JOSEPHSON

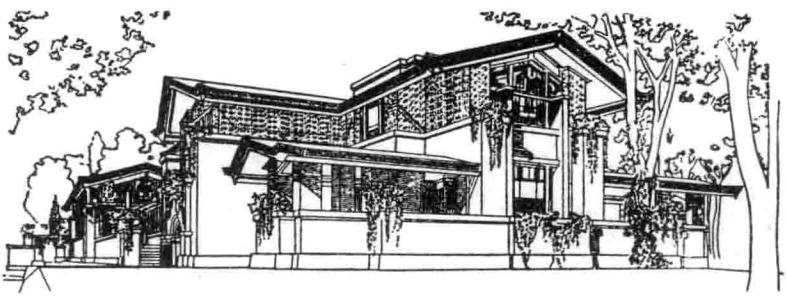
CHEMISTRY AND THERAPY OF ELECTROLYTE DISORDERS

# Chemistry and Therapy of Electrolyte Disorders

*By*

**BERTIL JOSEPHSON, M. D.**

*Clinical Laboratories, St. Erik's Hospital and*
*Crown Princess Lovisa's Children's Hospital*
*Stockholm, Sweden*



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# FOREWORD

Our *Living Chemistry Series* was conceived by Editor and Publisher to advance the newer knowledge of chemical medicine in the cause of clinical practice. The interdependence of chemistry and medicine is so great that physicians are turning to chemistry, and chemists to medicine in order to understand the underlying basis of life processes in health and disease. Once chemical truths, proofs and convictions become sound foundations for clinical phenomena, key hybrid investigators clarify the bewildering panorama of biochemical progress for application in everyday practice, stimulation of experimental research and extension of postgraduate instruction. Each of our monographs thus unravels the chemical mechanisms and clinical management of many diseases that have remained relatively statid in the minds of medical men for three thousand years. Our new Series is charged with the *nisus élan* of chemical wisdom, supreme in choice of international authors, optimal in standards of chemical scholarship, provocative in imagination for experimental research, comprehensive in discussions of scientific medicine, and authoritative in chemical perspectives of human disorders.

Dr. Josephson of Stockholm interprets the chemical deviations of electrolyte metabolism in clinical disorders at the bedside. Laboratory studies of clinical situations involving depletion or excess of fluid or electrolytes are clearly correlated with the clinical symptoms and signs of the individual patient, young and old, for accurate assessment and effective management. The problems of electrolyte concentration and fluid distribution are always the same but the solutions differ with the individual requirements of each patient. The primary chemical objective of reestablishing normal fluid and electrolyte equilibria must thus be adapted to the clinical needs of

the particular individual. It cannot be achieved by rigid rules for dynamic equilibria since correction of one abnormality may produce another. Even reinstatement of the total electrolyte pattern is futile without clearing the underlying disease. Otherwise, the conjectures of blind men trying to describe an elephant are reproduced at the bedside. Fortunately, Dr. Josephson keeps the laboratory approach to the patient in proper balance with the clinical evaluation against a background of understanding body behavior in metabolic disease. The scientific subject is difficult, the chemical tool complex, and clinical opinions diverse but this unique work somehow reduces absolute difficulty to relative simplicity. Chemical principles teach more in one session than clinical experiences in ten, and the two together provide vectorially a multitude of directive power over the debilitated patient with electrolyte disorders.

I. NEWTON KUGELMASS, M.D., PH.D., SC.D., *Editor*

# PREFACE

When, in the spring of 1958, the Editor of the Living Chemistry Series asked me to write a short monograph on the chemistry of the electrolyte disorders I was a little surprised because several good textbooks on similar subjects had been recently published. Now, that the manuscript is complete, I am still more in doubt whether there is a need for a new monograph on the subject, because meanwhile several new books have appeared dealing with the body electrolytes and the acid-base equilibrium. However, all the previous monographs are written by clinicians employing chemical points of view as required. The present book is written by a clinical chemist employing clinical points of view as required! Perhaps the difference will justify this publication.

The book is intended to be a short compilation of current experience, conceptions and theories. However, it must be emphasized that the aim is not to cover the whole field of the electrolytes—not even superficially. Instead reference has been made to some recent experimental work and clinical observations which the author considers to be of special interest. I confess that some preference has been given to Scandinavian papers.

The author is indebted to Dr. Härje Bucht (head of the Kidney Clinic of St. Erik's Hospital) and to Dr. Gunnar Fock and Dr. Jonas Bergström for valuable criticism and suggestions. Dr. Hugh Cleland has revised and corrected the English text.

BERTIL JOSEPHSON

*Stockholm*

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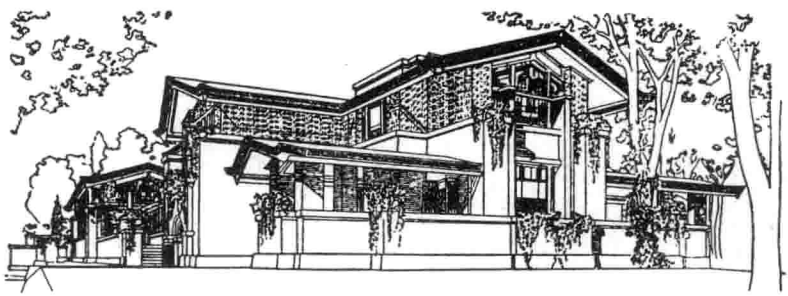

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## Chapter I

# INTRODUCTION

INVESTIGATIONS of the acid-base balance and of the distribution of the main electrolytes in the human body have been published for about fifty years. The importance of a constant concentration of different solutes in the extracellular fluid, and of a constant ratio between these concentrations, was emphasized by Claude Bernard (1813-1878) employing the term "le milieu intérieur." The cells would live and would function in a proper way only as long as this milieu had a suitable volume and composition.

However, the knowledge and understanding of the role of the body electrolytes increased slowly because of the difficulty in quantitative analysis of the electrolytes in the body fluids. Up to about the end of World War II analysis of sodium and potassium in serum was considered difficult and time-consuming in a routine clinical laboratory, and the available methods were not very accurate. Determination of the volume of the fluid spaces was also time-consuming and unreliable and tissue analysis was not practical, at least in man. As a consequence comparatively little was known about the mechanism for the distribution and interchange of the electrolytes among the fluid compartments of the body and the number of relevant publications was only moderate.

Already in 1929 Lundegårdh (16) published the first description of the flame photometer constructed by him in the Swedish university town of Uppsala. To begin with, the apparatus was used chiefly for agricultural purposes but soon it was also employed in a few investigations of physiological and clinical problems in man. Even the first paper on these investigations presented normal values

for the concentration of cations in human serum (18).

Research in the field of physiology and clinical chemistry of the electrolytes suddenly increased tremendously when easily-operated flame-photometers became available about 1945. Since that time an ever enlarging flood of papers on this subject has overwhelmed those trying to keep pace with its development. However, it is remarkable how modest the achievements in the field really are. Much work has been devoted to the field in laboratories and clinics all over the world, much useful information has been gained and several ingenious theories have been advanced. But, nevertheless, we do not know the answer to some of the most important questions such as why sodium and chloride are mainly extracellular and potassium is intracellular, or why potassium must be present in several enzymatic processes, or how aldosterone exerts its action on the exchange of sodium for hydrogen and potassium in the renal tubules etc.

The knowledge attained in the field and the abundant literature have frequently been collected and surveyed in monographs and reviews. When compiling the material for this book the author has gained valuable information and used many data from some of the most recent monographs on the body fluids, the acid-base balance and the physiology and chemistry of the body electrolytes (1, 2, 5, 6, 11, 15, 21, 22, 26). Further he wants to express his gratitude to Dr. Kruhøffer, Copenhagen, who has generously put at his disposal the proof-sheets to a valuable review (12) which has now been published. Finally it should be declared that much information and many data have been obtained from monographs and reviews on more circumscribed parts of the field (4, 7, 8, 9, 10, 13, 14, 19, 24) and on connected subjects (3, 17, 20, 23, 25).

The following discussions deal with sodium, potassium, chloride and bicarbonate, their normal physiology and metabolism and the chemistry of their disorders. Other electrolytes are not discussed either because too little is known about their influence as ions, e.g., phosphates, or because they are of importance and interest not as electrolytes but as members of special metabolic processes, e.g., calcium, magnesium, sulphates and the trace elements.

In the following chapters the author has tried to summarize some fundamental knowledge and some recent experience on the be-

haviour of the plasma and tissue electrolytes in health and in those diseases in which the electrolytes are especially significant. A number of references will be given but it is strongly emphasized that—with a few exceptions—only papers published during the last three to five years are mentioned. References will be made to older papers only in a few cases when there is some special reason for mentioning the respective paper or when the author believes that the paper should have more attention. That reference to a lot of authors and publications prior to 1953-1956 are omitted should not be considered as negligence.

Those who want a more complete list of references on the older literature can easily find this in the bibliographies of some of the monographs mentioned above. It is presumed that the physician, physiologist or chemist who wants to use this book for finding modern references will be primarily interested in the most recent work published in the field. In this connection it should also be pointed out that the list of references includes only a limited fraction of the work published recently. A complete list would make the book very heavy and imperspicuous. Finally some important papers may have been overlooked.

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