Web Activity: Web Quest—Cellulosic Ethanol
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As early as 1860, the first internal combustion engines used ethanol as their fuel. By the 1890s, ethanol fueled engines in farm machinery, locomotives, and the first cars. It was not until the 1920s that automobile engines started to use a greater percentage of gasoline, due to greater availability through oil exploration. Interestingly, the early engines used a blend of ethanol and gasoline because gasoline has a much lower octane rating and is less stable. The abundance of gasoline and improved refining techniques allowed petroleum to dominate the automotive fuel market for many decades. Now that fuel prices are at close to an all-time high, and pollution is increasing due to the number of automobiles on the road, the demand for cleaner fuels is gaining momentum. Ethanol is one of the alternatives under consideration.

There are three main methods of producing ethanol.

- The earliest used method was fermentation of sugars, which is the same method used in the production of alcoholic beverages. Distillation of the fermented sugar solution can concentrate the ethanol up to approximately 96%.
- Another method, which uses petrochemicals to produce ethanol, is the hydration of ethene. (See Figure 2 in Section 10.1 and the Summary in Section 10.3 of the textbook.)
- The third and the newest method is the production of ethanol from cellulose wastes such as wood pulp, straw, and sawdust. The cellulose in these wastes has traditionally been very difficult to break down into the sugars. Because of this, cellulosic ethanol production in the past has been very costly.

Both of the first two methods require a lot of energy, either to specifically raise and cultivate the crops or to extract the raw petrochemical feedstock. Recent developments in technology are going some way toward overcoming the difficulties of making cellulosic ethanol, thus bringing down the cost and making the process economically viable.

A company is proposing the building of a cellulosic ethanol plant in your community. Your scientific consulting firm has been hired to investigate the technological, environmental, and ecological impact of building this new facility.

Task

Your team will create an audio-visual presentation that will either support or oppose an application made by a company that is proposing the construction of a cellulosic ethanol plant in your community. These plants cost upwards of $250 million and take many months to build. This presentation will be used at a town hall meeting in your community as they decide whether to allow the building of this plant. In your presentation you will need to discuss:

- the environmental impact of building the plant,
- the environmental impact of using ethanol as a fuel,
- the availability of biomass and how it is transported to the plant,
- the economic impact of producing large quantities of ethanol at the plant, and
- the technology behind the production of cellulosic ethanol.

Process

1. Get together with a group or team based on instructions from your teacher. Your teacher may assign a pro/con position to your team for the building of the plant, or you may be allowed to choose your position based on your research. Each member of the team should be assigned a different task, such as a slide on a specific perspective.
2. Your team's a-v presentation should include:
   (a) a title slide, including a purpose for the presentation, with the names of the team members
   (b) an introduction slide listing the three main types of ethanol production (with reaction equations)

(c) one or two slides explaining the science and technology behind cellulosic ethanol production, which could include advantages or disadvantages over the other two methods
(d) one to three slides discussing the environmental impact of building the plant in your community, including the actual construction of the plant, the day-to-day running of the plant, and the transportation of biomass
(e) one to three slides discussing the economic impact of building the plant in your community, including the actual construction of the plant, the day-to-day running of the plant, and the transportation of biomass
(f) one slide stating your recommendation on the project, with a summary of your reasons

Make sure that cite any sources (such as Web sites, books, or personal communications) of information or images.

The appearance of your presentation is important. It should be well-organized, neat, appealing, and professional looking.

Resources

You might like to start your research at these sites and then find some of your own resources.

Ethanol: The Road to a Greener Future
Natural Resources Canada Web site supplies information on ethanol use in Canada, including environmental information.

Ethanol: Questions and Answers
This is a publication from the Office of Energy Efficiency, which is part of Natural Resources Canada. The document answers questions on ethanol production in Canada.

Canadian Renewable Fuels Association
This industry association promotes the use of Canadian biofuels. Click on Ethanol for specific information, including fact sheets and links to other resources.

Wikipedia: Cellulosic Ethanol
The popular online encyclopedia gives detailed information on the production methods of cellulosic ethanol, as well as economic issues. Click on *ethanol* for more general information.

Iogen Corporation
Iogen is a Canadian firm that is leading the way in cellulosic ethanol research and production.

Cellulosic Ethanol: Spinning Straw into Fuel
This article from *BioCycle* discusses many of the issues surrounding ethanol production using cellulose biomass.

Ethanol: Viable Fuel Option or Green Pipe Dream?
This **CTV.ca** story discusses many of the environmental and economic issues surrounding the production of ethanol in Canada.

Finally: Cellulosic Ethanol
The EVWorld Web site hosts this interview with Iogen vice president Jeff Passmore on the commercial future of cellulosic ethanol.

Talking Points
The American Coalition for Ethanol is not an unbiased source, but its Web site provides information about the use and production of ethanol in the United States, with details on energy, transportation, and pollution.

How Much Energy Does It Take to Make a Gallon of Ethanol?

The authors present their research on how much energy it takes to create ethanol using different processes. Note that this is 1995 data. You could search for more recent information.

Determining the Cost of Producing Ethanol from Starch and Lignocellulose Feedstocks
This technical report by the US National Renewable Energy Laboratory shows the cost of producing ethanol from starch and cellulose—including all factors such as equipment investment and depreciation.

Evaluation

Descriptor	4	3	2	1
Content of audio-visual presentation	• Presentation correctly lists the three **main types of production**, with reaction equations.	• Presentation lists the three **main types of production, with reaction** equations, mostly with minor errors.	• Presentation lists the three **main types of production**, with reaction equations, with significant errors.	• Presentation fails to list the three **main types of production**, with reaction equations.
	• The **science and technology** of production are clearly explained, with several advantages/ disadvantages	• The **science and technology** of production are explained, with some advantages/ disadvantages	• The **science and technology** of production are generally explained, with no advantages/ disadvantages	• There is little or no explanation of the **science and technology** of production, with no advantages/ disadvantages
	• **Environmental impact** is discussed fully and thoughtfully.	• **Environmental impact is** discussed adequately.	• **Environmental impact** is discussed to some extent.	• **Environmental impact** is not addressed.
	• **Economic impact** is discussed fully and thoughtfully.	• **Economic impact** is discussed adequately.	• **Economic impact** is discussed to some extent.	• **Economic impact** is not addressed.
	• A reasoned **recommendation** is clearly stated.	• A **recommendation** is stated with some reasoning.	• A **recommendation** is loosely stated with little reasoning.	• No **recommendation** is stated.
Overall quality of audio-visual presentation	• Presentation shows evidence of **detailed research**.	• Presentation shows evidence of **adequate research**.	• Presentation shows evidence of **limited research**.	• Presentation shows little evidence of **research**.
	• All **sources** of information are correctly cited.	• Most **sources** of information are correctly cited.	• Some **sources** of information are cited, but not always correctly.	• **Sources** of information are not cited.

	• Presentation was very well **organized**, easy to follow, neat, appealing, and professional looking.	• Presentation was well **organized**, easy to follow, neat, appealing, and professional looking.	• Presentation was somewhat **organized**, easy to follow, neat, appealing, and professional looking.	• Presentation was not **organized**, easy to follow, neat, appealing, or professional looking.

Learning Outcomes Addressed

30–C1.2k identify and describe significant organic compounds in daily life, demonstrating generalized knowledge of their origins and applications

30–C1.1sts explain how science and technology are developed to meet societal needs and expand human capability

30–C2.2sts explain that science and technology have influenced, and been influenced by, historical development and societal needs

- *describe processes involved in producing gasoline; e.g., adding compounds such as oxygenated additives (blending with ethanol)*

30–C2.3sts explain how science and technology have both intended and unintended consequences for humans and the environment

- *assess the positive and negative effects of various reactions involving organic compounds, relating these processes to quality of life and potential health and environmental issues; e.g., burning fossil fuels and climate change*

30–C1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- *analyze the contributions and limitations of scientific and technological knowledge to societal decision making in relation to the costs and benefits of society's use of petrochemicals, pharmaceuticals and pesticides*

30–C2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *use advanced menu features within a word processor to insert tables, graphs, text and graphics when preparing a report on an issue related to society's use of organic chemistry*.

In Summary

This Web Quest will give you some insight into the issues surrounding ethanol use in fuels and the production of ethanol in industry. Ethanol has been used as a fuel for a long time and, though it fell out of favour due to the availability of relatively cheap gasoline, it is seemingly making a comeback. Recent advances in technology have led to more and more efficient production of ethanol but there are still obstacles to overcome. Will we see the infrastructure put into place to use ethanol to its fullest potential? Will most vehicles in the future be produced with the ability to burn E85 fuel? Or will other environmentally friendly technologies become sufficiently viable to fully replace gasoline as a fuel?

