 41:298, 1942)

It is noted that our commercial varieties contain only one-third as much of the vitamin as the small-fruited ones representing the stocks from which the present varieties were derived. It is entirely possible that this original high

vitamin content might have been preserved if the existence of the vitamin and its importance had been known at the time the breeding and selection work was carried out. Today the investigators at the Breeding Laboratory are crossing one of the commercial varieties back to a small-fruited variety to try to recover some of this lost vitamin content.

These investigators have already demonstrated, in the case of cabbage, that it is possible to improve vitamin C content as well as yield and market quality through breeding. Here are some of the data:

VITAMIN C CONTENTS OF NEW AND STANDARD VARIETIES OF CABBAGE

<u>VARIETIES</u>	<u>YIELD PER ACRE</u> tons	<u>VITAMIN C</u> mg./100 gm.
<i>New</i>		
Hugenot	19.6	64
Madison	17.3	72
<i>Standard</i>		
Charleston Wakefield	14.5	57
Marion Market	18.6	49
Golden Acre	13.1	50
Copenhagen Market	16.5	51

It is noted that the new varieties, obtained by selection, are higher in vitamin C content than the standard varieties, and also higher in yield with the exception that Madison was outyielded by one standard variety.

Other examples of breeding accomplishments could be cited, such as the recent development of high-carotene, high-yielding sweet potatoes.

A particularly interesting possibility for study has recently arisen. We class apples as low in vitamin C, although in the amounts consumed by many farm families it does provide a significant source in the diet. The average value given in the National Research Council tables is 5 mg. per 100 grams. The two most popular apples in New York, the Northern Spy and the McIntosh, have been reported to contain 10 and 2 mg. per 100 grams respectively. Since

apples are widely grown, have good keeping qualities, and are a cheap fruit, improvement of their vitamin C content would have great practical importance. A report which challenges our interest here has recently come from New Zealand. Eleven varieties of the Nelson apple were studied, revealing variations ranging from 2 mg. per 100 grams for the poorest quality, to 36 mg. for the best (the Sturmer variety). No figure even approaching the latter has previously been reported for any variety of apple, so far as I know.

The possibility of an apple richer in vitamin C than a tomato and nearly as rich as citrus fruits is certainly intriguing. Several varieties of the Nelson apple are grown in the United States, although not widely, and the Sturmer, the top one, is now being used in breeding and selection studies at one of our Experiment Stations at least. This Station has just begun a study of its experimental material as to vitamin C content. Normally it is a matter of decades to develop a new apple variety. If this lead from New Zealand should prove fruitful, however, the results will come in a much shorter time because of the work already in progress. One shouldn't be optimistic about what the results will show, but the lead does illustrate the possibilities in the breeding field.

Of course crops grown experimentally can't be expected to behave exactly the same under different field conditions. Climate has much to do with vitamin content. But the limited evidence to date indicates that varieties which are high in vitamin content in one locality are likely to be high in another. This fact may be illustrated by data on the thiamine content of wheat, being obtained by workers in the Agricultural Research Administration. Eighteen hundred samples of different varieties of wheat grown in different locations throughout the United States in variety testing studies are being analyzed for the vitamin. The study thus far indicates that, while both heredity and en-

vironment are factors which control the thiamine content of wheat, strains which are high in one location tend to be high in another.

It is clear that the plant breeder has important contributions to make to better nutrition. But there must be public interest and support to encourage him to do the job. As Doctor Wade, Director of the Breeding Laboratory at Charleston puts it: "If some agency interested in the public welfare absorbs the cost of research in the production of new varieties with improved nutrition values, then there is no reason for the public's paying increased prices. Our experience in breeding improved varieties would indicate that those with high nutritive value can be as productive as those with lower values."

The influence of soil on the nutritive value of food crops first became apparent from observations with range animals. This is not surprising because these animals get their entire food supply from a given area. A classic example is cobalt deficiency. For decades prior to the discovery of cobalt as the essential factor, tens of thousands of grazing animals wasted away and died each year in certain areas of the world, while animals remained healthy in other areas close by. Now it is known that 0.1 of a milligram of cobalt a day is all that is needed to keep in health sheep that otherwise would die. The losses have been prevented by an application of as little as 28 ounces of a cobalt salt per acre in areas of deficiency. This has increased the cobalt content of the pasturage to an adequate level, and has restored sick animals to health. There are many other examples of nutritional deficiencies in animals resulting from soil deficiencies.

One would not expect similar troubles in man to be of comparable importance because few people get their entire food supply from any restricted area. Yet goiter troubles and the fluorine problem occur in specific areas where soil and water composition is the controlling factor. In certain rural areas in Florida nutritional anemia seems to be



correlated with iron deficiencies in the soil. The over-publicized situation in Deaf County, Texas, where a lowered incidence of dental caries is ascribed to soil factors is well worthy of further study.

It is recognized that the calcium and phosphorus content of foods can be markedly influenced by soil factors. The trace elements, to which we pay little or no attention in human nutrition because we assume they are always present in adequate amounts, are the ones which are the most

RANGES IN MINOR ELEMENT CONTENT OF CROPS

*milligrams per kilogram*

	<u>Iron</u>	<u>Manganese</u>	<u>Copper</u>
Cabbage	305-11	436- 5	28- 4
Carrots	490-49	91- 6	11-10
Potatoes	363- 7	94- 4	24- 1
Tomatoes	800-48	98-18	34- 8

(U. S. Plant, Soil and Nutrition Laboratory)

variable in our food supply. Recent discoveries have shown that crop production in many areas suffers from trace element deficiencies. The obvious and severe troubles in animals resulting from such deficiencies have raised the question whether unrecognized, subacute troubles may not be affecting animal nutrition and health much more widely. The human aspects may deserve study also. Unfortunately, minerals have less glamour than vitamins at present, and thus their study tends to receive less attention.

The most important question regarding soil-nutrition relations is whether soil factors affect the nutritive value of food crops in other respects besides a mineral content. It has been reported that on sulfur-low soils its addition increases the protein content of alfalfa. Mineral nutrition effects on the protein content of wheat have been noted. In a recent study in Texas, phosphorus fertilization of the soil resulted in a greater response in growth, reproduction and health in grazing animals than adding the needed phosphorus direct to their feed. There have been other reports

of an improvement in the overall nutritive value of forage by fertilization. But all of these observations must be followed up by more closely controlled studies to determine their real significance.

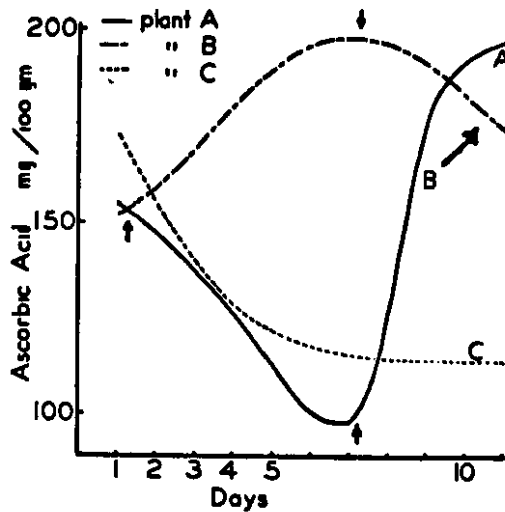
In studies at the U. S. Plant, Soil and Nutrition Laboratory, under carefully controlled conditions, neither deficiencies nor excesses, in terms of plant growth, of either the major or the trace mineral elements have had any influence of practical significance on the vitamin A or ascorbic acid content of tomatoes or on the carotene, ascorbic acid, thiamine or riboflavin content of turnip greens. On the basis of studies thus far made, it appears that soil conditions are not an important factor influencing the vitamin content of food crops.

It is clear, however, that vitamin content is markedly influenced by climatic factors, as is illustrated by studies carried out at the U. S. Nutrition Laboratory during the last four years, under the direction of Dr. Karl Hamner. When the same variety of tomatoes was grown in different parts of the country, marked differences (50 per cent) in vitamin C content resulted. But when the soils from these areas were brought to Ithaca, the differences in the fruits produced disappeared. It was next observed that plants grown in the greenhouse in the fall and winter produced fruit containing only one-half as much of the vitamin as did plants grown outside in the summer in the same medium. It was found that tomatoes purchased on the open market in winter contained much less ascorbic acid than those available during the summer. Certain studies with turnip leaves indicated that the carotene, vitamin C, and riboflavin contents were affected by climatic rather than soil factors.

Dr. Hamner next began a study to find out what specific factor or factors were involved. He set up experiments in rooms where temperature, humidity, and various light factors could be controlled. As a result, he found that the factor primarily concerned is light intensity. The leaves of

turnip plants exposed to intensities varying from 200- to 5,000-foot candles for a period of one week varied in ascorbic acid content from 28 to 235 mg. per 100 grams fresh weight. Thus, the leafy material produced at the highest light intensity had eight times the vitamin content of that produced at the lowest intensity.

In order to determine whether or not similar changes occur in older plants and how rapid is the response, the following experiment was carried out by Hamner and Parks (*J. Am. Soc. Agron.* 36, 269, 1944). Three large turnip plants which had been grown in the greenhouse for about four months were sampled for ascorbic acid determination. Plant B was then placed under an illumination of about 6,000 foot-candles while plants A and C were exposed to an illumination of 800 foot-candles. The ascorbic acid content of plant B rose to about 200 mg. per 100 gm. fresh weight, while plants A and C decreased in ascorbic acid content during the same period. At the end of seven days plant B was shifted to the low light intensity while plant A was placed at the high intensity. Plant A rapidly increased in ascorbic acid content while plant B



EFFECT OF ILLUMINATION ON THE VITAMIN C CONTENT OF TURNIP LEAVES.

showed a gradual decrease. It appears, therefore, that the ascorbic acid content of turnip greens may be varied at will by controlling the intensity of illumination of the plants.

Next, a study was carried out with tomatoes grown outside, part of the plants being kept under a cheesecloth shade which decreased illumination about 75 per cent. The latter plants produced fruit with an ascorbic acid content of 15.5 mg. per 100 grams. Comparable plants grown with full exposure to sunlight produced fruit with 25.8 mg. of ascorbic acid. When plants were transferred from sunlight to shade, the ascorbic acid content of the fruit dropped, and vice versa. It was demonstrated that the period just prior to ripening is the time when light intensity exerts its influence. One season's studies in the field under commercial growing conditions have indicated that the light intensity just prior to harvest has the same marked effect as in the experiments just reviewed. Further observations are needed to check this finding.

VITAMIN C IN TOMATOES GROWN IN SUNSHINE AND IN SHADE  
*milligrams per 100 grams*

	GROWN IN	
	<u>Sun</u>	<u>Shade</u>
Controls	25.8	15.5
	TRANSFERRED TO	
	<u>Shade</u>	<u>Sun</u>
1st bloom	17.0	26.1
1/2" diam.	17.3	26.2
"Mature green"	16.8	23.4

(U. S. Plant, Soil and Nutrition Laboratory)

Now, of course we can't control climatic conditions, or specifically light intensity prior to harvest, in growing crops which are important sources of vitamins. But this doesn't mean that the possibilities of practical application are nil. If light intensity is of as large importance as work today indicates it may be possible, by harvesting crops after

a period of bright, sunny weather, to obtain maximum yields of ascorbic acid. It is possible that in locating canning operations, areas might be selected in which high light intensity usually prevails during the harvest season.

Thus, we have genetic, soil, and climatic factors all affecting the nutritive value of foods of plant origin. They are interrelated and some of the problems involved are complex. But the results achieved to date make it clear that by learning more about the factors concerned we can control them in such a way as to improve markedly the nutritive value of our food crops. It will take many years to learn all the possibilities, but with the support which such a program deserves, in view of its high promise, each year should bring results of practical value.

With respect to products of animal origin, the principal factor causing nutritive variations is the feed of the animal. The vitamin value of butter is the outstanding example here. The mean annual potency of the butter produced in this country is around 15,000 I. U. per pound. While the summer butter is much richer than this general average, most of the winter butter ranges around 9,000 units. It would be entirely possible to raise the value of this winter butter, and, more important, of the fluid milk supply, by 50 per cent through appropriate feeding practices. These practices should not increase the cost of milk production because the feeds which will step up the vitamin A value of milk are those which will make the ration better in terms of total production as well. But there must be a real public interest to strengthen the hands of those who are trying to educate dairymen in these better feeding practices.

Similarly the vitamin A and vitamin D content of eggs are markedly affected by the nature of the ration. And here again the rations which promote the highest production improve the nutritional quality of the eggs as well. The eggs we eat today have a higher nutritive value than those of a decade ago because egg production per hen has

been stepped up by rations of higher nutritive value and this higher value is in turn reflected in the eggs produced. Further progress in the poultry industry will mean further improvement in the egg supply.

The present discussion has indicated that nutritive values can be improved in production. There is knowledge which can be utilized in practice now. Leads are available for further research with high promise of results of practical value. While it may take years to learn all the possibilities, results can come rapidly if there is public interest and support for such a program. A better food supply can be obtained without increased cost. The program is applicable to all basic foods. It thus holds particular promise for improving the diets of those who, because of low income, find it especially difficult to obtain adequate nutrition from foods within their reach.

But crop production programs must be implemented to make use of the information we now have, and much more information needs to be gained. Thus, the improved nutrition which would result can come only gradually. The general program cannot be expected to solve immediate problems. Is it a worth while undertaking considering the developments and problems that we foresee in the post-war world? There are those who feel that with the new industrial developments in the production and marketing of specific nutrients, notably the synthetic vitamins, the importance of nutritionally superior natural foods in the diet becomes less thereby. The extreme view is reflected by the following statement in an issue of Harper's Magazine:

"Factory production of milk—a purer and more healthful beverage—is sure to come and at cheaper prices. Milk is 87 per cent water anyway, and it will be relatively easy to substitute a machine for the cow as the agent for converting cellulose (grass) and such into a liquid we call milk."

Few would subscribe to such a statement, but all too many are being led to believe by the ballyhoo of advertising, and even by the over-enthusiasms of some scientists,

that a shot of vitamins can improve any diet and, in fact, make the nutritional aspects of food selection of minor importance. Those who discount the overall values of foods, and disregard the fact that nature may have endowed them with values as yet undiscovered, need the admonition of Hamlet: "There are more things in heaven and earth than are dreamt of in your philosophy."

With the tremendous productive capacity of industry which has been built up during the war we may expect an increasing opportunity and an increasing pressure for the incorporation in the diet as such, or as fortified foods, of synthetic vitamins, minerals, and probably amino acids. How far these developments should go is a question involving many vital considerations both physiological and economic. The physiological answers cannot be satisfactorily arrived at by a few rat experiments or short-time clinical observations. The question of a dietary regime which is best from the standpoint of the entire life cycle and for all peoples is at issue.

Inevitably, increased emphasis on fortified foods and synthetic supplements, in the interest of solving current problems of malnutrition, will result in a decline in the interest of either producers or consumers in the nutritionally superior natural foods and in their decreased use in the diet. Such a result would tend to be a lasting one. Thus the possible benefits of what may be thought of as emergency measures should be weighed against the much more permanent effects on the character of the food supply that is produced and consumed. From this long-term standpoint it appears to the speaker that a program for the production of foods of superior nutritional quality and for conserving their nutrients from the farm to the table should take precedence over any general program of food or diet fortification. In any event, the questions at issue deserve the careful consideration of those who by virtue of their knowledge and responsibilities in the field of health are particularly well qualified to provide the answers.

# VITAMINS AND HEALTH

CHARLES G. KING, Ph.D.

*Scientific Director, The Nutrition Foundation*

Visiting Professor of Chemistry, Columbia University; Member, Food and Nutrition Board and the Medical Nutrition Committee, National Research Council; Civilian Consultant, Office of the Quartermaster General



**E**NTIRELY ASIDE from the medical records of deficiency diseases, interesting as they are, the vitamins merit careful consideration from two strictly contemporary points of view. First, the vitamins are normal constituents of nearly all living cells; hence an understanding of what they are and how they function is basic to further progress in practically all of the biological sciences, including medicine. On that basis alone, to deny or to attempt evasion of their importance in relation to health would border on sheer stupidity. The second point is apparently more complicated, namely, an appraisal of the significance of present-day levels of vitamin intake in relation to health, independent of the incidence of the classical forms of deficiency disease.

Before discussing these two points I should like to emphasize that progress in the study of vitamins, more than in other phases of the science of nutrition, has been very rapid within the last twelve years. Consequently, there has been great difficulty in maintaining an adequate perspective in regard to what is important and sound. We are still in a research atmosphere.

How much do we know about how vitamins function in living cells? In our efforts to be complete in lectures and in textbooks, I believe there is a tendency to make the picture look more complete than it is. If we look at all of the vitamins that have been isolated in pure form, especially the first four to be identified, A, B, C and D, it should be clear that only the barest outlines have been developed concerning their function. A few faint clues are available concerning changes associated with vitamin A in the cells of the eye, but otherwise, almost nothing is known concerning its chemical role. Yet from an empirical point of view, when one watches the physical changes in a deficient animal, it is evident that the vitamin is essential in some way for the integrity of nearly all the cells in an animal body. The physical changes are clearly evident, for example, in the bones, teeth, skin, muscles, connective tissue and in practically all of the endocrine

and secretory glands. But chemically, these all present blank walls.

For the other fat soluble vitamins, D, E, and K, one can observe, respectively, rickets, muscular dystrophy (associated with sterility), and a special type of liver failure, but in none of these cases can anyone explain, even to a fellow scientist, how the vitamin works.

Again, if we take the other better known vitamins, B<sub>1</sub>, B<sub>2</sub>, B<sub>6</sub>, C, niacin, pantothenic acid, inositol, choline, and biotin, only a few elementary leads are available concerning their functions. Three of them are known to function as parts of enzymes, or catalysts, and it appears that they might all be catalysts, but the enzyme specialists would be first to admit that there are great gaps in the picture of their full role. The view is much like a close-up photograph of a spider web—a few sharp outlines of a design, but chiefly empty spaces projecting into the unknown. To a chemist or physiologist, the mere fact that the vitamins are so characteristic of the active, protoplasmic mass of nearly all cells justifies one's confidence that they are fundamental to the maintenance of the state we call normal health, whether it be in a yeast cell or in a human body. Many of the simpler forms of life have a remarkable capacity to synthesize some of the vitamins but man is a dire weakling in this regard—apparently he cannot make any of the vitamins—he must compensate with his brain for what his liver cannot do. To fail to give thought to our vitamin supply is, then, perhaps an indication that one is less than human—should we say sub-human? (The monkey-business in certain types of advertising would make us think so!)

The evidence by which one can relate vitamins directly to current problems in public health is fragmentary, to be sure, but it is nevertheless impressive in several respects:

first, the evidence seems irrefutable that current intakes of vitamins are commonly too low when compared with reasonable standards; second, there is much evidence from competent medical sources to indicate that tissue lesions caused by vitamin deficiencies are not uncommon, even though they are frequently unrecognized and there are still many refinements to be agreed upon in relation to specificity; third, careful studies in which vitamin intakes have been correlated with health records furnish evidence that current levels of health can be improved by more liberal vitamin intakes. The latter type of evidence is complicated, however, by the fact that increased levels of vitamin intake have been accompanied in most cases by improved consumption of other nutrients, including proteins, minerals and calories. This is a field where we are sorely in need of more information.

The recommended daily allowances (of vitamins) published by the National Research Council may not be entirely correct, but it is only fair to insist that the Council's report was prepared by competent personnel, and that they gave careful consideration to all of the evidence available. Many of their critics have been less thorough. The levels decided upon are freely acknowledged to be tentative, because every student of the subject knows that there is need for much more definite information than is now available. Assuming that the National Research Council levels represent a reasonable approximation, especially at the lower levels of caloric intake, we can scarcely avoid the conclusion that current food practices in the United States and Canada are far from ideal.

One difficulty is that strangely little information is available concerning the vitamin content of America's food supply *as consumed*. The composition of our foods *as produced* for the market, or *as purchased*, can be estimated

fairly well, but the vitamin content *as consumed* simply cannot be stated with reasonable accuracy. A great stimulus to research in this field was supplied by insistent demands for information by Army, Navy, and Public Health officials at the beginning of the war. As a nation we had done a reasonably good job in building up information on the vitamin content of our major food items as purchased, and there was reasonably good evidence concerning processing losses, but we were lamentably weak in regard to cooking, storage, and service losses.

In recent hospital and other institutional studies, our laboratory at Columbia and many others have found that, with the exception of citrus juices, 80 to 90 per cent of the vitamin C content of the diet was regularly lost between the market and the dinner plate. The losses of vitamin C are generally more severe than for the other vitamins, but it is clear that losses in thiamin and folic acid may be very high during cooking and storage, and that losses of other vitamins are commonly in the range of 15 to 40 per cent. In the over-all picture, it seems that these losses could be cut in half by giving moderate attention to the problem. The flood of papers on large scale cooking and storage losses during 1942, '43, '44 (and still to come) will render a great public service. They will supply the necessary facts, but that is only a beginning. The long, hard trail of educating our citizens to correct existing conditions still lies ahead.

Agricultural scientists are constantly improving the nutritive quality of raw supplies, the farm crops, and the food industry is constantly improving processing and marketing practices. Dr. Zscheile and his associates at Purdue University, for example, have pointed out that if they achieve reasonable success in their program of selectively breeding tomato varieties, developing strains high in vitamin A and C content, the tomato crop alone, at present

tonnage levels, would supply more than twice our total national vitamin A requirement and would more than meet our entire vitamin C requirement. These trends are important and should be heartily encouraged, but the prospect of educating the public and food service institutions is a staggering one.

With moderate improvements in our agricultural and industrial practices, there would be available for every person in America generous allowances of all the vitamins needed, together with the other requisite nutrients, in the form of attractive, low-cost, common food stuffs. Delicate and expensive items could be provided of course, for those who prefer them. But instead of being close to that happy state of affairs, we are in a relatively remote position. Allowing for the fact that all of the records are approximations, we find:

(a) In a Louisiana survey covering 5255 white children and 1453 colored children of public school age, Dr. Goldsmith and her associates (1) found (1943) that only 11 per cent of the white children and 3 per cent of the colored children received diets that were adequate in all respects. Approximately 29 per cent of the white children and 62 per cent of the colored children consumed diets that were rated as definitely poor in one or more essential nutrients.

(b) A paper by Downes in 1943 (2) reported that among 315 colored families in the Harlem district of New York, 39 per cent consumed diets that were definitely "poor".

(c) Men working in an aircraft factory in California (3) were found to be consuming diets that were a third or more below National Research Council standards for the following nutrients: vitamin C, 46 per cent; vitamin B<sub>2</sub>, 43 per cent; vitamin A, 15 per cent, and vitamin B<sub>1</sub>, 14 per cent. Although their incomes were relatively good,

only 17 per cent of the men had good or excellent diets.

(d) The Stiebling-Phipard surveys (4) in 1936-37, covering representative rural and village sections of the United States, showed that 52 per cent of the families in the north and west and 40 per cent of families in the southeast consumed diets that were rated as only fair; 25 to 30 per cent were rated as poor.

Turning from food consumption to medical examination records, one finds a similar but less clear-cut picture. We must grant that the criteria of judgment are still not developed satisfactorily, but the data are far more significant than many persons seem willing to admit. Nevertheless, one does not have to be an extremist to see that encouraging progress is being made. Compared to the medical position ten years ago, diagnoses based chiefly upon careful examination of the lips, tongue, gums, eyes, skin and nerve reflexes are gaining steady acceptance among clinical nutritionists. We are critically in need of well trained young physicians who will give their full attention to the field of human nutrition.

In parallel with the advances in detecting deficiencies based upon gross and biomicroscopic examination, chemical analyses of body tissues and fluids are being developed rapidly for clinical usage. The microprocedures being developed by Dr. Bessey and Dr. Lowry at the Public Health Research Institute in New York City are especially promising. Using only two or three drops of blood, obtained rapidly from a finger tip puncture, they can make accurate analyses for hemoglobin, serum protein, vitamin C, riboflavin ( $B_2$ ), vitamin A and carotene, and the enzyme phosphatase. The latter provides a useful index of calcium and vitamin D metabolism. By the techniques that they have developed, school and other local population groups can be surveyed very simply and very rapidly. In a recent school check-up, for example, four persons (two men with assistants) examined 80 children in 1.5 hours and essen-

tially completed the chemical analyses the following day.

The chemical evidence that has been obtained thus far is in fairly good agreement with what one would expect on the basis of the surveys of food intake. For example, Milam's observations in North Carolina (5), Youman's studies in Tennessee (6), Kruse's studies in New York (7), and many others (8), show widespread conditions of low tissue storage. The fact that there are many discrepancies regarding certain aspects of the data should not offset acceptance of the evidence which is reasonably good.

The methods and data for ascorbic acid (plasma, white cells and urine), riboflavin (urine and whole blood), thiamin (urine and blood pyruvate values) and vitamin A (whole blood, A and carotene) have been developed to the point of widespread acceptance as provisional indices of nutritional status. The problem of interpreting the relative levels of tissue storage is still very difficult in some respects, and will remain so until there is more evidence of their relation to health and physiological functioning.

Records of food intake provide a logical background for the following types of data based upon blood analyses:

SURVEY DATA, VITAMIN C

AREA AND REFERENCE	NO. OF PERSONS	REFERENCE STANDARD	CLASSIFIED DEFICIENT
		mg./100 ml.	per cent
New York City; children (7)	425	0.6	49.9
Maine; children (12)	86	0.6	85.0
California; adults (9)	1,170	0.6	52.4
Michigan; children (11)	475	0.5	49.3
North Carolina; rural (5)	218	0.3	61.0
North Carolina; N.Y.A. camp (10)	782	0.3	54.6

Despite the widespread evidence of low vitamin C intakes and low levels of tissue storage, well developed cases of scurvy are found only occasionally. Careful examination of the gums, however, presents a very different picture—lesions indicative of chronic deficiency then are found to be rather common.

Dr. Park's recent findings from very careful autopsy records in Baltimore (13) reveal what apparently is happening all too often. He observed histological evidence of lesions in the bone marrow caused by mild rickets in 42 per cent of the cases, and lesions of vitamin C deficiency in about 15 per cent of the cases. The medical records of these individuals before death, however, had revealed only occasional recognition of either rickets or scurvy.

The weakest spot in the current approach to human nutrition is, I believe, in the scarcity of evidence concerning the effects that current nutritive faults have upon the public health. A great many members of the medical profession, as well as well-educated laymen, are still doubtful concerning the seriousness of the problem. The result is too much indifference and unjustifiable delay in progress. I think we should meet the problem squarely and get more evidence—get the evidence so clearly established, on a conservative, objective basis, that there will be no reason to quibble over the need for action.

The kind of data presented by the Toronto group working with Dr. Tisdall (14) and by the Harvard group working with Dr. Stuart (15) provides an approach that should have great significance. Both groups observed markedly superior health records among mothers and their

RELATION OF HOME FOOD PRACTICES TO MATERNAL AND INFANT HEALTH, BASED UPON 216 CASES, OVER A PERIOD OF TWELVE YEARS (15)

MOTHER'S DIET	INFANTS CLASSED AS "SUPERIOR"	INFANTS CLASSED AS "POOREST"	INCIDENCE OF PRE-ECLAMPSIA AMONG MOTHERS
	per cent	per cent	per cent
Good or excellent*	56	3	0
Fair	35	18	8
Poor or very poor†	9	79	44

\* Approximately the levels recommended by the Food and Nutrition Board, of the National Research Council, 1943.

† Approximately 40 to 60 percent of the Recommended Dietary Allowances of the National Research Council.



infants when the mothers received good diets. The correlation between good nutrition and health in these two studies is so striking that anyone looking at the record can scarcely escape being impressed. To gain full and sustained conviction on the point, similar studies should be conducted in different areas and they should be continued through long periods of years. The task is a large and tedious one, but of paramount importance.

No one can say which specific nutrients are responsible for such contrasts in health. Rather, it is highly probable that the effect is a composite result from a great variety of vitamins, minerals and proteins. So far as the evidence goes, to date, the vitamins would seem to represent the nutrients of the most direct significance in the picture. In any event, however, only a few people need to be able to evaluate the human diet in terms of quantitative intakes of each separate nutrient; but *the practical means and the basic importance of maintaining a good diet should be known to everyone*. A point that will bear emphasis, is the fact that the "good or excellent" diets cited in the Burke-Stuart paper correspond roughly with the Recommended Dietary Allowances of the National Research Council. If the implication of that paper is valid for the entire population of the United States, then each year nearly a million infants are born with an initial handicap that is unnecessary.

VITAMIN C CONTENT OF GUINEA PIG TISSUES

*milligrams per gram*

CONDITION	ADRENALS	LIVER	KIDNEY
"Normal"	0.70	0.10	0.08
Depleted 4 days	0.25	0.06	0.05
Depleted 15 days	0.08	0.03	0.03
Depleted 28 days	0.03	0.01	0.01
	(FOR COMPARISON)		
Chicken	1.53	0.28	0.15
Rabbit	2.31	0.20	0.12

The data shown illustrate, with vitamin C, a condition that we have to deal with widely in our human nutrition problems. Guinea pigs in four days lose much of their vitamin reserve. After fifteen days of depletion they have lost a very large fraction of their total tissue reserve. At this period the first slight signs of scurvy usually appear. At twenty-eight days, which marks the terminal point, or death, from scurvy for most animals, a further, but relatively small quantity of the vitamin has been lost. The quantitative losses are much greater in the first few days of depletion. We have no adequate basis yet for evaluating the significance of those higher storage levels, but the next slides will show something of the implication that is there.

ASCORBIC ACID CONTENT OF MOTHER'S MILK

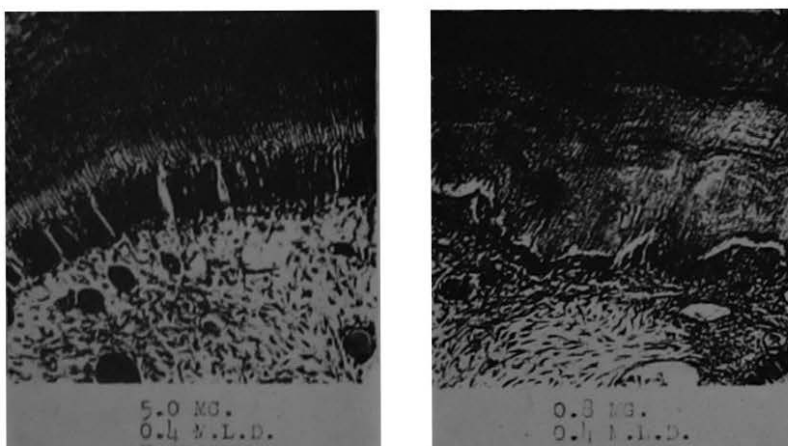
INITIAL VALUE	SUPPLEMENT	VALUE AFTER		
		1 DAY	2 DAYS	3 DAYS
mg./100 gm.	mg./day	mg./100 gm.		
7.2	500	8.0	8.3	8.3
8.0	375	8.1	8.1	8.2
4.3	310	5.3	7.4	7.8
1.9	310	1.9	2.1	3.2

Note the initial values for the vitamin C content of mother's milk. Notice that in the first two cases the content is practically at the maximum, since giving more vitamin C did not increase the vitamin C in the milk. In the third case, with approximately half the normal content, initially, on administering an intake of the vitamin in excess of normal requirements, the first day shows a slight pickup, followed the second and third days by a very marked increase. In the fourth case, the only one in which the vitamin C content of mother's milk was approximately as low as in cow's milk, even fresh cow's milk, administering a large amount of the vitamin did not provide a marked increase within the first three days.

That is a picture of what you may find in the human population, where there is no indication of scurvy what-

ever, but not enough vitamin C in the diet to supply the amount of the vitamin needed for the mother's milk.

The analogous condition in guinea pig teeth can be indicated very briefly. The requirement for a guinea pig



is roughly three-quarters of a milligram. The right side of the slide shows a cross section of a guinea pig incisor when it had had plenty of vitamins for good, normal growth, and a fat, sleek body. On giving a small amount of bacterial toxin, the teeth were markedly injured, as can be seen by comparing the right with the left half of the slide. The amount of toxin was the same, but the animal on the left had a more liberal vitamin storage.

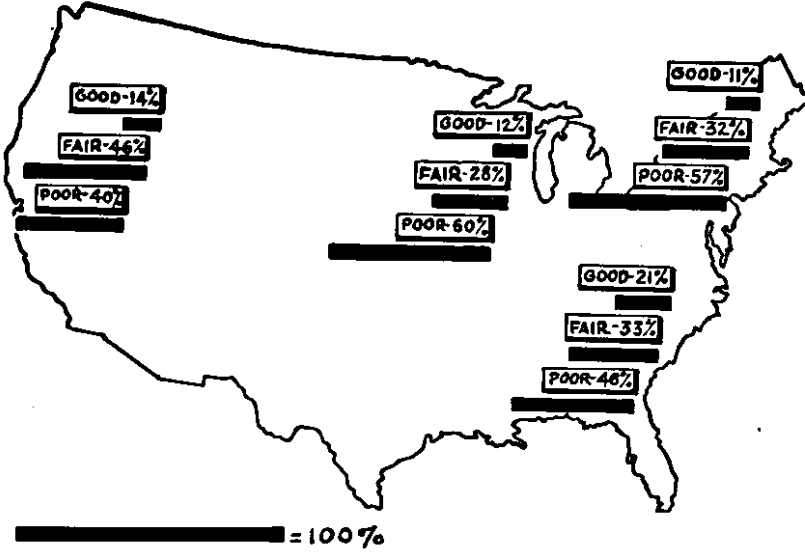
This map (4) shows the distribution of classified diets among the United States population. I think it illustrates that our national dietary pattern is far from satisfactory. Notice that those rated as good vary from 21 per cent in one area, down to 11 per cent and in addition:

1. More than one-half (51 per cent) of the 846 plants provided no lunchroom facilities for their workers.
2. In only one plant out of five (19 per cent) was hot food purchasable.
3. Only one-half (52 per cent) of the plants had milk available for their employees.

4. In three-quarters (77 per cent) of the plants only 30 minutes or less was allowed for lunch.

The figures above are taken from a study of feeding conditions in industrial plants during the war period.

Diets of American workers



Large numbers of American workers are not eating the food needed for robust health. The above map is based on a nation-wide survey by Drs. Stiebling and Phipard of the United States Bureau of Home Economics

In the enrichment of wheat flour we deal with a very practical situation, in which the American public will not

NUTRIENTS IN WHOLE-WHEAT, WHITE, AND ENRICHED FLOUR

NUTRIENT	<i>milligrams per pound</i>		
	WHOLE WHEAT	WHITE FLOUR	ENRICHED FLOUR
Riboflavin (B <sub>2</sub> )	0.48	0.18	1.2- 1.5
Thiamin (B <sub>1</sub> )	2.15	0.23	2.0- 2.5
Niacin	20.0	3.7	16.0-20.0
Iron	16.0	4.5	13.0-16.5

buy and sustain their purchases of whole wheat products in the market. The enrichment program is devised to

correct at least a part of the gross failure to supply the nutrients that we should expect to find in grains. The only departure from restoring to the original content is with riboflavin. The practice of putting in more of a given nutrient than the whole wheat normally provides may be questioned, I think, but from the point of view of providing for public health, the practice seems to be meeting reasonable acceptance.

Many people are alarmed to find that retail pharmaceutical sales of vitamin products in the United States have risen, from a very small figure 15 years ago, to roughly \$101,500,000 in 1942 and \$132,200,000 in 1943, an increase of 30.2 per cent in the latter year alone. The total retail cost of vitamins in drug stores during 1943 was almost exactly one half of the cost of all their prescriptions (\$265,802,000). There are many ramifications to this situation, but I think it is worth pointing out that we spent for food, through grocery store channels, roughly \$15,300,000,000 in 1942 and \$16,620,000,000 in 1943 (16). The total retail value of our food supply reached approximately \$30,000,000,000 in 1942 (17). In parallel with the increased use of vitamins as health products from the drug store, there has been a growing appreciation by the public and by the medical profession, of the importance of good food. In time, I think the importance of good food will reach both the public and the medical profession in reasonable degree, but we are, without doubt, far from the goal in 1944.

The quantities of synthetic vitamins coming onto the American scene merit recognition, too. Current production schedules for one of the vitamins is in the range of 1,000,000 pounds per year. Almost all of our vitamin D is produced by irradiation. Instead of resenting these developments, we should examine the possibility of their use for the improvement of both our food supply and the public health, within a sound economy. Their contribution to keeping the American, British, and Russian armies in

good fighting condition has been a factor of more than passing interest.

As supplied to the food industry and to wholesale establishments, the vitamins are really low-cost items. Thiamin, for example, is now supplied at \$0.16 per gram. That is equivalent to about two hundredths of one cent per person for a day's supply. The housewife or the hotel manager, however, can scarcely do their shopping for more than 40 essential nutrients, including provision for a satisfying meal, on this basis.

Two factors will undoubtedly force a trend in the direction of recognizing the importance of better food practices; first, the public will realize that good nutrition requires so many vitamins, minerals and amino acids, in both known and unknown quantities, that it is simpler, safer and more economical to choose good food than to buy endless capsules and concentrates; and second, the food industry, together with government and educational agencies, should solve the problem of providing for good nutrition in the simplest, most economic and most logical way. Meanwhile, the public's response to the undoubted need for vitamins and minerals is proving to be expensive, and irregular, but I am not inclined to view the situation with alarm. (I have some sympathy, however, for the man who suggested that maladvertising is becoming almost as much of a problem as malnutrition.)

Since the enrichment of basic food items, such as flour and bread, salt, margarine and evaporated milk, seems to accomplish an economic and broad coverage, I think we shall see a steady extension of such developments *in parallel* with wider provision for attractive, naturally protective foods.

In conclusion, I believe we are still far from recognition of the full import that vitamins have in relation to health and in all the biological sciences such as agriculture, physiology, biochemistry and medicine. Instead of worrying

about their infringement on the premises of either food or medicine, we should look forward to their intelligent and practical use.

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## DISCUSSION

**DR. WILLIAMS:** We have asked Doctor Arthur H. Smith, Professor of Physiological Chemistry, Wayne University College of Medicine to discuss the papers given by Dr. Maynard and Dr. King.

**DR. SMITH:** We in my kind of work—I happen to be teaching in the Medical School—are constantly on the lookout for devices for the better utilization of food, in other words we are on the receiving end, and as it happens, think relatively little of the tremendous benefit which nature has conferred upon us in these remarkable syntheses which have been more than touched upon this morning by Doctor Maynard.

Someone has said that, without any fuss or furore, in a cornfield on the Iowa plains, on a summer day, nature is carrying out syntheses which man will benefit by but has never in any respect approached. Doctor Maynard, I think, has brought that out very beautifully in his talk.

Another point of view which I think cannot possibly have escaped you, although it may be rather appalling to those of you who plan to do further work in your own training or with other students, is the sort of experience which both of these speakers this morning have been through in order to appear here with such significant messages. Perhaps we should say that if you are going to be a nutrition worker, better start with the study of agronomy, and of animal husbandry. Don't forget dairy chemistry, don't forget histology and pathology, and a great deal of organic chemistry, to say nothing of physical chemistry and physiological chemistry. We have two beautiful examples here of careers which have been moulded in that way, and which therefore permit these men to give you such a well-rounded view of things as they have done.

I know that Doctor Maynard is a very moral individual, but he does want to paint the lily, as he indicated when he said that we can get on the way to the millennium, as far as

nutrition is concerned, if we alter genetics and work on plants. On the other hand, he just as forcibly does not want a lily which appeals to the eye and smells as good, which isn't a lily. In other words, he would urge us to secure our nutrient virtues from nature's own sources.

I would like to ask one question of Doctor Maynard, whether his views support the claims for the superiority of California fruits. I really wonder whether that is so.

I would like to ask Doctor King whether the great mass of analyses which are in the current literature for vitamin C, are in his opinion anywhere near reasonably reliable?

DR. MAYNARD: Taking Doctor Smith's question first, I am not going to enter into that controversy of California versus the world. I will say this, that in connection with these vitamin C studies of tomatoes and of the effect of climate, we now have a study in progress in California, and in other areas, and we hope from them to get a little information on that question.

DR. J. M. ORTEN, Wayne University College of Medicine, Detroit: "Is there a relation between soil and climatic conditions on the amount or quality of proteins in cereals or other foods?"

DR. MAYNARD: That is a pretty large question. With respect to cereals, of course, we have had a large number of studies with wheat as to the effect of different environments, particularly on the character of the protein for baking purposes. There are some specific studies which indicate that the soil factors influence the percentage of protein in the wheat. With respect to the quality of protein I don't know of any studies.

There are some studies also with respect to corn, showing that the protein content can be increased. I don't know anything about effects on quality. Regarding other foods, I don't recall anything at the moment. In general, there

are comparatively few studies on the influence of soil factors on protein content, and particularly experiments controlled in such a way that we are sure that the results will hold. If you examine the literature, there are a lot of papers on the effect of soil on carotin content. You will find half the papers say yes and half the papers say no, and the actual answer is probably that the soil had little if any effect, but that other factors were concerned. Similarly, we don't have with respect to proteins enough information obtained under controlled studies.

**IRENE F. SULLIVAN**, Principal, Marxhausen School Detroit: "Does the peeling of apples lessen the value of the vitamins?"

**DR. MAYNARD**: I believe it is true that the vitamin C content of the apple is concentrated near the peel. On the other hand, apples really don't amount to much as a source of vitamins anyway, except vitamin C, and even here the contribution to the diet is very low, except where consumption is large.

**DR. JOSEPH A. JOHNSTON**, Henry Ford Hospital, Detroit: "Does the work of Holt, et al., showing the synthesis of B vitamins in the organism, render the survey data of Stiebeling and associates relatively worthless?"

**DR. KING**: I believe not. I think Doctor Holt's work is very interesting, and it explains many of the irregularities in the rate of onset of deficiency diseases, but I think it has been grossly misinterpreted, and over-evaluated as to its practical significance.

Certain it is that we have had many deficiency diseases, some acute. There is no doubt that many people cannot synthesize these vitamins in their intestinal tracts through the agencies of the bacteria, in sufficient quantities to protect them. As a matter of fact, Holt's own work shows that

roughly half of his patients did not have any capacity for intestinal synthesis and therefore his own work shows, right in his report, that intestinal synthesis does not provide any adequate insurance against deficiency diseases. It is just good luck, I would say, when a man happens to be thus fortified.

ZOE McCORMICK, Wayne University, Detroit: "How efficient are synthetic vitamins?"

DR. KING: I think on the whole synthetic vitamins are just as efficient as the natural vitamins. They are the same things; it could hardly be otherwise. There is no difference between a synthetic vitamin and one which develops in a tomato plant or beef steak. The difference is, and it is an important difference, that the synthetic vitamin preparations supply a very limited number, whereas when you eat beef steak, or tomatoes, or cabbage, or something of that kind, you get not only a few vitamins, but you get nearly all of them. I think that is the great contrast, the safety factor provided by the foodstuff in supplying a much greater variety of all of the vitamins, and not just the limited few one gets in any commercial preparation that is available.

IRENE TAR, St. Joseph Mercy Hospital, Pontiac: "If vitamins from foods are not assimilated, should synthetic vitamins then be taken?"

DR. KING: I hesitate to answer this question as a chemist, preferring that a physician answer. But, to save time, I will answer it and then let Doctor Jeans or Doctor Tisdall argue the point, if they are not satisfied with the answer.

There are many cases in medical practice, I am sure, when a physician should handle the matter of providing for vitamin supplementation, when foods are not normally

assimilated, but those are not normal people, and I think their cases come without the province of ordinary provision for public health among laymen. Those special cases should be completely, I would say, in the hands of a physician to solve the problem.

**DR. OTTO GROB, Women's Hospital of Detroit:** "Is there any danger of over-dosage of any of the vitamins bought in drug stores?"

**DR. KING:** I think, from a practical point of view, nearly all physicians and physiologists are agreed that the only one from which there is very much danger is vitamin D. Some of the newer products supply vitamin D with relatively high potency in one drop quantities, and then some housewife, who has had the experience of feeding cod liver oil by the teaspoonful three or four times a day, thinks if a little is good, more is better and gives the concentrated vitamin D source in a similar fashion. There have been a few cases of injury resulting from overdoses of vitamin D, with the highly fortified oils, but those are relatively rare, and when that is done, it is distinctly against the instructions printed on the bottle or package.

**EILEEN PECK, Detroit Board of Health:** "How are the assays for hemoglobin, B<sub>2</sub>, C and so forth, made from two drops of blood?"

**DR. KING:** It is a simple thing, as a matter of fact, when you see them do it. The only primary difference between the techniques they use and the techniques the average hospital uses when they draw 25 cc. or even 10 cc. of blood from a vein for analysis is that they use capillary tubes and very small apparatus for running the analysis. The capillary tube is so tiny you just see a little hair-like opening down the center of the tube, but by perfecting their technique of working with those capillary tube quantities, they have

been able to run not only single but duplicate analyses of all the things they need, and do them as accurately as the hospital laboratory ordinarily can work with large quantities. It is a refinement of technique with which they work. As a matter of fact, they could do two or three more analyses beyond those that I have named, if they thought they had any marked significance.

DR. FRANK J. SLADEN, Henry Ford Hospital, Detroit: "With the premise that attractive natural foods are more desirable than the drug store source for adequate vitamin intake, can we really accomplish this for vitamin B factors in today's available diet, and how?"

DR. KING: I think it is quite reasonable to accomplish that with the present dietary. The enriched bread program has gone a long way, I think, to alleviate the most common types of B deficiency in cereal diets, but certainly we should keep an ever-increasing emphasis upon whole grains, nuts, seafood products, meats and milk. Meats in general are very good sources of the vitamin B complex. Milk is an excellent source of riboflavin, so that with a reasonable use of the recommended protective foods, namely milk, meat, eggs, green leafy vegetables and whole or enriched cereals, there is no difficulty in achieving a very adequate intake of all members of the vitamin B complex, both recognized and unrecognized.

ROLE OF FOOD TECHNOLOGY IN  
IMPROVING NUTRITION

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**I**T MAY BE said that the commercial aim of the food technologist is to process foods for the satisfaction of the consuming public. Education of this consuming public in the practice of good nutrition is leading the food technologists to consider the nutritive value of his foods as one of the points of quality necessary to satisfy this consumer.

The broad object of practical significance in improving public health and welfare lies in the application of the findings of nutrition research to better food practices. Without in any way condemning synthetic vitamins, it seems evident that the final answer to optimum nutritional status of the American people rests with food—satisfying, appetizing, and nutritionally regulated food. Food processors *must* have an eye on the future importance of better nutrition, since better education in food selection and use most certainly will have an effect on the industry.

From a broader humanitarian viewpoint we like to think of good nutrition as one of the four major factors which have had and will have much significance in human health and happiness.

Great progress has been made in the field of *sanitation*. Progress originally inspired by the work and writings of such world-famous figures as Pasteur and Lister. In America there have been great improvements in sanitation as it relates to personal hygiene, clothing, living quarters, and water supply. Also, marked progress has been attained in sanitation for processing foods. Certainly these better sanitary habits have increased the survival of the infant and have avoided much illness in human beings.

*Immunization* has been carried to the point of mass benefits in this country during the past quarter century. Gone almost entirely are the superstitions and prejudices which prevented the infant and early school child from the proper use of protective medicine. Immunity from the dread plagues and epidemics of the past has added to the prevention of illness and to life's average span. This is the result of proper education.

The sulfa-drugs and anti-biotics are headlines in a new chapter of *chemotherapeutics*.



The application of the principles of good nutrition, through the acceptance of their importance by the general public, is the fourth factor in the betterment of man's physical well-being and will probably far outshine all the others. Optimum nutrition affords the opportunity for man to benefit himself from *within*, through improvement of growth and maintenance, as well as from *without*, by the purely protective methods. That better nutrition can result in improved physical specimens has been proved well in both human and animal experimentation. Observations indicate an improvement of mental capacity, also. If a similar effect on moral fiber could be demonstrated it would indeed put the science of nutrition on the pinnacle for service to man and society. The fundamentals of good nutrition have been applied very successfully in the livestock industry. Leading livestock raisers would not consider feeding their animals on any such hit or miss type of unbalanced diet as is eaten in many homes.

Since the future of applied nutrition seems to hold so much promise, it certainly behooves all food processors to do everything reasonable to help American families gain an improved food regime. When the educational process becomes really effective it may be *essential* to the commercial existence of a food processor to evaluate his processes by their effect on nutritive quality, whereas they now are gauged largely by sanitary and palatability standards.

The food technologist accepts this new challenge. He recognizes two important phases of his new task. First, to determine the effect of each step in the processing of food on the nutritive value of that food. Second, to invent and devise new processing methods which are less destructive of nutritive quality and yet offer the same advantages of palatability, sanitation, and preservation.

Likewise, the commercial organization engaged in the processing and distribution of foods is recognizing an obligation to do its part in nutritional education, in terms

that the layman will understand. I am fully aware of the vast amount of misinformation or misleading information put out in the form of advertising, but I am equally convinced that this is largely the result of unsettled questions in the science itself. The efforts of some advertisers to do an educational job is unmistakable, and, I believe, is a result of a trend in public opinion demanding such education. If this *is* a trend of public demand, the mistakes will correct themselves with time and further knowledge.

The important point is that these processors and distributors are in contact with the consumer in a way that you scientists can never hope to be. They are a necessary link between your research and its usefulness. Likewise, the food technologist is another link between your research and its application to the processing of foods. Many portions of the food industry have already contributed much to nutrition education. The citrus fruit industry, the dairy industry, and more recently the meat industry, to mention only a few, have had extensive and successful campaigns in making the average American more aware of the importance of better food selection.

There is another obligation recently forged in the consciousness of food processors and distributors. It is a recognition that the industry which exists on trade in these commodities owes a portion of its profits to the support of progress in the knowledge of the function of foods in human welfare. This awareness is beginning to be expressed in the establishment of fundamental research within their own laboratories; the placement of grant-in-aid to research in universities, and to cooperative action as exemplified by the Nutrition Foundation, Inc.

An immediate and practical contribution which the food processor can make to better nutrition is by a thorough survey of the effects of processing as practiced in his food operations. Such a nutritional survey must concern itself with at least the following factors:

## RETENTION OF NUTRIMENTS IN FOODS

- 1) Storage of fresh foods
- 2) Cooking of fresh foods
- 3) Preservation of foods
  - a) Canning
  - b) Curing
  - c) Dehydrating
  - d) Freezing
- 4) Storage of processed foods

Theoretically, the effect of each of these procedures or processes upon the nutritive quality of protein and fat, as well as on vitamin and mineral losses, should be studied. Actually, of course, mineral losses will occur only when solution takes place and the resulting liquid is lost, but there may be some effect on availability if severe temperatures are used.

As an example of some of the information which can be obtained through a nutritional survey of this nature, we have prepared from the research data of my associates a few slides illustrating some of the effects of processing in the meat industry. In some instances we have attempted to analyze and to present data taken from recent literature—reports which indicate comparable findings about the food products.

This slide shows the retention of B-complex vitamins during storage of fresh meat and milk. Meat is seldom

PERCENTAGE RETENTION OF B VITAMINS AFTER STORAGE  
OF FRESH FOODS

	<u>MEAT</u>	<u>MILK</u>
Thiamin	92	100
Riboflavin	90	25-100
Niacin	94	
Pantothenic acid	90	

held in fresh storage for more than a few days and then usually at temperatures not to exceed 40°F. You will note that there is not more than 10 per cent loss of any of these vitamins during such storage. While fresh milk

is rarely stored for more than two or three days, and then usually at temperatures which do not exceed those in the average refrigerator, there is sometimes only 25 per cent retention of riboflavin (1). The loss occurs during the relatively short period that the bottled liquid milk is exposed to sunlight.

PERCENTAGE RETENTION OF ASCORBIC ACID AFTER STORAGE  
OF FRESH FOODS

Green or leafy vegetables	40-70	after 3-4 days
Peas	80-90	after 1 day
Root vegetables	50-70	after 3-4 months
Apples	60-90	after 2 months
Berries	90	after 2 days
Berries (cut)	0-10	after 2 days

These figures show the effect of storage upon ascorbic acid retention by fresh vegetables and fruits (2). Note that in most instances losses in ascorbic acid occur within a relatively short time. These products were held at temperatures sufficiently low to keep them of good appearance. Fresh food products which are washed prior to sale or are kept under water sprays before marketing have been found to lose water-soluble nutrients up to 25 per cent. There is apparently no effect upon protein quality during the fresh storage period.

PERCENTAGE OF VITAMIN CONTENTS RETAINED IN MEATS  
AFTER COOKING

	<u>THIAMIN</u>	<u>RIBOFLAVIN</u>	<u>NIACIN</u>
Frying	90	100	94
Broiling	78	93	95
Roasting	68	92	90
Braising	63	96	90
Stewing	51	99	99

This slide shows the composite results of studies conducted at the University of Wisconsin, Texas Agricultural and Mechanical College, and the American Meat Institute, on vitamin retention in meats during cooking (3). These

data are averages of a rather large number of determinations. It is interesting to note that there is relatively little loss of riboflavin and niacin during any cooking procedure. Thiamin retentions range from 51 to 90 per cent. It should be noted that frying meats seems to be the best method of vitamin retention. Vitamin retention in fruits, vegetables, and cereals, during the cooking processes, seems to depend principally upon avoiding liquid losses and relatively high temperatures over long periods of time.

PERCENTAGE RETENTION OF VITAMINS IN CANNED MEATS

	PORK LUNCHEON MEAT	
	12 ounce can	6 pound can
Thiamin	67	43
Riboflavin	94	94
Niacin	90	90
Pantothenic Acid	76	76

Canning, of course, represents the major method of food preservation and we have investigated vitamin retention in meat canning. In the consumer size, 12-ounce can the processing schedule, which consists roughly of 235°F. for 62 minutes, permits the retention of about 65 per cent of the thiamin, over 90 per cent of the riboflavin and niacin, and about 76 per cent of the pantothenic acid in the product. The more severe schedule used for the 6 pound cans, consisting of approximately 235°F. for 200 minutes, has a more marked effect upon thiamin content.

In canning fruits and vegetables, the National Canners' Association has been supporting a series of vitamin retention studies (4). In general, I think it can be concluded that thiamin retentions in canned fruits and vegetables are somewhat of the same order as those found for canned meats. In some instances vitamin C retentions seem to be rather low.

## VITAMINS RETAINED IN CANNED FOODS

	<u>ASCORBIC ACID</u>	<u>THIAMIN</u>
Peas	—	50-70
Green Beans	25	83
Asparagus	—	70
Tomato juice	80-86	
Grapefruit juice	70-95	
Strawberries	50	
Orange juice	90-95	

Large amounts of meats are cured, principally ham and bacon. Note that losses of thiamin during curing are less than for cooked or canned meats, mainly owing to the lower temperatures involved.

## PERCENTAGE OF VITAMINS RETAINED IN SMOKED PORK HAMS

Thiamin	80-85
Riboflavin	90
Niacin	88

Although there seems to be considerable question as to the future consumer value of dehydrated food products, there has been a rather large amount of work reported on the affect of dehydration on the nutritional value of these foods. Studies made in our laboratory by Rice and Robinson (5), on vitamin retention during the dehydration of meat have been summarized:

## PERCENTAGE OF VITAMINS RETAINED IN DEHYDRATED MEAT.

	<u>BEEF</u>	<u>PORK</u>
Thiamin	76	63
Riboflavin	100	100
Niacin	92	92
Pantothenic acid	72	73

Meat dehydration as practiced in large scale production involves a 30 minute pre-cooking of the cubed, raw material, with a small amount of water, followed by hashing and drying in a current of air at about 180°F. Pork, which has represented well over 90 per cent of dehydrated

meat to date, shows an average thiamin retention of 63 per cent. Most of these losses occur during the cooking portion of the process. Extensive studies (6) in the dehydration of fruits and vegetables appear to indicate thiamin retentions of about 80 per cent, with the most severe vitamin losses occurring in ascorbic acid.

PERCENTAGE OF VITAMINS RETAINED IN DEHYDRATED FOODS

	<u>CAROTENE</u>	<u>ASCORBIC ACID</u>	<u>THIAMIN</u>
Green beans	—	4	84
Rutabagas	91	13	83
Beets	—	71	80
Potatoes	—	0	78
Sweet potatoes	93	—	—
Eggs	100	—	—

In the meat industry there is a class of products which are termed "table-ready-meats" since they are often eaten without further cooking, or with only a very small amount of home cooking. We have investigated the vitamin contents of these products and found their vitamin retentions high.

PERCENTAGE OF VITAMINS RETAINED IN MEATS AFTER COMMERCIAL COOKING PROCESS

	<u>THIAMIN</u>	<u>RIBOFLAVIN</u>	<u>NIACIN</u>
Frankfurters	98	100	95
Bologna	85	100	92
Braunschweiger	80	95	87
Meat loaf	84	98	86

Since foods are processed in cans to insure a supply during periods of non-production, the processed products must be storable for periods of time ranging up to two years. Since several of the vitamins are heat liable it can be expected that there would be some losses during storage at room temperatures.

These figures are results of studies that Dr. Rice and others in our laboratory have made on the products shown. While riboflavin and niacin seem to be completely stable

under the conditions given, thiamin losses are quite severe. We have been unable to find any vitamin losses in frozen

PERCENTAGE RETENTION OF VITAMINS AFTER STORAGE FOR  
ONE YEAR AT ROOM TEMPERATURE

	<u>THIAMIN</u>	<u>RIBOFLAVIN</u>	<u>NIACIN</u>
Canned Pork	40-50	100	100
Dehydrated Pork	15	100	100
Dried Milk	80-90	—	—

meats which are kept frozen throughout storage. It has been the expressed opinion of most nutrition workers that freezing is not a factor as far as vitamins are concerned. Some results of vitamin losses during freezer storage have been reported, but it seems probable that these have been due to improper holding conditions.

About the only instances of serious mineral losses occur in pre-canning processes of washing, pulp removal, and blanching. In our meat studies we have found no appreciable mineral losses.

Here is a summation of a report on mineral losses during blanching (7), which appear to be quite severe. Similar losses occur during canning. However, in this instance the minerals are simply in the liquid portion of the canned product and should not be lost to the consumer. Calcium is on the plus side because it is absorbed from the water.

PERCENTAGE MINERAL COMPOSITION AFTER BLANCHING

	<u>CALCIUM</u>	<u>PHOSPHORUS</u>	<u>MAGNESIUM</u>	<u>POTASSIUM</u>
Fresh peas	+42	-12	-30	-39
Dried peas	+60	-9	-12	-23
Green beans	+17	nil	-1	-40
Dried beans	+22	-19	-21	-21
Carrots	+9	-3	-21	-15
Potatoes	+30	-11	-25	-11
Spinach	-16	-48	-55	-47

Certainly the most serious consideration, relating to the deleterious effects of processing on food values, has been given to vitamin losses in cereal milling (8).



## PERCENTAGE VITAMIN RETENTION IN CEREAL AFTER MILLING

	<u>THIAMIN</u>	<u>RIBOFLAVIN</u>	<u>NIACIN</u>
White flour	13	31	15
Rye flour	69	63	67
Rice (polished)	22	53	46
Rice (converted)	64	77	80

While the entire bread and flour enrichment program has been based on similar information, it is not generally appreciated that mineral losses in milling are severe (9). Certainly the major portion of the calcium, phosphorus, iron, and copper are lost as far as human consumption is concerned.

## MINERAL RETENTION AFTER MILLING

	<u>WHOLE WHEAT</u>	<u>WHITE FLOUR</u>	<u>BRAN</u>
Calcium (per cent)	.045	.020	0.120
Phosphorus (per cent)	.423	.092	1.215
Iron (parts per million)	50	10	78
Copper (parts per million)	6	1.7	11.7

These figures show data which we obtained by the rat-growth method in studying the effect of processing upon the protein value of meat products (10). Although some

EFFECT OF PROCESSING ON THE PROTEIN IN MEATS  
(10 per cent protein ration)

	<u>RAT GAIN IN GRAMS PER GRAM PROTEIN CONSUMED</u>
Raw cured pork	2.73
Canned cured pork, Sample I	2.65
Canned cured pork, Sample II	2.29
Roast fresh pork	2.29
Fried fresh pork	2.57
Dehydrated pork	2.77

differences can be noted between one sample of canned cured pork and roast fresh pork, as compared to the raw cured product, it is believed that such differences are not particularly significant. It seems safe to conclude that

protein is not appreciably altered in any of the procedures noted. It is well recognized that the application of heat to soy-bean and certain other legumes improves their protein quality. With cereal proteins, in general, heat treatment has an unfavorable effect (11).

EFFECT OF PROCESSING ON THE PROTEINS OF CEREAL  
(10 per cent protein ration)

	RAT GROUP	RAT GAIN IN GRAMS PER GRAM PROTEIN CONSUMED
Rolled oats	9	1.52
Oven expanded cereal	12	1.60
Drum-dried oatmeal	15	1.55
Exploded oats—corn—rye	13	0.44
Rolled oats	14	1.14
Home cooked oatmeal	10	1.19
Rolled oats	22	1.52
Untreated oats—corn—rye	23	1.48
Exploded oats—corn—rye	24	0.48
Puffed oats	25	0.34

In brief summary, it may be said that there are undoubtedly relatively severe losses of the less stable vitamins during food processing and food storage. Protein quality seems to be little affected except in those processes which involve high temperatures, as in cereal preparation. Mineral losses occur practically only as a water separation effect. Losses of nutritive value in fats occur through the onset of rancidity and reversion, after which the products become actually distasteful to the user. Extremely rancid fats will tend to destroy vitamins which are susceptible to oxidation and may exert some toxic effect in themselves.

The nutritional survey of meat products in which we became active some three years ago is as yet far from complete. Certainly the data available in the literature on similar surveys for other foods are likewise fragmentary. It is almost self-evident that the times and temperatures used in food preservation are the major factors involved in nutrient losses, with the one exception of

treatment such as blanching which involves water solution. Greater retention of food nutrients during processing will probably depend upon new methods of food sterilization.

Food technology cannot be successful without full consideration of all practices, procedures, and new developments which may relate to nutritive values.

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DR. HOOBLER: We are very fortunate, today, to have Doctor King not only present his paper but open the discussion of Doctor Newton's paper.

DR. KING: Having spent most of my life in university work, I must say that it has been a pleasure to find how keenly alert men like Dr. Newton are, of the responsibility that the food industry has to the public which it serves. I have had some very interesting discussions with business executives in the food industry during the past three years, and I have yet to find a man in a position like that, of high responsibility, who was not sensitive to the responsibility that his industry has for public health.

But there are pressure movements within the food industry, obviously of a very partisan nature. It goes without saying that millers and bakers here and there resent the criticism that is pointed to the low nutritive value of white flour. They have made a gradual retrenchment, so to speak, in meeting that criticism in part by accepting the enrichment program, but I think many of us forget that they instituted the enrichment program before there was any requirement or pressure on them from the government. Many millers were exploring the field to see what could be done to improve the quality of a flour that the public would accept.

Now I think that if we can find ground on which the food industry can meet their responsibility to the public, there will be, on the whole, good acceptance and adoption of those policies. They are not so stupid, in my estimation, as to fall into the trap of attempting to promote policies, deliberately, that would impair public health. In contrast to doing that, I think you will find practically every large food dealer at the present time increasing his technically trained staff so that they can get factual evidence, evidence that will guide their administrative policies with respect to what their obligation truly is to the public.

Among the people that I have come in contact with, it has certainly been a pleasure to see the ardent leadership

that Dr. Newton has taken in technical organization such as the Institute of Food Technologists, in keeping those men alert to their responsibility in maintaining food production channels to protect the public health.

In commenting upon the advertising relation and responsibility to the public, I share in frank recognition of the importance that the advertising has in shaping public food practices. I wish that there were some way to get the advertising agencies within each individual firm in such a frame of mind and in such a position of acknowledged responsibility that they would check with their technical staff before releasing their advertising. I don't know how that can be accomplished. At the present time you have a process of education going on, and you have increasing pressure from government agencies to supervise advertising. I think that with the joint pressure of simply meeting the demands of honesty to the public, with the discussions within their own organization, plus the policeman's responsibility which the government agencies must take in surveying advertising policies, we will probably see improvements.

In general, it seems to me that the more spurious the product on the market, the more intensive is their advertising, and the more grossly are their statements exaggerated in appealing to the public. I am a little at a loss to note how very conservative the food people are who have an excellent product, to make a forthright claim for the quality of their own product. When the California Fruit Growers Exchange was shaping their advertising policy, between about 1932 and 1938, they were very reticent to even mention the word vitamin C in connection with orange juice. They thought it was getting over into medicine if they mentioned the fact that orange juice had vitamin C in it. They finally got over it, and I think one of the things that got them over the hump in stating that orange juice had vitamin C, was the fact that the pharmaceutical people brought out synthetic vitamin C and began to press that without restraint.

Somewhere, I think, in this milling back and forth between the conservatism of the food manufacturers and those who have other products to sell, we will make progress in the long run. I wish there were some way of accepting responsibility on the part of food serving institutions, in the way that food manufacturers have accepted it. It seems to me that if you take our hotel and institutional type services, we do not have anywhere near the same fine acceptance of responsibility for the nutritive value of what they serve the public, that we have within the food industry itself. If anyone can see an answer to that situation, I am sure that it is one which needs very ardent attention.

DR. NEWTON: Several of these questions relate to nutrition, and since I reported on some of the nutritional results of my associates I think they are proper questions, but I am very glad I made it clear that I am not a nutritionist.

SARA O'NEAL, student: The new rule for cooking war-time available meat, is to cook it a long time at lower temperatures. What would be the losses under these conditions?

DR. NEWTON: There has been a lot of work done on that in various laboratories and in general the losses are less. I can't give you the data, for I don't have any specific references here. They can be made available to you, though.

GRACE M. SUUGART, Southeastern High School, Detroit: Why cannot pork be kept as long as beef in the frozen food lockers?

DR. NEWTON: Simply, the reason is that both of them undergo a certain amount of dehydration, unless you have one hundred per cent humidity, which you never have in those lockers. Now then, when you get a little dehydration, a little drying out in spots, you expose the fat on the meat. It happens that the fat on pork is very susceptible to oxi-

dation and this gives an off flavor whereas fat in beef is very resistant to oxidation. So pork is not storable frozen for as long as beef. I think there probably is a practical storage limit for both of them, but the limitation would be a little shorter on pork than beef.

DR. MARTHA KOEHNE, Ohio Department of Health: Are there any data available showing whether modern compression of dehydrated meat reduces thiamin losses on storage?

DR. NEWTON: There have been a number of storage tests. What she is referring to is the tendency to compress these dehydrated food products into small blocks to save volume, and for various other reasons, in storage. There has been a lot of experimental work in compressing of dehydrated meat and a lot of work done on determining the losses in the storage of it. Whether those two have been combined, I don't know. I would not expect it to show any additional loss because of the compression, over storage of the same product uncompressed. I suspect that some of the data refers to compressed products, and we can find out by writing Doctor H. R. Kraybill of the American Meat Institute, because the program is centered around his office.

DR. ALINE U. ORTEN, Wayne University College of Medicine, Detroit: In the comparison of methods of cooking on vitamin losses, does any of the loss in the stewing process result from solution of the vitamins? In other words, is the determination made on the meat alone, or the meat and cooking fluid?

DR. NEWTON: The data I showed on the slide were compiled from five different sources. The total data includes results both on the meat and on the fluids that were cooked out, and on the mixtures of them. The summaries that I gave were for both, the meat and the cooked-out fluid.

RESEARCH AND NUTRITION FOR  
HUMAN HEALTH

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**I**N REGARD TO the relationship of nutrition to research on nutrition, to public health, and perhaps as you and I understand it better, to your health and your efficiency, and my health and my efficiency, I want to point out first of all that from the general public health standpoint, we are not concerned with the so-called deficiency diseases. They are the end result of an acute deficiency which today is rarely encountered, I believe, in most parts of the United States and Canada.

For instance, in 1925, at the Hospital for Sick Children, in Toronto, we had 154 cases of rickets, and ten years later, in 1935, we had four cases. At the Hospital, with an annual attendance of approximately one hundred thousand cases a year, we average seven cases of scurvy. Beriberi is practically unknown. Pellagra we rarely see in that part of the country. We had one case of xerophthalmia due to a lack of vitamin A, so you see these acute deficiencies are not a public health problem at the present time.

Have we any problem in nutrition? Well, we certainly have, because now we are concerned with finding out evidences of what happens if a group of people have a diet which is only seventy-five per cent perfect, or sixty-six per cent or fifty per cent.

How does it affect their efficiency? If you set out to find evidences of this lack or loss of efficiency, you would naturally pick out the periods in life when bodies are subject to stress and strain—so I am now going to attempt to show you the effect of stress and strain on people who are not adequately nourished. They are nourished adequately for prevention of deficiency diseases, ordinary deficiency diseases, but not to have the top efficiency when they are placed under a period of stress.

We can start right at the beginning, with the diet of the pregnant woman and its effect on her unborn child; then, the stress and strain of growth; the stress and strain of infection; the effect of adequate nutrition on being able to withstand severe physical exertion, which is a tremendous problem from a military standpoint now; the

effect of adequate nutrition on the prevention of undesirable psychiatric changes; the effect of diet on learning ability; and the effect of diet on the span of life.

Here you see a well-known picture, cases of rickets, with a normal child in the center. As I said before, this condition has largely disappeared.



N

CHILDREN SIX YEARS OF AGE SHOWING SEVERE RACHITIC DEFORMITIES COMPARED WITH NORMALLY GROWN CHILD (CENTER) OF THE SAME AGE.

In this picture of the mouth of a child with scurvy you can see the hemorrhages around the teeth, typical of scurvy, a disease also now almost unknown.

Here are some of the skin changes that occur in pellagra, and that again is practically unknown.

Now, the effect of diet on the pregnant woman's health, her efficiency, and the health and efficiency of her child. A study was done in Toronto, which was referred to this morning, in which two groups of people, pregnant



**MOUTH OF A CHILD WITH SCURVY**



**SKIN CHANGES IN PELLAGRA**

women, were observed over periods of two or three years. There were approximately one hundred in each group, and one group received additional food, simple everyday foods; milk, a pint and a half a day, that is a Canadian pint, and as you know, any of you who have gone across the border to get any liquids at all, the pint is larger in Canada; four and one-half ounces of tomatoes a day; about three-quarters of an ounce of wheat germ; an egg a day; an orange a day; and approximately an ounce of cheese. These are ordinary, everyday foods. As Doctor Icie Macy Hoobler and her staff here have shown, unless you have vitamin D in the diet of the pregnant woman, she will be in negative calcium balance, so there was vitamin D added.

## WEEKLY AMOUNTS OF FOOD SUPPLIED

Milk	10 pints (Imperial)
Tomatoes	32 ounces
Wheat Germ	14 tablespoons
Eggs	7
Oranges	7
Cheese	½ pound
Viosterol	2000 I. U. daily

## ANALYSIS OF DAILY FOOD SUPPLIED

<u>PROTEIN</u>	<u>FAT</u>	<u>CARBOHYDRATE</u>	<u>ENERGY</u>	<u>CALCIUM</u>	<u>IRON</u>
gm.	gm.	gm.	Cal.	gm.	mg.
45	46	60	840	1.45	.015

Now what happened when these foods were furnished to one-half of these women? I might say that their diet was not adequate to begin with. It wasn't bad however. They were not suffering from any deficiency disease. They appeared as normal, everyday women. In the tables the figures for the women who did not receive the extra food are labeled "poor diet." Every second woman was given the extra foods, and this group is designated "supplemented-good."

When the study was completed and the records compiled, and incidentally the obstetricians had no idea in which groups these women fell, the group on the poor diet, some thirty-six per cent, had been given a poor-bad prenatal rating by the obstetrician, as compared with only one-quarter the number, or nine per cent, when the diet was good.

PRENATAL RATING BY OBSTETRICIAN

	<u>GOOD-FAIR</u> PER CENT	<u>POOR-BAD</u> PER CENT
Poor Diet	64	36
Supplemented-Good	91	9

Then the rating during labor. Twenty-four per cent of those on the poor diet gave a poor-bad record, as compared to only three per cent of those who received the supplemented diet.

RATING BY OBSTETRICIAN OF CONDITION DURING LABOR

	<u>GOOD-FAIR</u> PER CENT	<u>POOR-BAD</u> PER CENT
Poor Diet	76	24
Supplemented-Good	97	3

The average duration of the first stage of labor for the primiparas on the poor diet was twenty hours, as against fifteen hours when the diet was good. The labor

AVERAGE DURATION OF FIRST STAGE OF LABOR

	<u>PRIMIPARA</u> HOURS	<u>MULTIPARA</u> HOURS
Poor Diet	20.3	11.1
Supplemented-Good	15.2	9.5

was definitely shortened, that is, in the primiparas. With multiparas, the times were eleven as against nine and one-half hours. In other words, the women were much more efficient when they had a good diet.

Then during convalescence, we find again eleven and one-half of the poor diet group with a poor-bad record as compared to three and one-half per cent of those whose diet had been good.

RATING OF OBSTETRICIAN OF CONDITION OF MOTHER  
DURING CONVALESCENCE

	<u>GOOD-FAIR</u> PER CENT	<u>POOR-BAD</u> PER CENT
Poor Diet	88.5	11.5
Supplemented-Good	96.5	3.5

In the rating of the condition and progress of the baby during the first two weeks, of the babies born of the mothers on the poor diet fourteen per cent gave a poor-bad record, while none of the babies from the mothers that were well fed had a poor-bad record.

RATING OF CONDITION AND PROGRESS OF BABY DURING  
FIRST 2 WEEKS

	<u>GOOD-FAIR</u> PER CENT	<u>POOR-BAD</u> PER CENT
Poor Diet	86	14
Supplemented-Good	100	0

When the mothers and their babies returned home, as far as we could tell, they were under the same economic situation in the two groups and had essentially the same care, yet the babies born of the mothers who had been on a poor diet had many more infections: frequent colds, twenty-one as against four per cent; bronchitis, four against one; pneumonia, five against one; mild rickets, five against none; tetany, four against none; difficult feeding, seven against one; and anemia, twenty-five against nine. In other words, the diet of the mother before the baby was born had a definite effect on the resistance and health of that child.

Then we come to the fairy story of the whole study.

There were fourteen babies lost: seven from miscarriages, four from stillbirths, two from pneumonia and one from

PRINCIPAL ILLNESSES IN BABIES DURING FIRST SIX MONTHS

	<u>POOR DIET</u> PER CENT	<u>GOOD- SUPPLEMENTED</u> PER CENT
Frequent colds	21.0	4.7
Bronchitis	4.2	1.5
Pneumonia	5.5	1.5
Rickets	5.5	0
Tetany	4.2	0
Dystrophy	7.0	1.5
Anemia	25.0	9.4
Deaths	3	0

prematurity. There were fourteen babies lost and every single, solitary baby came from the mothers who were poorly nourished. I think we can agree that here is some evidence to indicate that a diet that is not adequate, not perfect, can affect the efficiency and the health of the

MISCARRIAGES AND INFANT DEATHS

	<u>POOR DIET</u> PER CENT	<u>GOOD- SUPPLEMENTED</u> PER CENT
Total Patients	120	90
Miscarriages	7	0
Stillbirths	4	0
Deaths—Pneumonia	2	0
Prematurity	1	0
TOTAL	14	0
Congenital malformations	1	3
Prematures	9	2

pregnant woman, and also the health of her unborn child.

Now then, in regard to growth, back in 1926, Sir John Boyd Orr and Cory Mann, in England, showed that additional food to school children definitely affected their rate

of growth. Agnes Fay Morgan, in 1930, showed the same thing, that giving a diet that was slightly better, resulted in a more rapid increase in both height and weight of school children. One thousand freshmen at the University of Toronto, of an average age of nineteen years, when examined in 1920-21 had an average height of five feet eight inches, and an average weight of 138 pounds. Seventeen years later, in 1937, in a similar group of the same age, there was an increase in height of one and one-half inches, and a gain in weight of 5.21 pounds.

True, there have been changes in the general life between 1921 and 1937, but most of the changes are in the type of food. The housing had not improved; the clothing—well, I won't get into a discussion on that, whether the clothing had improved or not—but certainly there has been an improvement in the diet, and here we see a very definite increase in the height and weight of the children today, as compared to twenty years ago.

Doctor Summerfeldt and Doctor Ross made an investigation at an orphanage outside Toronto. These children were getting twenty-four ounces of milk a day, an ounce of butter a day, meat three to five times weekly, one to

#### DIET AT ORPHANAGES INCLUDED

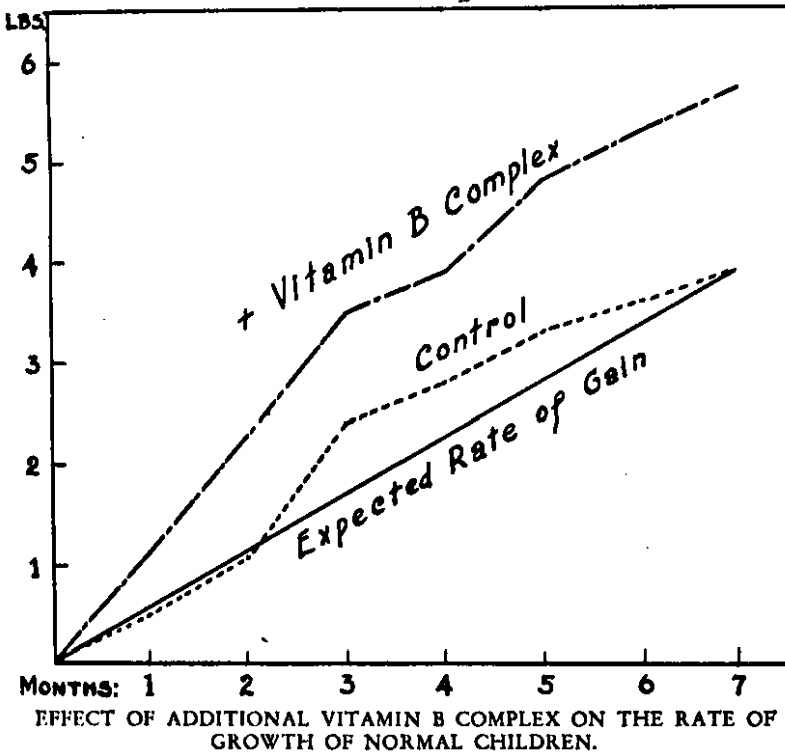
EGG	—24 ounces daily
VEGETABLES	— 1 ounce daily
FRUIT	— 3 to 5 times weekly
MILK	— 1 to 7 eggs weekly
BUTTER	—Potato and 1 or 2 other vegetables daily
MEAT	—Fresh fruit (apples, pears, oranges) for 9 months of the year. Dried or preserved fruits 3 months of the year

seven eggs weekly depending on the time of year, potatoes and one or two other vegetables daily, and fresh fruit some months in the year.

Children in one group were given additional vitamin



B complex in the form of a concentrate of wheat germ and yeast. The chart shows the way these children grew, the expected rate of gain of the two groups, the weight increase of the control group on the regular diet of the institution, and the weight gains of the group getting the additional vitamin B complex, which could not have supplied five extra calories a day, but, as you see, the children receiving it gained weight much more rapidly.



I think we can conclude that diet has a definite effect on the rate of growth, and a diet that is already good, if it is made still better, made perfect, will result in greater growth in both height and weight.

And then in regard to the psychiatric changes. There is not much need to go into these, because you all know of

the work of Doctor Jolliffe and others, particularly Doctor Wilder, who took a group of people and gave them a diet which was a little low in thiamin, and after a period of some months, there were definite psychiatric changes. They became irritable and morose.

This work was done, over a period of five years, by Doctor Elizabeth Chant Robertson at the Hospital for Sick Children, in Toronto. She took animals, divided them into two lots and put one lot on a diet deficient in one food substance, not completely absent, just low. The animals then were fed a measured amount of disease-producing organisms and the number of survivors were noted.

EFFECT OF IMPROPER NUTRITION ON RESISTANCE TO INFECTION

FOOD SUBSTANCES DEFICIENT	NUMBER OF ANIMALS	SURVIVORS ON	
		DEFICIENT DIET PER CENT	ADEQUATE DIET PER CENT
Vitamin A	24	40	79
Vitamin B	151	20	72
Vitamin D	739	28	55
Minerals	124	54	87
Animal Protein	81	40	90

When vitamin A was lacking in the diet the number that survived was forty per cent, as compared to seventy-nine per cent of the group getting a perfect diet. In another series, when the B group of vitamins was lacking, twenty per cent survived, as compared to seventy-two per cent when the diet was perfect. When vitamin D was low, twenty-eight per cent survived, as compared to fifty-five per cent when the diet was perfect. In another year, a group was given a diet lacking in minerals and fifty-four per cent survived as compared to eighty-seven per cent when the diet was perfect. And then, when animal protein was given to one group and another group had a diet that was lacking in animal protein, but had lots of protein from other sources, ninety per cent of those receiving

animal protein survived but only forty per cent of those without animal protein.

Such results should be of tremendous practical interest to every physician when he is dealing with patients with infections. Unfortunately, I believe at the present time the vast majority of us do not consider or pay much attention to the nutritional status of our patients, but the treatment of pneumonia—the treatment of any infection should include a very careful survey of the nutritional status of the patient.

Then in regard to the relation of diet to mental reactions—the results of the Harvard tests show that over a period of five days men receiving a diet lacking in all members of the vitamin B complex showed deterioration in capacity for easy work. The men receiving thiamin remained normal in this respect, but for exhausting exercise, there was a progressive, marked deterioration in the fitness of both groups. The daily administration of eighteen grams of dried brewer's yeast resulted in a complete return to normal in both groups in five days. The thiamin group improved more rapidly. They conclude that a lack of thiamin results in symptoms of lack of well-being, irritability, muscle pains and moderate impairment of physical efficiency. A lack of the other members of the B complex is characterized by few symptoms but by marked impairment of capacity for hard work, physical work. The tremendous importance of an adequate diet for our boys in the armed services who are undergoing severe physical strain is apparent.

Regarding learning ability, you know of the work of Mauer and Tsai, in which they took rats in the first four weeks of life and gave some of the mothers a diet from which they did not receive an adequate amount of the B complex.

After the rats were nursed four weeks, the controls whose mothers had had a good diet, and these others, were put on a perfect diet, carried along for some months, and

then their learning ability determined. The ones who were on the low vitamin B intake in the first four weeks of life, although at four to six months of age they appeared perfectly normal, were stupid. That work was repeated in Toronto, with some variations, and the next slide shows you some of these results. The control group had the perfect diet all through life. The B deficient group was only

THE EFFECT OF VITAMIN B COMPLEX DURING NURSING  
ON SUBSEQUENT LEARNING IN THE RAT

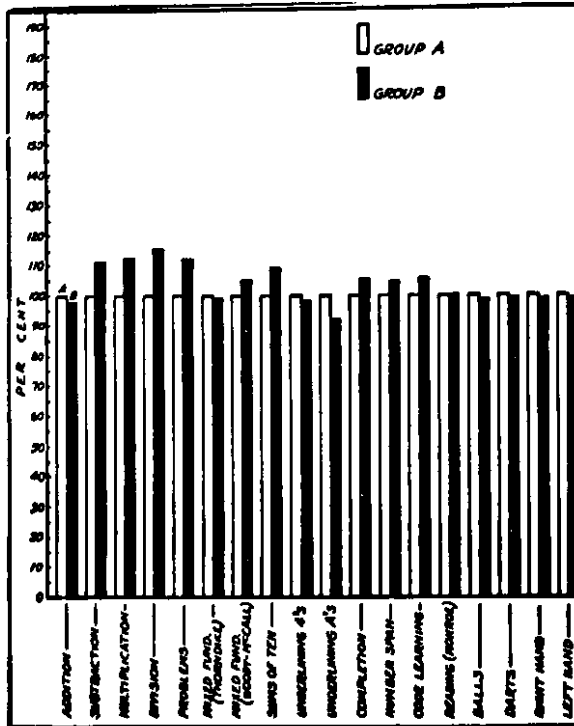
Karl S. Bernhardt  
(J. of Compar. Psychol., 1934)

MAZE SCORES

	CONTROL	VITAMIN B DEFICIENT
Average trials	26.0	39.8
Average time in seconds	1419.2	1705.2
Average errors	141.7	200.7
Average retraces	22.9	33.2
Excess distance	365.1	495.0

B deficient during the first three or four weeks of life. The test was a water maze for the rats to get out of the water at the other end. The average number of trials on the control group was twenty-six, while the B deficient animals in early life averaged almost forty. The average time in seconds was 1419 as against 1705. The average errors, 141 as against 200. Average retraces 22.9 against 33.2. The excess distance travelled 365 as against 495. These rats were physically excellent, but they were stupid, and as we look around we are quite convinced that some people were a little short of thiamin in their early life.

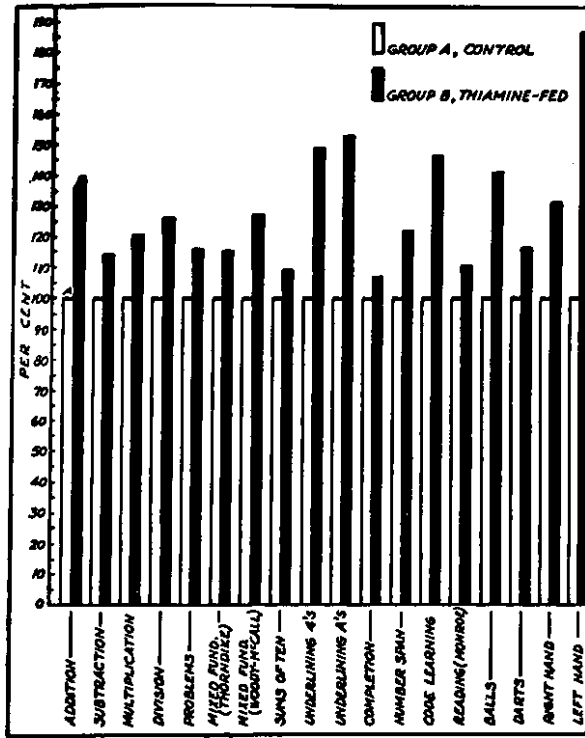
A most interesting study has been made in the last year or two by Miss Harrell, in which children at an orphanage were divided into two groups and then given about eighteen different tests of their learning ability. Group A was the control group and is shown by the white columns of the graph. Group B received, in addition to the regular diet of the institution which was a little low in thiamin, an additional two milligrams of thiamin a day, bringing



EFFECT OF ADEQUATE THIAMIN INTAKE ON THE LEARNING ABILITY OF CHILDREN. Relative standing of Group A and Group B on diet providing 0.9 mg. thiamin per day.

it well above the requirements. At the beginning, there was very little difference in the learning ability of the two groups on the various tests, addition, subtraction, multiplication and physical tests such as throwing darts. After some weeks they were re-tested.

The group getting the additional thiamin, in other words getting an adequate amount of thiamin, learned in every case more rapidly than the group on the slightly deficient diet. In fact, the average learning increase was about twenty-nine per cent greater than that for the other group, which is a most important observation for all educationists. It is also a most important observation for you and for me as taxpayers, because think of the tremendous expense of children repeating at the school. It is



EFFECT OF ADEQUATE THIAMIN INTAKE ON THE LEARNING ABILITY OF CHILDREN. Relative standing of Group A and Group B six weeks after diet for Group B was increased to 2.9 mg. thiamin. (Recommended allowance 1.2-2 mg.)

also of tremendous national importance, because if you have a nation of more intelligent individuals, you are going to have a stronger nation.

With respect to the effect of diet on the span of life, it was in 1919 that Professor McCollum, who is in the room today, published this work in the *Journal of Biological Chemistry*. He fed his animals a diet consisting of wheat flour and degerminated corn, dried potatoes, peas, beans, beets, turnips and dried beef steak. These animals at ten months of age, which is equivalent on the human scale to about eighteen years, had all the evidence, as you see, of old age, senescence. The diet of the lower animal included ten per cent of dried milk, and as you see, it is an entirely

SENESCENCE AT 10 MONTHS OF AGE



DIET

Wheat flour .....	20%
Degerminated corn ...	10%
Cooked dried potato ..	30%
Peas .....	10%
Navy beans .....	10%
Beets .....	5%
Turnips .....	5%
Dried beefsteak .....	10%



DIET

Same as above plus 10%  
dried whole milk

different picture. You might say that is an extreme situation, that it would not be encountered, but there are many places in the world today where you may find a diet almost identical with that one.

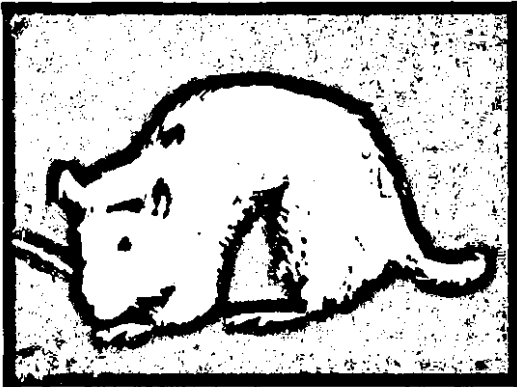
Here are some figures we obtained in a special study that was done in August by a group of people from the States, Great Britain and Canada, at the invitation of the Newfoundland Government. Note the similarity of the two diets. McCollum's diet contained wheat flour and degerminated corn, and is shown on a weight basis. The Newfoundland diet is on the basis of calories, but there is a large amount of white flour, potatoes, peas, beans, turnips,

SENESCENCE AT 10 MONTHS OF AGE



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Turnips	.....	5%
Dried beefsteak	.....	10%



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cabbage, and in place of dried beef steak, there is dried cod. Now, in addition those people have a small amount of milk and some margarine, and perhaps a bit of wild game, but you see the marked similarity of the diets. In examining these people, we found lots of evidence of aging in children ten to fifteen years of age. In many cases the skin had all the atrophy, all the lack of subcutaneous tissue that you see

COMPARISON OF DIET USED BY McCOLLUM IN 1919 WITH  
NEWFOUNDLAND DIET

<u>McCollum's Diet</u>		<u>Newfoundland Diet</u>	
	PER CENT		APPROXIMATE PERCENTAGE
Wheat flour	20	White flour	55
Degerminated corn	10	Potatoes	10
Cooked Dried Potato	30	Peas—less than	5
Peas	10	Beans—less than	5
Navy Beans	10	Turnips—less than	5
Turnips	5	Cabbage—less than	5
Beets	5	Dried Cod	10 ?
Dried Beef Steak	10		

In addition the Newfoundland people have a very small amount of milk and some margarine.

Calculated on basis of 2500 calories.

in a person of fifty or sixty years of age. In many cases we would all look at a woman and guess how old she was. The guesses would range from forty to fifty years of age and almost invariably she was in her early thirties. Here we find a people on a diet essentially the same as the one which McCollum, in 1919, showed would produce evidences of old age at an age corresponding to eighteen years. In the people of that nation we find early aging such as McCollum described twenty-five years ago. I may say that if all countries were blessed with as progressive a public health department as is now in effect in Newfoundland, we would all be very lucky, because they are going to clear up this situation and they are taking every possible step to do so, otherwise we wouldn't have been invited to go over there.

In the United States and Canada the food supply, on the whole, is better than in Newfoundland but dietary surveys have shown that a considerable portion of the people of both countries consume food that is not nutritionally adequate. The beneficial effect of taking a good diet and making it better is indicated by the work of Professor H. C. Sherman, published some years ago.

*Diet A* consisted of a mixture of one-sixth dried whole milk and five-sixths ground whole wheat, table salt and distilled water. Families of experimental rats are still thriving after 21 successive generations on this diet. *Diet B* had the proportion of milk powder in the food increased to one-third.

The two groups of animals were of the same heredity, and even kept under identical conditions in all respects except for the difference in food. The higher proportion of milk in *Diet B* means, in chemical terms, a richer intake of calcium, of vitamin A and B<sub>2</sub> (G), and of certain of the amino acids.

On diet A, 331 rats lived an average of 590 days, while on diet B, 287 rats lived an average of 654 days, or an increase of 64 days, or ten per cent. From further investigations, it seems probable that the increased intakes of calcium, of vitamin A and of riboflavin, may all have contributed to the higher degree of health and the increased length of life.

Hence, it may be regarded as established beyond any reasonable doubt that, starting with a diet which is already clearly adequate, it may still be possible to induce a very significant improvement in longevity by enriching the diet in certain of its chemical factors.

To the adequate *Diet A* (families are still thriving in the fortieth generation on this diet at the present time) were added (1) calcium, (2) vitamin A, (3) calcium and vitamin A, and (4) calcium, protein (slightly), and vita-

min B<sub>2</sub> (riboflavin). The groups of animals receiving additional calcium, additional vitamin A, and both, maintained their youthful appearance longer than those on Diet A. The additional calcium and vitamin A, either alone or together, resulted in an extension of the period of adult vitality, and also in longer life. The addition of calcium, protein and vitamin B<sub>2</sub> resulted in an increased rate of growth and a lengthened span of life.

Thus it appears that the three factors which were increased in greatest ratio, i.e., calcium, vitamin A, and vitamin B<sub>2</sub>, have all contributed to the improvement in nutritional well being and resultant health and longevity.

Here is everything that anyone could wish for, an extension of the span of life, and that extension has been accomplished by an extension of the period of youthful appearance and the period of adult vitality.

I have tried to trace for you what evidence we have of the effect of an adequate diet over an average diet, how it affects the health before birth, during growth, during infections, during severe physical strain, how it affects mental capacity, and finally the length of life. I think you will agree that there is probably no one factor that so affects our health today as the food we eat.

## MAINTAINING DENTAL HEALTH

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*Director, Department of Pediatrics, School of Medicine  
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Council on Food and Nutrition, American Medical Association

**D**ENTAL HEALTH consists chiefly of freedom from dental caries and my discussion will be restricted to this field. I believe this topic was assigned to me because of my relationship to a committee of the Food and Nutrition Board of the National Research Council, which is charged with the task of critical evaluation of the world literature on dental caries. This task has continued for nearly three years and much still remains to be done before it is completed.

For most of this period the full time of Dr. Gerald J. Cox was devoted to the review and it is largely through his effort that this report is possible in its present form. The bibliography at present contains nearly 3,000 references and more remain to be added. My discussion will be based in large measure on the results of this review. It is obvious that in this brief presentation only the more important conclusions can be discussed, and these somewhat sketchily.

Dental caries is our most widely prevalent disease. Much effort has been expended in determining its cause and methods for its prevention. Much has been learned but no real solution has yet received general acceptance. Nearly all observers in this field agree that diet is an important determining factor, but beyond this point of agreement controversy reigns concerning the important dietary factors and the mechanism of their operations.

On the basis of present concepts, diet may be related to dental caries in two major ways. One way is through changes produced in the oral environment. The other is the effect of diet on the resistance of the tooth through nutritional or other systemic means. The majority of observers in this field express a belief that oral environment is the effective factor, to the exclusion of the nutritional factors.

Critical examination of published evidence leads to the conclusion that *both* oral environment and nutritional factors are important. If both these factors are important, as they seem to be, a proper study of causes of dental caries should bring both factors into consideration. Too

often the studies have been set up in a manner pertaining only to the factors of oral environment, with complete neglect of control as to possible effects of nutrition. In some studies, tests for caries activity have been substituted for direct observation of the teeth. Fault may be found also with some of the nutrition studies because of failure to consider and control nutritional factors other than the one being studied. These and other faults in experimental procedure often make interpretation difficult.

Oral environment undoubtedly plays a prominent role in dental caries and fair agreement exists as to some, but not all, of the mechanisms. Many studies have been made of the composition of the saliva in relation to caries. No relation has been found between the pH of saliva and caries activity, though it is possible that an inverse relationship exists between potential alkalinity and caries activity. An inverse relationship may exist between caries activity and the calcium and phosphorus content of the saliva, but the evidence remains doubtful because of the wide ranges reported and the overlapping of values. Saliva has been shown to contain mild antiseptic agents; these agents appear to be more active against bacteria foreign to the mouth than to the normal inhabitants, but nevertheless they may affect the caries rate. An inverse relationship probably exists between the volume of saliva and caries activity. Removal of the salivary glands leads to extensive caries in the experimental animal, regardless of diet. Obviously, saliva is necessary to keep the teeth intact.

The view most widely held as to the initiation of caries is that it gets its start through the agency of acid produced by the action of acidogenic bacteria on carbohydrate in crevices or plaques. While this view seems plausible, satisfactory evidence in its support is lacking. It has been shown that acid may form very rapidly in plaques. Sufficient acid to decalcify enamel may develop within a few minutes after ingestion of carbohydrate. However, plaques exist over areas that are not carious and apparent-

ly early caries can be found without plaques.

Any teeth, no matter how sound, can be decalcified by acid, but the rate of attack is variable, depending on the enamel. Artificial caries develops most rapidly in areas of enamel the surfaces of which have been altered by abrasion, scratching or other means. The variation in attack of artificial caries indicates a resistance to caries in part within the tooth, especially the surface of the tooth. The resistance shown in this manner is independent of metabolism or of oral environment because the tooth used for experiment is outside the mouth and wholly immersed in an acid medium. The failure of some teeth or areas of teeth to be attacked under conditions of the artificial caries experiment has as a plausible explanation a difference in surface structure between different teeth and different parts of the same tooth. It is possible that initiation of caries is dependent on factors other than, or in addition to, the presence of bacterially produced acid.

While some question exists as to the mechanism of initiation of caries, the evidence is fairly good that, once caries is initiated, cavity formation is promoted by bacterially produced acids. Opinion as to which specific types of acidogenic bacteria are responsible for cavity formation is controversial. However, the evidence indicates that no one specific type is causative. Several types of acid producing bacteria have been found in association with active decay and it is reasonable to believe that several types may be responsible.

Good correlations have been found between the numbers of *L. acidophilus* in the saliva and the caries status. On the other hand, well conducted observations have shown that in some instances the acidophilus count may be low in the presence of active caries and high when no caries can be found. It thus appears that acidophilus counts cannot be accepted as positive evidence of caries status in individual instances. Acceptance of these counts for this purpose is common practice. Such acceptance leaves out of con-

sideration the fact that other acidogenic bacteria also play a role in caries increase. There is no evidence that *L. acidophilus* either initiates caries or is specific to its course.

Oral streptococci probably account for more destruction of the tooth than any other bacteria. They are constantly present and they form acid rapidly. They can penetrate deeply into the lesion in the dentin. It seems likely that cavity formation is the result of the activities of any organisms that form acids and of those that can destroy the organic substance of the dentin. The effective flora possibly may vary with the state of cavitation, one type being predominant in shallow cavities and another in deep cavities.

Because of the role of bacteria in dental caries, experimental effort has been made to decrease their number by means of antiseptics. Vitamin K and related quinones are bactericidal and have been used for this purpose. Antiseptic solutions of other materials also have been used as mouth washes. No noteworthy success in reducing dental caries has attended these efforts. Vitamin K has been fed to rats in dosages up to those with toxic effects, without effect in retarding caries induced by coarse cereal particles and promoted by sucrose.

Sugar in the diet is commonly blamed for the occurrence and activity of dental caries. On the basis of the evidence the role of sugar remains to be determined. Cavity formation presumably is promoted by any carbohydrate available, whether it be sucrose, dextrose or the cooked starch of cereals and cereal products. It has been shown that acid is formed by oral bacteria in greater amounts when acting on bread than on glucose or sucrose. In general, experiments conducted to show the role of sugar have not been conducted in a manner wholly satisfactory to give a conclusive answer. As sugar is increased in the diet, the ingestion of other foods is likely to decrease unless special precautions are taken. It becomes necessary to show that resulting increase in caries is not caused by decrease in the



intake of better quality foods. A satisfactory experiment with sugar would be one in which it is definitely known that all nutritional essentials are ingested in adequate amount in addition to the sugar. Caries may be decreased in activity, or arrested, by reduction of carbohydrate in the diet, but the proof that the effect is not from improvement of the diet in other factors is lacking.

Macy has shown that a craving for sweets is associated with the ingestion of diets poor in nutritional quality. As the quality of the diet improves, the desire for sweets decreases, concurrently and proportionately. On this basis a desire for sweets may be taken as an indication of a poor diet. For those who believe in nutritional causes of tooth decay, changes in intake of good quality foods are fully as important as changes in sugar intake. We have personally observed complete arrest of dentinal caries while the child was ingesting 200 grams of sugar daily in addition to a good diet. If the case against sugar is to be proved, an improved and closely controlled experimental set-up is required. Not only must it be known that the subjects ingest the sugar, it must be known also that the whole of a good diet is ingested. Most of the believers in the nutritional effects on caries would agree that addition of sugar to a poor diet is likely to increase caries. If sugar is the cause of initiation of caries, it surely is not the only factor involved. Some people are caries free who consume no less sweets than others who have extensive decay. In instances of caries immunity the caries promoting property of sugar is of no importance, whether the immunity is within the tooth or is produced by systemic or nutritional means.

What constitutes caries immunity in those who are free from this disease? The evidence indicates that the caries resistance resides within the tooth. Also, it indicates that the rate of cavity development, once initiated, depends, among other things, on the resistance of the tooth as governed by metabolic factors. Critical examination of the evidence leaves little doubt that metabolic factors are

important, yet this concept is rejected by a large proportion of those expressing an opinion. When dentinal caries arrests, the exposed dentin changes from a relatively soft structure permitting penetration by a dental tine, to a structure flinty hard. This dentinal change is dependent on metabolic change from within the tooth and is not necessarily related to any factor in the oral environment.

Among the several nutritional factors involved is vitamin D. The evidence is definite that vitamin D is concerned with structure of the teeth. The hypoplasia associated with rickets is an obvious effect of vitamin D deficiency. Published data as to the relationship of hypoplasia to dental caries offer the basis for some controversy. However, other evidence indicates that tooth structure is important to the occurrence of caries. Other evidence which can be cited includes the results of experiments with artificial caries and the effects of fluorine ingestion during the period of tooth formation. Enamel with defective structure need not decay if metabolic and oral environmental conditions are not conducive to decay.

The final report of the committee on dental disease of the British Medical Research Council contains the following conclusion: "The investigations described in this report show conclusively that a relatively high vitamin D content of the food can do much to diminish the incidence of caries if the vitamin is given during the development of the teeth; that a beneficial effect may be obtained if the vitamin is given at a fairly late stage of development; and that even when it is given after the eruption of the teeth, the onset and spread of caries is delayed."

The evidence seems satisfactory that vitamin D has a beneficial effect on prevention and arrest of dental caries when given after the teeth have erupted. In reaching such a conclusion certain related facts must be taken into consideration. The only function of moderate amounts of vitamin D, of which we are aware, is improvement in utilization of calcium and phosphorus. This function of

vitamin D becomes inoperative when the intake of calcium and phosphorus is inadequate. Conclusions as to the effect of vitamin D on caries cannot properly be drawn when the intake of these minerals is inadequate or when it is unknown. When vitamin D is added to a diet of unknown composition, negative effects on caries cannot be used as evidence against the effectiveness of this material. Definite reduction in incidence of caries by addition of vitamin D as the only change in the diet has been shown by May Mellanby in London, by McBeath and co-workers in New York and by Anderson and co-workers in Toronto. Published observations with contrary connotations have been made with unknown and uncontrolled diets. We have personally observed children with active caries, in a closely controlled study, who received vitamin D increased in amount by stages. Without vitamin D the calcium retentions were poor; at the level of 155 units a day the retentions improved; at 600 units a day the retentions were excellent. The caries status improved parallel with increased retention. Boyd and Drain and their co-workers have published three separate groups of observations showing a correlation of caries status with calcium and phosphorus retention.

It is not difficult to comprehend how calcium and phosphorous metabolism may be related to the formation of secondary dentin to arrest the carious process in the dentin. That calcium and phosphorous metabolism can be related to caries of the enamel is not conceded by those who emphasize the role of oral environment to the exclusion of nutritional factors. With our present knowledge of the physiology of the tooth, nutritional effect on caries prevention in enamel does not seem reasonable. Nevertheless, experimental observations have shown that prevention and arrest of enamel caries parallel arrest of dentinal caries when the arrest has been brought about by nutritional means. The decreased incidence of caries resulting from vitamin D administration and from improv-

ed calcium retention, previously referred to, included enamel caries as well as dentinal caries. The decrease in enamel caries occurred without change in the carbohydrate content of the diet.

The incidence of dental caries varies with the season, being greater in winter. Also, much evidence exists to indicate that the caries rate in this country is related to the amount of sunshine of the various regions. In neither instance is the proof definite that ultraviolet rays are the effective factor, but the evidence is suggestive.

Calcium, phosphorus and vitamin D can be effective for any metabolic purpose only when they are well utilized. Instances are not rare in which utilization is poor despite a good intake. A specific example can be cited. A teen-age girl was brought for care specifically because of rampant caries, 28 new cavities being present. An excellent diet, low in free sugar, was given under close control and supervision. Because no change was observed in the caries status and because calcium retention remained poor, the amounts of vitamin D and of milk were increased. Calcium retention continued poor and the caries status the same. Poor utilization of fat soluble vitamins was suspected and confirmed. The girl had very poor dark adaptation when tested. Administration of bile salts produced immediate improvement in dark adaptation and rapid improvement in calcium retention. The improvement in caries status paralleled that of calcium retention. In such instances as this one, we have excellent evidence of the close relationship between calcium and phosphorus metabolism and dental caries, independent of the oral environment. The diet had remained the same throughout the experimental observation period. The caries arrested only when calcium retention improved.

That fluorine may be related to decreased incidence of dental caries is well established, though controversy exists as to mechanism. A reduced caries rate exists in those regions where mottled enamel of moderate degree is found.

A reduced rate occurs when the water supply contains from 1 to 2 parts of fluorine per million, whether or not mottling exists.

The weight of evidence favors the view that the beneficial effects of fluorine are the result chiefly of its ingestion during the period of tooth formation. The effect presumably is in the structure or composition of the enamel. Reported observations have shown that carious teeth contain definitely less fluorine than intact teeth. It has been shown that enamel powder treated by brief contact with fluoride solution has reduced solubility in dilute acid solutions. That the fluorine of the enamel can act as a bactericide does not seem very probable; the fluorine is present in combination as a fluorapatite, and is not easily dissociated to act in this manner.

While some evidence may be interpreted as showing a beneficial post-eruptive effect of fluorine in the water supply in the proportion of 1 to 2 parts per million, it is not conclusive. The fact that less caries is to be found in the upper anterior teeth in fluoride regions is used as an argument for post-eruptive effect. Also, it has been shown that production of acid by bacteria is definitely inhibited by concentrations of fluorine as low as 1 part per million. Several facts exist on the other side of this argument. When dental caries exists in fluoride regions, acidophilus counts correlate with the caries status regardless of the fluorine content of the water being used. Such data as are available indicate that deciduous teeth are less protected by fluorine than are the permanent teeth. After birth the deciduous teeth receive the same protection from the water supply as do the permanent teeth, but before birth they receive through the placenta much less fluorine than is received after birth from the water supply.

It seems unlikely that the fluorine content of the saliva offers protection against caries. The usual content of approximately 0.1 part per million is considerably less than that believed to be necessary to inhibit acid formation by

bacteria. The amount in the saliva is relatively independent of the water content up to 1.8 parts per million.

Periodic application to the teeth of fluoride solutions of the order of 500 parts per million reduces the incidence of new carious lesions, but the effect on the extension of those already present is controversial. It is possible that fluoride used in this manner acts as a bactericidal agent, but it seems more likely that the fluorine enters into combination with the enamel to form an apatite which resists solution by acid.

The various studies with fluorine have shown that caries incidence can be importantly reduced by appropriate dietary use of this material. Similarly, other studies have shown that caries incidence can be reduced by giving vitamin D when the diet contains calcium and phosphorus in significant amounts. In all these instances the caries rate has been only partially reduced, never completely. On the other hand, caries has been completely arrested by diets complete in all nutritional essentials.

Particularly noteworthy in this field are the publications of Boyd and Drain. Active caries became arrested under hospital supervision and new caries did not appear later for as long a period as no departures from the prescribed dietary regimen occurred. In one of the reported studies 44 of 55 of the children had no new caries whatever for a period of more than two years. In the course of these observations it was found that omission of cod liver oil was a frequent deviation from the prescribed diet. With the subsequent use of this material further progression was not observed. The Boyd and Drain diet contained little free sugar and the good results obtained have been attributed by some to this fact. However, their reports also include instances of children who received large amounts of sugar, by intention, in addition to a complete diet; new caries was absent from this group also. Small importance is sometimes given to these reports for the reason that specific factors responsible for decreased

caries are not named. It does not seem appropriate to ignore the observations for such a reason.

Opinion often is encountered to the effect that mastication, particularly of so-called cleansing foods, is beneficial in prevention of dental caries. Review of the literature offers no demonstration of hereditary trends in opinion.

Opinion also is encountered that heredity may play an important role in caries resistance or susceptibility. The literature offers no demonstration of hereditary trends in tooth decay. It may be true that tooth form and position are related to caries, but proof that these are related to heredity is lacking. Susceptibility to caries, or lack of it, may be familial at times, but family dietary habit is more likely to be the cause than heredity. Certainly caries can be arrested satisfactorily with good diet, regardless of heredity.

Production or prevention of caries can be considered as the resultant of the effects of two opposing groups of factors, those tending to produce caries on the one hand and those tending to prevent caries on the other. Even though factors may be constantly present which tend to produce caries, caries will not appear if the opposing factors are stronger. Factors tending to break down the tooth and cause caries are in the oral environment. These are present, at least to some extent, in all persons. All mouths contain some acidogenic bacteria and food is provided for them several times daily. The effectiveness of the caries producing factors depends on the resistance of the tooth or on oral environment factors at present unknown. The evidence indicates that resistance of the tooth is increased by appropriate amounts of fluorine, particularly during the period of tooth formation. Tooth resistance seems to be increased also by good diet, independent of amounts of fluorine more than a trace in the water supply. If the caries preventing factors are sufficiently strong and the diet remains good to maintain this

state, the amount of sugar given in addition seems of no importance.

Having in mind the known facts concerning the cause and prevention of dental caries, what can one recommend as measures to decrease the incidence of this condition? There are those who advocate adding fluoride to the water supply. The advantages of this procedure are that the ingestion and whatever protection is afforded thereby are automatic and require no effort on the part of the individual. Such a measure gives at best only partial protection against caries and is not the complete answer. The addition of fluoride to water supplies has many opponents at present. It is believed that too little is known of the remote and systemic effects of long continued ingestion of fluoride in quantity. A safe and useful sub-mottling level is difficult to estimate because the amount of water consumed differs individually and seasonally. One part per million might be a suitable amount for the summer, but 1.5 or more parts per million may be required to attain the same intake during the winter. Several mass experiments along this line are getting under way. At best, such procedures can apply only to urban water supplies.

The only procedure by which caries has been arrested uniformly is the giving of a good diet under close control. Widespread application of this kind of control is obviously impractical, but it is highly effective when it can be attained. In this phase of the discussion the sugar question comes up again. It is possible that decreased consumption of sweets may result in improvement of the diet by causing greater consumption of other foods. It is also to be emphasized that improvement of the diet results in decreased craving for sweets.

The addition of vitamin D to the diet is to be recommended for all persons during the period of growth regardless of belief as to effect on dental caries. A high proportion of children do not receive vitamin D after the period of infancy. According to available evidence,



vitamin D in conjunction with good supplies of calcium and phosphorus has an important beneficial effect in reducing caries incidence, though it is to be recognized that the giving of these materials as the only anti-caries measure does not eliminate dental caries.

Dental care to the extent of keeping cavities filled has a useful place in the control of dental caries. The filling of cavities retards or stops their progression.

A review of the dental caries situation in a search for methods of controlling this disease leaves many questions to be answered. We do not yet know of a fully adequate preventive measure which can be applied universally and automatically. We are not yet ready to state all the factors involved. That calcium, phosphorus, vitamin D and fluorine are of value in prevention has been proved. These factors alone are not fully adequate. The one really adequate measure for prevention is a diet complete in all nutritional essentials. Is it asking too much that everyone have such a diet? This is a goal toward which nutritionists have been struggling for a long time.

## DISCUSSION

DR. HOOBLER: Doctor Howard B. Lewis, of the University of Michigan, will open the discussion of Doctor Tisdall's paper.

DR. LEWIS: As I sat here listening to Doctor Tisdall's paper, I was carried back to my own childhood a good many years ago, in New England, and I thought of the imperfections of our Connecticut Yankee diet. We lived on a farm and I am sure we had plenty of animal protein. We had skimmed milk because we had to sell the butter fat. We children had skimmed milk—except that I wouldn't drink it because of prejudice—but I am sure that we were adequately nourished in respect to animal protein, calories and probably in the B vitamins. I am quite certain that our diet was low in vitamin A, because we were not a carrot family, we were not a yellow vegetable family, and we didn't have much butter. Certainly our consumption of oranges and citrus fruits was usually the orange or two stuffed in the foot of the stocking at Christmas time.

As I see it, however, we probably did have sub-chronic nutritional disease in every part of New England at that time, owing, I think, to the lack of vitamin C. We had a great deal of soreness, of muscle soreness, of joint soreness, and children, particularly in March, had touches of so-called rheumatism. I am sure that this was some kind of sub-acute or at least incipient scurvy. The only saving grace was that we did have canned tomatoes, which we ate in my part of New England as a dessert at night, cold, and as I see it, the only reason why we didn't all have scurvy was because of that.

In thinking a little bit more about some of Doctor Tisdall's remarks, I was particularly concerned, and I hope that Doctor Cannon later may have something to say from his point of view, with his remarks on the greater effi-

ciency, in his opinion, of animal protein versus vegetable protein. I happen to be on a committee which has had thrown upon it, cast up to it, the task of answering, in the present war emergency, the question of what proportion of our national diet, and of the protein foods going to warring countries in Europe, should be vegetable, and what proportion should be animal. I think our committee have had to say without any hesitation, that we don't know; that convention says let's have more animal than vegetable protein, but that we do not feel that the scientific evidence is adequate. (See page 129.)

Doctor Tisdall evidently feels very strongly about animal versus vegetable protein, and I shall certainly be glad, in private conversation with him as I know we won't have time to take it up here, to discuss that. I want to thank him because he has done so much to answer the questions which confront so many of us. We say that the American diet is inadequate for optimal health. It seems to me that this afternoon he has presented something which we can all carry away with us, a summary of the evidence that improving the diet beyond the basal does something in all fields of human efficiency.

FLORENCE LANGFORD, Texas State College for Women: Is it possible to get the films shown here, to show nutrition students in the States? What procedure should be followed?

DR. TISDALL: I believe in your program you will note that some of those films belong to the National Film Board of Canada, and if you write to them, at Ottawa, you can get the answer as to whether they are available here in the States.

In regard to the Air Force film, "Training Table," I understand that it is distributed by the Educational Film

Library Association, 45 Rockefeller Plaza, New York 20, N. Y. If you have any difficulty, write to me in Ottawa and I will let you know the name.

DR. HOOBLER: We are very glad today to have Doctor Joseph Johnston, of the Henry Ford Hospital, open the discussion of Doctor Jeans' paper.

DR. JOHNSTON: In both instances, there arose the one little item that possibly justified my presence here, if anything does, and that is that both speakers did touch upon the fact that the nutritional state was dependent not only on the availability of a diet, but also on certain factors that affect utilization. That, to me, seems to demand a little bit more prominence in this discussion than we have so far given it, and I am hoping both of them may enlarge on it.

It is one thing to take in an adequate number of calories, an adequate number of grams of protein, calcium, phosphorus and vitamin D. It is quite another thing to be certain that the person who got them actually got them across the gastro-intestinal tract and made them an integral part of tissue.

Doctor Jeans quoted one instance of an eighteen-year old, in whom everything was satisfactory, except the fact that having gotten these things, they never did become an essential part of the girl. There are innumerable instances in three chief fields that affect this, that I think might well be enlarged upon, and both of these speakers have written of them, and possibly will enlarge upon them later.

One is the function of infection. In a little survey we made at one time, it seemed to us we found evidences of nutritional deficiency in one hundred youngsters from excellent homes, 96 of whom presumably, at least, were exposed to a good diet, yet all ninety-six of these children were badly off as a result, we thought, of improper absorp-

tion of food or interference or neutralization by some untoward accompaniment.

One of the items we studied was the item of a focal effect on the utilization, the absorption of both nitrogen and calcium. One of the most common everyday things, the presence of a pair of bad tonsils, for instance, we were able to show, could throw a balance from minus three grams a day of nitrogen over to a plus three—intake constant, adequate, perfectly satisfactory, but absorption and retention was completely out of line.

We have had similar experiences with calcium and phosphorus in youngsters. What led us to do it was a youngster who had to have something done to her because of tuberculosis, and the first step in the study, after getting some control observations of her utilization of calcium and phosphorus, was the cleaning up of some bad foci, following which we needed to go no farther. So it is that aspect of this whole program that I would like to see Doctor Jeans enlarge on, because from their clinic have come many contributions along that line, which he may have felt he didn't have time to give you.

M. BELCHER, Public Health Nurse: I did not hear the comment on repair of damaged dentin.

DR. JEANS: Well, I didn't make any, because the damaged part really isn't repaired. The sclerosis, or hardening, takes place in the more healthy dentin underlying the caries lesion, and the softened or damaged part must be eroded away eventually, to leave exposed the more healthy, sclerosed, underlying dentin.

DR. WILLIAM D. STURM, dentist: Where does the initial lesion of dental caries take place, in the enamel or in the dentin?

DR. JEANS: Well, it must take place in the enamel, and of course that makes logical the view that oral environ-

mental factors are important. They are important, but also I think there are opposing factors that can make them unimportant.

C. H. BURDICK, chemist: Is fluorine applied to water uniformly utilized by all people?

DR. JEANS: So far as I know, it is. I don't know anything to the contrary.

E. W. TILLITSON, chemist: What is the required minimum daily intake of fluorine to prevent dental caries in children and adults?

DR. JEANS: In the first place, there isn't any amount that will prevent it uniformly. Applying fluorine under the very best conditions that are known will not reduce caries to less than a third, presumably, of what it was, and often the reduction is less than that. The amount required ideally, if one is going to use this method at all, would be that which does not cause mottling of the teeth, but one which is slightly under that amount, if one knows what that is. One part per million is the figure usually stated in this connection, as being a safe and sub-mottling level, but the safe level must vary with the season and with the individual.

JEAN C. TRIPP, nutritionist: Is there any relationship between diet and the condition of a pregnant woman's teeth?

DR. JEANS: Well, one could discuss that for a considerable length of time. The published evidence, if one takes it just as it has been published, is that there is no relationship between pregnancy and dental caries. However, I think there is a good deal of interpretation required, and I don't believe we have time to give it. It is to be pointed out that the increased demand for calcium and phosphorus

comes in the last three months of pregnancy, and approximately half of that increased demand comes in the last month of pregnancy. Even for those who might think there is some relationship between withdrawal of calcium and phosphorus from the mother and her dental caries, that period comes so late in the pregnancy that one would not find any effect on the teeth from that cause during the period of pregnancy. Nearly everyone who has written on this subject has overlooked that point entirely.

What we need is some new approach in the gathering of data. It is the lactation period that is likely to do most in this direction, if anything is done at all. Of that we are not sure.

**JANE STAPLETON**, Merrill-Palmer School, Detroit: How important is a pregnant mother's diet on the child's teeth?

**DR. JEANS**: Again, that is difficult to answer. The formation of teeth presumably has some importance in whether or not tooth decay will occur ultimately. It is chiefly the first set of teeth that is formed during the period of fetal life. A very large part of the permanent teeth are formed after birth, so that in the formation of teeth there would be greater effect from post-natal diet than from pre-natal nutritional condition of the mother. Even though teeth have poor structure from poor formation, they still need not decay if the diet and conditions subsequent to the eruption of the teeth are good and not conducive to decay. A hyperplastic tooth does not necessarily decay because it is hyperplastic or poorly formed.

IMPORTANCE OF PROTEINS IN RESISTANCE  
TO INFECTION

PAUL R. CANNON, M.D.  
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**L**ndiscussion around four more or less categorical statements, facts or assumptions, viz:

(1) All disease-producing bacteria are foreign proteins; therefore from the standpoint of the host, their disposal is essentially a protein problem, a problem of protein digestion and absorption.

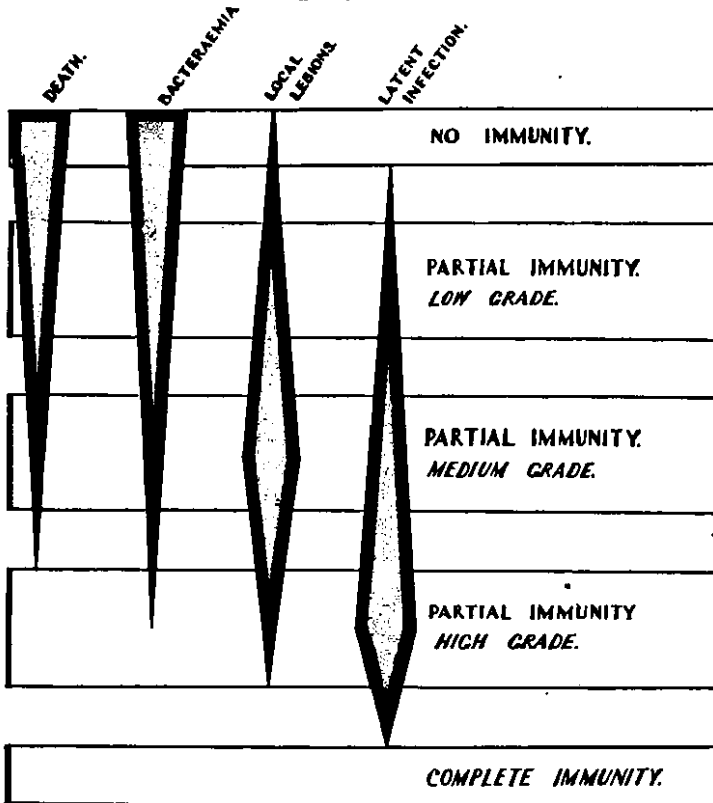
(2) Resistance to infection, whether natural or acquired, is dependent upon the processes of protein metabolism, although, of course, not exclusively so. In the development of the tissues concerned in anti-bacterial defense, for example the bone marrow, the phagocytic tissues of the spleen, liver, lymphoid tissues and lymph-nodes, a large part of their cells is made up of protein material, as, for instance, the nucleoproteins of the nuclei and the protein of the cytoplasmic matrix. Moreover, for the fabrication of immune substances proteins are necessary; therefore, from the standpoint of quantity and quality of tissues and of immune substances, amino acids are essential.

(3) Within recent years it has become definitely established that immune substances are serum globulins, that the synthesis of normal serum globulins is dependent upon diet, and that the synthesis of immune bodies is also dependent upon dietary intake.

(4) Any condition which affects protein metabolism either by leading to depletion of the protein reserves or by interfering with the adequate intake of high quality proteins, may depress resistance (1) through reduction in the quantity and the quality of the phagocytic tissues, or (2) through its adverse effects upon the antibody mechanism.

I would like to discuss now in more detail some of the facts and ideas that have guided us in developing our attitude toward this problem. Slide 1, presented for purposes of orientation, illustrates the contrasting tissue and bodily reactions in the presence or absence of immunity by comparing the size of the local lesion, and the tendency

for bloodstream invasion or for the development of latent lesions (1). Thus, in the absence of an effective resistance, as, for example, to the plague bacillus or, in the case of

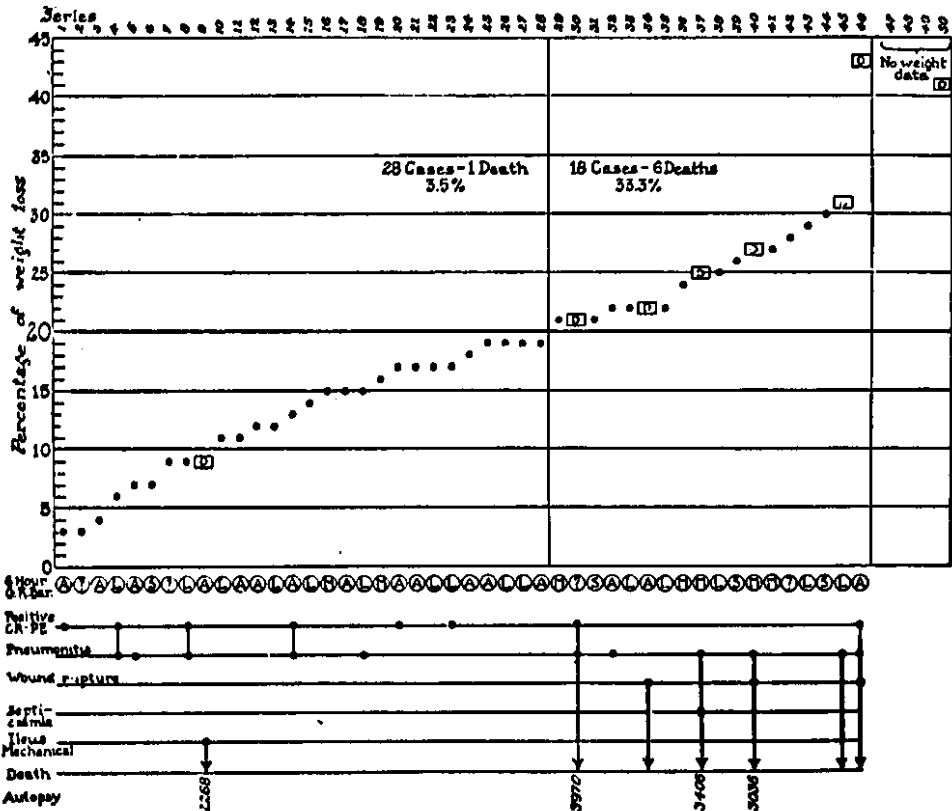


SLIDE 1

the rabbit, to pneumococci, there is a rapid invasion of the bloodstream by the bacteria and a high death rate. The opposite effect is seen in partial immunity, where there is but slight tendency to death or to bacteremia and a correspondingly greater development of a local lesion.

The object of immunization is, obviously, to convert susceptibility into insusceptibility. Conversely, any process or condition that works in the opposite direction is deleterious. One such adverse condition is profound undernutrition. We have known for long, in fact, that

there is a definite relationship between starvation and a tendency to infection. Slide 2 illustrates this idea in demonstrating the tendency of patients subjected to certain types of operation to develop post-operative complications.



SLIDE 2

The data are from a study made by Doctor Studely (2) in Cleveland a few years ago, in which he compared the post-operative course in patients subjected to gastrectomy for ulcer of the stomach. If we compare the post-operative course in patients who had lost less or more than twenty per cent of their normal body weight prior to operation, we see that, of the twenty-eight patients who had lost less than 20 per cent of their normal body weight, only one died, whereas of the eighteen patients who had

lost more than 20 per cent of their initial weight, six died.

Furthermore, among those who had lost more than 20 per cent of their weight, six developed post-operative pneumonia and in three there was wound-disruption. Blood protein determinations were evidently not made, but in view of the current emphasis on the relationship of hypoproteinemia to the tendency to wound-disruption, it is likely that there was marked protein deficiency in these patients. In any event, despite the fact that the numbers are small, we see a relationship between undernutrition and post-operative complications.

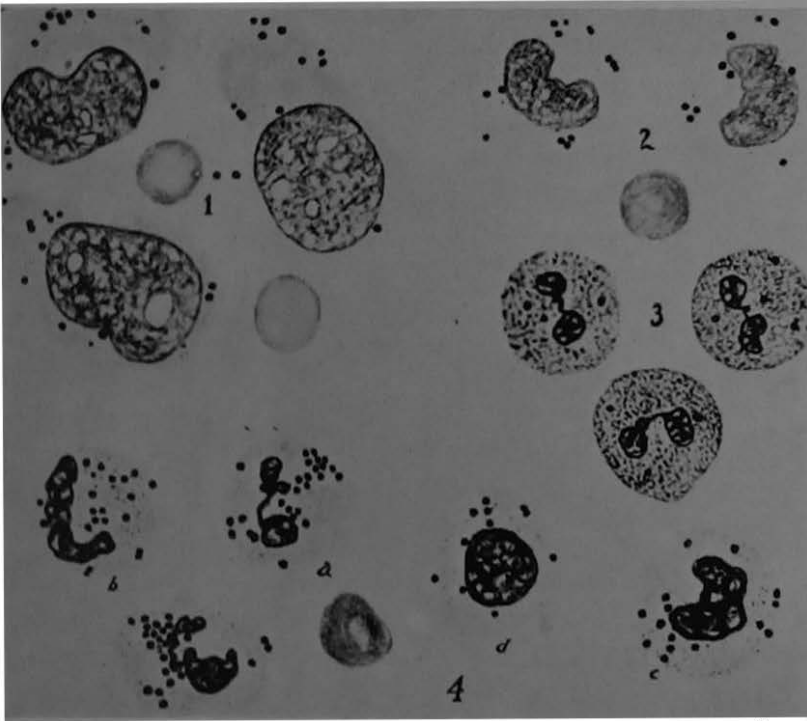
RELATIONSHIP OF HYPOPROTEINEMIA TO TERMINAL INFECTIONS

Case No.	Age years	Sex	Total Protein Grams %	Interval before death	Clinical diagnosis	Principal necropsy findings	Terminal infections											Remarks	
							Bacteriophage	Diphtheria	Paratyphoid	Typhoid	Typhus	Scarlet fever	Uterine infection	Septic atrophy	Septic meningitis	Septic osteomyelitis	Septic arthritis		
5899	60	♂	4.2	6	Coronary occlusion	Same	+	+	+										Emaciation Wound disruption
3114	3 1/4	♂	3.7	2	Nephrosis	"		+	+										1 Pneumococcal
4594	63	♀	4.0	10	Hypertension Diabetes	"	+				+			+	+				1 Pulmonary
5877	51	♂	4.1	1	Cs. of colon	"	+	+	+						+				Emaciation 1 Suppurative pyonephrosis
5701	57	♀	4.9	7	Thrombo- phlebitis	"	+	+		+	+		+						1 Acute renal infection
5926	45	♂	3.4	15	Sprue (non-tropical)	"	+		+						+				Emaciation Acute gastrointestinal ulcerations
2313	24	♀	5.19	6	Acute yellow atrophy of liver	"	+								+	+			1 Acute cystitis

SLIDE 3

Slide 3 illustrates a further relationship between protein deficiency and a tendency to develop serious terminal infections (3). It consists of a tabulation of the necropsy findings in patients who had developed spontaneous terminal infections and for whom protein determinations had been made shortly before death. Case No. 5899 is of especial interest. It is that of a man who came into the hospital with a perforated appendix. The patient was edematous at the time of operation and later there was

wound-disruption. His total serum protein concentration, determined six days before death, was 4.2 grams per cent. He developed a massive bronchopneumonia, pleuritis, generalized peritonitis and bronchitis. After his death we learned that, because of arthritis of the fingers, he had gone to a physician who had put him on a diet consisting largely of fruit juices and raw vegetables. He had eaten this diet, presumably, for several months and had developed a nutritional edema. At autopsy, all of his adipose tissues were gone, as would be expected in severe starvation, and he had but little resistance to the infecting micro-organisms which caused his death.

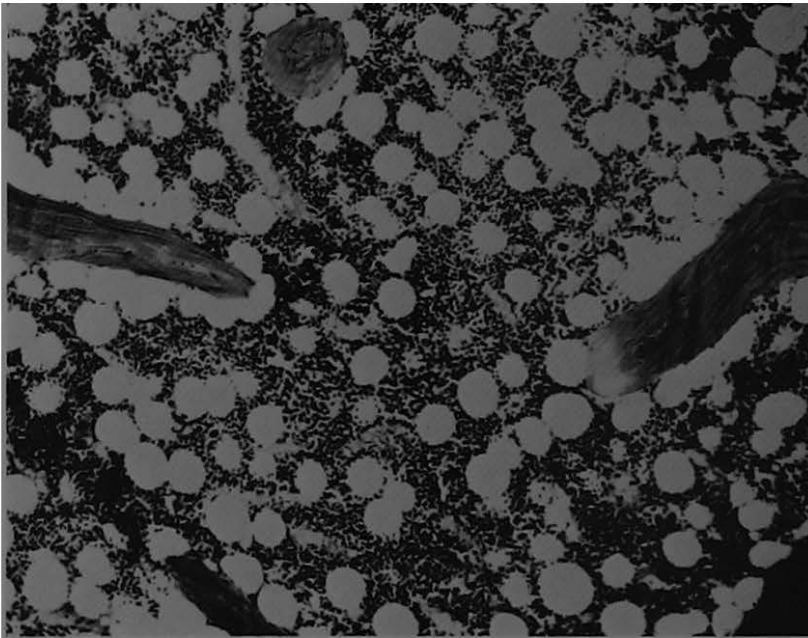


SLIDE 4

The second patient, a child, had nephrosis. Two days before death the total serum protein concentration was 3.7 grams per cent; the child developed a fatal pneumo-

coccic peritonitis. In the third case, a patient forty years of age, with a combination of hypertension and diabetes, there was also a severe hypoproteinemia. This patient developed a spontaneous bronchopneumonia and, in addition, had an unsuspected active pulmonary tuberculosis, a urinary tract infection, and a purulent bronchitis. Of the several types of disease tabulated in this slide it should be noted that all are characterized by debilitation, by marked loss of weight and by profound hypoproteinemia.

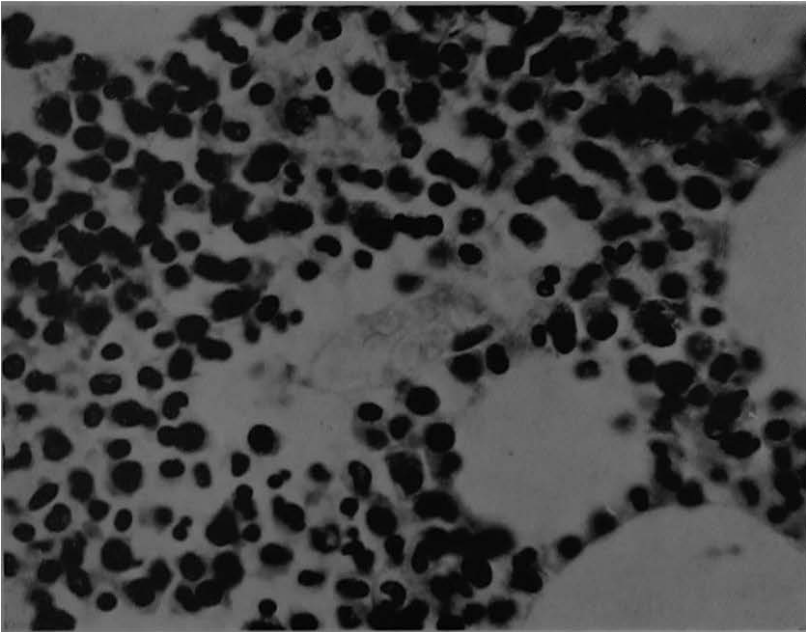
Coming to the consideration of the ways whereby protein deficiency might influence the mechanisms of active immunity, let us consider first the possible effects upon the mechanism of phagocytosis. A few years ago Doctors Strumia and Boerner (4) studied the phagocytic potentiality of leukocytes at various stages of maturity. Slide 4 shows that if myeloid cells of varying degrees of maturity are exposed to comparable numbers of staphylococci, the degree of phagocytosis, in other words, the



SLIDE 5

phagocytic ability, varies directly with the degree of maturity of the cells. Immature cells, in other words, are markedly lacking in phagocytic potentiality.

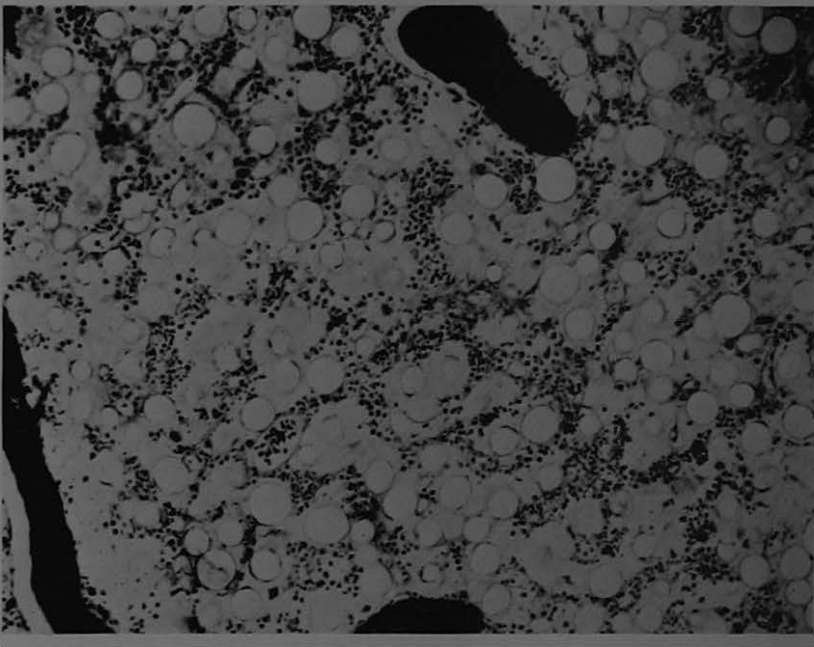
If we examine a microscopical section of normal bone marrow (slide 5) we see a richly cellular marrow, and, with a higher magnification (slide 6) we see many cells,



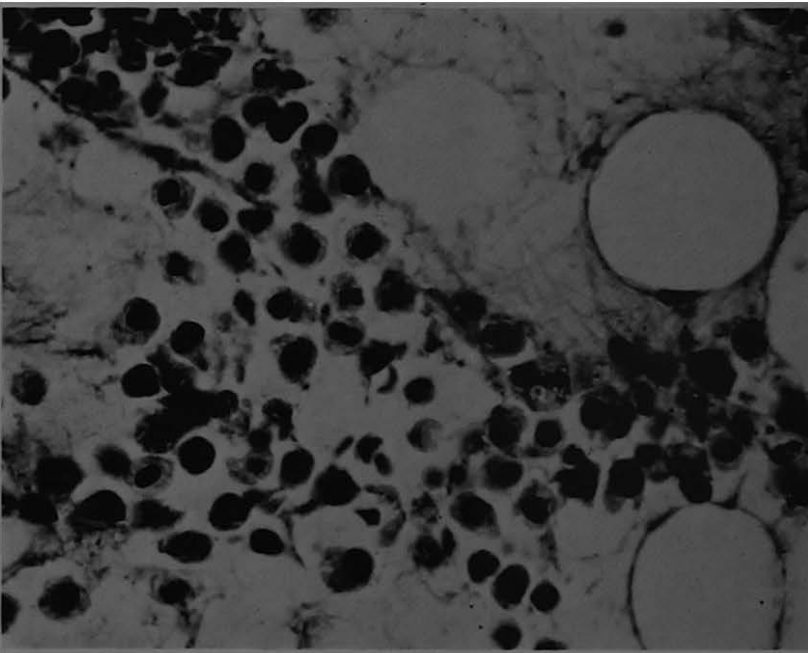
SLIDE 6

in various stages of maturation, as evidenced by the presence of myelocytes and metamyelocytes.

In contrast, slide 7 is a photomicrograph of a section of vertebral bone marrow from a patient who died because of a severe protein deficiency. This patient had an acute, ulcerative enteritis and, a few days before death, his total serum protein concentration was 3.89 grams per cent. The section demonstrates the marked hypocellularity of the marrow, and with higher magnification (slide 8) one can see that every cell is an immature cell, a mononuclear cell. In other words, very little cellular maturation is go-



SLIDE 7

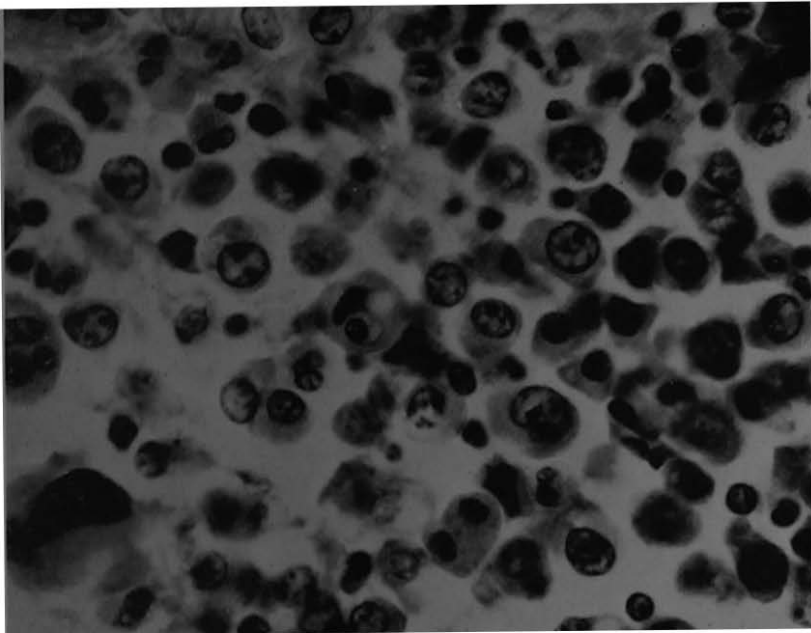


SLIDE 8



ing on, as evidenced by the absence of myelocytes. Two days before death this patient had a positive blood culture (*streptococcus viridans* and colon bacilli), illustrating again that, in association with severe debilitation, there was also a loss of resistance.

It is obvious, from inspection of these bone marrows, that there is a marked reduction in the total amount of phagocytic tissue as well as definite "shift to the left" in

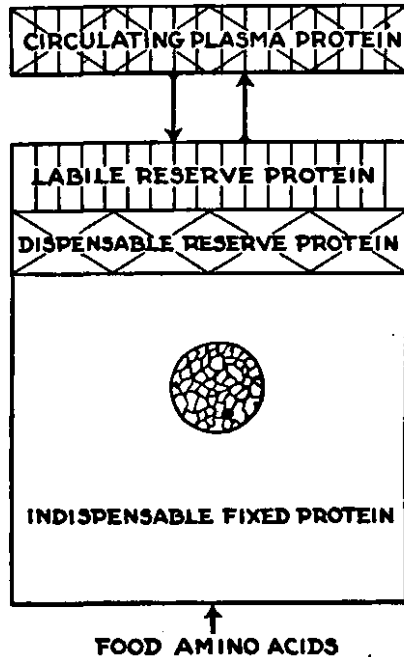


SLIDE 9

the degree of maturity of the myeloid cells. It is obvious, also, that in an emergency, as, for example, the development of an opportunistic infection, these immature cells would be markedly handicapped in their ability to engulf and destroy organisms. The situation might be compared with that in which a fire department must fight a fire, in one instance with high pressure in the hydrants, and in the other with low pressure.

Slide 9 furnishes another example of the effects of bone marrow inadequacy. A woman 32 years of age, seemingly

in fair health, was operated upon for cancer of the colon. Forty-eight hours later she was dead from a generalized peritonitis. Blood taken immediately after death showed a total serum protein concentration of 3.8 grams per cent. Then we learned that this woman, in the previous two years, had lost fifty pounds of her normal 150 pound weight and must have been more undernourished than was realized at the time of operation. In the photomicrograph of the bone marrow one can see that practically every myeloid cell is a myeloblast. These cells presumably were inadequate, after the first outpouring of matured cells, to combat the bacteria causing the peritonitis, and the infection became overwhelming.

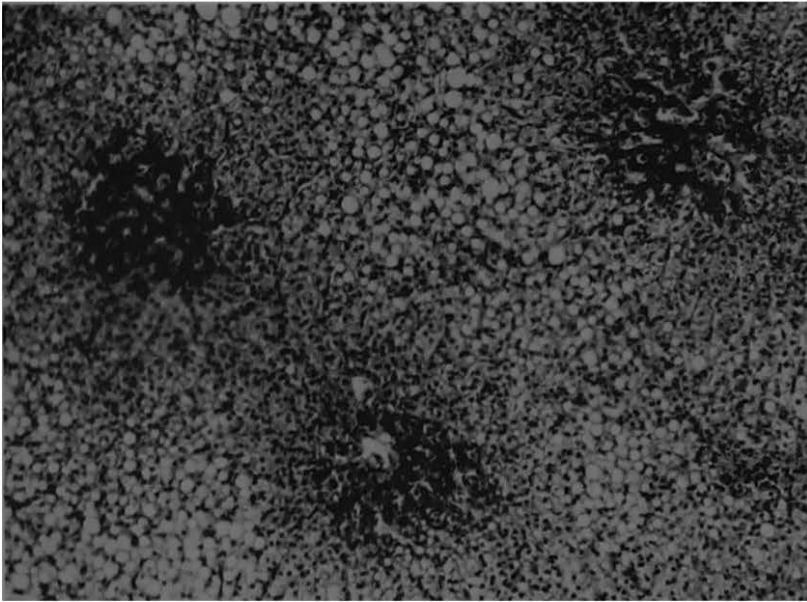


SLIDE 10

So much for emphasis upon the phagocytic potentiality of cells from the bone marrow. If, however, we carry the same thought to the reticuloendothelial system, composed of macrophages in the spleen, liver, bone marrow, and

lymph-nodes, and consider the effects of marked undernutrition and atrophy upon them, we can see that, similarly, if reduced in quantity and quality, they might be handicapped in their overall ability to combat infective agents.

Coming now to the humoral elements of acquired resistance, slide 10, taken from a paper by G. H. Whipple (5), illustrates his idea of the problem of the protein

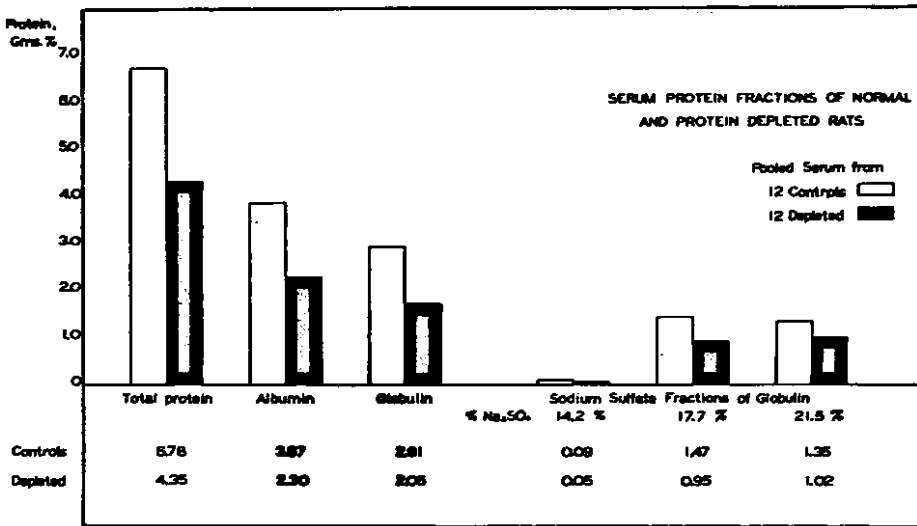


SLIDE 11

reserves. In this diagrammatic liver cell, the food amino acids are represented as entering the cell and being synthesized into protein; the cytoplasmic protein is termed "indispensable fixed protein". In addition, Whipple represents cellular protein as being stored in two forms, (a) "dispensable reserve protein", and (b) "labile reserve protein", these having a dynamic relationship to the plasma proteins. If, therefore, there is a loss of these reserves, as in starvation, a hypoproteinemia ensues. The contribution of cellular protein to the plasma leads, gradually, to marked depletion of the reserve proteins.

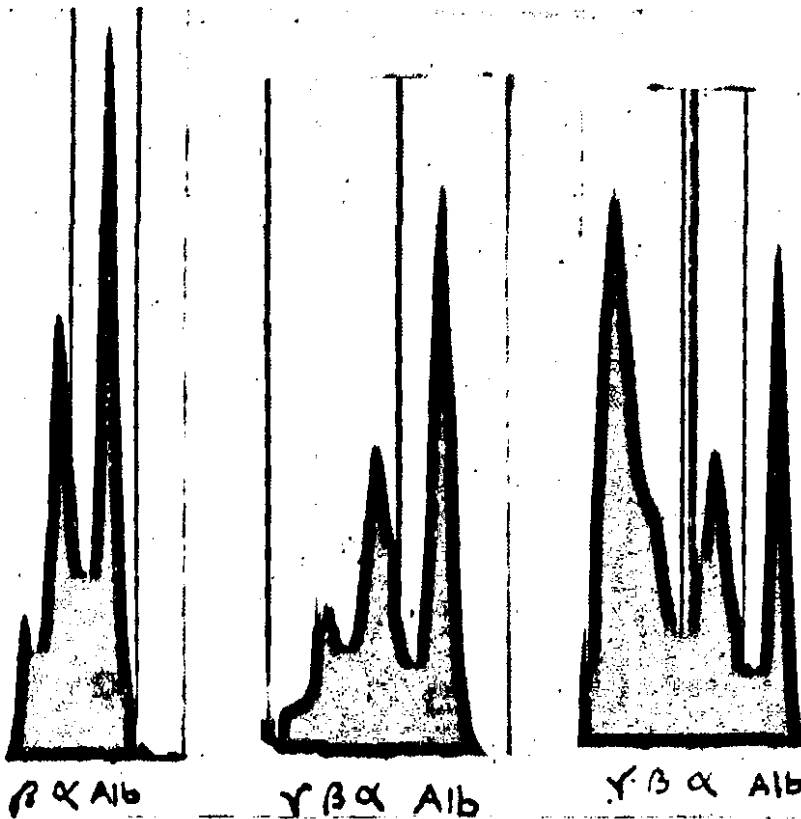
Slide 11 is a photomicrograph of a section of the liver from a patient whose bone marrow was shown in slides 7 and 8. When one looks at the amount of stainable material in the cytoplasm of the hepatic cells, there are only three areas in which normally stained liver cells are evident. The reason is that there is not enough protein matrix in the cytoplasm of those cells to retain the eosin; the other liver cells contain mostly infiltrated fat. It is obvious that the total amount of protein in the liver cells must have been greatly reduced.

Most of the emphasis on depletion of the protein reserves has been placed upon the albumin fraction, but the



SLIDE 12

globulin fraction is also important because it is this fraction that contains the antibodies. In profound starvation with a resulting hypoproteinemia there may be a reduction of both fractions of serum protein. Slide 12 demonstrates this fact in adult male rats fed a ration presumably adequate in every food essential except protein, the only sources of protein being raw carrots and brewer's yeast



SLIDE 13

(6). On such a diet, in about two and one-half months the animals lose from 30 to 35 per cent of their original weight and become both anemic and hypoproteinemic.

When the serums from well-fed animals and from such protein-depleted animals are fractionated by means of sulphate fractionation, one finds a reduction in concentration of total serum protein, as well as of albumin and globulin fractions. Moreover, if the globulin is precipitated by various percentages of sodium sulphate, there is also a reduction in its components.

One reason clinicians have become so uncertain about the significance of serum globulin is that in the determination of the albumin-globulin ratio the precipitate of glob-

ulin is regarded as homogeneous, whereas we know, by means of electrophoretic analysis, that there are at least three globulin fractions. By studying electrophoretic patterns one can get a better idea of the relationship of the antibody fraction to the total globulin fraction. Slide 13 is an electrophoretic pattern from the serum of a new born calf (7), and demonstrates the presence of the albumin, the alpha and beta components of the globulin fraction, but the absence of the gamma fraction. In a few hours, however, after the calf has eaten colostrum, the gamma globulin appears, the component which usually contains the specific antibodies.

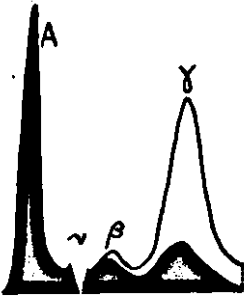


Figure 93  
The change in the electrophoretic pattern of anti-egg albumin rabbit serum produced by absorption of the antibody by antigen (from Tiselius and Kabat).

SLIDE 14

Years ago Doctors Theobald Smith and Howe demonstrated that if a new born calf is taken from the mother before it has had a chance to ingest colostrum, there is a marked tendency for the calf to develop a generalized colon-bacillus infection. If colostrum is eaten the globulin appears in the blood; we know now that it is the gamma fraction that appears.

When the globulin fraction is studied by electrophoretic analysis in the serum of a rabbit immunized against egg albumin (slide 14) one can see the characteristic pattern (8). After the serum has been mixed with egg albumin in order to absorb antibody, the normal gamma pattern is seen, demonstrating that the antibody gamma globulin has been removed.

Similarly, with anti-pneumococcal horse serum (slide 15) one can see the effects of antigenic absorption in the removal of the antibody gamma globulin (9).



**Figure 85.**  
A comparison of an antipneumococcal horse serum before and after absorption with specific polysaccharide. Compare with Figure 83 (from Moore, van der Scheer and Wyckoff).

SLIDE 15

Slide 16 furnishes another example (9). Under A is the normal horse serum pattern. Under B is seen the huge gamma fraction in hyperimmune serum. Globulin prepared by fractional precipitation is shown under C; this is the antibody-containing portion.



**Figure 84.**  
A. The normal horse serum pattern.  
B. The hyperimmune serum pattern.  
C. The antibody concentrate pattern (from Moore, van der Scheer and Wyckoff).

SLIDE 16

In slide 17 are three electrophoretic patterns of human plasma: (a) the normal pattern, showing the albumin, the alpha and beta fractions, fibrinogen, and the gamma globulin (9). In multiple myeloma (b), where protein tends to appear in the urine, we see the reduction in albumin, the small alpha fraction, the huge beta fraction and a small gamma fraction; yet by an ordinary albumin-globulin ratio method, there would be a marked reversal of the albumin-globulin ratio—from which one could think that there might be a high gamma globulin concentration when, as a matter of fact, in this instance there is not. Of even greater interest is the pattern in a patient with nephrosis (c). Here is shown the small albumin fraction,

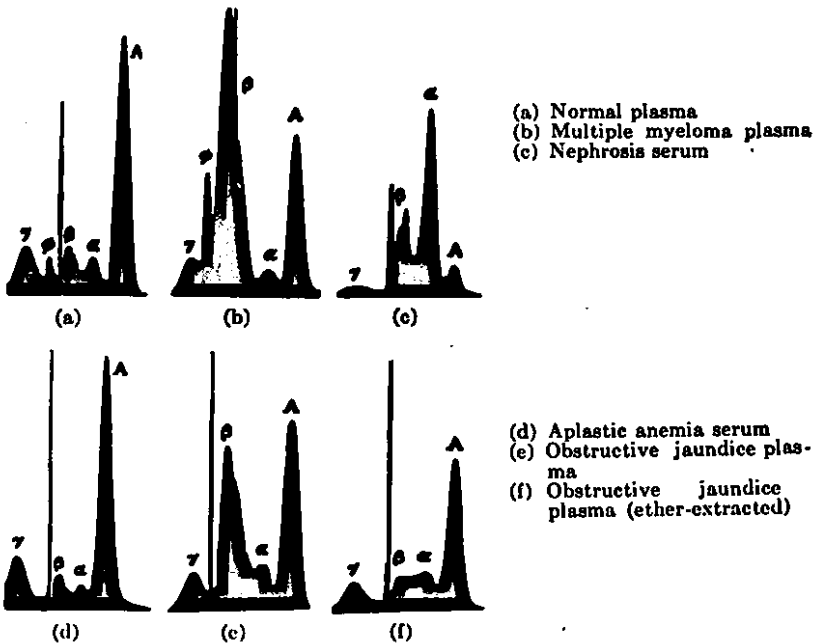


Figure 80. Electrophoretic patterns of the descending boundaries of human plasmas and sera from normal and diseased patients. Notice the changes in distribution of albumin (A), globulin (alpha, beta, and gamma), and fibrinogen (phi), (from Longworth, Shedlovsky and MacInnes).



the high alpha globulin fraction, a relatively high beta fraction but a very small gamma fraction. Here again, an albumin-globulin ratio would show a reversal.

With respect to the question of the composition of antibody globulins, slide 18 is taken from a paper by Pauling (10) and indicates his idea of the way in which a normal globulin molecule might be synthesized, in comparison with the synthesis of an antibody globulin molecule. The verticle column on the left illustrates his idea that amino acids are built up into a polypeptide chain, then the ends of the chain coil during the process of fabrication, resulting eventually in a globulin molecule made up of many amino acid residues. In the second and third columns Pauling represents what may happen if antigen is present in the globulin forming cell. Here the polypeptide chain is formed in relationship to the structural configuration of the antigenic molecules.

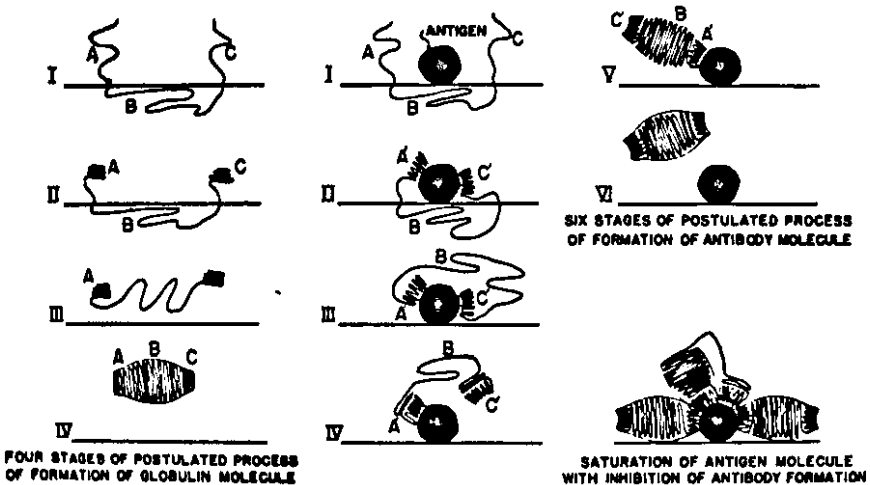


Fig. 1—Diagrams representing four stages in the process of formation of a molecule of normal serum globulin (left side of figure) and six stages in the process of formation of an antibody molecule as the result of interaction of the globulin polypeptide chain with an antigen molecule. There is also shown (lower right) an antigen molecule surrounded by attached antibody molecules or parts of molecules and thus inhibited from further antibody formation.

In looking further into the question of the chemical composition of normal and antibody globulin, some analytical data are available. In slide 19, taken from an article by Heidelberger (11), we see the relationship between normal horse serum globulin and purified, pneumococcus type I antibody (horse).

MEAN ANALYSES OF NORMAL AND ANTIBODY GLOBULIN

	Horse serum globulin fractions including normal	Toxin-antitoxin floccules	Normal horse serum globulin (total)	Purified pneumococcus Type I antibody	PNEUMOCOCCUS SPECIFIC PRECIPITATES	
					Type I carbohydrate anti-carbohydrate	Type II carbohydrate anti-carbohydrate
	per cent	per cent	per cent	per cent	per cent	per cent
Amide N	8.9	9.1	9.5	9.2	4.5	3.7
Monoamino N	66.9	67.8	(filtrate amino N) 59.2	59.4	75.2	75.0
Diamino N	24.3	22.9				
Cystine	2.8	2.1	(N) 1.1	(N) 1.3	2.6	3.1
Tyrosine	6.5	5.9			5.5	5.5
Tryptophane	1.8	1.8			2.1	2.2
Carbohydrate	2.2-4.5	3.5				
Arginine N			9.0	8.8	Arginine 5.0	5.5
Histidine N			5.9	6.0	Histidine 1.0	1.1
Lysine N			8.3	10.0	Lysine 5.4	4.8
P					None	None
S					1.3	1.3
Aspartic Acid					4.6	4.4
Glutamic Acid					6.6	6.3

## SLIDE 19

Slide 20 is presented in order to emphasize the recent demonstrations by Professor Rose and his associates of the eight indispensable amino acids (all except histidine) which have been shown by the nitrogen balance method to be essential for nitrogen equilibrium in man (12).

TENTATIVE CLASSIFICATION OF AMINO ACIDS

DISPENSABLE	SEMI-INDISPENSABLE		INDISPENSABLE
	Group A	Group B	
Glutamic Acid	Arginine	Cystine	Histidine
Aspartic Acid	Glycine	Tyrosine	Lysine
Alanine			Tryptophane
Serine			Phenylalanine
Proline			Methionine
Hydroxyproline			Threonine
			Leucine
			Isoleucine
			Valine

SLIDE 20

Slide 21 was prepared from analytical data reported by Calvery (11) of an incomplete analysis of serum globulin in which fourteen amino acids were isolated. Of these, seven are essential amino acids for growth of the rat, and five are essential for nitrogen balance in man. More recently Brand and his co-workers (13) have reported their results of amino acid analysis of some of the purified protein fractions of human blood plasma, including gamma globulin. In slide 22 we see, in gamma globulin, the presence of five of the eight amino acids essential for nitrogen balance in man. It is in this gamma globulin fraction, moreover, that Enders and his collaborators have demonstrated at least sixteen types of specific antibodies. In other words, it is obvious

AMINO ACID COMPOSITION OF SERUM GLOBULIN  
(Calvery - Schmidt)

	Percentage
Glycine	3.5
Alanine	2.2
Leucine E <sub>8</sub>	18.7
Isoleucine E <sub>8</sub>	
Phenylalanine E <sub>8</sub>	3.8
Tyrosine	6.7
Tryptophane E <sub>8</sub>	2.3
Glutamic acid	9.2
Aspartic acid	2.5
Proline	2.8
Arginine E	5.2
Cystine	1.0
Histidine E	0.9
Lysine E <sub>8</sub>	6.2
	63.8
	† Methionine E
	† Threonine E
	† Valine E
	+
	?
	.
Total	

SLIDE 21

that this gamma globulin fraction is a very complex protein, and that it contains many if not all of the amino acids essential for nitrogen equilibrium in man.

AMINO ACID COMPOSITION OF HUMAN PLASMA PROTEINS

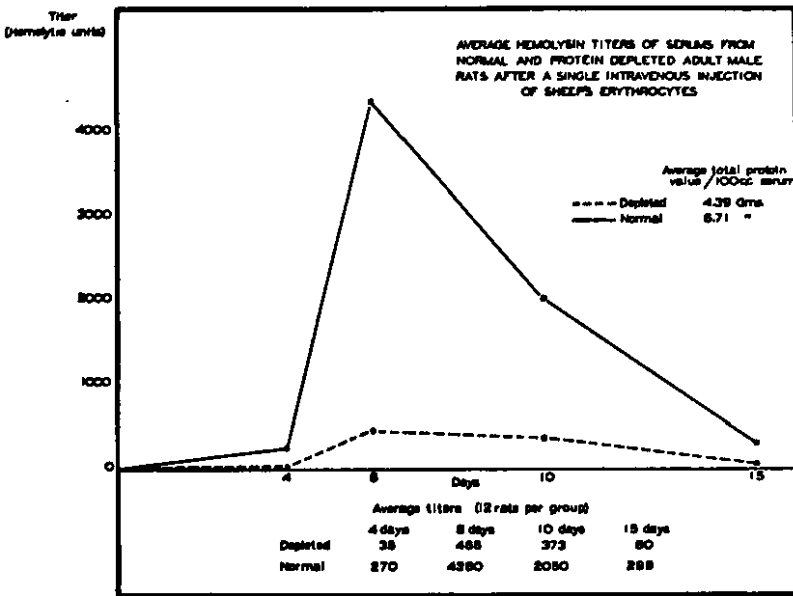
	Albumin crystal- lized from Frac- tion V	Gamma globulin purified from Frac- tion II	Beta globulin concen- trate from Frac- tion III-2	Fibrin- ogen purified from Fraction I	Fibrin clotted from Fibrin- ogen
Total nitrogen	15.95	16.03	14.84	16.9	16.9
Free amino N	0.72	0.21			
Amide nitrogen	1.07	1.35			
Arginine	6.15	4.80	5.64	7.9	7.9
Histidine	3.52	2.50	2.50	2.8	2.8
Lysine	5.8	6.7			
Total protein S	1.96	1.02	1.05	1.26	1.23
Cystine	0.70	0.70	0.20	0.41	0.60
Half-cystine	5.58	2.37	2.50	2.32	1.81
Methionine	1.28	1.06	1.54	2.52	2.62
Tryptophane	0.19	2.86	2.06	3.29	3.22
Tyrosine	4.66	6.75	5.60	5.75	5.75
Serine	3.7	11.4	8.4	8.3	9.8
Threonine	5.03	8.36	7.26	6.6	6.5
Hydroxyproline	0				
Leucine	11.9	9.32	8.9	7.1	7.1

SLIDE 22

If we assume that these eight amino acids are essential for man and that man cannot synthesize them, it then seems logical to assume, also, that if the protein reserves become markedly depleted by prolonged starvation or from protein loss, associated with an inadequate intake of proteins, that the individual might be hampered in his ability to synthesize such complicated protein molecules as gamma globulin. Moreover, in time he should lose his

resistance to various kinds of infectious agents because of his inability to manufacture specific antibodies in adequate quantities in time of need.

We have subjected this assumption to experimental tests in both rabbits and white rats and have found that, in the presence of a marked protein deficiency, there is also a loss of ability to fabricate several kinds of antibodies including agglutinins, precipitins and hemolysins.

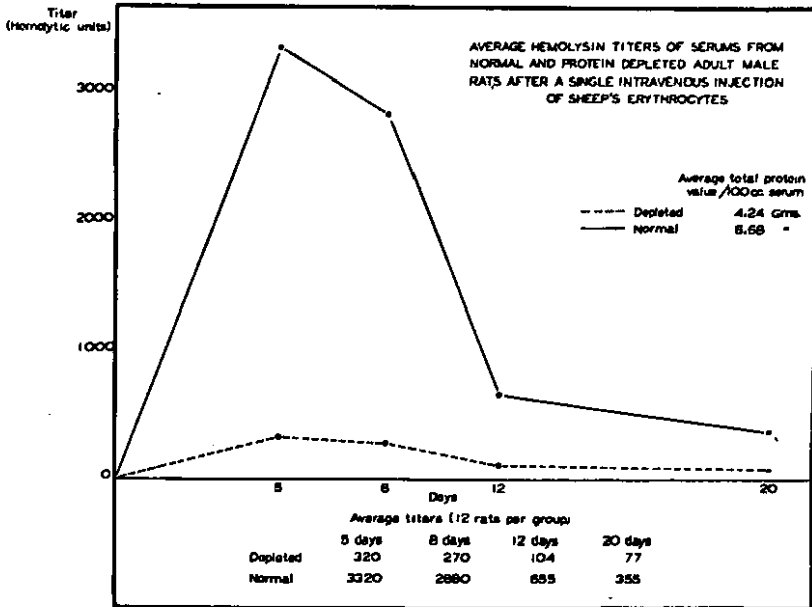


SLIDE 23

Slides 23 and 24 demonstrate what happened in groups of adult rats which were fed rations deficient in protein in comparison with control rats fed isocaloric rations containing 22 per cent of casein.

At the end of a few months the normal animals had an average serum protein concentration of around 6.7 grams per cent, in contrast to a concentration of 4.39 per cent in the protein deficient animals. The animals were then injected intravenously, simultaneously, with the same

quantity of sheep's erythrocytes, and their ability to form hemolysin determined. These are average curves for twelve well-fed and twelve protein-depleted animals. As can be seen, the peak of the antibody curve is at six days in the well-fed animals; in the hypoproteinemic animals there was a comparatively slight output of antibody.

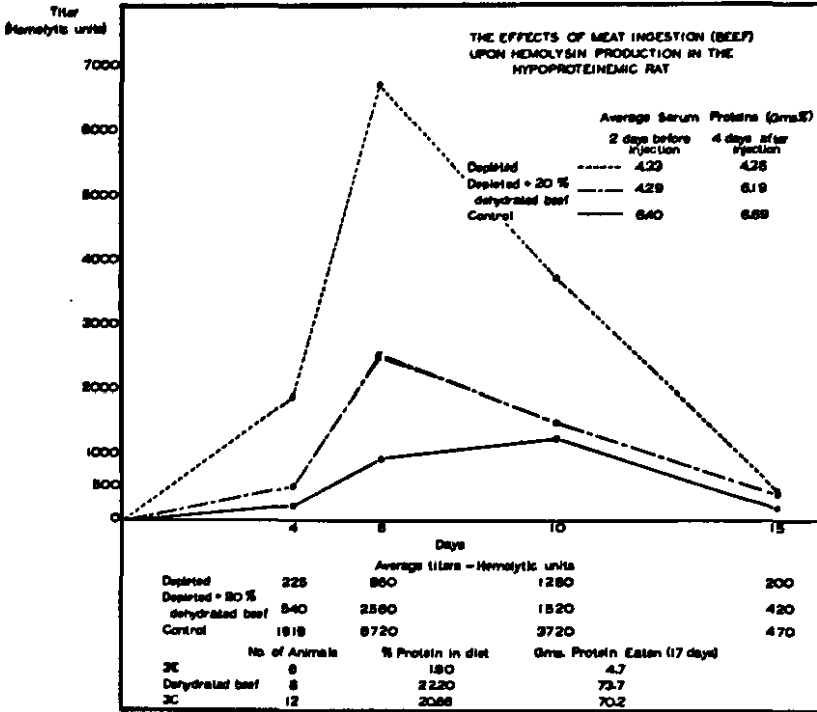


SLIDE 24

It should be added that the protein-deficient animals were eating a ration which contained 2 per cent brewer's yeast, 1 per cent of liver concentrate, choline and several synthetic vitamins, because we assume that protein synthesis must be mediated by intracellular enzymes and vitamins. In the absence of available amino acids for synthesis, however, the vitamins seem to be powerless to synthesize antibody.

We next took protein-depleted rats and fed them a ration containing 20 per cent dehydrated beef, for two days, and then injected them intravenously with sheep's

erythrocytes. In slide 25 we see the good antibody output in the control animals and an increased output in the beef-fed rats. Another group of protein-depleted animals

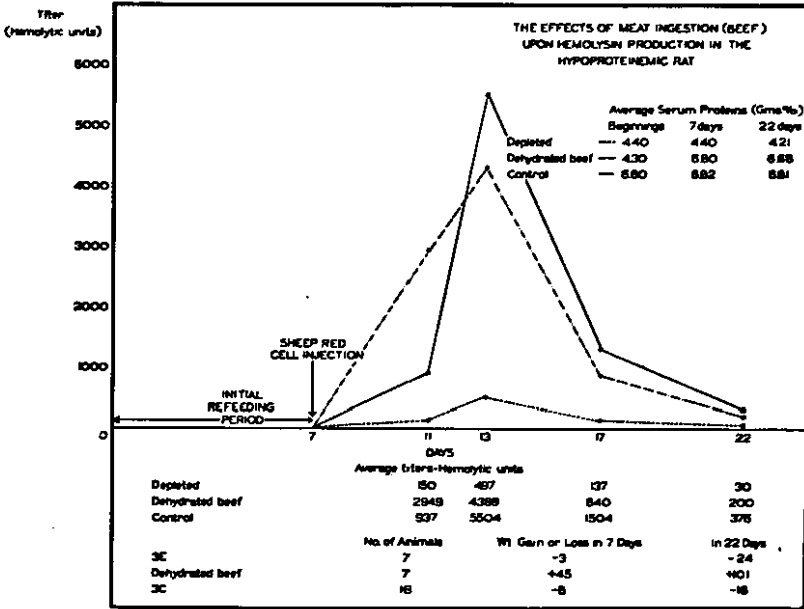


SLIDE 25

was then fed dehydrated beef for seven days before antigenic stimulation. Slide 26 demonstrates their rapid recovery of the ability to fabricate antibodies. We interpret this as evidence of repletion of the protein reserves and the concomitant restoration of the capacity to synthesize antibody-globulin.

In connection with Doctor Lewis' question my interpretation would be as follows: Inasmuch as gamma globulin is a complex protein, presumably containing many essential amino acids, the protein intake for repletion should be of the highest quality possible, in order to make available these essential amino acids. Therefore, the ideal

procedure would be to feed animal proteins. On the other hand, some vegetable proteins are relatively high in many of the essential amino acids—soy flour and some others, for instance, and also there is great variation in the extent



SLIDE 26

of depletion of the protein reserves. For the most depleted tissues, perhaps the highest quality protein would be indicated, for slight depletions perhaps poorer proteins might be adequate in relation to their ability to supply amino acids for fabrication of gamma globulin. (See question, page 99.)

One might ask, do these facts apply also to the human being? I would like to emphasize the fact that, so far as immune globulin is concerned, anti-serums from the horse or rabbit are therapeutically active in the treatment of pneumococcic infections of man. Moreover, immune serums from man can be used to combat infectious agents affecting lower animals; I see no reason, therefore, to assume that there is any fundamental species



difference with respect to the role of essential amino acids in the fabrication of antibody globulin. Our conclusions are that, in the presence of marked protein deficiency, there is both clinical and experimental evidence warranting the utilization of good quality proteins in the effort to restore depleted tissues and thereby promote a more effective functioning of the bone marrow and other phagocytic tissues, as well as to maintain and extend the potentialities of the antibody mechanism.

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NUTRITIONAL RECONDITIONING OF  
CHILDREN IN OCCUPIED COUNTRIES

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Served on Rockefeller Health Commission in France, November, 1940 to July, 1941; as Medical Advisor to Director of the American Red Cross in connection with its relief feeding of children in unoccupied zones, in France, August, 1942 to November, 1942, after which was interned at Lourdes, France (by French) to January, 1943, and at Baden-Baden, Germany (by Germans) until February, 1944; Consultant in Nutrition to the Surgeon General, United States Army

**T**O APPRECIATE the problems confronting those who will be responsible for the work of rehabilitation during the postwar period in the countries previously occupied by Germany, one must start with a study of the evidence as to the effects of war and occupation upon the nutrition of the people in these countries. I reviewed this evidence at a recent meeting of the American Public Health Association, and I believe the review will soon appear in the journal of that association. Owing to the lack of reliable and recent reports from other countries, it was necessary to base this study principally upon reports from the cities of southern France, but I believe that they apply reasonably well to all the occupied countries of western Europe. Conditions have probably been far worse in Greece and other parts of southeastern Europe.

Food shortages have affected principally the populations of large urban centers and industrial areas, while farmers have continued to live on a nutritional level not much lower than before the war. The diets of the major portion of the population have been on an inadequate level in many respects over a period of four or more years, with a tendency to become progressively less and less adequate. The foods most lacking have been milk and milk products, fats of all kinds, meat, fish, eggs and fruit. Many available foods have been of poor quality and nutritive content. The most obvious deficiencies have been in calories, principally owing to the lack of fats, and in protein from animal sources. It is probably correct to say that the great majority of people in France have been receiving over a long period of time less than 2000 calories per day, and that less than a third of all protein obtained has been from animal sources. Less constant and less marked deficiencies have existed in respect to certain vitamins and minerals. In general, the diets have tended to be moderately inadequate in a wide range of nutritional essentials rather than extremely deficient in any one. As a result, outspoken nutritional diseases have remained unusual occurrences, whereas the number of children described by competent examiners as malnourished has continually increased.

Study of the rations for special age categories shows that allowances generally do not increase with age as rapidly as do requirements. Furthermore, studies of the food consumption of family groups show that when provisions are scant, all members tend to share more or less alike, or at least actual differences in needs are not fully taken into account. It is obvious that a daily intake of 1700 calories would represent a moderate limitation for a ten-year-old girl whose optimum intake would be between 2200 and 2500 calories. However, 2000 or even 2500 calories might be far less adequate for a sixteen-year-old boy whose normal consumption would be between 3500 and 4000 calories. Hence, it is not surprising that malnutrition has been encountered much more commonly among older children, especially among those in the late school years. This difference in the effects of prevailing dietary shortages upon children of different ages should be taken into consideration in plans for relief feeding.

In many instances the diagnosis of malnutrition has been made on evidences of the nonspecific types, which are difficult to classify in respect to dietary lack and may in some instances be due to other than nutritional causes, yet which are usually attributable to undernutrition. In approximately half of the children studied by Kuhlmann in Marseilles, France, in the spring of 1943, there were indications of retarded growth or other signs considered indicative of malnutrition. Characteristically these children showed listlessness and inactivity, chronic fatigue and lack of muscular development. Among infants from 6 to 18 months of age, approximately one-half showed evidences, in X-ray films, of early rickets and about one-quarter of the older children showed moderate anemia.

Although great strides have been made during recent years in developing techniques for the recognition of the early stages of deficiency diseases, we are still unable to recognize some of the ill effects of undernutrition until they have become quite pronounced. Hence the failure

of the workers in France to classify more than half of the children studied as malnourished. Many of the other half were obviously not fine physical specimens, but there were no means by which any unsatisfactory attributes which they presented could be said with any assurance to be the results of inadequate diet.

In spite of all compensating factors and our failure to recognize malnutrition in many cases, it may be assumed that most children in the occupied countries have suffered to some extent from undernutrition. No class has been exempt from restrictions which have kept the daily allowances of calories and suitable proteins, and to a lesser extent of other important food constituents, well below the desirable levels for a period not of weeks or months but of years. The only exceptions appear to have been in small isolated rural communities which have been largely self-supporting with respect to animal foods as well as sources of energy.

From a scientific standpoint it is surprising that the long-continuing food shortages in Europe have failed to affect the health of the children more universally and more seriously than the most reliable reports seem to indicate. Granting that some children have been markedly affected and that half of the children of school age would be considered malnourished by our standards, one is principally impressed by the fact that the other half appear to have remained reasonably well-nourished and developed. For the great majority of children the diet actually consumed proved adequate to support life and to prevent obvious nutritional disease or progressive physical deterioration.

It may have been a very fortunate circumstance that the diet in France and elsewhere diminished in amount and deteriorated in quality rather gradually. This may have given children an opportunity to adjust to inadequate diets more successfully than if the changes had taken place abruptly. Mitchell (1) has recently suggested that most individuals are able to adapt themselves to restrictions in

diet by means of automatic adjustments in physical and physiological activities. By so doing they render actual food requirements somewhat flexible after a period of adaptation. Many children in France appear to have lost some weight or to have gained very poorly for a time when their diets began to fall behind their needs, and then to have reached an equilibrium at the lower level of food intake. This was evidenced by their continuing at approximately the same level of weight-for-build after the initial loss. This appears to have been accomplished primarily by reduced activity and secondarily by a slowing of the rate of growth and of development, but other more obscure adjustments may have been made as well. For some children the discrepancies between normal needs and actual food allowances were too great to be compensated for, but some children may not have been sufficiently adaptable to adjust to lesser discrepancies.

Thus it may be anticipated that at the close of the European war, when restoration of normal peace-time civilian life is undertaken, a state of general moderate-to-marked undernutrition will prevail throughout all countries. There will be a greater than normal incidence of diseases attributable directly or indirectly to nutritional factors, but there will probably be few cases of marked nutritional deficiency disease, few individuals who could be considered profoundly malnourished, and few who have become so retarded in growth and development that prompt and adequate provision of a liberal diet and good hygiene would not lead ultimately to satisfactory physical restoration.

Even if it were accepted as a working premise that 50 per cent of the children in previously occupied countries were not sufficiently undernourished to require supplemental feeding after liberation, it would not be possible to examine all children and to decide on this basis which were and which were not malnourished. There is no sharp line which divides, and there are no simple proce-

dures which distinguish malnourished from well-nourished children. Any arbitrarily chosen criteria for selection for relief feeding based on hasty studies of large populations of children would only select the extreme cases successfully. They would fail to recognize the borderline or moderately malnourished group which would probably represent a large proportion of the total and would contain many in real need of food supplements.

Since the entire population of the large cities and industrial areas may be considered in need of an improved diet, the primary objective of the rehabilitation program will be the restoration of a normal food supply for the population as a whole. However, this will be of necessity a slow process, as large increases of foods will be required. We cannot hope to spare, or to ship such quantities of food as would be required to bridge the gap until normal production and distribution have been re-established in all countries.

Our purpose should therefore be two-fold, first to take care of those who would suffer most if they had to wait for restoration of normal food supplies, and second to aid the governments concerned in building up their production, manufacture or imports of the types of foods which are most needed. I will devote my attention to the first of these purposes because it is the more immediate of the two and is more directly concerned with children and with relief operations. I would emphasize, however, the importance of outside aid to most countries in the matter of securing seed and farm implements, breeding stocks from which to develop new herds and other live stock, machinery for the processing or manufacture of foods and transportation facilities for their distribution. These are primarily problems to be dealt with by allied government agencies. We cannot hope to remain prosperous and at peace while large populations in Europe continue in want of food, and in their present state many countries are ill fitted to undertake the colossal task of rehabilitation unassisted.

I have said that a selection of individuals in need of relief feeding cannot be made on the basis of universal examinations. It is possible, however, to say that certain categories of the population have already suffered more than others and to predict that these groups would suffer most if there were to be a long delay before improving their diets. It will be possible to supplement the diets of the more needy of these groups with sufficient amounts of suitable foods to lessen if not to prevent entirely the ill effects of such delay. It will also be possible, when the time comes, to select that small percentage of the general child population which is seriously malnourished and in urgent need of relief. This can be done by established local medical services or relief agencies. It is by these two means that I believe the United Nations should attempt to prevent or minimize the serious consequences of long-continued underfeeding among children. It is for the relief of groups selected in these ways that I would recommend that selective feeding programs be established. I will, therefore, consider more specifically what might be done in these ways.

First, as to the selection of the groups or categories of the population for which as a whole special feeding programs should be instituted very quickly after military occupation has been discontinued. I am not considering the problems of the Civil Public Health Division of Civil Affairs or of the Nutrition Division of the Preventive Medicine Section of the Army, for their period of responsibility in most countries will be short, their opportunities for constructive rehabilitation limited, and their objectives primarily the prevention of disease and unrest.

I have said that the rural populations have suffered far less than those in urban areas and hence I would confine these feeding programs to the larger industrial areas or to other areas known to be in special need. I would insofar as possible meet the special needs of pregnant women and nursing mothers, since their special rations for the most part have been inadequate. I would then select children



on an age basis, feeding in the areas selected all children in the age groups which have suffered most, or for whom prolongation of underfeeding would be expected to lead to most serious consequences.

The evidence is sufficient to make it possible to say with some assurance what ages should be given priority. In principal, children in age periods when growth is most rapid will suffer most when rations are inadequate. The special needs of young infants have apparently been moderately well met in occupied countries by reserving the available milk for their use, but the shortage of milk has become increasingly acute and the allowances to infants over nine months have been reduced to dangerously inadequate levels. The supplies are often so low that having the special baby tickets does not assure that the milk can be secured regularly. This situation cannot be rectified quickly. As milk is particularly important for infants, such amounts as we can spare should be earmarked for them, and some method of direct distribution to these groups should be worked out in any country in which local supplies cannot quickly be made adequate for this purpose. The distribution of milk to infants as well as to pregnant and lactating women could be accomplished most satisfactorily by increasing the national stocks of dried and evaporated milks with the understanding that these would be reserved for use against the special tickets issued to these groups. This milk would therefore be distributed through the usual channels under government regulation.

Children grow at a relatively slow pace between four and eight or ten years of age, and the evidence seems to be that in France they have managed to get along surprisingly well during these years on the food available. Food requirements increase rapidly after ten years of age, but food allowances have not increased proportionately for older children and youth. It is unquestionably among children in their teens that diets have been most inadequate, and the retardations of growth and development resulting from

undernutrition during these years are least likely to be correctable. Hence a principal objective of all relief programs should be to minimize the shortages during these years. Unfortunately, the requirements during adolescence are very high and the small daily supplements provided by most relief programs, determined by the desire to spread limited supplies as far as possible, appear in the individual case to be of little help.

Milk is still the most valuable food during these years, but there will not be enough milk to go around and we have already given priority to infants for this golden commodity. Adolescent children and youth can and will eat almost any edible food, and the program of relief for them should be flexible, based upon available stocks, but including as much food from animal sources and of high structural values as will be possible. As caloric requirements are high and are not being met by a wide margin at these ages, one should include liberal allowances of foods rich in calories in order to cover energy requirements and thus to spare proteins for structural purposes.

The relief feeding of older children can best be accomplished by the provision of a daily meal at canteens in schools. The composition of these meals can be varied according to the supplies on hand, and the allowances to different classes can be adjusted according to the differing needs of succeeding age groups. This assures that the food is actually consumed by the individuals for whom it is intended. Older children who have left school could be admitted to the school canteens in the neighborhood where they work, and in this way the feeding program could be extended up through the last years of the growth period. This school canteen program should be supervised by a large relief organization having had experience with such undertakings, as, for example, by the American Red Cross.

There are always some children in any large community who are seriously malnourished because of poverty, ignorance or neglect. In times of peace and prosperity and with

abundant food supplies they will be few, and with a sensitive community conscience and well-organized social services they are usually recognized and provided with whatever is urgently needed. In times of war, political disorganization and general chaos the number of these underprivileged children is greatly increased, and with inadequate food for the population as a whole, the condition of these neglected children is likely to progress to far more serious stages of starvation before relief is provided. With such widespread suffering as has existed in many parts of Europe in recent years, people become callous to suffering, they are often too preoccupied with their own troubles to worry about those of others, and established social and relief agencies are inclined to throw up their hands at the enormity of the tasks which they encounter. I do not wish to imply that the relief agencies in France or elsewhere have not carried on valiantly, but it is clear that the load they have been attempting to carry has been too great to maintain high standards of child health protection. It will certainly be too great to allow them to re-establish satisfactory standards for a long time after the war has ended without outside assistance.

For the small proportion of the children in urban areas who are severely malnourished and otherwise in want, special food supplies and relief services should be made available by the United Nations. In most instances the children composing these groups are known to local medical, social or relief agencies, or could be readily located and referred by them. In some instances they could be cared for adequately by these local agencies if sufficient food was made available to the latter, but in most instances it will be found that these children need more than food; they will need extensive and long-continued rehabilitation. Even though the percentage of the population falling into this special category in urgent need may be small, the complexity of their problems due to displaced populations, broken homes and other vicissitudes of war will unquestionably create a

heavy burden. For a considerable period of time, therefore, opportunities for important services will be open to outside agencies. Nurseries or nursery schools, homes of various types, health centers and relief canteens will all have their place.

I believe this type of service can best be given by organizations which operate on a relatively small individualized community or problem basis, as exemplified by the American Friends Service Committee, in France. Obviously the work of all such agencies should be planned and integrated with the total situation in mind and therefore under the direction of a coördinating organization. The problem of securing the necessary food for this type of relief will be insignificant, owing to the relatively small numbers involved, in comparison with the problems of housing, medical and social services, relations with community agencies, securing suitably trained personnel and the like. However, this kind of relief work appeals to many people and will undoubtedly be well taken care of, if organizations with sufficient experience and able leadership are speedily and wisely assigned to suitable tasks.

In conclusion, the situation in the different countries of western Europe formerly occupied by Germany will be much the same in pattern of needs, although differing to some extent in the magnitude of various problems. There will be need for outside help in re-establishing normal food supplies, and this will require a considerable period of time. During this period certain age groups of the population will be in special need of relief feeding and occasional individuals or families in other categories will require more comprehensive rehabilitation. Much of this relief must come from outside sources. Thus, two types of services can be envisaged as suitable to meet the principal problems. First, there should be direct distribution insofar as our stocks of foods permit of small individual allowances to whole populations of pregnant women, nursing mothers, infants under two years, and adolescents. Dried or evapor-

ated milk would be the ideal food for this purpose and will be essential in the infant category, but other foods rich in essential substances will be valuable for the others. Second, facilities should be provided for the comprehensive care and relief of small numbers of the most seriously affected of the child casualties of the war. The American people stand ready to make the necessary sacrifice in respect to sharing their abundant food stocks, and thousands of Americans are prepared to offer their services or to contribute to defray the necessary expenses. The problems to be dealt with are now reasonably predictable. The job should be well done because upon it depends in considerable measure the influence which this country will have among the common people of these countries during the generation to come.

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## DISCUSSION

DR. WILLIAMS: We have asked Doctor Clement Smith, Professor of Pediatrics of Wayne University Medical School, and Medical Director of the Children's Hospital of Michigan, to discuss these papers.

DR. SMITH: Doctor Cannon has touched upon something that has interested all of us a great deal, particularly since we know there must be a very close connection between nutrition and resistance to disease. We have been waiting for studies such as those he has been carrying out, to make more clear what that connection is.

At the Children's Hospital of Michigan, our interest has centered around the portion of Dr. Cannon's work on which he touched in referring to the globulin pattern of a very young calf. Often, we find ourselves facing our most difficult problems, in infection and recovery therefrom, with babies of a few weeks or a few months of age, premature or not. As several investigators, Doctor Cannon among them, have pointed out, this globulin portion is also deficient particularly in the first few weeks or months of human life.

Now Doctor Darrow of New Haven, a few years ago, raised the question as to whether the globulin is deficient because it has not been challenged into full formation by various infections reaching the infant, and whether the globulin increases in the later months of infancy largely because of the stimulus provided by contact with infection. While we await larger supplies of the specific gamma globulin to treat sick infants with, we would very much like to know whether, if we feed these small babies a proper diet, they actually are able to make the globulin molecules upon which their immune reactions are based. I hope Doctor Cannon will say something about the infant's or the individual's ability, however well fed, to do his part in producing these substances which he does not produce when receiving a poor diet.

Doctor Stuart's paper was a great consolation to me. I think it was very wise to put it at the end of the program. I spent various portions of the morning and afternoon, hearing how very badly nourished we are, and now I go away convinced that there are other nations who are probably going to be worse off than we in the next few years, bad as our condition is. If what needs to be accomplished in our own country is impressive, the needs of other countries are gigantic.

The thing that I feel is very fitting about Doctor Stuart going to Europe to do this work, is that when I first knew him, he was not a nutritionist at all. He was a man who measured children. He took a great many measurements demonstrating what the normal child should be, which have been extremely helpful to a great many of us. Consequently, when he speaks of abnormalities he speaks with great authority, because he only became interested in the part nutrition plays in the growth of the children after he had exhaustively studied normal growth.

I suppose most people would like to ask him human interest questions, rather than scientific questions, and I would like to do just that. By any chance, Dr. Stuart, has it been possible for the measurements which you started taking over there, and were forced to abandon, to be continued by any local group in France, so that a conclusion will be made possible from that earlier study, after the war?

ALFRED H. FREE, Western Reserve University, Cleveland: Is there any evidence to indicate that a high protein diet will favorably affect immunity reactions, if no protein deficiency exists?

DR. CANNON: The only idea I can suggest in that connection is the interesting concept developed by Doctor Schoenheimer a few years ago. In the experiments of Schoenheimer and Heidelberger, during immunization of

an animal with pneumococcus, one amino acid containing heavy nitrogen was fed and then the serum was taken from this immune animal. The heavy nitrogen was looked for in comparison to the normal serum proteins, and as much was found in the antibody as in the normal serum protein. In other words, this idea of a dynamic inter-relationship among the various proteins might suggest that, regardless of protein deficiency, actually during the process of immune body fabrication the amino acids coming in in the food may participate in antibody formation. I think, however, that the stimulus is probably much greater in conditions of protein deficiency.

MRS. B. L. HAYDEN, Saginaw, Michigan: Do you consider vegetable and animal proteins interchangeably adequate, in diets for human beings?

DR. CANNON: My view is that an essential amino acid is essential, whether it comes from animal or vegetable protein. The problem as I see it, and I do not speak as a nutritionist because I am not one, is that if one could get a sufficient intake of all the necessary amino acids from vegetable proteins, perhaps that would be adequate, but as a matter of fact that seems to be impossible. Doctor Newton this morning showed charts illustrating the inadequacy of vegetable proteins. Furthermore, we all know that even when we have a good vegetable protein we too frequently overprocess it, thus taking out many of the food proteins that were originally present.

I might add here that I doubt whether many persons who consider themselves vegetarians exclude milk and eggs from their diet. Also, I wonder whether many vegetarians realize that in normal times six per cent skim milk powder is present in the bread they eat.

ANONYMOUS: Has any relationship been noted between tendency to malignant growths and hypoproteinemia?



DR. CANNON: I know of no particular relationship, but there is a trend in the study of cirrhosis of the liver suggesting the relationship of malnutrition, and as part of the process, protein deficiency, to the development of cirrhosis of the liver. Moreover, there is a tendency in about ten per cent of the patients with cirrhosis of the liver to develop primary carcinoma of the liver.

Furthermore, experiments have been conducted on the induction of primary carcinoma of the liver with so-called butter-yellow, first in Japan, then in Memorial Hospital in New York City. The workers in New York were unable at first to reproduce the Japanese results. Then they discovered that they were using a better diet, including more protein and certain accessory substances. When they reduced the protein and vitamin content of the diet, they were able to induce primary carcinoma, by the use of butter-yellow, in larger incidence.

DR. C. T. EKELUND, Pontiac, Michigan: Please briefly outline the technique for obtaining electrophoretic patterns, with special reference to a small hospital laboratory.

DR. CANNON: The apparatus is expensive and the method is definitely a research tool. I think it would be highly desirable to have some modification that might be utilizable, but so far as I know there is nothing in the offing at present. In our laboratory, Dr. Benditt is using the electrophoretic apparatus for the analysis of serums from animals under different conditions, and patients, in order that we may find out what co-relations there may be.

In connection with Doctor Smith's question on the globulin pattern in premature infants, full-term infants, and in malnourished infants, I am not prepared to discuss that now. I think it is worth while noting, however, that in the human being, the new born infant is quite resistant to many childhood infections. For instance, very young infants can be kept in bed with brothers and sisters hav-

ing measles and not contract measles, supposedly because of the transmission of immune globulins through the mother's placenta. After a few months this transmitted globulin presumably has been utilized and then the baby enters the most vulnerable period of life, perhaps, particularly in conditions of poverty, because then he must develop or acquire immunity from experiences with infectious organisms. It is in that period particularly, it seems to me, when good nutrition with an adequate intake of all the amino acids necessary to the development of the molecules of immune globulin is so important, and it is during that time that poor and starving infants are handicapped, presumably by inadequacy of amino acid intake.

I might cite figures published in the *Journal of the American Medical Association*, that during the first year of the Nazi occupation of Greece 90 per cent of the infants, particularly in Athens, died before they were six months of age. Many of these deaths no doubt were due to bronchitis or bronchial pneumonia, due possibly to their inability to resist microorganisms which, if they could have been overcome, would have been resisted later with relative ease.

DR. OTTO GROB, Detroit: How does the nutrition of children of England compare with those of France?

DR. STUART: I am not in a very good position to answer that exactly, but it is of course very much better. I believe most of the studies show that the planning which has been carried out in England, in the interest of seeing that English children were well fed, has very largely protected them, and there is some evidence I believe, that health is better and diet is better than before the war. I would not want to discuss that specifically, because that was not an occupied country, and I am not familiar with the details.

**ANONYMOUS:** Are there agencies already set up to deal with the psychological rehabilitation of these children in the occupied countries? If so, what are they?

**DR. STUART:** I don't know of any agencies that have definite plans for invading these countries when allowed, and setting up psychological work. I know that a good many groups are studying psychological effects from war, in one place and another. There have been some in England, and I believe agencies are interested. I believe that work along that line will be done when opportunity offers.

Now, as to Doctor Smith's question, of the continuance of the studies to which I referred. I went to France on two occasions, the first time to assist on the Rockefeller Foundation Health Commission in the establishment of a nutrition center in an institute in Marseilles, for the specific purpose of studying the nutrition of the population in that area. Since my return, the studies then established have been under the direction of Doctor Kuhlmann. I have had reports from him as recently as early this year, of studies made in the latter part of 1943.

He has had the opportunity of studying small numbers of children repeatedly in 1941, 1942, and 1943, and these are extremely valuable, although the numbers are not great enough to make the conclusions statistically significant. The children studied in 1943, who had been studied in 1942, had gained, on the average, about 65 per cent of the amount that would normally be gained during that year's interval, and there were other evidences of retardation. Unfortunately Doctor Kuhlmann was forced to leave Marseilles several months ago. I know that the institute is carrying on with other personnel, but whether or not they are continuing these studies, I don't know.

My second trip to France was primarily for the purpose of making rapid surveys, in different cities of France, for the American Red Cross in connection with their pro-

gram of milk feeding, to assist in deciding what age groups should be fed, what quantities and so on. A survey was set up and carried on by the professors at four different medical schools in France. I was taken away just at the time this survey was set in motion. I did have an opportunity to participate at each center for a few days.

Some of the x-rays from the studies under the American Red Cross program, were sent to me while I was in detention under the French, in Lourdes, France, and I had ample opportunity to study these x-rays rather carefully. They showed little in the way of disease, but considerable retardation in development, an average of between a year and a year and a half, in bone pattern. The results of this study have been published.\* I have not seen subsequent x-rays on the same children, to determine whether there has been progressive retardation or not.

Doctor Williams suggested I spend a minute or two telling something of the thirteen months which I spent as a guest of the Germans, in Baden-Baden. There we were as isolated as we could well be, in a hotel that was surrounded by a high iron fence on three sides, and with a river on the fourth. However, I did have an opportunity to pick up certain information about conditions in Germany, even though we were excluded from conversation with most of the population.

Our principal source of contact of course was with the Gestapo. We had ten of them living in our hotel, and no one ever went anywhere without being accompanied by one. They attempted in a certain measure to proselytize us, telling about the wonderful work done by Germany since the Nazi regime, in promotion of public health and medical care. However, as the physician to the group, I was given the special privilege of going to the hospital

\* Stuart, H. C. Studies of the nutritional status of children in unoccupied France in the fall of 1942. *J. Pediatrics* 25:257. 1944.

alone without Gestapo escort, whenever I had a patient there.

The glowing reports which the Gestapo gave me about the health services in Germany, and medical care, were hardly borne out by what I saw in the hospital. The shortage of doctors was so acute in Germany that medical care had deteriorated considerably, with elimination not only of all personal preventative health services, but of most optional surgery and care for minor conditions.

The Nazi regime had excluded from practice in Germany, well before the war, all the Jewish representatives of the medical profession, and that gave them a bad start when it came to providing physicians for the Army. I admired the elderly men, who were valiantly carrying on the urgent practice of the community, but there was no doubt that medical care had been reduced well below modern standards.

As to the food situation in Germany, I had an opportunity to eat their food, and I believe that the rationing has been on the basis of providing minimal maintenance amounts for all the population. Their basic rations will support life, if you can eat them. The only unfortunate thing is that Americans are not accustomed to eating large quantities of black bread, coarse vegetables and potatoes and subsisting in considerable measure on these foods, and in consequence the incidence of digestive disorders was very high within our group. It was the principal problem I had to deal with for the first six or eight weeks we were there. Most of the people lost a considerable amount of weight during this time. Fortunately, after about two and one-half months it was decided we really were prisoners, and therefore could have American Red Cross packages. These made it possible for us to exclude some of the things we could not digest and most of us got along much better from that point on.

As you know, Germany gives the people who are important to them and to their war effort more food than those who are not. The basic rations of elderly people, people only employed in shops or unimportant business are very near the borderline, and they are pretty hard to subsist on. All people in moderately important walks of life, like the police and the Gestapo and the diplomats, if you call them that, get rations and a half, and as we were in a diplomatic group, we were given rations and a half.

Industrial workers get double rations, and I believe the army and other special groups get triple rations, so you see the groups which the government wants to be sure are very fit and efficient get plenty of food, and they undoubtedly get the better quality of food. The other people are living near the borderline, but they certainly are in much better condition than the people in France.

The general appearance of well being among the people that we saw in the streets, their energy and determination and the long hours that they were working, led us to believe that physical unfitness was not undermining their morale, or their capacity for work to any great extent. Their morale seemed entirely too good, and we thought that it was going to take a long time to break, but that was in 1943 and early 1944.

**EVENING SESSION ADDRESS**

**HUGO A. FREUND, M.D.**  
*President of the Board of Directors*  
*Children's Fund of Michigan*

**H**ONORED GUESTS, ladies and gentlemen: This evening will mark the close of this conference on public health and nutrition, sponsored by the Research Laboratory of the Children's Fund of Michigan.

The Children's Fund, popularly known as the Couzens Foundation, began its activity in public health fifteen years ago, primarily devoting its resources to children of Michigan, yet indirectly serving children throughout the world.

Many of the men and women of this State, who are now in the fighting forces of our country, were children with whom our work began, and to them, like to many now engaged in actual fighting, was dedicated the Children's Fund of Michigan. Many of these young men and women, and I have known some of them personally, are in very prominent positions at this moment, defending the sacred principles of this and other English speaking peoples scattered over the earth.

It may be broadly stated that the observations and experiences growing out of the aftermath of the First World War were potent factors in establishing the Children's Fund of Michigan by the late Senator James Couzens, to promote the physical health, to set the example of growing children to the need for healthy bodies and minds, and to foster the teaching of the principles of nutrition. These fundamentals were elaborated by the establishment of several divisions, among which our research laboratory, under the guidance of Doctor Icie Macy Hoobler, has taken a leading part.

Throughout these years, we have collaborated frequently with other organizations, and we have assisted wherever possible in the development of problems, and the dissemination of knowledge relating to nutrition and public health. Close contact has been kept for many years with the policies and standards of the committee on public health, and the committee on nutrition of the League of Nations. Although the activities of the League of Nations



has been interrupted, the principles which were developed based on health and dietary studies, are thoroughly formulated and have continued to serve as guides in work in progress, and as reference for the continuation of studies in nutritional fields.

It is important that contact with these nutritional and health organizations be continued, so that the many problems which confront us now and will have to be faced in the next generation, will have continuity and purpose. Those who have been responsible for the work in the League of Nations have been vitalizing forces in this country, and among our Allies, through their leadership and through the facilities of committees which they have created, or which they have served upon.

Tonight, two men who have accepted responsibility in the past on the committees of the League of Nations, and who have devoted much time to the work in which we are all engaged, are here to address us. Doctor E. V. McCollum, Professor of Biochemistry, and head of the Department of Hygiene and Public Health at Johns Hopkins University, and a member of the permanent nutrition committee of the League of Nations, has given lavishly of his time to the National Advisory Council, to the United States Pharmacopeia, to the Lend-Lease Administration, to the Surgeon General of the United States Army, and to many similar activities.

Doctor Frank G. Boudreau, Director of the Milbank Memorial Fund, served for twelve years on the staff of the League of Nations. Primarily a pathologist and epidemiologist, his experience in public health matters is in all its phases, and has given him an overall understanding of post war needs.

Their topics this evening, taken together, imply that they will discuss problems of nutrition and of public health, for the individual, for the community, for the nation, and for the world.

# OUR NATIONAL DIET AND FUTURE HEALTH

E. V. McCOLLUM, Ph.D.

*Professor of Biochemistry, The Johns Hopkins University  
School of Hygiene and Public Health.*

Member, Food and Nutrition Board, National Research Council

**S**INCE I WAS asked to speak on our diet in its relation to future health, what I shall say is intended to apply to post-war conditions. Our war-time food and nutrition policies have been determined and are being administered. With the return of peace we shall meet new conditions, or rather, conditions which differ greatly from those of war time.

Thanks to the mechanical inventions which have multiplied the effectiveness of the farm worker by perhaps fifteen as compared with the farmer of one hundred years ago, and to the great improvement of food and feed plants by selection and breeding, our agriculture is easily capable of providing a generous and excellent food supply in the future, as well as affording a surplus for export should there be a demand for our foodstuffs in other lands. We have, except during war time, had moderate surpluses of foodstuffs over what the market could absorb, and the governmental machinery at Washington has been geared for decades to the maintenance of prices of farm commodities at levels which would prevent economic distress among farmers. Surpluses force prices down and the great numbers of farm families who have lost their land through inability to pay off mortgages because of the small monetary returns for their produce, shows that our legislators have not been able to cope with this difficulty. What concerns us here is that there seems every likelihood that we shall again have surpluses of all of our staple farm crops. Our problem as respects protection of human health through diet is, therefore, one of distribution and education.

Distribution involves making it possible for every individual to have sufficient income to purchase what he needs but does not himself produce. There are certain groups, such as the aged and incapacitated, and the children and adolescents, who must be provided for at public expense if those upon whom they are legally dependent are unable to supply their needs. In the main, however, we must assume that a great majority of the

population is to secure its food by its own efforts and not by charity. Hence, the problem is primarily economic, and its successful handling will depend upon the wisdom of our statesmen and economists, bolstered and sustained by an enlightened public opinion. In the formation of this enlightened opinion the nutritionists must play the part of leaders.

We are, so far as I can see, likely to continue to produce the same kinds of food crops as in the past. With these we are familiar and are yearly learning more about them as sources of essential nutrients. Thirty years ago we began to learn, through experimental studies on animals, what combinations of natural foods and products manufactured from them would, when combined, provide diets which were capable of supporting physiological well being where growth is the primary objective, and for the several specialized functions of nutrition in the adult. The more searching investigations of later years revealed in chemical terms, the reasons why certain foods make good the deficiencies of others. There is nothing better established than that we need to make a wise selection and combination of foods in order to provide ourselves with diets of excellent quality.

Before the first World War, Dr. Sherman and I each formulated simple rules which would enable the woman with little or no knowledge of either physiological processes or the chemical nature of foods to go to market and buy wisely without confusion or worry. These principles are being taught today more energetically than ever before, in slightly modified form, through the activities of governmental agencies. They tell her how to select her foods in order to provide menus for the family which meet its nutritional needs and its likes in taste and variety as well. A very important health problem has been solved in the working out of these discoveries and their practical application. We shall, I believe, continue, as in the past, to teach women the same facts about foods and how to use

them in the home as we are now doing. But we have some very important difficulties still to surmount.

It must seem folly to any reflective mind that we have accepted a highly refined food, sugar, in such quantity that the average consumption per person per year is about one hundred pounds. It supplies calories only. We have accepted highly refined wheat flour and corn meal, prepared in such a manner that the most nutritious parts of the grains go for animal food and the least nutritious parts for the nutrition of man. We now take approximately half of our calories in the form of refined cereal foods and sugar. Of the thirty-eight chemical substances which the diet must supply if it is to sustain health, wheat contains considerable amounts of all except five or six. How extraordinary that we should want to eat a milled product deprived of most of its original twenty-eight or thirty essential nutrients. The fact is that the public has accepted these refined foods and has not been persuaded, to any noticeable degree, to reduce its consumption of them by a great amount of writing and speaking over a period of thirty years. It seems probable that we shall continue to use the same kind of flour as we have been using.

I have defended the use of white flour in the belief that with milling concentrated in the Middle West, and with railway distribution involving considerable aging of flour before it can be made into bread, the manufacture of a long-extraction flour would result in considerable economic loss and a corresponding wastage of food. On the other hand, there can be no doubt that the distribution of a long-extraction flour would be an important step in improving the national diet. It seems to me that we could, if we exercised good judgment in selecting the half of our diet not derived from refined cereal products and sugar, secure from that moiety of the diet sufficient of all the essential nutrients. This view was formulated many years ago and on the basis of many fewer qualitative and quantitative data than we have now about the nature

and amounts of chemical substances which the diet must supply.

At the annual convention of the American Institute of Baking in French Lick Springs, in September, 1923, I urged the bakers to use the maximum amount of skim milk solids which was practicable in the bread mix, with the purpose of improving the quality of the loaf from the food standpoint. There was a decided movement in the direction of using milk in bread-making from that time on. At first there was disappointment because a great amount of the milk powder available was not satisfactory for baking purposes. That difficulty has long since been solved by the marked improvement of skim milk for baking purposes. On the return of peace-time conditions we shall doubtless again have a great abundance of skim milk, and it will be satisfactory to everyone if six per cent of skim milk solids is included in the bread mix. This makes a more nutritious loaf, which does not stale so fast as does a water bread. Also, it cuts with less crumbing and is highly acceptable to the palate.

I have never believed that our bread enrichment program is sound nutritionally. It is a misrepresentation of facts to mill out so many valuable nutrients as is done in the manufacture of refined flour and, after restoring three vitamins and iron, to call it by so good a name as "enriched". The Canadian and British bread policies in this war are more commendable than our own.

There are other practicable ways for improving the nutritive quality of our bread. We have very great nutrient resources in the form of wheat germ, corn germ and yeast which now are not being used for human consumption. De-fatted wheat and corn germs keep well. They are sufficiently valuable to warrant effective handling, packaging and transport to the bakeries for inclusion in the bread mix. But small amounts of these germs added to the bread mix, but one per cent of each plus a like amount of dried yeast, would produce a distinct im-

provement in the nutritive value of bread. The equivalent of approximately thirty million pounds of dried brewer's yeast has been produced annually in beer manufacture, and most of it has been thrown away. Now it is being in great measure dried, and might well find a place in the human diet.

If such additions to the loaf as I have recommended would make any beneficial change in the character of bread it should be our policy as nutritionists to create for it a favorable acceptance. We should not consider consumer demand as something for us to adjust ourselves to, but should exercise leadership in convincing the consumers of the advantages of taking what is good for them. Since people on the lowest economic levels consume a relatively higher proportion of their calories in the form of bread than do those who spend more freely for foods, it is apparent that provision of the most nutritious loaf of bread that can be made at approximately present cost would be of great significance in protecting the health of those who subsist on diets of low cost types.

The nutritionists generally believe today, as they have for twenty-five years, that daily menus should be planned with a view to maintaining a rather constant nucleus of dairy products, meat, poultry or fish, green and yellow vegetables, and every day an appropriate amount of some fresh raw vegetable food for its antiscorbutic value. The slogan, *Eat what you want after you have eaten what you should* is still useful for instruction of consumers.

We should not fail in our duty to make clear to the public that supplementing an inadequate diet with vitamin pills containing a few synthetic products is an unsound practice and a menace to health. Any one of us here could name at least fourteen vitamins which are known to be in certain foods. Sugar provides none of them; white flour, degerminated corn meal and polished rice contain but very inadequate amounts of any of them in terms of our physiological requirements. We should continue to

rely upon natural products for our vitamins. I believe any well-selected diet composed to the extent of half its caloric value with milk and milk products, meats, eggs, green and leafy vegetables, with some raw constituent, will supply everything we need in the way of nutrients. Germs of cereals, and yeast, are exceptionally rich sources of various vitamins and should somehow find their way into human consumption. When one takes a vitamin pill he gets the vitamins which are named on the label and no more. It is a short sighted policy for anyone to use such preparations rather than the more valuable foodstuffs which contain double or triple the number of vitamins contained in the pill.

An illustration of the inferiority of polyvitamin preparations from synthetic substances, in comparison with the vitamin value of a crude extract of a glandular organ, is afforded by a recent report of Gillman and associates (1). They report that among three hundred children admitted to the Non-European Hospital at Johannesburg, South Africa, suffering from severe malnutrition, more than 60 per cent manifested clinical signs of pellagra. Their description of signs and symptoms suggests that these children also suffered from deficiency of protein and had some of the manifestations of the sprue syndrome. Trowell, an outstanding clinician of experience with such patients, recorded (cited by Gillman, (1) ) the unresponsiveness of such patients to vitamin therapy, and stated that his records show a death record of about 90 per cent. In the series of Gillman and others, vitamin therapy failed to save the lives of more than 50 per cent of the children, and blood and serum transfusions proved valueless. Whole extract of hog stomach, on the other hand, produced dramatic responses in these patients. All the children given this preparation survived, and biopsies of livers showed that the great fat accumulations in that organ were mobilized and transported. The native negroes of South Africa are known to subsist largely upon corn and



millet mushes with inadequate amounts of other foods suitable for making good the deficiencies of such cereals.

We should not put so much confidence in the merits of synthetic vitamin preparations as is now being done by great numbers of people. Crude extracts and concentrates of glandular organs such as liver or stomach, of yeast, or of germs of seeds, or extracts of young leaves of plants will contain nutrients which are not likely to be made available by supplementing deficient diets with polyvitamin preparations. It is conceivable that some time in the future, when our knowledge of vitamins is much more extensive than it is at present and when every one which we need is available at low cost, the nutritionist of the future may feel secure in recommending the fortification of deficient diets, consisting to a large extent of refined cereal preparations and sugar, with synthetic vitamins and mineral additions. But our knowledge is at present far from complete, and meanwhile the safe procedure is to adhere to the best possible combinations of natural food products in planning our diets.

Concerning the protein element in the diet it seems apparent from experimental studies that the best diets will supply very liberal amounts of the essential amino acids and also such others as may be found to be useful to the body for the synthesis of any biologically active principles derived from this class of nutrients. Hence, the nutritionist of the future is almost certain to advise a relatively high protein diet. A statement now is not warranted concerning the percentage of the total calories which should be derived from protein. This will depend upon the biological value of the protein moiety. If this is high, a lower protein percentage should afford the same nutritional values as a higher intake of proteins of lower biological value. There seems to be no doubt that a high protein diet enables an individual to synthesize antibodies to a greater extent than is possible when the protein intake falls below the optimum. Surveys and clinical studies

clearly show that deficiency of protein is extremely common in diets of American people at the present time.

In America, the diets of the future must be more effectively planned to provide proper intakes of calcium and of iron. There are numerous studies with human subjects which show that many people respond to the administration of iron preparations. Sherman has for many years emphasized the deficiency of calcium in human dietaries.

About the year 1917 the late Dr. Alfred F. Hess started his campaign of educating American physicians and mothers to the necessity of providing every infant a suitable amount of some fresh fruit juice (vitamin C) to protect him against scurvy. This was a tremendously important reform in infant feeding. After 1922, when vitamin D was discovered, its administration to infants became the general rule. Any infant born in America after 1922 had a great advantage in health protection as compared with one born before that date. But there still remain infants and children who, for one reason or another, are neglected in respect to protection against scurvy and rickets. Greater efforts will be needed to bring protection to every child.

Study of the factors involved in the etiology of dental caries is in such a state of conflict that it would be premature to make any pronouncement as to how the nutrition authority of the future will deal with the problem of preventing tooth decay. The most important discovery thus far seems to be that relating to the protective action of the right intake of fluorine in the form of fluoride. Hitherto, the fluoride content of the drinking water seems to have been the significant source of this element. Fluorine, supplied in amount just below the level at which mottling of the enamel would result, unquestionably raises the level of immunity to dental caries. High authority might be cited for the statement that the optimum quantitative relations between calcium and phosphorus in the diet and the provision of daily prophylactic dosages of

vitamins A and D will go far toward insuring that the enamel of the teeth will be free from imperfections such as the pits resulting from developmental defects. Such pits are potential food traps where stagnation and acid fermentation may take place, with the production of acids which etch away the enamel surface and set up the caries process. The subject of dental caries in relation to diet has been discussed elsewhere in this program and need not be further elaborated here.

Returning to the fortification of foods, a subject which is being considered by many vendors of foods because of its possible sales appeal, I would emphasize that it is easily possible to secure in well planned diets from natural foods everything that the body needs. That this is true is shown by the fact that as scientific discoveries were applied to the problems of preventive medicine, as exemplified in present-day public health administration, more and more people have shown the capacity to live longer. This tendency was very evident before vitamins were seriously considered as safeguards to health. In the light of our history of achievement in every field of human activity during the nineteenth and twentieth centuries, in which so many great discoveries in the sciences have been made, health standards improved steadily, and athletic records broken almost yearly—notwithstanding the progressive dilution of the natural food moiety in our diets by refined products—the arguments of the proponent of the view that we need food fortified above their natural content of nutrients are vulnerable.

We shall need, both in the immediate and the more remote future, to give increasing attention to the conservation of nutrients in natural foods, from harvesting through transport to market, exposure for sale, and preparation in the home. Modern researchers have shown an astonishing loss of nutrients from foods owing to improper storage and cooking. The raw food proponents now have facts which no one foresaw a few years ago, to

support their claims to the superiority of uncooked foods.

While it would seem incontrovertible that a large part of our population is not suffering from malnutrition or undernutrition, as evidenced by the achievements noted above, there is abundant evidence that perhaps the greatest contribution to the raising of public health standards will be declared a few decades hence to lie to the credit of dietary improvement for those who are now subsisting on inadequate food supplies. One need only cite the extremely important demonstrations of what can be accomplished for the health improvement of pregnant and nursing women and infants in the studies of Dr. Harold C. Stuart, Mrs. Burke and their associates in Boston, and of Dr. Tisdall, Dr. Ebbs and their associates at Toronto. One cannot read these papers without realizing how far we may achieve safeguarding human health by making available a fully adequate food supply to everyone.

While much can be accomplished for the betterment of health by an administrative policy which will make it possible for all to secure the proper nutritious foods irrespective of their economic status, we shall have to take into account the problems confronting us in the emotional lives of a large part of the population. Many children are much of the time bearing a burden of emotional stress arising from unfortunate parental attitudes, teacher-child relations, and persecution by other children, with the consequence that the foundations are being laid in childhood for impairment of function of the digestive apparatus. The provision of good food is not enough for these children. The child who is scolded at school for failing to meet the teacher's standards, and is scolded again at home because of the poor record at school, may be expected to suffer impairment of its nutritional status even though the table provides excellent food. Not all children who are recorded as undernourished are so because of inadequacies of diet. The fact that so many respond to better feeding shows that inadequacy of diet is common

throughout the land. We must not overlook so important a matter as the sociological aspect of nutrition.

There is increasing attention by wise physicians to the emotional factors underlying malnutrition in people of all ages. The recent discussion by Dr. Sidney A. Portis (2) and the recent paper by Dr. Flanders Dunbar (3) on Psychosomatic Approach to Physiological Dysfunction and Disease should be required reading for all who are concerned with the human nutrition problem.

The problem is, fundamentally, for a great many people an economic one. Growers of cash crops such as cotton and tobacco represent this element in the population, but it also includes many wage earners' families in ordinary times. The wage check is not sufficient to provide everything that the family needs for even a low standard of living, and frequently the skimping is done mainly on food. This difficulty could be in great measure, if not entirely, overcome if every family now depending on a wage or small salary could have sufficient ground for the cultivation of a garden of proper size and character in order to provide a quota of foods of several kinds which it is unable to buy in the market; and if every grower of a cash crop such as cotton and tobacco could manage to grow a considerable amount of its food on the land, instead of planting the cash crop right up to the doorstep and buying the food supply largely from a list of non-perishable or long-keeping products.

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INTERNATIONAL IMPLICATIONS OF  
FREEDOM FROM WANT OF FOOD

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**W**E ARE accustomed to hearing of famine in India and China but it comes with something of a shock to remember that it occurred up to comparatively recent times in such a country as England.

Sometime in the middle of the eighteenth century, a change came in the affairs of men, showing itself in the freedom of thought and speculation which, in the nineteenth century, brought railroads, steamships, machinery and all that vast expanse of physical science which still—though part of our daily life—is a daily wonder to us all. What had been impossible before became possible to the men of the late eighteenth century and of the nineteenth century. What was this change? The question admits of but one answer. It was an increase in the surplus created by men's labor after the necessities of life had been provided. Sometime, therefore, about the year 1750, man's labor began to be more productive. The primal daily need of every living thing is food, and before the eighteenth century there had been in varying degrees of intensity a constant lack of food. If, therefore, at this time man began to have the leisure for study, which he must have if advance in knowledge is to be made, if men began at this time in Sismondi's phrase, to meditate and apply to the arts the fruits of their study, it must be because, during the eighteenth century food was slowly becoming more abundant and cheaper. Hungry men do not meditate about arts; as Dr. Samuel Johnson says, "He that pines with hunger is in little care how others shall be fed." Abundance of food at prices within reach of all is the first great need of human welfare. Food adequate to relieve this need is the achievement of the eighteenth and nineteenth centuries, and the Conquest of Hunger, the high production which machinery brought to a comparatively small population, is the conquest from which all present-day comforts have sprung. (1)

William Farr, the great English statistician, stated in 1846 in a communication to the Royal Statistical Society (2):

In the eleventh and twelfth centuries famine is recorded every fourteen years, on an average, and the people suffered twenty years of famine in two hundred years. In the thirteenth century the list exhibits the same proportion of famine; the addition of five years of high prices makes the proportion greater. Upon the whole scarcities decreased during the three following centuries; but the average from 1201 to 1600 is the same, namely, seven famines and ten years of famine in a century. This is the law regulating scarcities in England.

The advance of science and the development of the machine had made it possible to banish famine from the world.

But it has never been banished. Famine occurs regularly in China, India, and other densely populated countries where primitive methods of agriculture are practiced, and where modern transport and industrial development have not been attained. And a modified form of famine still occurs regularly in countries of Western civilization like our own, whenever the economic cycle is depressed. Here we have the ironic spectacle of famine in the midst of plenty, of hunger and huge food surpluses occurring simultaneously, the people crying out for the food wherewith to sustain life, and the farmers in ruin because there is no market for their products.

Most of you remember the last world-wide depression which began in 1929. Men's consciences had been slowly becoming softer over the centuries so that in the leading countries the people who could not afford to buy the food they needed were not left to perish. But even in England, France, Germany and America millions in the depressed areas did not get enough of the right kinds of food, and the state of the farmers who had the food to sell became so aggravated by inability to dispose profitably of their products that large numbers of them lost their land and their homes.

In 1935 the Director of the International Labor Organization referred to the world situation in these words (3):

It is not open to dispute that large masses of people are at present underfed or wrongly fed . . . Every country is faced with a problem of this kind, but its exploration is only beginning. . . . Looked at from another angle, it is evident that a higher and more variegated standard of food consumption would go far to solve the question of agricultural over production . . . The question of consumption is not only national but international in its scope. If it is agreed that the only real solution of the problem of economic balance is not through scaling down production but in leveling up consumption, then it follows that the best hope of finding a way out of the present troubles is to raise the standards of the millions who are now underfed, underclothed, under-equipped. . . . When all other remedies have been clearly seen to fail, it is in this direction that thought will eventually be directed, unless a



general regression towards lower standards is accepted as the ironical but inevitable outcome of a civilization condemned to decline through the excess of its own creative ingenuity and technical perfection.

At the moment when the world was in the depths of the economic depression, the League of Nations took up the subject of nutrition, and a wave of hope spread among the depressed peoples. Statesmen who had been discussing security, disarmament, balance of power and other international topics began to think and speak in terms of human welfare, the solid foundation of national security and international peace. Only those who actually witnessed what took place in Geneva at the International Labor Conference and League Assembly will credit the revival of interest in these international institutions when the subject of nutrition was taken up. The debate in the Assembly went on for three days and as a result the League initiated international and stimulated national action which is still going on today. Having come to the conclusion that the improvement of nutrition was of primary international as well as national importance, a Committee was set up in which all the elements concerned with nutrition were represented: science, agriculture, transportation, distribution, consumers, economics, finance, public health, and public welfare. This Committee made a series of far reaching recommendations, the first and most important being that every country should set up a national nutrition committee representing all the interested elements, for the purpose of formulating national nutrition policy. Parenthetically I should point out that before that time there was practically no such thing as national nutrition policy in any country. Public health and medical authorities might attempt to improve public nutrition by research, and education; welfare authorities might distribute food to those in need, but the efforts of these agencies were only too often completely offset by the agencies responsible for the economic and financial policies of the govern-

ment, for nutrition had never been considered by statesmen to be of sufficient importance to warrant consideration in the higher levels of government.

As a result of the League's recommendation national nutrition committees or councils were set up by 21 countries and 26 British dependencies. They began to study food consumption habits, to appraise the state of nutrition of vulnerable sections of the population, and to take stock of the actual and potential food resources of the country.

This widespread activity continued up to the outbreak of war in 1939, and even during the war it was not quiescent, for undoubtedly it was the root source from which sprang the United Nations Conference on Food and Agriculture held in Hot Springs, Virginia, in 1943.

Very little has been said about this Conference in the public press largely because of a mistaken notion among newspaper correspondents that they should have the right to be present even when delicate negotiations are going on between the delegates of governments. All parliamentary bodies, even in the most democratic countries enjoy the right of privacy when in executive session and there seems no valid reason why this privilege should not also be enjoyed by international conferences.

The United Nations Conference on Food and Agriculture at Hot Springs was one of the most successful international conferences ever held. If the governments carry out with good will the recommendations their delegates adopted at Hot Springs entirely new perspectives for human welfare will be opened up. When you leave the meeting this evening, you may forget everything I have said, but I hope that you will remember at least two items: first, that the ultimate success of the Hot Springs Conference is to a certain extent your own responsibility and second, that its success will mean that social science is being put to work for the first time on a large scale for human benefit. The bomb carrying airplane, the long range cannon, the modern battleship and the flame throw-

ing tank are familiar illustrations of the fact that the natural sciences have been put to work by mankind for its own destruction. But we have lagged far behind in the use of the social sciences for human welfare. If our civilization is to endure we must use the knowledge which the social sciences bring to us in our daily lives, in our politics and in our government. The results of the Hot Springs Conference give us the opportunity to utilize advances in the science of nutrition for the welfare of all peoples. And, as I have hinted already, the responsibility falls not only on the governments but also on the people themselves; particularly on physicians, health officers, and authorities in nutrition who are the natural leaders of this movement.

When the miracle of food production through science and the machine, in the middle of the eighteenth century, potentially banished the danger of famine from the world and let loose a vast multiplication of population, little was known of the science of nutrition or of human food requirements. Lacking this knowledge the potentialities of food production for human welfare could not be fully utilized. But during the last quarter of a century the science of nutrition has advanced by leaps and bounds, and it is still on the march. Much as we have learned of human nutrition I believe that we have only begun to unravel its mysteries, and that in a few years we shall look back with amazement at our present ignorance.

The Conference at Hot Springs described the bearing of nutrition on human health in four short sentences (4):

1. The kind of diet which man requires for health has been established.
2. Investigations in many parts of the world have shown that the diets consumed by the greater part of mankind are nutritionally unsatisfactory.
3. Diets which do not conform with the principles of satisfactory nutrition lead to impaired physical development, ill-health, and untimely death.

4. Through diet a new level of health can be attained, enabling mankind to develop inherited capacities to the fullest extent.

There is clear and convincing evidence of the association between faulty diet and ill-health. The ill effects of not eating enough of the right kind of food are manifold. In the first place, malnutrition leads to impaired vigor and lowered vitality, so that its victims cannot fully play their part as active and useful citizens. Secondly, the incidence of disease in general and the mortality rates among infants, young children, women in the childbearing period, and indeed among all age groups, are invariably higher in ill-fed than in well-fed populations. Recovery from disease is more prolonged when the diet is defective. Countries which enjoy the best diets have the lowest rates of mortality and the highest expectation of life. Thirdly there are various common diseases, such as tuberculosis, which are directly associated with lowered resistance caused by malnutrition. Finally there are a number of food-deficiency diseases, i.e., diseases directly due to lack of specific nutrients in the diet, which are prevalent in various parts of the world and lead to much unnecessary suffering since they are preventable but not prevented. Malnutrition in varying degrees is found in all classes and countries, but more particularly it is the close and constant companion of poverty, both national and individual. Poverty almost invariably means a poor and insufficient diet, and the latter is the main cause of the disadvantage of the poor in respect of health, so clearly shown by statistics of disease and mortality.

On the positive side, there is much evidence of the general improvement of health and physique which can be produced by the improvement of diets, and there are also striking examples of the successful prevention of deficiency diseases by appropriate measures. Maternal and infant mortality can, and has been, reduced by dietary means. In many of the poorer countries, death from tuberculosis number from 150 to 250 a hundred thousand, while among better-fed populations the mortality from this scourge has been reduced to 30 or 40 a hundred thousand.

Nutrition, therefore, becomes a primary concern of governments everywhere. To give conscious planned direction to mankind's need for food in the modern sense, each nation should develop a national food and nutrition policy, to the full fruition of which related social and economic policies will need to be adapted.

The delegates at Hot Springs were technical delegates, not plenipotentiaries. They could adopt recommendations but they could not bind their governments. But there was one thing they could do and they lost no time in doing it. They decided to set up an interim commission, to carry on after the Hot Springs Conference adjourned, and to

prepare the constitution and plan of work for the permanent international organization which the United Nations will presently set up. It may be the first permanent organization to be set up by the United Nations to facilitate international collaboration in what we hope may be a peaceful world. This organization will be of the greatest importance to every man, woman and child in the modern world, for its work will concern the world's greatest industry: agriculture—and it will seek to help all governments to bring the diets of their peoples up to levels regarded as satisfactory by modern workers in nutrition. I do not wish to leave the impression with you that I think such an organization can secure the peace of the world. On the contrary, the United Nations Organization for Food and Agriculture will not be able to function unless there is also an effective international security organization to prevent on all occasions the unauthorized use of force. But in the long run true peace cannot be forever maintained by the armed contingents of the United Nations Security Organization. It must depend on an expanding economy, on a rising standard of living throughout the world, on the production of ample supplies of the right kinds of food, on full well paid employment, on decent housing, and on the satisfaction of all of man's fundamental needs. It is in this field that the United Nations Organization on Food and Agriculture will play a prominent part, for as stated by the Conference at Hot Springs food is the most fundamental of the primary necessities which are required by mankind to promote freedom from disease and for the attainment of good health.

International cooperation in the matter of nutrition means not only proper relations with other countries as regards the exchange of agricultural products, it requires internal action on the part of every country. Here are some of the things this country must do when it joins the projected organization.

Undertake to increase the food resources and improve the diets of its people. It is common knowledge that the diets of a considerable proportion of our people are not up to health requirements. If anyone of you doubts this, I commend to him the perusal of Bulletin 109 of the National Research Council, (5) in which are analyzed and compared the results of the dietary and nutritional studies carried on in this country during the last ten years.

This country will also undertake to report periodically to other countries, through the international organization, on the state of our national nutrition and on the steps we have taken for its improvement.

We shall be bound to take special measures for the nutrition of the so called vulnerable groups: pregnant and nursing women, infants, preschool and school children, adolescents, and individuals receiving low incomes.

It will be our obligation to continue and extend our researches in nutrition, paying particular attention to the role of nutrition in those diseases which constitute our chief health problems.

As regards food deficiency diseases it will be our duty to ascertain their prevalence, treat them suitably by dietary and therapeutic means, and take steps to prevent their recurrence.

These are only a few of the steps we must take when we become members of the projected organization on food and agriculture. I give them to you simply for purposes of illustration, and to show how Hot Springs believed we should go about the business of raising our nutritional standards.

The Conference declared, in no uncertain terms, that the first necessity was to adopt a nutrition policy, and insisted that a national nutrition committee or organization was needed to formulate such a policy. Here let me digress for a moment. Can any one of you tell me what is now our national nutrition policy? Or can you tell me

what is the nutrition policy of the State of Michigan which is responsible for the health and therefore the nutrition of its people? I am afraid the answer must be in the negative for the simple reason that in general there is no such policy. State and federal governments, here and abroad, have not in the past considered nutrition to be of sufficient national or state importance to warrant the formulation of national or state policy concerning it. But it was our government which called the Hot Springs Conference, and it is inconceivable that the United States will refuse to carry out the recommendations adopted and in some cases put forward by our own delegates.

So we may look forward to the setting up in this country of a national nutrition organization, bringing together high officials of all government departments concerned in any way with the subject, and representatives of many other agencies and groups, including consumers. There will be private members—at least I hope so—for this was the intent of Hot Springs; private members who are not officials of any department of federal or state government, and whose expression of views will not be limited by official status. The Organization will be advisory, for the responsibility for the nutrition and health of its people must not be taken away from the government of the day. The work of the Organization will be to study the diets of our people and to appraise their nutritional status. It will then proceed to formulate national nutrition policy taking into due consideration the actual and potential resources of the country. And it will have the authority, according to Hot Springs, to make its recommendations public as well as to bring them to the attention of those agencies of government which are concerned in any way with nutrition policy, or indeed with social, economic and fiscal policy all of which affect any nutrition policies which may be adopted.

This country has a food productive capacity far greater than is necessary for the needs of its own people. And

the disposal of our surplus crops abroad often determines the economic condition of the farmer. Some countries have a lower productive capacity than is required for the needs of their people. So the national nutrition organizations, meeting together periodically, will work out according to Hot Springs, a system of mutual assistance so that surplus foods will be fed to hungry human beings and not burned or otherwise destroyed as was the case in the 1930s. Some or all of this food will be paid for; Hot Springs did not plan to set up a system of world charity. But would it not be better to give surplus food away to hungry people in other lands than to hold it in storage where it constitutes an ever present threat to the price structure? Little by little we are learning that the world in which we live is an economic and social unit; Wendell Willkie expressed it well in the title of his great book *One World*. For we are slowly learning that hunger, cruelty and injustice in any part of the world is as near to us as our nearest neighbor, and that failure to protest and to act when our neighbor anywhere in the world is attacked is to risk the lives of our own children. How many more American boys and girls must die on far-flung battlefields, as they died in the First World War and as they are dying now, before we take that lesson to heart?

When the proceedings of the Hot Springs Conference were published, many scoffed, some calling it the "Hot Air Conference" and others denying that enough food could be produced to feed the hungry people of the world. But events have occurred since the Conference was held which show clearly that its recommendations were the work of farsighted, practical men. I have time for only two examples. During the war and under the stimulation of war, the United Kingdom increased her food production from about 35 per cent of the amount necessary to feed her people, to 60 per cent in spite of all the wartime difficulties. Our own experience during the war has also been revealing. Perhaps you remember that predictions



were made early in the war that we might starve? Well, a report has come out, drafted by Americans, Canadians, and Englishmen, showing the amounts of food available per capita to civilians in 1943 as compared with the average for 1936-1939. (6). Please remember the difficulties which faced our farmers because of lack of manpower, rationing of gas, scarcity of farm machinery and all the other shortages of critical materials. In spite of those difficulties, and in spite of the huge quantities of food which went for the army and lend lease, civilians had more of the essential foods in 1943 than they had in the period 1936-1939 when there was practically no army and lend-lease was not functioning. Sugars and syrups were a little short, coffee, tea, and cocoa were less available but every other foodstuff increased, except fats and oils which about held their own. Increases were about as follows: milk and milk products 16 per cent, meat 6 per cent, eggs 15 per cent, potatoes and sweet potatoes 9 per cent, pulses 21 per cent, tomatoes and citrus fruits 17 per cent, leafy green and yellow vegetables 4 per cent, other vegetables 3 per cent, and grain products 1 per cent. You will perhaps be more interested in learning about the increase in terms of nutrients. Well the story here is even more amazing. Listen to these figures, remembering always that they represent percentage increases in 1943 over the pre-war years and concern the amounts of the various nutrients available to civilians on a per capita basis after the armed forces and lend-lease have had their huge helpings: calories 2 per cent, animal protein 9 per cent, vegetable protein 3 per cent, fat 5 per cent, calcium 15 per cent, iron 14 per cent, vitamin A 8 per cent, ascorbic acid 7 per cent, thiamin 37 per cent, riboflavin 18 per cent, niacin 14 per cent.

This is an amazing performance, showing what we could do if we set our minds to it in peacetime, when all wartime obstacles would have disappeared. In the Food and Nutrition Board we calculated that if the American

people were willing to make some small adjustments of production and in their diets, which would not reduce their nutritional value in any way, we could during the war export enough food to feed another population as great as our own.

Skeptics may say, but if food increased so much in amount, why were many foods so scarce? The answer is of course full employment at good wages. The reason a minority of us in peacetime could buy all the good food we wanted was because large groups in our population were not in the market; they did not earn enough to compete with us for the foods which are highest in nutrient content, the so called protective foods.

The lesson is of course that to nourish all the people as they should be nourished—and even now in this rich country there are underfed millions—more food must be grown and marketed than we have ever produced. For there has never been such a thing as a food surplus. What we have called food surpluses have existed when millions were suffering in health and vigor for the lack of the food which appeared to be a drug on the market.

I think, you will now agree that the Hot Springs Conference was one of the most practical conferences ever held and that, if we join with other governments which are resolved to put its recommendations into effect it will be the most practical step we have ever taken.

Here I would remind you once again that the ultimate success of the Conference is not a matter for governments alone; it depends on the people as well as the governments, and leaders in nutrition have a special responsibility. Such leaders, and in that group I would include physicians and public health workers, will, if they choose, enjoy increasing work and responsibilities as the movement for better nutrition throughout the world goes forward and gains momentum.

John G. Winant has said "When war is done . . . the drive for food to prevent the enemy from starving us,

must become a drive for food to satisfy the needs of all people in all countries." (7). He did not say that this drive might bring the world an expanding economy and greater prosperity, but this has been expressed by Sumner Welles in these moving words:

There is no limit then, to the material prosperity which is within the reach of the United States, and of mankind. The great thing that has happened in our time is that mankind at long last has taught itself enough of the means and techniques of production, of transport and of scientific agriculture so that it is technically possible to produce and to distribute on this planet the basic physical necessities of health and decent living for all of the world's people.

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## ADJOURNMENT

DR. FREUND: Tonight the Children's Fund of Michigan has taken pride, and at the same time immeasurable satisfaction in being the host to a group of men, who have willingly devoted their efforts toward charting a course for better health, total health, which implies disease control, nutrition planning, mental health, physical fitness, and race betterment, and so the Board of Directors and our Research Staff, Doctor Hoobler and Doctor Williams, join in expressing our appreciation for the impetus that your contribution will have given to improve here and elsewhere in the world, the health and the happiness of our fellowmen.



**L. EMMETT HOLT, JR.**  
*Now Professor of Pediatrics, New York University*

# AMINO ACID DEFICIENCIES IN MAN\*

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\*Unfortunately, Dr. Holt was unable to present the paper he had prepared for the conference. However, he made his manuscript available for inclusion in these proceedings. Dr. Holt is now Professor of Pediatrics at New York University.

**T**HE OBSERVATIONS which I shall present to you, are part of a study commenced three years ago by Dr. Anthony A. Albanese and myself, and still far from complete, in which we attempted to produce specific amino acid deficiencies in experimental human subjects with a view to determining: (1) the amino acids essential for man, (2) the minimum requirements for each and (3) the clinical and laboratory features of specific deficiencies.

There were particular reasons for undertaking this work at the present time. War conditions were bringing about shortages of high-grade food proteins in many parts of the world, a state of affairs conducive to specific amino acid deficiencies. A more accurate knowledge of human amino acid requirements gave promise of the more efficient use of the incomplete vegetable protein foods. The discovery of species differences in amino acid requirements—even in closely related species—made it unwise to make assumptions about human requirements from data obtained on the rat. The search for manifestations of specific amino acid deficiencies had little point when amino acids were regarded merely as building blocks of body proteins and when chemical tissue patterns were regarded as virtually constant. Under such circumstances Liebig's "law of the minimum" was held valid, according to which a deficiency of each essential amino acid would produce identical symptoms—loss of weight, failure of growth and hypoproteinemia. Only recently was it appreciated that essential amino acids have specific functions to perform, quite apart from their contribution to body structure; they furnish organic radicals that cannot be synthesized by the body which are needed for the production of hormones and other body catalysts. A breakdown of such specific functions, because of deficient intake or as a result of disease affecting the metabolism of one or another amino acid, might well lead to a great variety of clinical manifestations.

We have produced diets deficient in one or another amino acid by various degradation techniques applied to casein hydrolysates or to casein itself before hydrolysis. Such diets have the advantage over mixtures of pure amino acids that the amino acids are for the most part supplied in their natural or *l*- form.

Our experiments have been carried out on healthy adults of both sexes between twenty-one and twenty-five years of age, who were leading a sedentary life. They were given weighed diets providing approximately 40 calories per kilogram and 0.1 gm. of nitrogen per kilogram of body weight per day. These diets were constructed from sugars, starches, fats and fruits and vegetables selected for their low nitrogen content (oranges, apples, pineapples, apricots, tomatoes, cucumbers, celery, potatoes, carrots, asparagus, mushrooms), the latter furnishing about 10 per cent of the daily nitrogen intake. The remaining 90 per cent of the protein moiety consisted of a protein hydrolysate which had been rendered deficient in some one amino acid. Since such hydrolysates are decidedly unpalatable, they were flavored with tomato juice and taken at one gulp at the beginning of each meal, after which the remainder of the meal was consumed with pleasure.

We have carried out 30 experiments on 7 amino acid deficiencies. The deficient periods have been between three and six weeks in length, and have been preceded and followed by control periods in which a supplement of the missing factor was added to the diet. The subjects have been studied clinically and by a variety of laboratory techniques for evidences of deficiency, and nitrogen balances have been followed throughout by nitrogen assays of the food and excreta. The evidence we have obtained up to date on the essentiality of particular amino acids for man and on the symptomatology and laboratory criteria of deficiency will be considered separately.

*The Amino Acids Essential for Man.* Evidence obtained by nitrogen balance studies points clearly to the essen-



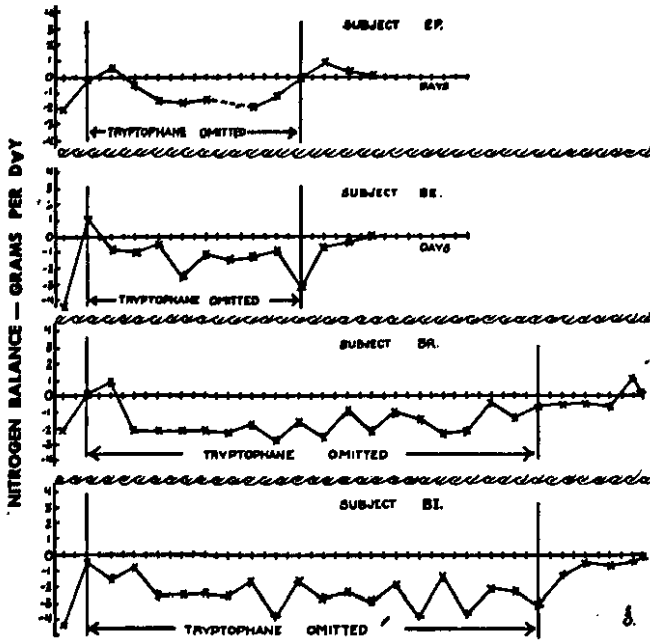


FIG. 1.—Observations on nitrogen balance in human subjects on a diet deficient in tryptophane.

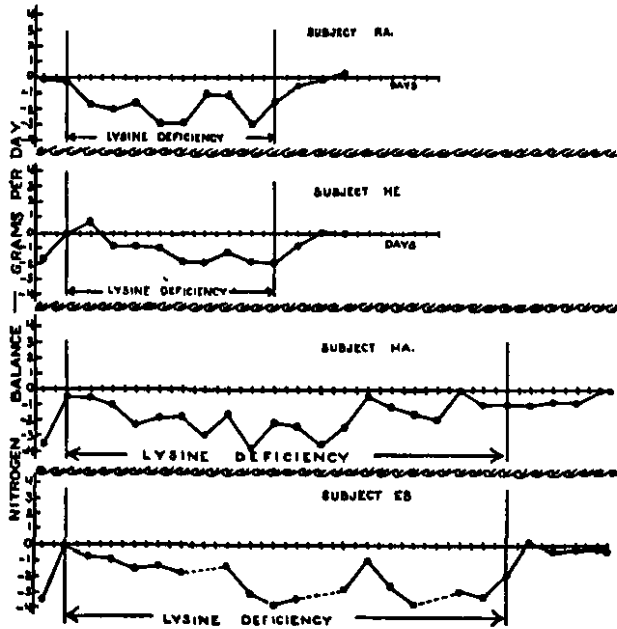


FIG. 2.—Observations on nitrogen balance in human subjects on a diet deficient in lysine.

tiality of tryptophane (1), lysine (2), and methionine (3), for man. Each of these deficiencies promptly leads to a negative nitrogen balance, and restitution of the missing factor restores nitrogen equilibrium with equal promptness. Although it is quite clear that when removal of a particular amino acid induces negative nitrogen balance that amino acid must be regarded as essential, the converse is not true. It is not possible to conclude from the fact that nitrogen equilibrium is maintained on a particular defi-

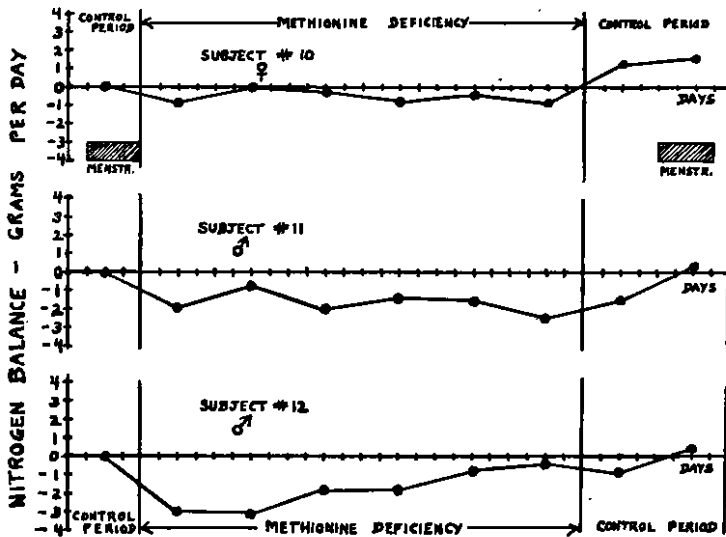


FIG. 3.—Nitrogen balance in human subjects on a diet deficient in methionine.

ciency that the missing factor is an unessential one. It is possible that stores of an essential factor exist which postpone for a considerable time the need for tissue destruction to supply it, and the resulting negative nitrogen balance. Another possibility is that the missing factor causes disintegration of some tissue which may be rich in it, yet this tissue represents such a small fraction of the body that its destruction is not detected in a nitrogen balance study. A third situation in which loss of tissue to provide a needed amino acid may not be reflected in the nitrogen

balance is that in which there is simultaneous atrophy of one organ and hypertrophy of another, the latter process masking the negative nitrogen balance which would otherwise occur. The tissue undergoing atrophy may supply the deficient amino acid, being richer in it than the tissue undergoing hypertrophy. Examples of independent varia-

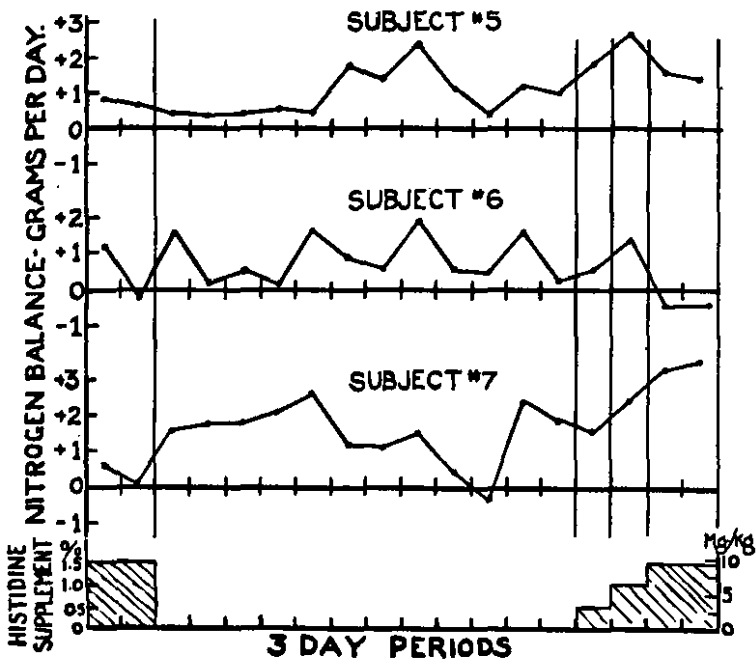


FIG. 4.—The nitrogen balance in human subjects on a histidine-deficient diet.

tion in the size of tissues are not difficult to find. That diet alone may cause such changes is apparent from the work of Addis and his collaborators (4). Before concluding that an amino acid, deficiency of which is not followed by negative nitrogen balance, is an unessential one, it is necessary to make sure that the body is not suffering anatomical, physiological or biochemical changes that are not reflected in the nitrogen balance.

We shall present two examples of amino acids, removal of which from the diet permitted nitrogen equilibrium

to continue. Yet a deficiency of one of these—histidine—gave rise to a biochemical defect which at least gives reason for suspecting that it may be essential, and a deficiency of the other—arginine—gave rise to an anatomical lesion which leaves no doubt as to its essentiality.

Figure 4 illustrates the failure of a histidine-deficient diet to induce negative nitrogen balance in human subjects (5). Nevertheless, study of the urine of these subjects showed that the histidine-deficient diet was promptly followed by the development of a chromogen in the urine which gave a green color with the Sharlit indican reagent. The administration of histidine caused prompt disappear-

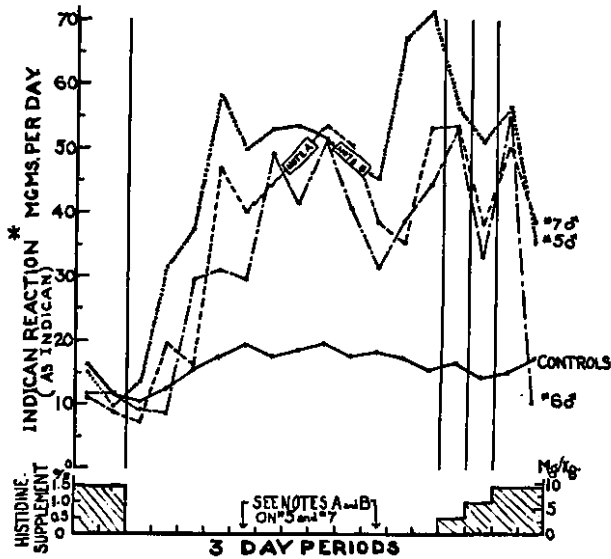


Fig. 5.—Variation in the "indican reaction" on a histidine-deficient diet.

\* Determinations were made with a photoelectric colorimeter, using a filter which transmits both the purple rays derived from indican and the green rays derived from the unknown material. The increase in total "indican reaction" on the histidine-deficient diet is due entirely to the appearance of the material giving the green color reaction.

*Note A.* During three of the ten days of the period designated by jagged line, Subject No. 7 received a daily supplement of 1 (+) histidine equivalent to 1.5 per cent of the protein hydrolysate.

*Note B.* During two of the four days of the period designated by the jagged line, Subject No. 5 received a daily supplement of 1 (+) histidine equivalent to 0.75 per cent of the protein hydrolysate.

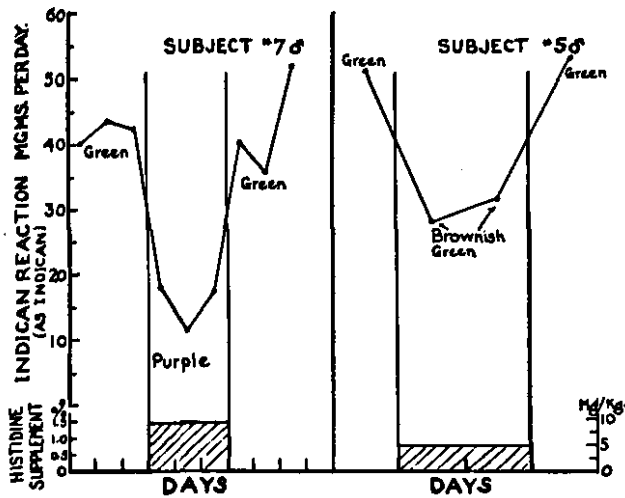


FIG. 6.—The effect of (+) histidine supplementation on the "indican reaction" of humans on a histidine-deficient diet.

ance of this chromogen from the urine. The abnormal metabolite is not yet identified, and its significance remains uncertain. It may represent an important perversion of metabolism or one of little significance.

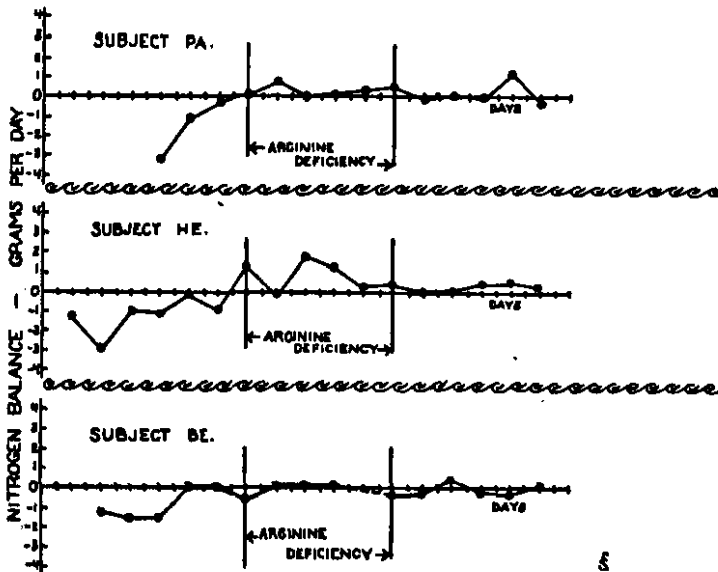


FIG. 7.—Observations on Nitrogen Balance in Human Subjects on a Diet Deficient in Arginine.

This graph illustrates the fact that three subjects on an arginine-deficient diet failed to develop negative nitrogen balances within a ten-day period (6). Nevertheless, a study of the seminal plasma of these same subjects (7) on the ninth day of the deficiency revealed such alarmingly low figures for spermatozoa that the experiment was promptly

ANALYSIS OF SEMINAL PLASMA IN HUMAN SUBJECTS ON AN  
ARGININE DEFICIENT DIET

	CHARACTERISTICS		
	Sperm count (millions per cc.)	Non- motile forms (per cent)	W.B.C. (millions per cc.)
Normal average values	120	5-10	None
Subject H.:			
After nine days on arginine-deficient diet	17	100	20
Several weeks after normal diet resumed	100	---	5
Subject B.:			
After nine days on arginine-deficient diet	15	95	15
One week after arginine supplementation	65	20	19
Several weeks after normal diet resumed	70	15	4
Subject P.:			
After nine days on arginine-deficient diet	12	90	15
One week after arginine-deficient diet	55	30	13
Several weeks after normal diet resumed	72	20	5

terminated. The addition of an arginine supplement caused a prompt rise in the sperm count, but it was only after many weeks on a normal diet that entirely normal figures were restored. Arginine is known to represent 85 per cent of the protein moiety of the heads of fish spermatozoa and it is probable that its concentration in the heads of mammalian sperm is likewise high.

The observations on arginine deficiency in human beings led us to restudy arginine deficiency in the rat. It had been reported by Rose (8) that arginine was not altogether essential for the rat, but could be synthesized by that animal at a suboptimal rate. This was based on the observation that, on a diet deficient in arginine, rats would grow, but at a suboptimal rate; no examinations of the tissues of arginine-deficient animals were reported. We

found that the growing rat, when placed on an arginine-deficient diet, develops demonstrable anatomical changes in the testis as early as the third week, and that in the course of two months the disorganization of that organ becomes so complete that the tissue is scarcely recognizable as testis (9); no evidence of spermatogenesis remains and

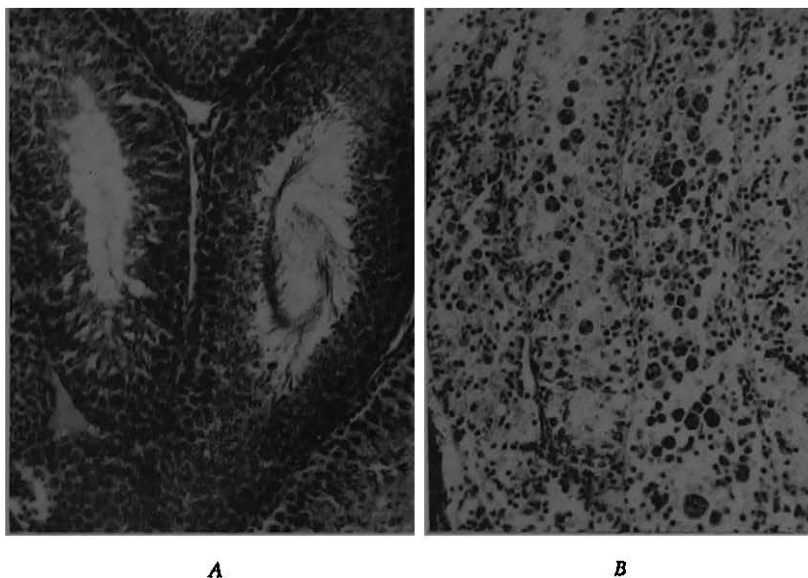


FIG. 8.—Effect of a diet deficient in arginine on the testis of the rat. *A*. Testis of control adult rat ( $\times 200$ ). *B*. Testis of adult rat after forty-seven days on arginine deficient diet ( $\times 200$ ).

the lumina of the tubules are filled with cellular debris, leukocytes, and multinucleated macrophages. Although we do not have biopsy data from our experimental human subjects on the arginine-deficient diet, the seminal analyses indicate that changes were in progress which might, if the experiment had been continued, have led to a similar picture.

On the basis of our observations, we can state that the amino acids tryptophane, lysine, methionine and arginine are essential to man and that histidine may be so, although further study is needed. The short term experiments recently published in abstract by Rose and his collabora-

tors (10, 11) in which negative nitrogen balances were obtained on the omission from the diet of certain individual amino acids give justification for adding threonine, leucine, isoleucine, valine and phenylalanine to the list of amino acids essential for human beings. The classification of amino acids in regard to their essentiality for man, as far as present knowledge goes, is given in this table. We

AMINO ACID REQUIREMENTS OF MAN			
ESSENTIAL		UNESSENTIAL (?)	
Tryptophane	Isoleucine	Cystine	Alanine
Lysine	Phenylalanine	Tyrosine	Glycine
Methionine	Threonine	Proline	Glutamic acid
Valine	Arginine	Oxyproline	Aspartic Acid
Leucine	Histidine	Serine	

should like to emphasize, however, that the amino acids in the unessential column must still be regarded as only tentatively in that category, since their only claim to unessentiality lies in the fact that in very brief experiments their absence from the diet has not induced negative nitrogen balance, a criterion which, as we have shown, cannot be relied on exclusively to establish the point in question.

*Symptoms of Amino Acid Deficiency in Man.* The symptomatology of amino acid deficiencies in our human subjects has been meagre as compared to the manifestations observed in animals to whom deficient diets have been given for a considerable time. Excluding vague subjective symptoms of a questionable nature, we have observed definite symptoms so far only on a lysine-deficient diet. Within a few days after this was instituted, several of our subjects noted nausea, headache, dizziness and abnormal sensitivity to noise. The symptoms cleared up when, without the knowledge of the subjects, a hydrolysate containing lysine was substituted for the deficient protein hydrolysate (12) and recurred when the deficient hydrolysate was again ingested.

It is probable that much longer experiments will be needed to demonstrate symptoms of most of the essential amino acids in man.



*Specific Laboratory Criteria of Amino Acid Deficiencies.* In the course of our studies, a number of observations have been made which give promise of development into tests useful for the detection of specific amino acid deficiencies. The color reaction obtained with the urine on a histidine-deficient diet has already been mentioned.

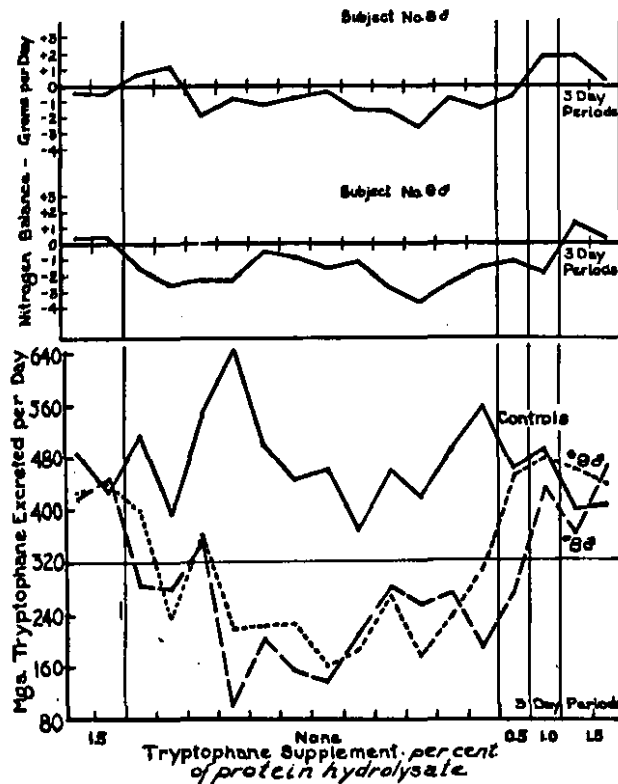


Fig. 9—The relation of tryptophane excretion to nitrogen balance in subjects on a tryptophane-deficient diet.

These curves illustrate the excretion of tryptophane in the urine of two subjects on a tryptophane-deficient diet as compared with control subjects on an identical basal diet who received protein hydrolysates containing tryptophane. It is apparent that the excretion of tryptophane in the urine falls off sharply in the tryptophane-deficient state.

We attempted to use the urinary methionine excretion as a criterion of methionine deficiency, but found, quite unexpectedly, that the urinary methionine excretion continued unchanged throughout the deficiency period. However, at the end of the deficient period, when methionine was restored to the diet the excretion rose to a figure well beyond the normal, indicating that a loss of tolerance to methionine had occurred. Observations are in progress to see if this phenomenon can be made the basis of a useful test.

In our lysine-deficient subjects the observation was made (12) that, shortly after the deficient diet was started, a sharp rise occurred in the excretion of non-ketone organic acids in the urine. The nature of the organic acid or acids excreted under these conditions remains to be elucidated.

*The Influence of Disease Processes on the Metabolism of Particular Amino Acids* is a field which is practically unexplored at the present time. With the development of chemical methods for studying the excretion of individual amino acids and related metabolic products in the urine, it seems not unlikely that perversions of amino acid metabolism may be discovered where they have not hitherto been suspected.

The observations described above on the relation between arginine and spermatogenesis led us to wonder whether or not cases of idiopathic hypospermia might be due in some measure to defective arginine utilization, and whether the administration of arginine in such cases would be of any value. Up to the present time, we have had the opportunity to study five such cases. It would appear that such cases are not all alike in their response to this measure. In two instances, both with very low sperm counts (below 10 million per cc.) virtually no response was obtained. In another, minimal improvement was noted. In the remaining two, definite stimulation of

spermatogenesis was obtained with relapse when arginine was withdrawn, and a second increase in sperm count when its administration was resumed. These cases are illustrated in figures 10 and 11.

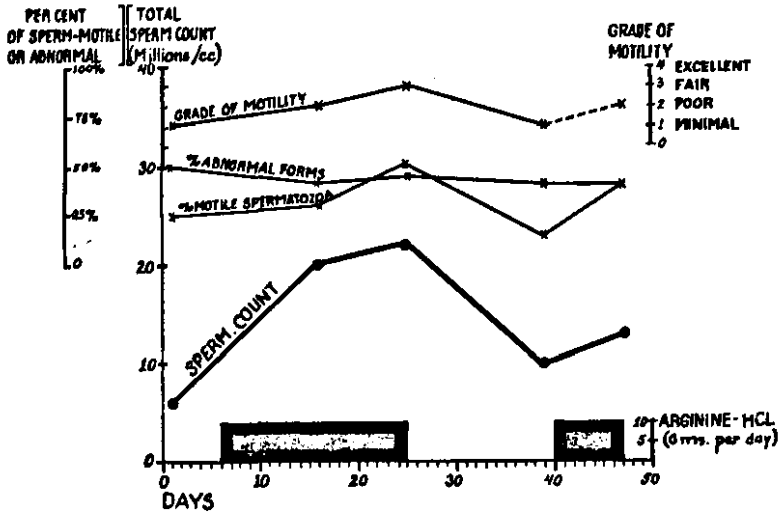


FIG. 10.—Effect of arginine supplement on spermatogenesis in idiopathic hypospermia (Patient I.L. 28).

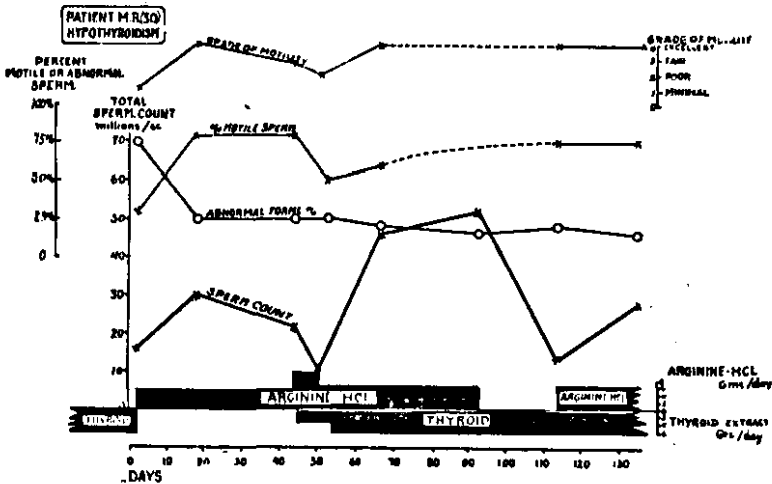


FIG. 11.—Effect of arginine supplement on spermatogenesis in idiopathic hypospermia.

The patient illustrated here requires a word of explanation, for his condition was complicated by hypothyroidism, which was controlled by treatment before the onset of the present study. By a misunderstanding, his thyroid treatment was discontinued coincidentally with the commencement of the arginine therapy, and although temporary stimulation of spermatogenesis occurred, it was not maintained and the sperm count fell off as hypothyroidism became manifest. Subsequently, with the restoration of thyroid therapy, the arginine effect is clearly demonstrable, the sperm count rising when it was given and falling when it was withheld.

As was already emphasized we are only at the beginning of our knowledge of amino acid deficiencies in man. Within the next few years it may be anticipated that our knowledge of amino acid requirements in health and in disease will be greatly extended.

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