Bioinspired Energy Conversion

Energy conversion is closely associated with all life and with society's development. It powers technology and animal locomotion, it is fundamental to cellular processes in all organisms, and is coupled to metabolic diseases in humans.

Energy conversion also includes processes of many types on many scales. A bird, for example, performs mechanical work on a larger scale during flight, and on a smaller scale through molecular motors in its cells. On a fundamental level, these processes are chemically powered. An airplane, on the other hand, converts energy from fuel into mechanical work through a long chain of complex events, including thousands of chemical reactions and a host of thermodynamic processes. Globally, both examples constitute the transformation of energy bound in organic molecules into carbon dioxide and work, but the pathways are completely different.

Since energy conversion manifests itself in so many types of processes, it tends to be studied by different methods in different disciplines. In a bird, for example, it may be studied by respirometry, while in a combustion engine it is studied by thermodynamic analysis. This diversity makes it difficult to communicate between different fields. On the other hand, this diversity of approaches and perspectives opens up possibilities for transferring methods and general ways of thinking between the fields. New perspectives tend to result in new ideas, and this is the aim of the Bioinspired Energy Conversion theme.

The participants come from various research areas that have energetics as a common denominator. They belong to the faculties of medicine, natural sciences and engineering. Some work with flight in animals and focus on how efficiently metabolic energy is transferred into mechanical work during flight. This field has several points in common with important engineering applications. But mechanical work only accounts for a part of an animal's full metabolic rate. There is a basal metabolism to consider as well. It consists of idle costs for powering internal organs and maintenance costs associated with, for instance, the immune system. There are several physicists in the team, working with energetics in small systems like molecular motors and stochastic thermodynamics. Researchers from the medical faculty work with pathological aspects of energy conversion. They study diabetes from the perspectives of glucose regulation, fatty acid mobilization, and protein phosphorylation. They also study the transformation between chemical and mechanical energy in tissue, which plays a role in cardio-vascular diseases, for example. The members from the engineering faculty mainly work with energy conversion and energy utilization in technical applications, with a focus on society's needs for transportation and power.

Our mode of working is to structure the energy conversion processes within our diverse topics into different categories and different length scales. A number of thematic topics will be formulated which tie these different categories together. Working with these themes we aim to identify new approaches and areas of research. During the course of our work these will be developed into specific ideas for research collaborations between two or more of the participating groups.

The immediate goal of the theme is not to solve practical problems, but rather to question and develop our ways of studying energy conversion. In the long run, however, this work could lead to new ways of interpreting and controlling the energy flows in everything from our own cells to the vehicles on our roads.

Members of he Bioinspired Energy Conversion theme

Öivind Andersson (coordinator)
Professor, Combustion Engines
Oivind.Andersson@energy.lth.se

Pål Börjesson
Professor, Environmental and Energy Systems Studies
Pal.Borjesson@miljo.lth.se

Hanna Isaksson
Assistant lecturer, Solid Mechanics
Hanna.Isaksson@solid.lth.se

Jonas Johansson
Associate Professor, Solid State Physics
Jonas.Johansson@ftf.lth.se

Heiner Linke
Professor, Solid State Physics
Heiner.Linke@ftf.lth.se

Johan Revstedt
Professor, Fluid Mechanics
Johan.Revstedt@energy.lth.se

Anders Hedenström
Professor, KVA Research Fellow, Evolutionary Ecology Anders.Hedenstrom@biol.lu.se

Christoffer Johansson
Associate Professor, Evolutionary Ecology
Christoffer.Johansson@biol.lu.se

Jan-Åke Nilsson
Professor, Evolutionary ecology
Jan-Ake.Nilsson@biol.lu.se

Carl Troein
Postdoctoral research fellow, Computational Biology and Biological Physics
Carl.Troein@thep.lu.se

Olga Göransson
Associate Professor, Protein Phosphorylation
Olga.Goransson@med.lu.se

Cecila Holm
Professor, Molecular Endocrinology
Cecilia.Holm@med.lu.se

Hindrik Mulder
Professor, Molecular Metabolism
Hindrik.Mulder@med.lu.se

Carina Siversson
Lund University Bioimaging Center
Carina.Siversson@med.lu.se

Karl Swärd
Associate Professor, Cellular Biomechanics
Karl.Sward@med.lu.se

Workshop June 10-11 2013

Bioinspired Energy Conversion

Can we find cross-boundary approaches in energy-related research?

Welcome to the concluding workshop on Bioinspired Energy Conversion! The workshop is free of charge but a "no show-fee" of 300 SEK will be charged unless cancellations are made in advance.

Please fill in and submit your application here

Venue: Ingvar Kamprad Design Center (IKDC), Lund, Sweden
Time: *June 10-11, 2013*

Energy conversion is of central importance across many disciplines – from engineering to the life sciences – but the methods for studying energy differ between fields. This workshop aims to identify possibilities for transferring ideas and perspectives across the disciplines. In the long term we hope this may lead to novel methods for studying energy conversion and even new areas of research.

The program is divided into four sessions. Keynote presentations will be followed by presentations by the participants in the Bioinspired Energy Conversion theme at the Pufendorf Institute for advanced studies. The aim of these presentations and the subsequent discussions is to identify challenges and opportunities for new research. Rather than presenting final answers to questions, we aim to present questions in need of answers.

Monday June 10

8.00-9.00 Registration
9.00-9.20 Welcome and introduction (Sune Sunesson, Öivind Andersson)

THE CASE FOR BIOINSPIRATION

Chair: Öivind Andersson
9.20-10.10 **Keynote:** Mick Pearce
(Mick Pearce Architect, Zimbabwe)
Bio-Inspiration in Engineering and Architecture

10.10-10.40 Andrew Copestake (Swedish Biomimetics 3000®)
From Biomimetic Inspiration to Implementation

10.40-10.45 Introduction to breakout discussions (Öivind Andersson)

10.45-11.30 **Coffee** + Breakout discussion groups: challenges and opportunities
11.30-12.00 Report from breakout groups and general discussion

Lunch

ENERGY CONVERSION AT THE MOLECULAR LEVEL

Chair: Hanna Isaksson

13.00-13.50 Keynote: Prof. David Nicholls
(The Buck Institute, US)
The Amazing Mitochondrion, Nature's Nanotechnology

13.50-14.40 Keynote: Prof. Alf Månsson
(Linné University, Sweden)
Chemomechanical Energy Transduction in Muscle

14.40-15.00 Juan Parrondo (Universidad Complutense, Spain)
Energetics of Small Systems

15.00-15.45 **Coffee** + Breakout discussion groups: challenges and opportunities

15.45-16.15 Report from breakout groups and general discussion

Tuesday June 11

ENGINEERING VIEWS ON ENERGY CONVERSION IN ORGANISMS

Chair: Christoffer Johansson/Johan Revstedt

8.30-9.00 **Coffee**

9.00-9.50 Keynote: Geoff Spedding
(University of Southern California, US)
Tales of Aerodynamic Efficiency in Birds and Planes

9.50-10.50 Öivind Andersson (Lund University)
Energy Efficiency Analysis of the Migration of the Bar-Tailed Godwit

Johan Revstedt (Lund University)
Heat Exchangers in Animals and Engineering Applications

Pål Börjesson (Lund University)
Comparison of the Energy Consumptions of Horses and Tractors

10.50-11.30 **Coffee** + Breakout discussion groups: challenges and opportunities

11:30-12:00 Report from breakout groups and general discussion

Lunch

METABOLIC DIFFERENCES AMONG ANIMALS

Chair: Carl Troein

13.00-13.50 Keynote: Prof. Tony Hulbert
(University of Wollongong, Australia)
Membranes and Energy Metabolism:
Insights From Mammals, Birds and Other Animals

13:50-14:50 Jan-Åke Nilsson (Lund University)
Energy Conversion in Animals – Implications for Health and Life Span

Cecilia Holm (Lund University)
Diabetes in Birds – Does It Exist?

Carina Siversson and Hindrik Mulder (Lund University)
Global and Focused Analysis of Energy Conversion – How Are They Imaged?

14:50-15:30 **Coffee** + Breakout discussion groups: challenges and opportunities

15:30-16:00 Report from breakout groups and general discussion

WHERE DO WE GO FROM HERE?

16.00-16.40 Panel discussion
Moderator: Olga Göransson

16:40-16:50 End words (Öivind Andersson)