

**U. S. DEPARTMENT OF AGRICULTURE.  
OFFICE OF EXPERIMENT STATIONS-  
BULLETIN NO. 109.  
EXPERIMENTS ON THE METABOLISM OF  
MATTER AND ENERGY IN THE HUMAN  
BODY, 1898-1900**

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**W. O. ATWATER & F. G. BENEDICT**

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*Atwater*

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 109.

A. C. TRUE, Director.

*Heron*

EXPERIMENTS

ON THE

Metabolism of Matter and Energy in the Human Body,

1898-1900.

BY

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WITH THE COOPERATION OF

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## LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,  
OFFICE OF EXPERIMENT STATIONS,  
*Washington, D. C., December 15, 1901.*

SIR: I have the honor to transmit herewith a general report of 13 experiments on the metabolism of matter and energy in the human body, by W. O. Atwater, special agent in charge of nutrition investigations, and F. G. Benedict, expert in these investigations, with the cooperation of A. P. Bryant, A. W. Smith, and J. F. Snell. Valuable aid was also rendered by Messrs. P. B. Hawk, H. M. Burr, E. Osterberg, and others. In addition to the details of these 13 experiments on the general subject of the metabolism of matter and energy a considerable number of general deductions are drawn from the experiments as a whole.

These experiments form part of a series which is in progress at Middletown, Conn., in cooperation with the Storrs Agricultural Experiment Station and Wesleyan University. They were made with the Atwater-Rosa respiration calorimeter. The apparatus and the earlier experiments have been described in previous bulletins of this Office (Nos. 44, 63, and 69). Such experiments as those reported have for their ultimate object the study of the fundamental laws of nutrition. The results obtained are of such a nature as to warrant the conclusion that the respiration calorimeter is a satisfactory instrument of precision. The experiments here described, like those previously reported, yield important data regarding the transformation and the conservation of energy in the body, the demands of the body for nutriment, the effects of muscular work upon that demand, and the nutritive values of different nutrients and different foods.

The report is submitted with the recommendation that it be published as Bulletin No. 109 of this Office.

Respectfully,

A. C. TRUE,  
*Director.*

HON. JAMES WILSON,  
*Secretary of Agriculture.*





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# METABOLISM OF MATTER AND ENERGY IN THE HUMAN BODY.

## INTRODUCTION.

The present report gives the details of 13 experiments upon the metabolism of matter and energy in the human body, made at Middletown, Conn., under the auspices of the U. S. Department of Agriculture, in cooperation with the Storrs Experiment Station and Wesleyan University. These experiments, which are in continuation of those reported in earlier bulletins of this series,<sup>a</sup> were carried on during the years 1898 to 1900, with the same respiration calorimeter<sup>b</sup> and by the same methods. In addition to the experiments reported in the present bulletin, 11 other experiments, which for convenience of reference have been numbered consecutively with these, were made with the same apparatus at Wesleyan University, during the same years, in connection with an independent investigation, and are reported elsewhere.<sup>c</sup>

## QUESTIONS STUDIED.

As has already been explained, the ultimate purpose of experiments with men in the respiration calorimeter is the study of some of the fundamental laws of nutrition, and the whole inquiry is based upon the principle that the chemical and physical changes which take place within the body, and to which the general term "metabolism" is applied, occur in obedience to the laws of the conservation of matter and of energy.

No one doubts that the law of the conservation of matter governs its metabolism in the living organism, and it is generally believed that the law of the conservation of energy likewise applies to the metabolism of energy. Quantitative determinations of the applications of this law are, however, desirable.

<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Buls. 44, 63, and 69.

<sup>b</sup> U. S. Dept. Agr., Office of Experiment Stations Buls. 44 and 63. See also Conn. (Storrs) Sta. Rpt. 1897, p. 212, and Physical Review, 9 (1899), pp. 130-163, 214-251.

<sup>c</sup> Memoirs of the National Academy of Sciences, Vol. VIII, Sixth Memoir, 1902.