Sort it Out NYC: Can Science and Technology Save the Earth? Design and Technology Solutions for Waste Reduction

Sort it Out **Recycling Education Series**
Interdisciplinary Education Enrichment Supplement
Created for Secondary New York City Public Schools
GrowNYC, August 2014

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The *Sort it Out* Recycling Education Resource was created to provide New York City secondary faculty, sustainability coordinators and other interested stakeholders a resource to facilitate the integration of waste reduction and recycling issues into the curriculum and classroom activities. It was not intended to offer independent lesson plans, scope or sequence but rather complement pre-existing resources with an enrichment supplement for adolescent academic and/or afterschool settings.

***Sort it Out: Can Science and Technology Save the Earth?* is designed to provide a resource to understand:**

- The most current design, technology, policy and behavioral solutions used to reduce, reuse and recycle our waste
- Why many of these solutions have been or are currently controversial
- Inter-connectedness of waste, energy consumption and climate change
- The key role that science, engineering and technology plays in waste reduction

Students are engaged in interdisciplinary problem solving in each section through:

- Discussion and Debate questions, looking at the controversy of waste reduction solutions
- Hands-on activities
- Relevant background information, current for the 2014-15 school year
- The most recent technologies and cutting edge programs
- Placed based information designed to engage learners in the greater New York City area

The *Sort it Out* Recycling Educational Series is a brand new pilot resource, released for use while still under development. The GrowNYC Recycling Champions Program welcomes all feedback for revision.

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Sustainability, Energy and Waste

Energy, recycling and our trash: what is the connection?
How is waste related to the generation of greenhouse gases?
What technologies are used to capture greenhouse gases?
What is the impact of the transportation of trash, and why is it controversial in NYC?
Mapping waste and recycling
Can getting hydrogen from waste water solve our energy crisis? Is a technological fix what we need?

Sustainable Practice: Understanding Recycling Behavior

How is mapping used to understand waste?
How can students map environmental habits and awareness in school?
What is the science of recycling behavior?
What effect has historical events had on recycling in the U.S.?

Corresponding STEM Standards:

How Are Plants and Animals in an Ecosystem Interconnected
Electricity and Magnetism
What are the Properties if Electricity and Magnetism
Simple and Complex Machines
How Does Energy Play a Role in Our Lives? How Do Machines Impact our Lives?
Diversity of Life
How Does the Transfer of Matter and Energy through biological communities support diversity of living things
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Motion and Newton's Laws
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Energy
Chemistry
Decomposition

Reaching for Zero Waste: Using Old and New Technologies

"Reduce, Reuse and Recycle" are strategies we can use to prevent and reduce the amount of waste we produce. The "three R's" can apply design principles and utilize different technologies, but to be effective, also require people to make decisions that prevent waste and adopt behaviors like sorting their waste into different streams.

Reduce or Pre-cycling refers to decisions and practices that prevent waste:

- Using re-usable items instead of single use: like backpacks and water bottles.
- Buying durable items that will last longer, avoiding useless items
- Purchasing items with less or recyclable packaging

Re-Use or Up-cycling refers to using an item again for another purpose, without re-manufacturing the material. Reducing the costs needed for materials for artists and the business community, up-cycled products can be found in craft markets, fashion shows, retail stores and online outlets.

Recycling is the process of breaking down materials in order to re-manufacture items into new products. Recycled content products are often labeled with the percentage of recycled material used- either recovered material (often scraps from factories) and/or post-consumer material (discarded after use.)

Discussion and Debate:

How does waste reduction and up-cycling impact Return on Investment (ROI)?

Can the 3 RRR's serve the interests of both environmentalists and businesses?

Zero waste is similar to the three R's, but is an expanded goal to redesign resource life-cycles so that all materials are re-used and waste is minimal. Discarded materials are recycled back into nature (e.g. compost) or recycled back into the marketplace (e.g. plastic bottles). Using a **systems approach**, not only can we manufacture products with waste prevention in mind, but also redesign how we construct and operate buildings, and even entire communities. **Resource recovery,** or collecting materials for recycling, composting and re-use, is part of a zero waste strategy and is a growing part of the U.S. economy.

Zero Waste is a type of **resource management** adopted by businesses and cities all over the world. For example, General Motors has 110 landfill-free facilities worldwide, with 97% of generated waste either recycled or reused. According to the U.S. Zero Waste Business Council, the Sierra Nevada Brewing Co. Chico facility reached a 99.8% diversion rate in 2013, which saved the company $5,398,470 in disposal costs and added $903,308 in revenue.

The **diversion rate** is the percentage of waste materials that are recovered that are recycled, composted, incinerated or reused rather than sent to a landfill. The US city with the highest diversion rate of 80% in 2014 is San Francisco.

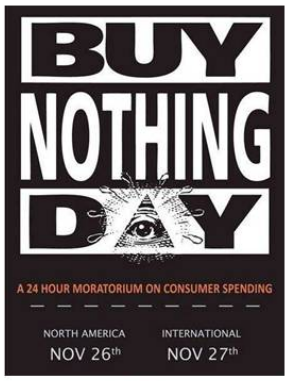
GENERATION ZERO Leaders of a WASTE-FREE AUSTIN	zero wastezone DOWNTOWN ATLANTA	This is a zero-waste event. ASK ME	Zero Waste SAN DIEGO

Zero Waste initiatives are gaining popularity in the U.S. as technology improves and disposal costs continue to increase.

Discussion and Debate:

How do these things relate to "Reduce" or "Pre-Cycling" Decisions?

Automatic Ice cream cone "spinner"



Up-Cycling Activity

Up-cycling can be a simple activity. Use decoupage glue as an adhesive to make almost any container new again- simply cut out used fabric, any paper, or decorative item and cover an old container. Waterproof decoupage glue is available in craft stores for those wishing to decorate outdoor school garden items.

Decoupage project: Use old maps, sheet music or fabrics to decorate an old table or container

If you live in NYC, your school or educational non-profit can visit Materials for the Arts to "shop" for free up-cycling items and/or learn how to use them. Visit www.mfta.org for more information

Sustainable Design and Practice

When we need to design a building, a factory, a container, a car, a farm, a pair of jeans, or a cup of yogurt, we make decisions about what materials, technologies and methods to use. How we decide to make a pair of sneakers can impact our environment and our community. When we design something to be **sustainable,** we create products and services that "sustain" or protect our resources (the ones we use to make something, but also the ones around us that support life) so that the next generations that follow can also continue to use those same resources again and again. Just like we have to stay within our budget when we purchase things at the store, we have to live within our means, in such a way that does not bankrupt our pocketbook or our earth.

In order to design something sustainable, we often need to have an understanding of how things are inter-connected. People have used this knowledge to design things since ancient times.

- Ancient Roman home builders could not block the sunlight from neighbors' windows. England passed similar laws in the 1500's.
- Farmers in places like Sicily and Egypt that were the "breadbaskets" for the Ancient Roman Empire recycled manure and food scraps to maintain fertile soils. Many are still in production today.
- Villages in India still use "living architecture" to create bridges from the roots of the Banyan tree to cross rivers during the rainy seasons.
- Metal used to make ancient jewelry, weapons, and house wares were melted down and recycled into new products by Roman soldiers after a conquest of new lands.

Masdar will be the world's first **carbon neutral *and* zero-waste city.**

Masdar, twenty miles from Abu Dhabi, uses both modern and ancient design to cool their desert homes and recycle water & waste. The windows offer light and breezes but are angled to shade the full sun, much like the pueblos built in the American desert. When complete in 2020, renewable energy will power this Arabic car-less city.
http://inhabitat.com/foster-partners-carbon-neutral-masdar-city-rises-in-the-desert/

Discussion and Debate:

Why are these ancient practices examples sustainable design or practice?
Can you list any other ancient technologies still in use today?
Can you list an example of an un-sustainable design used today? Why or why not is it important to re-design it?

Accumulating waste has always been an issue when people start to live in larger cities, although in ancient times all materials were biodegradable or for the most part re-used or recycled. The citizens of ancient Athens were required to dump their waste at least a mile from the city in the first municipal dump.

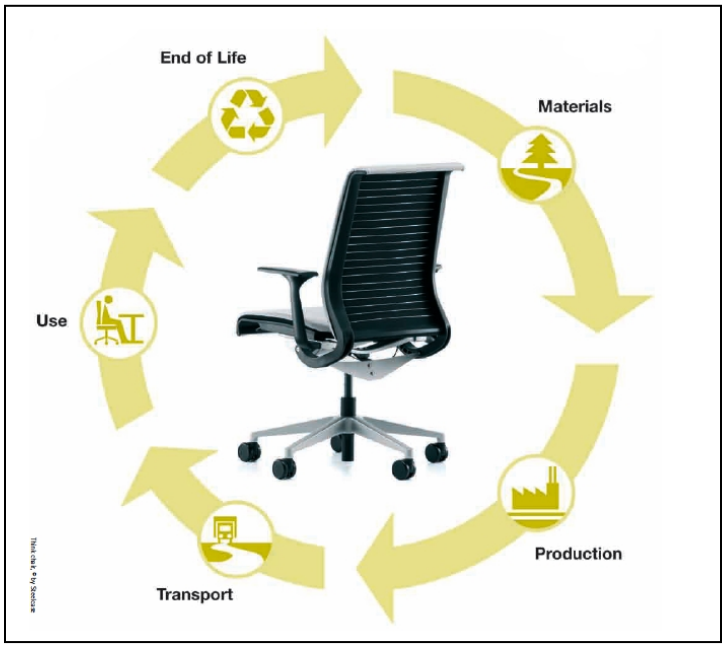
In many ancient cities, beeswax was applied on wood to create writing tablets, used for note taking (really great example) The shavings that scraped off from the stylus (writing stick or reed) were gathered and reapplied to the board.

Sustainable practices like re-use and recycling have always required people to participate. If no one re-applied the shavings, the board couldn't be re-used. It also required that the board be designed so that it *could* be re-used, constructed from locally sourced materials. Purchasing re-usable products is an essential strategy in zero waste programs.

Business Using Sustainable Design to Reduce Waste

There are many eco-design "green" products for sale in the U.S.- with symbols and images that market their environmental friendly features, which may or may not have rigorous certifications or requirements.

"Cradle to Cradle" by Michael Braungart and William McDonough is a landmark book and a set of sustainable design guidelines advocating that all products be designed to be recycled or composted. The entire "life cycle" of a product is considered in the design phase: from the source of raw materials used, (or the birth) construction, transportation, operation or use, and then final disposal, or the product's "grave." Considering the ecological impacts of disposal during the design process was considered to be revolutionary when the book was first published in 2002, as architects and industrial designers often focused more on manufacturing, using and/or operating items and buildings, rather than the disposal of them. Certified Cradle to Cradle products can include all types of products, including shampoos, fabrics, furniture and building products. **Cradle to Cradle design:** http://www.c2ccertified.org/product_certification



An advertisement for a Cradle-to-Cradle Certified office chair. All of the parts of the chair can be recycled or composted, so none of the components need to be disposed of.

Discussion and Debate:

Should we require sustainable design in manufacturing?

A National Academy of Engineering report, by Robert Ayers, calculated that 94% of the material used in industrial production in the United States is thrown away by the time the product is made! And what happens to the six percent of the materials that actually become products?
They are often thrown away after a single use.

From Why Recycle? Rice University Facilities Engineering Planning
http://facilities.rice.edu/recycling/why-recycle/

From Rags to Riches

In the book Cradle to Cradle, a textile manufacturer had high costs associated with hazardous waste disposal and polluted water coming from their plant.

Working with the chemical industry, the fabrics were redesigned from plant dyes and animal (wool) fibers, eliminating over 7,000 toxic chemicals. The fabric scraps left over from the factory are now used for mulch on local farms, the water is clean, and the company increased their profits, since they saved money on disposal costs and now also sell mulch.

The Sustainability "Triple Bottom Line" framework applies to the textile factory. If something is:

Good for the environment

Good for the community

-and-

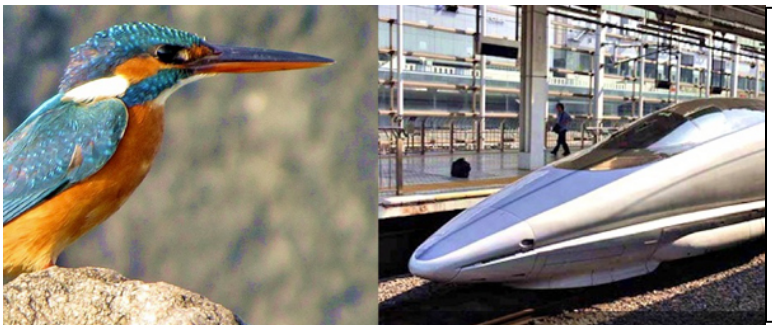
Good for the economy

it is "sustainable" and positive for the three P's: People, Planet and Profit

Biomimicry

Biomimicry is a new science that replicates models and systems from nature to guide the design of the built environment and the products we use. As architects and engineers, nature provides us with many solutions to build in a way that restores and regenerates rather than depletes our natural resources.
The rest of nature has no landfill trash, and unlike humans, plants and animals process all their own waste within their ecosystem, so natural systems can provide solutions to many of our solid waste design challenges.

Using nature to guide design is nothing new: Leonardo Davinci and the Wright Brothers studied birds and used what they learned to inform the design for their "flying machines" that led to the modern airplane.



The design for the front of this high speed train was inspired by a kingfisher's beak.

Discussion and Debate:

Nature always recycles, but we don't. If we have the design and technology, should it be a requirement when we design our built environment?

Nature Always Recycles. Air, water and soil cycles are examples of how nature recycles earth's resources. Animals also frequently reuse and recycle materials to construct housing, containers and even tools.

The Living Building Challenge challenges architects and engineers to create a truly sustainable built environment. Living Buildings are a great example of using and applying biomimicry in the design phase, in order to create regenerative buildings that *do not deplete* natural resources. Living Buildings produce as much energy as they consume over the course of the year, and use nontoxic, locally sourced renewable building materials.

Living Buildings are similar to LEED Certified Buildings (Leadership in Energy and Environmental Design) in that there is a third party certification system that verifies the footprint of construction and operations, but goes a step beyond LEED to also process most or all of its own waste. This is the first time recycling waste water (and in some instances solid wastes) during the use or operations of a building has been a key component for green building certification.
For more information about Living Buildings see: http://living-future.org/lbc

The Hood River Middle School in Oregon and The Packard Foundation Headquarters Building are both Certified Living Buildings, although their appearance is not unlike other modern commercial buildings.

For more information about biomimicry: http://biomimicry.net/
Twelve Sustainable design examples inspired by nature https://www.youtube.com/watch?v=n77BfxnVlyc

Sustainable Design: An Exploration of Materials

Many materials are used to make the products that surround us in our homes, schools and in the community. Are the containers and packages we use everyday designed with sustainable materials? Part of resource management is to think about what raw materials and resources we need to extract, transport and process to make products.



Activity and Discussion: What are the materials we frequently use made from?
Are they made from renewable or non-renewable resources?
Why is recycling materials important for resource management?

Non-renewable resources refer to those materials that are in limited supply and can't be replaced, and/or do not regenerate at the same rate of consumption. Oil and coal are examples of non-renewable resources.

Renewable resources are materials that we use that can be or will be replenished naturally. Solar and wind energy, trees, and top soil are considered to be renewable resources.?

The Carrying Capacity

of a species in an environment is the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water and other necessities available in the environment.

For humans, this includes our ability to conserve our resources, but also process our waste, *and recycle* since space used for landfills may not be used for other resources needed like food, shelter, energy production, etc. We are the only species that produces waste.

Activity: Take the Footprint Quiz!
www.ecologicalfootprint.org

One way to estimate human demand compared to ecosystem's carrying capacity is "Ecological footprint" accounting.

Do you know your personal ecological footprint?
Take the quiz and find out how many earths you are using to sustain your lifestyle. Measure that!

Plastics are made from what?

Plastics recycling was expanded in NYC in 2013 to include rigid or hard plastics, like yogurt containers, take out and berry containers, plastic toys and hangers.
Why is this so important? Plastic is made from petroleum.

Image from NYC's Recycle Everything campaign

Plastic production uses about 8 percent of yearly global oil production, and 4% of the US total—both as the raw material and for energy in the manufacturing process. Today Americans discard about 33.6 million tons of plastic each year, but only 6.5 percent of it is recycled and 7.7 percent is combusted in waste-to-energy facilities. This does not include the estimated 100 million tons of plastic litter in our oceans.

Reaching for Zero and Sustainable Design Section: Key Concepts

Biomimicry
Replicates models and systems from nature to guide the design of the built environment and the products we us.

Carrying Capacity
The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water and other necessities available in the environment.

Diversion Rate
The percentage of waste materials that are recovered that are recycled, composted, incinerated or reused rather than sent to a landfill.

Ecological Footprint
Measurement of the environmental impact of human activity. A carbon footprint is one part, energy consumption, of a total ecological footprint measure, which also includes waste, water, etc.

Reduce, Reuse and Recycle
The three RRR's phrase refers to the three most common strategies of waste reduction, including preventing waste, re-using resources for another purpose and remanufacturing materials into recycled content items.

Renewable resource
Materials that can be continuously regenerated and replenished without depleting our natural resources..

Resource management
The process of handling and distributing environmental, financial and human resources efficiently and effectively to ensure a continued and healthy supply.

Resource recovery
Collecting materials already distributed to residents, business and industry for recycling, composting and re-use.

Sustainable
A design, technology or practice that can "sustain" and protect our resources (the ones we use to make something, but also the ones around us that support life) so that the next generations that follow can also continue to use those same resources again. This can apply to a single item or an entire system.

Systems approach and/or systems thinking
Considering the interdependence of our activities, and how they may be inter-related. In problem solving, viewing "problems" as parts of an overall system, in the context of relationships rather than in isolation.

Triple Bottom Line Sustainability Framework
An accounting framework with three dimensions: social, environmental (or ecological) and financial, commonly called the three pillars of sustainability. To be sustainable, it is considered beneficial to all three: "people, planet and profit."

Zero waste
A program, product, policy or system that encourages the redesign of resource life cycles so that all products are reused. No trash is sent to landfills and incinerators and no toxins are left behind during the process.

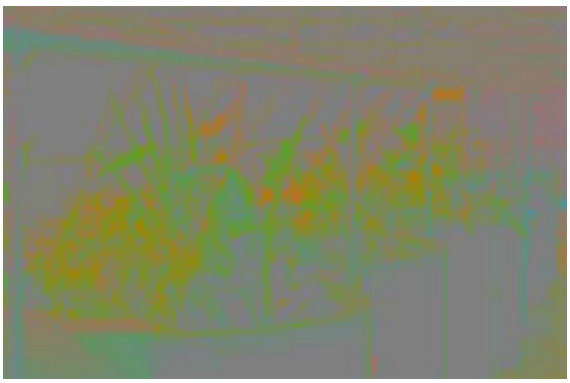
Sustainable Technology: Recycling Water Using Biomimicry

We recycle much of the water that we use every day in our homes- just like with solid waste, it doesn't just "go away" but gets piped to a municipal wastewater treatment plant to get processed and recycled.

Natural wastewater treatment systems use plants, instead of chemicals, to clean wastewater. Many aquatic plants naturally filter water, as the microorganisms on their root systems digest organic wastes. These plants are commonly found in **wetlands and the riparian buffer zones** next to streams and rivers, acting as a natural filter for our

We can engineer systems in greenhouses that replicate nature's filtering design. Wastewater can be pumped through a series of aerobic and anaerobic tanks, filled with plants that contain a large amount of natural microorganisms.

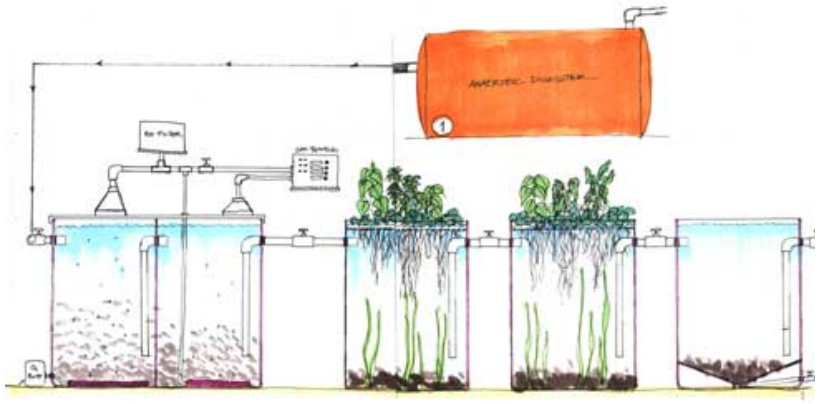
Treating wastewater can be costly and energy intensive for municipalities, but these natural systems can transform this process into one that not only cleans the water naturally but generates revenue for the community. Flowers and/or fish raised in the tanks can be sold in the marketplace, covering some of the operating costs. These **Living Machines** can be designed to recycle the water for flushing toilets, watering landscaping, or can produce potable (drinkable) water.



A natural wastewater treatment system at a rest area in Vermont. The city of South Burlington, Vermont and Fredrick Maryland use Living Machines to treat municipal wastewater.

When a garden is planted outdoors to serve as a filter for storm water running across a landscape in a built environment, it is called **a bio-swale or rain garden. Storm water management technologies** are especially important in cities like New York because so much of the surface on the ground is paved with **impervious** materials. When it rains, the water is blocked from the soil underneath and flows elsewhere, and can cause flooding.

Bioremediation uses biomimicry to clean up waste and pollution in water, soil, and air.
For example, planting sunflowers to clean contaminated soil in urban areas is a type of bioremediation.



Activity:
Construct a Living Machine

Replicate the filtering system of our wetlands by building a classroom Living Machine.
For design and curriculum:
http://jellobrain.com/node/50
Rhode Island School of Design and Brown University Ecology Lab MS/HS Curriculum

For more information about ecological wastewater treatment technologies, see:
http://water.epa.gov/scitech/wastetech/upload/2002_12_13_mtb_living_machine.pdf
Are businesses interested in water recycling in 2014? Companies like Levis have new recycling initiatives:
http://ecowatch.com/2014/02/26/levi-jeans-with-recycled-water/

Sustainable Technology: Packaging

Packaging- such as boxes, bags and food wrappers accounts for roughly a third of the waste that's dumped into landfills. (EPA, 2013) If packaging is made from organic materials, there is little to no waste if the material is composted. If packaging is made from 100% recycled and recyclable materials, if the material is recycled, there is little to no waste. Both types of packaging require resources, energy and water to manufacture, transport, recycle and compost them.

Are there other packaging technologies that are more sustainable? David Edwards, a bioengineer at Harvard University, created WikiCell, which is a bio-engineered edible packaging. The "skin" on the product is designed to replicate the natural covering on an apple or other fruit, but cover food products like cheese and ice cream. This would significantly reduce our solid waste problem- if consumers would be willing to eat them, and we knew that these products were as safe to eat as food already found in the grocery store. Bio-technologies like GMO's (genetically modified organisms) have been used to increase food production and improve preservation, but are a new application in packaging.
For more on Wikicells see: http://www.businessweek.com/articles/2013-02-28/david-edwardss-wikicell-makes-edible-food-packaging

Discussion and Debate:

Would you eat a food with a bio-engineered packaging? GMO's? Why or why not?
What are alternative solutions to reduce packaging waste?

Low tech bio-based packaging options have also grown in popularity, like a mushroom based replacement for Styrofoam peanuts. But these can also be controversial. Critics argue that growing food for anything but eating-like fuel or packaging-uses agricultural land needed for food production. http://www.ecovativedesign.com/mushroom-materials/

More is Less. Having to recycle or dispose of mountains of packaging is expensive, especially for large cities. For example, New York City taxpayers spend $600 million every year just to manage post-consumer packaging and printed paper. It can also cost businesses more money .

US municipalities have more than 70 extended **producer responsibility (EPR) laws** that require companies to take back their products for recycling, but packaging is usually not included.

Some cities like San Francisco **ban certain products** that generate costly additional waste, like Styrofoam take out containers. Yet these types of policies that restrict business and trade tend to be unpopular in the U.S., instead favoring technology solutions.
http://knowledge.wharton.upenn.edu/article/zero-waste-nil-landfill-now-practical-goal/

PBS Packaging: Design Squad
http://pbskids.org/
Try Engineering: Shipping for Survival
http://tryengineering.org/lessons/shippingsurvival.pdf
Snack Attack: Packaging Design Activities (Teachers)
http://teachers.egfi-k12.org/snack-attack-food-packaging/

Wikicell packaging
covering cheese and ice cream

NYC Green Job Alert:

Artistic and going green?
Did you know that you can get a good green job redesigning a milk carton?

The Fashion Institute of Technology in NYC offers bachelors' degrees and certificate programs in sustainable packaging design. Their graduates have very high rates of job placement in professional positions, without having to earn a graduate degree,
http://fitnyc.edu/13025.asp

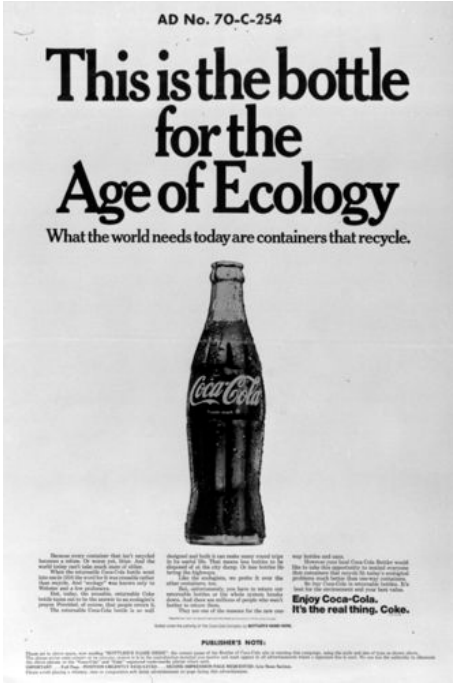
Discussion and Debate:

Package Deal?

Which solution is most effective:

Packaging Policy Solutions

or Technological Packaging Solutions?



Germany Green Dot Program requires manufacturers to pay a fee for packaging- the more packaging created, the higher the fee. This program launched many other pay as you throw programs.

Discussion and Debate:

In the U.S. an increasing number of municipalities require residents to purchase stickers and/or bags in order to receive trash collect services.

In Europe, bags can cost as much as 8 dollars (US equivalent.)

How would you change your purchases and your recycling habits if NYC adopted a pay as you throw program?

Should governments just ban certain types of packaging? Why or why not?

Incinerators: Trash to Energy

An incinerator decorated to reflect modern and whimsical architecture. Why do you think this municipality invested resources into its' appearance?

Incinerators are waste to energy plants that burn trash and recover some of the energy from that process, instead of burying it in a landfill like most municipalities in the US do. This "advanced thermal technology" generates electricity, while reducing trash to a leftover ash that is then buried.

Materials can also be separated from the waste stream and recycled using thermal technologies. Plastics can be converted into crude oil or other types of liquid fuel through pyrolysis, a high heat process. Agilyx, an Oregon-based company, convert ground unsorted plastic of all types into synthetic crude oil (which can be refined into ultra-low sulfur diesel, gasoline, or jet fuel.)

Currently the US has 86 waste to energy incinerators, but Europe has many more, providing power for over 30 million people as a significant part of the European Unions' strategy to reach Zero Waste by 2020 and reduce carbon emissions. http://www.midwestenergynews.com/2013/10/17/is-burning-garbage-green-in-sweden-theres-little-debate/

At the height of incineration in the 1960's, the New York City burned a third of its waste in more than 17,000 apartment building incinerators and 22 large municipal incinerators. http://www.gothamgazette.com/iotw/recycling/doc1.shtml

According to the NYC Budget Office, the cost to export our trash is more than double what the costs were to dump it into the Freshkills Landfill in Staten Island, and the costs are continuing to increase every year. Despite these rising costs, incinerators have not been part of NYC's waste prevention and reduction strategy. Most environmental nonprofits in the US, and the City of New York, advocate a zero waste strategy which includes reuse, conservation, sustainable design, recycling, composting, and up-cycling, to reduce trash to a minimum.

Discussion and Debate:
Techno fix or More Problems?

Incinerator technology was meant to solve an environmental problem, but the results are controversial.

How is that similar to other environmental technologies like chemical and biotech agriculture and even fossil fuels?

Europe has embraced incinerator technology while the U.S. maintains it is unsafe. This is similar to nuclear energy production. Why do countries embrace or reject technologies?

Can sustainable design or alternative technologies eliminate the need for both incinerators and landfills?

A study conducted by the Columbia Earth Institute recommended considering incineration during the Bloomberg Administration, concluding the risk from dioxin emissions was "minimal." "U.S. power plants today emit 47 tons a year of mercury and the entire waste-to-energy industry emits only 2 tons a year," said Nickolas J. Themelis, an environmental engineer and co-author of the report.

Other environmental groups and most US cities believe the risks are considerable, and have prevented any new incinerators to be built. Concerns include the safety of emissions and toxic ash, and little recovered energy as compared to recycling. It also does little to address the generation of waste, and the fossil fuels used in making that waste, now needed for energy production.
http://www.no-burn.org/downloads/Incinerator_Myths_vs_Facts%20Feb2012.pdf

Biological Technologies :
Recovering compost or energy from the decomposition process.

According to the Environmental Protection Agency, food scraps are the No. 1 material sent to landfills in the U.S.—more than paper or plastic. This uneaten food accounts for about 14 percent of all municipal solid waste, contributing almost 25 percent of methane emissions and costing roughly $1.3 billion to transport and dump in US landfills. (Living in the United States of Food Waste, Ira Sager, Bloomberg Business Week, January 10, 2013) In NYC, 30-35% of residential and institutional waste is made up of organic materials that can be separated and either composted or made into energy (PLANYC, 2013 Progress Report.)

We generate 21.5 million tons of food waste each year. If we composted that food, it would reduce the same amount of greenhouse gas as taking 2 million cars off the road.
https://www.dosomething.org/facts/11-facts-about-recycling

Composting is a method of speeding up the **decomposition** of organic or once living materials as they break down into a natural soil amendment that provides nutrients for plants. There are many types of composting or "aerobic digestion technologies" that utilize this natural breaking down of material to convert it into a valuable product.

Anaerobic digestion is another biological technology used to recover methane, which is a natural gas that is released during the decomposition process. Anaerobic digestion is the biochemical process where microorganisms break down organic material in a low or no oxygen environment, releasing **biogas**, comprised of methane and carbon dioxide. It occurs naturally in lakes, wetlands and bogs**,** breaking down complex organic molecules (carbon biomass) into single carbon compounds methane (CH_4) and carbon dioxide (CO_2) or biogas. The energy of the carbon is in the released methane (CH_4). The conversion of CH_4 to CO_2 produces large amounts of heat.
http://whatcom.wsu.edu/ag/compost/fundamentals/biology_anaerobic.htm

Activity: Root Beer Science: Ferment sugar to demonstrate anaerobic digestion
Anaerobic digestion is also used to ferment food and drinks.
Ferment something legal for minors to drink in the classroom: http://teachers.net/lessons/posts/1229.html

Bio-gas is a source of renewable energy

Used more frequently on commercial farms to process livestock manure in industrialized countries, digesters have been used for decades in rural areas where energy supplies (and firewood) are limited.

India and Britain have had biogas plants since the mid 19th Century. China currently has over 6 million small scale backyard digesters.

http://apps1.eere.energy.gov/tribalenergy/pdfs/course_biomass_duff_ad.pdf

Some of the organic material collected from NYC school cafeterias will be processed in digesters at the Newtown Creek Wastewater Treatment facility in Brooklyn to capture methane.

Composting Technologies:

Composting speeds up the natural **decomposition** of materials by controlling the density, temperature, moisture, and aeration of organic material in containers, piles or rows. In **aerated (active or turned) windrow composting**, organic material is placed in rows of long piles called "windrows" and aerated by "turning" the pile. In **Aerated static (passive) pile composting, the** organic material decomposes in one large pile instead of rows. Carbon rich "browns" like straw, wood chips, dried leaves or newspaper are layered with nitrogen rich "greens" or food scraps, which helps to aerate the pile. Commercial piles may pipe in air or water using temperature and moisture control sensors.

Composting indoors? Several composting technologies allow even those living in urban areas an opportunity to recycle their food scraps with limited space. Aerobic composting technologies include **enclosed systems** designed for indoor onsite composting. These may utilize the electronic circulation of air and temperature controls to speed up decomposition dramatically, or dehydration techniques to make pellets for fertilizer of livestock feed.
With new technology, how fast can compost be made? One company claims it can take only 24 hours. According to Biomax, the Rapid Thermophilic Digestion System uses special enzymes that are activated at very high temperatures to speed up decomposition.

Anaerobic composting speeds up the process of using bacteria to break down organic materials in an anaerobic environment. Decomposition without oxygen results in fermentation. For centuries, Chinese rice farmers used this method to bury fermented compost to keep their soil fertile. Sealed buckets, and other small scale systems used with added bacteria for indoor composting are often referred to as the Bokashi Method.

Vermi-composting creates compost using red worms (a specific type of worm) in bins usually filled with food scraps and paper waste. As the worms eat their way through the scraps, they leave behind nutrient rich "castings," in part replicating regenerative organic farming methods on a much smaller scale. "Worm bins" can be managed in homes, classrooms, porches or garages as the worms prefer to avoid light and leaving the interior of the bin.

The New York City Organics Collection Program is collecting organic waste from public school cafeterias to make use of both aerobic and anaerobic composting technologies. The material is brought to commercial composting facilities to make compost for neighborhood parks, community gardens and street trees, as well as to the Newtown Creek Wastewater Treatment Facility to be processed in an anaerobic digester for methane capture. Organics are also being collected from residents in select neighborhoods and at local farmers markets.

Compost in NYC? Visit www.nyc.gov/organics to find workshops, guides for indoor and outdoor composting, a listing of community-based drop-off sites and to learn more about DSNY residential Organics Collection Program.

Guide to Aerobic and anaerobic composting

http://extension.oregonstate.edu/lincoln/sites/default/files/documents/

Breaking it Down:
Why Materials Last So Long in a Landfill

Soil is part of the food chain, just like plants and animals, containing millions of micro- and macro-organisms called **decomposers**. In the soil food chain, first level **consumers** become the food for second level consumers, which in turn, are eaten by third level consumers. The decomposition of plant materials is part of the **cycling of carbon** within a given environment. As these consumers eat, organic materials break down into simpler forms of matter.

In **abiotic decomposition**, **microorganisms** such as bacteria, fungi, and actinomycetes, or **chemical decomposers**, change the chemistry of organic wastes As they obtain energy by oxidizing organic material, especially the carbon fraction, the compost pile heats up in the process.

In **biotic decomposition, macroorganisms** such as mites, centipedes, sow bugs, snails, millipedes, spiders, slugs, beetles, ants, flies, flatworms, and earthworms break down organic material as they eat. They are considered to be **physical decomposers** because they chew and grind materials into smaller pieces.

Activity: Rotten Apple:
Shrunken Apple Heads and Decomposition

Make shrunken apple heads by peeling and coring an apple. Carve a face into it. Combine 1 cup of lemon juice and one tablespoon of salt in a bowl. Dip the apple in the mixture for about 15 minutes, pat dry. Store in a warm and dry place for several days.

Place a slice of apple in different clean jars filled with each of the following: vinegar, water, & salt water.
Experiment also by placing slices: in tightly sealed and open jars, in dark enclosed spaces, brightly lit and next to a light bulb, and completely covered with dirt/compost. How do these conditions affect the rate of decomposition? Why? Which variables are also found in landfills?

Dr. Bill Rathje was an archaeologist who analyzed mummified objects in landfills to better understand our disposable society

Putrefaction is the breakdown of organic matter by bacteria. In colder, drier conditions, the process is slowed, because bacteria need heat and water to thrive. This is why we use refrigerators to preserve food. Before people had refrigerators, food was preserved using a variety of methods, usually with salt. That was why having a supply of salt was as important throughout history as it is today to have access to energy supplies for our communities to survive.

Organic material inside of a landfill decomposes very slowly compared to materials decomposing naturally. Landfills are lined and capped to seal them, in order to prevent waste from leaking into community waterways, to reduce odors and to help control the release of methane. But these seals and caps also reduce light, air, moisture, temperature and oxygen levels, which effect decomposers and slow or stop decomposition.

Trash in landfills can become "mummified" in a similar way to Egyptian mummies that are preserved for centuries. Egyptian mummies are coated with a sodium compound that dried out the outer layer of skin, which prevented bacteria from breaking down the skin. Salt (sodium) and baking soda are both desiccants. **Desiccants** remove water from any material it comes into contact with. An additional layer of bandages coated with resin created an additional barrier to the bacteria. Organs were removed because they also contain bacteria. A sealed coffin called a suhet further reduced the amount of light that the body was exposed to.

Activity: Mummify a Hot Dog
Complete cover a hot dog or apple 40 grams baking soda and 80 grams table salt (or another food group), cover, and store in a dry place.

Compare your results to mummified food, found perfectly intact in landfills by Professor Bill Rathje.

Activity: *Print out, fold in half and quiz your fellow students.*

How Long Does it Take to Decompose?

Paper Cups

Food Scraps

Styrene-foam

Plastic Bottles

Glass

Decomposition Rates Exposed to Air/Light or in Landfills:

Food Scraps-

When exposed to air/in composter: 2 Weeks to a few months

In Landfills: A few months but can be up to 50 years or more

Glass and Styrene foam-

When exposed to air/light: Millions of years, unknown

In Landfills: Millions of years, unknown

Plastic Bottles and containers-

When exposed to light: 500-1,000 years or millions/unknown,

In Landfills- 500 -1,000 years or millions/unknown

Paper cups-

When exposed to air: A few weeks to about 5 years.

In Landfills: A few months to about 5 years

Recycling: Sort it Out

Recycling is part of NYC's effort to implement a **zero waste strategy**, through conservation of resources, waste prevention, and resource recovery. Collecting post consumer materials in order to return them back into the marketplace so that they can be made into new products is both a public and private industry known as **resource recovery.** How valuable these items are fluctuates with the markets for them, just like new products or materials.

Between 75 to 95 percent of the trash in the U.S. is recyclable.

NYC's recycling rate is at about 15 percent, less than half the national average of 34 percent (but NYC residents also generate almost half as much waste per capita as the average American. Roughly 35 percent of NYC's trash is traditional recyclables (NYC Department of Sanitation, 2013.)

Activity : How Fast Can You Sort it Out?

Using a smart phone stop watch, compete to see how fast you can sort common items left on a cafeteria tray.

Too Much Trouble?

The Recycling Champions Program has been engaging NYC students in a competition to see how fast they can sort a cafeteria tray. Once familiar with how to recycle each type of material, it takes the average kindergarten student ***less than 10 seconds.***

Closed Loop Recycling is a term with two different meanings, sometimes referring to when the same product is manufactured out of collected recyclable material. An example of this closed loop recycling is making a new soda bottle out of a used soda bottle. Coca Cola is recycling its PET bottles and opened the world's largest bottle-to-bottle recycling plant in Spartanburg, SC to produce 100 million pounds of recycled plastic each year. Sometimes referred to as "**technical nutrients**" rather than "biological nutrients," these materials are returned to industry for reuse. In the case of some metals, they can be recycled indefinitely. Manufacturers increasingly collect these types of materials directly from consumers rather than from city agencies in **"take back" programs**.

Closed Loop Recycling or "**Close the Loop**" also refers to a three step process of recycling, ***Collection, Recycling and Purchasing,*** with the most important step perhaps being the last to include the consumer's purchase of recycled content materials.
The recycling icon, at right, with three chasing arrows was actually created to symbolizes these steps, rather than the 3 R's slogan, reduce, reuse and recycle.

Down-cycling is when a material is recycled but the quality of the material decreases and becomes less valuable. This is an issue for many plastics, which are made from polymers and melted down for recycling.

Debate and Discussion: Do you buy recycled content products like recycled content paper products commonly found in local markets? Why or why not?
How do we pay the costs of a product's lifecycle when we are not buying recycled content products?

Materials can also be turned into different products when they are recycled. Wellman Inc. a recycling facility in South Carolina, annually recycles about 2.4 billion plastic bottles into a polyester fiber known as Fortrel EcoSpun, which ends up in active wear like fleece jackets. It takes four plastic soda bottles to make enough plastic to fill a fleece vest.

The Science and Engineering of Sorting Recyclables

The machinery of a recycling sorting facility relies on basic **physics and properties of matter** to separate the materials collected. Designing sorting equipment is usually spearheaded by a **mechanical engineer**, who understands materials science, physics, and engineering, and joined by a team that would include environmental, applied, industrial, electrical, optical and computer engineers.

When loads of recyclables are brought to a **MRF (Materials Recovery Facility)** they are put into large machines that help sort out the different objects. The size and weight of recyclables is considered in the first strategy used to sort, as smaller objects fall through narrow spaces in bins pulled along in conveyer belts, and heavier objects fall downwards, using gravity- based systems, towards different parts of the sorting equipment. Understanding the **mechanical energy of objects and Newton's Laws of Motion** offers the engineer an option to design a system to sort materials with less human power and less fossil fuel energy. http://www.physicsclassroom.com/class

Metals and their alloys like iron and steel are **innately magnetic, or ferromagnetic,** so they can be sorted using magnets. Metals that are good **conductors**- like aluminum, can be placed in machines that induce magnetism using alternating polarity to repel cans off the line into separate areas.

Optic technologies can be used to identify types of plastics and glass using measure of light, and then separate them mechanically or with blowers or other equipment. X-rays can also used to measure density and particle size to identify materials found in electronics equipment. The **image processing software** depends on the material and facility.

Sorting and Video Games. Optic sensors found in recycling equipment are very similar to light guns found in video games, where you point the gun at a tv, computer or arcade screen and something blows up. The gun and the equipment often contains a photodiode (or a phototransistor) in the barrel. The photodiode is able to sense light coming from the screen. The gun also contains a trigger switch. The output of the photodiode and the switch are fed to the computer controlling the game.

In recycling equipment, the computer controls the puff of air or other mechanism that moves the recyclable material. These sensors can detect millions of colors of light-so are much more efficient at sorting than the human eye.
http://electronics.howstuffworks.com/question273.htm

Video game weapons use the same technology as recycling sorting facilities

Activities: How do optic sensors work?
Experiment with lasers and refraction
PBS Fiber Optics:
www.pbslearningmedia.org/resource/ate10.sci.phys.energy.lpoptic/fiber-optics/
Video about the physics of recycling centers
www.abc.net.au/catalyst/stories/2948255.htm

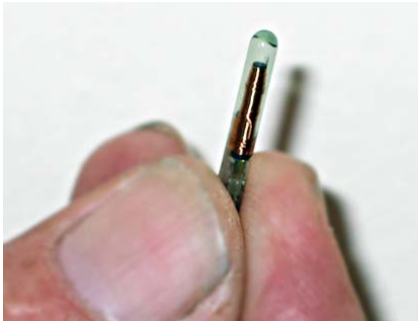
Field Trip: You can visit the SIMS Materials Recovery Facility Education Center in Brooklyn, NY to learn more about how NYC sorts out metal, glass and plastic recycling: www.simsmunicipal.com/Education

Single stream recycling refers to recycling systems that sort recyclable materials at a MRF *after they are collected,* so consumers can put recyclables all in one bin. These programs usually collect much larger volumes of materials, and reduce collection costs, but whether the material can be utilized varies greatly depending upon how contaminated the stream of material is, particularly the paper that is included.
http://www.earth911.com/living/health/when-it-comes-to-recycling-is-it-better-to-be-single/
http://www.acua.com/acua/uploadedFiles/Home/ACUA_Information/Outreach_and_Education/Jerry%20Powell.pdf

The Recycling Police: RFID Technology

Radio-frequency identification (**RFID**)electronic chips are a type of Automatic Identification and Data Capture (AIDC) technology that tracks and reports information about products, cars, animals and even people.

Used by municipalities and the resource recovery industry, they are often embedded in recycling and trash bins. The chips can identify and weigh bins, and can be used to record how often recycling bins are brought to the curb, and/or charge fees according to the weight of trash generated.
Cities like Houston, Los Angeles and Philadelphia currently use RFID's. Cleveland is implementing a new program to use RFID's to fine residents who don't put out their recycling bins. Recycling is mandatory in cities like New York and San Francisco, but fines are determined by neighborhood enforcement officials rather than RFID's.



A RFID chip used for tracking recycling.

Discussion and Debate:
Should RFID technology be used to track recycling, or is it an invasion of privacy? How is it different or the same from using public cameras?

Robot Recycling?

ZenRobotics, is a new robotic arm is being used to sort construction waste on a conveyer belt in Europe in 2014. This technology may prove useful in reducing recycling costs and even recovering valuable materials from landfills in the future. http://www.cnn.com/2013/06/07/tech/zenrobotics-recycling-robot/

Discussion and Debate:
Smart or Dumb Trash Cans?

Several Dutch cities have installed thousands of public street recycling bins that require an ID card to open and use RFID chips to charge the user for the weight of disposed trash, but recyclables are free.

It has increased recycling, prevented theft of bins but is controversial since it may encourage littering.

http://www.theblaze.com/stories/2012/09/14/dutch-robot-bins-require-id-and-charge-for-trash-by-weight/

Activity: On the Robotics Team?
Build Your Own Robot that Recycles:

Plans from Dr. David Simamora:
http://www.academia.edu/6666178/Robert_The_Recycler_Robot

Technology Preventing Waste: Food for Thought

In the U.S., over 40% of uneaten food is thrown out after it has reached stores, restaurants or homes, wasting precious food and using up valuable landfill space.

Discussion and Debate:
How can RFID's and other technologies be used to improve tracking and distribution systems to prevent waste?

Keeping it Fresh
Canning, pickling and drying have been used for centuries to preserve food. Today, **the silica gel packets** commonly found in products are filled with a desiccant that inhibits mold growth by absorbing oxygen.

MIT chemistry professor Timothy Swager recently developed a carbon nanotube sensor that detects ethylene, a chemical released by fruit as it ripens. This technology can alert stores and consumers about spoilage.
http://www.slate.com/articles/health_and_science/future_tense/2012/06/smart_food_packaging_to_keep_fruit_fresh_and_detect_spoilage_.html

abiotic decomposition, microorganisms such as bacteria, fungi, and actinomycetes, or **chemical decomposers**, change the chemistry of organic wastes as they break down the material.

anaerobic digestion is the biochemical process where microorganisms break down organic material in a low or no oxygen environment, releasing **biogas**, comprised of methane and carbon dioxide.

Automatic Identification and Data Capture (AIDC) technology- the methods of automatically identifying objects, collecting data about them, and entering that data directly into computer systems. Radio frequency identification is a type of AIDC.

bio-engineering engineering that applies biological processes to the manufacture of products

bioremediation using biological agents, such as bacteria or plants, to remove soil or water contaminants

bio-swale (or rain garden) When a series of plants serve as a filter and/or recharge area for water in a built environment

biotic decomposition, macroorganisms such as mites, centipedes, sow bugs, millipedes, slugs, beetles, ants, flatworms, and earthworms, or *physical decomposers*, break down organic material as they chew and grind materials into smaller pieces.

cycling of carbon- the movement of carbon as it is recycled and reused throughout the biosphere.

composting speeds up the natural decomposition of materials by controlling the temperature, moisture, and aeration of organic material in containers, piles or rows.

conductors materials that allow the flow of an electrical charge

decomposers consumers in a food chain that break down organic materials into simpler forms of matter.

down-cycling is when a material is recycled but the quality of the material decreases and becomes less valuable

image processing software computer programs that use optical images to organize, sort and/or analyze information

Incinerators burn trash to reduce it to a much smaller volume of ash. **Waste to energy plants** are incinerator facilities that burn trash and recover some of the energy from that process.

ferromagnetic- a substance, like iron, that below a certain temperature, the Curie point, can possess magnetization in the absence of an external magnetic field, the magnetic moments of the atoms are aligned

mechanical energy- is the sum of potential energy and kinetic energy, or the energy associated with the motion and position of an object

putrefaction is the breakdown of organic matter by bacteria

technical nutrients are non-biological materials used in the manufacture of products

Energy and Recycling

An advertisement linking energy use and recycling in Germany

The **embodied energy** found in products is all the energy consumed to grow, manufacture, store, transport, refrigerate, operate/use, recycle and/or dispose of our products. It is part of what scientists, environmentalists and businesses try to measure when calculating whether or not something is "green" or sustainable or not.

Discussion and Debate:

How green are "compostable" take out cups & containers ?

Calculating how "green" products are, even ones that are designed to help the environment, can be challenging. Many new "biodegradable" products like utensils made from new plastics, corn starch or bagasse, a waste product from sugar production, have a high amount of embodied energy. It is also debatable whether or not these products actually biodegrade in landfills. In contrast, most recycled content products use less energy than those made from virgin materials. That is why thinking about both recycling and using renewable energy sources to create and transport our products is so important. http://nature.berkeley.edu/classes/es196/projects/2013final/HarnotoM_2013.pdf
http://inhabitat.com/compostable-packaging-test-natureworks-ingeo-corn-cups/

Did You Know?
Making products from recycled materials, on average, can significantly reduce the amount of energy we use.

Recycled Plastic
1 ton of recycled plastic saves 16.3 barrels of oil
-Stanford University, 2013

Recycled aluminum
Uses 95% less energy than raw bauxite aluminum
- US Dept of Energy, 2012

Recycling just one aluminum can saves enough energy to power a TV for three hours or to listen to a full album on your iPod. Recycling 100 cans can light your bedroom for two whole weeks.
- EPA/NY DEC 2013

Recycled glass:
uses 50% less energy

Recycled paper:
uses 60% less energy with 90% less air pollution

For every steel can we recycle, we save enough energy to use a 60 watt light bulb for 36 hours

-EPA, 2013

While a recent MIT Study concluded that recycling some products save energy while others may use more, http://www.eurekalert.org/pub_releases/2011-05/miot-mnw051611.php
most of the research of products made from typical recyclables found in most municipal waste streams find that manufacturing recycled content products can significantly reduce energy consumption in many products.
http://www.epa.gov/region03/beyondtranslation/2013BTF/SessionB-Beautification/MichelleFeldman.pdf

More on Energy and Recycling: http://www.dec.ny.gov/docs/materials_minerals_pdf/geewhiz.pdf

Greenhouse Gases and Recycling

The collection, transportation, processing, disposal and decomposition of the New York City's solid waste generates 2.2 metric tons of carbon emissions. Recycling reduces **greenhouse gases** in a number of different ways. According to the NYC Department of Sanitation, these include reducing the **methane gas** released from landfills, from the energy consumption used in transportation and manufacture, incinerators, as well as increase the amount of **carbon** stored in trees. http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/planyc_progress_report_2013.pdf http://www.nyc.gov/html/nycwasteless/html/resources/wh

Did you know?

Landfills are the largest source of *man-made* methane?

Like carbon dioxide, methane is a greenhouse gas, which contributes to global warming.

As the materials you have thrown away decompose, they release methane. One pound of methane traps 25 times more heat in the atmosphere than a pound of carbon dioxide. (EPA, 2014)

Methane is also the main ingredient in natural gas, so it can be burned to produce electricity, heat buildings, or power garbage trucks. There are more than 500 Landfill to Energy Plants in the US. (EPA, 2014) http://epa.gov/climatestudents/solutions/technologies/methane.html

Discussion and Debate:

Why is using trash to produce energy considered to be a controversial solution to reducing our greenhouse gases?

Landfill Energy in NYC

Each day, the now closed Fresh Kills landfill in Staten Island captures nearly eight million cubic feet of landfill gas (a mixture of methane and carbon dioxide) using a network of suction pipes, pumps and wellheads.

Instead of venting it or burning it, it is processed on site, refined, and then sold as "pipeline-quality" gas to the local electric utility, National Grid. (NY Times, 2013)

While preventing the release of greenhouse gases, the city has made between $3 to $12 million a year in revenue over the last decade. http://www.nytimes.com/interactive/2013/09/15/nyregion/from-garbage-to-energy-at-fresh-kills.html?_r=0 http://www.bloomberg.com/news/2011-08-24/methane-fuel-trove-brings-new-york-12-million-a-year-as-dump-becomes-park.html ASK ROBBIE WHICH STAT CORRECT

In 2013, the city announced it is installing a 10 megawatt solar photovoltaic array, increasing solar energy production in NYC by 50%. Three times the size of Central Park, Fresh Kills is also being transformed into a 30,000 acre recreation area complete with wildlife tours. http://www1.nyc.gov/office-of-the-mayor/news/381-13/mayor-bloomberg-city-s-largest-solar-energy-installation-be-built-freshkills-park/

Before and After: Fresh Kills Landfill on Staten Island

Mapping Trash:
There is no "Away."

GIS mapping can be a useful tool in better understanding our waste challenges, so we can make informed choices about environmental decisions.

Mapping Trash

There is No "Away." All discarded material ends up somewhere. MIT researchers used sensors on discarded items to map the pathway of trash and recyclables, revealing the distance it travels, and ultimately its final resting place..http://senseable.mit.edu/trashtrack/press.php?id=5

Mapping the Paper Trail. Paper is the largest part of the school's waste stream. Purchasing recycled paper reduces the number of trees used to manufacture paper. This is important not only for fresh oxygen in the air and wildlife habitat, but also because trees absorb carbon dioxide from the atmosphere in a process called **carbon sequestration**. This helps mitigate the effects of our carbon emissions, reducing the effects of global warming.

Mapping is used to keep track of carbon sequestration efforts- which include trading, credits and mitigation efforts. Many of these credits are satisfied through the planting of pine trees, since most paper is made from that species. Dept. of Energy Mapping Sequestration: http://www.netl.doe.gov/

Mapping NYC paper recycling is much easier than mapping mitigation efforts: just order a pizza. Much of the paper recycled in NYC is sent to the Pratt Industries recycling facility in Staten Island, where it is used to make boxes for the pizza industry and retail stores.

Paper is the largest part of the waste stream of schools.

Activity: MAP Your Recycling

Which NYC Borough has the best neighborhood recycling rates?
Check out this interactive map of NYC to see if your neighbors are producing the most trash:
http://gothamist.com/2013/02/01/interactive_map_which_nyc_neighborh.php

Map Your School's Recycling Efforts:
Can you map what classrooms have the most contamination at your school, where the paper winds up in the trash instead of the recycling bin? Can you map pre- and post recycling campaign outcomes by classroom?
Free mapping tools: http://batchgeo.com/ and http://cooltoolsforschools.wikispaces.com/Mapping+Tools

Moving Mountains…of Waste

Trash in Transit

NYC generates 14 million tons of waste and recyclables annually. It has to be moved from homes, institutions and businesses to recycling centers or landfills.

New York City has a fleet of approximately 2,000 Department of Sanitation trucks, but another 4,000 private trucks collect the remainder of the waste from offices, businesses and construction sites.

Discussion and Debate:

Since *all the landfills have been closed in NYC*, trash has to travel as far as South Carolina to be put in a landfill!

What would happen if other states declined accepting our trash? Should they?

Sorting Out NYC: Largest MRF in North America

The new SIMS Materials Recycling Facility opened in 2013 at the South Brooklyn Marine Terminal in order to collect the NYC's metal, glass and plastic recycling. Some recyclables will be shipped using barges-which will displace about 150,000 annual truck trips, and reducing greenhouse gases.
http://www.environmentalleader.com/2013/11/19/recycling-facility-in-nyc-saves-truck-trips-money/

SIMS recycling facility in Brooklyn, NY

A 2014 protest against reopening the Upper East Side transfer station in NYC.

Discussion and Debate:

Not in My Backyard:
Where Do You Stand on Trash Transfer?

In NYC, all the waste collected has to be loaded on train cars, barges and trucks to transport it to landfills. Currently, most of the waste transfer stations are in the Bronx and Brooklyn, with none located in Manhattan.

Despite recent protests, the city has responded to environmental justice concerns and is re-opening an old transfer station in 2016 on the Upper East Side (UES) of Manhattan.
http://www.nytimes.com/2014/02/05/nyregion/fight-awaits-de-blasio-on-opening-upper-east-side-trash-transfer-site.html

Waste is a NIMBY issue, or "Not in my backyard" which is a common response to citing facilities that have negative impacts on communities.

Should NYC re-open the UES transfer station?
Does the city have a viable alternative?

How is this similar to other environmental justice issues in NYC?

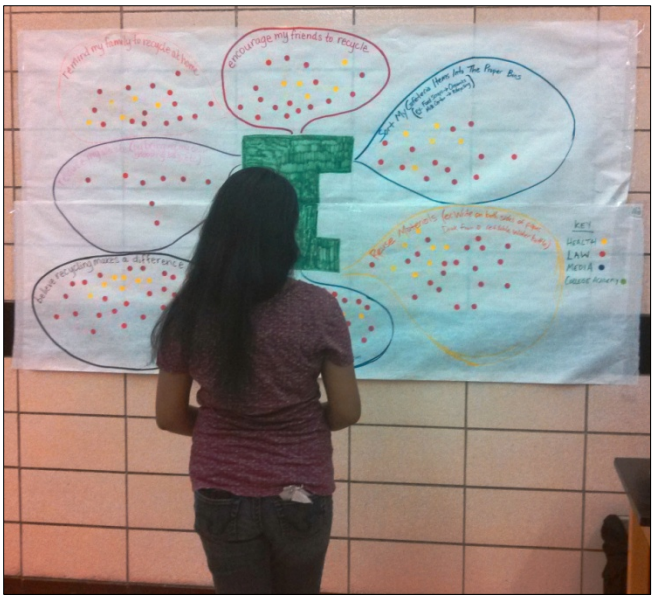
Discussion and Debate: Sorting Through NYC Recycling: A Long-term Solution or Future Problem?

SIMS Recycling has contracts with the city to accept recyclables at its new facility in Brooklyn for the next 20 to 40 years. While that protects the city from fluctuating markets, a historic problem, it does not take under consideration that the technology to sort and process recyclables may change dramatically over this time period. Should the City of New York have agreed to a 20 to 40 year contract with SIMS? Why or why not?

Read More about NYC's Solid Waste Plan:
http://s-media.nyc.gov/agencies/planyc2030/pdf/planyc_2011_solid_waste.pdf

Activity: I-Dot Student Survey

This activity is a simple way to measure student environmental habits and awareness.



Materials:

Butcher Paper	Stickers (optional)
Markers	Tape

Assembly:

Cut a piece of butcher paper (6'-8' long depending on the wall space) and draw a large "I" in the middle of the sheet. Around the "I" draw large "thought balloons" that connect the following phrases or ideas to the "I" in the center of the paper (see the photo). Be mindful to leave enough space in each of the balloons for participants to leave stickers.

Some sample survey phrases may include:

I…Encourage my friends to recycle
I…Reuse Materials (ex. write on both sides of the paper)
I…Turn off lights when leaving the room
I…Believe recycling makes a difference
I…Reduce my waste (use a re-fillable water bottle, bring my own shopping bag)
I…Remind my family to recycle at home
I…Sort my waste into the correct bins in the cafeteria

Participant Directions:

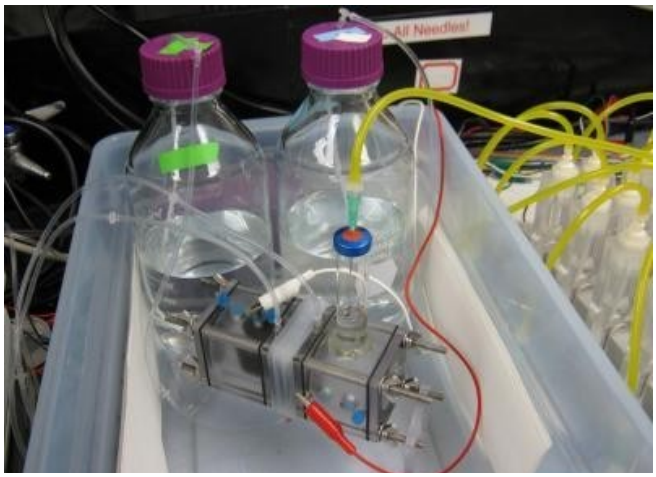
Ask students to place a sticker in each of the "thought balloons" that corresponds with an item or action that they do to benefit the environment. Students are encouraged to place stickers in as many categories that are true for them. If in a busy area or students are quick to pass by, you may solicit participants by asking students if they have a moment to take a quick survey.

Modifications:

- In place of stickers, student could draw a symbol or make a check mark in each category.
- Use different colored stickers to differentiate responses from different grades, schools, classes, etc. Additionally, using the different colored stickers allows for you to survey the interest/participation from the different groups.

Hydrogen from Wastewater: The Solution to Our Energy Crisis?

Researchers from both Penn State University and the University of California at Santa Cruz have successfully separated hydrogen from wastewater, a powerful source of renewable energy, using ***microbial fuel cells.*** Stayed tuned as they compete to make their technology cost-efficient, and introduce it to the marketplace. Although the pictures might look like technology demonstrated in a Middle School science fair project, they may hold the secret to solving our energy crisis. Hydrogen is the most abundant and powerful renewable energy source.



More information about the two contenders:
http://scitechdaily.com/new-device-produces-hydrogen-fuel-sunlight-wastewater/
http://www.dogonews.com/2011/10/2/turning-wastewater-into-hydrogen-fuel

Activity: Watch NASA Animated Video: How D Microbial Fuel Cells Work?
www.youtube.com/watch?v=V3ChCroWttY

Discussion and Debate: The Promise of New Technology:
Will it fix the problem? Or does it lead to inaction or more problems?

Rapidly changing technologies can transform our behavior and lifestyle, as we have seen with the development of computers and cell phones. Yet the promise of a technological fix to environmental issues such as climate change may result in the public and policy makers becoming less pro-active, as there may be a loss of urgency to act.

In their new book, Techno-Fix, Michael and Joyce Huesemann warn that our confidence in technology and belief that it will save us is "suicidal" and that many of our inventions are causing more harm than good.
http://sierraclub.typepad.com/greenlife/2012/02/techno-fix-why-technology-wont-save-us-or-the-environment.html

In contrast, the concept of "**ecological modernism**, " sees technology as key to solving big environmental problems, as our last "best hope" in solving climate change and other challenges.
http://www.theguardian.com/environment/2013/jul/15/technology-planet-ecological-modernism-environmental

Energy and Waste Reduction: Key Concepts

carbon sequestration the process in which trees absorb carbon dioxide from the atmosphere

carbon credit is a permit that allows a business, organization, or country to produce a certain amount of carbon dioxide and/ or greenhouse gas emissions that can traded if the full allowance is not used

ecological modernism the theory that technology can and will solve environmental challenges

embodied energy the energy used to grow, manufacture, store, transport, operate, recycle and/or dispose of our products, during the entire product lifecycle.

GIS mapping A geographic information system (GIS) creates a visual map of data to understand relationships and patterns within a specific location.

greenhouse gases gases that trap heat in the atmosphere are called greenhouse gases. There are four main greenhouse gases: carbon dioxide (CO2), methane (CH4), Nitrous oxide (N2O) and fluorinated gases, a combination of industrial emissions. The release of greenhouse gases contribute to the current trend of the increase in air, water and soil average seasonal temperatures, a phenomenon known as climate change or global warming.

methane is an odorless, colorless, flammable gas, CH4, the simplest hydrocarbon released during decomposition. Methane is also the main component of natural gas fuel, found beneath the ground. CH4 is considered a greenhouse gas, like carbon dioxide, that contributes to global warming. Methane can occur naturally or can result from human activity. It can be separated, collected, refined, burned and/or stored to be used for electricity, heating or as a fuel.

microbial fuel cells or biological fuel cell is a bio-electrochemical system that drives an electrical current by mimicking bacterial interactions found in nature

nimby issue or "Not in My Backyard" issue. Refers to the public rejection expressed to citing a facility with negative social, economic or environmental consequences in a particular neighborhood. The public rejection is usually not focused on the method or technology used but rather the location selected.

waste transfer station a facility**,** usually found in urban areas, to transfer collected trash from city sanitation trucks to rail cars, barges and/or tractor trailer trucks that transport the waste to landfills and incinerators.

The Science of Recycling Behavior

Recycling is a behavior that behavioral psychologists have been studying recycling for over 20 years.

Community based social marketing (CBSM) is used to get people to change individual and group behavior for the larger social good. First data is collected and then used to design a campaign, including the messaging, images and strategies. This is very similar to the private sector using **focus groups** and surveys to design an advertising campaign to sell a product. Municipalities use CBSM to identify barriers to adopting a behavior, and opportunities to increase it. CBSM Quick Reference Guide: http://www.csc.noaa.gov/digitalcoast/_/pdf/social_marketing.pdf

Information is Not Enough

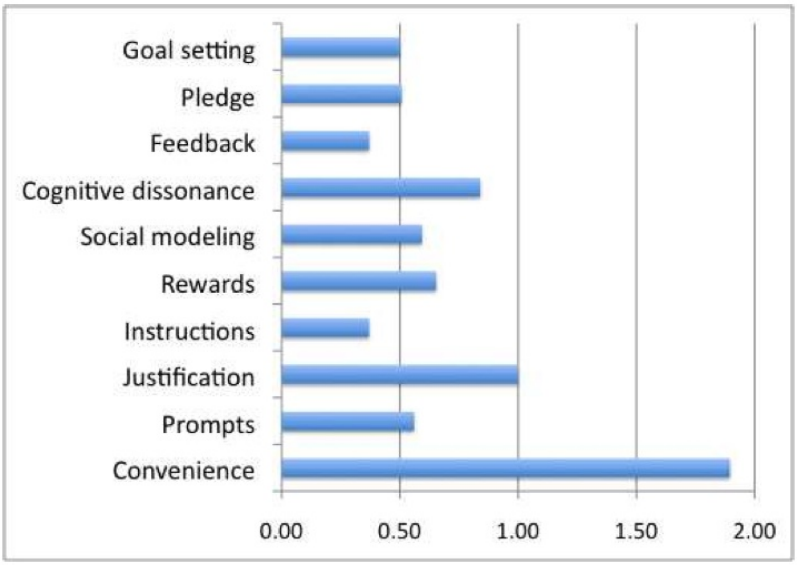
According to marketing professor Kate White of the University of British Columbia, concluded that the most effective types of recycling campaigns were ones that had urgent messages with information about negative consequences and loss , but worked best when clear instructions for recycling were included. "Feel good" messages that outline the benefits of recycling also worked more long term, particularly when they were paired with information about why recycling is important more generally. http://csi.gsb.stanford.edu/how-do-you-encourage-recycling

http://recyclemaniacs.org/sites/default/files/Strategy%20Guide_for%20web.pdf

Guide to More Effective Recyclemania: Using Behavior Change Strategies to Motivate Students to Recycle

In order to get people to recycle, an important first step in CBSM is to remove barriers and increase opportunities, like making sure bins and signs are placed in convenient areas.

What Works?



Note: Meta analysis of recycling studies, combined across three types of programs. N=41 public, N=52 curbside, N=18 central collection. Osbaldiston & Schott (2012)

Source: Osbaldiston, R., & Schott, J. (2012). Environmental sustainability and behavioral science: Meta-analysis of pro-environmental behavior. Page by Les Robinson.

History, Technology and Recycling

Recycling rates have fluctuated during different periods throughout U.S. and world history. These changes are connected to many variables, such as the economic health of the nation/community, international conflict, policy changes and technological changes in production and packaging.

Paper was made from recycled cloth rags and waste paper, not trees, until the 1920's when wood processing and transportation systems improved. In this case, technology was a key variable in recycling rates changing.

When it is required or necessary, recycling behavior increases, as it did across the U.S. during World War II. Huge quantities of materials were collected by mostly volunteer efforts. Government marketing campaigns connected recycling behavior with protecting soldiers and winning the war. These changes became part of the popular culture, as even Hollywood was recruited to promote recycling as part of the War Effort.

When the war ended, recycling rates declined as the government no longer needed huge quantities of materials for the *military industrial complex*. At the same time, U.S. corporations heavily marketed single use disposable items, as packaging technology improved and offered companies a way to increase their profit margin.

See Sort it Out Social Studies History and Recycling Unit for more info.

Rita Hayworth, a popular movie star during the 1940's, in a World War II recycling campaign. Just as movie stars are used to sell sneakers and soda, images from popular culture can be used to increase behaviors that help the environment. **How can you replicate these marketing techniques to increase recycling at your school?**

Activity: Creating a Research and Recycling Campaign

Check out the latest NYC School recycling campaigns: www.grownyc.org/rcp

A marketing campaign can increase recycling at your school. This can include posters, making videos, art work, website pages, educational presentations and/or newsletters to spread the word about recycling.

Interviewing students, faculty and staff about why they think people don't recycle, when and where they recycle, and what might increase recycling, will give you the data you need to identify recycling barriers and opportunities.

Creating educational messaging and content based on your findings, and help to remove any convenience barriers in the school. To be most effective, make sure the messaging includes more than recycling facts and figures to take advantage of what we understand about behavioral psychology and recycling.

Compare the effects of marketing messaging on recycling outcomes at different locations at the school:
At one location, include urgent messages, paired with instructional information.
At a second location, include some specific benefits of recycling with some general info on why it benefits the earth.

Compare the effects of different types of marketing (video, print, live presentation) on recycling rates of classrooms and/or grades.

Sustainable Practice: Understanding Recycling Behavior Key Concepts

Community based social marketing (CBSM) A systematic type social marketing designed to foster more sustainable behavior.

focus groups. Using qualitative research to collect information and interview a group of people to identify their preferences, beliefs, habits and other behaviors

social marketing using commercial marketing research and best practice techniques to influence behaviors that benefit individuals and communities for the greater social good, rather than to generate profits.

military industrial complex the relationships between policy makers, the military and the arms industry that connect their activities and influence their decision making.

Additional Resources:

Grow NYC Recycling Champions Program
K-12 Educational Resources
www.grownyc.org/rcp

Jason Learning and the Institute of Scrap Recycling Industries, Inc.
STEM Unit- Recycling Education Activities
http://www.jason.org/partner/isri

K-12 Education for Sustainability Curriculum
Putnam Northern Westchester BOCES Curriculum Council
Grade 4 Math/Science Lesson 2: Cycles & Systems
Grade 5 The Arts Lesson 1: Dash the Trash
Grade 6 Math Lesson 4: True Cost of a Water Bottle
http://www.pnwboces.org/efs/sample_lessons.html

EPA Educational Resources on Waste Issues
http://www.epa.gov/osw/education/teach_curric.htm

Waste-Less New York City Department of Sanitation Educational Resources
http://www.nyc.gov/html/nycwasteless/html/recycling/schools_rrrguide.shtml

Materials Recovery Facility Industry Recycling Education Website (Videos)
http://www.recommunity.com/education/

Recycle Bowl Educational Resources
http://recycle-bowl.org/playbook/educational-resources/

New York State DEC Recycling Education Resources
http://www.dec.ny.gov/chemical/8506.html