

## SYSTEMS THINKING TO EDUCATE ABOUT THE MOLECULAR BASIS OF SUSTAINABILITY

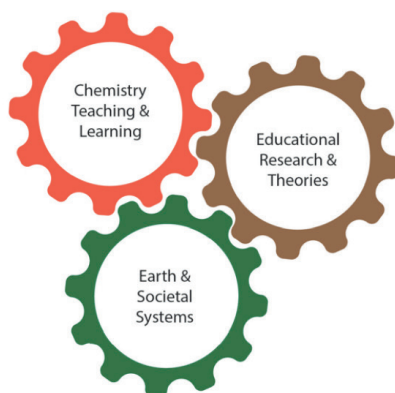
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A Systems Thinking in Chemistry Education (STICE) framework has been developed by a global IUPAC project team with the goal of moving learners from fragmented knowledge of chemical reactions and processes toward a more holistic understanding of the field. Systems thinking shows promise in guiding students to see the relevance of their chemistry education for addressing multiple emerging global challenges such as sustainability, alternative energy, planetary boundaries, and the UN Sustainable Development Goals. We will explore progress to date in implementing the IUPAC STICE project and suggest approaches that can be used by chemistry educators to help students develop a deeper understanding of the molecular basis of sustainability.<sup>ii</sup> To give chemists and educators a concrete example of how systems thinking can be used, we will consider the Haber-Bosch process for the synthesis of ammonia, and the way systems thinking visualization tools can help students move beyond a narrow view of this process to consider chemical and energy inputs, reaction conditions, outputs such as the Ostwald Process leading to ammonium nitrate, and the intended uses of nitrogen compounds derived from ammonia in agriculture and munitions, as well as unintended consequences resulting from the overuse of reactive nitrogen. Next steps for the IUPAC STICE project will be discussed, including suggestions arising from contributions to a special issue of the Journal of Chemical Education on "Reimagining Chemistry Education: Systems Thinking and Green & Sustainable Chemistry," to be published in late 2019.<sup>iii</sup>

Abstract graphic (if one can be used):



**Systems Thinking in Chemistry Education  
An IUPAC Project**

### References

1. Mahaffy, P. G.; Krief, A.; Hopf, H.; Matlin, S. A. (2018) "Reorienting Chemistry Education through Systems Thinking," *Nature Reviews Chemistry*, 2, 1-3.
2. Mahaffy, P.G.; Matlin, S.; Holme, T.A.; MacKellar, (2019) J. "Systems Thinking for Education about the Molecular Basis of Sustainability," *Nature Sustainability*, in-press.
3. Mahaffy, P.G.; Brush, E.J.; Haack, J.A.; Ho, F.M. (2018). "Journal of Chemical Education Call for Papers-Special Issue on Reimagining Chemistry Education: Systems Thinking, Green & Sustainable Chemistry," *Journal of Chemical Education*, 95 (10), 1689-1691.