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COUNT RUMFORD—SCIENTIST AND PHILANTHROPIST[1]

BENJAMIN THOMPSON, the future Count Rumford, was born on March 26, 1753, in his grandfather's farmhouse, which still stands in North Woburn, Mass. When Benjamin was about a year and a half old his father died. A year or so afterward his mother married again, and the boy went to live with his stepfather. A small inheritance from his grandfather was used toward the support and education of the boy. He attended school in the village and also in Byfield and Medford. He was fond of mathematics and, like his forerunner, Isaac Newton, he was interested in practical things and was skilful in making mechanical devices. His opportunities as a schoolboy must have been well utilized because the handwriting, spelling and grammar of these early days, at least before the age of thirteen, are almost faultless.

Being too good, or too bad, for a farmer, he was apprenticed when thirteen years old to an importer in Salem. But he did not like clerking any better than farming. One authority says he was more interested in the mechanical appliances behind the counter than in the customers before it. And it is also said he even played the fiddle in the store when he was sure the sounds would not betray him. But he was not idle. A minister, noting his interests, taught him algebra, geometry, astronomy and even higher mathematics, so that before the age of fifteen he was able to calculate an eclipse accurately—"correct within four seconds," he says. At this time, too, he gave attractive evidence of his natural ability as a designer, draughtsman and engraver. His work in this field ranged from initials and devices on the handles of knives of his acquaintances to an elaborate bookplate for himself. Like most boys of his age, he was interested in chemistry and fascinated by spectacular experiments. On one occasion he came near losing his eyesight, if not his life, by the premature explosion of some chemicals he was grinding in a mortar for the preparation of fireworks "of extraordinary and unparalleled brilliancy" to celebrate the news of the repeal of the Stamp Act. Letters to his friend Loammi Baldwin show that even at this early age he was also interested in light, heat and color—phe-

[1] An address delivered March 26, 1928, at Woburn, Mass., on the 175th anniversary of the birth of Count Rumford.

nomena which subsequently occupied many years of his life.

In 1769 Benjamin Thompson was apprenticed to a dry goods dealer in Boston, but he remained only till the following spring, owing to decreased business arising from the non-importation agreement. A memorandum book made by him at this time reveals his tastes as a youth and foreshadows his interests as a man. Among the items are recipes for fireworks (especially "rockets, serpents and raining fire"), the sums paid for instruction in French, for pew rent, for lessons in fencing and for an electrical machine. Twenty pages contain sketches with pen or pencil. A few are crude, but most give definite evidence of accurate perspective and a skilful hand.

During 1770–1771 Benjamin Thompson boarded with Dr. John Hay, of Woburn, and while with him studied anatomy, chemistry, materia medica, etc. In the summer of 1771 he attended lectures on experimental physics given by Professor John Winthrop at Harvard College. Entries made during July and August, 1771, in an account book show that these were days of varied and hard labor, interspersed with periods of systematic study and experiment. Much time and energy were spent on the construction of the electrical machine. In passing we note that he paid 2s. 6d. for an ounce of nitric acid, 40s. for a pint of lacquer, and 5s. for an ounce of shellac.

In 1771–1772 he taught school in Wilmington and Bradford, and in the summer of 1772 he became master of a school in Concord, N. H., which was then called Rumford. At this time Benjamin Thompson, according to a contemporary record, was an attractive young man, having a fine, manly figure, handsome features, bright blue eyes and dark auburn hair. His manners were polished and his ways fascinating. He had used his opportunities to become cultured, and his knowledge of men and affairs was far beyond that of most of his associates.

His zeal, activity and engaging ways enabled him to give satisfaction as a teacher. But his career as a teacher soon ended, for toward the close of 1772 he married the daughter of the Reverend Timothy Walker, one of the prominent men of the town. He acquired thereby a large estate and ample means and entered upon a new life. His days were spent in developing the estate and sharing in the social and political events of the time. He also read diligently, especially books on science, invention and discovery.

Benjamin Thompson, like other young men of his time, especially men of aristocratic tastes and autocratic temperaments, became entangled in the political net that was spread over New England and was compelled to leave the land of his birth. And since we are considering the scientific and philanthropic work of Benjamin Thompson, let us pass over the domestic, political and military events of this part of his life.

Resuming our account, we find him in England in 1778 making experiments on gunpowder and firearms, a field in which he was deeply interested. These experiments were undertaken to determine the most advantageous position for the vent in firearms, to measure the velocity of bullets and to study the recoil of the gun under various conditions; also to determine the force of fired gunpowder. The account of these experiments covers about 175 pages in Volume I of the edition of Count Rumford's work published by the American Academy of Arts and Sciences. Subsequently he made experiments to determine the maximum pressure produced by the explosion of powder, and showed that the value of powder in ordnance does not depend solely on the total amount of gas produced, but on the rapidity of combustion as well. Some of these experiments were made on shipboard and the results were utilized in naval guns. It was at this time, too, that he devised a new code of marine signals.

These investigations attracted the attention of Sir Joseph Banks, president of the Royal Society. Mutual tastes and interests led to a friendship which lasted many years. In 1779 Benjamin Thompson was elected a Fellow of the Royal Society, "as a gentleman well versed in natural knowledge and many branches of polite learning." This recognition elated him and opened a pathway to association with scientists of renown—an opportunity utilized throughout the rest of his life. Not yet weaned from a thirst for military fame, Lieutenant Colonel Benjamin Thompson left England toward the end of 1783 to travel on the continent, and perhaps to serve in the Austrian army against the Turks. But the would-be warrior never fought again, though he served a vast army in peaceful ways. Two accidental experiences led to a sudden reversal of his intentions, indeed, his whole subsequent life was profoundly changed. One event we state in his own words. An excellent person, he says, "gave me the wisest advice, made my ideas take a new direction, and opened my eyes to other kinds of glory than that of victory in battle." The other event was a chance meeting with Prince Maximilian, then Field Marshal of France, and afterward Elector of Bavaria. Colonel Thompson attended a military review at Strasbourg attired in a resplendent uniform and mounted on a fine horse. The prince was attracted by the bearing of this foreign officer and gave him a letter of introduction to the Elector of Bavaria (uncle of the prince).

The Elector of Bavaria, Charles Theodore, immediately invited Benjamin Thompson to enter his service in a semi-military and semi-civil capacity, and to assist in reorganizing his dominions and eliminating undesirable abuses. Before accepting this appointment, it was necessary for Benjamin Thompson, who was an officer in the British army, to obtain the permission of King George III. The king not only approved of the arrangement, but on February 23, 1784, conferred on him the honor of knighthood. The document permitting Sir Benjamin Thompson to display and use the arms of "the ancient and respectable family of Thompson of York" is now in the library of the American Academy of Arts and Sciences, Boston, Mass.

Sir Benjamin returned at once to Bavaria. To give him power and standing he was appointed colonel of a regiment of cavalry and made a general aide-de-camp. A palatial residence in Munich was provided for him, and here he lived in luxury. His days were spent in scientific and philanthropic work to which it would be difficult to find a parallel in all history. His aim was to discover scientific principles and apply them to the welfare of the people and the state, especially principles and applications involving economy and utility in living.

In 1788 he was made major-general of cavalry and privy councillor of state. At the same time he was made head of the war department and given instructions to carry out his plans for the reform of the army and the removal of mendicity.

The pay of the soldiers was a mere pittance per day, their living quarters were extremely uncomfortable and their drill and discipline were irksome. Sir Benjamin set to work to make "soldiers citizens and citizens soldiers." Their pay, uniform and quarters were improved; and the discipline was lightened. Schools were connected with all regiments, and here not only the soldiers, but their children were taught gratuitously. Moreover, the soldiers were employed in public works, thereby acquiring habits of industry, and their work was enlivened by music of their own military bands. They were also supplied with raw material of various kinds, and allowed, when off duty, to manufacture various articles and sell them for their own benefit. The garrisons were made more or less permanent, so that the greater part of a soldier's life was spent at home. Each soldier, too, was allotted a small garden for his own use, and its products were his sole property. Garden seeds, and especially seed potatoes, at that time not well known in Bavaria, were provided for the men. Under these circumstances a reform in the army was speedily effected and contentedly accepted.

Sir Benjamin's next work was with the mendicants. Munich itself was overrun with beggars. In many towns they were completely organized and stations of advantage were assigned in regular order or inherited according to established customs. In the country farm-laborers begged of travelers, and children were taught to beg from their infancy. The people had come to regard begging and its evils as inevitable. Sir Benjamin organized a regular system of military patrol throughout the villages, four regiments of cavalry being set apart for this work. Then on January 1, 1790, when the beggars were out in full force to keep their annual holiday, those in Munich were seized by the three regiments of infantry then in garrison. The beggars were taken to the town hall, and their names and addresses entered on lists prepared for the purpose. They were ordered to present themselves next day at the military workhouse, and a committee was appointed to inquire into the condition of each person. The inhabitants of Munich, relieved of a terrible evil, readily subscribed money for systematic relief, while the tradesmen contributed food and other requisites to the committee. In the military workhouse the former beggars made uniforms for the troops, besides a great deal of clothing to be sold in Bavaria and other countries. Sir Benjamin himself fitted up and superintended the kitchen where food was cooked daily for a thousand or more persons. Under his management, a nourishing dinner for a thousand could be cooked at a cost of about nine cents for fuel—a typical example of the useful applications of science and philanthropy advocated and applied by him.

During an interregnum the Elector of Bavaria became Vicar of the Holy Roman Empire, and he took advantage of his temporary power in making Sir Benjamin Thompson a Count of the Holy Roman Empire. The title which the new count selected was Rumford, the old name of the village in New England where he had spent the first years of his wedded life.

Count Rumford remained in Munich eleven years before returning to England. Let us consider some of the outstanding scientific accomplishments of this period.

One of his investigations was an elaborate series of unique experiments on the heat-conducting power of fluids. He showed among many other things that convection currents are the principal means by which heat is transferred through fluids, and described how, when a vessel of water is heated, there is generally an ascending current in the center, and a descending current all around the periphery. Hence he concluded it is only when a liquid expands by increase of temperature that a large mass can be readily heated from below. He also pointed out the exceptional behavior of water below 39° F., *viz.*, it contracts when heated and expands when cooled. Then he proceeded to explain how large bodies of water are prevented from freezing at great depths on account of the expansion which takes place on cooling below 39° F., and he mentions as an example that in the Lake of Geneva, at a depth of a thousand feet, the temperature was found to be 40° F. He emphasized the fundamental bearing of this unusual behavior of water on climate everywhere, and on the preservation of trees, fruits and vegetables during the winter in cold countries.

In his experiments on the heat-conducting power of liquids, Count Rumford tried the effect of increasing the viscosity of water by the addition of starch and of impeding its movements by the introduction of eider-down. The results enabled him to explain the inequalities of temperature in a mass of thick soup or stewed apples—inequalities which had once caused him to burn his mouth! He writes sagely on this point: "Heat passes with much greater difficulty or much slower in stewed apples than in pure water." Applying the same principles to moving air, he turned his conclusions to practical account in making warm clothing, not only of woven fabrics but also of feathers and fur. These experiments were a remarkable contribution to our knowledge of the function of heat in human experiences, and their record in the edition cited above covers nearly 250 pages.

In another series of experiments devoted to the radiating power of different surfaces he showed how the power varied with the nature of the surface and illustrated the results by demonstrating the effect of a coating of lamp-black in increasing the radiating power of a body.

He also investigated the absorption of heat by different surfaces. His results led to the law that good radiators are good absorbers, and the recommendation that vessels in which water is to be heated should be blackened on the outside. In speculating on the function of the coloring matter in the skin of the negro, he said:

> Were I called to inhabit a very hot country, nothing should prevent me from making the experiment of blackening my skin, or at least, of wearing a black shirt, in the shade, and especially at night, in order to find out if, by those means, I could contrive to make myself more comfortable.

Other investigations dealt with the use of steam as a vehicle of heat, new types of boilers and stoves for economizing fuel, the nutritive value of different foods, the calorimeter with which he determined the amount of heat generated by the combustion of various bodies, fireplaces and cooking utensils. He was particularly interested in the last two, and an entire volume of the edition of Count Rumford's works mentioned above is devoted to descriptions of fireplaces and cooking utensils.

In some of his experiments on light he used the military workhouse in Munich, where the beggars were housed. Before deciding on the best way to light it, he made experiments on the relative economy of different methods, and for this purpose designed his well-known shadow-photometer. By introducing colored glasses in front of the lights of the photometer he compared the illuminating powers of different sources with respect to light of a particular color. The complementary tints exhibited by the shadows led him to propose his theory of the harmony of complementary colors. Other experiments on light were devoted to light from luminous bodies, chemical properties attributed to light and the management of light in illumination. These experiments, like those on heat, were extensive, the part on management covering nearly 150 pages in Volume IV of the American Academy edition.

The experiments by which Count Rumford will be best known by future generations are those described in his essay entitled "An Inquiry concerning the Source of the Heat which is Excited by Friction." This essay, unlike most of the others, is short—only about twenty pages—but it is extremely important because it is a record of a wonderful discovery. While supervising the boring of cannon in the foundry he had built near the arsenal in Munich, he was amazed by the excessive amount of heat generated during the process of boring. He noted that chips of the metal shaved off were hotter than boiling water. And it occurred to him that further experiments might settle the age-long dispute as to "the existence or non-existence of an igneous fluid" called heat. The scientists of his day believed that heat was an imponderable fluid, called caloric, which flows from a body of higher temperature to one of lower, much as water flows from a higher to a lower level. They also believed that substances had different capacities for heat.

Now the French chemist Lavoisier had already established the fact of the conservation of matter, and Count Rumford reasoned thus:

If heat is a fluid, it can neither be created nor destroyed; consequently, either the same amount of heat must be present in the hot chips and cannon as in the unbored metal, or else heat must have reached the cannon from outside.

Having thus put the case clearly to himself, he proceeded to make experiments to determine whether or not heat is a fluid.

If no heat reached the cannon from outside, he argued, then the rise in temperature of the chips might be explained by the supposition that gunmetal in the form of chips has a smaller capacity for heat than metal in a block. When, however, he compared by experiment the capacities for heat of gun-metal in these two forms, they were found to be the same. It had seemed to him, from the first, unlikely that the observed rise of temperature in the process of boring cannon could be accounted for in this way, yet to be doubly sure he repeated the boring experiment, using a very blunt tool, pressed with a force of ten thousand pounds against the bottom of a revolving cylinder which he had cut off from the casting of a cannon. In this case, only 837 grains (Troy weight) of metal were detached, while the temperature of the apparatus rose 70° F. (from 60° F. to 130° F.) in an hour.

In the experiment just described, the external air had free access to the inside of the cylinder, so, to ascertain whether air could have imparted heat to the apparatus, he excluded the air by means of a piston and repeated the experiment. The result was substantially the same. But it might be possible, he argued with keen insight, that some heat was generated in this second experiment by the friction of the piston in the bore of the cylinder, so the whole apparatus was enclosed in a box containing water, and the experiment was repeated. This time the result was even more striking than before, for after boring two and a half hours the water actually boiled!

"It would be difficult," wrote Count Rumford in his essay, "to describe the surprise and astonishment expressed in the countenances of the bystanders on seeing so large a quantity of cold water heated and actually made to boil without any fire."

He had shown by experiments that the heat produced was not furnished by the chips of metal, nor by the outside air, nor by the water surrounding the apparatus. He had also shown this positive fact, *viz.*, that as long as friction continued heat was given off: "Whence did it come?" he asked. His answer is given in the last paragraph of the paper he read before the Royal Society in January, 1798, *viz.*:

> It is hardly necessary to add, that anything which any insulated body, or system of bodies, can continue to furnish without limitation, can not possibly be a material substance; and it appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in the manner the Heat was excited and communicated in these experiments, except it be *motion*.

In 1795 Count Rumford returned to England to renew his friendships with scientists, read his papers, apply his philanthropic ideas and publish the essays describing his scientific investigations and philanthropic work done in Bavaria. His wife had died three years previously, but the daughter Sarah, now a young woman twenty-one years old, was still living in America. So he invited her to come to England. She remained with her father more than three years and her autobiography gives much information about his activities.

While in England at this time Count Rumford attracted considerable attention by his practical and useful experiments on chimneys, stoves, fireplaces, use of fuel, cooking utensils and the art of cooking economically on both a household and an institutional scale. Some of his experiments gave him a conspicuous notoriety, but he was as sincere as he was successful in eliminating expensive discomfort in homes and hospitals and in substituting therefor economical use of fuel and inexpensive preparation of nutritious food. Not all his work in this field was done in England. It was an extensive field and the experiments consumed much time, especially those concerned with fireplaces and food. Over five hundred pages in Volume III of the edition cited above are devoted to fires in fireplaces, etc. Much space is given to cooking utensils, including the famous "roaster," boilers, stewpans, covers, handles and materials of which such things should be made. Processes of cooking are described, and tables of results of cooking, nutritive qualities and comparative food values are scrupulously and precisely compiled. It was a monumental piece of work, carefully executed, admirably illustrated by over one hundred cuts and done with the sole purpose of helping rich and poor to live more comfortably, economically and happily. Count Rumford was the first man to advocate sensible home economics and rational dietetics.

During this visit to England Count Rumford presented $5,000 each to the Royal Society of Great Britain and the American Academy of Arts and Sciences of Boston for the purpose of endowing a medal, called the Rumford medal, to be given each alternate year for the best work done during the preceding two years on heat and light. He directed that two medals, one in gold and the other in silver, should be struck from the same die. Whenever no award was made, the interest was to be added to the principal, and the excess of the income for two years over $300 was to be presented in cash to the recipient of the medal.

The first award of the medal by the Royal Society was graciously made in 1802 to Count Rumford himself, "for his various Discoveries respecting Light and Heat." Many famous scientists have been given the Rumford medal by the Royal Society, among them being Davy, Faraday, Pasteur and Tyndall. Tyndall received the medal only a few years before he came to Woburn for the express purpose of visiting the birthplace of Count Rumford.

The letter announcing the gift to the American Academy is in the library of the academy, together with many other letters from and to Count Rumford. The first man to receive a gift of money from the interest on the Academy Fund was Robert Hare, of Philadelphia, for "his invention of the compound blowpipe and his improvements in galvanic apparatus."

In the following summer (1796) Count Rumford and his daughter went to Munich, where they stayed two years. The daughter was made a countess, and the father relinquished part of his pension for her, thereby providing her with an annual income of $1,000 for life. Toward the end of their stay in Munich, Count Rumford was appointed minister plenipotentiary from Bavaria to Great Britain. But when he reached London in September, 1798, he found much to his chagrin that having been born a British subject he could not be accepted as an envoy from a foreign state. The daughter soon afterward returned to America and the Count remained in London. Relieved of political and diplomatic responsibilities, he devoted his time and energy to scientific and philanthropic activities. His chief work was the founding of the Royal Institution.

Count Rumford's visit to England in 1795–1796 had brought him into intimate contact with the Royal Society. His association with this exclusively academic society suggested the need of a society which would establish helpful and practical relations between scientists and workingmen. He drew up an elaborate plan for the formation of an "institution for diffusing the knowledge and facilitating the general introduction of useful mechanical inventions and improvements, and for teaching by courses of philosophical lectures and experiments the application of science to the common purposes of life." The "proposals," as the plan was called, gave a detailed plan of operation and management, including an elaborate exhibit of models.

A lecture-room and laboratory were to be fitted up with the necessary apparatus, and the most eminent expounders of science were to be engaged for the purpose of "teaching the application of science to the useful purposes of life."

The lectures were to include warming and ventilation, the preservation of food, agricultural chemistry, the chemistry of digestion, of tanning, of bleaching and dyeing, "and, in general, of all branches of manufacture." The institution was to be governed by nine managers, of whom three were to be elected each year by the proprietors; and there was also to be a committee of visitors, the members of which should not be the managers. The king became patron of the institution, and the first set of officers was nominated by his majesty. The charter of the Royal Institution, as it was aptly named, was sealed on January 13, 1800.

Count Rumford's elaborate plan for the Royal Institution was sincere. The conception was a perfect expression of himself. It combined science and philanthropy, its twofold purpose was to seek the truth and make it useful. But, like many institutions established on broad foundations to meet the specific needs of a period, it was not developed as the founder planned. The practical and the useful as seen by Count Rumford were soon overshadowed by the scientific. Stoves, kitchens and contemporary mechanical contrivances were gradually set aside and quietly forgotten. Models were replaced by men—in succession Davy, Faraday, Young, Tyndall, Rayleigh, Dewar, Bragg and many others. These men have carried out Count Rumford's aim, not his special plans, but his aim as a scientist and philanthropist—discovery of truth which helps mankind. Let me cite two discoveries made by one man—only two made by Faraday. Faraday in 1825 in the laboratory of the Royal Institution discovered the chemical compound called benzene (C_6H_6) which is the starting point of a vast number of organic compounds which are indispensable to the comfort, health, pleasure and happiness of mankind. A few years later Faraday discovered the scientific principle on which the dynamo operates. This discovery soon became of practical use and has developed into our stupendous, intricate system of applied electricity. These two discoveries alone justify the establishment of the Royal Institution. Faraday made them. Count Rumford made them possible.

The Royal Institution is still in existence and from its laboratories and lecture hall the truth flows forth —useful truth for many people.

Count Rumford's life in London after he had started the Royal Institution was not pleasant. In Bavaria he had been accustomed to carry out his projects like an emperor. In London emperors were not acceptable. He could not agree with his board of managers—individually or collectively. Perceiving that the actual scientific work was well placed in the hands of the chemist, Humphry Davy, whom he had chosen, and "ordering that all the resources of the institution should be at his [Davy's] service," Count Rumford left England in May, 1802, never to return.

After spending some time in Paris and in Munich, he married (in 1805) Madame Lavoisier, widow of the famous chemist. The union was not happy. The Count loved a garden and hated dinner parties. The Madame despised flowers and delighted in banquets. So, after a few years, Count Rumford retired to a small estate in Auteuil near Paris. Here he lived peacefully with his books, his flowers and his friends until his death in 1814. His grave in Auteuil is marked by an elaborate stone, kept attractive by joint contributions of the American Academy of Arts and Sciences and Harvard University.

Among Count Rumford's bequests was a considerable sum of money to Harvard College, now amounting to over $60,000. The general purpose of the gift according to the will is "to teach the utility of the physical and mathematical sciences for the improvement of the useful arts, and for the extension of the industry, prosperity, happiness, and well being of society."

The Rumford professorship of the physical and mathematical sciences as applied to the useful arts was established in 1816. Noted men have filled this chair, one being Eben N. Horsford, an industrial chemist, whose work has had a fruitful influence on the practical development of science in the United States.

Count Rumford's work as a scientist and philanthropist is commemorated not only in medals, but also in portraits and monuments. Two paintings show him as a young man, another just beyond middle life, when he was sent as ambassador to England, and two others in his later years—one by Kellerhofen and one by Rembrandt-Peale, the latter painted a short time before Count Rumford's death in Paris. There are two monuments in Munich. In front of the National Museum in Maximilianstrasse stand four bronze figures, ten feet in height; one of these is Count Rumford. This statue was erected in 1867, at the king's private expense. And in the English Garden, which Count Rumford planned and laid out, is a monument erected by grateful citizens during his absence in England in 1796. And in Woburn, Mass., there is a replica of the Munich statue.

Making an aerial survey, so to speak, of Count Rumford's work as a scientist and philanthropist, one is astounded by its extent, variety and originality. One marvels, too, that so much of his work was practical and useful, though planned by a scientific investigator and pursued in most cases solely to discover facts. One wonders, also, how he found time and strength to perform and record such a vast number of experiments. In this address much of his work has been left untouched, but enough has been considered to demonstrate that Count Rumford was a wonderful man and undeniably deserves the high place given him among the world's most famous scientists and philanthropists.

LYMAN C. NEWELL

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IMPROVEMENT IN MORTALITY RATES AND EXPECTATION OF LIFE IN THE UNITED STATES FROM 1890 TO 1920[1]

THE problem of race betterment is qualitative and quantitative. We shall deal only with some of its quantitative aspects. It is one thing to be alive and in full possession of those physical and mental faculties which come with freedom from disease and favorable inherited tendencies and quite another to be substandard in vitality and ability to think and act. But when we deal quantitatively with longevity we are obliged to depend upon data which tell us only that a man is alive or dead. This dichotomy is peculiar to the population and vital statistics gathered by our Census Bureau. We can take no account of the man who is half dead—we count him as living to the same extent as the most splendid physical specimen in our broad land—he is a unit either in the census or the death register.

From this mass of raw data every ten years we construct life tables. Census statistics may be regarded as the journal entries of our bookkeeping and the life tables as the periodic balances which we strike in the ledger of life. They tell us nothing about ourselves as individuals, but reveal many interesting and important things about us as we are in the aggregate. If men are going to live and die during the next two or three decades under the same essential conditions as during the last decade, life tables enable us to predict the rate of mortality, expectation of life and numerous other things for each year of age with remarkable precision. So certain is this forecast that one of the greatest activities of modern civilization, the insurance of lives, is based on life tables and generally regarded as the most stable financially among them all.

We shall take the figures from 1890 to 1920 furnished by the Census Bureau at their face value and draw from them the best conclusions we can, whether or not they agree with what we would like them to be. They are disappointing in some respects because they lead to the conviction that we are not strongly headed towards substantial improvement in longevity if we understand by this term that most men can reasonably expect in the near future to live to be eighty years of age or over. Our life tables show that in this country since 1890 the average length of life at birth has increased at the rate of about five months per year from forty-three years to fifty-five years, or more than twelve years in all. Nor is there as yet a

[1] Address given in Battle Creek on January 3, at the meeting of the Third Race Betterment Conference.