

PROTOPLASMATOLOGIA HANDBUCH DER PROTOPLASMAFORSCHUNG

HERAUSGEGEBEN VON

L. V. HEILBRUNN UND F. WEBER

PHILADELPHIA

GRAZ

BAND III

A 4

CHEMISTRY AND PHYSIOLOGY
OF MITOCHONDRIA AND MICROSOMES

BY

OLOV LINDBERG AND LARS ERNSTER

WENNER-GREN'S INSTITUTE
STOCKHOLM

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SPRINGER-VERLAG WIEN GMBH

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BAND III

CYTOPLASMA — ORGANELLEN

A

CHONDRIOSOMEN, MIKROSOMEN, SPHAEROSOMEN

4

CHEMISTRY AND PHYSIOLOGY OF MITOCHONDRIA AND MICROSOMES



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OHNE AUSDRÜCKLICHE GENEHMIGUNG DES VERLAGES IST ES AUCH NICHT GESTATTET,
DIESES BUCH ODER TEILE DARAUS AUF PHOTOMECHANISCHEM WEGE (PHOTOKOPIE, MIKROKOPIE)
ZU VERVIELFÄLTIGEN.

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IN 14 BÄNDEN

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1. Makromolekulare Chemie und ihre Bedeutung für die Protoplasmaforschung
2. Coacervates and Related Systems
3. Physikalisch-chemische Grundlagen der zytologischen Fixierungs- und Färbetechnik

II. Cytoplasma

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 - a. Cytoplasma-Struktur und Konfiguration
 - b. Cytoplasma-Systrophe in Pflanzenzellen
 - c. Plasmodesmata
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2. Cytochemie
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 - b. Organische Verbindungen
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 - c. *pH*
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C. Physik. Physikalische Chemie. Kolloidchemie

1. Viscosity of Protoplasm
2. Adhesiveness. Stickiness
3. Spinnbarkeit.
4. Quellung und Entquellung
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5. Spezifisches Gewicht
6. Optische Eigenschaften
 - a. Lichtbrechung
 - b. Doppelbrechung
Cytoplasma der Pflanzenzelle. — Cytoplasma der tierischen Zelle
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 - a. Osmotischer Wert, Saugkraft
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8. Permeabilität
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- D. Vacuum
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 - a. The Contractile Vacuoles of Protozoa
 - b. Nahrungsvakuolen
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- B. Der Ruhekern der Karyonta
1. Morphologie
 2. The Nuclear Membrane
 3. Der Nucleolus
 4. Chemie
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 - a. Optische Eigenschaften
Lichtbrechung
Doppelbrechung
Tierischer Zellkern. — Pflanzlicher Zellkern
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 6. Physiology of the Resting Nucleus
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- 2. Protoplasmatik und Medizin

XIV. Geschichte der Protoplasmatik

Chemistry and Physiology of Mitochondria and Microsomes

By

OLOV LINDBERG and LARS ERNSTER

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With 52 Figures

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Abbreviations

AMP = adenylic acid (adenosine-5-phosphoric acid)
ADP = adenosinediphosphoric acid
ATP = adenosinetriphosphoric acid
DPN = diphosphopyridine nucleotide
TPN = triphosphopyridine nucleotide
FAD = flavine adenine dinucleotide

CoA = coenzyme A* (adenosine-[5-phosphoryl]-5-pyrophosphoryl-pantothenyl- β -alanyl aminoethylmercaptide)

RNA = ribonucleic acid

DNA = desoxyribonucleic acid

Introduction

The study of cytoplasmic particles is today one of the most active fields of cytological research. We have attempted to describe the main features of the historical development in this field in a brief survey (Fig. 1), rather than to present exhaustive lists of data. Further historical aspects are, however, touched upon where practicable in the individual sections.

We wish especially to direct the attention of the reader to the convergence of cytological and enzymological lines of investigation which has become increasingly evident during the past decade in the study of the cytoplasmic particles. It has been possible to identify the mitochondria as the centres of cell respiration and of the distribution of metabolic energy within the cell. The microsomes, on the other hand, have been found to be the bearers of the cytoplasmic nucleoproteins and hence participate in protein synthesis and in the maintenance of the genetic continuity of the cytoplasm. Thus the cytologist has acquired for the first time an enzymological basis for the study of the structural elements of the cell, while the enzymologist has gained access to morphological data concerning his enzyme systems. In this lies the fundamental interest of our field of research.

The present monograph is designed to provide a survey of the chemistry and the physiology of the cytoplasmic particles. It will unfortunately be impossible to cover, even in a first approximation, the literature of our subject, which is enormous in quantity and highly varied in mode of approach. On the other hand, there has not yet been published, to our knowledge, any review in which it has been attempted to cover both the chemical and the physiological aspects of the cytoplasmic particles. We have therefore considered it our main task to collect together results from different lines of investigation, rather than to enter upon a detailed treatment of each line.

Our work has been greatly facilitated by the fact that there are already a considerable number of reviews which cover the various specialized branches. While we have had much recourse to these, we have nevertheless found it desirable, in order to fulfill our above-mentioned purpose, to write each section of the monograph with especial thought to the reader whose speciality is discussed in *other* sections.

In this endeavour we have often been confronted by the problem of balancing the content of a chapter in such a manner that it will be comprehensible to the non-specialist without appearing uninteresting and

* In formulae the symbol $R_{CoA}SH$ will be used. Analogously, lipothiamidepyrophosphate and glutathione will be abbreviated as $R_{LTPP}SH$ and $R_{glut}SH$, respectively.

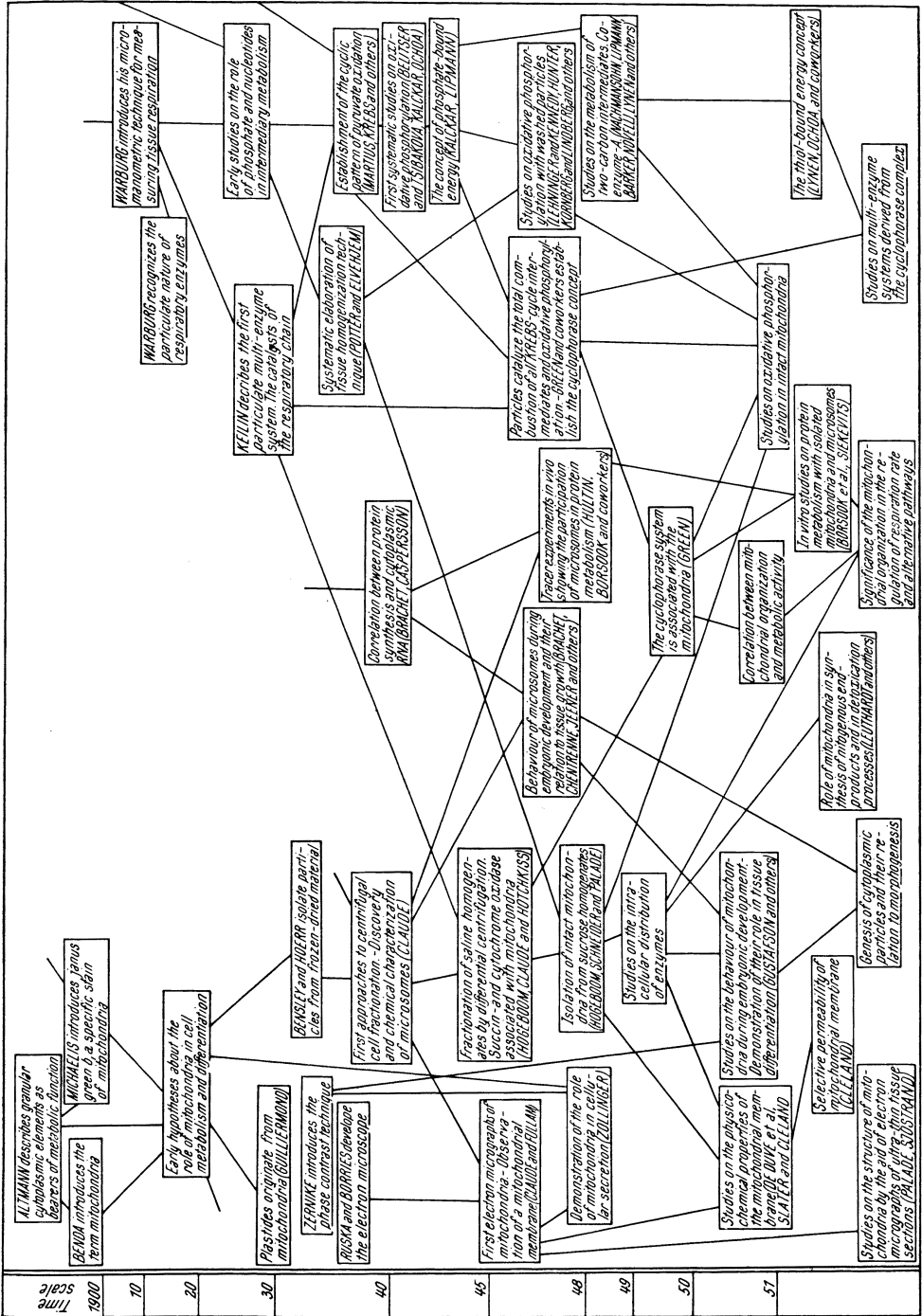


Fig. 1. Historical survey of research trends in the study of cytoplasmic particles

naïve to the specialist. We are well aware that any such attempt is foredoomed to some degree of failure, and we can only beg the indulgence of the reader in this matter. It was particularly difficult to prevent the chapter entitled "Enzymic processes concerned in the physiological function of mitochondria" from exceeding reasonable bounds, since many details, of little apparent significance, had to be included in order to provide links with certain sections in the chapter on mitochondrial physiology.

We therefore thought it advisable to treat the said chapter on the enzyme complement of the mitochondria independently of the two chapters on the chemical constitution and the physiology of the cytoplasmic particles. The three main chapters are preceded by a short survey of the morphology of the cytoplasmic particles and by a similarly brief review of the methods employed in the investigations.

Short Survey of Methods and Morphology

A. Methods

1. Histological methods

The methods employed for the study of mitochondria and microsomes *in situ* are based exclusively on histological techniques, such as fixing and staining procedures (BENSLEY and BENSLEY 1938, COWDRY 1943, LILLIE 1948), electron microscopy (CLAUDE and FULLAM 1946, MÜHLETHALER, MÜLLER and ZOLLINGER 1950, SjöSTRAND 1951), phase-contrast microscopy (ZOLLINGER 1950) and ultraviolet microscopy (CASPERSSON 1950, OPIE and LAVIN 1946). A technique especially valuable in the study of unicellular organisms and larvae, has proved to be centrifugal microscopy (HARVEY 1937). An account of these methods would be more in place in a morphological review and is beyond the scope of this book. For further information on the application of these methods to the study of cytoplasmic particles the references above should be consulted.

Some of the techniques, however, are also used and are in fact indispensable in studies of isolated mitochondria and microsomes. Perhaps the most important of these is the staining of mitochondria with Janus green B (diethylsafranineazodimethylaniline hydrochloride), introduced by MICHAELIS in 1900. This test, which is specific for mitochondria, and has indeed actually been used as a criterion for mitochondria, is based on the fact that the dye is specifically re-oxidized by cytochrome oxidase, an enzyme found only in mitochondria. For this explanation we are indebted to LAZAROW and associates, who have recently published a comprehensive account of their work (LAZAROW and COOPERSTEIN 1955, COOPERSTEIN, LAZAROW and PATTERSON 1955, COOPERSTEIN and LAZAROW 1955).

2. Isolation of cytoplasmic particles

The isolation of cytoplasmic particles dates back to the year 1954, when BENSLEY and HOERR reported the isolation of mitochondria from frozen-dried material. This initial success was followed by a development of the