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

WENNER-GREN'S INSTITUTE STOCKHOLM

SPRINGER-VERLAG WIEN GMBH

1954

PROTOPLASMATOLOGIA

HANDBUCH DER PROTOPLASMAFORSCHUNG

HERAUSGEGEBEN VON

L. V. HEILBRUNN UND F. WEBER

PHILADELPHIA GRAZ

MITHERAUSGEBER

W. H. ARISZ-GRONINGEN · H. BAUER-WILHELMSHAVEN · J. BRACHET-BRUXELLES · H. G. CALLAN-ST. ANDREWS · R. COLLANDER-HELSINKI · K. DAN-TOKYO · E. FAURÉ-FREMIET-PARIS · A. FREY-WYSSLING-ZÜRICH · L. GEITLER-WIEN · K. HÖFLER-WIEN · M. H. JACOBS-PHILADELPHIA · D. MAZIA-BERKELEY · A. MONROY-PALERMO · J. RUNNSTRÖM-STOCKHOLM · W. J. SCHMIDT-GIESSEN · S. STRUGGER-MÜNSTER

BAND III

CYTOPLASMA — ORGANELLEN

A

CHONDRIOSOMEN, MIKROSOMEN, SPHAEROSOMEN

4

CHEMISTRY AND PHYSIOLOGY OF MITOCHONDRIA AND MICROSOMES

SPRINGER-VERLAG WIEN GMBH 1954

CHEMISTRY AND PHYSIOLOGY OF MITOCHONDRIA AND MICROSOMES

BY

OLOV LINDBERG AND LARS ERNSTER
WENNER-GREN'S INSTITUTE
STOCKHOLM

WENNER-GREN'S INSTITUTE
STOCKHOLM

WITH 32 FIGURES

SPRINGER-VERLAG WIEN GMBH 1954

ISBN 978-3-662-24409-8 ISBN 978-3-662-26542-0 (eBook)
DOI 10.1007/978-3-662-26542-0

PROTOPLASMATOLOGIA

HANDBUCH DER PROTOPLASMAFORSCHUNG

IN 14 BÄNDEN

HERAUSGEGEBEN VON

L. V. HEILBRUNN UND F. WEBER
PHILADELPHIA GRAZ

MITHERAUSGEBER

Mitarbeiter

130, 3, 54, 20, B.

Disposition

I. Grundlagen

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

A. Morphologie

1. Mikroskopische Morphologie
   a. Cytoplasma-Struktur und Konfiguration
   b. Cytoplasma-Systrophe in Pflanzenzellen
   c. Plasmodesmata
2. Submikroskopische Morphologie

B. Chemie

1. Makrochemische Analyse
2. Cytochemie
   a. Salze
   b. Organische Verbindungen
      Eiweiße. — Enzyme. — Nukleinsäuren. — Kohlehydrate. — Lipoide
   c. *p*H
      *p*H of Plant Cells. — *p*H of Animal Cells

C. Physik. Physikalische Chemie. Kolloidchemie

1. Viscosity of Protoplasm
2. Adhesiveness. Stickiness
3. Spinnbarkeit.
4. Quellung und Entquellung
   Cytoplasma der Pflanzenzelle. — Cytoplasma der tierischen Zelle
5. Spezifisches Gewicht
6. Optische Eigenschaften
   a. Lichtbrechung
   b. Doppelbrechung
      Cytoplasma der Pflanzenzelle. — Cytoplasma der tierischen Zelle
7. Osmotische Zustandsgrößen
   a. Osmotischer Wert, Saugkraft
   b. Plasmolyse, Deplasmolyse
   c. Plasmoptyse
   d. Plasmorrhyse
8. Permeabilität
   a. Für Wasser
      Pflanzenzelle. — Tierische Zelle
   b. Für Nicht-Elektrolyte
      Pflanzenzelle. — Tierische Zelle
   c. Für Elektrolyte
      Pflanzenzelle. — Tierische Zelle
   d. Permeability of the Erythrocyte
   e. Permeabilitätstheorien
9. Isoelektrischer Punkt. Elektrophorese

D. Vitalfärbung. Vitalfluorochromierung

1. Vitalfärbung der Pflanzenzelle
2. Vitalfärbung der tierischen Zelle

3. Metachromasia
Metachromasy in Animal Cells. — Metachromasie in Pflanzenzellen
4. Vitalfluorochromierung der Pflanzenzelle
5. Vitalfluorochromierung tierischer Zellen

E. Cytoplasma-Oberfläche
1. Cytoplasmic Cortex
2. Chemical Nature of the Plasma Membrane of Animal Cells
3. Die Plasmahautschichten der Pflanzenzelle
4. Enzymology of the Cell Surface
5. Tension at the Cell Surface

III. Cytoplasma-Organellen

A. Chondriosomen, Mikrosomen, Sphaerosomen
1. Le chondriome de la cellule végétale
2. The Mitochondria of Animal Cells
3. Mikrosomen (Sphaerosomen) des pflanzlichen Protoplasmas
4. Chemistry and Physiology of Microsomes and Mitochondria

B. Golgi-Apparat

C. Plastidom

D. Vacuom
1. Vacuome des cellules végétales
2. Vakuolenkontraktion der Pflanzenzelle
3. Vacuom der tierischen Zelle
4. Spezial-Vakuolen
a. The Contractile Vacuoles of Protozoa
b. Nahrungsvakuolen

IV. Virus
1. Morphology of Viruses
2. Chemistry of Viruses
3. Reproduction of Viruses
4. Virus-Einschlußkörper
a. Virus Inclusions of Plant Cells
b. Virus Inclusions of Insect Cells
c. Virus-Einschlußkörper in den Zellen anderer Tiere und des Menschen

V. Karyoplasma (Nucleus)

A. Kernäquivalente der Acaryonta
1. Die Cyanophyceen-Zelle
2. Die Bakterienzelle

B. Der Ruhekern der Karyonta
1. Morphologie
2. The Nuclear Membrane
3. Der Nucleolus
4. Chemie
5. Physik, Kolloidchemie
a. Optische Eigenschaften
Lichtbrechung
Doppelbrechung
Tierischer Zellkern. — Pflanzlicher Zellkern
b. Andere physikalische Eigenschaften
6. Physiology of the Resting Nucleus
7. Biochemical Interactions between the Resting Nucleus and the Cytoplasm

VI. Kern- und Zellteilung

A. Amitose

B. Mitose
1. Chromosomen
2. Gene
3. Atraktoplasma, Zentrosom
4. Mechanics of Mitosis
5. Initiation and Prevention of Mitosis
6. Periodizität der Mitose
a. Bei Pflanzen
b. Bei Tieren
7. Dauer der Mitose
8. Pathologie der Mitose

C. Endomitose

D. Meiose
1. Normal Meiosis
2. Pathologie der Meiose

VII. Befruchtung und Kernverschmelzung
1. Fertilization
2. Kernverschmelzung

VIII. Physiologie des Protoplasmas
1. Protoplasma im latenten Leben
2. Protoplasma-Wachstum
3. Motilität
a. Protoplasmic Streaming
b. Amoeboide Bewegung
c. Zilien und Zilienbewegung
d. Contraction of Protoplasm
4. Elektrophysiologie
5. Stimulation and Anesthesia
6. Resistenz und Anpassung
7. Aktiver Stofftransport (Aufnahme — Transport — Abgabe)
a. Active Transport across Animal Cell Membranes
b. Aktiver Transport durch pflanzliches Plasmalemma
c. Stofftransport im Cytoplasma (Mesoplasma)
8. Cytoplasma-Regeneration und -Restitution

IX. Die Rolle des Cytoplasmas in der Vererbung

X. Pathologie des Protoplasmas
1. Cell Degeneration and Dysfunction
2. Red Cell Structure and its Breakdown
3. Action biologique des radiations
4. Aging of Protoplasm
5. Cancer Cell

XI. Vergleichende Protoplasmatik
1. Protoplasmatische Systematik
2. Protoplasmatische Pflanzenanatomie

XII. Protoplasmatische Ökologie der Pflanzen

XIII. Angewandte Protoplasmatik
1. Protoplasmatik und Pharmakologie
2. Protoplasmatik und Medizin

XIV. Geschichte der Protoplasmatik

Chemistry and Physiology of Mitochondria and Microsomes

By

OLOV LINDBERG and LARS ERNSTER

Wenner-Gren's Institute, Stockholm, Sweden

With 32 Figures

Contents

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-[3-phosphoryl]-5-pyrophosphoryl-pantothenyl-β-alanylaminoethylmercaptide)
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, lipothiamide-pyrophosphate and glutathione will be abbreviated as R_{LTPP}-SH and R_{glut}-SH, respectively.

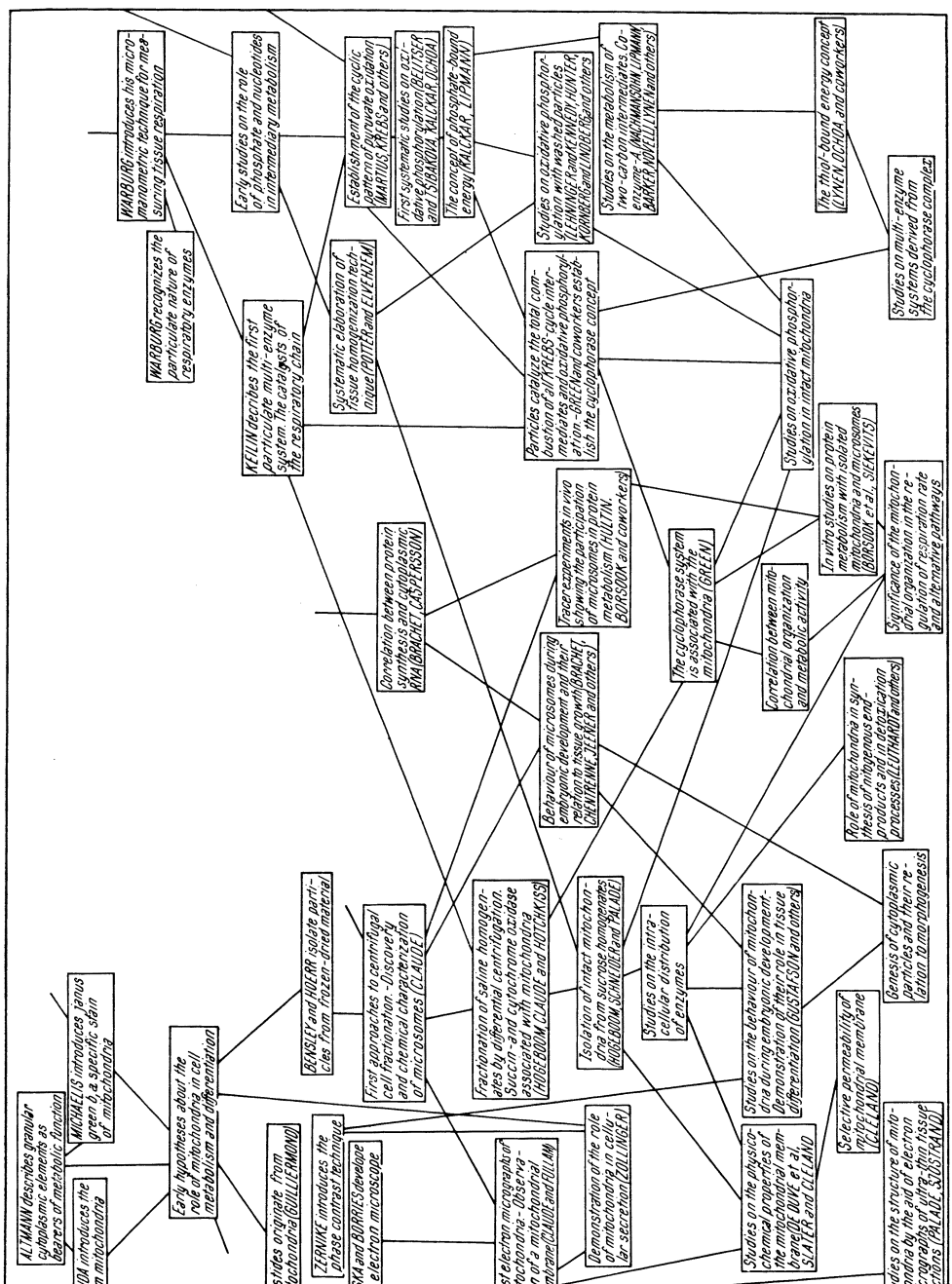

Fig. 1. Historical survey of research trends in the study of cytoplasmic particles

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 indispensible 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 1953, COOPERSTEIN, LAZAROW and PATTERSON 1953, COOPERSTEIN and LAZAROW 1953).

2. Isolation of cytoplasmic particles

The isolation of cytoplasmic particles dates back to the year 1934, when BENSLEY and HOERR reported the isolation of mitochondria from frozen-dried material. This initial success was followed by a development of the