



Oxygraph-2k

IOC-01. *Mitochondrial Physiology Network*

Courses on High-Resolution Respirometry – OROBOROS Oxygraph

International Summer Course Innsbruck 1991 Biological Energetics Research Group - BERG

CALORIMETRY, RESPIROMETRY, AND BIOLOGICAL ENERGETICS FROM THE ORGANELLE TO THE ORGANISM

Department of Zoology, University of Innsbruck, Austria
July 21 to 29, 1991

Five workshops and seminars:

Lecturers

Brian L. Bayne, Plymouth Marine Laboratory, GB
Erich Gnaiger, University of Innsbruck, Austria
Lena Gustafsson, University of Gothenberg, Sweden
Steven C. Hand, University of Colorado, Boulder, USA
Peter Hochachka, University of British Columbia, Vancouver, Canada
Ismo J. Holopainen, University of Joensuu, Finland
Aimo Oikari, University of Joensuu, Finland
Urs von Stockar, Swiss Federal Institute of Technology, Lausanne, CH
Wolfgang Wieser, University of Innsbruck, Austria

Workshops, Seminars

- I. CaloRespirometry Workshop.**
- II. Energy Budgets and Growth Efficiency.**
- III. Ecotoxicology and Physiological Energetics and
First CYCLOBIOS/OROBOROS Oxygraph Course.**
- IV. Adaptive Mechanisms of Metabolic Arrest.
Complementary Enzymatic and Thermodynamic
Control.**

Aim

This international summer course is aimed at providing a state of the art presentation of methodological and theoretical aspects of microcalorimetry, respirometry, and thermodynamics as applied to topics of biological energetics, biochemistry, ecophysiology and ecotoxicology. Lectures and research seminars will be given by experts of international reputation in the field. These scientists will discuss their approaches in seminars, and additional workshop sessions will be held to bridge the gaps between the various disciplines involved. Instrumental demonstrations and hands-on experience will provide the link to practical applications.

- Areas of interest** Comparative and ecological physiology, metabolic biochemistry, ecotoxicology and environmental monitoring, fermentation and biotechnology, biological energetics and physical chemistry, chemical engineering and instrumentation technology.
- Instrumentation** The respirometers and calorimeters available for this course have been developed by CYCLOBIOS/OROBOROS (Innsbruck, Austria), ThermoMetric AB (Järfälla, Sweden), and ANTON PAAR KG (Graz, Austria). Specifically, microcalorimeters (Thermal Activity Monitor), Twin-Flow respirometers, and Oxygraphs will be available, as well as respirometers and activity monitors for studies on the energetics of fish.
- Support** The group of E. GNAIGER is supported by the *Forschungsförderungsfond für die gewerbliche Wirtschaft*, FFF Austria Project Nr. 2/270, and by the *Fonds zur Förderung der wissenschaftlichen Forschung*, FWF Austria Project P7162-BIO. The International Summer Course Innsbruck 1991 and the participation of several students from Finland is supported by the Finnish Academy of Sciences.

PROGRAM

Sunday, July 21

- 16:00 **Registration.** We invite participants to a welcome drink and snack at the Department of Zoology, Technikerstraße 25, Innsbruck, throughout the afternoon and late evening. Participants are directed to their places of residence which are located in walking distance from the department or in the vicinity.

I.

CALORESPIROMETRY

3rd OROBOROS CaloRespirometry Workshop

Organized by E. Gnaiger and I. Holopainen

University of Innsbruck, Austria; University of Joensuu, Finland

July 22 to 26, 1991

Monday, July 22

- Morning
- 09:00 **Introductory remarks** (Erich Gnaiger, Ismo Holopainen, Wolfgang Wieser)
- 10:00 **An overview on CaloRespirometry in ecophysiology** (Erich Gnaiger)
- 11:00 **Tour of the facilities.**
- Afternoon
- 14:00 **Principles of calorimetric and respirometric techniques** (Erich Gnaiger)
- 15:00 **Demonstration of the use of calorimeters and respirometers for aquatic animals.**
- 17:00 **Ecology and ecophysiology of Sphaeriid clams in aerobic and anoxic environments: A basis for studies on ecophysiological energetics** (Ismo Holopainen)

Tuesday, July 23

Morning

- 09:00 **CaloRespirometry: system function and data analysis** (Erich Gnaiger)
 10:00 **Setting up application studies.**

Afternoon

- 14:00 **Applications of the Twin-Flow respirometer and microcalorimeter: Baselines, calibration, data acquisition.**
 Initiation of experiments which are continued throughout the summer course.
 17:00 **Calorimetry and entropy in physiological energetics: Concepts on nonequilibrium thermodynamics** (Erich Gnaiger)

Wednesday, July 24

Morning

- 09:00 **CaloRespirometry: experimental design** (Erich Gnaiger)
 10:00 **Experimental program.**

Aspects of aerobic and anaerobic energetics of Sphaeriid clams will be studied in a calorespirometric research program extending beyond the course. These experiments serve as a demonstration of the CaloRespirometer system (ThermoMetric Thermal Activity Monitor combined with the OROBOROS Twin-Flow respirometer).

Afternoon

- 14:00 **Experimental program and introduction into the software for data analysis.**
 17:00 **Application of CaloRespirometry to metabolic and developmental studies of terrestrial invertebrates, echinoderm eggs, crustacean embryos, and veliger and pluteus larvae** (Steven Hand)

II. ENERGY BUDGETS AND GROWTH EFFICIENCY 7th BERGshop (Biological Energetics Research Group)

B. L. Bayne, E. Gnaiger, Lena Gustafsson, U. von Stockar, W. Wieser
 Plymouth Marine Laboratory, UK; University of Innsbruck, Austria;
 University of Göteborg, Sweden; Swiss Federal Institute of Technology, Lausanne, CH

July 25, 1991

Thursday, July 25

Morning

- 09:00 **The oxycaloric equivalent, calorimetric-respirometric ratio, and aerobic ATP turnover. The link between calorimetry and respirometry** (Erich Gnaiger)
 09:45 **The production of biomass: Bomb calorimetry, degree of reduction, and elemental analysis** (Urs von Stockar)
 11:00 **The efficiency of aerobic microbial growth: CaloRespirometric monitoring of biomass production** (Urs von Stockar)

- Afternoon
- 14:00 **Calorimetry and energy budgets in mixed fermentations: Integration of aerobic and anaerobic metabolism** (Lena Gustafsson)
- 15:00 **Catabolic and anabolic enthalpy changes: Exothermic and endothermic reactions** (Erich Gnaiger)
- 16:15 **The energy cost of protein turnover: Information on the physiological ecology of the species** (Brian Bayne)
- 17:15 **Growth efficiency and energetics in larval fish** (Wolfgang Wieser)
- Evening
- 20:00 **The thermodynamic basis for the formulation of biological energy budgets** (Presentation of a project of the Biological Energetics Research Group; Discussion)

III. ECOTOXICOLOGY AND PHYSIOLOGICAL ENERGETICS

Lectures and

First OROBOROS Oxygraph Seminar

Brian L. Bayne, Erich Gnaiger, Lena Gustafsson, Aimo Oikari

Plymouth Marine Laboratory, UK; University of Innsbruck, Austria;

University of Göteborg, Sweden; University of Joensuu, Finland

July 26, 1991

Friday, July 26

- Morning
- 09:00 **Aquatic ecotoxicology: the potentials of studies on physiological energetics** (Aimo Oikari)
- 10:00 **The energy cost of protein turnover: Implications of advanced physiological energetics for ecotoxicology** (Brian Bayne)
- 11:00 **Specific information from CaloRespirometry in toxicology** (Erich Gnaiger)
- 11:30 **Calorimetric studies in ecotoxicology: Microbial and sediment systems** (Lena Gustafsson)
- Afternoon
- 14:00 ***Oxygraph*: Design, features and function** (Erich Gnaiger)
- 15:00 **Instrument demonstration of the OROBOROS *Oxygraph*.**
- 16:00 **Application seminars: mitochondrial bioenergetics; enzyme activity; ecotoxicology; pharmacology; microbial energetics at low oxygen** (OROBOROS: Haller, Méndez, Ortner, Steinlechner, Gnaiger)
- Evening
- 18:00 ***Informal discussion***

IV. ADAPTIVE MECHANISMS OF METABOLIC ARREST

Complementary Enzymatic and Thermodynamic Control

Erich Gnaiger, Steven C. Hand, Peter Hochachka

University of Innsbruck, Austria; University of Colorado, Boulder, USA;
University of British Columbia, Vancouver, Canada

July 27 to 29, 1991

Saturday, July 27

- Full morning lecture
- 09:00 **Overview of metabolic suppression in defence against environmental stress: The hypoxia example** (Peter Hochachka)
- Afternoon
- 14:00 **Catabolic arrest during estivation, anhydrobiosis and anoxia: Are different strategies used for developmental versus adult forms?** (Steven Hand)
- 16:00 **Thermodynamics and ergodynamics of animal anoxia: Calorimetry, efficiency and power of glycolytic ATP generation** (Erich Gnaiger)
- 20:00 **Group discussion**

Sunday, July 28

- Full morning lecture
- 09:00 **Anabolic and catabolic arrest during invertebrate dormancy: Regulation of subcellular differentiation, protein synthesis and protein turnover** (Steven Hand)
- Afternoon
- 14:00 **Nonequilibrium thermodynamics (ergodynamics) of ATP generation under anoxia at low cellular pH. Evaluation of chemical potentials versus adenylate energy charge** (Erich Gnaiger)
- 16:00 **Suppression vs. efficiency adaptations (in defence against hypobaric hypoxia)** (Peter Hochachka)
- 20:00 **Group discussion**

Monday, July 29

- Full morning lecture
- 09:00 **Muscle and mitochondria at rest and work: Adenylate control and the concept of chemical reaction pressure** (Erich Gnaiger)
- Afternoon
- 14:00 **Suppression mechanisms and functions in diving animals (ectotherms and endotherms)** (Peter Hochachka)
- 16:00 **Messenger RNA during quiescence: Masked message or ribosomal inhibition?** (Steven Hand)
- 18:00 **Summer course party** (Slide show – A global perspective of environmental physiology: Peter Hochachka)

List of Participants

Lecturers

BAYNE Brian L., Plymouth, UK
GNAIGER Erich, Innsbruck, AT
GUSTAFSSON Lena, Göteborg, SE
HAND Steven C., Boulder, US
HOCHACHKA Peter, Vancouver, CA
HOLOPAINEN Ismo J., Joensuu, SF
LIGHTON John, Utah, US
OIKARI Aimo, Joensuu, SF
VON STOCKAR Urs, Lausanne, CH
WIESER Wolfgang, Innsbruck, AT

External Participants

AALTO Sari, Joensuu, SF
ALBEIS Bert, Neuherberg, DE
ANLAUF Andreas, Köln, DE
BERGER Elisabeth, Wien, AT
BOCHDANSKY Alexander, Wien, AT
CAPELLI Carlo, Udine, IT
FINN Roderick Nigel, Bergen, NO
FRITZSCHE Dirk, Rostock, DE
GAMENICK Inez, Hamburg, DE
GEIGER Walter, Mondsee, AT
VAN GINNEKEN V.J.G., Leiden, NL
HAMBURGER Kirsten, Hillerod, DK
HARDEWIG Iris, Düsseldorf, DE
HELMINEN Harri, Turku, SF
HOKKANEN Timo, Joensuu, SF
KARASOWA Jitka, Prag, CZ
KARJALAINEN Juha, Joensuu, SF
KECKEIS Hubert, Wien, AT
KIDAWA Anna, Konopnickiey, PL
KOOP Jochen, Düsseldorf, DE
KUKKONEN Jussi, Joensuu, SF
LARSSON Christer, Lausanne, CH
MÄKELÄ Petteri, Joensuu, SF

MENOUD Laurent, Lausanne, CH
MESSANA Giuseppe, Firenze, IT
ORTEL Johanna, Wien, AT
PENTTINEN Olli-Pekka, Joensuu, SF
SAARIKO Jarmo, Joensuu, SF
SCHIEDEK Doris, Münster, DE
SCHNEIDER Anke, Düsseldorf, DE
SCHNEEWEISZ Bruno, Wien, AT
SCHULTZE-MOTEL Paul, Berlin, DE
STEEGER Hans-Ulrich, Düsseldorf, DE
VANURA Katrina, Tulln, AT

Participants Univ. Innsbruck

BURGSTALLER Wolfgang
DALLA VIA Josef
DALLINGER Reinhard
FLANDORFER Astrid
GRUBER Alexandra
INSAM Herbert
MOORE Christian
SCHWARZBAUM Pablo
THOMASER Astrid
WAPPL Edwin
ZANELLA A.

Collaborators

HALLER Thomas
KROTTHAMMER Manfred
KRUMSCHNABL Gerhard
MÉNDEZ Gabriela
ORTNER Martin
RECK Michael
REINDL Sonja
RIEGER Gunde
STEINLECHNER Rosmarie