beyondbenign
green chemistry education

The Green Chemistry Commitment
TRANSFORMING CHEMISTRY EDUCATION

K-12 Outreach and Education: Engaging Students Through Green Chemistry Innovations

Kate Anderson and Mollie Enright

Beyond Benign, Inc.

September 12, 2017

beyondbenign
green chemistry education

Non-profit organization founded in 2007 by Dr. John Warner and Dr. Amy Cannon, located north of Boston (Wilmington, MA).

Mission:

Beyond Benign's mission is to equip educators, scientists, and citizens with the tools to teach and practice green chemistry to achieve a sustainable society.

Vision:

Beyond Benign envisions a world where scientists and citizens enter the workforce with the skills to design and choose greener, sustainable technologies that spur the innovation economy.




www.beyondbenign.org
@beyondbenign

BB Programs

K-12 Curriculum & Training

- Open-access curriculum
- Lead Teacher program
- Teacher training institutes/workshops
- On-line course

Community Engagement

- **College Student Outreach Fellows**
- On-site field trips
- Outreach experiences and events
- Open-access activity plans

Higher Education

- Green Chemistry Education webinar
- GC resources for higher education
- Toxicology in the chemistry curriculum

www.beyondbenign.org
@beyondbenign

beyondbenign
green chemistry education

Community Engagement Matters

- Just TALKING to young people about STEM careers
  - Increases test scores
  - Increases STEM career interest
  - *Jan 2017 study from University of Chicago, Northwestern University, University of Wisconsin-Madison, University of Virginia*
- Support community partners in their missions
- Empowers next generation of problem solvers

Boston Leadership Institute

TRiO UPWARD BOUND

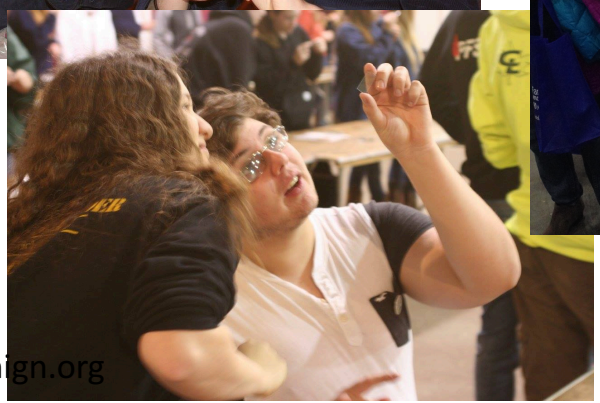
i2 CAMP

girls inc.®

ZOO NEW ENGLAND Franklin Park Zoo ♦ Stone Zoo

www.beyondbenign.org
@beyondbenign

Community Engagement Matters



www.beyondbenign.org
@beyondbenign

College Students as Change Makers

www.beyondbenign.org
@beyondbenign

Outreach fellows

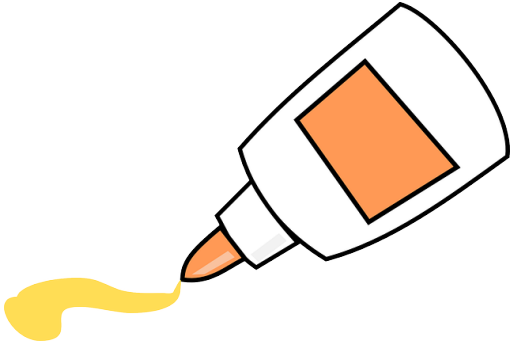
- Trained in green chemistry & outreach
- Full year commitment (2 semesters)
- Minimum of 4 community events
- Apply to represent Beyond Benign at GC&E conference OR USA Science & Engineering Festival

How can we learn from nature?

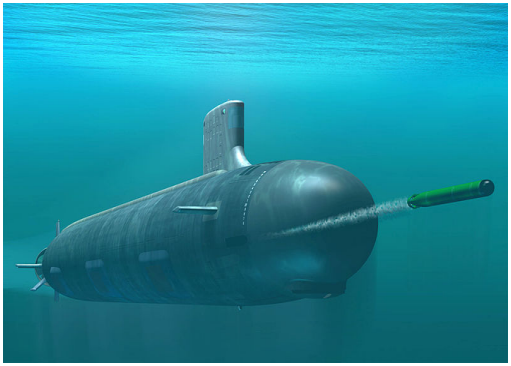
Biomimicry Matching Game

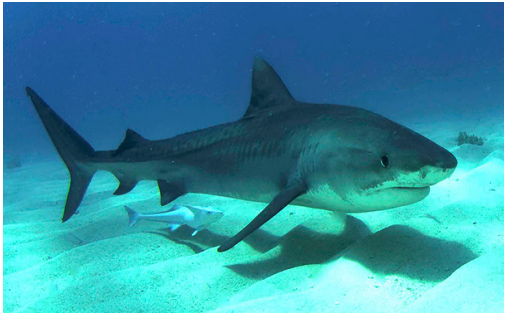
- Work in teams
- Match the technology with the plant or animal
- Explain “why and how” nature inspired the technology (form, function, shape etc)

www.beyondbenign.org
@beyondbenign



www.beyondbenign.org
@beyondbenign





www.beyondbenign.org
@beyondbenign

Introducing Green Chemistry

Biomimicry (from bios, meaning life, and mimesis, meaning to imitate) is a new discipline that studies nature's best ideas and then imitates these designs and processes to solve human problems.-*Biomimicry : Innovation Inspired by Nature* by Janine M. Benyus, 1997

- The natural world is based on systems and organisms that prevent pollution, handle waste, are energy efficiency, renewable and resilient.
- Biomimicry offers ideas and inspiration to scientists and engineers.

Green chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances.- *Green Chemistry Theory & Practice, P.Anastas, J. Warner 1998*

- Biomimicry can happen without green chemistry.
- Green chemistry can happen without biomimicry.
- Innovation and solutions to environmental challenges happen when green chemistry knowledge and skills are applied.

www.beyondbenign.org
@beyondbenign

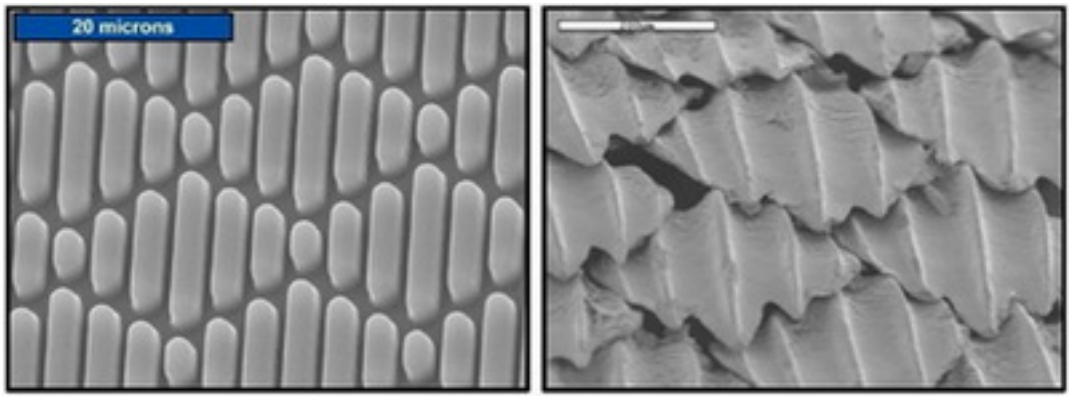
What do you know about sharks?

www.beyondbenign.org
@beyondbenign

What do you know about sharks?

www.beyondbenign.org
@beyondbenign

Sharklet film – biomimicry in action



Sharklet™ Surface Technology *Galapagos Shark Skin*

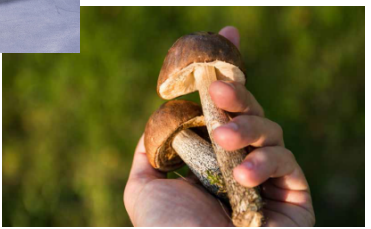
www.beyondbenign.org
@beyondbenign

How does it work? - Simulation

- Use model of pattern (made w/ sticky gems or puffy paint)
- Sticky notes on top of pattern vs flat surface
- Binder clips simulate accumulation of bacteria
- Students asked to explain why sticky note can't stick to Sharklet
- Sharklet doesn't have enough surface area for bacteria to adhere to!

Sticky note on Sharklet pattern: 5-10 binder clips
Sticky note on flat surface: 3—90 binder clips

Ecovative



- What do you know about Styrofoam?
  - List the function and benefits
  - List the challenges
- What properties of Styrofoam would you change? How?
- What if we could grow our own packaging?
- Let's look at the life cycles for Styrofoam & Ecovative mushroom materials

Non-renewable petroleum sources

Multi-step manufacturing process

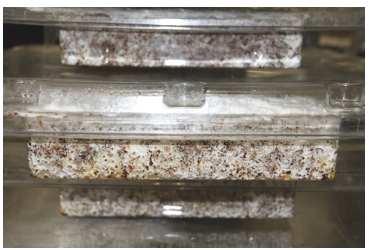
Consumer product

Minimal recyclability

Ends up in landfill

www.beyondbenign.org
@beyondbenign

Renewable resources → Natural Growth Cycle → Consumer product → Compost → Agricultural production with compost

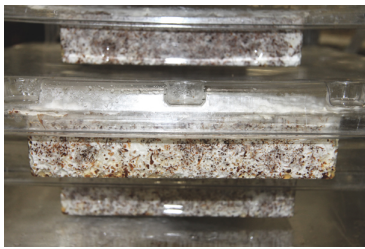


www.beyondbenign.org
@beyondbenign

Agricultural production with compost

Renewable feedstock from agricultural waste

Natural growth cycle



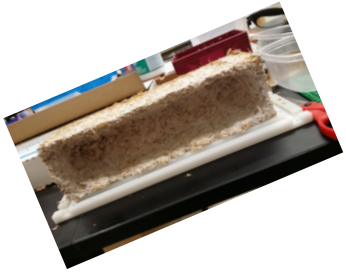
Consumer product

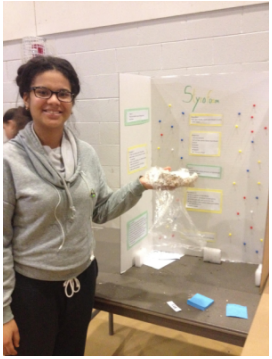
Compost (biodegrade)

www.beyondbenign.org
@beyondbenign

Visit: https://shop.ecovativedesign.com

Mushroom materials





Fabulous fabrics

- **Identify an unknown sample of fabric**
- Compare how different types of fabrics interact with dyes
- Main concepts
  - Life cycle
  - Properties of materials
  - Natural vs synthetic
  - Acids and bases

Fabulous Fabrics

Educational Innovations Inc.®

www.beyondbenign.org
@beyondbenign

Fabulous fabrics

Fabulous Fabrics

www.beyondbenign.org
@beyondbenign

What to do about CO_2?

www.beyondbenign.org
@beyondbenign

What to do about CO_2?

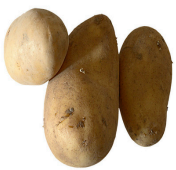
- What do we know about carbon?
  - Introduce carbon and carbon dioxide
- What do we know about acids and bases?
  - pH connections using pH scale with everyday items
- Where have we heard of CO_2 before? Can we predict what will happen when we add CO_2 to sea water?
  - CO_2 in the ocean lab

What to do about CO_2?

www.beyondbenign.org
@beyondbenign

What to do about CO_2?

- Green chemistry solutions:
  - Carbon capture technologies



What to do about CO_2?

- Green chemistry solutions:
  - Carbon capture technologies
  - Carbon dioxide feedstock

Where to find resources!

- www.beyondbenign.org

Fellows' Impact Since 2008

24,000+

www.beyondbenign.org
@beyondbenign

College Students as Change Makers

www.beyondbenign.org
@beyondbenign

College Students as Change Makers

www.beyondbenign.org
@beyondbenign

The Green Chemistry Commitment
Academic Signers
Summer 2017

Berkeley Center for Green Chemistry

School of Green Chemistry and Engineering, The University of Toledo

College of the Canyons

SUNY Fredonia

Eastern Mennonite University

UC Davis, University of California

Bridgewater State University

Department of Chemistry

Kingsborough Community College

Lawrence Tech

Berea College

Ramapo College of New Jersey

Wittenberg University

NECC

Washington College

Gordon College

Michigan Technological University

Simmons College

Stonehill College

Grand Valley State University, Department of Chemistry

Widener University

Salem State University

chemistry biochemistry, South Dakota State University

Montclair State University

University of Wisconsin Whitewater

St. Catherine University

Northeastern University

University of Toronto

Edgewood College

Drexel University

North Park University, Chicago

Elmhurst College

Loyola Marymount University, Los Angeles

CNM, Central New Mexico Community College

Michigan Flint

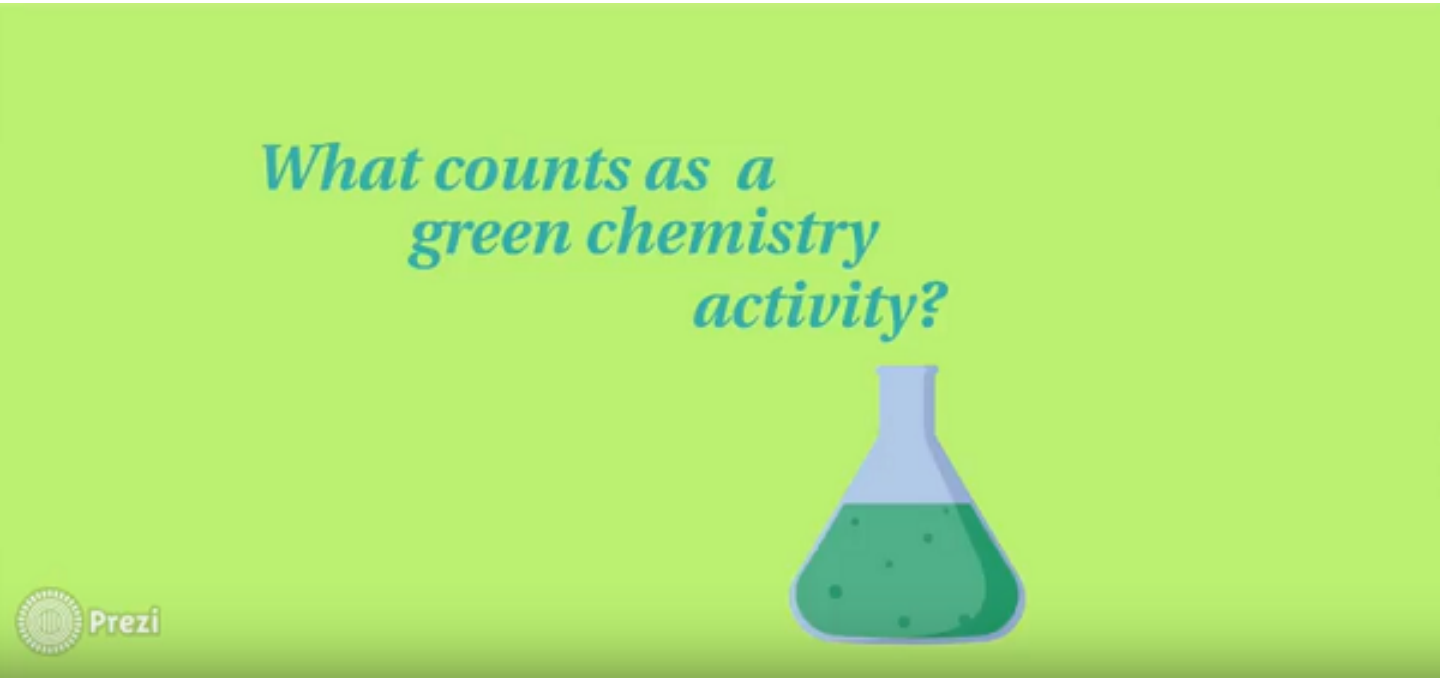
Tennessee Tech University

Worcester State University

Vancouver Island University

Saint Francis University, Founded 1847

Green Chemistry Student Chapters



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

www.beyondbenign.org
@beyondbenign

beyondbenign
green chemistry education

Thank you!

Mollie Enright
Program Manager
mollie_enright@beyondbenign.org
Kate Anderson
K-12 Director of Education
kate_anderson@beyondbenign.org

Facebook: Beyond Benign
Twitter: @BeyondBenign
www.beyondbenign.org