

Physiology and Pathology of Membrane Digestion

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Александр Михайлович Уголев

**ФИЗИОЛОГИЯ И ПАТОЛОГИЯ ПРИСТЕНОЧНОГО
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Foreword

The physiology and pathology of membrane (contact or surface) digestion of the three main components of the food of animals and man is a rapidly developing field, and there is little doubt that newer observations will become available as time progresses. As the discoverer of the phenomenon of membrane digestion, Professor Ugolev is well aware of the relative infancy of this subject, and in presenting the book at this time his primary purpose was to acquaint the reader with the experimental basis for the observed phenomenon and to stimulate interest in the further work required for the elucidation of details and for proper orientation.

Translations as means of communication of ideas and experimental facts are of obvious importance and they require no apologies or explanations, particularly to those who are engaged in scientific endeavors. In making this book available to those who find the Russian language an insurmountable barrier, our main efforts were directed toward preserving the author's meaning, spirit, and intent as accurately as possible. It is hoped that this objective has been attained, and that the minor unintentional errors will be forgiven by the reader and by the author.

The translator wishes to express to Professor Ugolev, whom he met in Leningrad in 1965, his appreciation for the trust in the ability of the translator to make Professor Ugolev's labor of love, the present book, available in the English language.

March 1968

Jakob A. Stekol

Preface to the English Edition

I gratefully accepted the offer of Plenum Press to prepare a special preface for the English translation of this book. However, as I write it, I am experiencing a feeling, familiar to all investigators, that everything I have done and written could have been done and written a little better.

In 1958 a series of facts forced me to come to two conclusions which until then I had carefully avoided: (1) There are three, and not two, types of digestion; in addition to the previously known intracellular and extracellular digestion, there also is membrane (contact) digestion. (2) The classic scheme of the activity of the digestive system in higher animals (cavital digestion-absorption) is insufficient. In reality the transformation of foodstuffs occurs by the scheme: cavital digestion-membrane digestion-absorption.

In short, there exists a process of digestion which takes place on the surface of cell membranes (in man and in higher animals these are the membranes of the microvilli of the intestinal epithelium). Thus, on the border of the extracellular and intracellular media there is not only an active transport of substances but also their depolymerization.

As will be shown in detail in this book, the hydrolysis of foodstuffs at the time of their contact with the enzymes localized in the membrane (hence the name "membrane" or "contact" digestion) differs materially from the other types of digestion in its mechanisms and possesses several biological peculiarities, including the possibility of close coordination of digestive and transport processes.

Regardless of the real role of membrane digestion, we had to investigate it in order to understand the evolution of the mechanisms which ensure the transformation of foodstuffs. But when it became clear that digestion in man and higher animals was mainly membrane digestion and that what had been considered the whole truth was only part of the truth, it did not take much imagination to come to the conclusion that these were only the first steps in the development of a field which is essentially limitless.

The first publications of this new concept in Russian and English were not met by widespread enthusiasm. The resulting solitude, however, was not unendurable, thanks to the encouragement and support of such scientists as Academicians A.E. Braunshtein and V.N. Chernigovskii. Their criticism and advice, and the certainty that further work in this field was my duty, were extremely important in the further development of our investigations. Three years later, membrane digestion was already under study by a group of collaborators. The reader will constantly encounter their names in this book.

As soon as the fact of the existence of membrane digestion ceased to elicit doubt, at least in those who studied it experimentally, we made an attempt to prepare our first book wholly devoted to membrane digestion. We had to consider various aspects of the problem, and these were many: physiology of membrane digestion; physics and chemistry of membrane digestion; enzymology of membrane digestion; ontogenesis and phylogenesis of membrane digestion; interrelationship of membrane and cavital digestion; interrelationship of membrane digestion and absorption; membrane digestion and pathology of the gastrointestinal tract; etc.

Any one or several of these problems could have been the subject of a separate review. I was convinced, however, that it would be more useful to consider all these problems together, even at the risk of being brief and furnishing an inadequate analysis of each.

We made three such attempts: the first monograph in Russian appeared in 1963; in 1965 we published a review in *Physiological Reviews*; and in 1967 we published the present monograph.

In reviewing the often widely separate aspects of membrane digestion, I gratefully recalled the names of my teachers, Academician V.N. Chernigovskii, who taught me general physiology and neurophysiology, Professor A.D. Slonim (ecological and comparative physiology), Academician A.E. Braunshtein (enzymology), and Professor N.N. Samarin (gastroenterology and experimental surgery). It goes without saying that I do not mention their names in order to conceal the weaknesses of this book under the mantle of their scientific accomplishments.

Finally, I hope that the author's shortcomings will not prevent the reader from seeing the importance of membrane digestion and its significance to biology and medicine.

* * *

In our time no work is the result of efforts of one person. In the Introduction to the original edition I gratefully mention several names.

Here it gives me great pleasure to express thanks to all my colleagues without whose investigations the concept of membrane digestion would have been impossible. I am deeply touched that Dr. Stekol took upon himself the difficult and thankless job of translating this book into English.

A. M. Ugolev

Preface

This volume has evolved from an earlier one, published four years ago, in which the first attempt was made to systematically analyze the basic problems related to the physiology and pathology of membrane digestion. If the time elapsed seems rather brief, this can be attributed to the rapid and significant development of the subject.

It is worthwhile to keep in mind that the development of any problem is accompanied not only by new facts and hypotheses but also by changes in the methods of evaluation of the results obtained. During the past few years analytical criteria have become considerably more severe and exact, and we note with some satisfaction that in spite of this, detailed analysis of available data has provided new and strong arguments supporting the important role of membrane digestion and also has permitted resolution of many previously debatable points.

In the present volume the various questions related to membrane digestion are treated from the standpoint of a person who regards this mechanism not only indifferently but skeptically or even somewhat antagonistically, but not with such fanaticism as to fail to see the facts and lose the capacity to analyze them. My colleagues noted this while reading the manuscript and suggested that this style may leave a certain sense of uncertainty in the reader's mind, but perhaps the reader will be compensated for this by the realization that the existence and the importance of membrane digestion are independent of the enthusiasm of the author.

The chapters of this book deal with the various rapidly developing aspects of the physiology and pathology of membrane digestion, each of which could be the subject of a separate monograph. The brevity of the book is thus due to lack of space and not to scarcity of available data.

We shall now give a brief description of the contents of the book. In Chapter I, an attempt is made to define the basic types of digestion and, what is less important, to explain why they have been preserved

and developed in the evolutionary process of the animal world and why an organism often employs two or even three types of digestion, not limiting itself to one type, the most "perfect" one.

Chapter II deals with intestinal digestion in mammals and the role of membrane hydrolysis in the performance of this important stage of treatment and assimilation of foodstuffs. In the characterization of views widely held in contemporary scientific literature, we, like others, were confronted by the absence of a thorough evaluation of experimental data. It appeared that many contradictions could be removed if a more exact description of the methods employed by various authors was obtained. Many of the contradictions thus proved to be apparent rather than real. This made it possible in the concluding section of Chapter II not only to appreciate the latest findings which define the role of membrane digestion in the activity of the gastrointestinal tract of mammals, but to present a picture which integrates all the known facts in this field.

Chapter III contains a very brief account of available information concerning the physicochemical and structural aspects of membrane digestion. We wanted to make this chapter broader, but since several substantial monographs have appeared which are devoted to membranes and the physical chemistry of biological surfaces, we limited ourselves to important information which is necessary to the understanding of membrane digestion and which is absent in these monographs. In addition, we included in this chapter more recent data obtained in our laboratory as well as hypotheses which may, perhaps, be useful later.

Chapter IV is devoted to a detailed description of membrane digestion, and Chapter V to its clinical aspects. Evolutionary problems of membrane digestion (Chapter VI) are treated relatively briefly in this book, but the data cited not only are important for the appreciation of the wide distribution of this mechanism among living organisms at various stages of the evolutionary ladder, but may prove useful to those who are interested in the comparative physiology of membrane digestion.

Although the existence of membrane digestion is no longer questioned, the author considered it his duty to analyze not only the arguments which prove the existence of this mechanism but also the arguments (hypotheses for the most part) developed by the opponents. Throughout, we have attempted to differentiate between facts and the conclusions derived from them via hypotheses (which are more useful the more one distrusts them).

In this book the terms "wall," "contact," or "membrane" digestion

are used synonymously. All three were proposed by the author in 1958, but the last one apparently can best be justified from a cytological point of view.

It is a pleasure to express my gratitude to a wide circle of investigators. First, my co-workers and friends: M.I. Dumesh, N.N. Iezuitova, R.I. Kushak, T. Ya. Nadirova, R.A. Ovdeichuk, K.R. Rakhimov, N.M. Timofeeva, M. Yu. Chernyakhovskaya, and K.I. Khalimov, as well as V.V. Chernousova (Bashkir State University), A.T. Stepanova (Pyatigorsk Pharmaceutical Institute), N.V. Toropova and Yu.M. Toropov (Frunze), and I.K. Salenietse, M.K. Marausk, Ya. Ya. Nursk, V.G. Kirs, G.G. Lapteva, and E.M. Ustinkova (Latvian State University). I am also grateful to Dr. P. De Laey (Belgium), with whom I collaborated for many years and to whom belongs the credit for significant contributions to the development of membrane digestion, and to Dr. O. Koldovsky and his associates (Czechoslovakia). Collaboration of our laboratories was stimulating to the solution of many important problems.

I am deeply indebted to N.N. Iezuitova, V.G. Kassil, G.V. Maku-khina, N.M. Timofeeva, E.N. Yakobson, and particularly to my wife, S.V. Ugoleva, for aid in the preparation of this book.

Valuable comments during the preparation of this book were made by Professors G.P. Conradi and V.I. Rosengardt, and Dr. M.N. Maslova.

The first critics of our initial investigations of membrane digestion were Academicians V.N. Chernigovskii and A.E. Braunshtein, to whom I am grateful for the valuable advice which was so crucial to all our subsequent work.

Finally, I am grateful always to my teachers, Academician V.N. Chernigovskii and Professor A.D. Slonim.

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