The Nutrition Triangle

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All of us spend a considerable fraction of our time eating. But most of us have not spent any appreciable amount of time on a scientific study of how to specify what we eat or how to determine the optimum nutrition.

1. The Mathematics of Nutrition

The first step is to develop a coordinate system in which our diet can be specified. Since all foods are made up of proteins, lipids and carbohydrates it is possible to specify our food at any meal by a point in the interior of the nutrition triangle, Fig. 1. The nutrition triangle could be drawn with the sides at any angle. However, since we are accustomed to plotting points in rectangular coordinates it is convenient to draw the nutrition triangle as a right triangle even though angles in nutrition space are meaningless. We are certain that we would not want to live on a diet that is pure protein, pure lipid or even pure carbohydrate so the significant diets are all represented by points in the interior of the nutrition triangle.

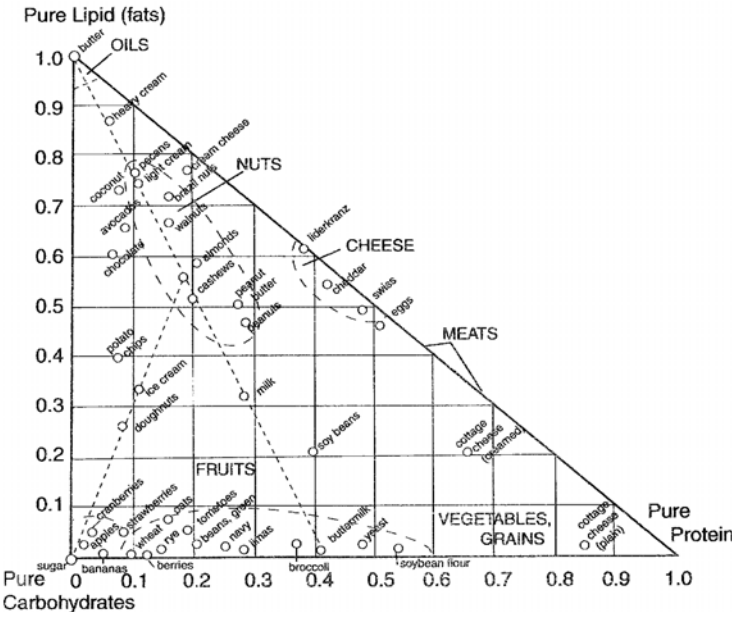

Fig. 1. The Nutrition Triangle

Butter, a pure lipid, is represented by the upper left hand corner of the nutrition triangle. Cottage cheese is close to a pure protein at the lower right hand corner of the nutrition triangle. Fruits, vegetables and grains are represented by points between the base of the triangle and the line representing 0.1 oil. Meats and cheeses are made up of proteins and lipids and are represented by points near the sloping side of the nutrition triangle. Avocados, chocolate, nuts and cream are represented by points near the top of the triangle [1].

How can we determine the optimum diet for human beings? Professor Moon and I wrote our first paper [1] on the geometry of nutrition in 1974. A more extensive paper [2] was published by Spencer, Mascardo and Tan in 1991.

The foods eaten by people in different countries vary widely. How can we determine the optimum balance point in the nutrition triangle? Fortunately, data are available for death rates in different countries and for the diets eaten by people living in those countries. In Fig. 2 the death rate per 100,000 from cardiovascular diseases in the 55-59 years age group is plotted versus the average daily consumption of animal protein (grams). Note that the highest death rate occurs in the United States, Finland and Canada where the consumption of animal protein is highest. The lowest death rate from cardiovascular diseases occurs in Japan, Portugal and Yugoslavia where the consumption of animal protein is less than 1/8 of that consumed in the United States.

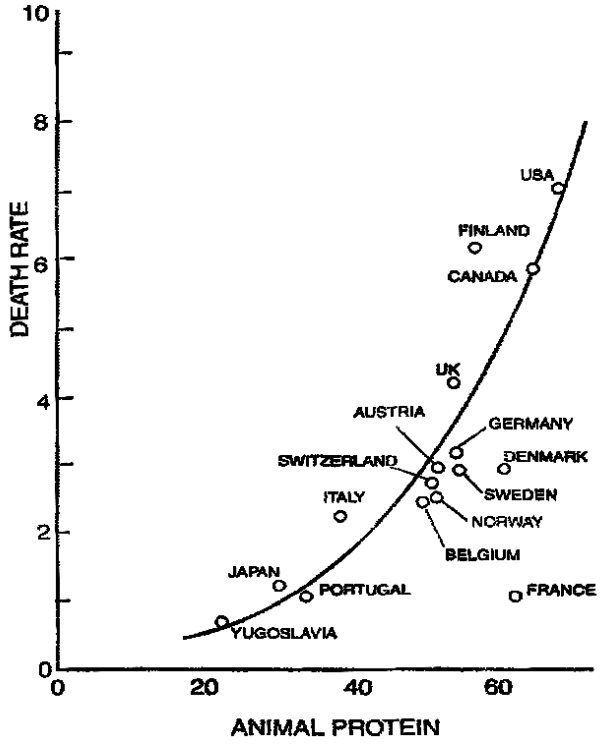

Fig. 2. Death rate per 100,000 from cardiovascular diseases for men in the 55-59 age group plotted vs. average daily consumption of animal protein

The balance points of the various countries shown in Fig. 3. Note that all the balance points in the nutrition triangle cluster about the vertical line at $n^1 = 0.14$. What should the balance point be in the vertical direction? In Fig. 3 we have suggested a value of $n^2 = 0.14$. However, the even lower value of $n^2 = 0.10$ is suggested by the low death rate in Japan and by the research on curing heart problems with diet [4] done by Dr. Dean Ornish.

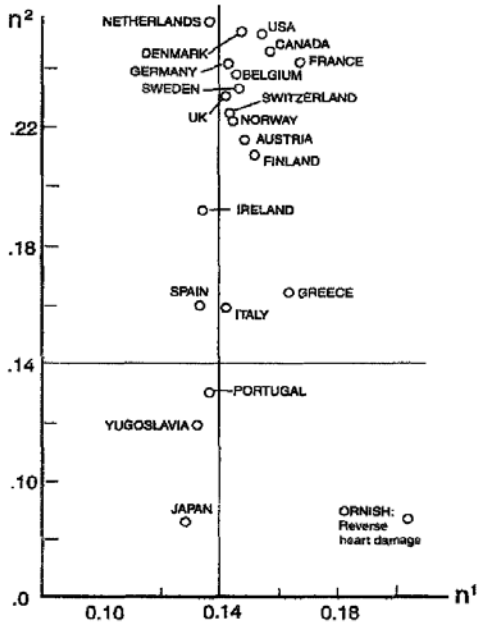

Fig. 3. Balance point in the nutrition triangle for various countries

In a remarkable book [5], Gruberg and Raymond have suggested that the degeneration of the lining of the blood vessels is a precursor to both heart attacks and strokes. They have concluded that the key to understanding arteriosclerosis is the homocysteine theory, Fig. 4. Low values of Vitamin B_6 in the diet combine with high levels of homocysteine in the blood. The walls of the arteries become thickened and the cellular linings of the blood vessels are damaged. The result may be a heart attack or stroke. The mathematical representation of the Gruberg and Raymond criterion is shown in Fig. 5. Plotting $H^1 = \text{mg}$ of methionine in the diet versus $H^2 = \text{micrograms of vitamin } B_6$ in the diet we have the graph of the *H*-vector. If the diet contains excess methionine, $H^1 > H^2$, the diet will tend to produce further arterial damage and to increase the likelihood of heart attack or stroke.

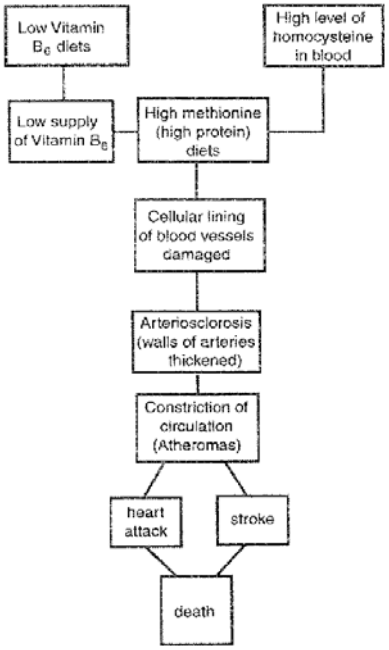

Fig. 4. Arteriosclorosis according to the homocysteine theory

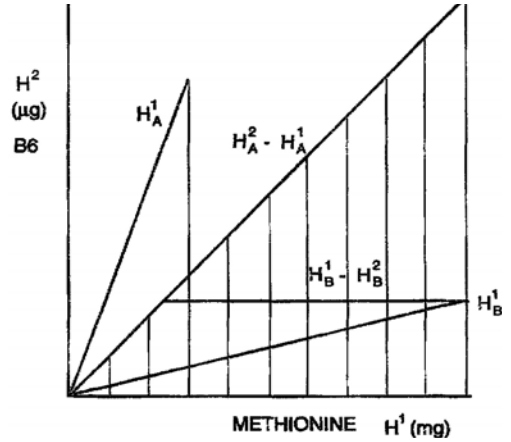

Fig. 5. The *H*-vector: $H^1 = \text{mg}$ of methionine; $H^2 = \mu\text{g}$ of B_6

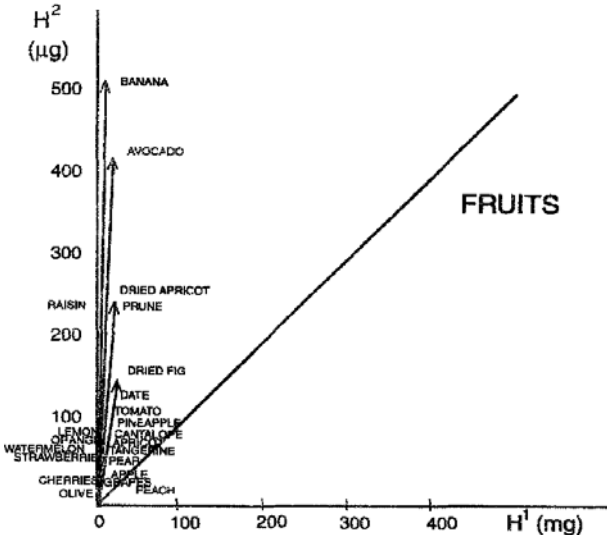

Fig. 6. *H*-vectors for Fruits

The *H*-vectors for fruits are shown in Fig. 6. Note that all of the *H*-vectors for fruits are in the healthful region. All of the fruits lie in the region above the slanting line and will tend to make people healthier and to reward them with longer lives. Bananas are represented by the longest vector which is always in the best direction. Not far behind are avocados, apricots, prunes and figs.

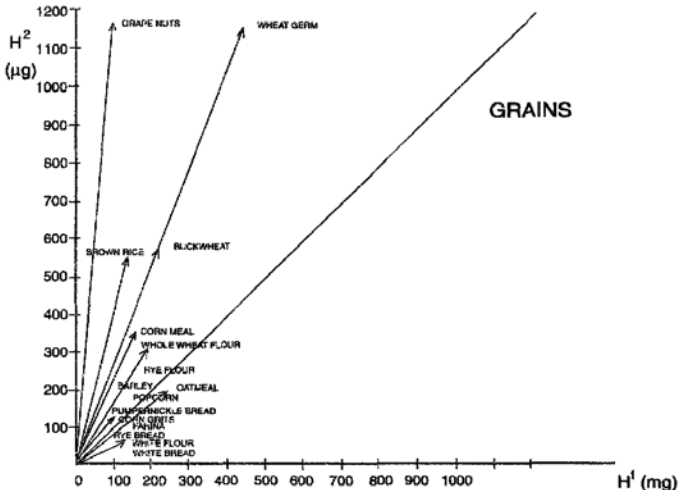

Fig. 7. *H*-vectors for Grains

The H-vectors for grains are shown in Fig. 7. Nearly all of the grains are in the healthful region. The longest vectors represent Grape Nuts and Wheat Germ. Nearly all the grains are in the healthful region including brown rice, buckwheat, corn meal, whole wheat, rye, barley and pumpernickel bread. However, oatmeal, rye and white bread are represented by short vectors in the unsatisfactory lower half of the diagram.

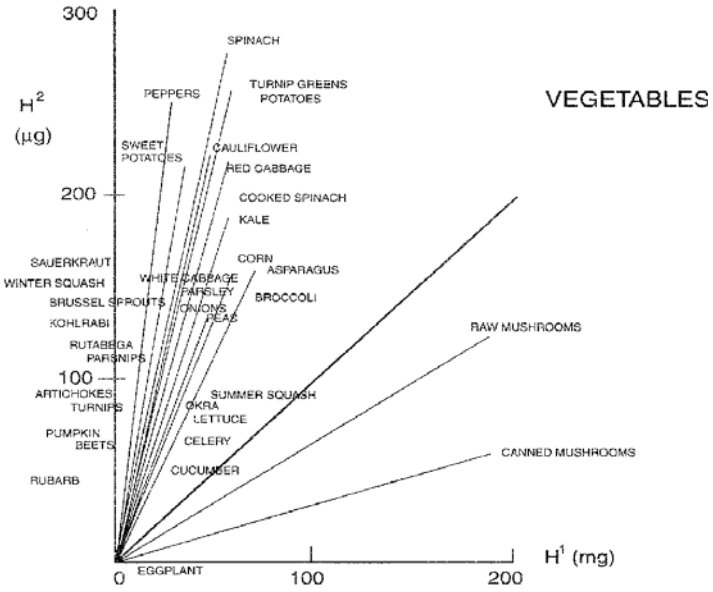

Fig. 8. *H*-vectors for Vegetables

The next illustration, Fig. 8, shows the H-vectors for vegetables. Note that the most nutritious are peppers, sweet potatoes and spinach. Only mushrooms are represented by vectors lying in the lower half of the diagram.

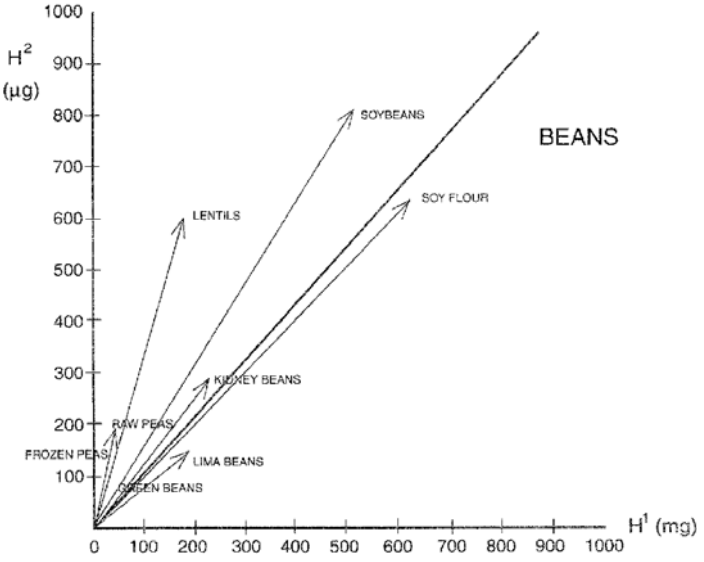

Fig. 9. *H*-vectors for Beans

The bean family is shown in Fig. 9. The most nutritious are lentils and soy beans. The only beans that are slightly undesirable are lima beans.

Nuts are shown in Fig. 10. Walnuts, peanuts and pecans are the most nutritious members of the nut family. Coconuts, almonds and Brazil nuts are represented by vectors in the undesirable region.

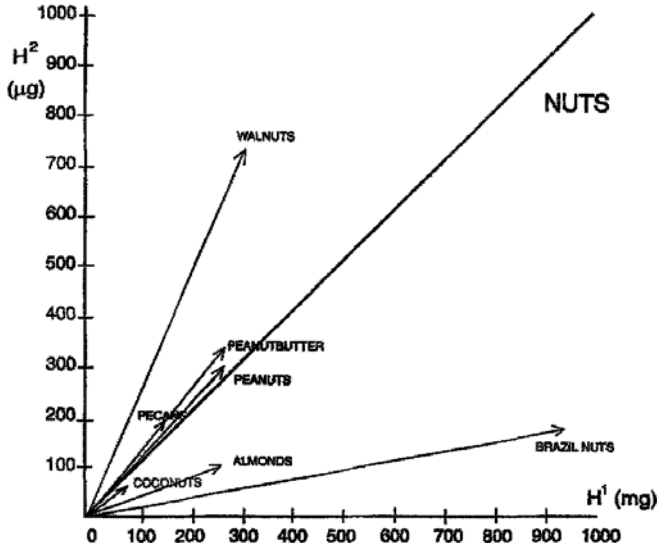

Fig. 10. *H*-vectors for Nuts

Dairy products are plotted in Fig. 11 Here all of the vectors representing eggs, milk and all varieties of cheese are in the unsatisfactory region. Only two varieties of raw fish lie slightly above the boundary between satisfactory and unsatisfactory foods.

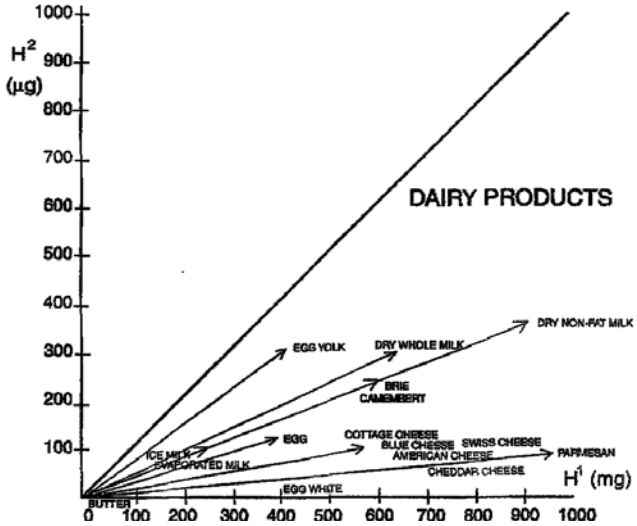

Fig. 11. *H*-vectors for Dairy Products

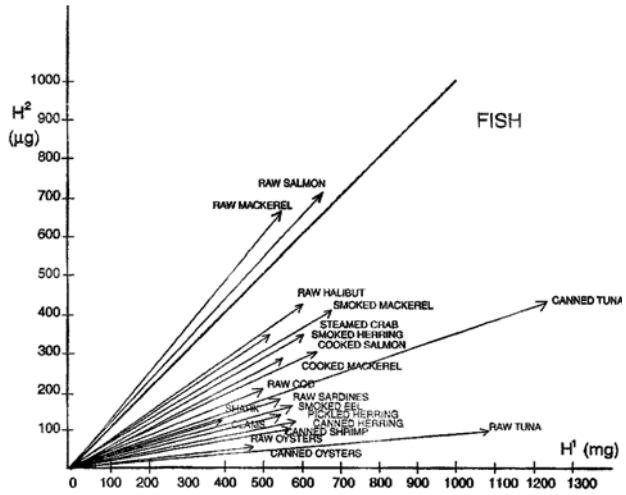

Fig. 12. *H*-vectors for Fish

The foregoing analysis can be summarized by stating that the representation of our diets in the nutrition triangle shows a way of visualizing the diets that will permit us to live the longest and healthiest lives. The optimum diets are represented by balance points in the vicinity of 0.1, 0.1 in the nutrition triangle.

Fish are shown in Fig. 12. Except for 2 varieties of raw fish, all are represented by vectors in the undesirable region. Meats shown in Fig. 13, are nearly all represented by vectors in the undesirable region.

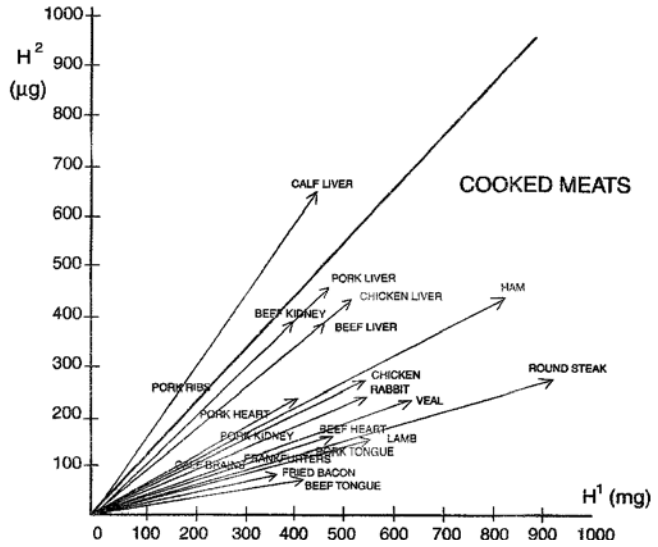

Fig. 13. *H*-vectors for Cooked Meats

2. Personal Testimony

Now I would like to conclude this paper with a summary of my own personal experience. Albert Einstein was born on March 14, 1879 in Ulm, Germany. Two days later on March 16, 1879 my mother, Ina May Eberle was born in New Castle, Pennsylvania. Mother was 21 years old in 1900. She wanted to go to college and have an education. As her childless aunt and uncle operated a boarding house for students across the street from a nearby college, she could easily have lived with them while attending a good college. But my dear grandfather Eberle would not allow it. The only higher education he was willing to permit was at a local business college. My mother went to work in the office of the largest furniture store in New Castle.

The owner of the furniture store was Andrew Berger Spencer, a tall (6 ft 4 in) handsome man who had a very different background. He was one of a family of a dozen children and was always devoted to his twin sister Rose. In his family education was not considered important. He was only allowed to finish third grade before he was expected to go to work. At the age of fifteen his right arm was cut off at the shoulder in an industrial accident. Eventually, he established the largest furniture store in New Castle, Pennsylvania where he hired my mother to work in his office.

Soon they were studying Italian together and he began to call Ina, Carina, an endearment translating to "Dear little one" in Italian. In 1906, they were married and had a wonderful honeymoon traveling by train clear to San Francisco where they explored the effects of the earthquake which had devastated that city earlier in the summer. In 1907, my blond sister, Vivian, was born. She was educated by private tutors and studied music and dancing. We lived at 1005 Highland Avenue in a house with large beautiful grounds containing an artificial lake and a large garden. In 1920, on September 26 I was born in the front bedroom of that house. My sister, Vivian, began to teach me about Jesus when I was 2 hours old. The painting she showed to me of Jesus and his cousin John the Baptist now hangs in my bedroom. By the time I was two years old I could read fluently. Vivian made learning a delight.

When Vivian was 16, Mother studied all of the nearby colleges and decided that the best one for Vivian was Oberlin College in Ohio which had been founded in 1833 and was the first coeducational college in the United States. Fortunately, our father had put our home in Mother's name. She never even considered applying for a scholarship at Oberlin. She sold our beautiful home in New Castle to obtain money to pay for Vivian's education at Oberlin College. When I was 4 and Vivian was 16 we moved to Oberlin, Ohio. Vivian soon decided that Mary Emily Sinclair, the first woman to obtain a Ph.D. in mathematics at the University of Chicago was her favorite professor and that she would major in mathematics.

In Oberlin I did not go to school as a child. I did my schoolwork with Vivian. Mathematics was a fun game I played with my big sister whenever she had a vacation. When I was six years old I began to study piano with Mrs. Miller at Oberlin Conservatory. At seven, I added the study of violin with Don Morrison. At nine, I started to study the flute. When other children were in school I won the reading contests at my Sunday school.

When Vivian was awarded a fellowship at the University of Pennsylvania where she did her Ph.D. thesis with a wonderful Russian named Shohat we moved to Philadelphia. I attended Friends Select School which was founded by William Penn in 1689. I studied Latin with Master Arnold who taught me to think precisely, French and defended FDR in Teacher Ruth's History Class and spent most of my spare time drawing and painting in the Art Room with Miss Balderston, and riding on horseback in Fairmont Park with Master Charles. In my junior year, I studied high school physics.

The summer I was fifteen Vivian thought it would be fun for me to take freshman physics at M.I.T. She wanted me to learn some calculus before I started my first course at M.I.T. I airily insisted that they did not use calculus in physics. They didn't in my high school physics course! So I arrived at M.I.T. innocent of any calculus. About a week after my course started I told my professor that I understood everything in the new assignment except the meaning of the strange symbol that resembled an "S". He told me it was an integral sign. So I telephoned Vivian who was by then Chief of the Census of Mineral Industries in Washington D.C. and told her that they did use calculus in freshman physics at M.I.T. Over the 4th of July weekend, Vivian came up to Boston and taught me enough calculus to survive freshman physics. She also discovered the Sailing Pavilion and bought me a red, white and blue sailing outfit. I spent as much time as possible for the next five years sailing on the Charles River Basin.

According to the officer in charge of awarding scholarships at M.I.T. girls were a bad investment. He said they either flunked out or got married. When the M.I.T. tuition was $500 per year he awarded me a $50 scholarship! I discovered advanced standing examinations. For no additional fee one could sign up to take

them. I spent my birthday taking two examinations and began to figure out how I could obtain three M.I.T. degrees for as little tuition as possible.

My best undergraduate physics professor was Julius A. Stratton, who later became President of M.I.T. I did my Bachelor's Thesis on the reflection of electromagnetic waves from an overcast sky under him.

When I was ready to start graduate work, I decided to change to mathematics. But I had never taken any mathematics course in either high school or college! So I walked into the office of the head of the mathematics department, Henry B. Phillips, and told him I wanted to do graduate work in his department. He leaned back in his chair, put his feet up on his desk and said, "I'm teaching advanced calculus, the most elementary graduate course, this fall. If you can do well in that course, I will give you credit for all your undergraduate mathematics. "He also suggested I register for Prof. Struik's couse in tensors. Within a month, Struik suggested a research topic in mathematics." What was the meaning of Study's, "Geometrie der Dynamen" which had been published in German in 1908? This was the first research in mathematics that I had ever heard about in any class. It became both my Master's and Ph.D. theses. I had discovered an exciting world of original scientific research.

The last year at M.I.T. they finally gave me a full scholarship. My advisor was quite determined that I should not register for any more courses-just finish my Ph.D. thesis. I was determined to get the most learning possible from my full scholarship. I insisted on registering for a course with a professor in the Electrical Engineering Department that I had heard about from my crews at the Sailing Pavilion. His name was Prof. Parry Moon. In the fall semester, I registered for his course in lighting design. In no time, Prof. Moon was suggesting ideas for new research. He pointed out that if students were working at slanted drafting boards in a room with rectangular windows; their actual light sources were both rectangular and triangular! In my spare time, I set to work on my first scientific paper: Calculation of Illumination from Triangular Light Sources. My former physics professor was also editor of the Optical Society Journal. He quickly accepted my paper. Before the spring, my first scientific paper was published. I was invited to give my first colloquium lecture. The fact that the secretary erroneously said that I would talk on "Triangular Lightning" made my lecture room thunderously overcrowded!

The last semester I registered for two courses with Prof. Moon, adding his course on Vector Field Theory. Thus began a magic collaboration that lasted until he died at the age of 90 in 1988 after we had collaborated on eight scientific textbooks and over 300 scientific papers-and had married and had a son, Dr. Euclid Eberle Moon who is now a research scientist in the Electrical Engineering Department at M.I.T. and already holds nine patents in the field of nanotechnology.

Now let us return to my talented mother. About 1900, she heard of the great vegetarian playwright, George Bernard Shaw, in Great Britain, and of the work of the Great Russian vegetarian, Tolstoy. She decided that being a vegetarian and never being responsible for the death of any fish or animal was a direct application of Jesus' admonition to do unto others as we would that they should do unto us. Certainly we would not like to be killed so that we could be eaten by a tribe of giants. So Mother decided to become a vegetarian about 1900. When she married my father six years later, and her parents wanted to continue to live with her, she said they could if they became vegetarian too. So my family has now been vegetarian for over a century.

My mother lived in excellent health until she was over 98 years old. The last Sunday she went to church, came home and lay down on the sofa for a nap while I cooked dinner. She walked to the dining room table with me and sat down. As I was offering her a glass of pineapple juice, suddenly she was gone! No illness! No suffering! And what a wonderful long life!

When I was born in 1920, my family had been vegetarians for twenty years! I have always been a vegetarian. I never had any illness in my childhood nor have I ever been sick in my long life! I still feel as though I were 16 because of my mother's perception in becoming a vegetarian over a century ago. My graphs and statistics prove that human beings are designed to live the longest and healthiest lives if they follow the ideals of Jesus of living in peace and harmony with all creatures that can receive our love.

References

[1] W. Day, **Bridge From Nowhere A Story of Space, Motion, and the Structure of Matter** (House of Talos Pub., East Lansing, MI, 1989).

[2] W. Day, **Bridge From Nowhere II, The Photonic Origin of Matter** (Rhombics, Cambridge, MA, 1996).

[3] W. Day, **A New Physics** (Foundation For New Directions, Cambridge, MA, 2000).