Good Nutrition for the Good Life

by LINUS PAULING

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I believe that it is possible by rather simple means, essentially nutritional, to increase the length of life expectancy for young people and middle-aged people (and to some extent, perhaps, old people too) by about 20 years. Not only can the life expectancy be increased, I believe, but also the length of the period of well-being can be increased by the same amount, or perhaps even a little longer; because it is likely that, as long as the process of aging goes on, the process of deterioration that culminates in death will proceed more rapidly at a late age than an earlier one.

The principal procedure to use is that of introducing nutrient substances into the human body in the optimum amounts. Take the vitamins, for example. We have in the United States a committee called the Food and Nutrition Board that is described as consisting of outstanding nutritional scientists, which makes recommendations to the people about the intake of vitamins and minerals. These recommendations are made for vitamins in the amounts that will prevent overt manifestations of avitaminosis for most people—95-99 percent of the people.

For example, for vitamin C, the studies that have been made with a rather small number of human subjects show that 10 milligrams a day is enough to prevent overt manifestations of scurvy from developing over a period of several months, or years even—the time it takes scurvy to develop for people on a scorbutic diet—and 45 milligrams might be enough for most adults, even taking into account their biochemical individuality. It is true that Roger J. Williams—who discovered one of the D vitamins, pantothenic acid—has suggested, on the basis of studies with guinea pigs, that the amount required for good health varies by a factor of 20, probably even among guinea pigs, and by even a greater factor among human beings, who are more heterogeneous genetically than the guinea pigs that he was using. There may well be some people who will become prescorbutic, with only 45 milligrams per day.

About 40 years ago, Albert Szent-Györgyi, who in 1928 made the first preparations of ascorbic acid, which turned out to be vitamin C, asked the question, What is the amount of vitamin C that would lead to the best of health for human beings—not just the amount that prevents them from dying of scurvy, but the amount that would lead to the best of health? He apparently decided that 1,000 milligrams a day might be a reasonable estimate, because he started taking 1,000 milligrams a day himself, and I think rather recently has increased his intake to 2,000.

This is a question that has been essentially ignored by the Food and Nutrition Board, not only for vitamin C but for all other vitamins too. It has been pretty much ignored by nutritional scientists as well; yet it is an important question. One way in which we might try to answer it is to ask, What amounts of various vitamins did human beings or their predecessors receive from the natural foods they were eating? It may be that at some time our predecessors were vegetarians rather than meat eaters, or catholic eaters—meat, vegetables, and so on. But in checking raw natural plant foods for the average amount of vitamin C in them, I found that for 110 foods the average amount in a day's ration of the various vitamins came out between two and five times the recommended daily allowance of vitamin A and thiamine and riboflavin and pyridoxine.

This, I think, suggests that the optimum intake of these vitamins might be two to five times the recommended daily allowances, but it is no more than a rough suggestion. On the other hand, for vitamin C the amount came out 55 times 45 milligrams, the currently recommended daily allowance. I think that this calculation is significant,

and it may well be that the daily recommended allowance of vitamin C should be much larger than the present value, and that the optimum intake is in the neighborhood of several grams a day, rather than a few tens of milligrams a day.

In 1949 G. B. Bourne, an English biochemist, was engaged in discussing the question of what the British recommended daily allowance of vitamin C should be—10 milligrams per day or 20 milligrams per day. Bourne pointed out that the bamboo shoots and other foods eaten by gorillas in the wild state contain about 5 grams of vitamin C, corresponding to something like 2 grams (2,000 milligrams per day) for a human being, taking the smaller body weight into consideration, and he asked the question, Should we not, instead of discussing whether 10 milligrams or 20 milligrams is the right amount to recommend, be discussing whether 1,000 or 2,000 milligrams is the right amount?

Irwin Stone, a biochemist from Staten Island, who now lives in Mountain View, California, collected information about vitamin C over the years and in 1965 and 1966 published four papers on "Hypoascorbemia, a Genetic Disease." He contended that the human race as a whole has been suffering from a deficiency in the intake of ascorbic acid and from a disease that he named hypoascorbemia, too small a concentration of ascorbic acid in the blood.

He gave several arguments to support his contention. For one thing, plants manufacture vitamin A, vitamin B_1 (thiamine), vitamin B_2, B_6, and other vitamins for themselves. Animals require these substances exogenously, and we can ask why. I think the answer is this: In the early days of the existence of animals, they had inherited from their plant ancestors the machinery for making these important substances. But they were eating plants, and the plants manufactured these substances, so they were getting a supply of them in their food. It may well be that the amount of vitamin A that animals were getting was just about as much as they needed—close to the optimum. Now if a mutant came along that had suffered a genetic deletion, losing the genes that are involved in producing the enzymes that catalyze the reactions leading to the synthesis of vitamin A, the mutant would still have vitamin A from his food, but he would be a streamlined animal, not burdened by the machinery for *making* vitamin A, and in the competition with a more slowly moving competitor who was handicapped by this machinery, he would win out. The situation would be the same with thiamine, riboflavin, pyridoxine, and other vitamins. I believe that this is what happened, and that this is why all animals require the vitamins.

But this didn't happen with vitamin C. The dog, the cat, the rat, the mouse, and other animals make their own vitamin C. Only human beings and their close relatives require exogenous vitamin C, and a few other animals such as guinea pigs. The reason, I would say, is that there isn't enough vitamin C in the plant food. For one thing, vitamin C is required for the synthesis of collagen, the connective tissue in animals. Plants don't synthesize collagen, so far as I am aware. They use cellulose for connective tissue. There's an extra need for ascorbic acid among animals. The fact is that these animals did not give up the power to make ascorbic acid—and I calculated 2,300 milligrams per day as the amount available in a diet for man of raw natural plant foods. This, I would say, surely means that the optimum intake for man is greater than 2,300 milligrams a day.

But human beings and anthropoids all require exogenous vitamin C. What happened? I think with little doubt that these are not separate mutations for human beings and gorillas and rhesus monkeys and other primates, but

rather a single mutational loss—a common ancestor 25 million years ago, living in a tropical valley where the fruit foods were especially rich in vitamin C (providing 10 or 15 grams per day for a body weight of 70 kilograms), underwent a mutation. The mutant lost the machinery for making the vitamin C and was correspondingly streamlined and able to compete and as a result the mutant won out and we are all descended from this mutant, who suffered this unfortunate accident. As long as our ancestors stayed in this area they were getting enough vitamin C. When they moved into temperate and sub-arctic regions, the food available contained less vitamin C, and they began to suffer from scurvy.

One measure of good health is resistance to disease. There have been about a dozen carefully controlled studies carried out on a comparison of vitamin C tablets and placebo tablets in blind trials, with respect to the incidence and severity of the common cold. Every one of these studies carried out with people exposed to cold viruses by casual contact with other people has shown that vitamin C has protective value. There is no doubt about it. In fact, if, in addition to taking regular doses of vitamin C, you carry a supply with you and increase the intake at the first sign of a cold, or even other illness, taking 10 to 20 grams during the first day, and then tapering off, you can stop the cold. Many cold medicines make you feel better, but they don't prevent the cold from developing. Vitamin C will do this. Not only that, but vitamin C prevents other diseases.

In 1965 it was reported by Claus W. Jungeblut, working in the College of Physicians and Surgeons at Columbia University, that concentrations of vitamin C that you can produce in the blood plasma by taking the substance in good amounts will inactivate poliomyelitis virus, so that when this virus is exposed to the solution for half an hour and then injected into the brains of monkeys the monkeys do not become paralyzed, although monkeys treated with virus that has not been activated in this way get paralysis. Also, monkeys given large doses of vitamin C did not become paralyzed, and those receiving small amounts did. Jungeblut and others also reported that inactivation of other plant and animal viruses could be effected by treatment with vitamin C, and Japanese workers have published a half-dozen papers during the last three or four years on inactivation of bacterial viruses by vitamin C.

About a year ago Hume and Weyers in Scotland reported in the *Scottish Medical Journal* on the protection against bacterial diseases by vitamin C. It had been known for several decades that the white cells, leucocytes, are effective phagocytes (that is, with the ability to engulf bacteria) only if the leucocytes contain 20 micrograms per 100 million cells or more of vitamin C. Hume and Weyers found that people in Scotland eating an ordinary Scottish diet with perhaps 15 or 20 milligrams per day of vitamin C had an average of 20 micrograms in their white cells. When they caught cold, the value dropped in the first day to 10 micrograms and stayed that way for three days, and then began slowly to rise. That's below the limit at which the leucocytes have phagocytic activity. By giving extra vitamin C—1,000 milligrams per day, and 8 grams per day when the person caught cold—this effect was averted. The concentration was 30 micrograms per 100 million cells and it dropped to no less than 24, so that the phagocytic activity was retained. This explains why people who take vitamin C, even if they catch cold—a viral cold—do not get a secondary bacterial infection, in general.

Vitamin C seems to be valuable in many different ways. Constance Spittle, a pathologist in England, reported that she had been monitoring her own serum cholesterol, which ran about 210 milligrams per deciliter. Then she began taking about 1 gram a day of vitamin C and found that her serum cholesterol dropped to 130 micrograms per deciliter. She found a similar effect in over 50 subjects.

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About 15 years ago I gave a Friday Evening Lecture at Caltech on aging and death. In this talk I mentioned the Englishman, Gumpertz, who 150 years ago showed that the age-specific death rate is a logarithmic function of chronological age. Take a population and determine the rate at which people are dying, and plot the logarithm of the death rate against the age. You get a straight line from about age 30 on. The slope of the line is such that there is a doubling of the death rate for every 8 years' increase in chronological age.

If you take two populations—for example, the population of nonsmokers in the U.S. and the population of one-pack-a-day cigarette smokers—you have a Gumpertz curve that has shifted by 8 years toward lower ages. (The two-pack-a-day curve shifts by 16 years toward lower ages.)

If you plot the death rate by coronary heart disease alone, for smokers and nonsmokers, you find a similar shift of 8 years, doubling the age-specific death rate by heart disease for one-pack-a-day smokers—that is, at a given age, such as 50, a one-pack-a-day smoker has twice as much chance of dying of heart disease as a nonsmoker, and a two-pack-a-day smoker has four times the chance of dying of heart disease as a nonsmoker. The same effect is also found for other diseases.

The incidence of disease—not just the death rate, but the morbidity, the number of cases of disease—as well as the mortality, is also twice as great at a given age for a one-pack-a-day smoker as for a nonsmoker. The average smoker is a one-pack-a-day smoker, and about half of the people in the U.S. smoke. If cigarette smoking were abolished, there would be a four-year average increase in longevity and a four-year average increase in the length of the period of well-being.

But about vitamin C—Edmé Régnier, a physician in Salem, Massachusetts, wrote some papers about vitamin C and the common cold and then got out a book, *You Can Cure the Common Cold*. In this book he describes the studies he carried out with his friends and patients. He decided some 15 years ago that vitamin C in proper doses had value against the common cold, and he gave tablets to his friends and patients, sometimes a vitamin C and sometimes a placebo, with instructions that they were to take a tablet every hour at the first sign of a cold and continue throughout that day and the next day. He reported that 90 percent of the colds were averted by the simple procedure of taking only a few grams of vitamin C per cold.

After five years Régnier had to give up his study because his telephone began ringing in the middle of the night and one of these people would be saying, "You gave me the wrong tablets," because the cold didn't go away as it had before.

I don't know why it is that there has been so much opposition by the establishment to vitamin C as a way of controlling the common cold and other diseases, but there has been. A couple of years ago I wrote a paper with Ewan Cameron on "Ascorbic Acid and the Glycosominoglycans: A Contribution to the Orthomolecular Treatment of Cancer." Cameron is a cancer surgeon in Scotland. We talked about where we would publish the paper, and I said, Why don't I send it to the *Proceedings of the National Academy of Sciences*? So I did, and it was turned down. The policy of the NAS had then been for 58 years, since it was started, that a member had the right to publish papers, but they decided to change the policy and turn this paper down.

When word of this leaked out—I didn't say anything, but an article was published in *Science* about it—I got a telegram from the editor of *Oncology*, saying that their policy was that papers were not accepted for *Oncology* until they had been refereed and examined thoroughly, but in this case they would accept the paper sight unseen. So it was published 14 months ago, and although many people have written for reprints, it hasn't caused any great stir so far as I am aware, and the dangers stated by the editorial board of the NAS that we would be raising false hopes in people haven't materialized.

I think there's no doubt that ascorbic acid is helpful in preventing and treating cancer, but there is still doubt as to how great its benefit is. There are good arguments. You know ascorbic acid is required for the synthesis of collagen; connective tissue contains collagen fibrils, and the tissues are strengthened by an increased intake. It's valuable for wound healing. There is little doubt that the proper intake of ascorbic acid strengthens the tissues enough to permit them to offer increased resistance to infiltration by a growing malignant tumor. There is also evidence that ascorbic acid works against the enzyme hyaluronidase, probably by facilitating the synthesis of hyaluronidase inhibitor. Many cancerous growths produce this enzyme, which attacks the hyaluronic acid in the intercellular cement of the surrounding tissues and weakens these tissues in such a way as to permit infiltration by the cancer.

When I spoke at the dedication of the Ben May Laboratory for Cancer Research at the University of Chicago in November 1971, I said that with the proper use of ascorbic acid the mortality from cancer could be reduced by about 10 percent. I am now willing to make an estimate that the age-specific incidence of this disease might well be decreased by 50 percent. In fact, I think it may well be that with ascorbic acid alone, a proper intake—getting people back to the level of animals that manufacture their own ascorbic acid; perhaps we might say to the natural level—the age-specific morbidity and mortality in general can be decreased by 50 percent. This means an extension of the period of well-being by 8 years, and an extension of the life expectancy by 8 years.

With the proper use of ascorbic acid the mortality from cancer might well be decreased by 50 percent

I am now director of the Institute of Orthomolecular Medicine in Menlo Park, a new institution just across from the Stanford campus; the assistant director is a former Caltech student, Arthur B. Robinson, who received his BS in chemistry in 1963. I invented the word "orthomolecular" in 1968. It is from the Greek "ortho," meaning right or correct, as in "orthodox"; and "molecular," meaning molecular. "Orthomolecular" means the right molecules in the right amounts—having the right molecules in the right concentrations. The right molecules are those that are normally present in the human body. Many of them are required for life—such as the vitamins and essential amino acids. Orthomolecular medicine is the prevention and treatment of disease, the preservation of good health, by varying the concentration

continued on page 28

Good Nutrition for the Good Life

. . . continued from page 9

of these molecules in the human body. The powerful drugs that are used by doctors, who treat crises with these crisis drugs, do the job, but they usually have serious side effects and you have to be careful about them. In particular they shouldn't be taken day after day, whereas the vitamins can be taken day after day for the rest of your life.

The paper in which I introduced the word orthomolecular had the title "Orthomolecular Psychiatry." In 1954 I began work here at Caltech with the support of a grant from the Ford Foundation and later from the National Institute of Mental Health on the molecular basis of mental disease. After some time I learned about the work of Drs. A. Hoffer and D. Osmond in Saskatoon, Saskatchewan. Hoffer had observed that large doses of one of the B vitamins, the antipellagra vitamin nicotinic acid, niacin, seemed to be beneficial to schizophrenic patients. Hoffer and Osmond carried out the first double blind test done in psychiatry, and they concluded from the results of this test that, taken in amounts of several hundred times the amount that will prevent pellagra, the substance did have value for many schizophrenic patients—especially young, acute schizophrenics who were hospitalized for the first time.

I wrote a paper in 1968 in which I presented a number of arguments about why megavitamin therapy should be especially valuable for mental disease. This argument appealed to people who were using this therapy to such an extent that there is now a journal named *Orthomolecular Psychiatry* and an International Academy of Orthomolecular Psychiatry, and a book, *Orthomolecular Psychiatry*, published a year ago—of which a psychiatrist, David Hawkins from Long Island, and I are co-editors—about the basis of megavitamin orthomolecular treatment.

I believe there's no doubt that the statements made by the orthomolecular psychiatrists are right. The ordinary treatment with the use of phenothiazines mainly for acute schizophrenics leads to about 35 to 45 percent success. This means that 35 or 45 percent of these acute schizophrenics are released from the hospital and do not suffer a second hospitalization. But if they also receive orthomolecular treatment in addition to the phenothiazine and whatever else the psychiatrist wants to give them, it is said that 80 percent of them are released and not hospitalized a second time. They are to continue the vitamins the rest of their lives. The phenothiazine they stop taking quickly.

In my paper, I pointed out that the brain is probably the most sensitive of all organs to its molecular composition, and that it is not surprising that the megavitamin therapy should have been developed first of all for mental disease. But it is valuable also for physical disease.

The amounts given these schizophrenic patients vary—they are not the same for individual patients, but they usually run about 6 grams a day—4-8 grams of ascorbic acid, about 8-20 grams a day of niacin or niacinamide, and about 400-800 milligrams of pyrodoxine and sometimes 400-800 units of vitamin E and thiamine. These all vary, but usually with emphasis on ascorbic acid and niacinamide.

Vitamin E is an important substance. The Food and Nutrition Board brought out a few months ago a statement to the effect that they have reduced the daily recommended dosages of vitamin E from 30 milligrams to 15 units. It's hard to know why they have reduced it, but I believe it would have been wiser to increase it. Perhaps one reason for reducing it is that the big food companies have begun stripping the cooking fats, the oils, of their vitamin E so that the fats you eat don't contain as much vitamin E as they used to. Then they sell the vitamin E, and it's rather high priced—nearly $100 per kilogram. (Vitamin C can be be purchased for $7.50 per kilogram as pure crystals, and it is cheapest this way.)

Well, about vitamin E—in the Food and Nutrition Board report they said that there is no evidence that any disease, except one rare disease among infants, is benefited by taking large doses of vitamin E. So I wrote to Jean Mayer, professor of nutrition at Harvard, who has a newspaper column in which I first saw this reported, and asked him why he made the statement (he is a member of the committee) in light of the report by Knut Haeger of Sweden about peripheral occlusive arterial disease, and the other reports on this disease. And he replied by a letter in which he said that he was asking the Food and Nutrition Board to send me a copy of the statement, and that was all. The statement arrived, and it was just as he had quoted it. So I wrote to the chairman of the Food and Nutrition Board three months ago asking why they made this statement in the light of Haeger's results, and I haven't gotten an answer from them.

Knut Haeger published a paper in 1968 about a seven-year study he had made of patients with peripheral occlusive arterial disease. He had 220 patients under observation—people perhaps with diabetes or prediabetic conditions who have hardening of the peripheral arteries with a decreased flow of blood to the extremities; sometimes they get gangrene in the foot. He gave half of them 300 units a day of vitamin E and the other half a placebo. They were age-matched so that the average ages were the same in these two groups. During the seven years of the study, one of the vitamin E patients had to have a leg amputated because of gangrene, and 11 of the control group had to have legs amputated; this difference has high statistical significance. It's not a statistical fluctuation—one chance in a thousand of that. Nine of the vitamin E patients died during the seven years, and 19 of the control patients. This difference has borderline statistical significance—about 10 percent chance of its being a statistical fluctuation.

These people have what is called intermittent claudication—that's a highbrow name for limping occasionally. They can start out walking at a good rate; after they have walked a while, they develop angina in the calves of the legs. The work of the muscles uses up the oxygen so that they have to stop walking because of the pain caused by anoxia. It takes about six months for them to get in a stable state. After about six months, though, the vitamin E subjects could walk on average about twice as far as the control subjects before they developed claudication, and this is statistically significant too—the standard deviations are such that the difference is statistically significant. There are a number of other studies that report essentially the same thing.

Haeger asked the question, Who is it who believes that angina in the calves of the legs is different from angina in the heart muscle caused by anoxia? There have been no good double blind studies made of vitamin E in relation to heart disease. But Wilfred and Evan Schute in Canada treated 30,000 heart patients by giving them large doses of vitamin E, and they report that there is no doubt they are benefited. For example, a Dr. George wrote them about himself. He had diabetes and had a leg amputated because of gangrene—poor circulation—and then after that he heard of the work the Schutes were doing and he started taking vitamin E. He was scheduled to have the other leg amputated, but it healed when he took the vitamin.

And yet the medical profession as a whole has rejected this evidence in the same way that they have rejected the evidence about the value of vitamin C for the common cold and other diseases.

Now I don't know just what the optimum intake of vitamins is. I take 1,200 units of Vitamin E per day, which gives an indication of what I judge to be the sensible thing to do. And I take super-B vitamins every day which contain 50 milligrams (that's about 25-30 times the recommended daily allowance) of thiamine, and 50 milligrams of riboflavin and 50 milligrams of pyridoxine, and 100 milligrams of nicinamide (though I usually take 300-400 milligrams of nicotinic acid separately too) and a multivitamin tablet that gives me 4 000 units of vitamin A plus other vitamins and minerals, and sometimes I take 25,000 units of vitamin A. I am trying to see if I can discover what the optimum intake of vitamin A is. But this is a hard problem. I think there should be hundreds of millions of dollars expended on finding out what the optimum nutrition is for a human being.

Avoid sucrose, take a fair amount of vitamins, stop smoking cigarettes, and you'll have a longer and happier life

I think that vitamin E has great value, and that these other vitamins have value, and I'm willing to estimate that the morbidity and mortality of various diseases and the rate of aging can be decreased by another factor of two in this way.

There's one more nutritional orthomolecular treatment that I'll mention. This is a negative one involving sugar—sucrose. John Yudkin was professor of biochemistry and nutrition at the University of London 15 years ago, and he published a paper on his research on sucrose in relation to heart disease. He studied the incidence of heart disease as a function of the amount of sugar ingested, and he concluded that people who take 120 lbs of sugar per year have six times the chance at a given age of coming down with coronary heart disease as people who take 60 lbs per year or less. Those who take 150 lbs or more a year have 15 times the chance at a given age of developing coronary heart disease as those who take 60 lbs or less.

Two hundred years ago practically no one got any sugar. And the intake—you get small amounts in fruit and honey—measured up to 15-20 lbs per year. The average in the U.S. is now over 100 lbs per year. It's 110-120 lbs in England, and Holland, and some other countries. This is an unnatural situation, to ingest so much sucrose—and it is harmful. A study was made by Milton Winitz, a biochemist, in the state correctional institution at Vacaville. He got 18 volunteers in a locked ward and fed them a small-molecule diet consisting of 17 amino acids, a small amount of essential fat, all of the vitamins in the recommended daily amounts, and all of the essential minerals, and glucose as the only carbohydrate. He measured 26 clinical characteristics and found that they all stayed the same when the prisoners went from the prison diet over to this chemically determined diet—except one. The serum cholesterol dropped from 207 milligrams per deciliter average to 155 average within a month. Within a week it was down half way. After a few months the patients complained about the taste of the food, so Winetz replaced a quarter of the glucose with sucrose—with everything else the same—and the serum cholesterol went back up to the original level. It's the sucrose—not the carbohydrate—that's the culprit.

I believe that if people were to avoid sucrose—hardly ever spoon out a spoonful of sugar from the sugar bowl onto anything, avoid sweet desserts except when you're a guest somewhere, avoid buying foods that say "sugar" as one of the contents—they could cut down on the incidence of disease and increase life expectancy. Take a fair amount of vitamins. Stop smoking cigarettes. And you'll have a longer and happier life—more vim and vigor and a better time altogether. □