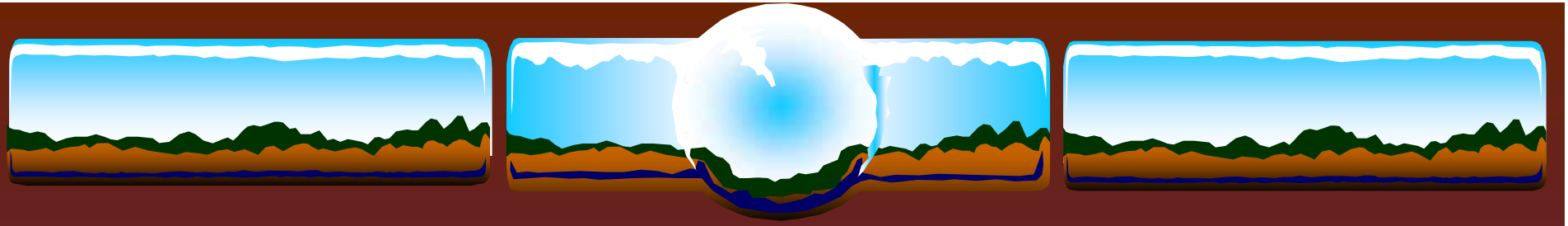
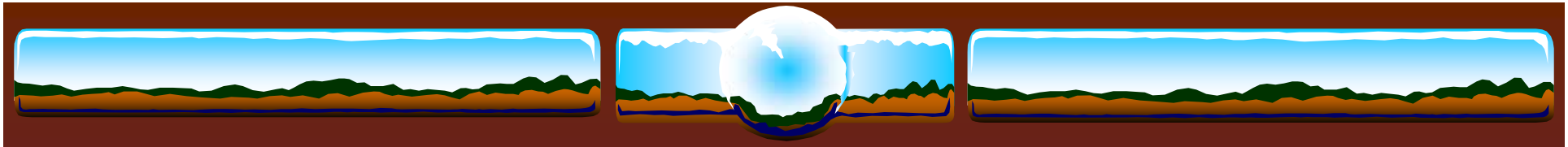


Green Chemistry and the Great Lakes BTS

Exploring Alternatives to Managing Toxics Contamination of the Great Lakes

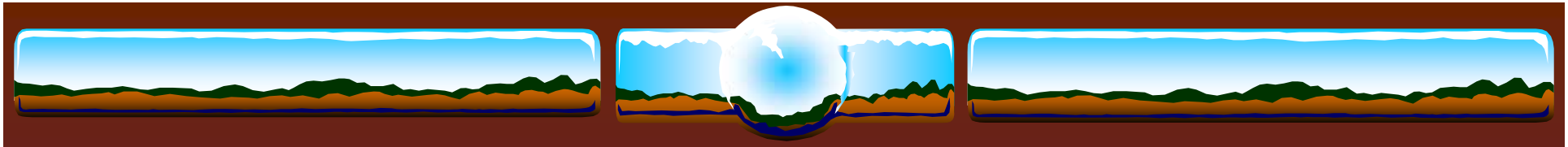


GLBTS Integration Workshop Meeting Windsor, Ontario February 16, 2006

Lin Kaatz Chary, PhD, MPH

for

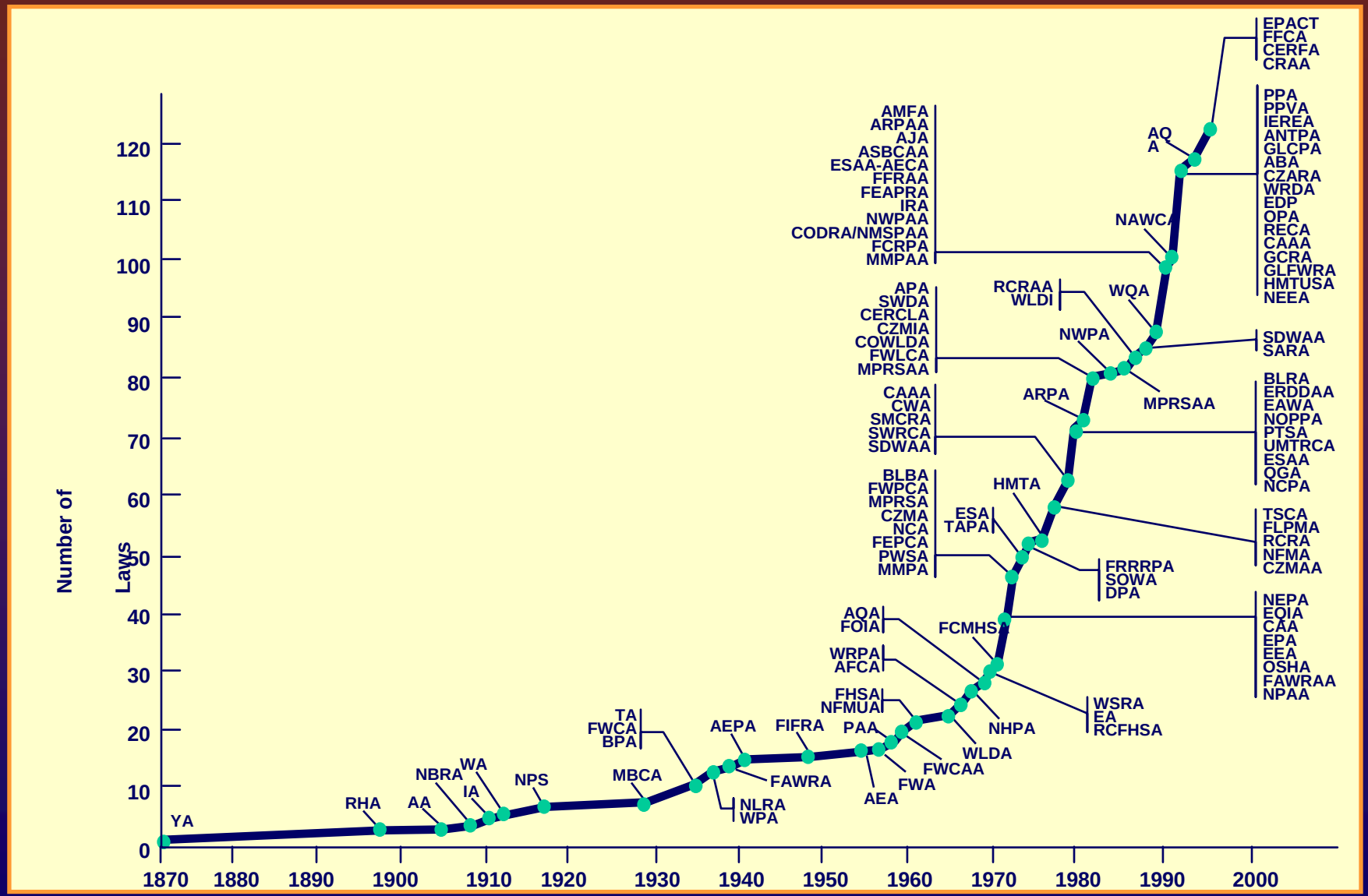
Great Lakes United

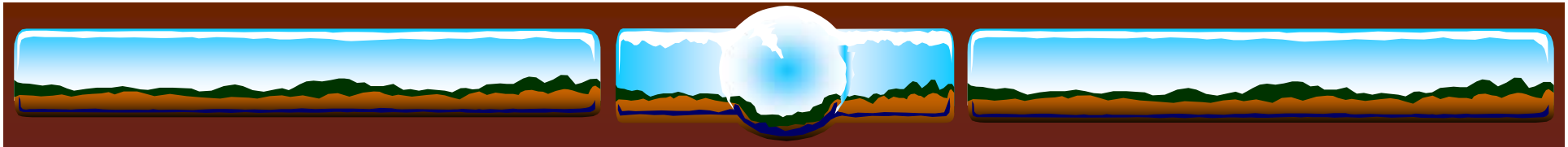


Binational Toxics Strategy

- **Legacy Contaminants**
  - PCBs
  - Heavy Metals
- **New and Continuing Toxic Inputs**
  - Mercury
  - Halogenated Flame Retartants
    - PentaBDE, OctaBDE, DecaBDE
    - Dechlorane Plus
    - Others?
  - PFAS: Perfluoroalkyl sulfonates
    - PFOS: Perfluorooctanyl sulfonate
    - PFOA: Perfluorooctanoic acid
    - FTOH: Fluortelomer alcohols
    - PFCA: Perfluorocarboxylic acids
  - Others?

Growth in Environmental Regulation in the U.S.



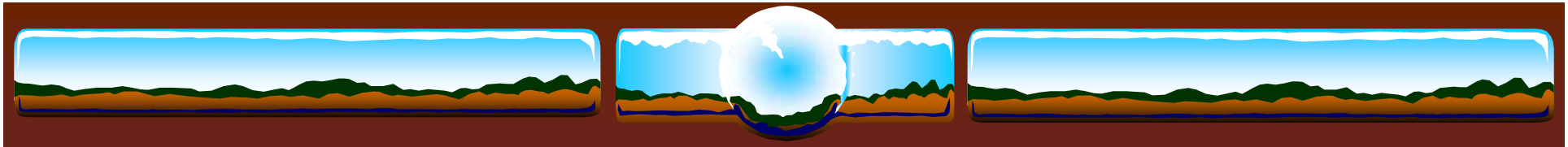


Economics of Regulation in the U.S.

US industry expenditures on environmental controls (i.e., compliance with regulation, waste treatment, etc.) is approximately 2% GDP:

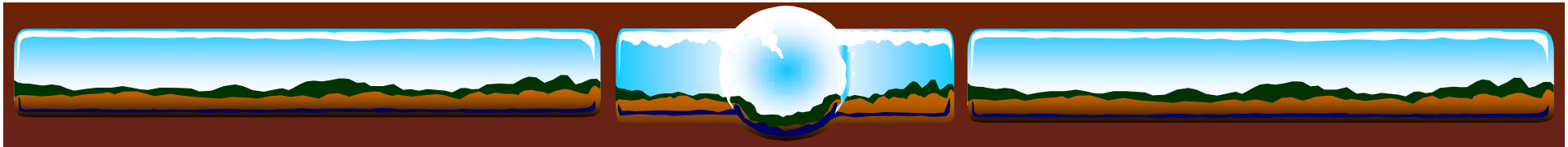
- **$200 billion per year (USD)**
- **$550 million per day (USD)**
- **$22,900,000 per hour (USD)**
- **$380,000 per minute (USD)**

Paul Anastas, 2006



What is Green Chemistry?

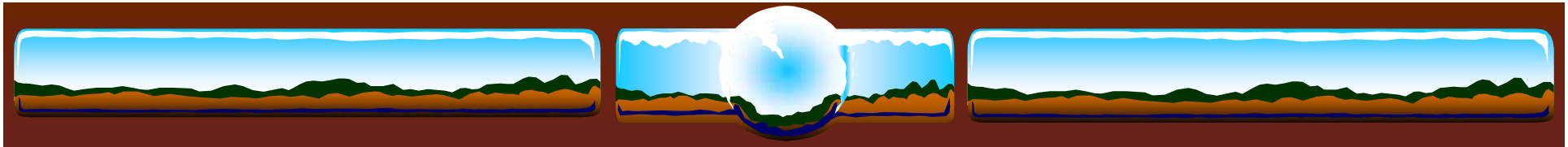
Green chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances (Anastas et al. 2000).



The 12 Principles of Green Chemistry

The principles of green chemistry and green engineering provide a framework for scientists and engineers to use when designing new materials, products, processes and systems.

(Green Chemistry Institute, 2006)



❖1. Prevent waste:

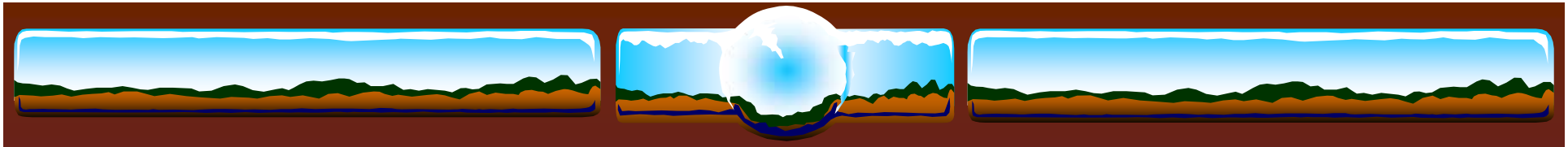
Design chemical syntheses to prevent waste, leaving no waste to treat or clean up.

❖2. Design safer chemicals and products:

Design chemical products to be fully effective, yet have little or no toxicity.

❖3. Design less hazardous chemical syntheses:

Design syntheses to use and generate substances with little or no toxicity to humans and the environment.



❖4. Use renewable feedstocks:

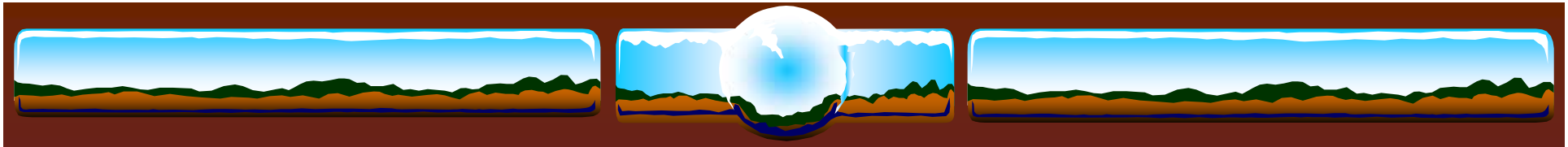
Use raw materials and feedstocks that are renewable rather than depleting. Renewable feedstocks are often made from agricultural products or are the wastes of other processes.

❖5. Use catalysts, not stoichiometric reagents:

Minimize waste by using catalytic reactions. Catalysts are used in small amounts and can carry out a single reaction many times.

❖6. Avoid chemical derivatives:

Avoid using blocking or protecting groups or any temporary modifications if possible. Derivatives use additional reagents and generate waste.



❖7. Maximize atom economy:

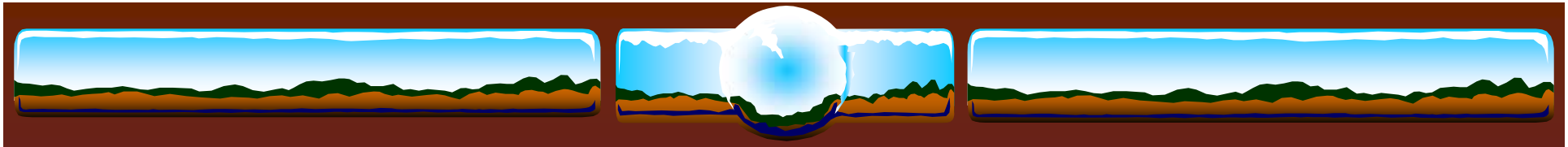
Design syntheses so that the final product contains the maximum proportion of the starting materials. There should be few, if any, wasted atoms.

❖8. Use safer solvents and reaction conditions:

Avoid using solvents, separation agents, or other auxiliary chemicals. If these chemicals are necessary, use innocuous chemicals.

❖9. Increase energy efficiency:

Run chemical reactions at ambient temperature and pressure whenever possible.



- **10. Design chemicals and products to degrade after use:**

Design chemical products to break down to innocuous substances after use so that they do not accumulate in the environment.

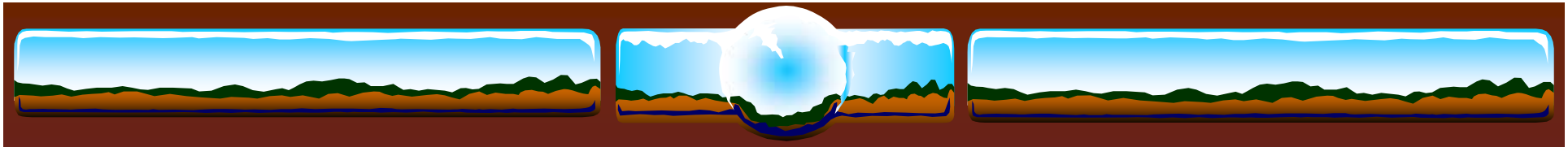
- **11. Analyze in real time to prevent pollution:**

Include in-process real-time monitoring and control during syntheses to minimize or eliminate the formation of byproducts.

- **12. Minimize the potential for accidents:**

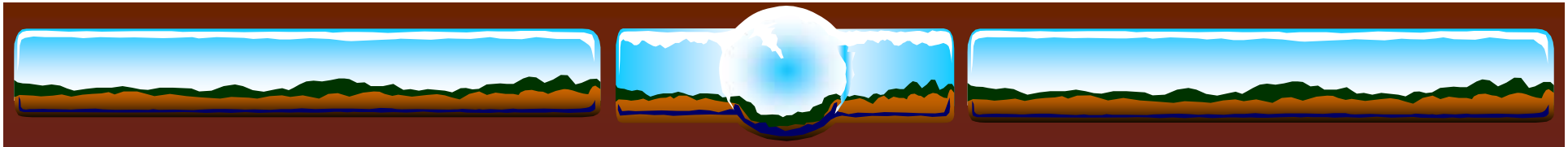
Design chemicals and their forms (solid, liquid, or gas) to minimize the potential for chemical accidents.

(U.S. EPA – www.epa.gov/greenchemistry)



Can Green Chemistry become a useful tool for the BTS?

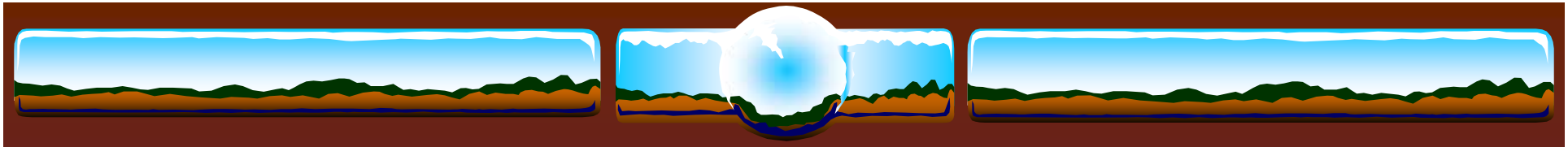
How does Green Chemistry fit into the review of the Great Lakes Water Quality Agreement?



Proposal:

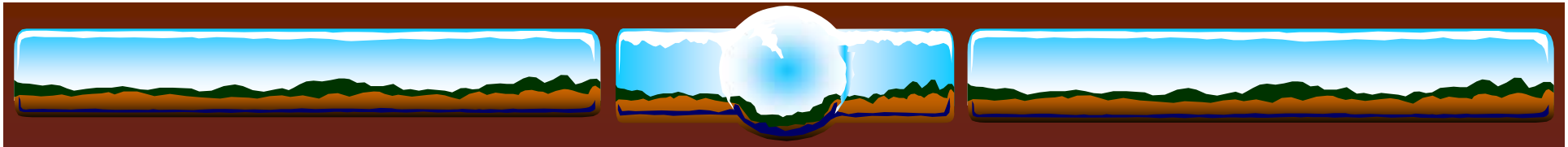
GLBTS Integration Workshop Roundtables

- *What is Green Chemistry? How does it differ from conventional science?*
- *Is there a role for Green Chemistry in the BTS?*
- *Where is it being applied? Marketplace potential, innovations in industry.*



Resources

- ***U.S. EPA Green Chemistry*** *(www.epa.gov/greenchemistry)*
- ***Green Chemistry Institute of the American Chemical Society*** *(http://www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=greenchemistryinstitute\index.html)*
- ***University of Massachusetts Lowel Toxics Use Reduction Institute*** *(www.turi.org/)*
- ***Carnagie Mellon University Institute for Green Oxidation Chemistry*** *(http://www.chem.cmu.edu/groups/Collins/)*
- **Green Chemistry: Theory and Practice**, *Paul Anastas and John Warner, Oxford University Press, USA, 1998.*



Problems cannot be solved at the same level of awareness that created them.

Albert Einstein

Thanks to Paul Anastas