THE FOUNDATIONS OF NUTRITION

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# PREFACE

Anyone can learn to run an automobile by rule. "Turn on the gas, start the engine with clutch in neutral, release the brake" has been mastered by hundreds of thousands who know very little about electricity or theories of mechanics; who never pause to consider how the battery starts the motor or how the gasoline is converted into power. Nevertheless, great numbers of automobile owners have found it to their advantage to study the mechanism of their cars because it saves money in upkeep and repairs; it often saves time in waiting for some one to help in an emergency; and it may save much strain on the car, prolonging its life and increasing its period of service.

Much the same can be said of the human machine. Everybody knows that food is required to run it, but the appetite is such a reliable "self-starter" for food consumption that no one has to be taught what to do with a plate of attractive viands. Like running an automobile driving can be done by rule of thumb, without any understanding of what the food is doing to the body beyond the passing pleasure of the meal; or it can be managed with intelligence and foresight, avoiding in course of time many disabilities and saving the body unnecessary wear and tear, which insidiously but inevitably cut down its efficiency and impair the value of the individual to himself and to society.

This book is written for those who wish to live more intelligently. An effort has been made to present within a small space some of the fundamental principles of human nutrition in terms which call for no highly specialized training in those natural sciences upon which the science of nutrition rests. The selection of topics and the relative amount of space devoted to each are based on much experience in presenting the subject of nutrition to beginners whose object is to be well informed as to the significance of food in daily life so that they may order their own lives more successfully and may have a better understanding of the part which nutrition plays in health in the world at large.

Each essential factor in an adequate diet is discussed in detail with many references to animal experiments which help to make clear the reasons why it must have a place in the daily program. The foods which serve the best purpose of these essentials have been indicated, and a very practical new method of comparing nutritive values of common food materials has been described with many concrete examples.

The reading references at the end of each chapter have been chosen for their availability and clearness. For the sake of those who may wish to enter into a very thorough study of the subject, references to original literature have been included as footnotes throughout the text.

The author wishes to express her very great appreciation of the encouragement and valuable criticism received from Professor Henry C. Sherman and also of many helpful suggestions from other members of the Department of Nutrition of Teachers College. Special acknowledgments are due to Dr. Margaret C. Hessler and Miss Hazel K. Stiebeling for their coöperation in the development of the simplified method of denoting food values presented in Chapters XI and XII. Dr. Hessler was the first to suggest the use of the term "share" to indicate the amount of protein or of any mineral elements which should accompany each 100-calorie portion of a normal family dietary, and Miss Stiebeling very kindly prepared the "share" table in the Appendix.

Special thanks are due to Dr. Edgar J. Smith for the privilege of reproducing a rare portrait of Lavoisier, and to others who have kindly aided with the illustrations.

M. S. R.

# FOREWORD

A living being considered as an object of chemical research, is a laboratory, within which a number of chemical operations are conducted; of these operations, one chief object is to produce all those phenomena, which taken collectively are denominated LIFE; while another chief object is to develop gradually the corporeal machine or Laboratory itself, from its existence in the condition of an atom, as it were, to its utmost state of perfection. From this point of utmost perfection the whole begins to decline as gradually as it had developed; the operations are performed in a manner less and less perfect, till at length the being ceases to live; and the elements of which it is again set free, obey the general laws of inorganic nature.

JÖNS JACOB BERZELIUS
1779–1848

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# THE FOUNDATIONS OF NUTRITION

## CHAPTER I

## HISTORICAL INTRODUCTION

### Section I

### SOME LANDMARKS IN THE DEVELOPMENT OF THE SCIENCE OF NUTRITION

The idea that there is a close connection between man's diet and his well-being is no innovation of the twentieth century. In an ancient chronicle we may read: "In the third year of the reign of Jehoiakim, king of Judah (607 B. C.) came Nebuchadnezzar, king of Babylon, unto Jerusalem, and besieged it." When the city fell into his hands, the king ordered that certain noble youths, "well-favored and skilful in all wisdom," be selected for training as courtiers. They were to have a special education and a daily portion of the king's meat, and of the wine which he drank. Living a carefully prescribed life, at the end of three years they would presumably be fit to stand before the great monarch. One of these youths "with knowledge and skill in all learning and wisdom" objected to the dietary part of the program and purposed in his heart that he would not eat the king's meat nor drink his wine; but the prince of the eunuchs, who had him in charge, protested, saying, "I fear my lord the king." The young man countered with a reasonable proposal: "Prove thy servants, I beseech thee, ten days; and let them give us pulse to eat and water to drink. Then let our countenances be looked upon before thee, and the countenance of the youths that eat of the king's meat." This seemed a fair bargain and so the nutrition experiment was undertaken, with the result that at the end of the ten days "their countenances appeared fairer and fatter in flesh than all the children which did eat the portion of the king's meat. So the steward took away their meat and the wine which they should drink and gave them pulse;" and when at the end of their probationary period the king examined them they passed with a score ten times better than all the magicians and enchanters in his realm.[1]

## What Becomes of Food Eaten?

From that time to this, man has given much thought to the problem of where food goes when it is eaten and what it does to the one who eats it. But for many centuries the answers to such questions were philosophical rather than scientific. The greatest philosopher among the ancients with regard to food was Hippocrates, the famous priest of Æsculapius officiating in the celebrated Health Temple of Cos in Greece in the day of Socrates and Plato, who by his wisdom and skill earned the title of Father of Medicine. The historian Strabo says that he was trained in dietetics, and some of his aphorisms have a modern sound, for example: "Growing bodies have the most heat; they

[1] *Daniel* I: 1–15.

therefore require the most food, for otherwise their bodies are wasted. In old persons the heat is feeble and therefore they require little fuel, as it were, to the flame for it would be extinguished by much." (Aphorism 14.)[1] But Hippocrates and his successors for two thousand years accounted for the disappearance of food as "insensible perspiration" and "heat" without any real understanding of what either term meant.

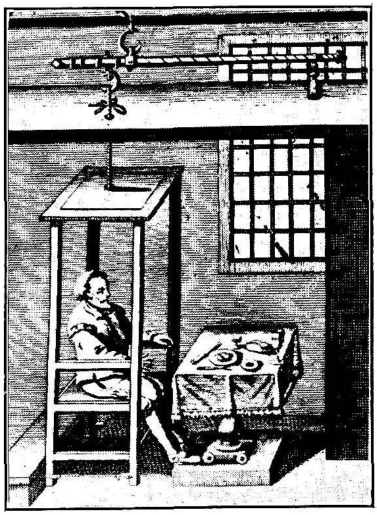


Fig. 2.—Sanctorius on the steelyard which he devised to weigh himself before and after meals.

In 1614 A. D. a university professor with a practical turn of mind devised a chair connected with a steelyard to weigh himself before and after meals, so that he might find out the amount of this "insensible perspiration," for he said: "He only who knows how much and when the body does more or less insensibly perspire will be able to discern when or what is to be added or taken away, either for the recovery or the preservation of health." (Aphorism 3.)[2] Even Sanctorius's painstaking efforts did not solve the mystery because in his day there was no science of chem-

[1] Adams, Francis. *Genuine Works of Hippocrates*, page 197. William Wood and Co. (1891).
[2] Lusk, Graham. *Science of Nutrition*, 3d edition, page 18. W. B. Saunders Co. (1917).

istry. This did not begin its active development until about half a century later.

### Air is Essential for Life

In 1627 was born the Honourable Robert Boyle, seventh son of "the great Earl of Corke," destined to receive the best education of his day in England and on the continent and to become known to every student of chemistry or physics as a result of his studies on the "weight and spring of the air." In the course of his extensive investigations of the properties of the air, he conducted a large number of "pneumatical experiments about respiration." He put into the receiver of his "pneumatical engine" all sorts of small animals—"a kitling newly kittened," "a duckling that was yet callow," "a large and lusty frog"—to find out "whether there reside in the heart of animals such a fine and kindled, but mild substance, as they call a Vital Flame, to whose preservation, as to that of other flames, the Air (especially as is taken in and expelled again by respiration) is necessary," and he found that it was necessary, as the following experiment will serve to indicate:

"Experiment I. We included in a round vial with a wide neck (the whole glass being capable of containing about 8 ounces of water) a young and small mouse, and then tied strongly upon the upper part of the glass's neck a fine thin bladder, out of which the air had been carefully expressed, and then conveyed this phantastical vessel into a middle-sized receiver, in which we also placed a mercurial gage (adjusted by our elsewhere mentioned standard); this done, the air was by degrees pumped out, until it appeared by the gage, that there remained but a fourth part in the external receiver (as for distinction sake I call it) whereupon the air in the internal receiver expanding itself, appeared to have blown the bladder almost half full, and the mouse seeming ill at ease by his leaping, and otherwise endeavoring to pass out at the neck of his uneasy prison; we did, for fear the over thin air would dispatch him, let the air flow into the external receiver, whereby the bladder being compressed, and the air in the vial reduced to its former density, the little animal quickly recovered."[1] So this ardent chemist demonstrated to his full satisfaction the dependence of animals upon the air they breathe for life.

Still more significant respiration experiments were made by a young chemist named John Mayow, who came under the influence of Boyle and in 1668, at the age of twenty-eight, published a "Treatise on Respiration" in which he showed that if a burning candle and an animal be put together in a bell jar both will expire sooner than either one alone. Mayow seems to have been the first to recognize that breathing brings the air into contact with the blood. He wrote: "Air loses somewhat of its elastic force during respiration by animals as also in combustion. One must believe that animals, like fire remove from air particles of the same nature." [2] Mayow's death at the age of thirty-four delayed the development of true conceptions of respiration for nearly a hundred years.

[1] *Works of Robert Boyle*, Vol. 3, page 128. A. Millar (1744).
[2] Lusk, Graham. "History of Metabolism," Barker's *Endocrinology and Metabolism*, Vol. 3, page 10. D. Appleton and Co. (1922).

## The Gases of Respiration

In 1754 a young Scotchman named Joseph Black, who was studying medicine at the University of Edinburgh, published his inaugural dissertation for his M. D. degree on the subject of magnesia and quicklime; substances in which he was specially interested because the medicines in vogue for the cure of gall-stones all seemed to derive their efficacy from quicklime. He had discovered that a cubic inch of marble yielded about half its weight of pure lime and "as much air as would fill a vessel holding six wine gallons." His lectures were published after his death from his manuscript notes, and his biographer wrote in the preface: "It was not only a most unexpected and curious thing to find that a matter so solid and impenetrable as marble could appear in the form of air, and this air be again put into our hands in the form of marble; but this new acquaintance had properties which forcibly called for the most serious attention. This air can be poured from one jar into another like as much water; and when it is poured out on a candle, or even on a fire in sufficient quantity, they are extinguished in an instant, as if water had been poured on them. . . . It has also been discovered that this air, so destructive and salutary, is forming in vast quantities every moment around us."[1] He called it "fixed air," a little later to be identified as carbon dioxide. He also found that limewater was made cloudy by breathing into it through a tube, as well

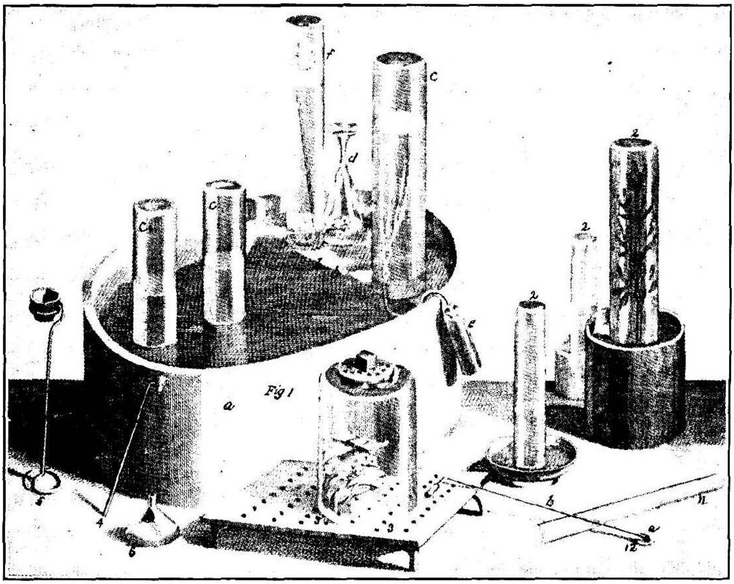
[1] Lectures on the Elements of Chemistry, delivered in the University of Edinburgh by the late Joseph Black, M. D., Professor of Chemistry in that University. Published from his manuscripts by John Robison (1807).

as by shaking it in a jar in which a candle had just gone out, and concluded that the breathing of animals changes "common air" into "fixed air."

While Black was winning renown as a professor in the University of Edinburgh and a devoted following as a practicing physician in the city, a dissenting clergyman in England, by the name of Joseph Priestley, was earning his living by acting as librarian for a rich patron but devoting all his spare time to chemical experimentation.

Priestley took a living plant (a sprig of mint) and put it into a closed receptacle in which a candle had already burned out. After several days another candle was introduced into the same jar and this time it did not go out but burned brightly. Soon after this, he took a jar, filled it with mercury, and carefully inverted it in a vessel containing mercury, so that no air entered the jar. He then introduced through the opening, under the mercury, some red oxide of mercury, which rose and floated on top of the mercury inside the mouth of the jar. Upon this he converged the heat of the sun by means of a powerful burning glass, and this is how he described the result: "I presently found by means of this lens air was expelled from it (the mercuric oxide) very rapidly. Having got about three or four times the bulk of my materials, I admitted water and found that it was not imbibed by it. But what surprised me more than I can well express was that a candle burned in this air with a remarkably brilliant flame." [1] Priestley had discovered a new gas,

[1] Priestley, Joseph. *Experiments and Observations on Different Kinds of Air*, Vol. 2, page 107. Thomas Pearson (1790).



(*Courtesy of the New York Public Library*)

FIG. 3.—Apparatus Used by Priestley.

Plate and description from "Experiments and Observations on Different Kinds of Air," (1790).

"I first used an oblong trough made of earthenware, Plate 1, Fig. 1, about 8 inches deep, at one end of which I put some flat stones, about an inch or half an inch, under the water, using more or fewer of them according to the water in the trough. I afterwards found it more convenient to use a larger wooden trough of the same form, with a shelf about an inch lower than the top, instead of the flat stones above mentioned. In one end of this trough are ledges on which it can slide. . . . The several kinds of air I usually keep in cylindrical jars, as C, C, Plate I, Fig. 1, about 10 inches long, and 2½ inches wide. . . . If I want to try whether an animal will live in any kind of air, I first put the air into a small vessel, just large enough to give it room to stretch itself; and as I generally make use of mice for this purpose, I have found it very convenient to use the hollow part of a tall beer-glass, *d*, Fig. 1, which contains between two and three ounce measures of air. In this vessel a mouse will live 20 minutes or half an hour. . . . In order to keep mice, I put them into receivers open at the top and bottom, standing upon plates of tin perforated with many holes, and covered with other plates of the same kind, as Plate 1, Fig. 3. . . . In the same manner in which a mouse is put into a vessel of any kind of air, a plant, or anything else may be put into it, viz., by passing it through the water. . . . When I want to try whether any kind of air will admit a candle to try to burn in it, I make use of a cylindrical glass vessel, Plate 1, Fig. 11, and a bit of wax candle, *a*, Fig. 12, fastened to the end of a wire, *b*, and turned up in such a manner as to be let down into the vessel with the flame upwards."