

Vegetarian nutrition: past, present, future^{1–3}

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ABSTRACT

Early human food cultures were plant-based. Major religions such as Hinduism and Buddhism have recommended a vegetarian way of life since their conception. The recorded history of vegetarian nutrition started in the sixth century BC by followers of the Orphic mysteries. The Greek philosopher Pythagoras is considered the father of ethical vegetarianism. The Pythagorean way of life was followed by a number of important personalities and influenced vegetarian nutrition until the 19th century. In Europe, vegetarian nutrition more or less disappeared during the Middle Ages. In the Renaissance era and in the Age of Enlightenment, various personalities practiced vegetarianism. The first vegetarian society was started in England in 1847. The International Vegetarian Society was founded in 1908 and the first vegan society began in 1944. Prominent vegetarians during this time included Sylvester Graham, John Harvey Kellogg, and Maximilian Bircher-Benner. A paradigm shift occurred at the turn of the 21st century. The former prejudices that vegetarianism leads to malnutrition were replaced by scientific evidence showing that vegetarian nutrition reduces the risk of most contemporary diseases. Today, vegetarian nutrition has a growing international following and is increasingly accepted. The main reasons for this trend are health concerns and ethical, ecologic, and social issues. The future of vegetarian nutrition is promising because sustainable nutrition is crucial for the well-being of humankind. An increasing number of people do not want animals to suffer nor do they want climate change; they want to avoid preventable diseases and to secure a livable future for generations to come. *Am J Clin Nutr* 2014;100(suppl):496S–502S.

INTRODUCTION

In this article, the term *vegetarian nutrition* refers to all forms of this diet. Whenever vegan, raw food, or related diets are implied, this is explicitly mentioned.

The anatomic and physiologic characteristics of carnivores and herbivores in the animal kingdom compared with the characteristics of humans show that humans are omnivores by nature (1). However, plant foods may be the most important food source for human health (2–5).

In former times, plants and their fruit were most likely always available, and they were easy to gather. Hunting animals was difficult and often dangerous, so that animal products were probably only consumed sporadically, except for short periods such as in the Paleolithic Era. It is likely that the consumption of small and slow-moving animals, eggs, fish, and possibly bone marrow and carrion may have played a role in the development of the human brain. With the introduction of agriculture, human diets became increasingly plant-centered.

THE HISTORY OF VEGETARIAN NUTRITION

The data on the early phase of vegetarian nutrition are fragmentary and are not always consistent. Some helpful information can be derived from the writings of historical authors (6). It is fairly clear that major early human cultures practiced a predominantly plant-based nutrition, but the precise historical extent of vegetarianism remains unknown (**Table 1**).

Many major religions include certain rules with regard to what to eat and drink and rules about conduct toward animals, ranging from kind treatment to an equal standing with humans. These rules remain influential in many religions and cultures to the present time.

The oldest written documents on vegetarianism in Europe date back to the sixth century BC by followers of the Orphic mysteries. This religious group banned the sacrifice of animals and the consumption of meat and refused to eat anything animal-based (including eggs). At approximately the same time, the Greek philosopher and mathematician Pythagoras developed his ideas about reincarnation, which led to the avoidance of the consumption of meat. He is considered the father of ethical vegetarianism and his name gave rise to the term *Pythagorean way of life*. The Pythagorean way of life was embraced by a number of prominent classical philosophers and writers (**Table 2**) and influenced nutrition in Europe until the 19th century.

Most of the reasons given for practicing vegetarian nutrition have hardly changed over the past 2.5 millennia. The ancient Greeks believed that animals were related to humans and that they were able to communicate and think. It was held that humans are legally responsible for animals and that killing them meant injustice and harm. The ancient Greeks were of the opinion that animal welfare taught humans about humanitarianism and they believed in reincarnation. The ancient Greeks observed that eating meat can be harmful to health and felt that it influenced the mind. They were of the opinion that plant food was supposed to cleanse the soul and that vegetarianism leads to an alignment with the gods. Also, they knew that there was enough food without eating meat (6).

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TABLE 1
Staple foods of important early human cultures¹

Culture	Staple foods
Egypt	Wheat, barley
China	Wheat, soya, sorghum
India	Corn, rice, wheat, lentils
Middle East	Wheat, chickpeas
Mexico, Mayas	Corn/maize, amaranth
Peru, Incas	Potatoes, quinoa

¹Data from reference 6.

There are no records of vegetarian nutrition in Europe after the ancient Greek and ancient Roman periods (sixth century AD). In the Renaissance era, Leonardo da Vinci practiced vegetarian nutrition. He was convinced that “the time will come when we condemn the eating of animals, just as today we condemn the eating of our own kind, the eating of humans.” During the Age of Enlightenment, individuals such as Tyron, Rousseau, Voltaire, Wesley, and many others practiced vegetarian nutrition. The number of vegetarians at that time is unknown but it was probably small. Many people who ate mainly plant food probably did so for financial reasons.

In 1847, the first vegetarian society was started in England. The American Vegetarian Society was founded in 1850 and the German Vegetarian Society was initiated in 1867, followed by the establishment of vegetarian societies in many other countries. The International Vegetarian Union was started in Dresden in 1908; the first Vegan Society began in Leicester, England, in 1944; and the European Vegetarian Union was established in Brussels in 1985.

These developments were fostered by prominent representatives of vegetarian nutrition such as Sylvester Graham (United States, 1784–1851; invented Graham bread, based on whole-grain flour, and recommended eating raw food); John Harvey Kellogg (US physician, 1853–1943; invented cornflakes and patented a process for making peanut butter); Maximilian Bircher-Benner (Swiss physician, 1867–1939; invented muesli, speculated about phytochemicals in plant foods).

During this time there were also some eminent vegetarians, such as George Bernard Shaw, an Irish playwright (1856–1950), who said “Animals are my friends, and I don’t eat my friends.”

TABLE 2
Famous vegetarians in ancient Greece¹

Name	Profession	Dates of birth and death	Reference to vegetarianism
Pythagoras	Greek philosopher and mathematician	570–500 BC	Considered the founder of ethical vegetarianism. He recommended animal food only from living organisms (milk, eggs).
Plato	Greek philosopher	428–348 BC	In his book <i>Politeia</i> , he suggested that town people be vegetarian to stay healthy. Only meat eaters living in the country need a physician.
Xenokrates	Greek philosopher	395–314 BC	Wrote the first paper on vegetarianism (not preserved, documented by other Greek writers).
Theophrastus	Greek philosopher	370–287 BC	Believed that humans and animals are related to one another physically and mentally.
Apolloius	Greek philosopher and preacher	40–90 AD	Was considered the first documented prominent vegan.
Ovid	Roman poet	47 BC to 17 AD	In his book <i>Metamorphosis</i> he provided strong arguments against eating meat.
Plutarch	Greek poet	45–120 AD	Wrote the first paper on vegetarianism that is preserved. In his book <i>Moralia</i> he recommends respecting animals.
Plotin	Egyptian/Greek philosopher	205–270 AD	Revived the Pythagorean way of life.
Porphyrios	Greek author	234–305 AD	Wrote the first book on vegetarians that has been preserved.

¹Data from reference 6.

The Indian statesman Mohandas Mahatma Gandhi (1869–1948) said, “There is enough for everybody’s feed, but not enough for everybody’s greed.” Albert Einstein, the German-US physicist (1875–1955) believed that “Nothing will increase the chances of survival for life on earth as much as the evolution to a vegetarian diet”; and Albert Schweitzer, German physician (1875–1965), said, “We must renounce meat consumption and speak up against it.”

RECENT VEGETARIAN NUTRITION

In the last decades of the 20th century, plant-based nutrition became a topic of formal scientific inquiry. The attempt to identify the most beneficial diets for humans was initiated by ecologic data from the then still young science of epidemiology obtained by studies in African, Asian, and Mediterranean countries. These data showed that populations living in these regions had, on average, the lowest rates of diet-related non-communicable diseases and lived a rather long life (7–9). Traditional Asian and Mediterranean diets are largely based on plant foods, suggesting that a plant-based diet provides health benefits beyond supplying nutrients in adequate amounts.

This heralded the replacement of one conceptual world view by another, commonly called a paradigm shift. The recognition of this paradigm shift toward vegetarian diets was first documented by Joan Sabaté of Loma Linda University (10, 11). This paradigm shift took place in various phases and was illustrated by Sabaté in 3 graphical models. The models depict the expected health risks and benefits of populations adhering to either a meat-based diet or a vegetarian diet. The models are a description of the historic progression of the scientific understanding of the effects of these 2 distinct diets.

Phase 1

The first model shows that in the 1960s (and actually prevailing through the 1970s), a population following a vegetarian diet was thought to be at a higher risk of developing a nutrient deficiency than a population adhering to a meat-based diet. It is important to note that in this model the potential benefits of a vegetarian diet, such as the prevention of chronic and degenerative diseases, were not included (**Figure 1**).

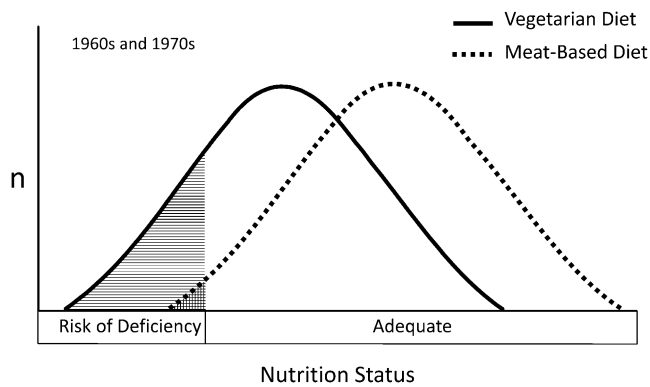


FIGURE 1. Early model on the adequacy of vegetarian diets that prevailed through the 1960s. The area under each curve represents the proportion of individuals in a population for which a given diet pattern may be adequate or deficient. The variable “n” on the y-axis represents the number of individuals in a population following a diet that results in a health outcome, either disease or health. Reprinted with permission from reference 11.

Remarkably, this assessment was not based on the available observation that people in some Asian countries had consumed vegetarian diets for millennia without nutrient deficiencies, as long as they had enough to eat. This assessment was based on the longstanding observation that in poor countries with widespread malnutrition, diets consisted mostly of plant foods. This type of malnutrition, however, is largely attributable to poverty, which leads to an unbalanced diet (12, 13). The fact that some vegetarians with medical issues came to the attention of the media and that some children in Western countries consuming vegan or macrobiotic diets were indeed malnourished (14, 15) fostered the belief and the widespread prejudice of the inadequacy of vegetarian diets. This cultural bias against vegetarian nutrition was also in accordance with the mainstream opinion at that time that vegetarian diets would lead to malnutrition (15).

Phase 2

During the 1980s and the 1990s, numerous nutritional epidemiologic studies documented the benefits of vegetarian and other plant-based diets (4, 16–19). In particular, the reduction in the risks of many chronic and degenerative diseases (obesity, ischemic heart disease, diabetes, and certain cancers) and total mortality, as well as increased longevity, were attributed to the greater amount and variety of plant foods and their various components, as well as to the absence of meat. Protective effects were consistently shown for diets of plant origin, whereas detrimental effects were correlated with the amount of meat consumed. It appeared that the positive effects of plant foods for disease prevention were more important than the adverse effects of meat consumption. This knowledge did not quite convince the greater scientific community, as depicted in the second model, which represents the general opinion of the last decades of the 20th century (Figure 2).

As indicated in Figure 2, the available evidence from studies in vegetarians was ignored to a large extent and skepticism toward a vegetarian diet still constituted the prevailing view. This is shown in Figure 2 by the minimal extent to which the potential risk of nutrient deficiency was reduced compared with that shown in Figure 1 for a vegetarian diet. A novel aspect of the model in Figure 2 was a small increase in disease risk associated with a vegetarian diet attributable to obesity in sedentary vegetarians

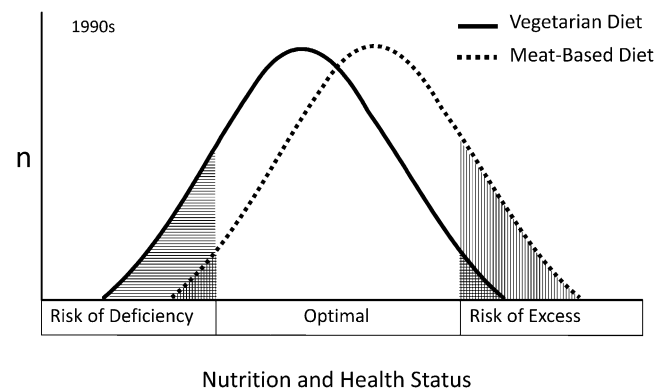


FIGURE 2. The model on population health risks and benefits of vegetarian and meat-based diets that prevailed during the 1980s and 1990s. The area under each curve represents the proportion of individuals in a population for which a given diet pattern may be a health risk or benefit. The area in the center represents the proportion of individuals for which the diet is optimal or most beneficial. The variable “n” on the y-axis represents the number of individuals in a population following a diet that results in a health outcome, either disease or health. Reprinted with permission from reference 11.

consuming more ready-to-eat plant foods that usually contain high amounts of low-quality fat or monosaccharides or salt (11). The risk of nutrient deficiency associated with a meat-based diet was only slightly increased because of the rather unbalanced nutrient composition of fast food and other nutrient-poor diets (11). Disease risk increased substantially on the basis of the increase in obesity in adults and children alike in sedentary populations worldwide, particularly for those living in affluent circumstances (11, 20).

Phase 3

At the time of the conception of the models at the turn of the century, model 2 showed the then existing opinion. On the basis of increasingly robust scientific data on vegetarian diets, a new paradigm emerged (Figure 3).

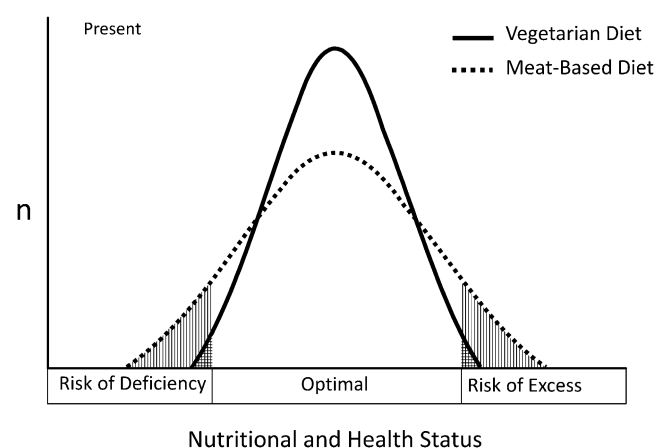


FIGURE 3. The model that prevails today. The area under the curve represents the proportion of individuals in a population for which a given diet pattern may be a health risk or benefit (optimal). At both extremes of the health continuum, there is risk of disease for deficiency or excess of nutrients or other food compounds. The area in the center represents the proportion of individuals for which the diet is optimal or most beneficial. The variable “n” on the y-axis represents the number of individuals in a population following a diet that results in a health outcome, either disease or health. Reprinted with permission from reference 11.

Model 3 was based on increasing epidemiologic, clinical, and basic science data showing numerous health advantages of vegetarian diets (2, 4, 21), particularly those associated with the increasing recognition of the various benefits of antioxidants in the form of phytochemicals (22–24). As the term implies, phytochemicals are synthesized by plants only and are only present in minimal amounts in animal products. At present, we know a fair amount, but certainly not everything, about phytochemicals and their metabolic roles. Plants synthesize phytochemicals for many of their functions; and on the basis of data from basic and clinical science and studies in animals and tissue cultures, our body uses these substances in various functions (22) (Figure 4). The reduction in the occurrence of cardiovascular diseases and certain cancers in populations consuming a vegetarian diet is ascribed in part to these bioactive plant compounds (25). Conversely, some experts consider that meat-based diets cause a phytochemical deficiency (26).

Model 3 is no longer a projection into the future but has become reality and represents the current understanding. The available data have confirmed the health benefits of vegetarian diets (18, 19, 27–32).

VEGETARIAN NUTRITION TODAY

Today, vegetarian nutrition has a growing international following. The increase in the number of vegetarians and vegans is attributable to health concerns and is also attributable to ethical, environmental, and social concerns. Vegetarians still remain a small minority in all countries except for India, where approximately one-third of the population is vegetarian. The information concerning the number of vegetarians is based on census data but also on intelligent “guess-timates” (Table 3). The data show that ~10% of vegetarians are vegans; the number of vegans is increasing more rapidly than those of vegetarians.

The vegetarian movement is now supported by many leaders in the arts, sciences, music, and sports. In addition to the growing number of vegetarians and vegans, increasingly more people in Western countries continue to reduce their meat consumption.

SPS	A	B	C	D	E	F	G	H	I
Carotenoids	✓		✓		✓	✓		✓	
Phytosterols	✓							✓	
Saponins	✓	✓			✓			✓	
Glucosinolates	✓	✓						✓	
Flavonoids	✓	✓	✓	✓	✓	✓	✓	✓	✓
Phenolic acids	✓	✓	✓		✓	✓			✓
Protease inhibitors	✓		✓						✓
Monoterpenes	✓	✓				✓		✓	
Phytoestrogens	✓		✓		✓				
Sulfides	✓	✓	✓	✓	✓	✓	✓	✓	
Phytic acid	✓		✓		✓				✓

A = anticarcinogenic F = anti-inflammatory
 B = antimicrobial-viral G = blood pressure-modulating
 C = antioxidative H = cholesterol-lowering
 D = antithrombotic I = blood glucose-modulating
 E = immunomodulatory

FIGURE 4. Functions of phytochemicals. Reprinted with permission from reference 22.

TABLE 3
Numbers of vegetarians in selected countries¹

Country	Population	No. of vegetarians	Proportion of vegetarians
	<i>Million</i>	<i>Million</i>	<i>%</i>
India	1260	450	35
Italy	61	5.9	9
Great Britain	63	5.4	9
Germany	82	7.4	9
Netherlands	17	0.7	4
United States	320	12.1	4
Canada	35	1.3	4
Austria	8	0.25	3
Switzerland	8	0.23	3
France	64	1.2	2

¹Data based on average values of different censuses of different vegetarian societies. In Africa, Eastern Europe, and South America, the number of vegetarians is mostly <1%. See references 33 and 34.

This can be documented by the average amount of meat consumed in a country such as Germany, where the consumption of meat has decreased by nearly 10% in the past 30 y (35). By comparison, meat consumption is still increasing in the United States and in most emerging economies (36, 37).

Today, many vegetarians are not fully aware of the health potential of plant diets. In addition, those who follow a vegetarian diet because of concern for animals or the environment may not be aware of potential nutrient deficiencies. Following are 3 areas of importance for nutrition education for vegetarians.

- 1) An individual’s decision to change to a vegetarian way of life affects the quality of his or her nutritional status. The extent of nutrient deficiencies is higher in persons who become vegetarians for intellectual (ethical, moral, religious, spiritual) and social (ecologic, economic, political) reasons compared with those who turn to vegetarianism for physical (health, hygiene, toxicology, physical performance) reasons (33). The latter are primarily concerned about their health, and they wish to obtain information as to how to properly prepare vegetarian meals. The former worry more about the fate of animals, and they continue their previous dietary habits with the exception of omitting meat and possibly other animal products from their diets (38).
- 2) Vegetarians are not always aware of the fact that food is best eaten in its natural form or minimally processed. Nutrient losses by food processing, such as milling and heating, are considerable and are usually unknown to consumers. For example, nutrients lost by producing white flour from grain are immense (Table 4). Bread, cakes, noodles, and pasta made from whole grains reduce blood cholesterol concentrations and decrease the risk of cancers of the digestive tract (25). This effect is mainly attributable to the higher dietary fiber content of whole-grain foods. However, isolated dietary fibers added to meals do not have the same effect.
- 3) The health benefits of raw foods may be underestimated by vegetarians. Raw foods do not lose any nutrients by processing and need to be chewed thoroughly to procure the full benefit of their inherent nutritional value. Chewing also

TABLE 4
Nutrient losses attributable to processing grain¹

Whole-meal flour (=100%) compared with white flour	Reduction
	%
Dietary fiber	58
Folate	61
Iron	62
Thiamin	78
Zinc	79
Magnesium	90
Selenium	92

¹Data from reference 39.

stimulates salivation and cleanses the teeth. Raw food increases satiety, supports digestion, and normalizes gut transit time. Last, but not least, raw food prevents overeating (40). The recommendations for raw food intake vary widely and range from almost no raw food (Ayurveda) to 100% raw food (strict raw food eaters). The German Nutrition Society recommends an intake of 100 g raw food/d (41). The concept of wholesome nutrition recommends that approximately half the food consumed should be raw (42). It is worth noting that raw food may not always provide full health benefits. For example, certain phytochemicals (eg, β -carotene, lycopene) are absorbed to a much larger extent from cooked vegetables than from raw vegetables (24).

- 4) Some of the uncertainties voiced by vegetarians are related to the widely differing recommendations for critical nutrients across countries. Critical nutrients are those that are most often identified as not being supplied in sufficient amounts in certain population subgroups (Table 5). Unexpectedly, there are only small differences in what constitutes a critical nutrient between meat eaters and vegetarians because most critical nutrients are the same for both groups. One exception is folate, which is considered a critical nutrient for meat eaters but presents no problem for vegetarians and vegans. In addition, vitamin B-12 and possibly the n-3 fatty acids are critical for vegans and for some, but not all, meat eaters or lactoovoovegetarians.

Whether a nutrient is considered critical depends to a large extent on the respective nutrient recommendations, which differ between countries. For example, if the assessment of calcium

TABLE 5
Potential critical nutrients in the average population of Western countries

Nutrient	Groups at risk ¹ (group averages)
Iron	Especially girls and young women
Iodine	Only 70% of the official recommendation is attained
Zinc	Especially children and senior citizens
Calcium	Especially the young and the old
Vitamin D	Depending on synthesis in the skin
Folate	Especially vegetable avoiders
n-3 Fatty acids	Only 50% of the official recommendation is attained

¹Common at-risk groups with increased nutrient requirements: children, pregnant and nursing women, the elderly, and the ill. See references 34 and 43.

status is based on the German recommendation, the percentage of vegans that ingest an insufficient amount of calcium in a particular group amounts to >90%, but using the UK recommendation the rate drops to <10%. A similar scenario applies with vitamin B-12 (Table 6). It is interesting to note that the different recommendations are based on the same international scientific data. However, recommendations for a specific country are made on the basis of the circumstances of that particular population. Less variation in recommendations would eliminate some of the controversies and fears associated with an inadequate nutrient supply for vegetarians and especially vegans. Ultimately, the adequacy of a diet depends on the foods that are consumed and not on the name of the diet. To summarize, vegetarians need as much nutrition education as the rest of the population.

THE FUTURE OF VEGETARIAN NUTRITION

The future of vegetarian nutrition is promising. On the one hand, there are an increasing number of food scandals that usually concern animal-derived foods. This causes a loss of confidence in these products. On the other hand, there is a growing awareness of the numerous long-term positive effects of a vegetarian way of life. These positive effects are part of the new science discipline of nutrition ecology (46, 44) and of the concept of the "new nutrition science" (48). Both concepts are driven by the urgent need to seriously consider sustainability in the food chain as well as in all human activities. A summary of these 2 new concepts is found in the Giessen Declaration (49).

There are 4 specific reasons why the future of vegetarian nutrition is promising, as follows:

- 1) Ethical, moral, religious, and spiritual reasons: people no longer want animals to suffer a miserable life just to satisfy the

TABLE 6
Current recommendations for intakes of calcium and vitamin B-12 in selected countries¹

Country	Calcium	Vitamin B-12	Reference or source
	mg/d	μ g/d	
United Kingdom	500	1.5	43
Japan	600	2.4	Japanese Society of Nutrition and Food Science ²
Canada	700	2.4	Canadian Nutrition Society ³
United States	800	2.4	44
Germany	1000	3.0	45

¹ Values are for adults 20–50 y of age. Data are from references 43 and 44.

² Y Nishida, personal communication, 4 December 2013.

³ H Delisle, personal communication, 6 December 2013.

appetite of meat eaters. Industrial animal production should be discontinued. Organic farming should be supported.

- 2) Ecologic, economic, and political reasons: people neither want a destruction of the foundation of life on our planet nor do they want the climate to change (46, 50–52). Waste and excesses need to be kept to a minimum. A new principle of prudence is indispensable.
- 3) Health and hygienic reasons: people no longer want to suffer from preventable, nutrition-related, noncommunicable diseases. The risk of contemporary diseases can be substantially reduced by a vegetarian way of life.
- 4) Sustainability and peace reasons: people want continued quality of life combined with responsibility for themselves, their children, and generations to come. Mindfulness is called for (46, 50, 51).

Albert Einstein nicely summed up his view about the future: “For the weak it is the unattainable, for the scared it is the unknown, for the brave it is the opportunity.” We are challenged and obligated to accept the responsibility for the opportunities that are inherent in a vegetarian way of life.

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