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Abdeslem El Idrissi • William J. L'Amoreaux
Editors

Taurine 8

Volume 2: Nutrition and Metabolism, Protective Role, and Role in Reproduction, Development, and Differentiation

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Editors
Abdeslem El Idrissi
City University of New York
Center for Developmental Neuroscience
College of Staten Island
Staten Island, NY, USA

William J. L'Amoreaux
City University of New York
Department of Biology
College of Staten Island
Staten Island, NY, USA

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Preface

The organizing committee wishes to thank all attendees of the 18th International Taurine Meeting that took place in Marrakesh, Morocco, from April 7th to 13th. This year, the conference highlighted the "*Mystique of Taurine*." Taurine investigators have had the privilege of attending these scientific meetings on three continents: Asia, Europe, and North America. This marked the first time that our conference was held in Africa. As a result, we present here the data from investigators from five of the six continents (sadly taurine research has yet to hit Antarctica). With this geographical expansion, the interest in taurine research has exponentially grown. This international meeting was attended by approximately 120 scientists. We present here information on the roles of taurine in a variety of organ systems, from the brain to the reproductive system and every system in between. As you are keenly aware, there is certainly a mystique to taurine. Is it beneficial or harmful? Does it protect cells or induce cell death? Can it be used in conjunction with another molecule to benefit health or cause death? The answer (or at least a hint to the answer) to these and other questions lies within this body of works. Of course, not all questions were answered but there were many discussions that generated numerous new ideas that will be taken home and tested in the laboratory.

This meeting was also unique in that many undergraduate and graduate students from the College of Staten Island/CUNY attended and presented their research as part of a study abroad program. This opportunity represented the first time that most of these students attended an international conference. More importantly, it served to stimulate interest in taurine research and recruit future taurine researchers. We are greatly appreciative for the overwhelming support of the College of Staten Island's administration, particularly Dr. Deborah Vess, Associate Provost for Undergraduate Studies and Academic Programs; Dr. William Fritz, the provost; Renee Cassidy, study abroad advisory from The Center for International Service;

Debra Evans-Greene, Director of the Office of Access and Success Programs; and Dr. Claude Braithwaite of the City College of New York and the Louis Stokes Alliance for Minority Participation.

The abstracts of the conference were published in the journal "Amino Acids" (Vol. 42, Issue 4). We thank Drs. Lubec and Panuschka for making this possible.

Because of the success of this meeting, the organizing committee wishes to gratefully acknowledge the following:

- Taisho Pharmaceutical Co., Ltd., Tokyo Japan for their generous financial support.
- Professor Dr. Gert Lubec, FRSC (UK), Medical University of Vienna and Editor in Chief of AMINO ACIDS.
- Dr. Claudia Panuschka, Springer Wien, New York, Senior Editor Biomedicine/ Life Sciences.
- Dr. Portia E. Formento, Editor, Biomedicine, Springer US.
- Dr. Melanie Tucker (Wilichinsky) Editor, Genetics and Systems Biology, Springer US.

On behalf of the organizing committee, I thank all the attendees of the 18th international Taurine Meeting and the sponsors that made this meeting possible.

Staten Island, NY, USA Abdeslem El Idrissi

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Chapter 1
Taurine, Glutathione and Bioenergetics

Svend Høime Hansen and Niels Grunnet

Abstract Biochemistry textbook presentations of bioenergetics and mitochondrial function normally focus on the chemiosmotic theory with introduction of the tricarboxylic acid cycle and the electron transport chain, the proton and electrical gradients and subsequent oxidative phosphorylation and ATP-production by ATP synthase. The compound glutathione (GSH) is often mentioned in relation to mitochondrial function, primarily for a role as redox scavenger. Here we argue that its role as redox pair with oxidised glutathione (GSSG) is pivotal with regard to controlling the electrical or redox gradient across the mitochondrial inner-membrane. The very high concentration of taurine in oxidative tissue has recently led to discussions on the role of taurine in the mitochondria, e.g. with taurine acting as a pH buffer in the mitochondrial matrix. A very important consequence of the slightly alkaline pH is the fact that the NADH/NAD^+ redox pair can be brought in redox equilibrium with the GSH redox pair GSH/GSSG.

An additional consequence of having GSH as redox buffer is the fact that from the pH dependence of its redox potential, it becomes possible to explain that the mitochondrial membrane potential has been observed to be independent of the matrix pH. Finally a simplified model for mitochondrial oxidation is presented with introduction of GSH as redox buffer to stabilise the electrical gradient, and taurine as pH buffer stabilising the pH gradient, but simultaneously establishing the equilibrium between the NADH/NAD^+ redox pair and the redox buffer pair GSH/GSSG.

S.H. Hansen (✉)
Department of Clinical Biochemistry, 3-01-1, Rigshospitalet,
Copenhagen University Hospital, København, Denmark
e-mail: shhansen@rh.dk

N. Grunnet
Department of Biomedical Sciences, University of Copenhagen,
København, Denmark

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Abbreviations

GSH	Glutathione
GSSG	Oxidised glutathione
ROS	Reactive oxygen species

1.1 Introduction

The chemiosmotic theory proposed by Peter Mitchell in the 1960s is today accepted as the basis for the understanding of the oxidative phosphorylation and subsequent ATP production in the bioenergetic processes in the mitochondria (Mitchell 1966, 1968; Nicholls and Ferguson 2002). The presentation in most biochemical textbooks focuses on the pH and the electrical gradients across the mitochondrial membranes. The gradients combine to form an electrical potential ΔE_{Total} for moving protons across the inner-membrane:

$$\Delta E_{\text{Total}} = \Delta\Psi - \log(10)\frac{\text{RT}}{\text{F}}\Delta\text{pH}. \tag{1.1}$$

This potential, often referred to as the proton-motive force, drives by use of proton movement the ATP production through the ATP synthase protein complex localised in the mitochondrial inner-membrane.

A series of arguments based on experimental observation can be given that the pH in the cytosol is about 7.0–7.4, and in the mitochondrial matrix pH is most likely in the range 7.8–8.5. In order to stabilise the ATP production, it seems evident that localisation of a pH buffer in the mitochondrial matrix is necessary (Hansen et al. 2010).

Furthermore, it is generally accepted that the proton-motive force can be considered as constant about 200 mV. It is generally accepted that no appreciable dependence on the matrix pH is observed [e.g. Fig. 4.5 in Bioenergetics 3 (Nicholls and Ferguson 2002)]. However, such constancy of two apparently independent contributions needs explanation from a theoretical argument (see later in Sect. 1.2.6 and Fig. 1.1).

1.2 Mitochondria: pH and Redox Buffering

1.2.1 Taurine: pH Buffer

Taurine has previously (Hansen et al. 2006, 2010) been presented as a compound that possesses the optimal characteristics to be a pH buffer in the mitochondrial matrix. Taurine is found ubiquitously in animal tissue with concentrations in the millimolar range. Notably high concentrations of taurine in oxidative tissue lead to