CHAPTER

1

Sociopolitical food and nutrition: pre-20th century

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Populations will only increase if and when they have sufficient basic means to do so. One of these basic needs involves access to a plentiful supply of natural resources such as food and water, not to mention the collective organization and governance of its people. Although the latter is not necessarily quite so obvious, we will look at this aspect in more detail later. In this way, with adequate governance, provisions, time, and a smattering of luck, in due course, social evolution and collective ideology have been shaped and reshaped to define

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humanity, most often for the better. However, this evolutionary process requires a critical mass of people, the majority of which need to be moving collectively in the same direction for things to get started. Yet, the reality for millennia was that population numbers had remained static at around the 200 million mark. That was, until a certain set of circumstances came together, prevailed and which then collectively encouraged the increase in population figures. Such circumstances included the industrial revolution, the industrialization of agriculture, and an age of enlightenment among others.

Ever since civilizations first began to participate in sedentary cultivation rather than hunting and gathering, they were naturally inclined to share the fortunes and failures of their labors with the rest of the community (next section). As such a hitherto unknown concept of food security emerged, adapted, and evolved. Such is its importance, though that no book about food and society would be complete without something in the way of explanation of the food security concept. Consequently, this and many other food-related topics are included. In this way, the whole picture of food and society comes together from the macro- to the microenvironment of food.

1.1 The growth of agricultural civilizations

Pinning down the birth of modern humanity is fraught with disagreement and contention. The problem is there are numerous theories, scholarly and otherwise, that try to describe the specific origins of the agricultural evolution and the subsequent impetus that gave rise to the complete transition from hunter-gatherer to the very origins of agriculture as we know it today. Many such theories include the demographic, oasis, evolutionary, or socioeconomic hypotheses among others (Childe, 1936; Sauer, 1952; Binford, 1968; Rindos, 1987; Hayden, 1992, 1995; Weisdorf, 2005; Rosen, 2007). However, such theories aside it was widely understood or at least acknowledged that the genuine origins of farming evolved somewhat simultaneously and somewhat independently around 10,000 years ago at several sites around the world. This change (or growth if one prefers) has been said to have been largely fueled as a direct result of the abundance of freshwater—important and undoubtedly of great overriding geologic influence. This was collectively encouraged as previous bands of mobile hunter-gatherers came to understand the numerous benefits of living a static existence nearby to rivers, springs, and lakes (Miller, 1980; Gopher et al., 2001; Weisdorf, 2005; Guisepi, 2009; UOR, 2009). Consequent growth from this mini agrarian revolution, coined in 1935 by philologist turned archaeologist V. Gordon Childe as the "Neolithic Revolution," was understood to be pivotal, or the primary mover in "sedentary cultivation." Directly resulting from such a fundamental change in living styles, Weisdorf (2005) claims that the transition from hunter-gatherer to agriculturalist at this juncture has been universally recognized as one of the most crucial moments in human civilization. Indeed, stemming from this and subsequent population increases resulted in the establishment and growth of many early civilizations (Greene, 1999; Guisepi, 2009). From this point, empires and great civilizations were established, including the Chinese Empire along the Yangtze, Huang, and Yellow Rivers (UOR, 2009); the Mehrgarh and Harappan civilizations along the Indus river; and many Mesopotamian and Near East cultures which eventually settled along the Tigris, Euphrates, and the Nile Delta regions (areas which later collectively became known as the "Fertile Crescent") (Time, 1936). It was also understood that this life-changing transition from hunter-gatherers to farmers was also more than likely a slow one, with early settlers more inclined to still hunt and gather while supplementing their efforts with crop plantations of foods gathered in the wild. All this before the full conversion to pure domestic agriculture-based economies was finally embraced (UOR, 2009). Furthermore, such plant and animal domestication also stood out as a pivotal time for mankind—one in which humans became increasingly dependent on the environment and ultimately (perhaps a little unwittingly) constrained by the environment too (Furon, 1958; Weisdorf, 2005; UOR, 2009).

So, what fueled this new agricultural paradigm, apart from the aforementioned settlements in advantageous geographic locations? Well, technological innovation for one, which although might seem rudimentary by today's standards, in fact, evolved in great leaps in contemporary times. For a start, early farming tools were made of wood and stone. This included the stone "adz" (an axe-like tool); the sickle or reaping knife (which was used to gather grain); the digging stick (later adapted as a spade or hoe); and a rudimentary plow (later adapted to be pulled by oxen). As civilization progressed, new and improved practices and metal tools of bronze and iron greatly improved cultivation with things like the cast-iron moldboard plow. New irrigation systems too, powered by wind and water mills, allowed hitherto unyielding or previous unproductive land to be brought back into cultivation. Productivity was also increased with the introduction of "biowaste" or more commonly animal manure fertilizers. On top of this, the practice of crop rotation and leaving land to fallow was a great leap in understanding of the sustainability and extant land use. Storage methods were also refined; granaries where jars, dry cisterns, silos, and bins all containing stored grains popped up providing an all-round food supply for increasingly needy populations.

1.2 Modern agriculture: on the shoulders of giants we prosper

With the previous model, as mentioned, the population levels still remained fairly static. Clearly there was something missing that allowed for such numbers to increase as they did so around the 19th century. The answer, although evident in the increasing pseudo-societal groups, was the slow evolvement and advantages of collectivization. The next few millennia, for instance, witnessed the sociocultural transformation of small dynamic, mobile egalitarian groups of hunter-gatherers into sedentary agriculturist societies while simultaneously allowing for increased social, political, and technological complexity (Johnson, 1997; Guisepi, 2009). This new complex societal and political paradigm by nature further encouraged the reorganization necessary for social and economic development, as well as the diversification of nonagricultural trades such as craftsmen, politicians, and priests, etc. Moreover, in certain regions, the division of society did not stop at the introduction of a diversity of trades but was also responsible, in certain places, for the introduction of social class systems (Bender, 1975; Price and Gebauer, 1995; Weisdorf, 2005; Agropolis Museum, 2009; Guisepi, 2009). Apart from class-based society, such a marked change in the way society easily adapted to, and adopted a fledgling market-based system of food and nonfood goods, went a long way to accepting a formal basis of modern economic civilization (Cavalli-Sforza et al., 1993; Agropolis Museum, 2009). However, on the flip side, in some quarters, talk and rumor of this new collectivization brought with it fears of insufficient food provision and access for the neediest (more later). Some notable influences over the centuries gave agriculture and by extension society more than a boost.

1.2.1 The eighth-century Muslim Agricultural Revolution

Today the current agricultural economy resembles what it is largely thanks to the collective knowledge of our forefathers. The oft overlooked "Muslim Agricultural Revolution" (MAR) of the eighth century, for example, was privy to many new and "borrowed" techniques and advancements. Yet by the Middle Ages, the MAR were the first to disseminate their collective gained knowledge through detailed written agricultural practices, procedures, and technologies across the Islamic world (Glick, 1977; Al-Hassani et al., 2007). The Romans too built lucrative trade and export businesses based on techniques pioneered by the Sumerians. Jointly, as a consequence of these long-learned lessons and advances, a healthy economy across the Old World was spreading, which over time further facilitated the distribution of replicable farming techniques.

1.2.2 The Columbian Exchange 1492 AD

Frequently cited as the second prodigious food revolution, the Columbian Exchange began with Christopher Columbus and flourished with his successors. Christopher Columbus had an inquisitive mind and in the agricultural field this meant introducing new people to new foods and with it subsequent increased trade in terms of crops, livestock, and, of course, disease between the "Old" and the "New" worlds. Consequently, as a direct result of the Columbian Exchange, new crops such as American corn (maize), the humble potato, and tomato, among others, were introduced into Western Europe, while North America benefited from new livestock including cattle, sheep and pigs. Grains (particularly wheat) were also a point of significance, as it also found its way into the Americas and other places.

Moreover, the Columbian exchange aside, Africa and Asia via Western traders and slave routes became important conduits for labor, rice, onions, olives, grapes, coffee beans, bananas, and sugarcane—all at one point or another put down roots in the New World (Agropolis Museum, 2009). Also, as agricultural trade brought with it increased economic benefits, the rise of "plantation economy" flourished and grew. These large agricultural estates producing bulk demanding crops such as cocoa, cotton, sisal, sugarcane, coffee, banana, citrus trees, palm trees, and indigo were introduced. These measures described above all contributed to the ability of populations to grow through greatly increasing agricultural productivity, albeit on the back of much slave labor (Agropolis Museum, 2009).

1.2.3 Colonial agriculturalism

Around the time of 15th and 16th century Europe, new economic theories of growth emerged based largely on the creation of wealth. This abutted and was perhaps further fueled by this new period of global exploration and colonization. The result was a rich harvest in which exotic or hard to find food and other wealth-creating opportunities for the colonizing home countries were created. International trade was truly born. To this point, the sum collection of agricultural know-how had generally been passed down from generation to generation and from culture to culture—ultimately from civilizations' forefathers. By now, agricultural trade did not only stop at "goods and services" but also through a healthy new trade in knowledge transfer (Danhof, 1949; Johnson, 1997). This substantial flow of knowledge across time did not begin with the growth from the advancement and sophisticated techniques traded during the periods described above. Instead its humble beginnings started before the Neolithic period and subsequently included the MAR and the Columbian exchange (Crosby, 1972; Watson, 1974; Glick, 1977; Salvaggio, 1992; McNeill, 2003; Al-Hassani et al., 2007; Agropolis Museum, 2009). This flow of knowledge cannot be stressed enough. In fact, Justus Von Liebig remarked rather eloquently in his book of the period that

> One of the most remarkable features of modern times is the combination of large numbers of individuals representing the whole intelligence of nations, for the express purpose of advancing science by their united efforts, of learning its progress and communicating new discoveries … ***(Playfair, 1847, pg 3).***

And so, it was that this gathering of knowledge set the backdrop from which the relatively more modern agricultural and industrial revolutions both grew.

1.3 The agricultural and industrial revolutions

Perhaps the two main revolutions from about 1650 AD onward, in terms of agricultural led population growth, were the agricultural and industrial revolutions, with perhaps a smattering of the soon-to-grow enlightenment revolution.

1.3.1 Agricultural revolution

True agricultural pioneering research is often cited as beginning from around the 16th and 17th century periods (Johnson, 1997). Moreover, it is often upheld that the revolution began first in England before spreading to America and beyond into Europe and elsewhere by the mid-17th century, after which momentum continued with the industrial revolution of the early to mid-18th century (Frey, 1996; UNEP, 1996; Johnson, 2000).

It was boom time; alongside flourishing trade and the ongoing transfer of crops from lands of origin to all corners of the world, Old and New, progress was also being made in areas of selective breeding of both plants and livestock. This was also a period that witnessed the first real attempts at pest control management using poisons and certain biological controls. Further noteworthy production output and rising yields were also buoyed through the heavy use of fertilizers and reclamation of land. And it did not stop there, the knowledge gap was closing; with extensive irrigation projects, proper and adequate drainage, improved and/or increased animal husbandry, and the increasing use of hormones and antibiotics, the foundation of the industrialization of agriculture was established (Johnson 1997, 2000). All in all, such practices led to the specialization and empowerment of the sector. Consequently, it was not long before the great cities of North Africa including the Near East, Europe, and Asia and the Americas were all supporting technically advanced agricultural systems including crop rotation, irrigation, and pest control measures and fertilization use (Cohen, 1995; UOR, 2009). The same period, especially throughout Europe, also saw the widespread practice of feudalism in the agricultural sector where the "… lord of the manor (or liege) presided over his vassals" (Gibson, 2016). Few people at the time understood the ramifications of increasing agricultural efficiency and by extension land productivity.

Increased agricultural output tapped directly into the subsequent increases in the carrying capacity of the earth and the growth in populations too (UOR, 2009). A great deal of anticipation was expected from new and improved agri-science and what effectively started with advances in agricultural practices, experimentation and scientific application continued to encompass all elements of the food chain, especially in the areas of transportation and mechanization (Durand, 1916). This also paved the way for inadvertent consequences in the shape of competition and the displacement of previous long-established trading associates as well as the displacement of suppliers. One more advantage of the global agricultural revolution was the increase in yields per unit area, thus permitting more of the populace to be fed from the same area of land (UOR, 2009). Alas, from such collective advances in agricultural knowledge and practice, this period witnessed the considerable growth in populations and their standards of living especially among the industrialized nations. Notable too were the marked changes for the better in local economies, income growth, and distribution of the labor force, among other things (Watson 1974, 1983; Gardner, 2002).

1.3.2 Industrial revolution

Swiftly on the back of the agricultural revolution came the industrial revolution. This was a period of rapid industrial growth beginning in England toward the second quarter/half of the 18th century (1725–50 AD), which then moved throughout the Europe and the United States. The early part of the revolution observed great leaps of invention, mechanical innovation, and general improvement in labor efficiency, especially on the agricultural playing field among many other sectors of industry. Among many advances in agriculture were the wooden plow, new horse-drawn threshers, grain and grass cutters, cultivators, rakes, and the labor-saving corn shellers and the like. Many in turn were superseded or improved on with arrival of the industrial revolution. Add to this the arrival and application of steam power during this time, which eventually led to the mechanization and industrialization of agriculture. This further led to the commercialization of food and ultimately to the beginning of the food-processing industries (UOR, 2009). Table 1.1 records some of these advances or seminal moments of the agricultural and industrial revolutions. However, during this period, the real coup was undoubtedly the invention of the internal combustion engine in the 1850s. This effectively freed up large agricultural labor forces, allowing millions for the first time to migrate to urban employment (Johnson 1997, 2000).

1.4 The enlightenment: sociocultural movements

As humanity evolves, cultural values exist in a state of flux, constantly adapting out of necessity and circumstance. Yet, far from being fickle, as the description might suggest, cultural values in this context are just the values that constantly evolve. And values do change,

TABLE 1.1 Key innovations of the agricultural and industrial revolutions.

Date	Innovation and invention
1698 The first steam engine	The first practical incarnation of a steam-powered engine was the water pump. However, developed by Thomas Savery, it was not particularly efficient and was readily prone to explosions.
1701 Seed drill	Created by the famous agrarian Jethro Tull, the seed drill allowed for more efficient and workable seeding.
1712 Improved steam engines	Hopping on the Bandwagon, Thomas Newcomen developed a steam engine that was more robust and reliable while operating at atmospheric pressure.
1730 The iron (Rotherham) plow	The first real success in commercial iron plows was the Rotherham plow patented by Joseph Foljambe in 1730.
1732–86 The first threshing machine	Building on unsuccessful threshing machines like Michael Menzies (1732) and Mr. Stirlings machine (1758) (which only threshed wheat), Andrew Meikle in 1786 devised the first successful mechanized threshing machine.
1775 James Watt steam engine	In partnership with Matthew Boulton and James Watt together they improved on previous engines with up to 75% reduction in fuel consumption.
1794-98 Plow	After many improvements on previous plows, innovations by Thomas Jefferson allowed for deeper and more efficient pulling of the plow.
1799 High-pressure steam engine	Around 1800, improvements of atmospheric engines witnessed new engines using high-pressure steam engines first introduced by Richard Trevithick. These were more powerful and smaller in design than those previous.
1800–31 Mechanical reaper	After many unsuccessful attempts between 1800 and 1831, the first useful mechanical reapers were introduced in 1830–34 by McCormack and Hussey.
1804–10 Sealed containers and canning	During this period, advances in technology saw the improvement of hermetically sealed foods for preservation by Francois Appert and canning by Peter Durand in 1810.
1837 Steel plow	Steel plow was invented by John Deere in 1837.
1840s Fertilizer manufacture	During this period saw the introduction of manufactured chemical fertilizers by Baron Justis Von Liebig in the 1840s.
1841 First portable steam threshers	Ransomes first introduced the portable steam threshing machines.
1850s–78 Internal combustion engine	This period witnessed the first successful gas-fired internal combustion engine developed by Etienne Lenoir (1859) and refined by Nikolaus Otto (1878), (Britaninca, 2019).
1871 Pasteurization	Pasteurization is invented by Louis Pasteur.
1890s–1910 Tractors	Engine technology was constantly being pushed to new limits. Benjamin Holts early steam traction engines of the 1900s and the internal combustion engines of the 1850s eventually paved the way for the first internal combustion tractor of 1910.
1888/95 Pneumatic tires	John Dunlop invented the first air-filled pneumatic tires in 1888 for bicycles. However, in 1895, André Michelin was the first to use pneumatic tires on automobiles.

(*Continued*)

TABLE 1.1 Key innovations of the agricultural and industrial revolutions.—cont'd

Date	Innovation and invention
1895 Refrigeration	While refrigeration had been around by now for 40 years or so, it was Carl Von Linde who developed the first safe domestic refrigerators in 1895.
1899 Artificial insemination (AI)	Pioneering work, built on previous efforts by Spallanzani (1784), Heape (1897), (Francis and Jolly, 1906), and others, led E. I. Ivanow to establish AI as a practical procedure in Russia.

Compiled from Tull 1762; de Graffigny, 1898; Fouts, 1921; Ogburn and Thomas, 1922; Morris, 1933; Kuo-Chün, 1958; Olmstead, 1975; Rasmussen, 1977; Powell, 1988; Hills, 1989; Martin, 1991; Fox, 1993; McMichael, 1995; Brunt, 2003; Heldman, 2003; Kauffman, 2003; Nuvolar, 2004; Elliott, 2008; Britannica, 2009.

whether over time or through circumstance. What is important today might not have been on the agenda yesterday; and by the same token, values which our forefathers fought hard to defend might seem trivial under the microscope of the 21st century. Yet in all of these instances, such values have shaped and forged a sort of collective social glue—one that promotes common ethical and moral frameworks and perceptions of right and wrong. Social cultural values then are a "Force Majeure" and one that is no less evident than in "values" that have in some cases, grown up around the food we eat or which in some cultures, have actually shaped the food we eat.

Food has always been central to human societies; in early cultures, the desire to share food was strong and could be defined as one of the many leading markers of growing humanity. As communities became more complex, so food became entrenched in traditions, habits, and meanings that varied widely over time, geographic location, and cultural practices. From these humble beginnings, it can be seen that no culture is ever static and cultural adaptation in ever-changing environments is a constant feature of world history. This is especially so when it comes to changes in the food supply. For instance, there was no bigger upheaval in this field than in Europe and the Middle East between the 15th and 18th centuries. This 300-year or so period saw sweeping cultural and intellectual developments, most notably the "scientific" and "industrial" revolutions, as well as the "enlightenment," which once it entered the fray spurred on both the cultural and agricultural revolutions, which in turn helped redefine the global food landscape. At the same time, increased movement of labor and goods between large empires (such as the Mughal and Ottoman) encouraged a growing globalized society, carrying with it a wave of changing cultural patterns with economic, demographic, and environmental consequences. Importantly too, globalization, in the form of trade, movement of labor, and/or the changing political environment (especially colonialism), was a two-way affair. That is to say, whether economically, politically, or socially, both sides generally benefitted from this mutual interaction. However, this is not to suggest benefits were equally shared—not by a long shot. However, this mixing of values was especially evident at the cultural level. The sharing of foods helped assimilate global cuisines, as more and more societies came to rely on similar staples such as potatoes, corn, or rice to supplement their diets. This had profound social, cultural, and economic consequences. Sometimes, the introduction and exchange of foods altered existing cultural practices, and in other instances, food was reworked into existing traditions. In fact, in many food cultures of today, the food and cultural histories of many countries and regions cannot be fully understood without reference to the wider world at large. Food then, from an historical and cultural perspective, not only shapes regional identities but also expresses cultural values. Importantly too, food also conveys significant messages about the individual as the 19th-century French philosopher and gourmand Jean Anthelme Brillat-Savarin (1826) noted

> Dis-moi ce que tu manges, je te dirai ce que tu es (*Brillat-Savarin 1826*)

which translates as "Tell me what you eat, and I will tell you who you are"—put another way "we are what we eat." In this little nugget, Brillat-Savarin clearly believes culture in relation to food and defines the individual. However, from an historical perspective, one could legitimately ask whether food indeed shaped culture or whether culture has in fact defined traditions, foods, and habits. In reality there is probably not one answer; it is more likely a mix of the two, a sort of "back and forth" exchange whereby, depending on time and circumstances, one comes to dominate and define the other and on occasion vice versa. In view of present day situations though, there are several instances where food is certainly and overtly shaping the cultural mix. This is perhaps more evident in three areas than in any others—that of population, globalization, and wealth creation. For background purposes, the first and second items, population and globalization as well as changing patterns of wealth are discussed later in the book.

While much came before, the real emergence of the science, for instance, in terms of tradition and nutrition, leap-frogged on the back of previous knowledge, shaping the beginning of the 20th century. However, even after Thomas Malthus' and others' prophetic warnings, the powers are still managed to relegate hunger (or malnutrition) to a mere technical anomaly of food provisioning (Anon, 1798; Malthus, 1803). The inference being that such conditions could be avoided altogether through sufficient and adequate planning. This collective thinking essentially concreted hunger's social and political trajectories. However, having said that it was the waning enthusiasm of this position (in the early 1910s) that people realized there was more to hunger than a mere "sideshow." Instead and in large part due to the people's collective social awakening, spurred on by a growing body of sensationalist journalism, hunger issues in general were now coming to the forefront of the minds of scientific and lay people alike. At this juncture, things changed and a great deal of this new-found attention helped fully politicize the notion of hunger and starvation; in particular interventionist policies were now being spurned on in many countries at both the government and institutional levels (Aronson, 1982; Vernon, 2007).

Once again, while acknowledging this position, interventionism was not something new, rather, governments, particularly Western governments, had for a prolonged period of time been involved (or actively inserted itself) into the agricultural market in the form of the Corn Laws in the United Kingdom, and elsewhere in the Western world through sometimes controversial use of political and economic strategies in the form of local and international tariffs and protectionism (Barnes, 2006; Vaidya, 2006). However, such measures (the adequate provision of food) were still largely seen as an issue of production and supply. Although directly as a result of the sidelining the notion of adequate food for all, humanitarianism was gaining social and political traction which ultimately squeezed it into the political arena of the time.

Meanwhile, on the subject of health and nutrition, 19th century was a very active time.

1.5 Health and nutrition: an emerging discipline

Through the 19th century, particularly coinciding with better railway links, the newly found mobility of individuals encouraged the spread of communicable diseases across Europe. The problem was recognized at the international level and initial efforts were slow and beset with poor international coordination and agreement. One exception was the International Sanitary Conference held in Paris in 1851 (WHO, 2010). In the initiative, several European countries came together in the effort to tackle the issue of contagion in a way that would not overly hinder trade, etc. Protocols were introduced and quarantine precautions were set in an effort to slow or stop the spread of cholera in this instance.

A few other sanitary conferences were held between 1851 and the close of the century, yet there was a fundamental problem. That is to say that while in principle the sanitary code was agreed upon by its members, it was never actually properly ratified. Although this and a few other coordinated efforts by other international initiatives offered little in the way of successes, collectively, the efforts served to set significant precedents in the introduction of global governance in matters of global welfare. Interestingly despite limited success, the initiative to work together on issues of health was taken up at the fourth International Sanitary Conference (ISC) in Vienna in 1874. The conference discussion ensued about the need for a permanent international agency that would exclusively tackle the question of health. However, in spite of agreements and recommendations, it was only in 1903 that 12 European countries joined together to create the Paris-based Office International d'Hygiène Publique (OIHP) in 1907 that the sanitary conferences' visions were fulfilled. The OIHP continued the work of the international sanitary conferences by adopting their conventions and directing studies on epidemiological diseases and the implementation of quarantine protocols to avoid the spread of the likes of the plague and cholera among others. Thus the OIHP became the first real international health organization (EoN, 2009).

In Britain about this time despite previous limited success regard to health initiatives, the nation's health policy was moved over to the President of the Local Government Board. In operation this ultimately ensured that by the early 20th century, public health amenities (plus sanitation and environmental health) now fell under the auspices of the "Poor Law." It was a relatively hit or miss affair whereby through assistance from voluntary hospitals, workhouses, and the like, only some but not all access to such services, was available. Furthermore, services were patchy in quality and application. Consequently, in 1919 the responsibility of the nation's health fell to the Ministry of health (more later).

1.5.1 The chemical revolution

Further linking health and nutrition in the diet were many scholars around the turn of the 18th century. At this point many had already set their sights on understanding how the body worked physiologically and how food/nutrition was being utilized in the process. However, it was one man—Antoine Lavoisier during what has been described as the "chemical" revolution—who paved the way for further insight (Nichols and Reeds, 1991; Carpenter 1994, 2003; Weaver, 2006).

1.5.1.1 Lavoisier, Antoine

Lavoisier, often referred to as the father of modern chemistry, had a certain interest in metabolism. As an influential man in his field, he had already determined that excreted carbon dioxide from the body was the end product of oxidative activity proposing the connection between oxygen absorbed by the body and the excreted carbon dioxide. He had achieved this by putting guinea pigs into a calorimeter and measuring the amount of melted ice in a process called direct calorimetry. In doing so, Lavoisier working with Pierre-Simon Laplace illustrated that the ice melt was quantitatively related to the amount of carbon dioxide expired by the guinea pig (Passmore, 1982). In other words, Lavoisier established oxygen's role in animal and plant respiration as basically a slow combustion of organic material. In Lavoisier's mind, the conclusion was obvious—animals created energy through a "combustive reaction" involving oxygen. These respiratory experiments were the first studies that would eventually lead to a fuller, more holistic understanding of the metabolic process (Lavoisier, 1780; Lavoisier and Laplace, 1784; Lusk, 1906; Underwood, 1944; Nichols and Reeds, 1991; Bensaude-Vincent, 1996; Gibson, 2016).

1.5.1.2 Boussingault, Jean Baptiste

Having established the respiratory functions of animals, all eyes now turned to energy inputs and outputs. Building on François Magendie's food experiments with dogs, Boussingault had already suggested that foods which *did not* contain any nitrogenous compounds could not help support life. From this it was therefore understood that the nutritional value of a food such as vegetables could be found in the nitrogenous gluten and vegetable (Carpenter, 2003). Buoyed by such progress Boussingault began experimenting in the 1830s. Experimenting first with plants and then animals, he learned two things: firstly, that atmospheric nitrogen could only be synthesized by plants albeit indirectly; and secondly, through the examination of animal excreta, Boussingault determined that the nitrogen content of the animals ingested food was sufficient to meet their needs. In this way, there was no necessity to obtain nitrogen directly from the Earth's atmosphere (Dumas and Boussingault, 1844).

1.5.1.3 Liebig, Justus von

Without doubt, Liebig was the leading German organic chemist of the day. And building on Lavoisier's methodology vis-à-vis organic analysis, Liebig managed to improve the systematic approach to experimentation within the field. A new discipline organic chemistry was born. Liebig did not waste any time either; he questioned Jean Baptiste Dumas's findings about animals, food, and oxidation, suggesting that animals must also be able to convert carbohydrates to fat, requiring reductive changes (later metabolism) rather than solely through oxidation (Carpenter, 2003). Building on this and other similar research in the field, Liebig added and indeed improved upon this work and further hypothesized that energy was actually created through the metabolization of proteid (protein), carbohydrates, and fat (Lusk, 1906). It was also understood that protein contained nitrogen, and Liebig further postulated, based on the conservation of energy, that it might well be conceivable to establish equilibrium between nitrogen intake and excretion from urine and feces (Nichols and Reeds, 1991).

1.5.1.4 Voit, Carl

Such hypotheses and experiments were not without value. They had implications beyond scientific research alone to those of practical real-life nutritional values. In 1857, Carl Voit (a student of Liebig's) determined beyond a shadow of doubt that Liebig's proposed nitrogenous equilibrium could be met. In doing so Voit also recognized that any imbalance in nitrogen intake against that of excreta was reflected in a corresponding loss or gain in body tissue (Lusk, 1906). In 1866, additional experiments, this time by Voit and Pettenkofer, using respiration chambers focused on carbon dioxide and nitrogen waste helped confirm Liebig's theory postulating that not only protein but also carbohydrate and fat were broken down or metabolized and used as energy (Passmore, 1982). We must not forget too that it was Lavoisier who put forward the idea that a person's body heat derives from the oxidation of ingested substances in the body (Ziegler, 1922). Furthermore, while "metabolization" was not fully understood at the time, it was nevertheless proposed that energy released this way produces heat and as such it was offered that

> … heat may become a measure of the total activity of the body. ***(Lusk 1906, pg31).***

1.6 The first dietary studies

By now the sciences and knowledge began to converge and create a new discipline called nutrition. Experiments, hypotheses, and leaps of insight by a plethora of some of the most skilled minds of the era were now coming together, lending scientific credibility to a new and exciting subject—one that was moving stridently in the public and political spheres. By the mid-19th century, many were working on dietary standards such was the leap in knowledge. Out of this, the first formal action by any government, in this case the British Privy Council in 1862/3 introduced the first public policy of dietary recommendations, firmly grounded in scientific principles. These first recommendations arose out of the pioneering efforts of Edward Smith who calculated a minimum basic daily requirement sufficient to avert starvation and disease (Acheson, 1986; Carpenter, 1991; McArdle et al., 1999). From his food intake surveys among Northern England's low-income groups, Smith considered that a minimum basic daily requirement should be equal to about 4300 grains of carbon and 200 grains of nitrogen (equivalent to about 2800–3000 calories) (Tomlinson, 1978; Oddy, 1983; Harper, 1985). He also suggested reduced rations for women by about 10% were required because of their smaller stature and their perceived reduced needs.

1.6.1 Frankland, Edward

Momentum was growing and among the many practitioners, Voit, after visiting Edward Frankland, returned to Munich with a Thompson calorimeter to aid in his studies. That was 1860, and by 1866, Frankland managed to combust organic material through oxidizing it with a mixture of potassium chlorate and potassium nitrate in a calorimeter and then measuring the heat produced. By utilizing this method, the values of 29 foodstuffs were calculated in "heat units" (carrying equal value as calories). These experiments successfully established the first direct measurement of heat from food energy and in the process introduced the quantifiable concept of food energy (Frankland, 1866; McLoed, 1905; Ensminger et al., 1993/4; Russell, 1996; Carpenter, 1998).

1.6.2 Voit, Carl

Not having missed a beat, Voit and Pettenkofer, using the calorimeter, experimented on a fasting man and established how much food was burned in the body and whether or not there was any net gain or loss. From these experiments, in 1866, Voit organized a table in which he calculated the metabolic rate of man to be between 2.25 and 2.4 million small calories—equal to about 2250–2400 Kcal. In achieving this, Carl Voit was the first man to routinely define the energy potential of food in caloric terms (Hargrove, 2006).

1.6.3 Rubner, Max

Additional experiments by Voit began as he worked on the interchangeability in the diet of carbohydrates and fats. The idea was further taken up by a student of Voit's called Max Rubner. Rubner had, by 1884, determined the per gram caloric conversion rates of the macronutrients, establishing energy equivalent factors for fat at 9.3 kcal/g, protein at 4.1 kcal/g, and carbohydrates at 4.1 kcal/g. Such was the importance of further experimentation that it became the foundation of Rubner's 1884 isodynamic law, which specified that foodstuffs replaced each other: "… in accordance with their heat-producing value …"; in other words the changeability of the main food groups was now established (Rubner, 1885; Lusk, 1906; Mudry, 1974; Nichols, 1992; Ensminger et al., 1993/4; Hwalla and Koleilat, 2004).

1.6.4 Atwater, Wilbur Olin

Atwater, working with Max Rubner in Voit's laboratory, acquired a great deal of knowledge which he then took back to America where he carried on working with calorimetry. From this knowledge, the work of calorimetry grew and being at the pinnacle of an already eminent career built the first calorimeter that could take a human in 1892. Built at Wesleyan University in collaboration with Edward Bennett Rosa, the pair also built a bomb calorimeter for gauging energy values in foods. Originally referred to as the Atwater-Rosa calorimeter, it was later refined by Francis Benedict who also worked with Atwater shortly after this time. Consequently, the final device became known as the Atwater-Rosa-Benedict calorimeter (Chambers, 1952). Shortly after between 1894 and 1900, Atwater also worked on Rubner's earlier energy conversion factors. In doing so Atwater factored in the potential losses due to metabolism and digestion itself and considered conversion factors for protein, fat, and carbohydrate. Working with different animal and plant foods, Atwater based his on calculations as averages equating to 5.65 kcal/g for protein, 9.4 kcal/g for fat, and 4.15 kcal/g for carbohydrates. Of note is the notion that these figures signified actual energy conversion factors of the food rather than what the body absorbed. In fact, later because of the substantial variability within each grouping of macronutrients, Atwater ended up with two main conversion factor tables. By way of example, it was noted that protein energy within potatoes was poor and only equal to 2.78 kcal/g while the higher-quality protein found in eggs contained energy equivalent to 4.36 kcal/g.

Such were the differences according to Atwater, the only reasonable thing to do to compile a table of specific group values which fully replicated the different food conversion factors. The other general table of conversion factors applied to all food groups regardless of a specific food nutrients actual composition. In this way, the previous figures of 5.65, 9.4, and 4.15 kcal/g were recalibrated characterizing actual metabolizable energy, i.e., which was actually absorbed by the body. Such general figures equated to 3.9 kcal/g for both protein and carbohydrates and 8.99 kcal/g for fats (Atwater and Woods, 1896; FAO, 2003). The importance of Atwater's work is still as relevant today as it was toward the end of the 19th century. In fact, many caloric composition tables being used today are still based on the rounded-out Atwater values of 4 kcal/g for both protein and carbohydrates and 9 kcal/g for fats (Nichols, 1992; Ensminger et al., 1993/4; Gibson, 2016).

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