American Chemical Society

ACS Green Chemistry Institute®

ACS Student Chapter
Green Chemistry Activity
CCEW 2018

Starting an ACS Student Chapter

- Identify at least 6 student members of the ACS at your school
- Identify a faculty member to serve as the chapter faculty advisor
- Complete a charter application form
- Compose a set of proposed bylaws. Bylaws set the basis for your chapter's mission
- Email or mail your application and bylaws to the ACS
- Once your application is approved, ACS will grant your school a charter. A charter certificate will be mailed to your faculty advisor or the chair of the nearest ACS local section, who will present the charter to your new ACS student chapter!
- More about ACS Student Chapters

Green Chemistry Activities

Chapters who engage in at least **three** green chemistry outreach and educational activities during the school year are eligible to win a Green Chemistry Student Chapter Award.

By incorporating sustainable and green chemistry into your student chapter's activities you can:

- Become a spokesperson on your campus for sustainability and the solutions chemistry can bring through green chemistry
- Start a movement of sustainability across your campus and in the community
- Make a difference through chemistry
- Have a positive impact on human health, the environment & the future
- Improve the "image" of chemistry

http://www.acs.org/content/acs/en/greenchemistry/students-educators/green-chemistry-student-chapters.html

Activity Instructions

In order for this to count as **one** of your Chapter's **three** green chemistry activities, please do all of the following items with **at least 6 members** of your ACS Student Chapter and include details in your annual Chapter Report:

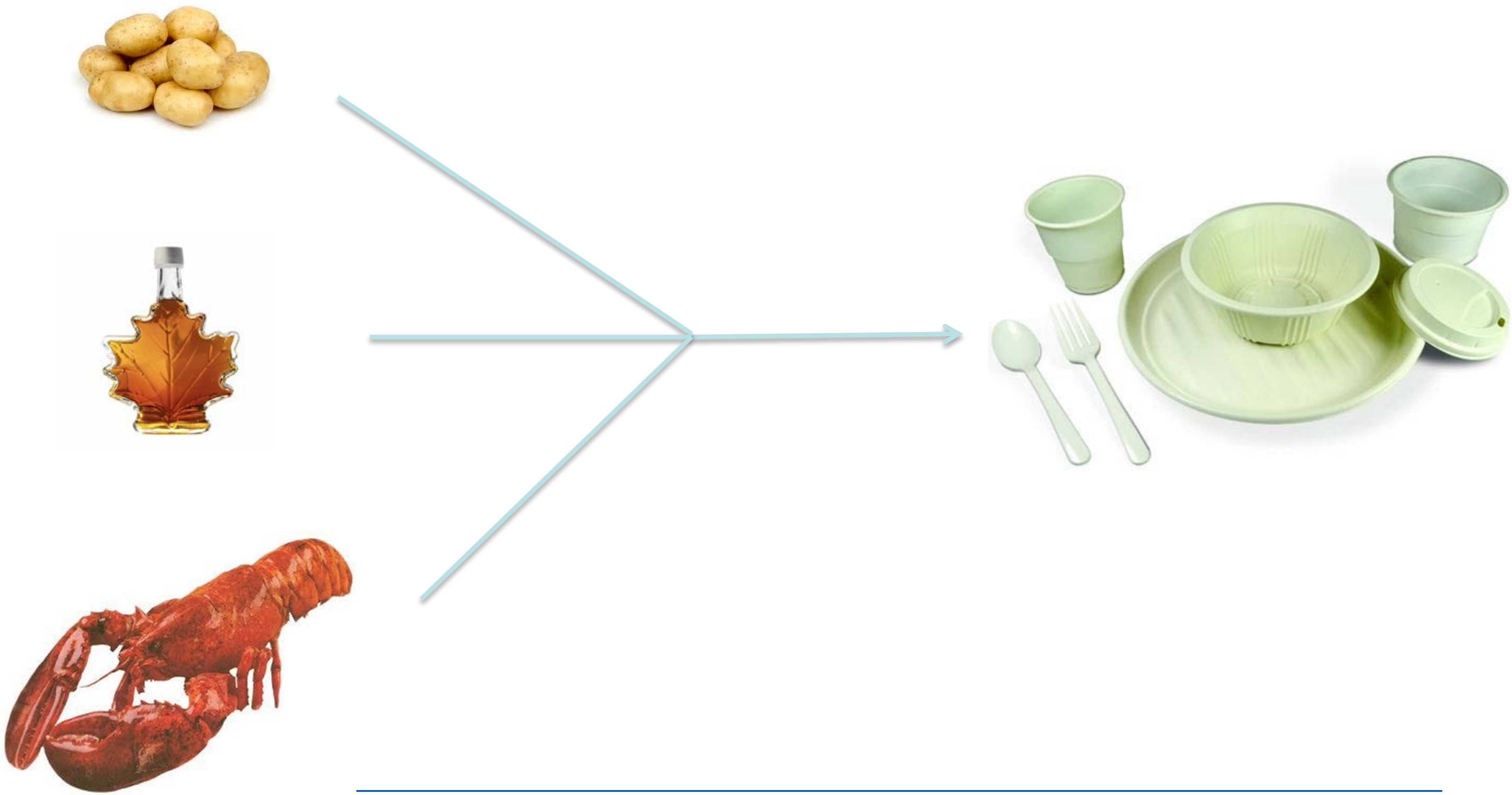
- **Watch** the ACS Webinar on April 25 during CCEW. **Register Here**
- **Read**: **From Lobster Shells to Plastic Objects: A Bioplastics Activity**

  Reuben Hudson, Samuel Glaisher, Alexandra Bishop, and Jeffrey L. Katz

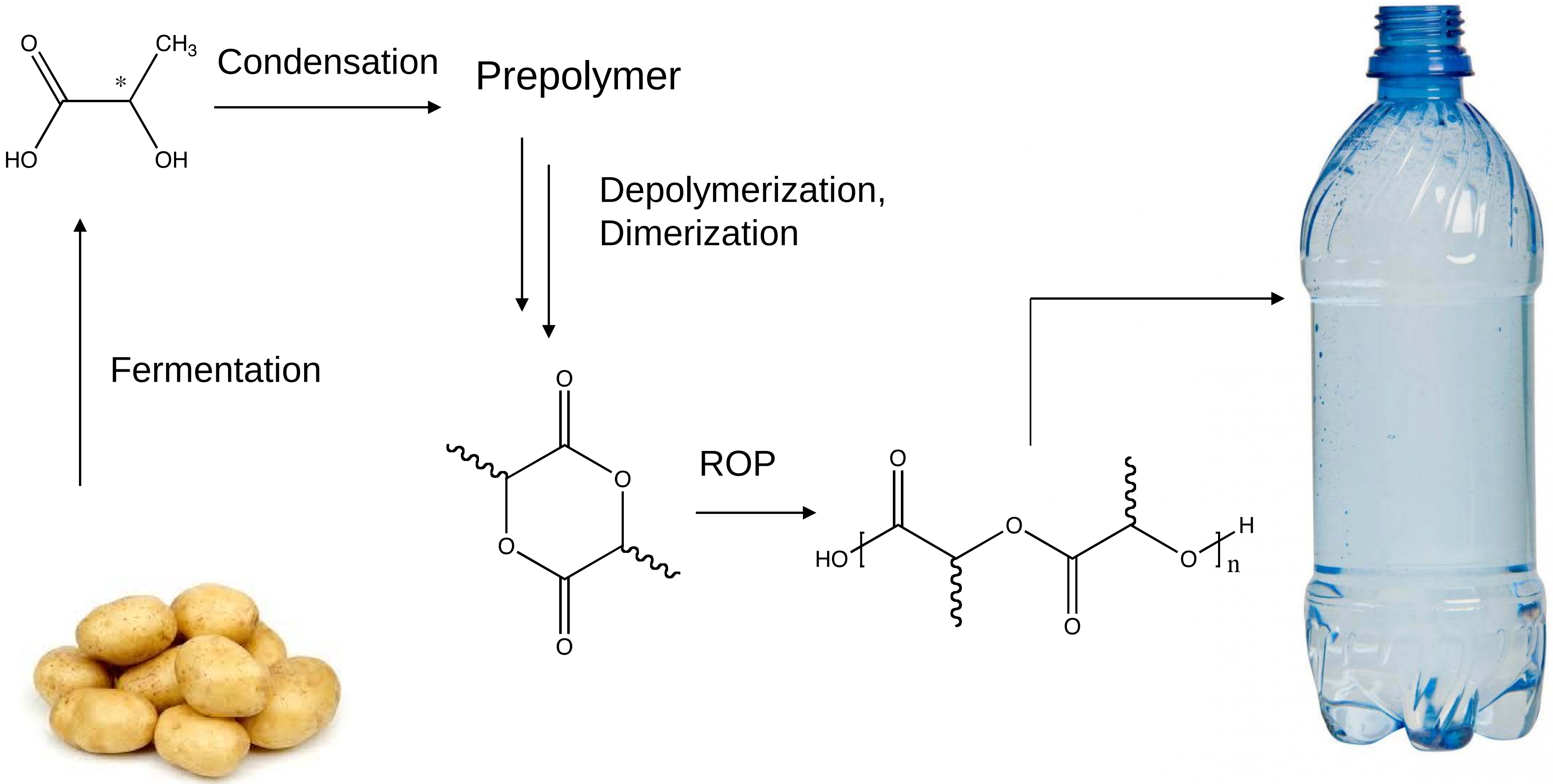
  Journal of Chemical Education **2015** *92* (11), 1882-1885

  DOI: 10.1021/acs.jchemed.5b00108
- Do the **Activity**!
  - You could do this as an outreach activity or with your Chapter
- Host a **Discussion**
  - Review slides 6-13
  - Discussion questions on slides 14
  - Discussion Leader Notes on slides 15-18

Polymers from biomass



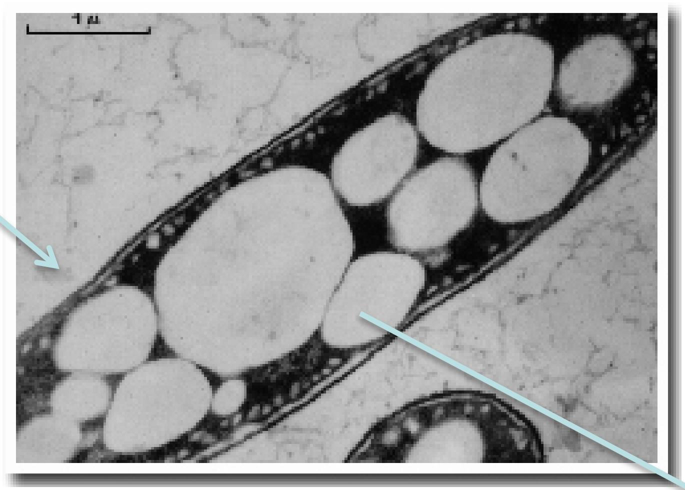
Bioplastics: PLA



PLA Production

- Fermentation of potatoes/corn to lactic acid
- Condensation to a pre-polymer
- Depolymerization and Dimerization to lactide monomer
- Ring opening polymerization to PLA (often with a Tin catalyst)

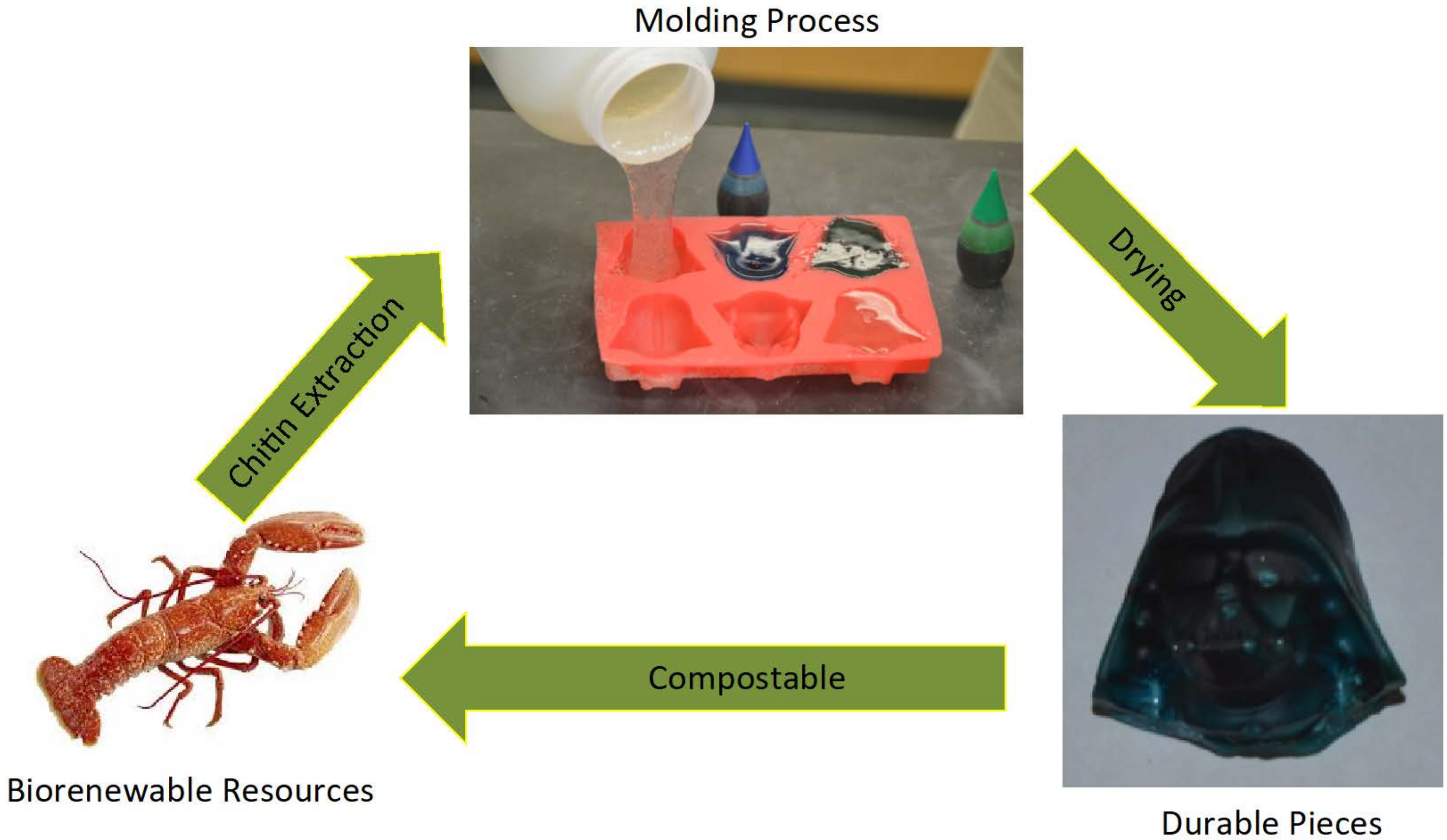
PHB from maple sap



Polyhydroxybutyrate Production

- Specific microorganisms, if given an environment rich in sugars, but with a limiting supply of other essential nutrients (maple sap, for example) will intake those sugars and store them. Where we would store them as fats, they produce polyhydroxybutyrate—stored in large vesicles (image on previous page).
- Centrifuge the cells down, and harvest just the polyhydroxybutyrate to process into plastic objects.

Chitin Plastics



Chitin Plastics

- Chitin is extracted from the shells of marine crustaceans
- It is dissolved in dilute acetic acid
- Poured into molds
- Dried into durable plastic objects

12 Principles of Green Chemistry

1. Prevent waste
2. Atom Economy
3. Less hazardous synthesis
4. Design benign chemicals
5. Benign solvents & Auxiliaries
6. Design for energy efficiency
7. Use of renewable feedstocks
8. Reduce derivatives
9. Catalysis
10. Design for degradation
11. Real-time analysis
12. Inherently benign chemistry for accident prevention

https://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry/principles/12-principles-of-green-chemistry.html

Questions

- For the three biopolymers, where does the chemical complexity come from?
- For each bioplastic, would large-scale production divert resources from food production?
- Discuss the synthesis of each biopolymer through the lens of the 12 Principles of Green Chemistry

Discussion Leader Notes

- For the three biopolymers, where does the chemical complexity come from?
  - PLA: Some of the chemical complexity comes from the original corn or potato—although it is altered in the fermentation to lactic acid and again through the various synthetic steps
  - Polyhydroxybutyrate: The chemical complexity of the polymer is built entirely by the microorganism
  - Chitin: The chemical complexity of the polymer is built entirely by the crustacean.

Discussion Leaders Notes

- Discuss the synthesis of each biopolymer through the lens of the 12 Principles of Green Chemistry
- **PLA:**
  - Waste Prevention: Solvents, catalyst and energy associated with various transformations all contribute to waste
  - Atom Economy: Much of the starting material is indeed incorporated into the final product
  - Less Hazardous Chem. Synth: The Tin catalyst is not great from a toxicological standpoint
  - Energy Efficiency: The multiple steps from potato to final product suggest a significant energy investment
  - Use of Renewable Feedstocks: The process uses corn or potatoes, which are renewable on an annual basis
  - Reduce Derivatives: The pre-polymerization, then depolymerization, adds extra synthetic steps
  - Catalysis: A catalyst is often used in the final polymerization because it offers better control of the final polymer's properties
  - Design for Degradation: Enough of the biomass' original chemical complexity is retained so that biological systems are able to easily break it down (by microorganisms in compost, for example)

Discussion Leader Notes

- Discuss the synthesis of each biopolymer through the lens of the 12 Principles of Green Chemistry
- **Polyhydroxybutyrate:**
  - Waste Prevention: No synthetic steps means limited waste production
  - Atom Economy: Much of the starting material is indeed incorporated into the final product
  - Less Hazardous Chem. Synth: Zero chemical synthesis = non-hazardous chemical synthesis (this is entirely a bio-based synthesis)
  - Energy Efficiency: The few steps aren't energy intensive
  - Use of Renewable Feedstocks: The process can use maple sap (or other sources of sugars) which is a renewable resource
  - Catalysis: No catalyst necessary
  - Design for Degradation: The entire material is made from nature, so it has enough of the chemical handles that nature (microorganisms) recognize and use to break down the material. It is biodegradable.

Discussion Leader Notes

- Discuss the synthesis of each biopolymer through the lens of the 12 Principles of Green Chemistry
- **Chitin:**
  - Waste prevention: Extraction and dissolving process lead to waste production
  - Atom Economy: All of the starting material is indeed incorporated into the final product
  - Less Hazardous Chem. Synth: The extraction and dissolving are relatively non-hazardous. Dilute acetic acid is essentially vinegar.
  - Energy Efficiency: The few steps aren't energy intensive
  - Use of Renewable Feedstocks: The process uses bio-renewable crustacean shells which are a waste product from food production
  - Catalysis: No catalyst necessary
  - Design for Degradation: The entire material is made from nature, so it has enough of the chemical handles that nature (microorganisms) recognize and use to break down the material. It is biodegradable.

Acknowledgements

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- The CCEW and ACS Webinars Teams