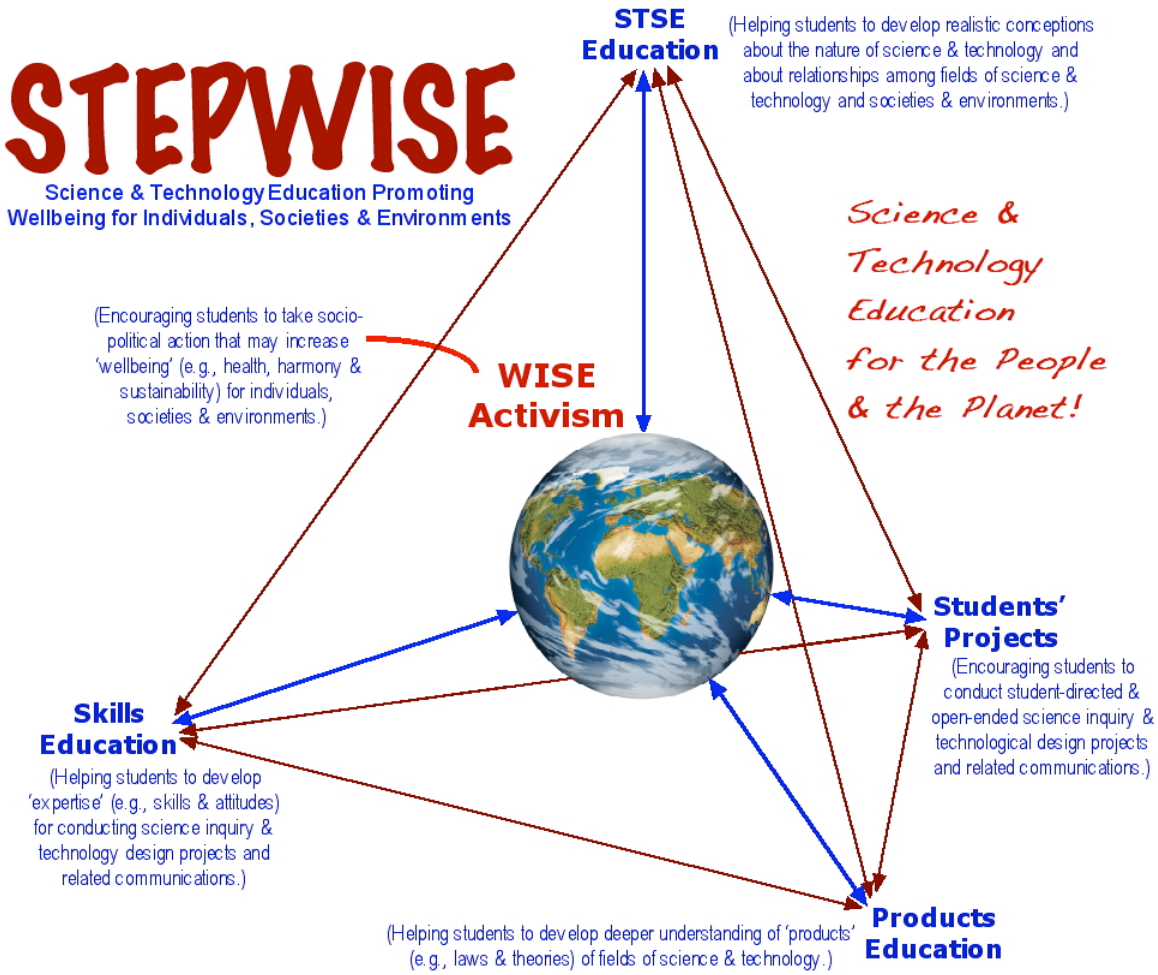
STEPWISE

http://www.stepwiser.ca

BIO-PLASTICS

Case Method

The case method provided here is based on the STEPWISE curriculum and instructional framework provided below. This and other case methods provide some basic information about a 'WISE' issue, such as possible problems relating to petroleum products. Teachers then provide instruction in each of the STEPWISE elements, and encourage students to conduct research to enhance their knowledge, skills and findings (in the case of Students' Projects) — related to the STEPWISE framework. Instruction and student work culminate in students' WISE Activism; i.e., action(s) to address the WISE issue.



ACKNOWLEDGEMENTS

This resource was produced for STEPWISE, a research and development project funded by the Social Sciences and Humanities Research Council (SSHRC), Canada. STEPWISE is under the direction of Dr. J. L. Bencze, OISE, University of Toronto. This resource was initially created by Kelli Hazzard and revised by members of the STEPWISE committee. The diligent work by these people is gratefully acknowledged, as is the funding from SSHRC.

STEPWISE Case Method

PROTEINS IN YOUR CAR?

Introduction

There is currently a very large area of research being undertaken that is focusing on bio-plastics. Bio-plastics are a new generation of biodegradable plastics, whose components are derived entirely or almost entirely from renewable raw materials. Bio-plastics are exciting because they have the potential to alleviate the tremendous problems associated with waste management and can help preserve non-renewable resources such as petroleum, natural gas, and coal, that are currently being used in the production on plastics. However, before we take a closer look at bio-plastics we need to understand what plastics are today.

<table>
<tr><th>WISE Issue</th><th colspan="3">Resources/Factors in Decision-making</th><th>WISE Action</th></tr>
<tr><td rowspan="3">Impact of the use of fossil fuels in the production and use of polymers (plastics)</td><td>STSE Expertise</td><td>Products Expertise</td><td>Activism Expertise</td><td>Possible Action Projects</td></tr>
<tr><td>Environmental and health impacts associated with the production, use and disposal of fossil fuel-based polymers (plastics)</td><td>Chemical composition of carbon-based polymers (plastics)

Technologies used for the extraction of fossil fuels and for the production of polymers.</td><td>Assessing the benefits and hazards of a specific technology.

Developing and carrying out an action plan.</td><td rowspan="2">Education campaign e.g. informational brochure or ad.

Community change campaign e.g. display posters identifying products that are packaged in biodegradable and non-biodegradable materials.

Personal lifestyle change e.g., avoiding the purchase and use of non-biodegradable plastics; avoiding purchase of overpackaged goods; preferentially purchase goods packaged in biodegradable materials.</td></tr>
<tr><td>NoST Expertise

Opportunities to explore:
the economic and cultural factors that can influence science and technology</td><td>Skills Expertise

Expertise for: hypothesizing, experimenting, developing prudent conclusions</td><td>Project(s) Findings

Results and conclusions from experimental studies on the biodegradability of packing materials.</td></tr>
</table>

Prior Knowledge

Students should be able to:

- Recall that carbon-based fossil fuels are used to produce most of the plastics used to produce and package goods.
- Recall that carbon-based plastics resist degradation in the environment.

Curriculum Expectations Addressed

This case is appropriate for the following grades and strands:

Grade	Course	Strand	Specific Expectations Addressed
7	Science and Technology	Relating Science and Technology to Society and the Environment	IE1.01 investigate the impact of the use of technology on the environment (e.g., greenhouse effect, disposal of obsolete technology such as computers and personal audio devices, use of pesticides) and identify personal choices that can minimize these impacts. IE1.02 identify factors (e.g. economic, social, environmental) that should be considered in the management, use and preservation of the environment for sustainability (e.g., the cost of recycling, environmental impact of ecotourism) and communicate the pros and cons of the decisions. IE3.03 identify and explain the roles of producers, consumers, and decomposers in food chains and their effects on the ecosystem (e.g., plants as producers in ponds, black bears as consumers in forests, earthworms as decomposers in soil).
		Life Systems: Interactions in the Environment/Interactions Within Ecosystems	
9	SNC 1D, SNC 1P	Chemistry: Atoms and Elements	CAE1.2 assess the social and environmental impact of the production, use and disposal of elements or compounds and propose a plan of action that addresses the impact.
11	SCH 3U	Chemical Reactions	CR1.1 research and report on the safety concerns related to human health or the environment, and associated with the

			production or use of a chemical substance in industry (e.g., mining, agricultural, pulp and paper, automotive).
12	SES 4U	Earth Material	EM1.1 assess the direct and indirect impact of the exploration, extraction and refinement of Earth materials (e.g, gold, uranium, diamonds, sand, gravel, dimension stone, and fossil fuels) on local, provincial or national economies (e.g., metals mined in one community are refined in a second, processed in a third, used to assemble products in a fourth and then sold all over the province or nation.)

What are plastics?

Plastics are substances that satisfy three primary conditions:

1) It's main ingredient must be a *polymer* material
2) It must be fluid at some point during processing (usually processed using heat),
3) It must be solid in its final form

Have students investigate what polymers are and the various chemical structures of polymers. What properties of polymers make them strong and flexible? Have students identify examples of plastics. Make sure to include nylon, carpets, and polyester shirts.

Currently, one of the main ingredients in plastic is oil and as a result plastics are manufactured in petrochemical factories, which consume about 270 million tons of oil and gas every year worldwide. Fossil fuels provide both the power and the raw materials that transform crude oil into common plastics such as polystyrene, polyethylene and polypropylene. Fossil fuels are non-renewable and the burning of them significantly contributes to global warming. Some projections suggest that the world could run-out of oil within 80 years.

Plastics are heavily used car manufacturing and make up everything from dashboards to bumpers. According to the Ecology Center in the US, the amount of plastics used in vehicles increased from 0.6 percent in 1960 to 7.5 percent in 2003, accounting for 4.3 billions pounds of plastic annually in the United States alone. Many of these plastics release toxic chemicals and are difficult to recycle. For example, PVC is made of fossil fuels and chlorine and is found in products such as dash boards and exterior trim. As a result of all of these issues, car manufacturers and researchers have been focusing on finding more sustainable and environmentally-friendly alternatives to petrochemical-based plastics.

Have students brainstorm some naturally occurring substances that they feel might be used as a plastic. Teachers should provide some examples of strong substances like fingernails and spider webs to get students started.

Bio-plastics

Naturally occurring biopolymers that have potential to be used or are being used as green plastics include, cellulose, starch, collagen, casein, soy protein, and polyesters. In

addition, there are also natural materials that can be made into polymers including, lactic acid and triglycerides.

With students, brainstorm what properties make bio-plastics practical? (consider strength, resilience, flexibility, elasticity, durability, cost-effectiveness, environmental impact – including production, biodegradability, renewability). Assign students a biopolymer and have them come up with an advertising campaign based on their research of that polymer. The ad should address the properties and bio-chemical structure of the substance that makes it a good candidate for use as a plastic. Students should determine which types of application or products the substance would be best suited for and why.

Examples of bio-plastics in use today include:

- *Starch-based bioplastics* - least expensive biopolymer and can be processed by all of the methods used for synthetic polymers, like film extrusion and injection molding. Eating utensils, plates, cups and other products have been made with starch-based plastics.
- *Soybeans* -soy protein, with and without cellulose, can be processed with modern extrusion and injection molding methods. Ford has spearheaded this research (Henry Ford began research into the uses of soy beans back in the 1930's!)
- *Water soluble biopolymers* – these inlude starch, gelatin, soy protein, and casein which form flexible 'films'. Although such films are regarded mainly as food coatings, it is recognized that they have potential t be use as stand-alone sheeting for food packaging and other purposes.
- *Poly (lactic acid)* – this has become a significant commercial polymer. Its clarity makes it useful for recyclable and biodegradable packaging, such as bottles, yogurt cups, and candy wrappers. It has also been used for food service ware, lawn and food waste bags, coatings for paper and cardboard, and fibers-for clothing, carpets, sheets and towels, and wall coverings. In biomedical applications, it is used for sutures, prosthetic materials, and materials for drug delivery.

What are some of the issues with bio-plastics?

Currently, bio-plastics are not without issue. For one, being able to biodegrade comes at a price – the release of carbon dioxide and methane into the environment. These substances are targeted greenhouse gases that contribute to global warming. In addition, in the manufacturing of bio-plastics, fossil fuels would still be needed to power the process. There are also many environmental concerns associated with agricultural practices and these practices would likely been greatly amplified by the need to manufacture certain crops to make bio-plastics from. It is important that these issues are considered since it essential that one environmental concern is not traded for another.

A recent breakthrough…

In early 2005, two researchers at Cornell University discovered they could make plastics from citrus fruit (oranges) and carbon dioxide. Essentially, orange peel oil (limonene) and carbon dioxide are combined using a catalyst to form a polymer, polylimonene carbonate, that has many of the characteristics of polystyrene (a petroleum-based plastic currently used to make many disposable plastic products). The big benefit is that the process requires carbon dioxide to drive the process.

Additional teaching suggestions

- Have students make 'bio-plastics' out of gelatin and other substances – there are a variety of recipes on the web
- Have students come up with their own bio-polymer that could be used to manufacture bio-plastics

Assessment Rubric

Criteria	Level 1	Level 2	Level 3	Level 4
Knowledge and Understanding	- demonstrates minimal understanding of the nature of fossil fuel-based plastics and biodegradable plastics.	- demonstrates some understanding of the nature of fossil fuel-based plastics and biodegradable plastics.	- demonstrates considerable understanding of the nature of fossil fuel-based plastics and biodegradable plastics.	- demonstrates a thorough understanding of the nature of fossil fuel-based plastics and biodegradable plastics.
Application	- connects knowledge of biodegradable and nonbiodegradable plastics with impacts on the environment with minimal effectiveness.	- connects knowledge of biodegradable and nonbiodegradable plastics with impacts on the environment with some effectiveness.	- connects knowledge of biodegradable and nonbiodegradable plastics with impacts on the environment with considerable effectiveness.	- connects knowledge of biodegradable and nonbiodegradable plastics with impacts on the environment with a high level of effectiveness.
Communication	-communicates information with limited clarity - Information is communicated with minimal organization. -employs language skills with limited effectiveness.	- communicates information with some clarity - Information is communicated with some organization. -employs language skills with some effectiveness.	- communicates information with considerable clarity - Information is communicated with considerable organization. -employs language skills with considerable effectiveness	- communicates information with a high degree of clarity - Information is highly organized. -employs language skills with a high degree of effectiveness.

References

http://www.post-gazette.com/pg/05066/466660.stm
http://www.greenplastics.com/
http://www.news.cornell.edu/releases/Jan05/Orangeplastic.deb.html
http://www.mindfully.org/Plastic/Biodegrade/Green-PlasticsAug00.htm
http://www.michigan.gov/mda/1,1607,7-125-1570_2468_2469-12681--,00.html