THE MYTH OF THE CALORIE

by

Dr. William M. Riggins, Ed. D.

publication information at:
sites.google.com/site/eulogiabooks
ver. 150 711

ACKNOWLEDGEMENTS

The author is deeply grateful for the help and inspiration he received from many sources. Prof. Joan Gussow of Teachers College, Columbia University was an adviser, supporter and critic in the best sense of each of these words. Sue Ruegg, and K. Joseph Hartman provided invaluable insight and editorial assistance.

Thanks also go to Dr. Paul Webb of Webb Associates in Yellow Springs, Ohio for his scientific objectivity and his friendly help; to Prof. Douglas Sloan of Columbia University for his insight and advice; to Prof. Robert McDermott of the Institute for Integral Studies for his guidance and inspiration; to Dr. Gerhard Schmidt of Dornach, Switzerland for his decades of nutrition research and for his personal help; to Helga Rincker of the Konnersreuth Circle in Bavaria for providing material about Therese Neumann; to Dr. Gregory Riggins of Johns Hopkins Hospital in Baltimore for research assistance; and to Nick Halkias and the staff of N. H. Laboratories in Harrisburg, Pennsylvania for technical support.

For generous financial contributions, the author thanks the trustees of the Future Values Fund, and also William and Margaret Riggins, Raun Griffiths and the late Walter Keller. Special thanks go to John Hartmann for his enthusiasm and faith in this project. Finally, the author acknowledges with gratitude the guidance and inspiration he received from the scientific works of Rudolf Steiner and Johann W. Goethe.

This work is dedicated to the spirit of truth which enlightens the souls of those who aspire to educate, heal and serve their fellow human beings.

Table of Contents

PREFACE TO THE SECOND EDITION

Since the research for this book was completed over twenty years ago, much has been made public on the subject of energy and nutrition. *Living on Light* (Ellen Greve a. k. a. Jasmuheen, 1998), *Life from Light* (Michael Werner, 2007), the film *In the Beginning there was Light* (P. A. Straubinger, 2010) and the hospital studies conducted on the Indian ascetic, Prahlad Jani in 2003 and 2010 are examples of this. They all claim that it is possible for a person to live without physical nourishment. More importantly, they show that the mechanistic view of the human body is increasingly being called into question. Skeptics and supporters alike of the phenomenon of "breatharianism" or "light nutrition" have made emotional and often overly broad or irresponsible statements. There have even been cases of people dying as a result of simply trying to give up food and water.

Perhaps an encounter with a person who lived without food can help to put this into context. Paramahansa Yoganana wrote about his meeting with Therese Neumann of Bavaria, whose life is discussed in this book. He recounts an exchange between himself and the holy woman of Konnersreuth:

> [Yogananananda:] "Your sacred life is a daily demonstration of the truth uttered by Christ: 'Man shall not live by bread alone, but by every word that proceedeth out of the mouth of God.'"
>
> Again she showed joy at my explanation. "It is indeed so. One of the reasons I am here on earth today is to prove that man can live by God's invisible light, and not by food only."
>
> "Can you teach others how to live without food?"
>
> She appeared a trifle shocked. "I cannot do that; God does not wish it." (Paramahansa Yogananda, *Autobiography of a Yogi*)

Thus, in her own simple and straightforward way, Therese is saying that human nutrition and energy metabolism do not simply pose factual questions. They also pose moral questions, questions of right and wrong: Can we understand the human body in a manner that is consistent with human dignity, with human freedom and with the divine-spiritual origin of the human soul? And can we apply this understanding to agriculture and nutrition in a way that respects the sacred nature of the world and ourselves?

"Light nutrition" is a case in point. There have been many saints and holy people who have lived for extended periods of time without physical food. But living without physical food does not make one holy. Vegetarianism is another example. Many holy people—like monks, nuns and ascetics in the eastern Christian and non-Christian traditions—live without meat. On the other hand, Lenin and Hitler—among other people who were anything but holy—were vegetarians, non-smokers and teetotalers. So obviously, vegetarianism alone does not make a person virtuous.

How, then, can we understand the relationships among nutrition, morality and holiness or spiritual development? The ultimate goal of mankind is to establish love on the earth. Christ said to his apostles:

> A new goal[1] I give unto you, That ye love one another; as I have loved you, that ye also love one another. (John 13:34)

At a certain point on the way to achieving the goal of true, unselfish love—which must by its nature be accompanied by true freedom—physical food becomes unnecessary. But let us be clear about cause and effect here. The moral and spiritual development is the *cause* and the dietary change is the *effect*. The work of Sorokin referred to

1 This word is often translated as "commandment". However, the Greek "εντολην" refers to the "telos" or ultimate goal. **Strong's Greek Bible Dictionary** writes: 1785 *entolḗ* (a feminine noun derived from *en*, "in," which intensifies *télos*, "reach the end, consummation") – properly, "*in* the end," focusing on the *end-result* (*objective*) of a *command.*

in Chapter 7-E, for example, can help to understand this. Love is an objective power in the universe, whose manifestation in the realm of biology is life itself, or "vital energy". As an individual incorporates and manifests this love, in freedom, profound changes in his physiology take place. Love of the creation and the will to heal and transform the earth replace the necessity to eat in order to live.

However, people may try to abuse their freedom and try to escape from the necessity of eating for egotistical reasons using various methods or techniques. Some may see the folly of this endeavor and go back to eating. Others may become ill or even die along the way. Still worse, some may succeed in "short-circuiting" the path of evolution, only to find themselves far from the path of true, divine love—the path which leads to becoming truly human. The dawn of the third millennium appears to be a time of great possibilities for spiritual development, for healing and growth on the path of love and freedom. However, it is also a time when we are confronted by new dangers and temptations, and therefore a time when we must develop greater powers of discernment and understanding.

The scientific research presented in this book is not as ground-breaking or surprising as it was twenty years ago. However, the moral and educational questions raised in it are perhaps even more relevant today than they were then.

W.R. — July 2015

I. INTRODUCTION

This work began as a quest. During his years of graduate work in the department of Nutrition Education at Teachers College, Columbia University, the author sought a bridge between the physiological phenomena of nutrition and the spiritual significance of food and eating which is seen in almost every culture and religious tradition. He saw it as his duty as an educator not only to teach about nutrition in a way that is factually correct and logically consistent, but also to offer a positive moral impulse which can help to lift up, ennoble and humanize present-day culture through the study of nutrition. It occurred to him that perhaps such a bridge could be found by considering the concept of warmth in nutrition, for although it is physical in expression and works in matter, it is not itself material. Thus, he set about exploring what modern nutrition scientists had to say on the subject.

He was at once led to the concept of the calorie, for this is the scientist's tool for expressing heat as a quantity. He had only the faintest idea of what he would find as he searched out the historic and scientific underpinnings of this concept. The quest took an unexpected turn when he discovered the words of a leading expert in the field of calorimetry who considered studies which measured the balance of energy in the human body and concluded that "the more careful the study, the more clearly there is evidence of energy not accounted for" (Webb 1980, 1300).

Another turning point occurred when the well documented case of Therese Neumann was brought to the author's attention after his research was well under way. Here was a woman who ate nothing but a daily communion wafer for nearly thirty-five years, from 1927 until her death in 1962. Therese Neumann was a living example of the spiritual approach to nutrition which the author had come to.

This quest may well last a lifetime. However, the time came when the results of the search were ready to be presented in the form of a doctoral dissertation. This work presents that dissertation with some minor changes by the author. It is offered in the sincere hope of bringing light into the field of human nutrition for both professional and lay-person alike.

II. SCIENCE AND THE CALORIE

A. Education, Science and Objectivity

Nutrition education is based on the science of nutrition. The educator relies on, applies and conveys the results of scientific research that is based on commonly accepted methods and assumptions and on a commonly accepted world view.

The history of science is the story of the transition from one world view to the next. Often, this transition is accompanied by heated and even bitter debate and invective as the proponents of the old and the new world views confront each others ideas. This is not surprising. To understand it, we might consider the Greek ideals of truth, beauty and goodness as they apply to science.

In judging a proposed statement from within a given world view, one need only be concerned with its truth. A true statement is accepted as fact and a false statement is rejected as error. But when we evaluate the world view itself, we must be more fully engaged. We must also use our aesthetic sense for beauty to see the elegance of its explanations and theories. And we must use our moral sense for goodness to evaluate the results of the world view—to "judge the tree by its fruits." Hence, we are challenged to attain a greater level of objectivity when examining a scientific world view than when considering a fact from within a given world view. Our arbitrary passions and prejudices, our accustomed habits, must be excluded from not only our thinking about truth, but also from our feeling for beauty and our will to do good.

This work is an examination of the concept of the calorie in nutrition science and education. Yet this task inevitably led the author to a fundamental examination of the world view within which the concept is currently used. The reader is therefore invited to exercise the enhanced objectivity we spoke of above, and to join the author in this examination.

Johann W. Goethe, the nineteenth century scientist, statesman and poet once said that he promised to be objective, but not impartial. Let us proceed in this spirit: free of prejudice, yet fully engaged and not lukewarm in portraying and presenting the truth which we find. For this is the spirit of true education.

B. Transitions

As the consciousness of humanity evolves, so does its scientific world view. In his classic book, ***The Structure of Scientific Revolutions***, Thomas Kuhn wrote:

> ...historians confront growing difficulties in distinguishing the "scientific" component of past observation and belief from what their predecessors had readily labeled "error" and "superstition." The more carefully they study, say, Aristotelian dynamics, phlogistic chemistry or caloric thermodynamics, the more certain they feel that these once current views of nature were, as a whole, neither less scientific nor more the product of human idiosyncrasy than those current today. (Kuhn 1970, 2)

Science is always changing. It is often easy to see the errors and limitations of previous world views. But, in order to make progress, we must look at the present-day scientific world view with the same objectivity, and to see it as just one phase in an evolutionary process.

An analogy might serve to make this more clear. Throughout the course of life, a person's world view changes. For example, as a toddler, one might believe in magic and believe that Santa Claus brings good things to deserving children. As an adolescent, one may believe that magic is nothing but sleight of hand and that there is no Santa. As an adult, one may believe that it is better to give than to receive, that there is magic in the spirit of generosity, and one may honestly teach little children that there is, indeed, a Santa Claus. Each of these views is true in itself and is appropriate during a particular period of life. However, it is inappropriate during the wrong period. A toddler who held the adolescent's view would be overly cynical. An adult who held the toddler's view would be naive.

What is true here for the individual also applies to whole civilizations. World views outlive their usefulness and become outmoded. Then, during a time of reexamination and upheaval, they are replaced.

The present is a time of such reexamination. This work is dedicated to reexamining one aspect of the presently dominant world-view (the old world view) and offering a context (the new world view) for understanding it which is, perhaps, better suited to the needs of the present. This process of reexamination is actually occurring in the field of physics. The increased sophistication of instruments for measuring the results of atomic phenomena led to a remarkable discovery. Rather than being able to make predictions with greater accuracy, physicists found that there are some occurrences which in principle cannot be predicted. In a book exploring the boundaries of modern physics, we read:

> One of the major revolutions in the realm of physics has been the increasing role of indeterminism—or the realization that it may be impossible to predict the outcome of an experiment no matter how much information we know about matter. Before the advent of quantum theory most physicists believed in a universe that was totally causal. On the level of quantum mechanical events, however, nothing even approaching causality has been found to exist. (Talbot 1981, 23-24)

More will be written about this below, primarily in the conclusion (Chapter VII).

C. What is a Calorie?

One of the most basic concepts used by nutrition educators is that of the calorie. A dietician counseling an obese client on how to lose weight might estimate the client's energy needs—and recommend a diet—based on calories. A school teacher might have the class compare the number of calories in various types of snack foods. An adviser to a hunger relief program might estimate the food requirements for a starving group of people based (among other things) on how many calories per day each person should receive. A nutritionist working for the food industry may propose a new version of a product which is lower in calories than the old version.

In each case, the educator is applying a theory which is generally held to be scientifically valid. We will call it the calorie theory of food or, for the sake of brevity, simply the calorie theory. It is the application of the theory of the conservation of energy to the human body. According to the theory, energy must be conserved; the energy value of the food taken in must equal the energy value of what is used up, stored or excreted by the body.

Physicists have defined a calorie as the amount of heat needed to raise the temperature of one gram of water by one degree centigrade at a certain temperature and pressure. The calorie theory of food is based on the idea that every food contains a certain amount of energy which theoretically could be released as heat and measured if the food were completely oxidized. This quantity of heat is the caloric value of the food. Furthermore, it assumes that the human body produces a quantifiable amount of energy in the form of heat, work and storage. This, too, can theoretically be measured in calories. Finally, it holds that the caloric value of food which a person eats is equal to the caloric value of the energy produced by that person's body (minus the caloric value of whatever is excreted or stored) when the food is metabolized.

D. Calories and Life

The application of the laws of thermodynamics—including the law of the conservation of energy—to inorganic matter has proven to be a great success. But we must question whether this application can be transferred to the human body. We must wonder whether scientists in the fields of biology and human physiology have not become intoxicated with the success of the physical sciences. Have they tried to apply methods and presuppositions which are appropriate to non-living things wrongly to the phenomena of life? If so, the implications for the field of nutrition education are far-reaching.

Thus, we ask two questions. First, can calorie theory be practically applied to the human body in a way which brings greater understanding or health? Second, does the calorie theory of food apply to the human body, i.e. is it correct to teach people that the law of the conservation of energy always applies to the human body?

To answer this question, we will begin with an historical overview of western thought about heat and nutrition. We will then examine whether or not the calorie theory, as currently understood, can usefully be applied to the human body. This will lead to looking at whether or not the theory actually has a firm experimental basis to confirm its truth. Finally, we will look at a case where all the evidence points to the fact that the calorie theory of food did not apply.

III. A BRIEF HISTORY OF WARMTH IN NUTRITION

A. The Classical Concept

A radical change took place in the view of warmth in nutrition during the eighteenth and nineteenth centuries. The basic scientific world view which was established at that time still holds sway today.

We may think of this change in terms of the centuries-old debate in western science between the proponents of vitalism and those of mechanism (Asimov 1964, 25). Stated briefly, vitalism holds that life has a nature, and is subject to a lawfulness, of its own. Living phenomena can only be compared to inanimate objects by means of rough analogies. Mechanism, in contrast, holds that all living phenomena can be reduced to and explained in terms of the laws of physics. Living entities are essentially mechanisms, differing only in complexity, but not in quality, from machines.

The transition which took place in scientific thinking after the Renaissance was a gradual shift towards more general acceptance of the mechanistic view of life. This, of course, was intimately connected with the scientific view of warmth in living beings.

In order to understand this change—and thereby to understand the ideas underlying the modern concept of warmth in nutrition —we need to look at the scientific world view which preceded it. This world view reached the flower of its expression in the writings of the ancient Greeks, especially Hippocrates (c. 460-377 BC), Aristotle (384-322 BC) and Galen (c. 130-200 AD).

Their view of the process of digestion and the generation of warmth in the human body was the result of a basic philosophical orientation. The ancients held that every realm of phenomena requires a method of knowledge which is appropriate to it. Living phenomena are fundamentally and qualitatively different from non-living phenomena. Likewise, sentient creatures (beings endowed with perception and feeling) are different from other living creatures. Thus, they say that the sciences of physics, biology and psychology must each be unique and independent from one another.

To the ancient mind, the laws of biology could not be reduced to physical laws. To be sure, they saw analogies and similarities. The warmth from a wood fire, the bodily warmth of a cow or a horse, and the psychological warmth of a kind or generous person were seen to be similar to each other in *quality*. Yet in *essence*, they were held to be fundamentally different from one another.

For example, Hippocrates, wrote about something which the ancient scientists called "innate heat." It was thought of as the warmth generated by humans and warm-blooded animals. Hippocrates taught that breathing nourishes the "internal fire" —i.e. what we might call metabolism today—of the "innate heat." He saw an analogy between vital warmth and the fat in food, on the one hand, and fire and wood on the other hand. Just as the fire consumes wood to produce heat, so does the vital warmth metabolize fat to produce heat. However, like all Greeks of that time, he held that the "innate heat" is a motive power "outside the range of physical causation" (Mendelsohn 1964, 22).

Aristotle put forth a similar teaching (Mendelsohn 1964, 9-12). He held that the heart is the center of the "innate heat" of the human body, as well as the seat of the human soul. For him, breathing served only to cool the body. Likewise, since the soul was seated in the heart, the brain merely served the purpose of cooling the blood. Like Hippocrates, he maintained that elemental fire (physical warmth) is an earthly element. The "innate heat," in contrast, is cosmic in origin. It comes from the stars and is derived from the "ether," the so-called "fifth essence" (quintessence) which gives form and purpose to the four elements of earth, water, air and fire. Just as the sun gives life to plants and animals on the earth, so does the "innate heat" give life to the body. It was, for Aristotle, like a bit of the sun internalized in the organ of the heart.

The basic outline of Aristotle's theory can be found in the work of his teacher, Plato. In the ***Timaeus***, he speaks of bodily warmth as "vital heat." He calls it "the cutting power which aids in digestion" (Plato 1978, 80-d). He too saw the heart as the center and origin of this heat, and held that the lungs merely serve to cool the body.

The last of the great ancient thinkers to influence the western concept of warmth was the second century Greek physician, Galen of Pergamon (Mendelson 1964, 20-22). He taught that the "innate heat" causes and directs the process of digestion. He recognized the role of respiration in the generation of warmth, and saw an analogy between metabolism in the human or animal body and combustion of inanimate objects. Both, he notes, require fuel and air, and both produce waste products and heat.

Nonetheless, Galen, like his predecessors, held that bodily warmth and external heat are fundamentally different in origin and quality. The "innate heat" can only exist in living beings. Indeed, he held that this "innate heat" produces both motion and sensation by its action in the blood of animals and humans. Therefore, it is only to be found in these living creatures.

B. The Transition to Modern Science

The ancient conception of vital warmth held sway throughout the Middle Ages and Renaissance. It saw great proponents (such as Paracelsus) at the end of the Renaissance, and then began gradually to fade.

Jean Baptista van Helmont (1614-1672) was a supporter of the classical ideas of warmth and digestion as they began to fade. Van Helmont held that life is a chemical process (Asimov 1964, 27). More precisely, he called it an alchemical process. That is to say, it involved the transmutation of substances: it raised matter from the sphere of the physical to the sphere of the living. Nonetheless, as with the ancient Greeks, these two spheres were essentially different for him.

However, van Helmont's student, Franz de la Boe put forth the idea that digestion is a merely chemical process (Asimov 1964, 27). He said that digestion in a living organism is not merely analogous to an inorganic, physical process, but rather that it is essentially similar to one. Specifically, he held that digestion and fermentation were similar processes. Of course, to understand his position, we must recall that microscopy had not yet been developed in his time. Thus, the micro-organisms which cause fermentation were unknown, and it was held to be a merely chemical reaction.

With de la Boe we have, already in the seventeenth century, the assertion that a physical process is identical to a process in a living organism. This century also saw the work of William Harvey, the scientist who discovered the circulation of the blood in modern times. In 1628, he published a theoretical calculation of the amount of blood pumped by the heart (Asimov 1964, 24).

Although this did not apply directly to digestion and the generation of warmth, it nonetheless bears on our theme for two reasons. First, it is the first application of mathematical physics to the human body. By calculating the amount of blood pumped by the heart in the same way one would calculate the amount of water moved by a mechanical pump, Harvey was saying that the laws of inorganic, physical nature also apply to life processes. Second, this approach relegated the heart—the seat of the soul and the center of the "innate heat" for the ancients—to a simple mechanism, a mere pump. This, of course, opened the door to a wholesale attack on the idea of "innate heat." If it does not derive from the "ether," via the heart—as Aristotle taught—then perhaps its origin is no different than that of heat produced by combustion.

The major attack on the classical conception of warmth did not, however, come until the eighteenth century. In 1752, René de Réaumur tried to prove that the process of digestion can be independent of a living creature. He removed the digestive juices from a hawk's gizzard and applied them to a piece of meat (Asimov 1964, 46). When he saw that the meat was dissolved, he concluded that this dissolution must be the result of a chemical process since it can take place outside of the body of the living animal. However, the fact that the digestive juices had their origin in a live creature made his argument less than compelling.

C. The Quantification of Living Warmth

A milestone was soon reached in the theory of warmth. In 1772, the French scientist Antoine Lavoisier (1734-94) made a significant breakthrough in applying the law of the conservation of matter to non-living things. He discovered that air plays a role as an agent in some chemical reactions such as combustion, the oxidation of metals and the reduction of ores (Guerlac 1961, 85). He then set about to apply the same reasoning to living organisms.

In 1777, Lavoisier put forth his theory of respiratory physiology. He held that the life process of metabolism is essentially the same as combustion (Asimov 1964, 90). Both combine fuel and oxygen, and both produce warmth and waste products. Like the other scientists in the French Academy at that time, Lavoisier believed that all production of heat was the result of "an elastic, imponderable fluid surrounding all particles of matter" (Welch 1991, 1902), which was called calorique or "caloric" in English. He held, furthermore, that the nature of this caloric was identical in both living and non-living entities, and that it could be quantified and measured in both cases.

To prove this, he and Pierre Simon de Laplace set about measuring the heat produced by animals from about 1780 to 1785. They developed an "ice calorimeter" (Welch 1991, 1903). This involved an outer chamber filled with ice, and a basket suspended in the center of it. A guinea pig was placed in the basket for ten hours, and was found to melt thirteen ounces of ice. In addition the amount of "fixed air" (carbon dioxide) produced by a guinea pig in ten hours was measured.

Then carbon was burned to produce the same amount of carbon dioxide as was given off by the animal. That same amount of carbon was then placed in the ice calorimeter, and was found to melt

10½ ounces of ice. Lavoisier reasoned that, since 10½ is approximately equal to 13, the amount of heat released by a living animal and a burning charcoal is the same when they produce the same amount of "fixed air" (McKie 1952, 144).

His conclusion was as follows:

> Respiration is therefore a combustion, admittedly very slow, but otherwise exactly similar to that of charcoal; it takes place in the interior of the lungs, without the evolution of light, since the matter of fire set free is immediately absorbed by the moisture in these organs. (McKie 1952, 145)

As one can see, this apparatus could give only rather crude results. Moreover, the researchers appear to have simply ignored results which did not fall within their rather wide margin of error. But Lavoisier was convinced that his theory was correct, and the spirit of the times — the "age of enlightenment" — so favored a quantifiable, rationalistic approach to living phenomena that research in this direction continued.

With the beginning of the nineteenth century, the idea of "caloric" began to fade. Rather than thinking of heat as something unique unto itself—as a "primal phenomenon" in the sense of Goethe (Bortoft 1986, 15)—scientists began referring to the amount of work it could do. In 1807, the English physicist Thomas Young used the term 'energy,' from the Greek en (within) and ergos (work) (Asimov 1964, 48). This included movement, heat, light, electricity and magnetism.

By being subsumed under the concept of energy, heat could now be evaluated according to its power to move physical objects. The attitude of the ancients toward the "innate heat" was one of reverence: the "vital warmth" derived from the heavens and made possible the life of the body as well as the earthly life of the soul. In contrast, the new attitude toward heat as energy was strictly utilitarian. Heat was measured, analyzed, quantified and put to use for the purpose of moving things. It was appreciated not for what it could reveal about the nature of life, but for the power it gave to humankind to satisfy their needs and wants.

D. 1842 and the Triumph of Mechanism

The year 1842 marks a watershed in the history of the biology of warmth. It was around this time that the English physicist James P. Joule demonstrated the interconvertability of heat and work. The measure of work which bears his name is, in fact, used today (especially in Europe) as a measure of the heat value of food.

At the same time, Julius Robert von Mayer spoke of the unity of all forms of energy (heat, motion and electricity). He went on to develop the concept of energy transformation in animals—that is to say that animals transform the heat of combustion into motion.

Meanwhile, it was in 1842 that Justus von Liebig set the stage for our modern analysis of the caloric value of foods. In that year, he separated the three macro-nutrients and went on to determine a rough average caloric value for carbohydrates, proteins and fats (Asimov 1964, 90).

Liebig—who is also credited as being the father of chemical fertilizers—was one of the strongest proponents of the mechanistic view of biology. He was convinced that all the forms and functions of living things can be derived from the laws of inanimate nature, from chemistry and physics. The contrasting view, the theory of vitalism, as we have seen, holds that life is a unique phenomenon which cannot be reduced to, or explained by, inanimate causes. Vitalists therefore believe that a living organism (unlike a machine or an inanimate object) is more than the sum of its parts. They would say that it is composed just as a piece of music is composed; the context, order and rhythm of the notes are just as important as the number of times each particular note occurs.

Thus, Liebig was attacking the heart of vitalism with his work. He spoke of the composition of a foodstuff as being simply how much water, carbohydrate, protein, fat, fiber and ash it contained. Rather than speaking about the vivifying quality of foods, he spoke of how much energy they provide upon being burned. He was aware of the discrepancies in Lavoisier's calculations. However, he believed that they were simply the result of mismeasurement or other experimental error, and that an animal could not produce any more warmth than what was accounted for by the amount of carbon dioxide it produced (Shenstone 1895, 133).

E. Mechanism and Animal Life

From Liebig's approximate calculations of the caloric values of the macro-nutrients until the use of the bomb calorimeter by Pierre Berthelot in 1879 (Schmidt 1985, 16), the idea that animal warmth is the result of a combustion process became firmly entrenched in scientific circles. Despite objections from the proponents of vitalism—Louis Pasteur (1822-1895) being one of the most famous—the mechanistic view of life came to hold sway in the thinking of the time.

In 1847, Hermann von Helmholtz derived a mathematical formulation for the first law of thermodynamics, the law of the conservation of energy. Neither he, nor apparently any other scientist at that time, claimed that this law could be applied to the human body. He did, however, seal the fate of the ancient concept of "innate heat" by demonstrating that all living tissues—not just the blood or the heart—produce heat and consume oxygen. The door was thus open to the idea that respiration (understood as a form of combustion) took place throughout the entire body.

Based on this idea, several apparatuses for measuring the energy metabolism of animals were developed. One example was made by Henri Victor Regnault (Welch 1991, 1904). It involved sealing an animal in a glass chamber. The amount of oxygen consumed and the amount of carbon dioxide produced were measured. In addition, the excretions of the animals were collected and analyzed for combustible substances. Based on these measurements, a theoretical value for the amount of food "burned" could be calculated and compared to the change in the animal's weight. This all proceeded "under the proviso that the organism is a heat machine" (Welch 1991, 1904).

The calorie was extolled as a measure of the ability of a foodstuff to enable warmth and movement in an animal. In contrast to our modern popular aversion to high-calorie foods, it was thought that the calorie, in essence, measured the very ability of a food to provide life. This idea was deflated in the early 1850's by the work of François Magendie (Asimov 1964, 86). He discovered that the caloric value of food alone is not sufficient to sustain life.

He fed dogs a diet of sugar, olive oil and water and found that they could not survive on this diet. Since fat and carbohydrate alone could not nourish the animals, he came to the conclusion that protein must be essential in the diet. However, this obviously did nothing to dislodge the notion that the calorie measured the amount of heat a substance could produce in a living dog just as well as it measured the heat produced in a laboratory calorimeter.

F. Mechanism and Human Life

If we may speak of the late eighteenth and early nineteenth centuries as the time of rationalism, we can characterize most of the nineteenth century as the time of materialism. This intellectual climate included the work of Charles Darwin (1809-1882) and saw the blurring of any essential distinctions between human beings and animals. This blurring also occurred within the scope of our theme.

In 1860, Karl von Voit and Max von Pettenkoffer built the first calorimeter for humans. They used its measurements to calculate the basal metabolic rate of their subjects. Nonetheless, it was not until 1894 that Max Rubner publicly put forth the idea that the laws of thermodynamics apply to animals and human beings just as they do to inanimate objects (Schmidt 1985, 16). In experiments with dogs, he was able to get consistent results in showing energy balance. Atwater and Benedict continued work in this vein beginning around 1899.

By this time, the scientific community was convinced that respiration—and with it, warmth and movement—was produced in animals and people in a way that could be measured and (theoretically) reproduced in a test tube. It was not until 1937, however, that they went beyond a kind of black-box mentality. Then Hans Krebs put forth the "Krebs cycle" which posited a biochemical mechanism for the transformation of glucose into energy. A person then did not need to simply believe that a gram of sugar produced four thousand calories in his body. He supposedly had a mechanism for explaining how that happened.

With this, the role of the calorie seemed assured of a prominent place in nutritional research and clinical application. However, all is not as it would seem in this regard. We shall explore the utility of the concept of the calorie, based on recent research and experience, in the following chapters.

IV. THE UTILITY OF CALORIE THEORY

A. The Limits of Calorie Theory

As was shown in the previous chapter, the laws of thermodynamics were developed for application to the realm of non-living things. Indeed, we saw that it was not until the end of the nineteenth century that the law of the conservation of energy was applied to the human being.

The thesis that the processes of human life are, in essence, identical to those of inorganic nature was well received during the age of "Enlightenment" of the eighteenth century and the prevalence of materialism in the nineteenth century. Conceiving of the human body as a machine—albeit a very complex one—led to a feeling of emancipation. The human being no longer needed to believe that his life was dependent on God, Mother Nature, or any other creative or intelligent power outside of himself. Man viewed himself as possessing the supreme intelligence in the world. Once he understood the mechanisms of life—or so it was thought—all of life could be subjected, by the power of his rational mind, to serve his desires.

To be sure, there is experimental evidence to support the application of the law of the conservation of energy to the human being. Among the best and earliest examples of this are the studies done by Atwater and Benedict at the beginning of this century (Atwater and Benedict 1903). They used direct calorimetry (i.e. measurement of the heat given off by the human body), indirect calorimetry (i.e. a calculation of the theoretical amount of heat produced, based on the consumption of oxygen and the production of carbon dioxide), and measurement of the heat value of the food eaten and waste products excreted by their subjects.

When the results from all subjects were pooled, it was found that, on the average, the production by the human body of heat and work corresponded to the caloric value of the nutrients metabolized within a reasonably narrow margin of error. Based on such work, it was widely held that answers to practical questions about the food requirements of human beings—as well as those about the effects of over-eating or under-eating—could be answered using a simple formula:

$$E = F + \Delta S - X$$

where E is energy output (body heat and work), F is the heat value of food consumed, ΔS is the change in the heat value of bodily stores (fat, glycogen, etc.), and X is the heat value of any bodily excretions.

However, as scientists have gathered more precise experimental results and become more discerning in their analysis, it has been necessary to revise—some might even say embellish—that simple equation. In the following chapters, we will examine some flaws in the truth of the mechanistic approach to human energy metabolism. Here we will confine ourselves to examining the utility of applying calorie theory to human life.

Six factors which complicate the application of the original, simple conception of calorie theory will be examined in this chapter. They are: the thermogenic effect of food, meal size and frequency, starvation adaptation, body composition, the effect of alcohol and chemical thermodynamics.

B. Thermogenesis

In both humans and animals, there is a tendency for the body to produce more heat after eating a meal than it does when fasting. The increase in heat production after eating is known as the thermic (or thermogenic) effect of food, or "diet-induced thermogenesis" (Kinney 1988, 527). This effect was previously called the "specific dynamic effect" of food (Blaxter 1985, 91). In 1918, Benedict and Carpenter published a summary of the available information on the thermic effect of food, and concluded that it was at least 6% of the food energy of carbohydrates, 2% for fat, and 12% for protein rich diets (Blaxter 1985, 91).

In 1948, Glickman and coworkers published the results of a series of studies which involved measuring the heat production of their subjects for six to seven hours after eating (Glickman et al. 1948, 40). This was much longer than had been done theretofore. They concluded that the previously established values for the thermogenic effect of food were too low. Their study led to estimates that a high protein diet had a thermogenic effect of 17%, and a high carbohydrate diet, 11%.

Modern estimates of the thermogenic effect of food put it at roughly 10% of the metabolizable energy of the ingested diet (Pi-Sunyer 1988, 804). However, the word 'roughly' must be emphasized here. Scientists will admit that much in this area is not known. Kenneth Blaxter, a prominent British researcher in the field of human energy metabolism wrote:

> The results of observations on man show that there is considerable uncertainty about the thermogenic effect of food, largely stemming from problems related to its determination. Consequently, little can be said about its variation from subject to subject. (Blaxter 1985, 92)

Another example comes from John Kinney, senior attending physician for medical and surgical services at St. Luke's-Roosevelt Hospital in New York City. In discussing the differences in dietary-induced thermogenesis during over-nutrition and under-nutrition, he wrote:

> Since errors in the calculation of energy intake and expenditure in man may be of greater magnitude than those of diet-induced thermogenesis, the precise measurement of this aspect of human thermogenesis is difficult. (Kinney 1988, 527)

We see, therefore, that although the thermogenic effect of food is held to be important in calculating the amount of food required by a person, it is not readily determined. Its practical value, when applied to making predictions about the physiology of an individual person, is extremely limited.

C. Adaptation and Diet-Induced Thermogenesis

There is another complication in the application of diet-induced thermogenesis to understanding human physiology. The thermogenic effect of food—to the extent that it can be accurately determined—appears to differ under different circumstances. We saw above that the composition of a meal—in terms of the proportions of fat, carbohydrate and protein—will influence its thermogenic effect. It has also been found that the thermogenic effect changes according to whether a person is eating more or less than normal.

Already in 1915 and 1919, F.G. Benedict measured a decrease in the rate of metabolism of human subjects when they were under conditions of starvation (Benedict 1915) or under-nutrition (Benedict et al. 1919). This phenomenon has been seen by other researchers, both in humans and in animals (Blaxter 1985, 93). In addition, animal studies have repeatedly shown an increase in the thermogenic effect of food when the animals are fed more than they need to maintain their body weight (Blaxter 1985, 91).

Part of the increase in metabolic rate after eating is thought to be the result of the energy generated by digesting, absorbing and transforming food. This has been called "obligatory diet-induced thermogenesis [DIT]" (Kinney 1988, 527). The rest of the increase is called "adaptive DIT." As an historic note, it was originally referred to as Luxuskonsumption (literally "luxury consumption") since it was thought to be the burning of excess or "luxury" nutrients, that is, food which was eaten beyond what the body needs (Kinney 1988, 527).

The subject of adaptive DIT is a source of controversy today, in part because of the difficulty of doing human studies to confirm its existence. However, the fact that it has been proposed is significant. It points to the necessity we discussed above of adding to—and therefore making more complicated—the existing theory of the conservation of energy in humans.

We are also led here to see the limits to the usefulness of the calorie theory, as applied to human beings. After considering a review of human studies regarding adaptive DIT and the metabolic effects of overfeeding, John Kinney (quoted above) wrote the following:

> Such data strongly suggest that the common factors considered in calculating energy requirements are not sufficient to predict weight gain or weight loss in any given individual by simply knowing the energy intake. (Kinney 1988, 528)

He goes on to add that:

> ...it is extremely difficult to determine the actual energy expenditure of individuals throughout their normal daily life. (Kinney 1988, 528)

The thermogenic effect of food is not only affected by whether a person is over-eating or under-eating. The size and frequency of meals may also play a role. Recent research suggests that, given the possibility of eating exactly the same food in the same amounts, the total thermogenic effect of the food will decrease if it is eaten as a number of small meals rather than as one big meal.

Researchers from St. Luke's-Roosevelt Hospital and New York University published a study on this subject (Tai, et al. 1991, 783). In reviewing previous work, they found a number of studies which supported the hypothesis that thermogenic effect is affected by meal size. However, they also noted some studies which found no such influence. They wrote:

> Thus the effect of meal size and frequency on the thermic effect of food remains uncertain. (Tai, et al. 1991, 783)

Their study involved seven healthy young women of normal weight. A standard meal (with a heat value of 750 kcal) was composed. The women were alternately fed the meal either all at once (over ten minutes) or divided into six small meals, eaten thirty minutes apart over the course of three hours. The metabolic rate of the subjects was measured before and after the meals. They concluded:

> ...that the temporal pattern in which a mixed caloric load is eaten affects the thermogenic response and may be an important determinant of energy balance after a meal. (Tai, et al. 1991, 783)

We find here a rather complicated theoretical framework. The requirement of a human being for food depends upon his or her energy expenditure which, in turn, depends (among other things) upon his or her bodily heat production, which depends (among other things) upon the thermogenic effect of his or her food, which depends (among other things) upon the size and frequency of his or her meals. The useful application of this formulation to real-life situations is called into question, both because of its complexity and because of the difficulty of obtaining accurate estimates of the quantities involved.

D. Under-nutrition: When Less is More

We spoke above about the effect of under-nutrition on the thermogenic effect of food. Consideration of undernourished subjects clouds the simplicity and utility of the calorie theory in another way as well. Under-eating or fasting appears to significantly affect not only diet-induced thermogenesis, but also the overall energy metabolism of the human body.

Biologists speak of the "adaptive response" of the body. This is thought of as the tendency of the body to conserve energy when food is unavailable. This is yet another factor which must be accounted for when attempting to quantify human energy metabolism.

In a collection of essays on weight control, one scientist wrote the following:

> Starvation results in a series of adaptive changes that tend to conserve energy, glucose and protein and, thereby, prolong survival in the face of inadequate caloric intake. Frequent starvation (or semi-starvation) leads to improvement in the adaptive responses, i.e., with each

> dieting episode, the rate of weight loss is slower and, with return to normal eating, the rate of weight gain is more rapid. (Callaway 1988, 97)

This phenomenon has been observed for quite some time, now. As far back as 1907, Benedict published the results of his study of a man who was paid to undergo a number of prolonged fasts (Benedict 1907). He found that—even when the decrease in lean body mass was accounted for (using the methods available to the researchers at that time)—the basal metabolic rate (BMR) of the subject dropped significantly during fasting, even before an appreciable amount of weight was lost.

This tendency was confirmed in a study from the Committee on Human Nutrition at the University of Chicago (Luke and Schoeller 1992). The authors reviewed studies measuring basal metabolic rate and body composition in human subjects. In writing about underfed individuals, they tell us:

> Specifically, while BMR has been frequently reported to decrease in semi-starvation and in weight reduction, it is still not clear whether the decrease in BMR can be accounted for by a decrease in FFM [fat-free mass] or BCM [body cell mass], or if it reflects a down-regulation of BMR in response to weight loss. (Luke and Schoeller 1992, 450)

Elsewhere they write "the mechanisms involved in the down-regulation of BMR are unknown" (Luke and Scholler 1992, 455). Thus, the decrease in basal metabolic rate during semi-starvation is more rapid than the decrease in (measurable) metabolically active tissue.

Benedict also noted that volunteers could usually be sustained for about sixty days under conditions of starvation. Yet, when the theoretical energy requirements for survival—based on the metabolism of a normal, healthy subject with adequate food—are calculated and compared with the energy stores of the human body, the theoretical survival time is only about three weeks (Callaway

1988, 99). Thus, it appears that at least some people, in a clinical setting, can live roughly three times longer than one would expect based on a simple, unmodified application of calorie theory.

More recent research has confirmed that human metabolism is affected by under-eating. For example, a study of patients recovering from anorexia nervosa was conducted in 1977. It was found that the basal metabolic rate of the subjects was only about one half of the value that would have been predicted for their age, sex, size and weight (Stordy 1977, 138). The prolonged period of prior under-eating appears to have radically altered the energy requirements of the subjects recovering from anorexia.

We see, then, that consideration of under-nutrition is yet another complication in the simple application of calorie theory to humans. An automobile will go twice as far on two gallons of gasoline as it will on one, all else being equal. But we cannot say that a human being can always go twice as far or twice as long on twice as much food, partly because in humans, all other things are never equal. When considering living human beings, less (food) sometimes appears to be more (energy per calorie consumed).

E. Body Composition

It has long been known that the metabolic rates of various individuals differ according to their body size, age and gender. In 1919, the well-known Harris-Benedict equation was put forth by the scientists after whom it is named. It was a rough estimate of the basal metabolic rate of a subject based upon a formula involving weight, height and age (Cunningham 1991, 965). The formulae are:

$$BMR = 655 + (9.6) \cdot W + (1.85) \cdot H - (4.68) \cdot A \text{ for women}$$

$$BMR = 66 + (13.8) \cdot W + (5.0) \cdot H - (6.8) \cdot A \text{ for men}$$

where BMR is basal metabolic rate in (kcal/day), W is weight (in kilograms), H is height (in centimeters) and A is age (in years).

The Harris-Benedict equation generally produces reasonable results when applied to people of average weight and in good health.

However, it is a poor predictor of energy expenditure based on actual measurement in underweight, obese or ill people. This was seen, for example, in a review of three major studies involving 222 obese men and women (Cunningham 1991, 965). The Harris-Benedict formulae predicted the actual measured basal metabolic rate (within a margin of error of ±10%) only 40% to 60% of the time. It over-estimated just as often as it under-estimated.

Similar formulae by other researchers have also been developed, but their usefulness is not appreciably better. The same can be said for equations based on the surface area of the subject's body (Cunningham 1991, 965).

These limitations led researchers to look for another approach to predicting the metabolic energy expenditure of human beings. Their reasoning went somewhat as follows. Relative to their size, the fat cells in the body undergo only a negligible metabolism compared to most other cells. Perhaps, then, resting energy expenditure can be predicted using a formula based on the fat-free mass of the individual. This can be approximated from calculations based on various kinds of measurements: skin fold thickness, under-water weighing or electrical resistance.

Indeed, it was found that calculations based on fat-free mass are somewhat more accurate in predicting energy expenditure than those using only weight, height and age. However, they are far from being totally accurate. In all, they explain about 85% of the individual variation in resting energy expenditure (Cunningham 1991, 963). They are based—as those who use them acknowledge—on hypothetical assumptions about the way energy metabolism actually occurs in the human body. Current thinking in this area is necessarily theoretical because of the inability of scientists to make direct measurements. This was reflected by the author of the review of studies on the subject cited above. He writes:

The compartment representing the true "active protoplasmic tissue" at rest continues to elude measurement. FFM [fat-free mass] serves as a reasonable surrogate for this compartment in healthy individuals... (Cunningham 1991, 968)

By adding body composition as a factor which must be included in determining the rate of energy metabolism, it is perhaps possible to come a little closer to predicting the energy expenditure of a person. But the weight of this argument is based purely upon statistics, and it must therefore be used with caution in nutritional assessment and counseling, for there is no guarantee that a particular individual will fall within the statistical norm.

Calculation of body composition may be seen as an elaboration of what began as a simple and elegant theory. It thus complicates the application of calorie theory to humans. In addition, we see here a lack of confirmation by direct measurements of much current thinking about the true nature of energy metabolism. The latter point will be discussed in subsequent chapters.

F. Alcohol Calories

Another anomaly in the prevailing thought about energy metabolism appears when large amounts of alcohol are consumed. It is well known that excessive use or abuse of alcoholic beverages can alter a person's nutritional status for the worse in a variety of ways (Lieber 1991, 976). It can displace other nutrients, as some people have a tendency to drink alcohol instead of eat. It can lead to medical complications which make eating more difficult or digestion less efficient. It may also impair a person's ability to buy or obtain food.

However, in addition to these factors, alcohol appears to have a "negative caloric effect." In a bomb calorimeter—a laboratory device for measuring the heat value of a food—the burning of ethanol produces 7.1 kilocalories per gram. But when it is ingested in large quantities, it does not appear to have the same effect as fats or carbohydrates of the same caloric value. A researcher at the Alcohol Research and Treatment Center of the Bronx V.A. Medical Center in New York wrote the following:

> ...the above-mentioned clinical reports, as well as a score of other observations suggested that independent of its effects on nutrient digestion and absorption, ethanol may, in some way, be associated with an energy deficit. The latter was clearly established in controlled studies carried out under metabolic-ward conditions. (Lieber 1991, 976)

The studies referred to involved subjects in a hospital metabolic ward. They were fed diets with carefully controlled caloric values. Gradually, over the course of twenty-four days, some of the food was replaced by alcohol of equal caloric value, until the diet consisted of 50% ethanol by calorie. This isocaloric substitution of alcohol for food was associated with a drop in the weight of the subjects (Lieber 1991, 977).

Another study involved adding alcohol (with a value of 2,000 kcal) to the daily diet of a subject. There, no increase in weight was noted. The experiment was repeated under similar conditions, except that this time, chocolate with a value of 2,000 kcal was added instead of alcohol. The subject then showed a precipitous gain in weight (Lieber 1991, 977).

Similar experiments with rats led to similar results (Lieber 1991, 978). These involved both isocaloric substitution with ethanol, as well as addition of ethanol to the animal's diet.

It must be noted that the results of these studies are not conclusive. Although a number of hypotheses have been proposed to explain them, none have been conclusively confirmed. Moreover, the phenomenon does not occur when moderate amounts of alcohol are consumed (i.e. one or two drinks daily). Nonetheless, the phenomenon merits our consideration because, it would appear that all calories are not alike. In the case of alcohol, excess calories do not always result in weight gain.

G. Chemical Thermodynamics

Advances in the science of chemistry have influenced the thinking of scientists in the fields of biology and human physiology. The problems associated with the simple "black box" approach to applying the calorie theory to the human body, which we have discussed above, are evident. They have led some researchers to try to go beyond conceiving of the body as a closed system. Consideration has been given to using the ideas of "open system thermodynamics" and "chemical thermodynamics" (based on the work of Josiah W. Gibbs [1839-1903]) to understand human biology. This involves application of the concept of "Gibbs free energy," the mechanical or heat equivalent of chemical transformations.

Thus, one modern biologist has said:

> Yet, living systems are not the mechanical heat engines as conceived by Lavoisier and others in the early days; they are, basically, "chemodynamical" machines. Accordingly, the heat produced by an organism represents the unused part of the Gibbs free energy released from the metabolism of nutritive substances. (Welch 1991, 1905)

This assertion leads to an important conclusion. We come to see that scientists are not able to fully explain or describe the actual workings of the human body by means of the principles of physical or chemical thermodynamics. The biologist quoted above thus stated this admission—albeit in a less radical form—at a symposium on human energy metabolism held by the American Institute of Nutrition in Washington in 1990. He said:

> In particular, the reality of metabolic microenvironments *in situ* casts a specter of mismeasure on conventional macroscopic methods of calculating ΔG [the change in Gibbs free energy] for cellular processes. Before advancing the cause of thermodynamics at the organismal level, it is essential that we set firm our understanding of cellular bioenergetics. (Welch 1991, 1906)

Here again, we find the simple elegance of the basic calorie theory overlaid with serious complications. Although the author cited above does not go so far as to abandon the application of thermodynamics to human nutrition entirely, he does point out that it is now known that the process of oxidation which takes place in a bomb calorimeter is neither quantitatively nor qualitatively identical to the metabolism of food in a human body (Welch 1991, 1906). Just as significantly, the utility of using the concept of calories with regard to human nutrition is called into question, since we are unable to make the measurements which would allow the calculation of energy dynamics in real-life situations.

H. The Usefulness of the Calorie

To summarize, we have seen that the application of the physical laws of thermodynamics to the human body is not as simple as was thought by its proponents at the turn of the century. Scientists found that a simple measurement of the caloric value of food eaten (as measured in a bomb calorimeter) is not useful in determining either how much energy a subject produces in a laboratory setting or how much a person needs to eat in real life.

In order to adjust the theory to account for new observations, it was refined with ancillary calculations to account for: diet-induced thermogenesis, meal size and frequency, starvation adaptation, body composition, the effect of alcohol, and (at least in theory) chemical thermodynamics. These have complicated the elegance of the original theory. Some of these quantities, indeed, cannot be calculated at all.

We can therefore come to only one conclusion. Given the present state of our scientific knowledge, it may not be useful or practical to conceive of the human body as operating strictly according to the thermodynamic laws of inorganic nature. In the next chapters, we will consider whether such a conception is even true.

V. IT DOES NOT ADD UP

A. What Good are the Numbers?

In the last chapter we examined a number of additions and refinements which have been added to the calorie theory—the theory of the conservation of energy as applied to the human body. We also saw the difficulty, or even impossibility, of making some crucial measurements. Thus, the usefulness of this theory when applied to understanding or counseling any particular individual about his or her energy requirements is, at best, limited.

Now we face another question. Can we say that, based on accepted scientific knowledge, a person can only produce as much energy (or its equivalent in body stores) as he or she takes in as food? To put this in other words: does current scientific evidence support the idea that the warmth and mechanical work of the human body can be quantified and traced back to the energy value of its food?

If we are considering large groups of people from a homogeneous population, then we may be able to say that we have some knowledge of their energy requirement as a group, based purely upon statistics. But if we are talking about individuals, then the situation is not as clear.

An analogy can serve to help us here. Let us say that, in some country, the average age of the population is twenty-eight years. I may travel to that country and take an adequately large sample of the population. If that sample is truly random—or, better put, if it is representative of the general population—then I can assume that the average age of the people in that sample will be about twenty-eight. But if I choose just one individual from that country, it would be foolish to assume that this individual will necessarily be twenty-eight years old. What holds true for the group as a whole does not necessarily hold true for any one individual within that group.

A similar situation exists regarding the food requirements of humans. It may be that, on the average, the bodily energy and fat production of a large, homogeneous group of people is a function of the caloric value of their dietary intake. But it does not follow that I can accurately predict how quickly—or even if—a particular individual will gain or lose weight based on his or her dietary intake and energy production.

In the considerations below, we will see that even in a controlled, artificial setting, where the oxygen taken in and carbon dioxide released can be measured, we still cannot predict, in all cases, how much heat and work the body will produce. We must therefore call into question whether it is completely accurate to think of respiration as being merely a form of combustion. Two blocks of carbon which consume the same amount of oxygen will always produce the same amount of heat. With human beings, however, it is not so.

B. Food Requirements

When nutrition is taught today, whether in schools, the popular media or in colleges and universities, people are often told that their bodies are similar to machines. In applying the law of the conservation of energy to the human body, it is said that we can calculate how much food a person needs in order to maintain his or her body weight. If "energy in," in the form of food equals "energy out," in the form of heat and work, then body weight will remain the same. Thus, by implication, one is taught that eating less than the theoretical "maintenance level" diet (calculated for a person's size, age, sex, etc.) will always cause a person to lose weight, and that eating more will cause a gain in weight.

In popular works, this theory is often put forth as established scientific fact, and is espoused within the penumbra of the authority of "Science." However, we might ask if scientists themselves universally hold this same view. In asking this, we come to an interesting answer: they do not.

Perhaps the best testament to this is in an essay in Nature magazine (Durnin, et al. 1973). This essay was written by four leading researchers in the fields of human nutrition and human physiology in Scotland and England. The title posed an interesting question: How Much Food Does Man Require? The answer of these eminent scientists was, in effect, to say that we do not know. They wrote:

> We believe that the energy requirements of man and his balance of intake and expenditure are not known. Paradoxically, we conclude this from results of the increasingly sophisticated studies of food intake and energy expenditure which show that in any group of twenty or more subjects, with similar attributes and activities, food intake can vary as much as two-fold. (Durnin, et al. 1973)

Some very interesting facts were brought up in the essay. First, it was pointed out that many people in the world, with normal healthy lives, eat appreciably less than they ought to be able to in theory. In their words:

> The results of careful studies in a number of countries suggest that some people, perhaps through some mechanism of adaptation, are able to be healthy and active on energy intakes which, by current standards, would be regarded as inadequate. (Durnin, et al. 1973)

Terms such as "healthy and active" and "current standards" may, admittedly, be colored by personal predilection or cultural bias. Nonetheless, this statement was made by eminent researchers in the field of human nutrition and published in a reputable scientific journal. It therefore shows us that at least some members of the scientific community considered certain fundamental questions about human energy requirements in free-living populations to be unresolved.

A fact was mentioned by the authors which challenged the current hypotheses about energy balance in humans. They pointed to the existence of studies where the subjects were given large amounts of food beyond what they theoretically needed to eat, and yet they showed little or no increase in body weight.

The third discrepancy between theory and observation to which they point relates to obesity. They speak of the "well recognized fact that many fat people eat no more, and sometimes less, than those who are not obese" (Durnin, et al. 1973).

After pointing out these discrepancies, they admitted that they ultimately did not know what relationship there is between the caloric value of a person's food, and how much fat and energy that person produces. They wrote:

> These observations underline the extent of our ignorance about the mechanisms by which energy balance is maintained. (Durnin, et al. 1973)

Admittedly, this statement was made over twenty years ago. Moreover, the conclusion of the authors is not as radical as the thesis we are putting forward here. They have a belief—based not upon empirical evidence, but rather upon faith and tradition—in the applicability of the theory of the conservation of energy to humans. This being the case, they call for better studies and more refined methods of human calorimetry. Nonetheless, if we leave aside their personal and professional prejudice, and confine ourselves to the facts which they put forth, we are faced with what might be a surprising discovery for the nutrition educator. The application of the calorie theory to the human body is not nearly as useful as has often been believed.

C. Unexplained Variation

The bedrock upon which calorie theory rests is the assumption that energy production by the human body is a function of quantifiable biochemical reactions. Specifically, it is held that these reactions are similar to combustion and that they involve the consumption of oxygen and the production of carbon dioxide. In our discussion of the history of calorie theory in Chapter III, we saw that early researchers attempted to measure both heat output and carbon dioxide production in small animals. Indeed, there was a rough mathematical correlation between the two.

Their methods and results were quite crude. Yet in spite of this, the fundamental hypothesis was accepted: respiratory gas metabolism is directly linked in a quantitative, mathematical relationship to energy production in the human body. Although much research—and a tremendous amount of education—has been based on this hypothesis, there have been relatively few studies done to confirm it.

An important exception to this is a study by a metabolic research team in Ohio led by Paul Webb (Webb, et al. 1980). Webb is a medical doctor who specializes in calorimetry and metabolic research, and has written an authoritative book on the history, construction and operation of human calorimeters (Webb 1985). This team did a series of experiments on thirteen subjects regarding the energy metabolism of humans. They placed their subjects in a calorimeter which consisted of an insulated, water-cooled suit. The subjects were kept in the calorimeter for twenty-four hours, and changes in the water temperature were measured to establish the amount of heat produced.

While the subjects were in the calorimeter, their consumption of oxygen and production of carbon dioxide were also measured. These measurements became the basis for calculating the metabolic energy produced. In addition, the subjects were given varying amounts of food which were carefully measured.

We have here the use of two types of calorimetry: direct and indirect. Direct calorimetry is the direct measurement of the heat produced by the body. In this case, it was measured using the water-cooled suit. The temperature of the water is measured both as it goes into and as it leaves the suit, and heat production is calculated based on the volume of water and the difference between these two temperatures. Indirect calorimetry involves measuring the oxygen absorbed and the carbon dioxide exhaled by the subject (Kinney 1988). Since fat, protein and carbohydrate have different respiratory quotients (i.e. the ratio of oxygen consumed to carbon dioxide produced), urinary nitrogen is also measured to determine the amount of protein oxidized. Then, the amount of carbohydrate and fat oxidized are calculated using a simple mathematical formula. Finally, the caloric value of the oxidized nutrients is calculated to determine the "metabolic expenditure."

The results of Dr. Webb's experiments pointed to a crucial discrepancy between the theoretical amount of energy produced by metabolism (the result of indirect calorimetry) and the actual measurable (by direct calorimetry) amount of energy produced by the body. In six of the experiments, the direct measurement of heat (direct calorimetry) and the theoretical energy production (indirect calorimetry) agreed within ±3% (Webb, et al. 1980, 1295). This was within the expected margin of error for the procedure.

However, in the other seven experiments, there was significant disagreement between the results of direct and indirect calorimetry. This disagreement ranged between 8% and 23%—far beyond the margin of error for the instruments used (Webb, et al. 1980, 1295). It tended to occur in those cases where the subjects ate food with either a greater or a lesser energy value than their measured energy expenditure.

The authors were very cautious about the conclusion they drew from these discrepancies. After describing the results of the six experiments where the two forms of calorimetry agreed, they wrote:

But in the other seven experiments the comparison of direct and indirect calorimetry was surprisingly different, giving the appearance of energy imbalance, a term we avoid since it implies that energy is not conserved. We prefer to say that sizable mismatches come from unmeasured energy. (Webb, et al. 1980, 1295)

A careful reading of the above quotation can help us to separate the objective facts which these researchers discovered from the theoretical framework—the old world view which we referred to in

Chapter I—within which they are trying to fit them. A number of possible explanations of this "unmeasured energy" might be offered, perhaps involving a change in stored energy in different body "compartments." Nonetheless, it might also be taken to suggest that the calorie theory may not hold in all cases.

To be sure, the study does not conclusively disprove the theory either. It simply points to a fundamental lack of knowledge and understanding on the part of the scientific community about the relationship between the calories in food and the energy metabolism of the human being. It should make the nutrition educator and clinician think twice before teaching calorie theory as if it were a reliable expression of experienced reality.

D. More Unexplained Variation

After obtaining such unexpected results, the director of the above-mentioned study began to look at other similar studies. He looked from the beginning of the century and the work of Atwater to the time of his writing (1980). In all, he found fifty-two studies comparing direct and indirect calorimetry which were applicable to his inquiry. What he found confirmed the results of his own laboratory work. He wrote:

> Unmeasured energy is evident in complete studies made by others, although it has not been recognized as such. It appeared under circumstances similar to those in our experiments, namely the presence of food deficit. Thus it became more than academic to review critically the studies in which energy balance has been measured. The more careful the study, the more clearly there is evidence of energy not accounted for. (Webb 1980, 1300)

Faced with this evidence of "energy not accounted for," the author felt that it was necessary to introduce a new term into the calculation of energy balance. He used the term QX to refer to the difference between directly measured energy production (heat and work) and energy production based upon metabolic expenditure as measured by the production of carbon dioxide and the consumption of oxygen. Thus, QX is the difference between the results of direct calorimetry and indirect calorimetry.

The calculated heat (caloric) value of the metabolic expenditure, as determined by indirect calorimetry, he called QM. In referring to directly measured energy expenditure, he used the terms QHL for heat loss, QWK for mechanical work, and QDH for the change in heat stores, i.e. the change in the subject's body temperature. He then put his findings as follows:

Although it is generally believed that indirect and direct calorimetry are equivalent, so that QM can be substituted for (QHL + QWK + QDH), it is argued here that...during conditions of food excess and food deficit another quantity, QX, is needed for equivalence. (Webb 1980, 1300)

In expressing the relationship between human metabolism and energy production as an equation, he put it this way (Webb 1980, 1300):

$$QM = QHL + QDH + QWK + QX$$

The necessity of putting an unknown quantity into the equation reveals a decisive and essential fact. Based upon current knowledge, one cannot assume that the human body behaves in the same way as a non-living system. One cannot assume that the law of the conservation of energy is demonstrably applicable to the human body. We have come here to the boundary of what is currently known about this in scientific circles.

In a telephone conversation with Dr. Webb in May, 1993—more than a decade after the above-mentioned research was published—he related to the author that his work has "made a lot of people uncomfortable." Nonetheless, he has not discovered, nor has he been offered an explanation for, QX—the unmeasured energy of the human body—by any one in the scientific community. The response has been, as he put it, "just hemming and hawing."

It should be noted that the quantity of this "unmeasured energy" is significant. It was mentioned above that, in Webb's own experiments, it was 8% to 23% of the calculated metabolic energy expenditure in cases of over- or under-eating. In a survey of fifty-two studies which examined energy balance during either under-eating or over-eating, he also found a significant amount of unmeasured energy. If QX is considered without regard to sign, on the average QX is 27% of QM in this survey (Webb 1980, 1307).

This can be looked at in another way which is directly applicable to the nutrition educator. In popular literature and textbooks it is generally said that a pound of body fat is roughly equivalent to 3,500 kcal (Whitney 1983, 216). Yet, Webb writes that:

In the studies analyzed here, loss of a kilogram of fat appears to have resulted from deficits of anything from 3,000 to 8,000 kcal, and these studies were selected for the care and completeness of their measurements. (Webb 1980, 1307)

At the very least, we must conclude from this that there is tremendous variation among individuals when it comes to the relationship between weight loss and diet.

E. What is Known?

The scientific evidence which we have examined in this chapter suggests that the law of the conservation of energy can seldom be readily applied to the living human body. However, it must be emphasized that we have not proven this to be so.

What we have shown, though, is that there is no scientific basis for assuming that the body is subject to the laws of thermodynamics in the same way that an inanimate object is. This being the case, it should lead us to ask if it is proper to teach people about weight maintenance and the caloric value of food as if the body were merely a complicated machine. Is it simply that the living human body is too complex for us to measure all of its processes with our instruments as they exist now? Or might we ask: if the laws of physics cannot completely explain all the phenomena of the human body, are there perhaps laws which are uniquely applicable to living creatures? Could it be that the vitalists—whom we discussed in Chapter III—were aware of an important truth which has been lost sight of in more recent times?

We will return to these questions in our conclusion in Chapter VII.

VI. AN EXCEPTION TO THE "RULE"

A. Where Calorie Theory Fails

The calorie theory of food, as it is generally understood today, is universally applied. In other words, it is held that in every animal or human being, the amount of energy produced by the body is equal to the energy value of the food and drink ingested, minus the energy value of the nutrients which are either stored or excreted. In short it is, as we have seen, the first law of thermodynamics—the law of the conservation of energy—applied to living organisms.

Although this assumption normally is merely implicit in literature dealing with diet and energy expenditure, it is occasionally put explicitly. For example, a popular nutrition textbook says:

> Fat loss always obeys the rule that a person losing weight (fat) must experience a deficit of 3,500 kcal for every pound lost. (Whitney and Cataldo 1983, 263)

As we saw in the previous chapters, competent scientists would balk at such a general statement. But in clinical practice or popular textbooks and literature, apparent exceptions to the "rule" are generally either ignored, or it is assumed that mistakes were made in measuring or calculating either the intake or the energy expenditure of the individual in question. In the light of the difficulties in—if not the impossibility of—making such measurements in a living human body, we see that this assumption is not based on the results of empirical research.

In order to properly evaluate the applicability of the "balance of energy" theory of human nutrition, it would surely be helpful to examine at least one case where, based on the weight of prima facia evidence, it simply cannot apply. Certainly, such would be the case if a person were found who maintained a constant body weight and normal bodily activity while eating little or nothing.

There are, indeed, a number of accounts of such persons to be found in the western world. Primarily, these accounts have been made within the tradition of the Catholic Church. It should be noted here that the author of this work is not, and has never been, affiliated with the Roman Catholic Church. However, an objective treatment of the question of calorie theory and energy metabolism cannot ignore the claims made over the years of people who subsisted on nothing more than water and a daily communion wafer. These have included: St. Nicholas von der Flüe, St. Liwina of Schiedam, Angela of Foligno, St. Catherine of Siena, Elizabeth de Rent and Dominica Lazarri in earlier times (Schimberg 1947, 52-53). In this century and the last we find Louise Lateau (1850-1883) of Belgium, St. Gemma Galgani (died 1903) (Schimberg 1947, 52-61), Anna Katherina Emmerich (died 1824) (Vogl 1967, 24) and Therese Neumann (1898-1962).

The evidence for most of these claims is quite old, and in most cases is based only on observations by family, friends and religious colleagues of the person in question. Thus, it would be difficult to prove or disprove them using modern scientific or historical research methods. When dealing with a claim which is so utterly shocking to the scientific consciousness of today, the proof of its validity needs to be quite rigorous.

However, in the last person mentioned—Therese Neumann—we are faced with an instance which simply cannot be ignored by the conscientious researcher. Her case is recent. It was closely investigated both by men and women of her own religious faith and those outside of it. The investigators included physicians, nurses, psychiatrists, journalists, scholars and clergymen. If one found it to be true, it would require a fundamental re-thinking of the whole usual approach to "calories" and "energy balance."

B. A Brief History of Therese Neumann

Therese Neumann was born on Good Friday, April 8, 1898 in Konnersreuth. She grew up and spent most of her life in that small German village near the Czech border in Bavaria. Her father was a farm worker. She grew up with her family in relative poverty and obscurity, and resided in her father's house until her death on September 18, 1962, at the age of sixty-four (Steiner, J. 1967, 19-26).

At the outbreak of the First World War in 1914, Therese's father was drafted into the army. In order to bring in money for her family's living expenses, she took a job as a farm hand. In 1916, the manager of the farm where she worked and his assistant were drafted. Therese and her two sisters took over running the farm.

On March 10, 1918 a fire broke out at a neighboring farm. While helping to put it out, Therese wrenched her back and dislocated her spine between the second and third lumbar vertebrae. She was to be bedridden for seven years as a result. In March of 1919 she became totally blind. Around Christmas of 1922, she strained a muscle in her throat, and was unable to eat solid food. She only drank liquids after that.

Her parents sought help for her from all quarters, looking to both established medical doctors and to "nature healers." They met with no success. Her condition did not improve until April 29, 1923 when her eyesight was miraculously restored. In May of 1925, her lameness began to heal gradually, until she was finally able to walk quite normally.

Although her health was improving dramatically, Therese continued to be unable to eat solid food. After August of 1926, it was reported that she took no nourishment except for daily communion (often only a small particle of the wafer) and about two teaspoons of liquid each day. After Christmas of 1926, her daily intake was communion, once daily, with a few drops of water. After September of 1927, she stopped taking in even the few drops of water (Steiner, J. 1967, 27).

For the next thirty-five years, she was to live without being seen taking any food or water, save a daily communion wafer, until her death in 1962. Her parish priest and spiritual adviser, Fr. Naber, reports that she ceased to have any elimination from her bladder or bowels after 1930 (Steiner, J. 1967, 28). In 1947, a researcher reported that Therese slept, on the average, about two to three hours per week, except for the Saturday before Easter, when she slept virtually all day (Schimberg 1947, 72).

This extraordinary physical condition was accompanied by an unusually active spiritual life. Visitors seemed most impressed by her constant joy and happiness. An American army chaplain was among the tens of thousands of soldiers who visited her in the years right after the Second World War. He wrote the following about her in America magazine, published in September, 1945:

> You do not have the impression that you have spoken to a saint, because it is not yours to determine who is and who is not a saint. You do know that you have spoken to one who is especially gifted by God, to one who is simple with the simplicity of the Gospel, and that you have met in the midst of so much suffering and destruction and sorrow and discontent a person who is truly happy, possibly the happiest person in the whole world. (Schimberg 1947, 9)

Another aspect of Therese Neumann which characterized her spiritual life was her experience of the stigmata. This phenomenon began in 1926. It involved the spontaneous formation of wounds in the hands, feet, chest and elsewhere—corresponding to the wounds inflicted on Christ at His execution—which appeared while she was immersed in visions of the life of Christ. These wounds would bleed and the corresponding ecstatic visions would occur virtually every Friday. This intensified during the time of the year leading up to Easter. It involved the loss of an appreciable amount of blood. Her body weight generally dropped five to six pounds after each experience, as was documented during her clinical observation (Schimberg 1947, 55).

Much more has been recorded and commented on regarding Therese's spiritual life. However, as it goes beyond the scope of this work, the interested reader is referred to the books on her life cited in the bibliography.

C. Authenticity

It was mentioned above that there have been a number of people who, it is claimed, subsisted with little or no food or water. The case of Therese Neumann, however, is unique in that it was subjected to careful scrutiny by medical and scientific professionals in the twentieth century.

As one might imagine, the circumstances surrounding Therese drew a tremendous amount of interest. Thousands of visitors flocked to see her. For example, it was estimated that in the two years after the Second World War, some twelve thousand American troops visited her (Schimberg 1947, 10). There were reports of many Catholics being renewed in their faith after a visit, and even of a few skeptical Protestant and Jewish visitors converting to the Catholic faith after an encounter with her.

Because of this great interest, a number of investigators were sent to determine the authenticity of the claims about Therese. Foremost among these claims—and central to our topic—was her ability to live without food or water, save a particle of communion host. The first source used in these investigations was the sworn testimony of dozens of individuals (Steiner, J. 1967, 27). This testimony carried with it the possibility for both civil and ecclesiastical penalties in case of perjury. It was taken from Therese herself, her parents, her siblings, other relatives, her parish priest and lifetime confessor, and the many friends at whose homes she stayed when away from Konnersreuth.

The results of this testimony were universally positive. No one questioned her moral character, nor had any reason to suspect any fraud on her part. No one had seen her take any food after 1926. During the Nazi era, she was not issued a food ration card (Steiner, J. 1967, 30). (In exchange, the authorities gave her an extra soap ration, which she needed for washing after her Friday ecstasies.) No one had seen her take any water after 1927. No one had seen her give evidence of elimination from bowel or bladder after 1930 (Steiner, J. 1967, 202).

In 1971, an ecclesiastical commission was appointed under the direction of a Prof. Carl Strätter, S.J. He went to Konnersreuth and had a notice both published in the local newspapers and preached from the pulpits of the local churches. He asked any one to come forward who had anything to say against Therese Neumann regarding her stigmatization, her lack of nourishment or her moral behavior. No one came forth with a single negative comment (Steiner, J. 1967, 202).

Before turning to the results of the clinical observation, the sworn testimony of Therese herself—given to an ecclesiastical commission in January of 1953—is offered here.

> I have been living absolutely without nourishment, and without any need for food or drink, since Christmas of 1926; in the period from Christmas 1926 to September 1927, I regularly received the Sacred Species at Communion with a spoonful of water. Since that time, I have no longer done so; since August 6, 1926 I have felt a strong repugnance and nausea towards it. According to my conviction and knowledge, I am living from the sacramental Savior, who remains within me, according to eyewitness accounts and my own experience, until shortly before the next Communion. After the dissolution of the Sacramental Species, I am seized with a feeling of weakness and a strong physical and psychological longing for Holy Communion. (Steiner, J. 1967, 202-203)

D. Medical Observation

The remarkable circumstances surrounding Therese Neumann caused quite a bit of interest and controversy in her case. In response to this, the bishop of Regensburg asked her to submit to a rigorous medical examination, both to determine particulars about her physical state, and to rule out any possibility of fraud, be it conscious or unconscious.

Therese agreed to the examination, and it took place over a two week period from Thursday, July 14 until Thursday, July 28, 1927. Two physicians were appointed to conduct the examination (Vogl 1967, 80). Dr. Ewald, M.D.—a professor at the Federal Psychiatric Research Clinic at the University of Erlangen—was appointed director. He was a Lutheran by confession. His close collaborator in the project was a Catholic: Dr. Otto Seidl, M.D., a physician from Waldsassen, Bavaria.

The physicians were assisted by a team of four trained nurses from Mallersdorf. They were Catholic nuns, and came from the departments of surgery, x-ray and dentistry. Both medical doctors and all four nurses were under oath (Vogl 1967, 18).

The rules of the investigation were as follows:

1. The sisters were to work in two shifts, two sisters in each. All occurrences were to be recorded on paper.

2. Therese was not to be left alone, day or night.

3. She was to be bathed with a damp cloth; a sponge, which might have held some water, was prohibited.

4. Water used in cleaning her teeth had to be measured before and after.

5. The amount of water used to enable her to swallow the Host was to be measured.

6. Any bodily discharges were to be carefully reserved for measurement and chemical analysis.

7. Temperature and pulse were to be checked periodically each day.

8. The blood shed during her sufferings was to be carefully caught, measured and analyzed.

9. Very accurate and detailed descriptions were to be recorded, in writing, of the bleeding periods during the Friday ecstasies.

10. The cloths used to cover the head and heart wounds were to be saved.

11. Photographs were to be taken of the stigmata and, circumstances permitting, also of various phases of the ecstasies.

12. Observations and recordings were to extend to Therese's religious life, as well as to her behavior toward her family and visitors.

13. Dr. Seidl was to remain immediately available, to enable the sisters to relate their observations with technical accuracy and to clear up any questions of the relevancy and significance of what was observed. (Vogl 1967, 80-81)

The results of the investigation confirmed the previous statements given by Therese. Aside from communion, never once did she eat, nor demonstrate any urge to eat. Her consumption of water over the entire fifteen day period was 45 cc—about two tablespoonfuls. Her total bodily discharge was measured as being 345 cc, that is, a little more than seven times her total intake (Vogl 1967, 82).

The daily communion consisted of a particle of the host, roughly one eighth of its size. The investigators concluded that the total weight of the communion wafers eaten by Therese over the two-week period could not possibly have exceeded thirty-nine grams (Steiner, J. 1976, 185). Thus, her total caloric intake was less than 160 kcal, which averages out to less than 11 kcal per day, a virtually negligible figure.

Equally surprising—given the fact of her virtual abstinence from food—was her body weight. Some recordings were as follows (Vogl 1967, 82):

Date	Body Weight	
Wednesday, July 13	55 kg	(121 lbs.)
Saturday. July 16	51 kg	(112 lbs.)
Wednesday, July 20	54 kg	(119 lbs.)
Saturday, July 23	52.5 kg	(116 lbs.)
Thursday, July 28	55 kg	(121 lbs.)

In other words, she appeared to have lost from two and a half to four kilograms (i.e., about five to eight pounds) of body weight on the Fridays of the examination, and to have gained it back with only negligible intake! Therese was not in any kind of state of "suspended animation" when this took place. She displayed an alert waking consciousness. Her body temperature was normal, and she moved about in her room.

Likewise astounding is her increase in body weight over the years, although she was not subjected to the same degree of scrutiny that she received during the clinical observation. When she stopped eating in 1927, she weighed about 121 pounds. After the war, in 1945 she weighed 185 pounds. By 1953, she was up to 235 pounds (Vogl 1967, 25).

One of the physicians performing the clinical observation, Dr. Seidl, wrote the following in his report:

> The fact...that Therese showed a gain in weight, three kg. in the first case and 2.5 kg in the second case, without taking any nourishment or liquids is to be explained by none of our physiological laws or experience. (Steiner, J. 1976, 186)

His statement leads to a question which will be explored in the next chapter: are our physiological laws, then, sufficient by themselves to explain the activity of the human body and to guide us in the field of human nutrition?

E. Alternate Explanations

The normal tendency of the scientifically trained mind of today is to dismiss the case of Therese Neumann as fraudulent, or to simply ignore it. It cannot be explained using calorie theory, or physical laws such as the conservation of energy or the conservation of mass. And yet the careful and apparently factual accounts remain.

We must therefore decide what to do with it. We could dismiss it out of hand, without closer examination, because it does not fit the leading scientific world view of our time. An initial reaction might be to consider her to be a fraud, and to give no further attention to her case. However, the results of the clinical observation, and the sworn testimony of numerous witnesses who knew her well suggest that this is not the case. Moreover, her bearing and character do not suggest any fraud. Her kindness and selfless devotion to the needs of others also speak against any duplicity on her part. Although none of this constitutes undeniable proof, it is certainly enough to warrant even the greatest skeptic keeping an open mind.

Another alternative would be to simply accept Therese's case as an anomaly. We might then say that it is a miracle, and believe that the miraculous exists in a realm where science and rational inquiry cannot extend. This attitude places unnecessary limits on human knowledge. This was seen by the Indian teacher Paramahansa Yogananda, who visited Therese Neumann in 1935. He wrote:

> A "miracle" is commonly considered to be an effect or event without law, or beyond law. But all events in our precisely adjusted universe are lawfully wrought and lawfully explicable. The so-called miraculous powers of a great master are a natural accompaniment to his exact understanding of subtle laws that operate in the inner cosmos of consciousness. Nothing may truly be said to be a "miracle" except in the profound sense that everything is

> a miracle. That each of us is encased in an intricately organized body, and is set upon an earth whirling through space among the stars—is anything more commonplace...or more miraculous? (Yogananda 1977, 321)

So we see that both of these alternatives are unsatisfying to the inquiring human mind, for they are intellectually lazy, if not even intellectually dishonest. A conscientious approach to the question of human energy metabolism demands that we at least be open to an explanation outside of the boundaries of our existing theories and hypotheses.

This issue will be discussed in the concluding chapter. Here, however, we might consider the explanation offered by Therese Neumann herself. Her pastor and confessor, Father Naber, wrote:

> Whenever she was asked what she lived on, Therese would say, quite simply, "on the Savior." She meant "on Holy Communion." Her life was a literal fulfillment of the Lord's words: "My flesh is meat indeed and my blood is drink indeed." (Steiner, J. 1976, 188) [2]

This is certainly not the kind of "scientific" explanation that we are used to today. Nonetheless, it may serve to shake us from the modern complacency with physical explanations to biological phenomena. And it may also point the way to how we can teach people about nutrition in a way which is true to the phenomena of human existence, supportive of human dignity, and useful to people in their daily lives.

F. Therese Neumann as Example

The question naturally arises: to what extent can Therese Neumann be seen as an example for men and women in the present time? Two things must be considered in answering this. First, it must be emphasized that Therese's sanctity was not the result of her abstaining from food. On the contrary, her ability to live eating

2 The biblical reference made by Fr. Naber is to John 6:55.

nothing but the consecrated host was the result of her sanctity, her pious nature, her moral bearing and the grace which worked through her. We must not confuse cause and effect. Likewise, we must not confuse end and means. The ability to live with almost no physical food is not an end in itself. It may have been useful to Therese to do so, but the purpose of her life was to serve God and His creation, and to embody and spread His love and joy to her fellowman.

The second consideration deals with the stage of human evolution which Therese Neumann stood at during her lifetime. She was clearly a remarkable and exceptional being. But did she represent the highest ideal toward which humanity in our age may strive? A clue to answering this question can be found in the Bible. As Christ spoke to the people about His forerunner, John the Baptist, He said:

> ...John came neither eating nor drinking, and they say, he hath a devil. The son of man came eating and drinking, and they say, Behold a man gluttonous, and a winebibber, a friend of publicans and sinners. (Mt. 11:18-19)

Clearly, He was pointing out the hypocrisy of those who spoke against Him. Yet He also revealed a mystery with this saying. John, the forerunner, ate little. But Christ, who was the fulfillment of John's mission and prophecy, and who stood at a higher spiritual level than John, ate and drank freely.

One way of looking at this is to see in John a teacher of liberation from the constraints of earthly passions and physical matter, and to see in Christ Jesus the embodiment of the principle of the transformation of fallen creation. He took the food and drink—the substances of the earth—into Himself, transforming them without becoming dependent on them. Under certain circumstances in the present stage of the evolution of the earth, eating and drinking may actually represent a higher stage than abstaining, in the case of highly developed spiritual masters.

Thus, we cannot point to complete abstinence from food and drink as the highest example for our time. But we can say that what Therese Neumann accomplished was truly remarkable. She was a living testimony to the power of the spirit over matter and a living refutation of the materialistic theories and prejudices regarding nutrition and energy metabolism in our time.

VII. TOWARD A NEW WORLD VIEW

A. What is Known?

The considerations put forth in the preceding chapters make at least one fact quite clear. There is a lack of fundamental knowledge within the modern scientific community about the relationship between food and energy production in the human body. What is currently known is less complete and useful than one might have imagined. Moreover, we have seen that at least some scientists are quite candid about this.

What is known is the following. There appears to be some relationship between food intake and weight management or energy production. Moreover, when looking at the averages of homogeneous populations—i.e. groups of healthy adults from similar backgrounds with similar life-styles—there is a mathematical relationship between the caloric value of food eaten and the caloric value of energy produced.

However, this relationship cannot be applied with certainty to individuals. The most obvious instance of this is the case of Therese Neumann which was looked at in Chapter VI. This woman ingested food with a heat value of no more than 11 kcal per day, and yet she thrived and gained weight. It follows, then, that we cannot speak of a universal law of the conservation of energy when it comes to the human body. One may speak of a tendency, but the existence of even one exception precludes speaking about universal laws.

B. The Old and the New World Views

We now come to an important question. Can we find a new world view which offers not only a more thorough and accurate explanation of the phenomena of human life, but could also engender results in the areas of education, nutrition and agriculture which bring health to our planet and its inhabitants?

The old world view might be called materialistic reductionism. Historians of science have also called it mechanism. It rests on the belief that all phenomena can be reduced to physical causes, and thus explained by the laws of physics and chemistry. The scientist may be moral or religious in his personal life, but concepts of right and wrong or of the Creator do not enter into his scientific explanations. He is simply the observer of the outside world, and his own inner life is excluded from consideration.

The new world view will unite inner experience and outward, sensory observation. As such, we may call it holistic monism. It includes a unified view of all human experience: the objective experience of the physical world, the subjective experience of the psyche, and the trans-subjective experience of creativity and morality, i.e. the spirit. It is holistic because it includes all areas of human experience. It is monism because it bespeaks the essential unity of these areas.

The word 'spirit' has taken on a wide variety of meanings, which we will not address. We use it here simply to refer to the creative element in the world—to that which brings something new into existence. In nature, the spirit creates from outside. Minerals, plants and animals are the result of this creation. But the spirit is within the human being; the human being is itself creative, is itself spirit. It brings forth works of art, social forms, inventions, philosophical ideas and religious doctrines.

One can see that the human spirit can lift up and ennoble physical matter. Music can make the metal of a flute or the wood of a violin express a heavenly beauty. A stone can be transformed into a statue, or a piece of canvas into a painting. The human body is itself a work of art, for it expresses and reveals the unique human individuality.

We are here led to a question which may well appear absurd to many people today, but which is nonetheless important. Can one's human spirit work directly, solely by means of the will, into the matter of one's physical body? Can it creatively accomplish transformations between energy and matter? If so, then the old world view, which is based on materialism, and which therefore excludes consideration of the creative spirit, cannot hold true. A hundred years ago, it would have sounded absurd to the western scientific community to speak of transforming matter into energy. Today, nuclear weapons and reactors are routinely designed and operated based upon the reality of such transformation. They are conceived of by the human spirit and manifest in the outer world through the creative will of men and women. Ought we not to at least be open to the possibility that a process may occur in the living human body which is just as profound as a nuclear reaction, but is creative and moral rather than destructive? Is not the transformative power of life at least as profound and wondrous as the phenomenon of nuclear fission?

Modern physics has already made strides toward understanding the relationship between the spirit and matter. Werner Heisenberg saw that the observer could not be separated from the phenomenon being observed because the very process of observation affects the object of study (Talbot 1981, 22). Other physicists have even gone on to say that the consciousness of the observer affects the experiment. One, Jack Sarfatti, the director of the Physics/Consciousness Research Group, wrote:

> The full meaning of quantum theory is still in the stage of being born. In my opinion, the quantum principle involves *mind* in an essential way along the lines suggested by Parmenides, Bishop Berkeley, Jeans, Whitehead et al. (Talbot 1981, 3)

An historian of the development of modern physics describes the relationship between the observer and the observed—between subject and object—as follows:

> ...there is no strict division between subjective and objective reality; consciousness and the physical universe are connected... This relationship between mind and

> reality is not subjective or objective, but "omnijective." (Talbot 1981, 2)

So we see that modern physicists are pointing to the activity of the human spirit, not only in understanding material phenomena, but also in creating them. Richard Morris, a physicist and author in San Francisco, wrote:

> It no longer seems possible to do research on the frontiers of physics without confronting questions once thought to be metaphysical. (Morris 1990, 220)

The same must now be said about research—and education—on the frontiers of human nutrition.

A hint of how this applies to the human body can be found in our language. The word 'hematopoiesis' means the creation of blood. The Greek root 'hemato' relates it to the blood. The root 'poiesis' is of the same origin as our word 'poesy' or poetry. It means to create, and implies an artistic, holistic creation, a bringing of something entirely new into existence. Thus, the originators of this word tacitly suggest that it is possible to imagine the blood as more than just the result of a chemical reaction and that it can be envisioned as the creation of the human individuality.

If we can go beyond thinking of such creation as a possibility to seeing it as a reality—if we can awaken a power of inner vision which sees that our creative, moral impulses become manifest in physical matter, we will then be experiencing the new world view. As one sees the world of outer phenomena as the product of the creative spirit, one is filled to the depths with a feeling of responsibility. One sees the results of human creativity—both moral and immoral—everywhere on the planet.

Justus von Liebig, the nineteenth century scientist whom we referred to in Chapter III, is credited with being the father of chemical agriculture. His work was based on the old world view. Although it had many apparently good and positive fruits, the continued application of this way of thinking has led to debasing the earth's soil and to jeopardizing the sustainability of our agriculture.

In contrast, the agricultural work of the twentieth century scientist Rudolf Steiner led to the "biodynamic" agricultural method in 1924. It is an holistic approach to farming. His work was based on the new world view, and the result has been farmland with increasing fertility and topsoil when the method is properly applied.

He addressed the question of the relationship between the human body and food as follows:

> Most of what we consume is actually excreted again, so that with regard to metabolism, the important thing is not so much the correct weights and proportions, but whether or not the vitality of the forces in the food can be taken up in the right way. We need this vitality, for instance, whenever we walk or work, or simply move our arms. (Steiner, R. 1993, 62-63)

From within the old world view, such words would be dismissed as nonsense. But understood from the new world view—the world view out of which they were spoken—they lead to positive practical results.

C. Implications for Educators

Having reconsidered a fundamental tenet of nutrition science, we must ask what practical value this has for the nutrition educator. We have seen that, because of the complexity of the living human body, the calorie is at best a rough tool when applied in a clinical or counseling setting (Chapter IV). The fundamental questions about the universal applicability of the calorie theory to the human being (Chapters V and VI) likewise call its application into question.

What, then, ought the educator to tell people about the relationship between food, body weight and energy? To begin with, one needs to be honest. Calling the body a "machine" and speaking of food as providing "fuel" and "spare parts" does not present a realistic picture. Nor is it correct to say that a deficit of 3,500 kilocalories in any person's diet will necessarily result in the loss of a pound of body fat. About all that can be said with certainty is that sometimes people gain weight when they eat a lot, and sometimes people lose weight when they eat very little. But what constitutes "a lot" or "a little" is actually quite individual.

It should be emphasized that this individuality is not merely the result of calculable physical factors. It might be said, for example, that different automobiles have different levels of energy efficiency. This analogy is somewhat useful, as long as we are aware of its limitations. But the analogy of a car to the human body is incomplete and can therefore be misleading. The efficiency of the car is based on factors which can be measured—e.g. friction, heat loss, or incomplete combustion. There is no evidence that this always applies to the human body. In fact, there is evidence to the contrary. Moreover, there are social and moral implications to presenting the human body as being determined only from without which we will address below.

An avenue that might well be explored is that of offering alternatives to a strictly quantitative, mechanistic view of energy metabolism. It is not the purpose of this work to carefully examine all possible alternatives to the calorie theory of food. The author's intention is merely to show that such alternatives are necessary, and to urge that they be explored. With this in mind, a few possibilities for further exploration are offered below.

In counseling people about weight loss or gain, one might speak about meal composition, and especially about the amount and proportion of fat in the diet. One might also look at questions of appetite control. Is a person eating too much—for his or her own individual body—because of underlying psychological reasons? Does that person over-eat because the sensory qualities of his or her food are lacking, because the food does not taste, smell and feel satisfying? Or could over-eating be an attempt to compensate for a diet which is deficient in some essential nutrient which the body is craving? Questions of this type, although outside the scope of this work, have already been explored to varying degrees, and may hold promise. Of course, speaking to people's attitude about food and their bodies from a holistic point of view—which we will address below—is also of great significance.

D. Social and Moral Implications

What people are taught, and how they are taught, about the relationship between their bodies and their food has far-reaching consequences. The predominant scientific world view today sees the human body as being exclusively under the influence of physical laws and, therefore, of physical necessity. The attempt is made to reduce or trace back all activity of the body to the laws of physics and chemistry. Questions of free will and morality are left to religion and philosophy. They are considered to be outside the realm of science and, by implication, outside the scope of what can be truly known.

When this attitude is translated into the practical activity of nutrition education, it leads to teaching people to look outside of themselves for their controlling influences. As an example relevant to our theme, they might be taught that their body weight can only be controlled by eating food with the right number of calories.

Thus, a person is led to accept the authority of experts based on ideas and occurrences outside the sphere of the person's own experience. Many lay people may have only a vague idea of what a calorie is. To them, it is simply a measure (as we have seen, a fallacious measure) of how fattening a food is. Certainly very few will own bomb calorimeters, or even have ever used or seen one. They become, in a subtle but nonetheless significant way, dependent on outside authority.

Teaching people that the body is a machine, that food is its fuel, and that the energy value of that fuel can be strictly quantified in terms of calories takes this tendency even further. For a machine is wholly determined by laws external to itself. To be sure, a religiously or philosophically oriented educator might go on to say that the body is a machine, but that the mind or the soul is the operator. Yet that still leaves the impression that body and soul are fundamentally alienated from each other, even while being intimately bound to each other.

The social implications of this approach to nutrition education become clear when thought of in this way. It accustoms people to think of themselves as being inextricably bound by laws foreign to themselves, and this thinking will permeate their entire lives, not just their eating behavior. Thus, they become less likely to look within—to the moral law revealed in the conscience of the individual—and more likely to be influenced by political, commercial or other outside forces.

E. An Alternative to Materialism

The considerations presented in the preceding chapters reveal that another approach to food and energy is possible. It is not inconsistent with known scientific knowledge to teach that the body is not merely the tool of the individual, but is—to a greater or lesser degree—an expression of one's spiritual individuality. Thus, a person's relationship to food is healthy to the extent that it is raised out of the realm of what is predictable and quantifiable and into the realm where spontaneous creativity, morality and love hold sway. For in doing this, the person comes into harmony with life itself.

Pitrim Sorokin was a well-known professor of sociology and the founder of the Harvard Research Center in Creative Altruism. He saw that love, as the highest moral value, is the basis of biological life. He wrote the following:

> The biological counterpart of love energy manifests itself in the very nature and basic processes of life. This energy, still little known, and often called the "vital energy" that mysteriously unites various inorganic energies into a startling unity of a living—unicellular or multicellular—organism, is the first biological manifestation of the Empedoclean energy of love...without the operation of a

biological counterpart of love energy, life itself is not possible... (Sorokin 1954, 9) [3]

From this point of view, some one like Therese Neumann is not an aberration whose condition is irrelevant to that of the rest of humanity. She simply manifested to a very high degree the love which is inherent in every single human being. Contemplation of moral heroes or "heroes of love" as Sorokin (p. 464) called them awakens and strengthens this dormant power of love. Thus, Therese could be seen as a pioneer, preparing and showing the way to a nutrition that has become totally spiritual. She manifests clearly and plainly the spiritual aspect of nutrition which is at work in all human beings. Her condition thus represents an ideal to which the nutrition educator could point. Of course, it is not advisable to urge most people to stop eating altogether! Still, much could be done to heal our relationship to food by teaching that we are fed not only by the quantifiable matter and energy in our daily food, but also by the love —as a concrete spiritual reality—in it.

This message could, perhaps, be offered in a different form to people of different cultures and religions. The basis for it is quite strong within the Jewish and Christian traditions. For example, one can look at the words of Moses:

> And he [the Lord] humbled thee, and suffered thee to hunger, and fed thee with manna, which thou knewest not, neither did thy fathers know; that he might make thee know that man doth not live by bread only, but by every word that proceedeth out of the mouth of the Lord doth man live. (***Deuteronomy*** 8:3)

This was spoken again by Christ, as recounted in the Gospels:

> And when the tempter came to him, he said, If thou be the Son of God, command that these stones be made bread. But he answered and said, It is written, Man shall

3 The ancient Greek philosopher, Empedocles, taught that the world is made up of four elements—earth, water, air and fire—and two universal principles or forces which work on them: love and strife.

> not live by bread alone, but by every word that proceedeth out of the mouth of God. (***Matthew*** 4:3-4)

Of course, it is not the task of the nutrition educator to put forth any kind of religious belief, or to engage in any kind of proselytizing. However, it is permissible—and may in many instances be helpful—to present important truths in the language of the religious tradition of the people or person to whom one is speaking, for these traditions are rooted deeply within the souls of many human beings.

F. Practical Significance

How might we imagine the effects on nutrition education of adopting the new world view? What would be the practical results of holistic monism for the nutrition educator? One result would be a bridging of the cleft between the cognitive life and the spiritual life, between science and religion. This would not involve bringing any kind of dogmatism or blind faith into science. It would, however, involve bringing literal explanations and conceptual clarity to spiritual phenomena, even while approaching them with reverence.

The old world view attempts to explain the phenomena of living organisms using concepts taken from the realm of inanimate objects. Put into biblical metaphor, it is the attempt to turn "stones" (the science of lifeless objects) into "bread" (the science of living organisms). The new world view seeks to understand the phenomena of life by considering not only their material basis, but also their spiritual origin.

For example, in the quotation above, Moses spoke about the manna from heaven which fed the Hebrew people in the desert. In saying that "man doth not live by bread only, but by every word that proceedeth out of the mouth of the Lord" he was saying—albeit in partially allegorical language—that nutrition has not only a physical, terrestrial component, but also a spiritual, cosmic aspect. In other words, he was speaking holistically. This same idea can be found in the literature about biodynamics, such as the agricultural work of its founder, Rudolf Steiner, whom we mentioned above. In the biodynamic method, crops are cultivated taking into consideration what comes from the heavens, such as the rhythms and forces of the sun and moon. Even the subtle influences of the planets are considered (Steiner, R. 1993, 23). Teaching people about nutrition from the perspective of holistic monism involves awakening them not only to the tangible component of their food, but also to the intangible elements—such as light and warmth—which are dependent on the method used to grow them.

Furthermore, we would be able to speak about the quality of food per se, without having to reduce quality to quantitative terms. People could be taught to value the experience of their sense organs. Color, taste and smell, or how a food makes the body feel, would be just as important as the food's mineral content or fatty acid profile.

Another result would be to work toward strengthening the individual in his or her relationship with food. This involves schooling the appetite. The counselor could help the client to improve his or her relationship to food—regarding both the quantity and the type of food—to reflect the true needs of the body. For example, the counselor could offer imaginative pictures of different foods. For people in urban areas or others with a weak connection to the land, this might involve a visit to a garden or farm. It might even involve planting and tending a garden and sharing the produce with others. In living with these imaginations, the client can begin to have a conscious longing to eat appropriate foods and to avoid those which are unhealthy or inappropriate for him or her. A detailed description of this imaginative approach to nutrition goes beyond the scope of this present work. The interested reader is referred to the books Dynamics of Nutrition and Essentials of Nutrition by Gerhard Schmidt which are cited in the bibliography.

As an example, we might ask what advice could be given to a nutritionist trying to counsel an overweight client, based on our findings. Let us assume that the client is truly overweight and that there are sound medical reasons for weight reduction. Helping to bring the client into the right relationship with food, as outlined above, would certainly be appropriate. As he or she becomes more conscious of what food is and where it comes from, and more aware of the real nature of his or her body, it will be easier to choose the right foods in the right amounts.

More importantly, however, the counselor should strive to help the client put eating in its rightful place. A person with an undirected or unconscious hunger for God and for a creative spiritual life may seek to satisfy this longing with physical food. This would need to be recognized and turned in the right direction.

This, then, points to the fact that the education of the nutritionist needs to go beyond a strictly quantitative approach to food and nutrition. A development of the aesthetic sense through art, and an understanding of philosophy, ethics and the spiritual life would all be very helpful.

In addition to an imaginative presentation of foods, the awakening and strengthening of the human spirit through nutrition education can be furthered through an imaginative presentation of the human being. Biography is one way of doing this, and our presentation of Therese Neumann in Chapter VI is offered as an example. Her story reveals that the human body is not only subject to the laws of physics and chemistry, but also to the spirit. It can give hope to others, and point to the fact that biological heredity need not be destiny, that people may form their bodies in such a way that they become true expressions of the individual spirit.

Our research would suggest that this process can be enhanced as a person decreases his or her dependence on physical food and looks more toward supernal nourishment. Therese Neumann was one example of this. We also find that fasting is part of most major religions and spiritual traditions, whether it be during Lent for Christians, at Yom Kippur for Jews or during Ramadan for Muslims. It lifts one out of the realm of the mechanical and predictable and allows for greater spiritual purification and growth. From this point of view, it is not surprising that in the calorimetry studies by Dr. Webb (Chapter V), the greatest discrepancies between theoretical and measured energy were seen when the subjects had restricted food intake.

This brings us to the question of whether the calorie has any place in the study or teaching of human nutrition. We find that a mechanistic approach to nutrition is applicable only insofar as a person has embodied the nature of a machine. A loveless, predictable and mechanical approach to food and eating places the body in the realm of mechanical predictability—i.e. into the realm where counting calories works. Eating food in prayer and gratitude and connecting with one's spiritual nature in love lifts one out of this realm. Just imagine how Therese Neumann would have answered someone who asked her about counting calories!

Another point which Therese Neumann's case teaches us is that our morality and spiritual life are inseparable from our nutrition. This is obvious when we consider the environmental and social impact of our food choices. It takes on an additional and profound meaning when we think about Therese who—to put it in the metaphors used by Moses—lived not by bread alone, but from every word of God.

The third century philosopher and theologian, Origen, wrote about a Greek word which may help us to understand this. In the Lord's prayer—one of the pillars of Christian religious tradition—we find the petition: "Give us this day our daily bread" (Matthew 6:11). The word translated as "daily" is ἐπιούσιον (epiousion). It is derived from οὐσία (ousia) (Origen 1979, 140) which means "that which is" (A Greek-English Lexicon, s.v. "ousia") or "essence." Thus, the word epiousion means that which rests on the essence, the "source of being"—in other words, upon the spirit of the Creator. Is the "essential" bread not the same as the manna spoken of by Moses, only presented through the Greek language? What nourishes us must be essential—it must come from the Creator—either directly or indirectly through plants, animals, sunshine, rain, etc.

Our relationship with the Creator is not merely physical; it is also moral and spiritual. Viewed holistically, it is not mere coincidence that Therese Neumann had such a pronounced spiritual development, that she attained a high degree of selflessness, piety and joy in God and His creation. She entered into life in a spirit of service to both the divine and to her fellow human beings. The ability to work creatively and positively into earthly matter requires a communion with—and embodiment of the virtues of—the Creator of this matter.

We must therefore conclude that nutrition education (like all education) can and ought to be moral education. This does not mean that it should present a fixed code of conduct. Rather, the very presentation of the phenomena of agriculture and nutrition should awaken the innate sense for the difference between right and wrong, and the will to do what is right, which every human being possesses as his or her individual conscience.

The way a food is grown, the way it is stored and prepared, and the gratitude with which it is received and eaten all play an important role. The nutrition educator working out of the new world view will find ways—suited to his or her own talents, the needs of the learners and the needs of the community—for bringing about this awakening.

It must be emphasized that we have not conclusively proven that the human body need not be subject to the laws of thermodynamics. But we hope to have shown that calorie theory can only be applied in nutrition education in a very limited way. Furthermore, we hope to have shown that there is room for assuming that there are human bodily phenomena which cannot be explained by known physical laws.

Likewise, we have not proven that the principles of nutrition must be taught out of the world view of holistic monism, in such a way that the body is seen as an expression of the human individuality. Indeed, such ideas lie in a realm where proof has no utility, and must be replaced by experience. So it is left to the reader to search his or her own heart for the truth of what we are saying about a new approach to nutrition education, and to act according to what is discovered there.

In closing, we offer some words of a song sung in the author's church as a meditation for those who might choose to undertake this search:

Joy is life from the Father.

Love is warmth from the Son.

Peace is manna from the Spirit.

In all three, we are one.

* * *

BIBLIOGRAPHY

Asimov, Isaac. 1964. ***A Short History of Biology***. Garden City, NY: Natural History Press.

Atwater, W. O. and F. G. Benedict. 1903. ***Experiments on the Metabolism of Matter and Energy In the Human Body, 1900-1902***. U.S. Department of Agriculture, Office of Experiment Stations Bulletin no. 136. Washington, DC: United States Government Printing Office.

Benedict, F. G. 1915. ***A Study of Prolonged Fasting***. Washington: Carnegie Institution.

————. 1907. ***The Influence of Inantition on Metabolism***. Washington: Carnegie Institution.

Benedict, F. G., W. R. Miles, P. Roth and H. M. Smith. 1919. ***Human Vitality and Efficiency Under Prolonged Restricted Diet***. Washington: Carnegie Institute.

Blaxter, Kenneth. 1985. "Energy Intake and Expenditure." In ***Nutritional Adaptation in Man***, ed. K. Blaxter and J.C. Waterlow. London: John Libbey & Co.

Blonz, Edward R. and Judith S. Stern. 1981. "Obesity and Fad Diets." In ***Controversies in Nutrition***, ed. Leon Ellenbogen. New York: Churchill Livingstone.

Bortoft, Henri. 1986, ***Goethe's Scientific Consciousness***. Tunbridge Wells, England: Institute for Cultural Research.

Callaway, C. Wayne. 1988. "Biologic Adaptations to Starvation and Semistarvation." In ***Obesity and Weight Control***, ed. Frankle and Yang. Rockville, MD: Aspen Publishers.

Coleman, William. 1971. ***Biology in the Nineteenth Century***. New York: John Wiley & Sons.

Cunningham, John J. 1991. "Body Composition as a Determinant of Energy Expenditure: a Synthetic Review and a Proposed General Prediction Equation." ***American Journal of Clinical Nutrition***. 54: 963-969.

Durnin, J., O. Edholm, D. Miller, and J. Waterlow. 1973. "How Much Food Does Man Require?" ***Nature*** 242: 418.

Glickman, N., H. Mitchell, E. Lambert and R. Keeton. 1948. "The Total Specific Dynamic Action of High Protein and High Carbohydrate Diets on Human Subjects." ***Journal of Nutrition***. 36: 40-57.

A Greek-English Lexicon. 1968. Comps. Henry G. Liddell and Robert Scott. Oxford: Claredon Press.

Guerlac, Henry. 1961. ***Lavoisier—the Crucial Year***. Ithaca, NY: Cornell University Press.

Hippocrates. 1952. ***Hippocrates on Diet and Hygiene***. Ed., trans. and introd. John Precope. London: Zeno.

Kinney, John M. 1988. "Food As Fuel: The Development of Concepts." In ***Modern Nutrition in Health and Disease***, eds. M.E. Shils and V.R. Young. Philadelphia, PA: Lea & Febiger.

Kleiber, M. 1975. ***The Fire of Life***. Huntington, NY: Robert E. Krieger Publishing.

Kuhn, Thomas. 1970. ***The Structure of Scientific Revolutions***. Chicago: University of Chicago Press.

Lichtman, S., K. Pisarska, E. Berman, et al. 1992. "Discrepancy between Self-Reported and Actual Caloric Intake and Exercise in Obese Subjects." ***New England Journal of Medicine***. 327:1893-1898.

Lieber, Charles S. 1991. "Perspectives: Do Alcohol Calories Count?" ***American Journal of Clinical Nutrition***. 54: 976-821.

Luke, A. and D. Schoeller. 1992. "Basal Metabolic Rate, Fat-Free Mass, and Body Cell Mass During Energy Restriction." ***Metabolism***. 41: 450-456.

Mendelsohn, Everett. 1964. ***Heat and Life***. Cambridge, MA: Harvard University Press.

McKie, Douglas. 1952. ***Antoine Lavoisier: Scientist, Economist, Social Reformer***. New York, NY: Schuman.

Morris, Richard. 1990. ***The Edges of Science: Crossing the Boundary from Physics to Metaphysics***. New York: Prentice Hall.

Mount, Ellis and Barbara List. 1987. ***Milestones in Science and Technology***. Phoenix, AZ: Oryx Press.

Naber, Joseph. 1987. ***Tagebücher und Aufzeichnungen über Theres Neumann***. Munich: Verlag Schnell und Steiner.

Nordenskiöld, Erik. 1935. ***The History of Biology***. Trans. Leonard Eyre. New York: Tudor Publishing Co.

Origen. 1979. "On Prayer." In ***Origen***, trans. Rowan A. Greer. New York: Paulist Press.

Pi-Sunyer, F. Xavier. 1988. "Obesity." In ***Modern Nutrition in Health and Disease***, eds. M.E. Shils and V.R. Young. Philadelphia, PA: Lea & Febiger.

Plato. 1978. "Timaeus." In ***The Collected Dialogues of Plato***, ed. and trans. E. Hamilton and H. Cairns. Princeton, NJ: Princeton University Press.

Schimberg, Albert Paul. 1947. ***The Story of Therese Neumann***. Milwaukee: Bruce Publishing Co.

Schmidt, Gerhard. 1980. ***The Dynamics of Nutrition.*** Trans. G. F. Karnow. Wyoming, RI: Bio-Dynamic Literature.

———. 1987. ***The Essentials of Nutrition***. Trans. W. M. Riggins. Wyoming, RI: Bio-Dynamic Literature.

———. 1985. ***Zür Qualitätsfrage in der Ernährung***. Krönbuhl, St. Gallen, Switzerland: Proteus Verlag.

(English translation of text: "Quality in Nutrition", Trans. W. M. Riggins, Hudson NY: Anthroposophic Press)

Schoeller, Dale A. 1988. "Measurement of Energy Expenditure in Free-Living Humans by Using Doubly Labeled Water." ***Journal of Nutrition***. 118: 1278-89.

Schumacher, Joseph. 1965. ***Die Anfänge abendländischer Medizin in der griechischen Antike***. Stuttgart: W. Kohlhammer Verlag.

Shenstone, W. A. 1895. ***Justus von Liebig: His Life and Work (1803-1873)***. London: Cassell & Co.

Sorokin, Pitrim A. 1954. ***The Ways and Power of Love***. Boston: Beacon Press.

Smith, Wesley. 1979. ***The Hippocratic Tradition***. Ithaca, NY: Cornell University Press.

Steiner, Johannes. 1967. ***Therese Neumann: A Portrait Based on Authentic Accounts, Journals and Documents***. New York: Alba House.

———. 1976. ***The Visions of Therese Neumann***. New York: Alba House.

Steiner, Rudolf. 1993. ***Spiritual Foundations for the Renewal of Agriculture***. Trans. C. E. Creeger and M. Gardner. Kimberton, PA: Bio-Dynamic Farming and Gardening Association.

———. 1988. ***The Philosophy of Spiritual Activity***. Trans. W. Lindemann. Hudson, NY: Anthroposophic Press.

Stordy, B. J. 1977. "Weight Gain, Thermic Effect of Glucose and Resting Metabolic Rate During Recovery from Anorexia Nervosa." ***American Journal of Clinical Nutrition***. 30: 138-146.

Tai, Mary M., P. Castillo, and F. X. Pi-Sunyer. 1991. "Meal Size and Frequency: Effect on the Thermic Effect of Food." ***American Journal of Clinical Nutrition***. 54: 783-787.

Talbot, Michael. 1981. ***Mysticism and the New Physics***. New York: Bantam Books.

Vogl, Adalbert Albert. 1967. ***Therese Neumann: Mystic and Stigmatist***. Rockford, IL: T.A.N. Books and Publishers.

Webb, Paul, James Annis and Samuel Troutman. 1980. "Energy Balance in Man Measured by Direct and Indirect Calorimetry." ***American Journal of Clinical Nutrition***. 33: 1287-1298.

Webb, Paul. 1985. ***Human Calorimeters***. New York: Praeger.

———. 1980. "The Measurement of Energy Exchange in Man: An Analysis." ***American Journal of Clinical Nutrition***. 33: 1299-1310.

———. 1991. "The Measurement of Energy Expenditure". ***Journal of Nutrition***. 121: 1897-1901.

Welch, G. Rickey. 1991. "Thermodynamics and Living Systems: Problems and Paradigms." ***Journal of Nutrition***. 121: 1902-1906.

Whitney, Eleanor Noss and Corine Cataldo. 1983. ***Understanding Normal and Clinical Nutrition***. St. Paul, MN: West Publishing Co.

Yogananda, Paramahansa. 1977. ***Autobiography of a Yogi***. Los Angeles, CA: Self-Realization Fellowship.