National Science Foundation
Directorate for Mathematical and Physical Sciences
Charge to: MPSAC Subcommittee for Studying the Role of NSF/MPS in Food Systems (SFS)

Background

Productive, modern agriculture is based *inter alia* on nitrogen- and phosphorus-derived fertilizer[1,2] and fresh water. Manufacturing nitrogen-based fertilizer (ammonia) is energy intensive, as is the purification of sea water[3] and of water denatured by industrial processes. The latter issue is of particular concern because future supplies of fresh water may be inadequate as a result of climate change, overuse of groundwater aquifers, and competing use of water in energy production.[4] Another concern is that production of phosphorus-based fertilizer may fail to meet world demand by mid-century.[2] Thus, there is an urgent need to discover new science and engineering that will allow large-scale, low-energy water purification, and similar production and recycling of key chemicals. Furthermore, most synthetic chemicals applied to farms wash into streams and rivers, and the small percentage of chemical fertilizer consumed by humans and animals in food eventually ends up as waste that also collects in coastal waters. The resulting nutrient pollution[5] spurs the growth of algae and subsequently of bacteria that feed on algae. The growth of bacteria depletes coastal waters of oxygen which leads to widespread loss of aquatic life. There are prominent "dead zones" as a result in the Mediterranean Sea, the Chesapeake Bay, the Gulf of California, and the Gulf of Mexico. Algal blooms and hypoxic waters have led to severe economic losses in the commercial fishing and tourism industries.

This document charges a subcommittee of the MPSAC to identify *fundamental* science drivers critical to achieving a sustainable world in the specific areas outlined above. These issues are tightly coupled because energy is expended to produce chemical fertilizer and fresh water, and increasingly society is forced to choose between using land and fertilizer for food or bio-renewable energy production, and between using fresh water for energy production (e.g., hydraulic fracturing) or agriculture.

Charge to the Subcommittee

The Subcommittee on Food Systems (SFS) will:

1. Envision an expansive path to breakthroughs in catalysis chemistry that would transform chemical manufacturing by using less energy than current practice. An example could be the articulation of a vision for new catalysis science that will allow a low-energy alternative to the Haber-Bosch process for generation of ammonia-based fertilizers.

2. Develop a vision for enabling the discovery of new fundamental science needed to advance scalable, low-energy purification of seawater and industrial wastewater to provide a secure and sustainable supply of fresh water for human consumption and food and energy production.

3. Develop a vision for enabling new scalable separation science that will allow the sequestration of chemicals used in agriculture and their eventual reuse and recycling, to prevent and/or mitigate nutrient pollution and to ensure future US phosphate security.

Timeline

Charge to Committee – April 2013
Interim reports to MPSAC will be due quarterly. These will report on the progress being made and bring to the attention of the MPSAC any major issues. The reports can be delivered via Web-Ex or similar meeting tool. These will be coordinated by MPSAC.

A final report will be due July 2014 with a presentation to the MPSAC at its Summer 2014 meeting. This presentation may be delivered remotely or in person.

Resources

The NSF will arrange for and host Web-Ex meetings as needed by the subcommittee, and cover associated costs. NSF/CHE will provide financial support for a workshop on the topic, which will be timed to inform the subcommittee.

Points of Contact at Federal Agencies:

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iii. GEO or ENG contact?
iv. DOE representative. TBD
v. USDA representative. TBD
vi. Other representatives (NOAA, Gates Foundation, etc.) TBD

References

1. Hager, T. “The Alchemy of Air”, Three Rivers Press, New York, NY (2008)
2. Cordell, D., White, S. “Peak Phosphorus: Clarifying the Key Issues of a Vigorous Debate about Long-Term Phosphorus Security” *Sustainability*, 3, 2027-2049 (2011)
3. (a) Drinan, J.E., Spellman, F., “Water and Wastewater Treatment: A Guide for the Nonengineering Professional”, second edition, CRC Press, Boca Raton, FL (2012). (b) Rischard, J-F, “High Noon: 20 Global Problems, 20 Years to Solve Them”, Perseus Books, New York, NY, (2002)
4. Yergin, D. “The Quest: Energy, Security, and the Remaking of the Modern World”, Penguin Group, New York, NY, (2012)
5. “The facts about nutrient pollution.” United States Environmental Protection Agency; http://water.epa.gov/polwaste/upload/nutrient_pollution_factsheet.pdf