The BLOOM School Box

Learning Scenario

Yeast, biofuels and novel biotechnology techniques

This learning scenario is part of the BLOOM School Box, which consists of a set of learning scenarios combining bioeconomy into science, technology, engineering and mathematics (STEM) subjects.

This resource was developed as part of the BLOOM "Teach bioeconomy!" competition and is one of the winning entries that have been evaluated by an international team of bioeconomy experts and expert teachers. This learning scenario has been developed as part of the BLOOM project.

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Learning scenario summary

Using discussion methods, lab experiments, data analyses, this learning scenario gives students an introduction to bio-based product and their use for energy production.

Subject	**Science, Biology, Chemistry**
Topic	**Biotechnology for the biobased economy**
Age of students	**16-18**
Preparation time	**45 minutes**
Teaching time	**315 minutes**
Online teaching material	• Socrative: https://socrative.com/ • Canva: https://www.canva.com/ • https://www.ncca.ie/media/3446/colab_guidelinesforassessingcollaborativelearning_2018_pub.pdf **Resources about CRISPR:** • https://www.youtube.com/watch?v=6tw_JVz_IEc • https://www.youtube.com/watch?v=jAhjPd4uNFY • https://www.youtube.com/watch?v=sweN8d4_MUg • https://www.sciencedaily.com/releases/2016/01/160126162324.htm • http://babec.org/wp-content/uploads/2016/09/Jason_Peters.pdf
Offline teaching material	• 8 (or more) packets of yeast • 4 clear glass, half-litre containers • stirrers • measuring spoons • flour, salt, sugar, vinegar • heating element • thermometer • timer **For the groups:** • Oil burners (two per group – one filled with diesel and one filled with biodiesel) • Small funnel • Lighter • 250 ml Graduated cylinder • Balance accurate to 0.01g (Weight capacity: ~500 g)
Bioeconomy resources used	• https://geneticliteracyproject.org/2018/08/15/crispr-edited-yeast-could-make-biofuel-production-more-efficient/

- https://bbsrc.ukri.org/documents/practical-biofuel-activities-complete-pdf/
- https://www.europabio.org/cross-sector/publications/achieving-potential-genome-editing
- http://www.cpalms.org/Public/PreviewResourceLesson/Preview/149175
- https://ec.europa.eu/research/bioeconomy/pdf/eu_bioecnomoy_apartment_katalog.pdf
- https://www.vtt.fi/inf/julkaisut/muut/2017/syntheticbiologyroadmap_eng.pdf
- http://www.bio-step.eu/fileadmin/BioSTEP/Bio_documents/BioSTEP_Bioeconomy-in-everyday-life_Glasgow_Exhibition-Guide.pdf
- The BLOOM School Box: Bloom your school with your biofuel and soap lab learning scenario

Relevant trends

Relevant trend(s) the Scenario is intended to respond to. E.g. at http://www.allourideas.org/trendiez/results

STE(A)M Learning

Collaborative Learning: a strong focus on group work.

Edutainment: playful learning. Learning while having fun.

Cloud Based Learning: data, tools, software are all online and can be reached and modified from different devices.

Aim of the lesson

What are the main objectives? What will students achieve by the end of the lesson?

By the end of this lesson students will be able to:

- Describe and explain bioeconomy
- Describe the production of ethanol from renewable sources
- Carry out fermentation to produce ethanol and analyse the rate of fermentation of different sugars
- Discover and understand the challenges of producing biofuels from yeast on an industrial scale
- Understand how modern biotechnology (gene editing via CRISPR/Cas9 and similar technologies) can contribute to a move towards a biobased economy
- Evaluate the use and economic advantages of producing liquid biofuels from sugar

Activities

Name of activity	***The detailed description of the activity***	***Time***
Introduction to bioeconomy	The teacher introduces the idea of bioeconomy. For this, it's possible to use resources presented in Module 1 and in Module 2 of the "Boosting bioeconomy knowledge in schools" MOOC and the BLOOM School Box, especially the following learning scenario: Bloom your school with your biofuel and soap lab. The class is discussion driven and topics include biobased products, the role of plants in our ecosystem and for energy production, biofuels, the importance of bioeconomy and the circular economy, difficulties that researchers face when upscaling from lab to industry production, the role of biotechnology and novel methods of gene editing. Students are divided into groups of four. Each group is given a topic to research before coming to class. For this activity, the alternative to a discussion based method (whole class contributes to the discussion, one coordinator is appointed and one person is taking notes) is the jigsaw method.	45 minutes
Biofuels from yeast	Students are working in pairs and performing a lab experiment about yeast fermentation. After the completion of the experiment, each student must individually submit a laboratory report. Students will investigate fermentation by testing different substances such as flour, salt, sugar and vinegar. The laboratory procedure for this activity has been documented in different papers and sites. We will use as reference the following two and develop a laboratory worksheet. 1. http://teachers.egfi-k12.org/class-activity-ethanol-fermentation/ 2. https://bbsrc.ukri.org/documents/practical-biofuel-activities-complete-pdf/ Students must also investigate the effect of temperature and the effect of sugar concentration and pH. Each group can select their variables and design their own experiment.	90 minutes
Comparing fuels: Combustion of renewable and fossil fuels	In this laboratory exercise, students will understand energy content and combustion emission differences between diesel and biodiesel. Students have one oil burner filled with diesel in front of them and begin the procedure using that burner. Afterwards they will repeat the procedure using an oil burner filled with biodiesel. The activity can be found online, as it has been documented in many articles. Students work in pairs to complete a data table and analyse their data. For each fuel they will be asked to:	90 minutes

Name of activity	*The detailed description of the activity*	*Time*
	• Calculate change in temperature (Δt) and the mass of fuel burned (g). The change in temperature Δt (°C) equals final temperature minus the initial temperature. • Calculate the mass of fuel burned. Mass of fuel burned (g) equals final mass of oil burner minus the Initial mass of oil burner. • Calculate the amount of heat transferred to the water q=mCΔt • Calculate the heat of combustion by dividing q by the mass of fuel used.	
Debate: Challenges of producing biofuels from yeast. Is biofuel from yeast a promising alternative fuel source?	Students research the question and give a brief report, either orally or in a written form. The class can then choose sides and prepare arguments for a formal debate. For example: ethanol is a promising alternative fuel source, however there are concerns about the costs of its production. Students will address the challenges for producing biofuels from yeast. For example: the challenge faced by researchers is that some chemicals used to speed up the breakdown of plants for production of biofuels such as ethanol have a poisonous effect to the yeasts that turn the plant sugars into fuel. This will be the connection to the next activity – the importance of biotechnology advancements for achieving a biobased economy.	45 minutes
The potential of using CRISPR for a biobased economy	In the past few years rapid development in a series of genetic technologies – most notably CRISPR – has made it to make targeted changes to genomes. The potential application of these technologies for the efficient production of biofuels is very promising. Students will be introduced by a short presentation to what CRISPR is. Some resources that may be used are: 1. https://www.youtube.com/watch?v=6tw_JVz_IEc 2. https://www.youtube.com/watch?v=jAhjPd4uNFY 3. https://www.youtube.com/watch?v=sweN8d4_MUg 4. https://www.sciencedaily.com/releases/2016/01/160126162324.htm 5. http://babec.org/wp-content/uploads/2016/09/Jason_Peters.pdf If time and material available students could perform a bacterial CRISPR experiment. A kit for a classroom CRISPR experiment can be found online.	
Create and present an infographic	For the final assessment, students use online tools to design an infographic about how advancements in biotechnology and	45 minutes

Name of activity	***The detailed description of the activity***	***Time***
about: Biotechnology the biobased economy	bioeconomy are interconnected. Students will then present their infographic in class and exchange feedback.	

Assessment

What are the main types of assessment used?

Online quiz in Socrative (https://socrative.com/)

Laboratory Report: students will present their yeast fermentation experiment in a lab report that will be assessed by a rubric addressing two criteria:

- Design of the experiment
- Collection and processing of results

Students will create and present in pairs **an infographic** about "Biotechnology for the biobased economy" using tools such as Canva (https://www.canva.com/). A rubric will be created in order to assess the infographic and the presentation according to Co-Lab guidelines.