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Chemistry and time☆

The Beilstein Symposia address contemporary issues in chemistry and neighbouring sciences by emphasizing interdisciplinarity. Scientists from a wide range of areas — often outside chemistry — are invited to present aspects of their work for discussion with the aim not only to advance science, but also to enhance interdisciplinary communication.

Temporal measurements of phenomena have been carried out continuously by natural scientists over the centuries. Time is the dimension used to order events from the past via the present to the future and is not reversible (even though mankind still dreams of time machines that enable travel into the past or future). This irreversibility is determined by thermodynamics, which describes the direction of events by the increase of entropy. For most people, the external ''Zeitgeber'' that regulate our biological rhythms combined with aging, reproduction, evolution and geology make time very real and directional. Time is relative and asymmetric — or isn't it?

Whether time is real or an illusion is an ancient question that is still waiting to be answered. The ancient Greeks had two words for time: chronos and kairos. Chronos refers to the sequential nature of time and kairos the right moment to make a decision, for example during signalling, synchronization of events, regulation and monitoring.

In chemistry and biology, reactions depend on external factors such as light and temperature. The velocity of a reaction is determined as products formed per time unit, which is expressed by kinetics. The bottleneck of a ''time-dependent'' reaction is not time but intramolecular (reversible) modifications, diffusion, ligand binding, electron or energy transfer and molecular association and dissociation processes (which all are a function of time). However, the processes are characterized by time-dependent rate coefficients.

In nature there is no mechanical clock that sets up a scale unit for processes that need to follow each other, such as biochemical reactions in plants, animals and microorganisms. There are different mechanisms that arrange the order of chemical reactions depending on the need for their products: biochemical pacemakers as investigated in chronobiology, separation of reactions or charges by space and external pacemakers such as light and temperature. Reactions can be fast or slow, from femtoseconds to thousands of years. Biological time covers events from near instantaneous to generations. Chemistry must take the required sequence of events and the correct timing into account.

This symposium brought together experts from many disciplines to present and discuss their latest research results and give participants different perspectives on chemistry and time. Areas covered include: signalling, chronobiology, drug development, delivery and resistance, real-time monitoring of reactions and biochemical events and developmental biology.

We would like to thank particularly the authors who provided us with written versions of the papers that they presented. Special thanks go to all those involved with the preparation and organization of the symposium, to the chairmen who piloted us successfully through the sessions and to the speakers and participants for their contribution in making this symposium a success.

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Martin G. Hicks*
Beilstein-Institut zur Förderung der Chemischen Wissenschaften, Trakehner Str. 7 — 9, 60487 Frankfurt/Main, Germany

Carsten Kettner
Beilstein-Institut zur Förderung der Chemischen Wissenschaften, Trakehner Str. 7 — 9, 60487 Frankfurt/Main, Germany

*Corresponding author.
E-mail addresses: mhicks@beilstein-institut.de (M.G. Hicks), ckettner@beilstein-institut.de (C. Kettner)

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