NEW VOICES IN CHEMISTRY

DALIBOR SAMES

# THE MAGIC OF CHEMICAL TRANSFORMATIONS

## Reaction invention and development form the basis for future excitement, challenge, discovery

Chemistry is a fascinating science that is concerned with the material world on a molecular level. It encompasses the structures of molecules and their aggregates as well as their interactions with other molecular entities and with energy. Understanding fundamental processes such as information (energy) storage, transmission, and conversion is possible only through a sufficient command of the molecular underpinnings of these processes. In this light, the central position that chemistry assumes among all fields of science is clear: Chemistry penetrates and drives other basic and applied fields at the same time that it draws inspiration from them.

Within such a broad spectrum of subjects, reactions themselves have always been pivotal to chemistry. The importance of chemical reactions stems from two of their major functions: First, they provide the essential tools for the preparation of new molecular entities (that is, synthesis); second, chemical transformations themselves are carriers and converters of information (that is, information storage and relay), particularly in the context of larger networks.

PHOTO BY EILEEN BAROSO

**REACTION APPEAL** **The magic of chemical transformations has attracted inquisitive minds for centuries, Sames says.**

From such a global perspective, I clearly see that the inventors of new reactions will face the most exciting challenges and discoveries, and that reaction development will maintain its important role in chemistry.

In the realm of synthesis, the ultimate goals are well-defined, namely, the development of new reactions that will enable the concise, efficient, and environmentally conscious preparation of desired materials. The focus on synthesis will not diminish, because it has such a broad impact in industry and academia—from the synthesis of small organic molecules (for example, bulk and custom chemicals, pharmaceuticals) to the preparation of mesoscale oligomers and aggregates. Regarding the latter, new challenges for synthesis begin to emerge, such as achieving control over the length, functionality, and stereochemistry of the oligomer chain. Furthermore, there is a need for new reactions that will enable the manipulation of surfaces of mesoscale structures and continuous films. Clearly, the available arsenal of reagents and catalysts not only determines our synthetic abilities but also influences the design process itself.

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The second major area of reaction development—and perhaps the most exciting one because of its novelty—will focus on the discovery of reactions compatible with and able to be integrated with complex networks of molecular interactions and transformations. For instance, the living cell, a functional unit of life, is a complex system with intriguing abilities to sense, integrate, and convert multiple forms of information and energy. I believe that the living cell will become a new frontier and a new test tube for reaction inventors.

The sheer vision of conducting noncoded reactions in living cells affords entirely new challenges and possibilities associated with the complexity of such an environment. On the other hand, the tasks that must first be addressed in this context are, in essence, identical to the fundamental mantra of synthetic chemistry—that is, how to maneuver among multitudes of functional groups. Progress in this direction may permit the marking of essential components and processes in cells, eventually yielding new insights into the biology and pathology of cells and tissues. Furthermore, new reactions that interface with or extend metabolic pathways may allow us to tap into such tremendous abilities of cells as sensing and information processing.

How do we develop new reactions and catalysts that will meet the projected demands of these new paths? The answer may lie in the further integration of rational design and molecular evolution. The use of molecular evolution and combinatorial chemistry will become routine and immensely valuable not only to practical synthetic chemists but also to mechanistically inclined investigators. The eclectic selection of building blocks will provide the flexibility and diversity necessary for the construction of catalysts assembled from fully synthetic components, biomacromolecules, and hybrids thereof. The success of such efforts, however, will depend on the development of catalysis assays that will allow the direct evaluation of chemical transformations in high-throughput formats.

Thus, I envision that reaction invention and development will continue to stand at the center of the chemical sciences. The intrinsic magic of chemical transformations has attracted inquisitive minds for centuries, reaching as far back as the age of alchemists. This area of chemistry will undoubtedly continue to seek and formulate the new challenges that lie ahead.

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