

**A BIOMETRIC STUDY
OF BASAL
METABOLISM IN MAN**

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A Biometric Study of Basal Metabolism in Man by J. Arthur Harris & Francis G. Benedict

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J. ARTHUR HARRIS & FRANCIS G. BENEDICT

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Judge Peter H. Hall

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PREFACE.

In carrying out the work underlying this volume we have attempted to do more than to treat the available data for the basal metabolism of normal men, women and children by a method which is practically new in its application to human physiology; we have endeavored to make this investigation a prototype of that specialization in methods and coöperation in problems which we believe will be characteristic of the best scientific work of the future. We are convinced that this coöperation of specialists of widely dissimilar training is the only means by which science can attain both the height of refinement of measurement and analysis and the breadth of comparison and interpretation which is essential to continued progress.

The measurements considered in this volume have been made possible by the painstaking coöperation of a score or more fellow-workers, all of whom are connected or have been associated with the Nutrition Laboratory. How large their contribution has been will be evident from the names of the observers in the protocols of data and from the references to earlier publications scattered through the following pages. The exacting clerical and arithmetical work has been carried out at Cold Spring Harbor by the Misses Gavin, Holmes, Lockwood, and Peckham, who deserve the highest praise for the energy and care which they have devoted to this task. We are indebted to Major C. B. Davenport, Director, for permission to have this work carried out at the Station for Experimental Evolution. Finally it is a great pleasure to acknowledge our indebtedness to our associate, Professor W. R. Miles, who went over the first draft of the manuscript with us and offered many helpful suggestions, and to Mr. W. H. Leslie, in charge of the computing division at the Nutrition Laboratory, who has aided in correcting the proofs.

In taking up this work over two years ago, the authors fully recognized that the data must be wholly rearranged and interpreted as the statistical constants might indicate without any regard to opinions heretofore expressed from the Laboratory. Practically all of the conclusions already drawn at the Nutrition Laboratory have been fully substantiated by the statistical constants, and it is naturally a source of satisfaction that so little of the ground already held has had to be given up as a result of a wholly independent analysis from the outside.

This original conviction has been strictly adhered to, and every effort has been made to have the treatment physiologically sound throughout. We have endeavored to carry the analysis of the data to the practicable limits of the biometric formulas, at the same time preserving all that is of value in the older and simpler methods of treat-

ment which are more familiar to physiologists. We shall appreciate the fullest criticism by fellow physiologists, biologists, and statisticians, but criticisms to carry weight must be based on either statistical or physiological foundations and not merely the *ex cathedra* expression of the personal opinion that the new line of attack is valueless.

We are presenting this volume, not as a finished treatment of the subject of basal metabolism, but merely as an introduction to the many problems which await solution by the use of the more refined methods of analysis when more extensive data are available.

*Nutrition Laboratory of the Carnegie Institution
of Washington, Boston, July 10, 1918.*

CHAPTER I.

INTRODUCTORY.

The purpose of this volume is to present the results of a first attempt to analyze the data of basal metabolism in normal men and women by the higher statistical or biometric formulas.

These methods, associated primarily with the names of Sir Francis Galton and Professor Karl Pearson, are steadily making their way in the most varied fields of biological work. While Pearson and his associates at the Biometric Laboratory and the Galton Laboratory for National Eugenics, University College, London, have touched on various problems of interest to physiologists in their studies of inheritance and of environmental influence, the methods have, up to the present time, been little employed in the domain of human physiology. Perhaps the most important papers in their bearing upon the problems with which we are here concerned are those by Bell,¹ by Whiting,² and by Williams, Bell and Pearson³ on oral temperature in school children. Valuable as such studies unquestionably are from the standpoint of social and general biological science, statistical constants based on the returns of the public-school medical officer or of the prison surgeon can not be considered adequate for the requirements of modern nutritional physiology, in which measurements of a high degree of accuracy and made under carefully controlled conditions are indispensable.

Both the unfamiliarity of the biometric methods to most physiologists and the relative paucity of data on basal metabolism have probably been responsible for the failure of physiologists up to the present time to apply the higher statistical methods in this field. While physiologists have been engaged for several decades with the problem of the exact measurement of the metabolism of man and the lower animals, both by the direct determination of the amount of heat produced in the calorimeter and by the indirect calculation of heat-production from oxygen consumption and carbon-dioxide excretion, satisfactory data have until recently been exceedingly limited.

This state of affairs may be attributed to various causes. First of all, satisfactory apparatus is expensive and technical requirements exacting. The number of fully equipped laboratories and of adequately trained workers have, therefore, been very limited. Again, there is a personal element in all investigations based on normal human individ-

¹ Bell, *Biometrika*, 1911, 8, p. 232.

² Whiting, *Biometrika*, 1915, 11, p. 8.

³ Williams, Bell, and Pearson, *Drapers' Company Res. Mem., Stud. Nat. Det.*, London, 1914, 9.