CHEMATICA: FROM CHEMICAL NETWORKS TO A COMPUTATIONAL CHEMICAL "BRAIN"

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The millions of reactions performed and compounds synthesized by organic chemists over the past two centuries connect to form a network larger than the metabolic networks of higher organisms and rivaling the complexity of the World Wide Web. Despite its apparent randomness, the network of chemistry has a well-defined, modular architecture. The network evolves in time according to trends that have not changed since the inception of the discipline, and thus project into chemistry's future. Analysis of organic chemistry using the tools of graph theory enables the identification of most 'central' organic molecules, and for the prediction of which and how many molecules will be made in the future. Statistical analyses based on network connectivity are useful in optimizing parallel syntheses, in estimating chemical reactivity, in the algorithmic discovery of tandem/sequential reactions that reduce the overall cost of organic synthesis by more than 50%, and in planning green syntheses. Most importantly, the use of machine-learning techniques allows teaching the computer hundreds of thousands of synthetic design and optimization rules culminating in computational retrosynthetic planning. Almost thirty years after the first attempts by Corey to do so, there is now a computational machine – called *Chematica* – which can actually do chemistry! The press worldwide dubbed this revolutionary software an in-silico chemical brain. In my lecture, I will provide live demonstration of *Chematica* and discuss how it has been used in the U.S. academia, industry, and even U.S. Army and counter-intelligence.

Key References:

1. C.M. Gothard, S. Soh, N.A. Gothard, B. Kowalczyk, Y. Wei. B. Baytekin & B.A. Grzybowski* Rewiring Chemistry: Algorithmic Discovery and Experimental Validation of One-Pot Reactions in the Network of Organic Chemistry. *Angew. Chem. Int. Ed.* 51, 7922 -7927 (2012)

2. M. Kowalik, C.M. Gothard, A.M. Drews, N.A. Gothard, A. Wieckiewicz, P.E. Fuller, B.A. Grzybowski* & K.J.M. Bishop* Parallel Optimization of Synthetic Pathways within the Network of Organic Chemistry. *Angew. Chem. Int. Ed.* 51, 7928-7932 (2012)

3. P.E. Fuller, C.M. Gothard, N.A. Gothard, A. Wieckiewicz & B.A. Grzybowski* Chemical Network Algorithms for the Risk Assessment and Management of Chemical Threats. *Angew. Chem. Int. Ed.* 51, 7933-7937 (2012)

4. B.A. Grzybowski, K.J.M. Bishop, B. Kowalczyk, C.E. Wilmer The wired universe of organic chemistry *Nature Chemistry* 1, 31 (2009).

5. K.J.M. Bishop, R. Klajn & B.A. Grzybowski The core and most useful molecules in organic chemistry *Angew. Chem. Int. Ed.*, 45, 5348 (2006).

6. M. Fialkowski, K.J.M. Bishop, V. Chubukov, C.J. Campbell & B.A. Grzybowski, The architecture and evolution of organic chemistry, *Angew. Chem. Int. Ed.*, 44, 7263 (2005).