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Guest Editorial

Highlight: The physiology and dynamics of cellular microcompartments

Eukaryotic cells rely on organelles that separate macromolecules, enzyme activities and different metabolites in a spatiotemporal manner, thereby providing a framework for the compartmentalization of cellular reactions, which can quickly be adjusted to physiological needs. However, it has become apparent that bacteria and organelles also harbor distinct compartments, which serve as basic functional units and provide a local environment where reactions can take place in a temporally and spatially highly-restricted manner. Such 'microcompartments' can occur as nonmembrane-bound granules in the cytosol where they are, for example, involved in RNA metabolism or they can be found in restricted regions of the plasma membrane, which can serve as local signaling modules. Microcompartments can occur in specialized regions within mitochondrial and chloroplast membranes to separate functional units that are involved in energy metabolism or redox homeostasis. They can also form between cells or at the contact sites of cells and components of the extracellular matrix, where they contribute to tissue development and specialization.

The Collaborative Research Center 944 (SFB 944) was established in 2011 to study the structure and function of such microcompartments as a common principle in cell physiology and during tissue development. The SFB 944 is located at the universities of Osnabrück and Münster in the German States of Lower Saxony and North Rhine-Westphalia and is being funded by the German Research Foundation (DFG) for an initial period of 4 years. The title 'The physiology and dynamics of cellular microcompartments' reflects the intention of the group of researchers who come from different disciplines and work on diverse model systems to work together to reveal the common principles of microcompartments as basic functional modules in the physiology of cells and cell assemblies. The aim of this collection of review articles is: (i) to contribute towards developing the concept of microcompartmentalization as a common principle of sub-organellar organization in a variety of cells and tissues; (ii) to present and discuss paradigmatic microcompartments in mitochondria, at the yeast plasma membrane and in plant cells; and (iii) to develop general features and properties of microcompartments during tissue differentiation and function, as exemplified in the *Drosophila* heart and the mouse brain.

The Highlight Issue starts with a contribution by Holthuis and Ungermann (2013), who set the scene by outlining the general principles of cellular microcompartments and their physiological regulation. The authors also describe technical constraints and challenges in studying membrane-based microcompartments and organelle contact zones, which play an important role in lipid and ion exchange. Interactions between membrane components and membrane-associated proteins are crucial for efficient energy transfer and regulation, which is reflected by the dynamic formation of protein complexes in the bacterial plasma membrane, the thylakoid membrane of chloroplasts, and the inner mitochondrial membrane. In this context, Busch and colleagues (2013) introduce recent advances and techniques that are important for studying and understanding the physiology of bioenergetic microcompartments. Merzendorfer and Heinisch (2013) focus on the heterogeneity of the yeast plasma membrane and the formation of dynamic microcompartments in and at the membrane. The authors describe recent advances in our understanding of how cells select the sites of cell division during cytokinesis, sense cell wall integrity, and organize chitin synthesis. The principles and themes that become apparent in yeast as a simple and accessible model for eukaryotic cells are likely also recapitulated and modified in the more complex mammalian cells. Microcompartmentation as a dynamic process to adjust to physiological needs is affected by changes in cellular homeostasis. This is most apparent in plant cells, which – as sessile, autotrophic organisms – depend on continuous adjustment to rapidly changing and often adverse conditions. Zachgo and colleagues suggest (2013) that the formation of transient microcompartments by redox-dependent association/dissociation of proteins to subcellular structures in organelles, the cytoplasm and nucleus could be a general principle of a signal transduction network that is particularly suited to plant cells. Brandt and Paululat (2013) extend the concept of microcompartments as sub-organellar functional units in cellular physiology in a way that also includes contact zones between different cells and between cells and components

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of the extracellular matrix. They develop general features and properties based on two quite different examples – the development and maturation of the *Drosophila* heart and the dynamics of synaptic contacts in the mammalian brain. The development of new techniques, in particular advances in microscopy and imaging techniques, is often crucial for the birth of novel cell biology concepts. This is also evident for the study of the structure and dynamics of cellular microcompartments, where novel microscopic techniques play an important role. Therefore, the articles in this issue of *Biological Chemistry* will be complemented by a review from Hensel and colleagues (Imaging the invisible: uncovering cellular microcompartmentation by superresolution microscopy approaches) that will be part of a future issue where the authors provide an overview of the recent advances in imaging techniques that have helped to resolve the dynamics of microcompartments, with a particular focus on various developments in super-resolution microscopy.

We are confident that the articles will provide a good starting point from which to promote the emerging concept that microcompartments follow common principles and act as sub-organellar functional units for regulating cellular physiology in different contexts and in a wide variety of cells and organisms. We think that further development of the concept of microcompartments requires a close and interdisciplinary collaboration between researchers who focus on different aspects of cellular physiology, work with diverse plant, cell and animal models, and master and develop novel techniques, as it becomes evident in this collection. We hope that our articles will foster a further interest in understanding the formation and dynamics of cellular microcompartments beyond traditional biological disciplines, for example with respect to the development of physical and mathematical models, which consider molecular and supramolecular interactions leading to the integration of molecular and modular function within microcompartments.

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