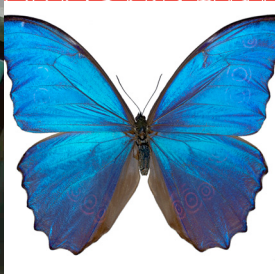
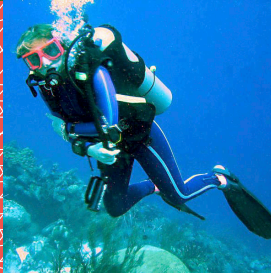
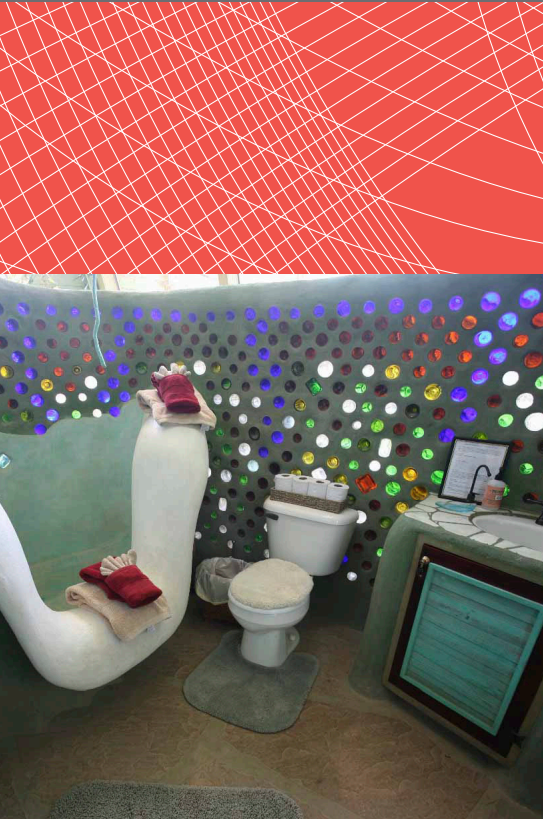




CleanTech

Inspiring High School Students in STEM, Sustainability, and Careers in the Emerging Green Economy

MATERIALS





CleanTech

Inspiring High School Students in STEM, Sustainability, and Careers in the Emerging Green Economy

MATERIALS

ACKNOWLEDGMENTS

ABOUT SOLAR ONE

“Green Energy, Arts, and Education Center.” We inspire New Yorkers to become environmentally responsible city dwellers. Solar One offers innovative programming to K-12 students throughout all 5 boroughs of New York City in the areas of renewable energy, sustainable design, estuarine ecology and environmental art.

The mission of Solar One’s education program is to facilitate applied experiential learning opportunities through science, design, art and entrepreneurship. Our staff of educators are here to help you make the Green Design Lab an integral part of your school’s curriculum and learning objectives.

Cleantech is Solar One’s High School curriculum that engages students in sustainable design, problem solving, and innovation in the emerging green sector. Cleantech was made possible through generous funding provided by The Rockefeller Foundation and the National Science Foundation under Grant No. DRL-1139308.

The Green Design Lab™ is also generously supported by our founding sponsors including Con Edison, The Mertz Gilmore Foundation, HSBC USA, N.A., the JC Kellogg Foundation, the Schmidt Family Foundation 11th Hour Project, and the Leslie and Daniel Ziff Family Foundation. We would also like to thank our partner, the New York City Department of Education Sustainability Initiative.

VISIT US ONLINE AT SOLAR1.ORG

The Green Design Lab™ © 2012 Solar One - New York, NY
The Green Design Lab™ is a trademark of Solar One. All rights reserved.

Except for Activity Worksheets and Readers, no part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, or any other information storage and retrieval system, without written permission from Solar One. Reproduction of Activity Worksheets is for educational purposes only.

Publisher: Solar One
Solar One Green Energy, Arts and Education Center
24-20 FDR Drive, Service Road East
New York, NY 10010
Tel. (212) 505-6050

CURRICULUM ADVISORS

Solar One gratefully acknowledges the insightful guidance provided by our distinguished Cleantech Steering Committee. Thought leaders in the field, they provided input on everything from big picture thinking and pedagogy to fact checking and typos. *Thank you!*

CLEANTECH STEERING COMMITTEE: **Jill Andersen** (Director of Policy and Chief of Staff, NYPA), **Kathy Boden** (VP, Gas Operations, Con Edison), **Bill Browning** (Founder, Terrapin Bright Green), **Toby Cumberbatch** (Professor, Cooper Union), **Micah Kotch** (Director of Operations, NYC ACRE at NYU-Poly), **Denise McNamara** (Secondary Science Instructional Specialist, NYC Department of Education), **Halton Peters** (Neon), **Pat Sapinsley** (President, Build Efficiently), **Robert Wyman** (Google)

MATERIALS ADVISORY COMMITTEE: **Bill Browning** (Founder, Terrapin Bright Green), **Toby Cumberbatch** (Professor, Cooper Union), **Holcim US, Inc.**, **Pat Sapinsley** (President, Build Efficiently), **Christina Salvi** (GrowNYC)

CURRICULUM DEVELOPMENT

Fronsy Thurman, Assistant Director for Instruction
Esther Siskind, Director of Programs
Sarah Pidgeon, Director of NYC K-12 Education
Dawne Adams
Joe Chavez
Alex Smith

REVIEWERS

Chris Colins, Executive Director
Sarah Holloway, Senior Consultant

BOOK DESIGN: Adam Bezer



Any opinions, findings, and conclusions or recommendations expressed in this material are those of Solar One and do not necessarily reflect the views of the National Science Foundation.

TABLE OF CONTENTS

Page	vi	INTRODUCTION
	vii	CURRICULUM MAP
<hr/>		
	01	Lesson 1: Introduction to Materials
	13	Lesson 2: Life Cycle of Materials
	31	Lesson 3: Waste And Recycling
	44	Lesson 4: Production-Consumption Cycle and the Consumer
	60	Lesson 5: Electronics and E-waste
	71	Lesson 6: Material Focus: Concrete
	77	Lesson 7: Sustainable Materials
	87	Lesson 8: Green Architecture
	102	Lesson 9: Biomimicry
	113	Glossary

INTRODUCTION

CLEANTECH MATERIALS is an innovative high school curriculum that uses a multidisciplinary approach to integrate study across the full spectrum of the diverse field of materials and waste. Designed to increase student awareness and knowledge of the science, issues and emerging technologies in materials-related fields, CleanTech Materials contains the most current information and research available along with relevant and engaging student-led activities. The Unit begins with an introduction to materials science and an overview of material families. Equipped with this foundational knowledge, students take a critical look at materials through an investigation of the materials life cycle and its environmental, social and economic impacts, including a close study of disposal and waste. From global socioeconomic effects to consumerism, the curriculum surveys the trends and consequences of materials consumption. Students are given opportunities to evaluate drivers of consumption patterns and analyze alternative business models. The focus of the curriculum then shifts to methods and innovations in sustainable materials and design, in which students explore principles of sustainable design and emerging green technologies. The hands-on sustainable design activities allow students to apply concepts such as climate change adaptation and mitigation, to real-world problem-solving in sustainable materials engineering, green architecture and biomimicry. CleanTech's unique holistic approach supports Science, Technology Engineering and Math (STEM) skills, while encouraging student participation and careers in a sustainable and green future.

HOW TO USE THE CURRICULUM MAP

CleanTech Materials offers a wide array of activities and resources, covering topics ranging from materials science to electronic waste to emerging trends in sustainable architecture. Each lesson is designed to work independently or as part of a larger course of study, allowing teachers to tailor CleanTech Materials to meet the individual needs of their classroom. Curriculum activities are grouped into three categories:

GENERAL ACTIVITIES emphasize the foundational knowledge and general concepts of materials-related fields of study. Hands-on projects and investigations stress comprehension and application of classroom knowledge. These activities are appropriate for all grades as an introduction to the topic.

ACCELERATOR ACTIVITIES center on policy, economics, and technology, with the purpose of introducing students to the complexities and evolving nature of the fields of materials science and sustainable design. These activities are research-oriented and stress analytical thinking, encouraging students to synthesize and evaluate information from a variety of sources. Accelerator activities involve data analysis and may be appropriate for older grades. Computer access is strongly advised for certain activities.

GREEN SKILLS ACTIVITIES are modeled on career and technical training for careers in the green industry. They focus on developing hard skills and the knowledge base required for real-world application, particularly in the field of sustainable design and construction.

The Curriculum Map is intended as a guide to help schools and teachers navigate the curriculum to develop dynamic and engaging study for their students. For all participating classes, it is encouraged to try as many activities as possible.

CLEANTECH MATERIALS CURRICULUM MAP

MATERIALS LESSONS AND ACTIVITIES	General	Accelerator	Green Skills
Lesson 1: Intro to Materials			
Activity 1A: The Science of Materials	•		•
Lesson 2: Life Cycle of Materials			
Activity 2A: Life Cycle Analysis		•	
Lesson 3: Waste and Recycling			
Activity 3A: Paper or Plastic?		•	
Lesson 4: The Production- Consumption Cycle and the Consumer			
Activity 4A: Deconstructing Advertising	•		
Activity 4B: Collaborative Consumption Case Studies		•	
Lesson 5: Electronics and E-Waste			
Activity 5A: From Extraction to Endgame: Uncovering the Electronic Trail		•	
Lesson 6: Materials Focus: Concrete			
Activity 6A: Concrete Comparison	•		•
Lesson 7: Sustainable Materials			
Activity 7A: Sustainable Materials Mix and Match	•		•
Lesson 8: Green Architecture			
Activity 8A; Designing for Climate Change	•		•
Activity 8B: 3D Building Design		•	•
Lesson 9: Green Design: Biomimicry			
Activity 9A: Biomimicry Card Game	•		•
Activity 9B: Nature by Design		•	

CLEANTECH, SOLAR ONE'S HIGH SCHOOL CURRICULUM,

engages students in sustainable design, problem solving, and innovation. Through hands-on learning, students explore emerging clean technologies and sustainability-related policy and economic issues at the local, national and global level. Cleantech is designed to inspire the next generation of green engineers, scientists, architects, building system managers, energy auditors, economists and entrepreneurs.

Cleantech is an integral part of Solar One's Green Design Lab™, the only curricular blueprint of its kind that looks at the school building as both a laboratory for learning and a tool for environmental change. CleanTech expands on the core concepts of the existing Green Design Lab interactive curriculum with more advanced and technical content. It introduces students to the Cleantech industry through STEM (Science, Technology, Engineering & Math) focused reading material, research projects and hands-on labs. Through four units – Energy, Materials, Water and Food – students learn about topics like electric grid transmission, renewable energy, battery storage, demand management water technologies, biomimicry, stormwater management, and hydroponics, to name a few. In addition to addressing the foundational aspects of these four subjects, CleanTech offers Accelerator activities that cover a broad range of science, economic and policy research topics, and Green Skills activities that focus on developing hard skills in such areas as renewables and hydroponics.

The Materials Unit uses a multidisciplinary approach to integrate study across the full spectrum of the diverse field of materials. The Unit examines the social, economic and environmental impacts of the materials life cycle as well as elements and techniques of sustainable design, including close study of topics such as biomimicry, electronics and much more. Designed to increase student knowledge and awareness of the science, issues and emerging technologies in materials-related fields, the Unit contains the most current research along with engaging student-led research and activities.

