Boosting European Citizens' Knowledge and Awareness of Bio-Economy Research and Innovation

D 4.1

The BLOOM School Box

Report

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Executive Summary

This document aims to describe the development of the BLOOM School Box - a collection of five bioeconomy related teaching resources produced as part of WP4. The School Box, developed by 20 pilot science teachers, serves as a pioneering collection of teaching resources for implementing bioeconomy in the classroom. Moreover, the BLOOM School Box acts as the core of the BLOOM learning strategy, which offers interested teachers many professional development opportunities. Among these are the "Boosting Bioeconomy Knowledge in Schools" massive open online course, which allows participants to gain insight into the topic of bioeconomy through the BLOOM School Box (and the associated "Teach bioeconomy!" competition, where the best 15 learning scenarios will be added to the School Box), the BLOOM teacher trainings, which will further enhance the dissemination and uptake of bioeconomy learning resources among interested teachers and the BLOOM interdisciplinary school competition, which will encourage teachers everywhere to bring bioeconomy into their teaching.

This deliverable is divided into two main parts. In the first section, we strive to introduce the BLOOM School Box, its aims and methodology. Then, we exhibit the co-creation process of the learning scenarios and finally, display the outreach and dissemination activities organised to upscale the use of the BLOOM School Box. In the second part, we describe the five learning scenarios.

Teachers are the basis of knowledge transmission and innovation in the classroom and are key in forming the ideas of future generations. The BLOOM project recognizes teachers' continuous work and aims to build on their first-hand experience when it comes to introducing bioeconomy to primary and secondary classrooms. The BLOOM School Box is the result of a fruitful collaboration and co-creation process.

1. Introduction to the BLOOM School Box

The BLOOM School Box (Task 4.1) is a pioneering collection of bioeconomy related teaching resources which educators can use to introduce the concept of bioeconomy in their classrooms as a trigger to raise student interest in science subjects and their awareness of important societal challenges. The basis of the BLOOM School Box are five innovative learning scenarios, co-created and tested in classrooms by the 20 BLOOM pilot teachers from Austria, Belgium, Croatia, Greece, Italy, Israel, Poland, Portugal, Spain and Sweden. These Future Classroom Scenarios were developed using the Future Classroom Toolkit methodology (http://fcl.eun.org/toolkit).

The five learning scenarios are not only useful because they can be readily implemented in primary or secondary classrooms, but also because they serve as an example for other teachers who wish to create learning resources that introduce bioeconomy in schools. Additionally, the BLOOM School Box uses the most recent educational methods, such as project-based learning (PBL) and inquiry-based science education (IBSE), and focuses on developing 21st-century skills of students.

1.1. Aims and methodology

1.1.1. Aims

In addition to increasing stakeholders' engagement in issues related to bioeconomy, the BLOOM project recognizes the vital role played by education and training as important pillars in the process of raising knowledge and awareness of bioeconomy among the youth.

The BLOOM School Box is one of the main educational outcomes of the BLOOM project, as it serves as a collection of good practices of bringing bioeconomy teaching in schools. The BLOOM School Box can be used by teachers everywhere as a tool for bringing innovation into their classrooms and for motivating their students towards STEM studies and careers, with the help of bioeconomy.

Beyond direct pedagogical use, educating young people on the perspectives of bioeconomy, has a societal importance: this generation will also grow up to be or already is an active consumer layer. It is important that they make well-informed and environmentally sustainable choices.

1.1.2. Methodology

Special attention was given to ensuring that the developed learning scenarios are complementary and not competitive to the national curricula, which fosters their maximum use and adoption. For this, the teachers used the Future Classroom Scenario template and followed the Future Classroom Lab (FCL) methodology.

The FCL toolkit helps teachers collaboratively create a Future Classroom Scenario, to act as a vision for change. A Future Classroom Scenario is a narrative description of learning and teaching that provides a vision for innovation and advanced pedagogical practices supported by technology. Future Classroom Scenarios are designed to help schools evolve and respond proactively to trends in society, education and technology. The developers of the scenario should share their views and ideas on what current, relevant trends are, and how education practice should respond to them.

Having a more flexible frame than a traditional lesson plan, a Future Classroom Scenario helps teachers 1) create an ambitious but realistically achievable educational vision; 2) identify relevant educational trends that they aim to follow; 3) focus on advanced pedagogical practices and change management, and 4) bring innovation through the use of digital technologies to support learner acquisition of 21st-century skills.

The BLOOM learning scenarios consist of the following sections:

- Area or subject
- Relevant trends
- Learning objectives and assessment
- Learner's role
- Tools and resources
- Learning Space
- Future Classroom Scenario Narrative
- Learning Activities

The Future Classroom Scenario template is ideal for developing projects, as opposed to shorter lessons, and an interdisciplinary implementation, as opposed to a subject-based approach. These two characteristics proved to fit the topic of bioeconomy well, because of its vastness and cross-disciplinary nature.

1.2. Co-creation of the BLOOM School Box

1.2.1. The BLOOM Pilot teachers

The 20 BLOOM pilot teachers (2 teachers from each of the 10 involved countries) were selected based on an open call[1] published on the European Schoolnet (EUN) portal and with the collaboration of EUN's network of Ministries of Education who supported the promotion of the call and validated the selection of teachers at a later stage. Teachers were required to apply in pairs. During the selection process, special attention was given to cover as many STEM subjects as possible, with a focus on interdisciplinarity. To ensure the pilot teachers' capacity

[1] http://www.eun.org/news/detail?articleId=1145757

in fulfilling their pre-defined tasks, EUN provided them with continuous support, via three face to face workshops in Brussels, regular online meetings and email support.

The final compostion of the BLOOM pilot teachers can be found in Table 1.

TABLE 1. CHARACTERISTICS OF SELECTED BLOOM PILOT TEACHERS

Country	Teacher number	Teacher Role	Subjects that both teach	Age of students both teach in 2017/2018 and 2018/2019
Austria	Teacher 1	Coordinator	Physics Chemistry Biology Maths	14-15 15-16 16-17 17-18 18+
	Teacher 2	Support		
Croatia	Teacher 1	Coordinator	Physics Chemistry Biology Technology Engineering	12-13 13-14 14-15 15-16 16-17
	Teacher 2	Support		
Israel	Teacher 1	Coordinator	Physics Chemistry Biology Technology	13-14 14-15 15-16 16-17 17-18 18+
	Teacher 2	Support		
Italy	Teacher 1	Coordinator	Chemistry Biology	14-15 15-16 16-17 17-18 18+
	Teacher 1	Support		
Poland	Teacher 1	Coordinator	Physics	16-17 17-18 18+
	Teacher 2	Support		
Portugal	Teacher 1	Coordinator	Biology	15-16 16-17 17-18
	Teacher 2	Support		
Spain	Teacher 1	Coordinator	Biology Maths Technology	10-11 11-12
	Teacher 2	Support		

Country	Teacher number	Teacher Role	Subjects that both teach	Age of students both teach in 2017/2018 and 2018/2019
Sweden	Teacher 1	Coordinator	Physics Chemistry Biology Maths Technology Engineering	10-11 11-12 12-13 13-14 14-15
	Teacher 2	Support		
Greece	Teacher 1	Coordinator	Physics Chemistry Biology Maths Technology Engineering	9-10 11-12 12-13 13-14 14-15 15-16 16-17 17-18 18+
	Teacher 2	Support		
Belgium	Teacher 1	Coordinator	Technology Engineering	12-13 13-14
	Teacher 2	Support		

1.2.2. Development of the learning scenarios

As mentioned above, the BLOOM School Box is the result of the work of 20 pilot teachers who worked together for almost a year in an intensive creation-and-review process. The teachers were supported by EUN through three face-to-face meetings and online support (Task 4.2). The teachers worked together based on a two-tiered working method: within their national teams and in international teams as well. The BLOOM pilot teachers were involved in peer review and supported each other during the implementation phase. The development of the BLOOM Future Classroom Scenarios followed an iterative process, starting from the refinement of an initial idea, through several sessions of implementation and peer feedback.

After their selection in February 2018, the 20 teachers were introduced to the project and started familiarising themselves with the subject of bioeconomy. The work of the teachers started in the **first workshop** organized in Brussels during 2-4 March 2018 with 10 teacher coordinators from Austria, Belgium, Croatia, Greece, Italy, Israel, Poland, Portugal, Spain and Sweden[2]. During this meeting, the teachers became familiar with different bioeconomy

[2] The frst face to face meeting of the BLOOM pilot teachers was organised in the framework of the 20th Science Projects Workshop in the Future Classroom Lab, whcih run in collabroation with Scientix, the

concepts and started working on the envisioned teaching resources. They received training from a WP1 expert from the Wageningen University and Research (WUR). This co-creative workshop involved a variety of techniques, such as group and one-to-one discussions and included the initial identification and collection of bioeconomy content and materials, as well as developing the first draft of the bioeconomy related teaching resources. The teachers were divided into international teams: Italy-Belgium, Croatia-Spain, Israel-Portugal, Austria-Poland and Greece-Sweden, each consisting of four team members.

Furthermore, teachers received training about the Future Classroom Lab (FCL) toolkit, which involved learning how to develop a Future Classroom Scenario that caters to the needs of today's students while enhancing their 21st-century skills. After the workshop, the 10 teachers went back to their national teams (teacher coordinator and support teacher), where the developed teaching resources were improved further with the support of the other teacher from their country. Collected feedback then lead to the revision of the BLOOM learning scenarios. A webinar was organised with the support of WUR, to ensure that both teacher coordinators and support teachers were provided an introduction to the concept of bioeconomy.

During the **second 2-day workshop**[3] (14-15 September 2018), the 10 teacher coordinators[4] worked further on developing the BLOOM learning scenarios. Then, the groups reviewed each other's work based on a rubric developed specifically for the BLOOM objectives. After receiving peer feedback, the teams finalised their learning scenarios. Then, the teachers returned to their classrooms to test and improve these learning scenarios during an implementation phase.

In the final **2-day workshop**[5] (25 - 26 January 2019), 16 BLOOM pilot teachers participated and had a chance to finalise the BLOOM School Box, share experiences and evaluate the whole creation process.

Community for science education in Europe. The common agenda can be accessed at the following link: http://files.eun.org/SPWs/SPW20/SPW20_Mar_2018_Scientix-BLOOM-programme-post.pdf

[3] As in the case of the first BLOOM Pilot teachers' meeting, this second meeting was organised in collaboration with Scientix. The common agenda can be accessed at the following link: http://www.scientix.eu/documents/10137/774446/SPWatFCL24_Programme_final.pdf/0042b778-0976-477f-95ce-64d6723a8c90

[4] In the cases where Teacher Coordinators were unavailable to travel, their places were allocated to the Support teachers from the same country.

[5] The agenda of the third face to face training of BLOOM Pilot teachers can be accessed here: http://www.scientix.eu/documents/10137/813897/SPW26_Jan_2019_BLOOM-programme-online-small/986e8b02-4df4-4b69-b64c-f29088b114f4

The BLOOM School Box is available on the BLOOM repository (https://bloom-bioeconomy.eu/repository/) and on a dedicated page on the BLOOM portal: https://bloom-bioeconomy.eu/schoolnetwork/schoolbox/. By autumn 2019, the five learning scenarios developed by the BLOOM pilot teachers will be made available in German, Swedish, Spanish, Polish, Dutch and Finnish, in addition to English. Furthermore, all five learning scenarios have been included in the Scientix[6] resources repository (http://www.scientix.eu/resources), so any teacher who needs to use the resources in a language other than English can request the translation through the Translation on Demand service of Scientix.

1.3. Outreach and dissemination

Three actions are being pursued to ensure the BLOOM School Box reaches out to as many teachers as possible:

1. The BLOOM teacher trainings, which will ensure that the School Box is used by teachers outside the pilot group;
2. The BLOOM Massive Open Online Course (MOOC), an important action in upscaling the international use of the School Box material, and the "Teach bioeconomy!" competition, whose main outcome is to expand the BLOOM School Box with 15 additional learning scenarios;
3. The interdisciplinary school competition, which aims to further upscale the use of the School Box

In the following, we provide and overview of how these activities will contribute to the increased outreach of the BLOOM School Box.

1.3.1. The BLOOM teacher trainings

One of the main tasks of the BLOOM pilot teachers is to carry out teacher training activities in their respective countries in the use the bioeconomy teaching resources of the project. The trainings aim to achieve a minimum of ten participants trained per participating country. Furthermore, after each training, at least five of the trained participants are to implement one of the BLOOM School Box learning scenarios, with the support of the BLOOM pilot teachers. In total, a minimum of ten BLOOM trainings are expected. Through these trainings, it is

[6] Scientix (http://scientix.eu), the Community for Science Education in Europe, promotes and supports a Europe-wide collaboration among STEM teachers, education researchers, policymakers and other STEM education professionals. Scientix has been running since 2010 organizing teacher-training activities, dissemination conferences and events, and supporting the exchange of knowledge and experiences in STEM Education via its portal, publications and events. Scientix is funded by the European Union's Horizon 2020 research and innovation programme, and coordinated by European Schoolnet.

expected that the number of teachers who will use bioeconomy in their lessons will grow exponentially.

1.3.2. The BLOOM MOOC and the "Teach bioeconomy!" competition

The "Boosting Bioeconomy Knowledge in Schools" MOOC was launched on 4 March 2019 on the European Schoolnet Academy, an established platform where teachers learn about innovation in the school and classroom through online professional development courses. The BLOOM School Box served as the basis of this course. The main objectives of the course are to enhance participants' knowledge of bioeconomy and its educational uses and encourage teachers from across Europe and beyond to explore the BLOOM School Box and learn how they can use it in their teaching. It is expected that this enhances the outreach of the BLOOM School Box and significantly increases the possibility of bioeconomy entering the public consciousness. More information about the BLOOM MOOC will be provided in D4.5 MOOC development and outreach report.

The BLOOM "Teach bioeconomy!" competition was launched on 25 March via the BLOOM MOOC. The competition aims to raise awareness of the educational gains offered by teaching with bioeconomy and to celebrate those teachers who, inspired by the "Boosting Bioeconomy Knowledge in Schools" course created inspiring learning scenarios around using bioeconomy concepts in their STEM teaching.

An important and tangible outcome of the competition is to increase the number of educational resources about bioeconomy available to educational professionals. Therefore, fifteen of the best submissions will be published in the BLOOM repository to serve as an inspiration to other teachers eager to integrate topics related to sustainability, waste management, carbon usage and climate change, among others in their teaching, to increase their students' interest in STEM studies.

1.3.3. The Interdisciplinary school competition

An interdisciplinary online competition will also be launched in early 2020, aiming to reward the most creative and innovative classroom implementations of the BLOOM School Box (expected to include, by 2020, 20 bioeconomy related teaching materials). The competition will encourage teachers to use bioeconomy in their schools and will inspire further interest around the BLOOM bioeconomy educational materials in particular, and in the possibilities offered by teaching with bioeconomy in triggering student interest in STEM subjects. Further information about the BLOOM competition is included in D4.4 School competition framework.

2. The BLOOM Learning Scenarios

The BLOOM School Box is a set of five teaching resources that tackle bioeconomy from different points of view, thus emphasizing that bioeconomy lends itself to a variety of classroom implementation approaches. In the following, we provide short descriptions of each learning scenario included in the School Box. The full learning scenarios are included in the annexes to this report.

2.1. Learning scenario 1: Bloom your school with your biofuel and soap lab

- Link to the resource: https://bloom-bioeconomy.eu/wp-content/uploads/2019/02/BLOOM-LS-TEAM1-Bloom-your-school-online.pdf
- Teachers: Sweden & Greece
- Subjects covered: Science, Biology, Chemistry, Physics, Technology and Arts
- Age of students: 13 - 16 years old

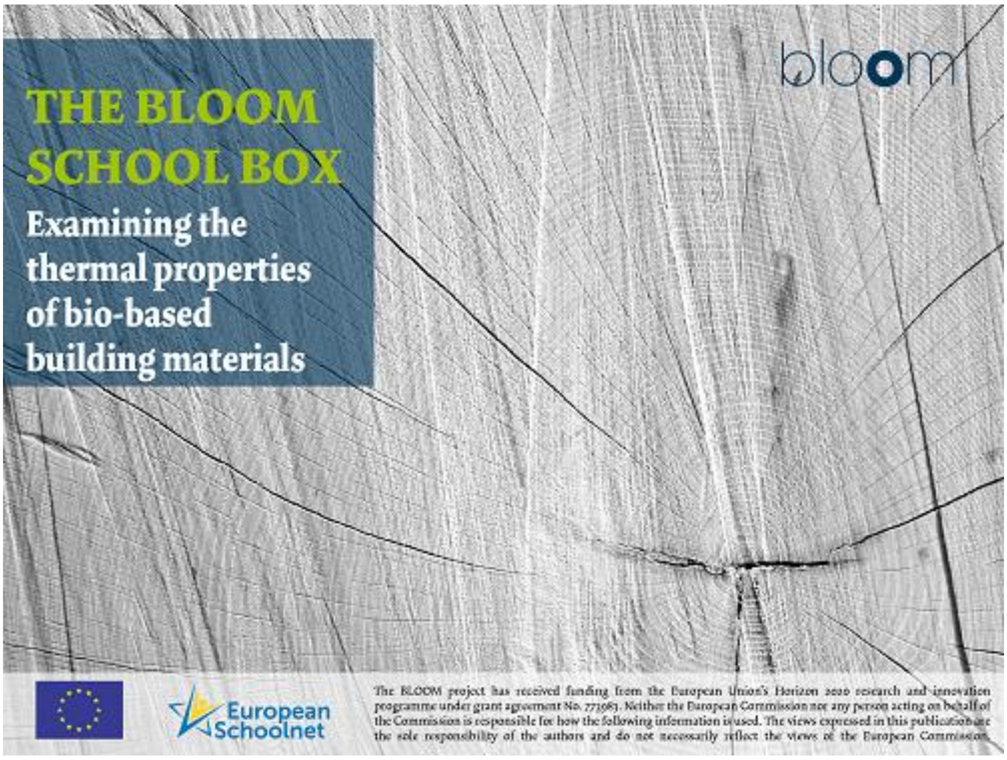
This learning scenarios aims at an overarching understanding of bioeconomy by connecting everyday life examples to the topic at hand, then developing further into an entire project. First, learners create a poster on bio-based products they found in the market. Then, they are involved in experimental laboratory work. Students conduct three experiments, collect data and make conclusions according to the instructions given in three worksheets:

  - 1st Experiment: Making your Biodiesel
  - 2nd Experiment: Testing your Biodiesel

- 3rd Experiment: Making your Soap

Finally, students produce a 1-minute-long creative advertisement.

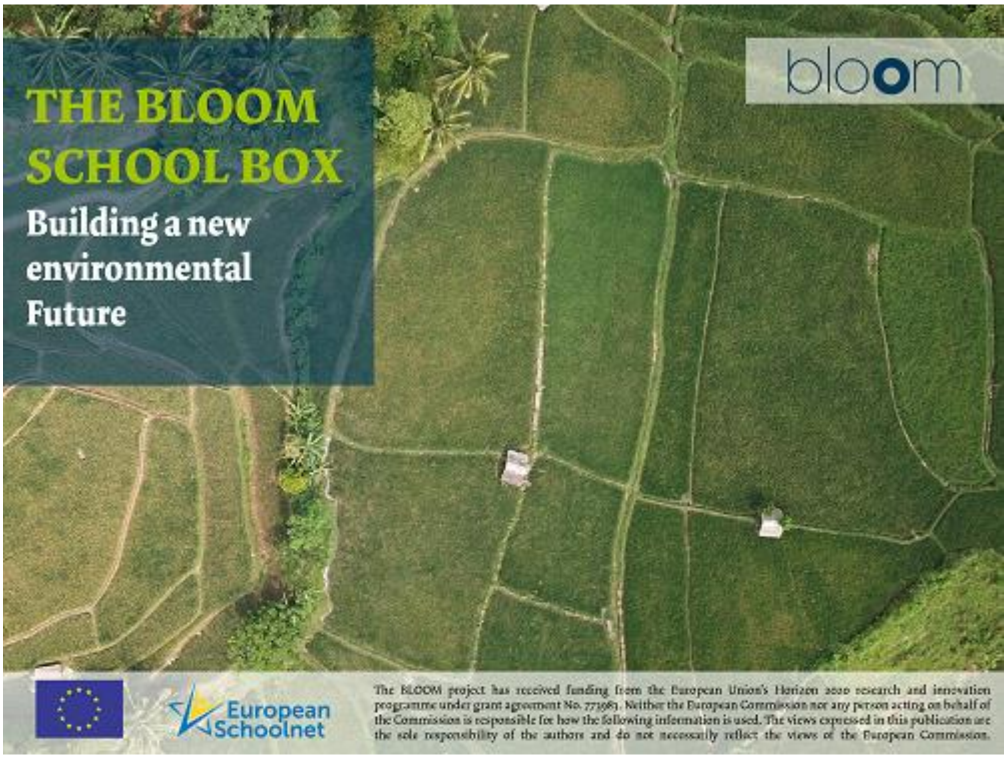
2.2. Learning scenario 2: Examining the thermal properties of bio-based building materials



- Link to the resource: https://bloom-bioeconomy.eu/wp-content/uploads/2019/02/BLOOM-LS-TEAM2-Examining-termal-online.pdf
- Teachers: Poland & Austria
- Subjects covered: Physics (standard and higher level), Mathematics, Chemistry, Biology
- Age of students: 16 – 19 years old

This learning scenario connects bioeconomy to temperature and heat flow. The learning scenario is divided into three lessons. The first lesson, Knowledge Café, aims to provide a definition on bio-economy. The second lesson, Experimental Laboratory, aims to introduce students to thermal insulation. Students will undertake experiments to investigate the thermal insulation of bio-based and non-bio-based building materials. The third lesson, Mathematical Analysis in PC-Lab aims to teach students how to conduct empirical analysis using suitable mathematical techniques.

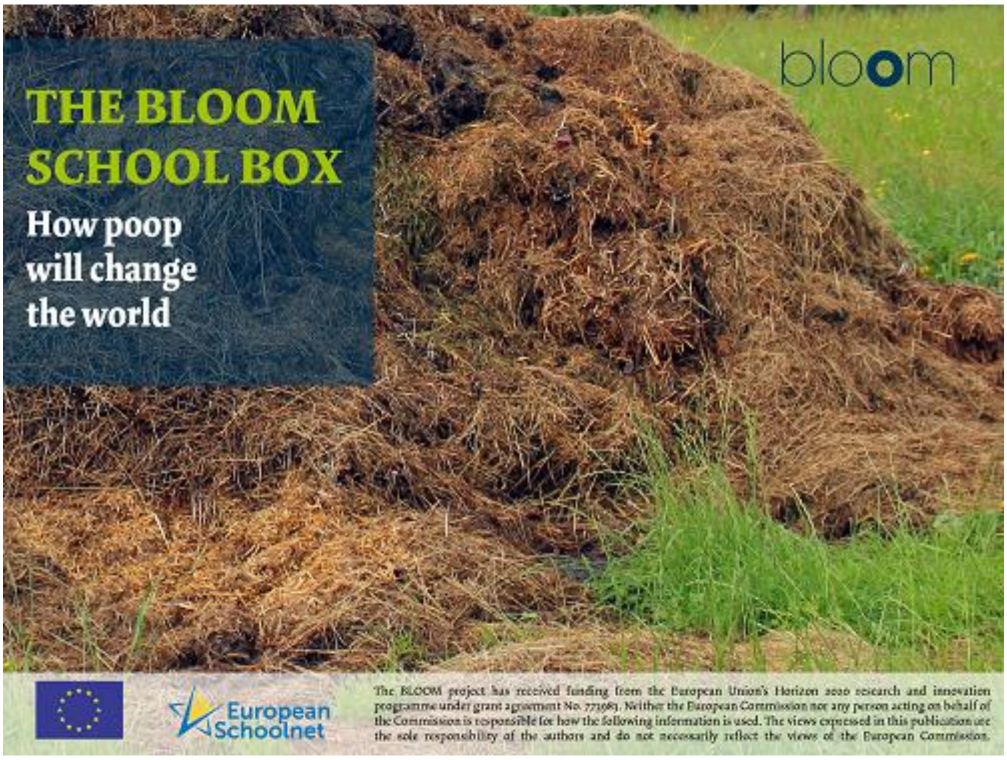
2.3. Learning scenario 3: Building a new environmental Future



- Link to the resource: https://bloom-bioeconomy.eu/wp-content/uploads/2019/02/BLOOM-LS-TEAM3-Building-online.pdf
- Teachers: Portugal & Israel
- Subjects covered: Biology, Chemistry, Biochemistry, Geology, Natural Science
- Age of students: Adaptable for different levels and ages, primary and secondary.
  - For younger students (13 -15 years old)
  - For older students (15 -17 years old)

This learning scenario is divided into three parts. The first part introduces bioeconomy. After watching a short clip about bioeconomy, students receive different objects that they have to categorize according to them being bio-based or non-bio-based. The second part involves finding ways to use different energy sources with minimal waste. For older students, this part can also include a visit to a local industry. The third part for younger students involves planning an exhibition or science fair; for older students: planning a science project, together with local stakeholders.

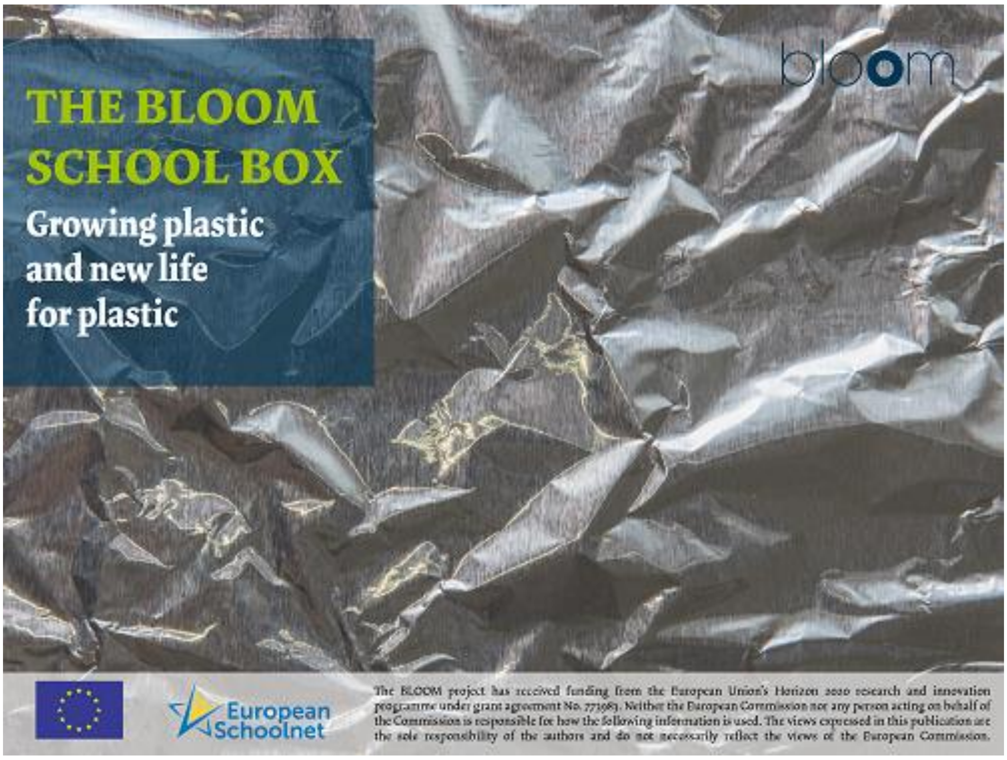
2.4. Learning scenario 4: How poop will change the world



- Link to the resource: https://bloom-bioeconomy.eu/wp-content/uploads/2019/02/BLOOM-LS-TEAM4-How-to-change-online.pdf
- Teachers: Croatia & Spain
- Subjects covered: Physics, Chemistry and Biology
- Age of students: 13-15 years old or 10-12 years old.

This learning scenario aims to engage younger students in the topic energy and ways we can produce energy. First, this lesson starts with a discussion about energy and about the production of energy in the future (including human waste and animal waste). Secondly, students listen to a lecture about bioeconomy. Then, they engage in an exercise: the creation of a brochure about fossil fuels, biomass and renewable energy sources. Then, they present their findings and their brochures. Finally, there is a quiz about energy and bioeconomy.

2.5. Learning scenario 5: Growing plastic and new life for plastic



- Link to the resource: https://bloom-bioeconomy.eu/wp-content/uploads/2019/02/BLOOM-LS-TEAM5-Growing-plastic-online.pdf
- Teachers: Belgium & Italy
- Subjects covered: Biology, Technology, Engineering, Environmental Education, Chemistry, Statistics
- Age of students: 11-18 years old

This learning scenario tackles the issue of plastic pollution and aims to familiarize students with bioplastic. First, students analyse pictures about plastic pollution. The teacher follows up with a discussion. Then, the class identifies a solution: biopolymers. Students investigate bioplastics and their properties. Students work in the lab: during this activity, students make plastic from potato starch and other foods. Then, students investigate the effect that adding a 'plasticiser' has on the properties of the polymer that they make. Finally, the class creates a 3D model, using a 3D printer.

3. Conclusions

In the above, we presented the development of the BLOOM School Box, as part of deliverable D4.1. As visible from Section 2, one of the most positive aspects of these five learning scenarios are their variety both in topic and in delivery. It is also evident from the above that the developed learning scenarios serve as solid basis for professional learning activities for teachers and students in the field of bioeconomy and will do so long after the end of the BLOOM project. The BLOOM School Box will be extended with an additional 15 learning scenarios after the "Teach bioeconomy!" competition concludes, which will enrich this already diverse collection. Furthermore, the dissemination of the BLOOM School Box will certainly add to the effort to raise awareness of bioeconomy among the wider public.

4. Annexes

The BLOOM School Box

Future Classroom Scenario

Bloom your school with your biofuel and soap lab

This scenario is part of the BLOOM School Box, which consists of a set of five Future Classroom Scenarios combining bioeconomy into science, technology, engineering and mathematics (STEM) subjects. These resources were developed and tested in classrooms by 20 BLOOM expert teachers from 10 different countries.
This Future Classroom Scenario has been developed as part of the BLOOM project, using the methodology of the Future Classroom Toolkit (http://fcl.eun.org/toolkit).

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Area / Subject

In which subject(s) or area of expertise can the scenario be used?

Subjects: Science, Biology, Chemistry, Physics, Technology and Arts

Curriculum: National, International Baccalaureate, As and A –Level

Age of students: 13 - 16 years old

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: An increased focus will be given to Science, Technology, Chemistry, Physics, Biology and Arts will be incorporated into the educational process.
Collaborative Learning: A strong focus on group work.
Lifelong Learning: The learning process does not stop when leaving school.
Cloud Based Learning: data, tools, software is all online and can be reached and modified from different devices.
Edutainment: Students learn while having fun.
Visual Search and Learning: Images and multimedia are more powerful than verbal stimuli as the main part of the communication process happens non-verbal.
Assessment: the focus of assessments is shifting from "what you know" to "what you can do".
Peer Learning: Students learn from peers and give each other feedback.

Learning Objectives and Assessment

What are the main objectives? What skills will the learner develop and demonstrate within the scenario? (e.g. 21st Century Skills). How will the progress in achievement be assessed, ensuring the learner has access to information on their progress so they can improve?

Learning Objectives:

Content Knowledge:

After the lesson, learners will be able to:

- Define and explain what bioeconomy is
- Discover different ways of applying bioeconomy
- Compare bio-based and non-bio-based products
- Compare biofuels and other fuels
- Design/suggest bio-based solutions instead of non-bio-based products

Learning , Innovative and ICT Skills:

Learners will enhance their:

- Experimental skills through laboratory work
- Critical thinking on bioeconomy topics
- Collaborative work, communication and responsibility by working in teams
- Information, media and technology skills as well as creativity by creating their own advertisement

Assessment:

Learners will be assessed based on the delivery of the following products:

- Poster: Learners create a poster on bio-based products they found in the market. Learners get feedback from the teacher.
- Experimental Laboratory: Learners conduct three experiments, collect data and make conclusions according to the instructions given in the three worksheets. The teacher provides feedback to enhance students' understanding.

- Creative advertisement: Learners are peer assessed on the advertisement they have produced

Learner's Role

What sort of activities will the learner be involved in?

The learner will be involved in activities that focus on the following areas:

- Content knowledge
- Critical thinking
- Scientific inquiry
- Laboratory skills
- Data collection
- Creativity
- Reflection
- Collaboration

Activities:

1. Learners create a poster on bio-based products they found in the market.
2. Learners are involved in experimental laboratory work. Students conduct three experiments, collect data and make conclusions according to the instructions given in the three worksheets:
    - *1st Experiment: Making your Biodiesel*
    - *2nd Experiment: Testing your Biodiesel*
    - *3rd Experiment: Making your Soap*
3. Learners produce a 1-minute-long creative advertisement.

Tools and Resources

What resources, particularly technologies, will be required?

Videos :

Bioeconomy starts here: https://www.youtube.com/watch?v=2xvXkOMRTs4 [in English]
Bioeconomy in our everyday lives: https://www.youtube.com/watch?v=ir3MgOSmvLg [in English]
The girl who silenced the world /20th Anniversary - Best Quality: https://www.youtube.com/watch?v=FlQn1KwW4Es&t=1s [in English]

Articles:

A Bio-Economy in Everyday Life: http://www.bio-step.eu [in English]
Biodiesel Lesson Plans, Institute of Environmental Sustainability, LOYOLA University Chicago: http://www.luc.edu/sustainability/initiatives/biodiesel/high-schools/lesson-plan/ [in English]

PowerPoint presentation: Bloom presentation (Annex 1)

Worksheets (Annex 2)

Laboratory Equipments:

1st Experiment:

- 100 mL graduated cylinder
- 10 ml pipette
- Large separatory funnel with ring stand

What resources, particularly technologies, will be required?

- Waste (vegetable) cooking oil
- Alcohol (methanol)
- Potassium hydroxide solution (KOH) 0.6M in ethanol
- Beakers
- Alcohol thermometer

2nd Experiment:

- Glass rod
- Clay triangle
- Tripod stand
- Forceps
- Ring stand with ring attached
- 1 crucible
- beakers
- 250 ml graduated cylinder
- 10 ml graduated cylinder
- 3 pieces of foil
- 3 pieces of wick
- 5- 10 ml biofuel (e.g. biodiesel)
- 5-10 ml fuel A (e.g. ethanol)
- 5-10 ml fuel B (e.g. petrol)
- Lighter
- Alcohol thermometer
- Scale accurate to 0.1g (Weight capacity: ~500 g)
- Ruler
- Stopwatch

3rd Experiment:

- Glycerine (Methanol Removed)
- Essential Oil (optional)
- Coconut Oil
- Citric Acid
- 250 ml graduated cylinder
- Potassium Hydroxide solution (KOH) 9M
- 1,000 ml beaker
- 250 ml beaker x 2
- Pot
- Burner
- Lighter
- Thermometer
- Silicone moulds

ICT: Mobile phones or Cameras

Learning Space

Where will the learning take place e.g. school classroom, local library, museum, outdoors, in an online space?

- School classroom
- Science laboratory
- Local market
- Online space

Future Classroom Scenario Narrative

The detailed description of the activity

Number of Students: 20
Instructor: 1
Time: 5 lessons (40 min each)
Teams: 5
Age of students: 13-16

1st Activity: Introduce the idea of bioeconomy

Duration: 1 lesson (40 min)
Learning space: School class
Aim: Provoking learners to think critically on bioeconomy topics
Educational material: BLOOM presentation (Annex 1)

1. Organise students in groups of four.

2. Discuss about environmental issues nowadays.
Use a video as a trigger to introduce environmental issues. For example: "The girl who silenced the world/20th Anniversary - Best Quality" https://www.youtube.com/watch?v=FlQn1KwW4Es&t=1s

Reflect on the video and use the presentation to discuss with students the following questions ("think-pair-share"):

a. What would you like to change in the world?
b. Which are the main environmental issues nowadays?
c. Is there anything we can do?

3. Introducing the idea of bioeconomy
Use pictures of bio-based products as a trigger to introduce bio-based products from the presentation (Annex 1).
Discuss with students the role of plants in our ecosystem. Plants are great engines of creating energy for us.
Define what biomass and biofuels are.
Discuss with students the importance of bioeconomy and circular economy.

Key ideas for discussion:

- What do we use plants for?
- What do we do with the parts of plants we do not eat?
- Can we use plants as fuel?
- What is used to create biomass fuels?
- Why do biofuels have an advantage?
- Besides fuel, what can biomass be used to create?
- How can biofuels reduce the amount of petroleum we use without entirely replacing it?
- How are biofuels created?
- Why are biofuels favourable?

Extra videos:
Bioeconomy starts here: https://www.youtube.com/watch?v=2xvXkOMRTs4
Bioeconomy in our everyday lives: https://www.youtube.com/watch?v=ir3MgOSmvLg

4. Homework Project (optional): *Bio-based products of our market*

The detailed description of the activity

Encourage students to go to the supermarket and find as many bio-based materials as possible, then take a picture of them.
Ask students to find biofuels and bio-based material that is already used in different countries.
Ask students to work with in their teams and collect all the information.
Finally, students should create a poster to present their results.

2nd Activity: Making your biodiesel

Duration: 1 lesson (40 min)
Learning Space: Experimental Laboratory
1st Experiment (Annex 2 (a))

3rd Activity: Testing your biodiesel

Duration: 1 lesson (40 min)
Learning Space: Experimental Laboratory
2nd Experiment (Annex 2 (b))

4th Activity: Producing soaps from glycerine

Duration: 1 lesson (40 min)
Learning Space: Experimental Laboratory
3rd Experiment (Annex 2 (c))

Homework Project: Ask students to create a 1 min advertisement of a bio-based material in their groups, which their fictional company is looking to introduce in the market.

5th Activity: Presenting your advertisement

Duration: 1 lesson (30 min)
The advertisements of the students will be presented in class and uploaded in YouTube (optional).
The rest of the class will have to find arguments whether this is a good product to use or not.

Key ideas for arguments:

- Recycling PLA endlessly
- Eco-friendly
- Differently Quality
- Economy

Learning Activities

Link to the Learning Activities created with Learning Designer (http://learningdesigner.org)

https://v.gd/eOVIGy (Full text available in Annex 3)

Annexes

Annex 1: BLOOM presentation

bloom

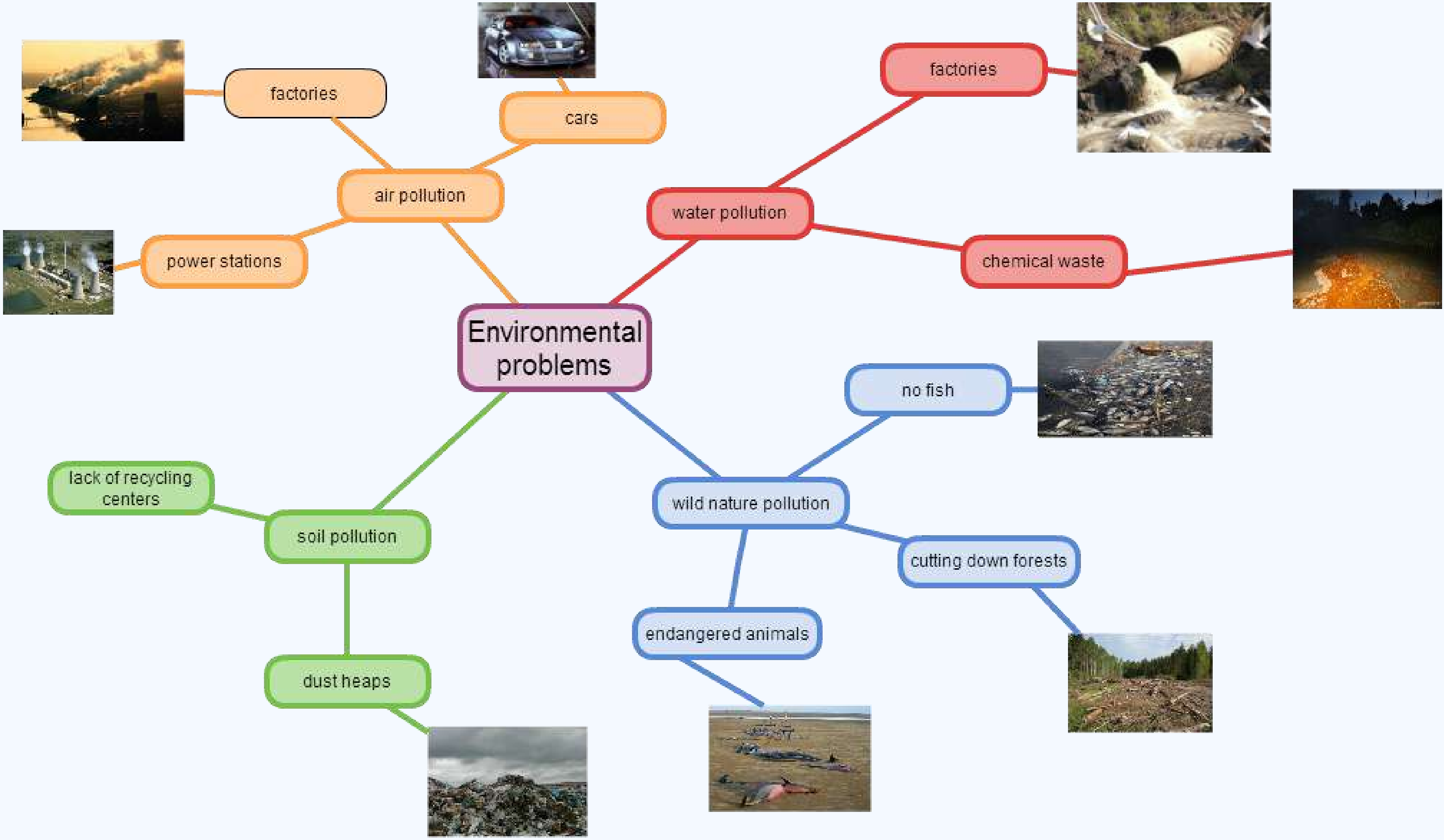
Boosting
European Citizens'
Knowledge and Awareness
of Bio-Economy
Research and Innovation

Funded by the European Commission under the Horizon 2020
Framework Programme Grant Agreement n. 773983

What would you like to change in the world?

Video: https://www.youtube.com/watch?v=FlQn1KwW4Es&t=1s

Environmental Problems


Environmental problems
air pollution
factories
cars
power stations
water pollution
factories
chemical waste
wild nature pollution
no fish
cutting down forests
endangered animals
soil pollution
lack of recycling centers
dust heaps

Is there anything we can do?

What are they made of?

Edible spoons

Edible spoons made from sorghum flour, a crop commonly grown in South Asia, Africa and Central America. The spoons are durable, easy to eat, and come in three flavours: plain, sweet and savoury.

(Founded in 2010 by Bakeys, an Indian company)


IE
These Edible Plates
are The Ultimate
Eco-Friendly Solution

What is this?

World's first human urine brick

South African university researchers have created bricks using human urine.

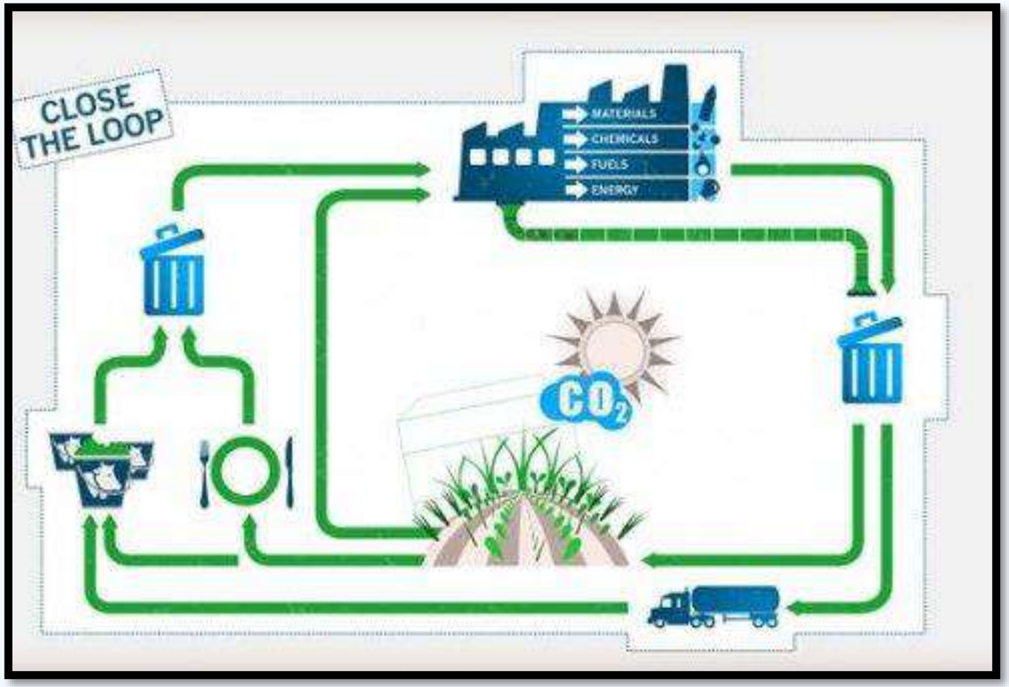

I'm green


KeyShot

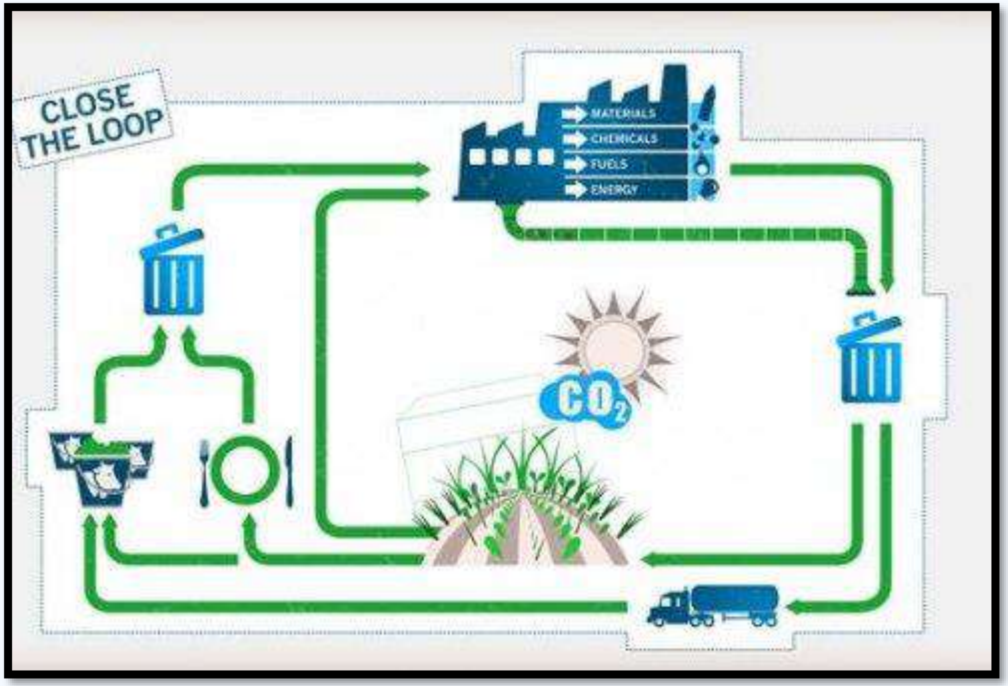

EM 05
KeyShot

World’s first circular car, Noah, mainly made by flax.

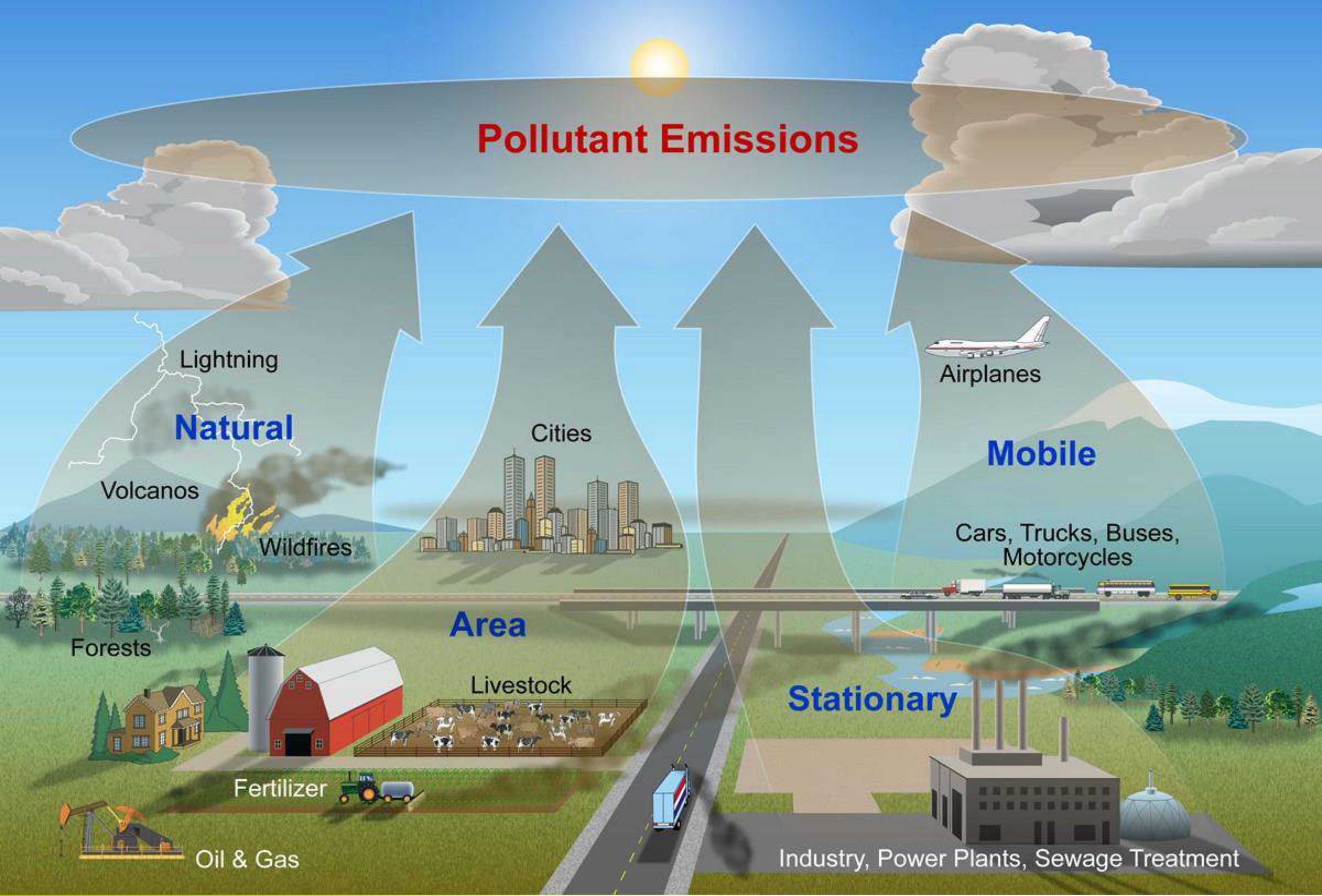
Bio-based products



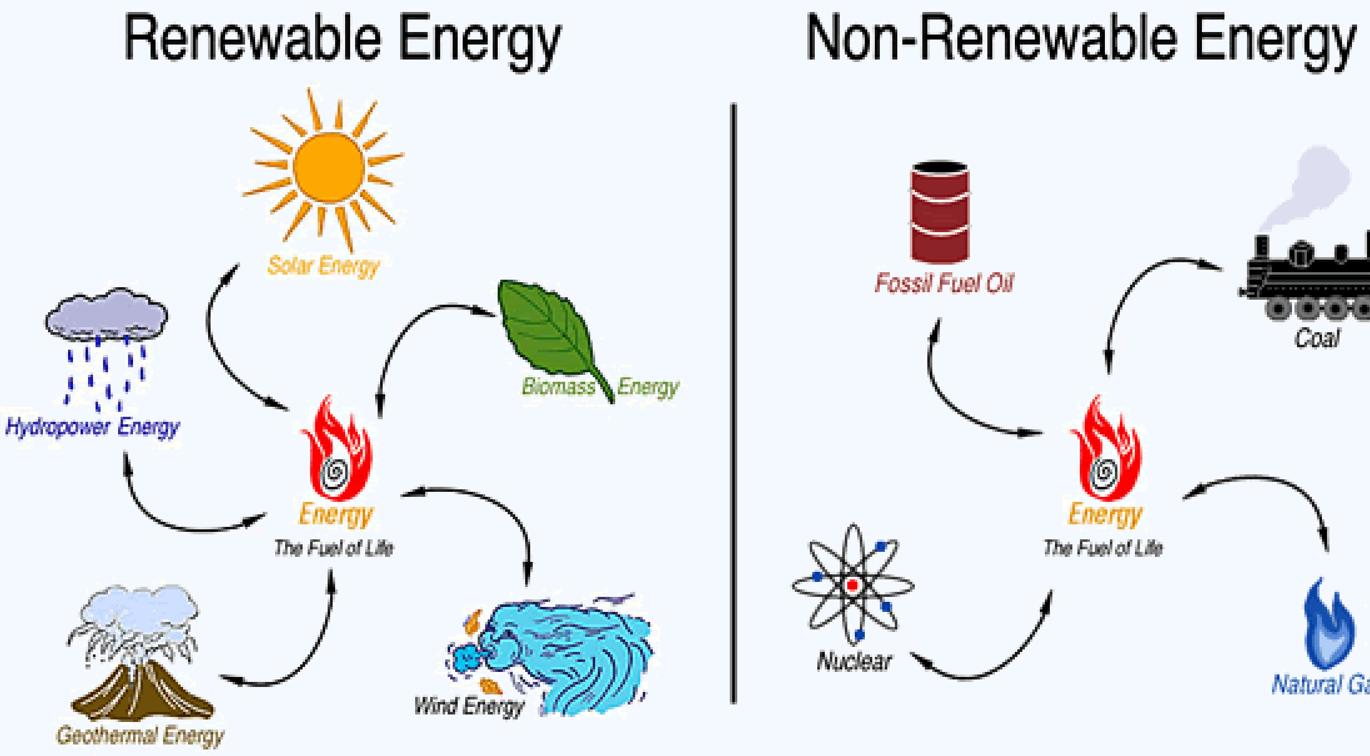
Bio-based products



- ✓ The term **bio-based product** refers to products wholly or partly derived from **biomass**, such as plants, trees or animals.
- ✓ (The biomass may have undergone physical, chemical or biological treatment).
- ✓ Some of the reasons of the increasing interest in bio-based products lay in their benefits in relation to depletion of resources and climate change.


Pollutant Emissions
Lightning
Natural
Volcanos
Wildfires
Forests
Cities
Area
Livestock
Fertilizer
Oil & Gas
Airplanes
Mobile
Cars, Trucks, Buses, Motorcycles
Stationary
Industry, Power Plants, Sewage Treatment

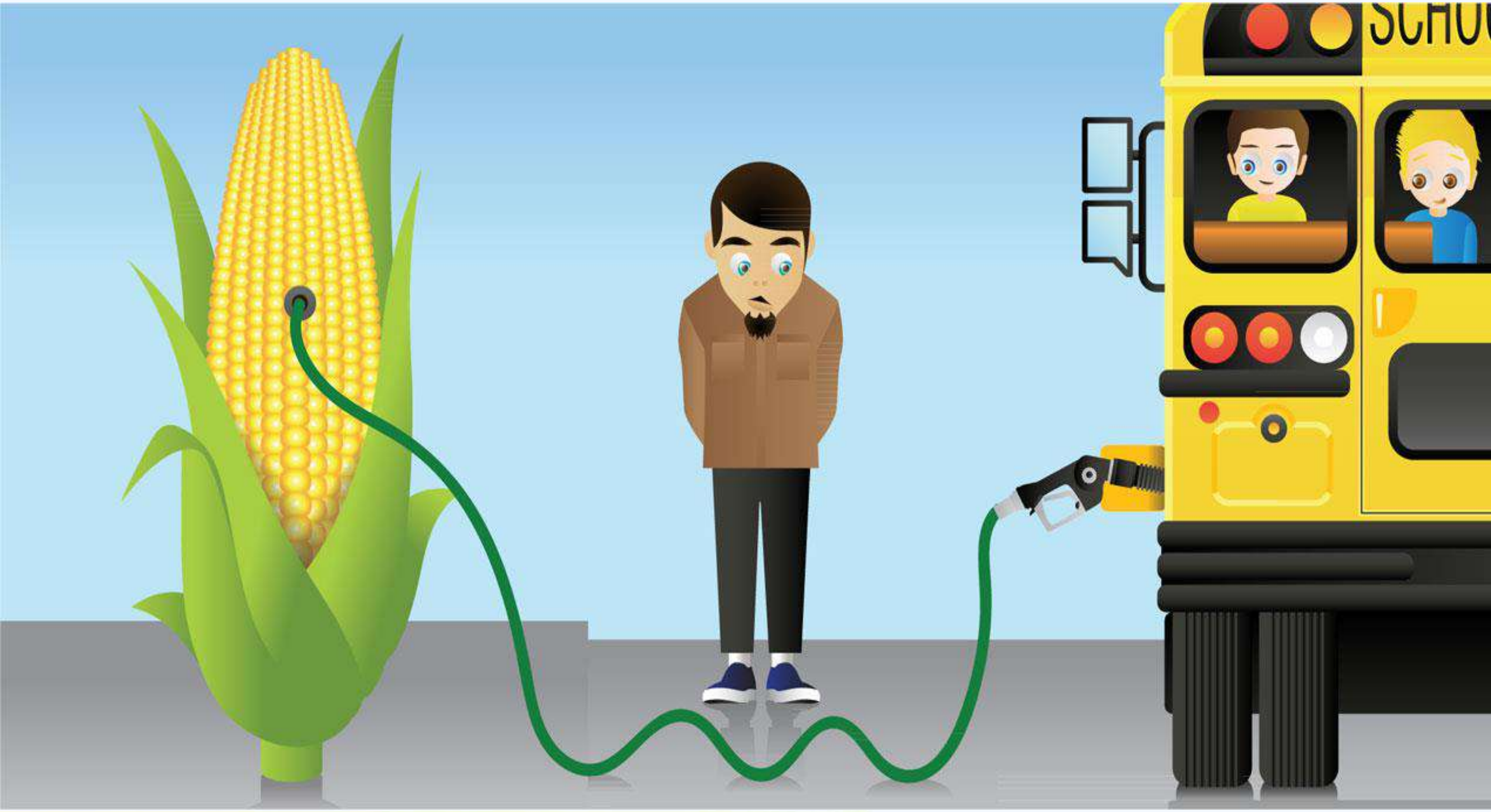
Energy Resources



Plants…

Great engines of energy production!

Biofuels



Biofuels

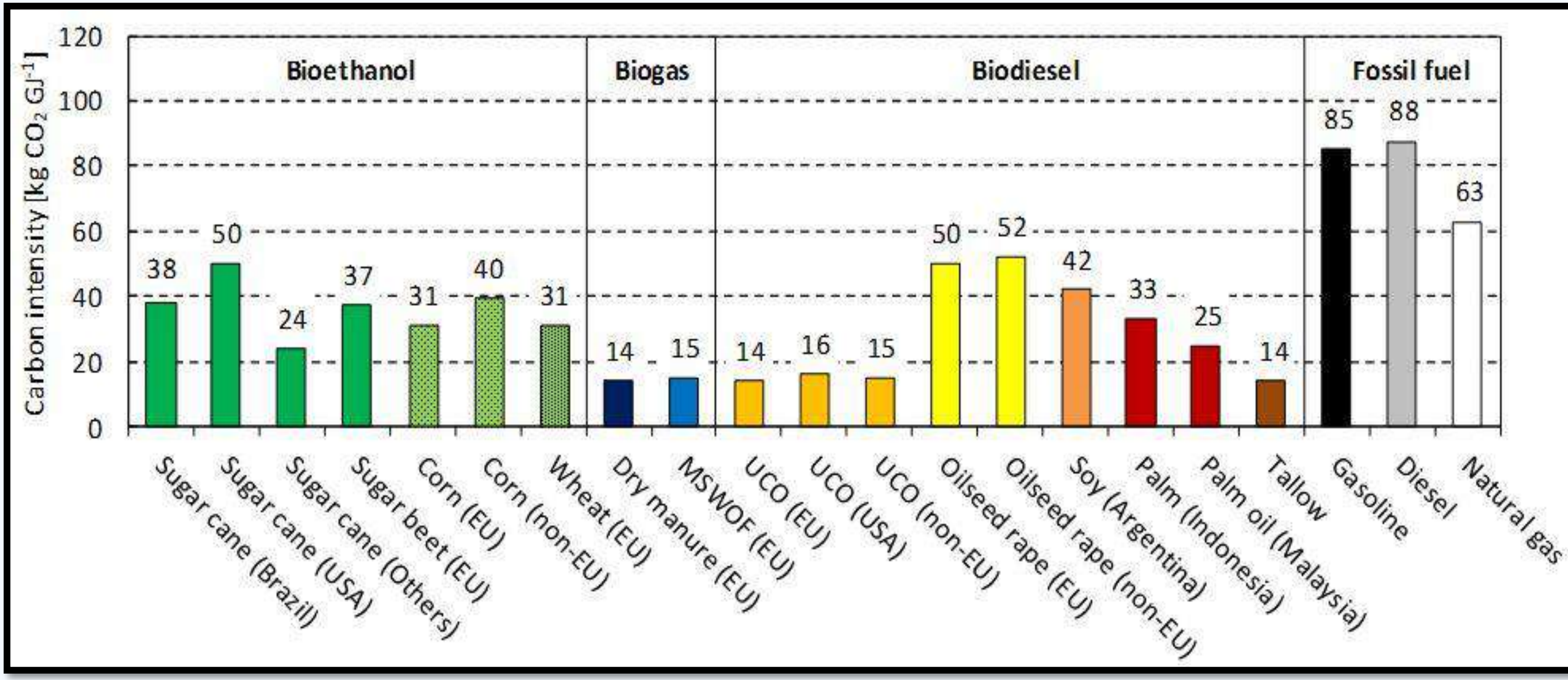
- Biofuel is one type of fuel that shows a lot of promise for our energy future, because it is both **renewable** and **environmentally friendly**.
- Biofuels are usually produced from **plant materials that cannot be eaten by humans**, such as corn stalks, grasses, and wood chips.
- Biomass is another name for the plant materials that are used to make biofuels. When biomass processed, scientists can break down and convert the plant cells into renewable fuels or chemicals. So, instead of waiting a million years for nature to change plants into fossil fuels, scientists are trying to speed up this process by using clever chemistry to make biofuel from plants that are alive today.

Now, wait a second!

- If burning fossil fuels, which are made from ancient organic matter, pumps CO_2 into the atmosphere … does not burning biofuels create the same problem?

- Fortunately, the answer is no!
- Burning biofuel does indeed release CO_2, but remember that the plants used in biofuel are not ancient – they were living on the earth at the same time as you and me. And while we, as humans, breathe oxygen to stay alive, plants instead breathe CO_2. This means that because the plants used for biofuel consume CO_2 as they grow, there is no total increase in the amount of CO_2 in the atmosphere when they are burned. They are only replacing what they have taken. In addition, unlike petroleum, we can always grow new plants for biofuel when we need them.

Pollutants



Carbon intensity of **biofuels** compared to traditional **fossil fuels**.
(http://dx.doi.org/10.4136/ambi-agua.1492)

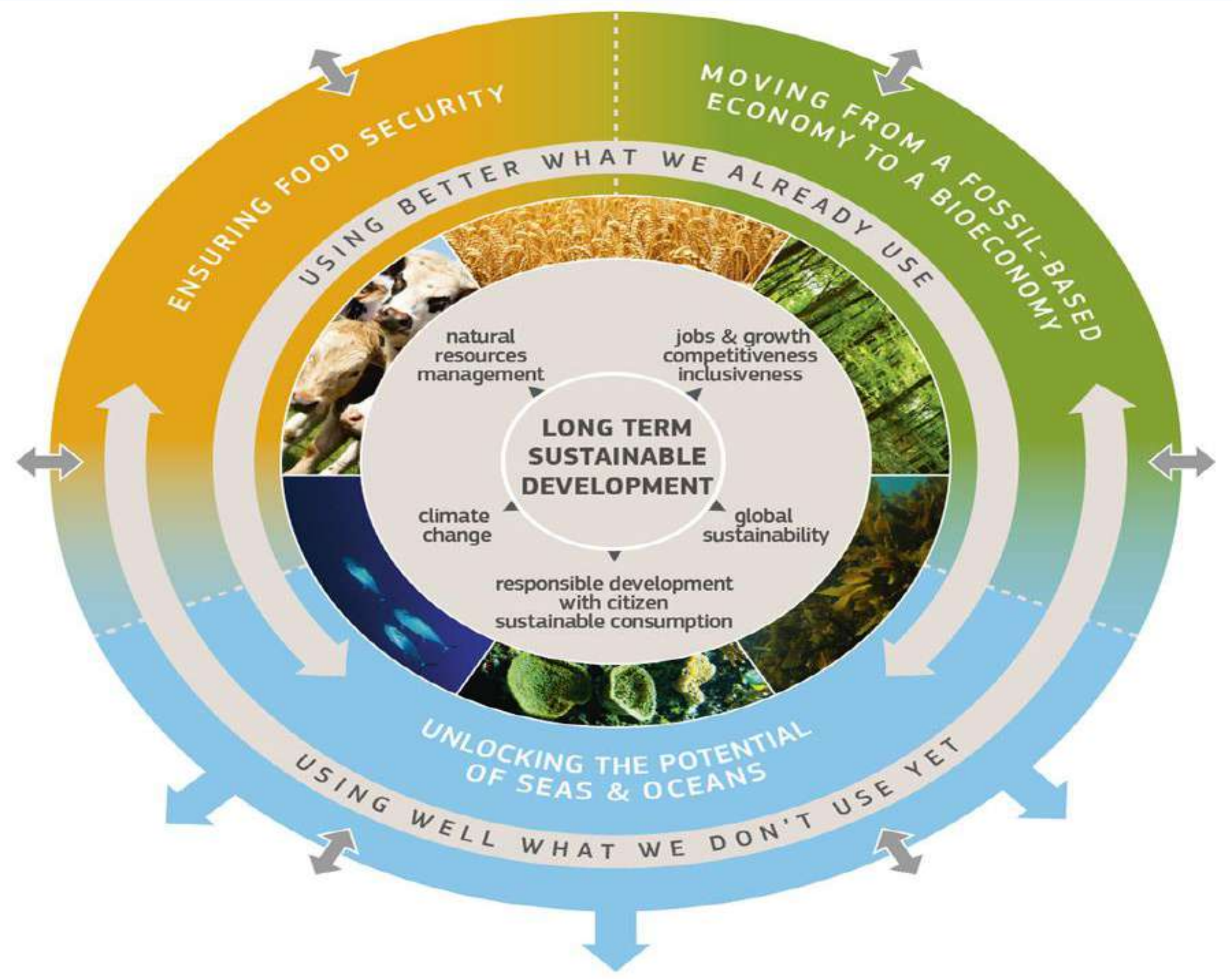
Bioeconomy

Bio + Economy:

Economy based on biological products

The bioeconomy is a circular economy that uses renewable biological resources from land and sea – such as crops, forests, fish, animals and microorganisms – to produce food, materials and energy.

Video: https://www.youtube.com/watch?v=xvXkOMRTs4



Annex 2 (a): 1st Experiment

NAME: ___________________________

DATE: ___________________________

GROUP: ___________________________

SCHOOL: ___________________________

Introductory Vocabulary

Match each picture with the correct scientific terminology.
Equipment

- Pipette

- Graduated cylinder

- Beaker

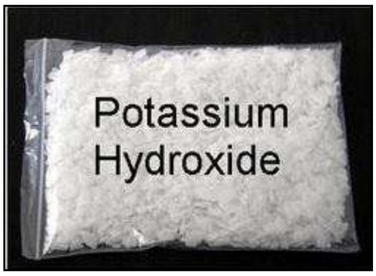
- Large separatory funnel with ring stand

1st Experiment: Making your Biodiesel

Question: **Can biodiesel be produced by vegetable cooking oil?**

Background:

Biodiesel is a mixture of methyl esters of fatty acids. It can be made very easily from vegetable cooking oil. The synthesis is a simple chemical reaction that produces biodiesel and glycerol. Cooking oil is mixed with methanol and potassium hydroxide. The products separate into two layers, with the biodiesel on the top. The biodiesel is separated and washed and is then ready for further experimentation.



Materials:

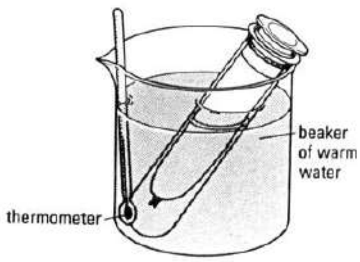
- 100 mL graduated cylinder
- 10 ml pipette
- Large separatory funnel with ring stand
- Waste (vegetable) cooking oil
- Alcohol (methanol)
- Potassium hydroxide solution (KOH) 0.6M in ethanol
- Beakers
- Alcohol thermometer

***Safety Rules*:**

- ✓ You must wear goggles, gloves and an apron.
- ✓ Alcohol is flammable.
- ✓ Potassium hydroxide is corrosive.

Procedure:

1. Measure 18 ml of methanol, using a graduated cylinder, and pour it into the separating funnel.
2. Using a pipette, carefully add 3ml of the KOH solution into the funnel as well.
3. Swirl gently.
4. Measure 72 ml of waste cooking oil using the cylinder.
5. Warm the cooking oil up to 40°C, using a water bath and an alcohol thermometer. A water bath is made from a container, such as a big beaker, filled with heated water. (approx. 100ml of heated water)



6. Add the 72ml of cooking oil into your separating funnel.
7. Swirl and sake the mixture for 10 minutes. Occasionally release any pressure.
8. Transfer the mixture into a beaker.
9. Let the mixture stand.
10. Record your observations (eg. color, viscosity, odor of the mixture). Data collection should include observations before, during and after the reaction.
11. Allow the mixture to sit and separate for one day.
12. Next day record your observations again.
13. Remove the top layer (biodiesel) by using a pipette and store it for next lab day.

14. Carefully remove the bottom layer (glycerin) by using a beaker and store the glycerin for next lab day, as well.

Data collection:

Mixture	Starting Observations	Interim observations (optional)	Final Observations
Color			
Viscosity			
Other			

Questions:

1. Which were the reagents and which were the products in this experiment?

____

2. Why did you use as a catalyst?

____

3. What did you observe as you mixed the oil with the alcohol?

____

4. Why do the biodiesel and the glycerin separate?

____

Annex 2 (b): 2nd Experiment: Testing your Biodiesel

NAME: ___________________________

DATE: ___________________________

GROUP: __________________________

SCHOOL: _________________________

Question: **How does biodiesel compare with other fuels?**

Background:
Combustion involves a series of chemical reactions between a fuel (i.e. a hydrocarbon, or an organic compound containing only carbon and hydrogen) and oxygen. The result is a major reorganization of both matter and energy.

Materials:

- Glass rod
- Clay triangle
- Tripod stand
- Forceps
- Ring stand with ring attached
- 1 crucible
- 2 beakers
- 250 ml graduated cylinder
- 10 ml graduated cylinder
- 3 pieces of foil
- 3 pieces of wick
- 5- 10 ml biofuel (e.g. biodiesel)
- 5-10 ml fuel A (e.g. ethanol)
- 5-10 ml fuel B (e.g. petrol)
- Lighter
- Alcohol thermometer
- Scale accurate to 0.1g (Weight capacity: ~500 g)
- Ruler
- Stopwatch

Safety Rules:

- ✓ You must wear goggles, gloves and an apron.
- ✓ Alcohol is flammable.
- ✓ You should not use fuels such as petrol on your own, they are really flammable!!!

Procedure:

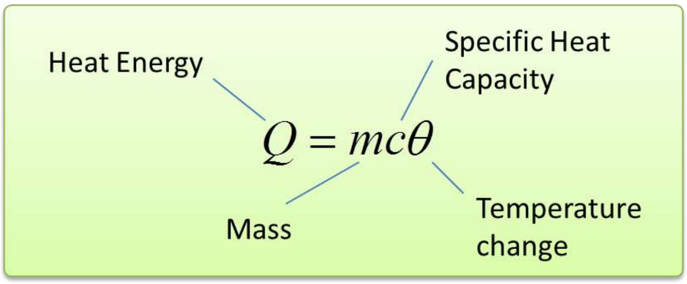
Making a fuel burner:

In this part you will make the fuel burner you will use for the combustion.

1. Measure 10ml of the biodiesel, you created during the 1st experiment, using a graduated cylinder.
2. Soak entire the wick into the fuel.
3. Use the glass rod to submerge the wick.
4. Position the wick in a crucible in a way that part of it (1/4) is outside the crucible.
5. Cover the top of the crucible with foil so as only the wick is exposed.
   The foil must completely cover the opening.
6. Light the wick and wait for the flame to die down.

Combustion

7. Record the mass of the fuel burner, using the scale, on the data table.
8. Measure 200 ml of water using a graduated cylinder.
9. Pour the water into a beaker.
10. Record the mass of water in the beaker on the data table.
    Note: 1 ml H_2O = 1 g H_2O at room temperature
11. Place the beaker on the ring stand carefully.
12. To measure the initial temperature of the water, hold an alcohol thermometer in the water so that it does not touch the sides of the beaker. Record the temperature in the data table.
13. Place your fuel burner on a tripod stand under the beaker.
14. Adjust the ring height so that the top of the wick is a measured 3 cm below bottom of the beaker. Center the fuel burner under the beaker.
15. Light the wick using a lighter.
16. Use a thermometer to measure the temperature of the water.
17. Use the thermometer to stir the water periodically.
18. As you burn your fuel make observations on your data table about associated smells, and the nature of the flame and smoke.
19. Continue heating and stirring the water until the temperature has increased by ~25°C. At that point, record the maximum temperature the water reaches.
20. Remove the beaker from the ring and quickly extinguish the flame by placing another beaker over the wick.
21. Calculate the heat transferred in water by using the formula: $Q=mc\Delta T$,
    Specific heat capacity of water: c = 4.186 J/g °C
    Mass of water: m (g)
    ΔT= Change in Temperature (°C)



22. Record the final mass of the fuel burner (with the cap, wick and the remaining fuel) using the balance.
23. Calculate the used mass of the fuel burner.
24. Repeat steps 1- 23 with another fuel (e.g. petrol or ethanol).
25. Answer questions 1-5.

<u>Data collection:</u>

	Biodiesel	**Fuel A** ----------	**Fuel B** ----------
Initial water temperature			
Final water temperature			
Change in water temperature (ΔT)			
Heat (Q = m c ΔT) (J) c = 4.186 joule/gram °C			
Initial mass of fuel burner			
Final mass of fuel burner			
Mass of fuel burner			
Observations			

Questions:

1. Where did the energy you measured as heat come from?

____

2. Did you witness complete or incomplete combustion of diesel and biodiesel? How do you know?

____

3. What did you observe as you mixed the fuel with the alcohol?

____

4. Can you explain the differences in the combustion results described above?
   (Hint: Look at the molecular formulas of diesel and biodiesel!)

____

5. What are the comparative advantages of using biodiesel instead of regular diesel?

____

Annex 2 (c): 3rd Experiment: Making your Soap

Question: **Can glycerin from biodiesel be turned into a liquid soap?**

Background:

By-products retain both financial and environmental value that we can capture through other chemical processes. Biodiesel glycerin is actually a mixture of free fatty acids (FFA) that were neutralized during transesterification, soaps, water, catalyst (NaOH or KOH depending on what was used to make the biodiesel), methanol, and glycerin.
Once the methanol is removed, the glycerin is safe to handle and is suitable for making soap. The remaining contaminates are all ingredients in soap making soap production the easiest way to capture the value of the glycerin. The following lab is designed to show how glycerin, from biodiesel made with KOH, can be turned into a liquid soap with a multitude of uses from hand soap to stainless steel cleaner.

Materials:

- Glycerin (Methanol Removed)
- Essential Oil (optional)
- Coconut Oil
- Citric Acid
- 250 mL graduated cylinder
- Potassium Hydroxide solution (KOH) 9M
- 1,000 mL beaker
- 250 mL beaker x 2
- Pot
- Burner
- Lighter
- Thermometer
- Silicon molds

Safety Rules:

- ✓ You must wear goggles, gloves and an apron.
- ✓ Alcohol is flammable.
- ✓ Potassium hydroxide is corrosive.

Procedure:

26. Heat glycerin and coconut oil in a pot.
27. Stir your mixture.
28. Pour 40ml of hot glycerin into a beaker.
29. Add 40ml of KOH solution into the beaker as well.
30. While stirring you can put essential oil and color to your mixture. (Optional)
31. Pour the mixture into the silicon molds.

Questions:

1. What is the purpose of adding glycerin to the soap? What is the purpose of adding an essential oil?

____

2. What would happen if we dissolved the soap paste in water?

____

3. What could this soap be used for?

____

4. How does making soap fit in with making biodiesel?

____

Annex 3: Learning Design

Description	
Context	**Topic:** Bioeconomy **Total learning time:** 400 h **Number of students:** 20 students **Description:** Science, Chemistry, Physics, Mathematics, Technology and Arts **Curriculum:** National, International Baccalaureate, As and A -Level **Age of learners:** 13 – 16
Aims	The scenario aims on enhanicing learners': 1) Content knowledge on bioeconomy topics. 2) Experimental skills by conducting experiments. 3) Critical thinking on bioeconomy topics 4) Creativity by producing their own soaps 5) Collaborative work, communication and responsibility by working in teams. 6) Information, media and technology skills by producing a 1 min advertisement.
Outcomes	Knowledge (Define) Define what bioeconomy is Comprehension (Explain) Explain what bioeconomy is. Knowledge (Recognise) Recognise different ways of applying bioeconomy. Comprehension (Contrast) Contrast biobased to non-biobased products. Synthesis (Design) Design a biobased solution. Evaluation (Reflect) Learnrs reflect on the bioeconomy products they designed.
Teaching-Learning activities	
1st Activity: Introduce the idea of Bioeconomy **Duration:** 1 lesson (40 min) **Learning space:** School Class	***Read Watch Listen*** ***5 minutes*** ***20 students*** ***Tutor is available*** 1. Create groups of 4 with which you will work during the Bioeconomy project.
	Read Watch Listen ***10 minutes*** ***20 students*** ***Tutor is available*** 2. Start the lesson by watching a video: • Older learners: The girl who silenced the world for 6 minutes: https://www.youtube.com/watch?v=d7ep_8SLQho • Younger learners: There's a Rang- Tan in my bedroom: https://youtu.be/3Ha6xUVqezQ Ask the students to discuss in their group (Think Pair-Share) • What is the problem in the video? • Is it real? • What can we do to solve this? • Can humans use something else and stop cutting trees • Which plant grows fastest?
	Discuss **15 minutes** **20 students** ***Tutor is available*** 3. Introducing the idea of Bioeconomy

	The Bioeconomy starts here: https://www.youtube.com/watch?v=2xvXkOMRTs4 The Bioeconomy in our everyday lives: https://www.youtube.com/watch?v=ir3MgOSmvLg - Start showing examples of biobased products. - Discussing with students the importance of bioeconomy and circular economy. **Key idea: Plants are great engines of creating energy for us.** - What do we do with the plants? - What do we do with the parts of the plants we do not eat? - Can we use plants as a fuel? - What is used to create biomass fuels? - Why do biofuels have an advantage? - Besides fuel, what can biomass be used to create? - How can biofuels reduce the amount of petroleum we use without entirely replacing it? - How are biofuels created? - How does biochemical refining work? - How does thermochemical refining work? - What happens if you add oxygen to the process - thermochemical gasification? - Why are biofuels favourable? Energy 101/Biofuels: https://www.youtube.com/watch?v=-ck3FYVNl6s&feature=youtu.be Algae Power: https://www.youtube.com/watch?v=waPgGQNppHY&feature=youtu.be
	Collaborate ***10 minutes*** ***20 students*** ***Tutor is available*** 3. Mind Map: Create a mind map of bioeconomy
	Investigate ***100 minutes*** ***20 students*** ***Tutor is not available*** 4. Homework Project: - Go to the supermarket and find as many bio-based material as possible. Take a picture of them. - Find biofuels and biobased material that is already used in different countries. Work with your team and collect all the information. Create a poster to present your results.
2nd Activity: Making your Biodiesel **Duration**: 1 lesson (40 min) **Learning Space:** Experimental Laboratory	***Produce*** ***40 minutes*** ***20 students*** ***Tutor is available*** Experimental work: Students make their own Biodiesel from used cooking oil of their school Worksheet of the 1st experiment (Annex 2 (a))

3rd Activity: Testing your Biodiesel **Duration:** 1 lesson (40 min) **Learning Space:** Experimental Laboratory	***Investigate 40 minutes 20 students Tutor is available*** Experimental work: Students test the biodiesel by comparing it with other fuels. Worksheet of 2nd experiment (Annex 2 (b))

The BLOOM School Box

Future Classroom Scenario

Examining the thermal properties of bio-based building materials

This scenario is part of the BLOOM School Box, which consists of a set of five Future Classroom Scenarios combining bioeconomy into science, technology, engineering and mathematics (STEM) subjects. These resources were developed and tested in classrooms by 20 BLOOM expert teachers from 10 different countries.
This Future Classroom Scenario has been developed as part of the BLOOM project, using the methodology of the Future Classroom Toolkit (http://fcl.eun.org/toolkit).

Authors:

Nikolinka Fertala, Elzbieta Kawecka, Lucas Sylvester Glaz, Bernhard Weikmann

Table of contents

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Area / Subject

In which subject(s) or area of expertise can the scenario be used?

Subjects: Physics (standard and higher level), Mathematics, Chemistry, Biology
Curriculum: National Curriculum, International Baccalaureate, GCSE, GCE A-Level
The learning scenario includes three lessons for students **aged 16-19**.

Relevant Trends

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

Flipped Classroom: Students become familiar with basic concepts regarding the bio-based building materials while watching movies at home. The time spent in the classroom is used to reflect, discuss in the form of the knowledge café in order to develop the assigned topic.
Collaborative Learning: A strong focus on group work.
STEM Learning: An increased focus will be given to Science, Technology, Engineering, and Mathematics that are essential subjects in the curriculum.
Lifelong Learning: The learning process should not completed by leaving school.
Mobile Learning: Due to the process of rapid digitalization of the education, students can learn anytime and everywhere.
Edutainment: Students acquire knowledge while having fun while involved in laboratory experiments.
Visual Search and Learning: Images and multimedia are more powerful than verbal stimuli as the main part of the communication process happens non-verbal.

Learning Objectives and Assessment

What are the main objectives? What skills will the learner develop and demonstrate within the scenario? (e.g. 21st Century Skills). How will the progress in achievement be assessed, ensuring the learner has access to information on their progress so they can improve?

Learning objectives

Students will:

- Acquire a basic concept of bioeconomy including an introduction of bio-based products. Special emphasis will be given to building materials.
- Obtain knowledge on communication using subject-specific vocabularies.
- Learn to collaborate with each other while working intensively on bio-based building materials in groups.
- Learn to conduct experiments in a laboratory setting employing data logging equipment.
- Learn to implement mathematical techniques to analyse the empirical data collected.

Assessment

Poster on bioeconomy and round table: The posters created during the lesson will be collected and the teacher will provide feedback. The discussion during the round table will show the progress in students' understanding of the topic.
Kahoot quiz: The teacher will offer feedback to all answers provided by the students.

Experimental laboratory: The students will send the collected empirical data to the teacher in order to receive comments on them before starting with the mathematical analysis.

Learner's Role

What sort of activities will the learner be involved in?

The learner will be involved in activities such as:

- Knowledge café as introduction to bioeconomy and insulating bio-based and non-bio-based materials
- Kahoot quiz
- Experimental work in a laboratory
- Mathematical data analysis (results of measurement).

General objectives (student outcomes):

Students should have a practical knowledge of temperature and the flow of heat from areas of high temperature to areas of low temperature. They should be able to connect the modelled and real heat flow while using bio-based building material. Students should be familiar with plotting points manually on the Cartesian plane, as well as with the significance of dependent and independent axes. They should be capable of preparing investigations, which allow to model the speed of a heat transfer and insulating efficiency of examined bio-based materials (see Annex 1: Heat Transfer).

Tools and Resources

What resources, particularly technologies, will be required?

Videos:

- Bioeconomy: https://youtu.be/2xvXkOMRTs4 [in English]
- Different types of insulation/fuel poverty: https://youtu.be/ZXPvaroR2AI [in English]
- How does insulation work? https://youtu.be/aaUz_SqOXnI [in English]

Books and Articles:

- Jones, Dennis and Christian Brischke (2017): Performance of Bio-Based Building Material, Elsevier Ltd. (https://www.elsevier.com/books/performance-of-bio-based-building-materials/jones/978-0-08-100982-6)
- ARUP (2017): The Urban Bio-Loop, Growing, Making and Regenerating (https://www.arup.com/publications/research/section/the-urban-bio-loop)
- Bioeconomy in Everyday Life (http://www.bio-step.eu)
- Lange, Lene (2016): The Fundamentals of Bioeconomy, The Bio-based Society.

Other resources:

- https://ed.ted.com
- Kahoot Quiz: https://kahoot.com/
- Data-logging equipment for each group: interface, two temperature probes, software to register and analyse data
- Different types of insulating materials (bio-based and non-bio-based)
- Spreadsheet software (e.g. Excel) or GeoGebra.

Learning Space

Where will the learning take place e.g. school classroom, local library, museum, outdoors, in an online space?

The learning process will take place as follows:

- Home
- School classroom
- Experimental laboratory

Future Classroom Scenario Narrative

The detailed description of the activity

The learning scenario includes three lessons for students aged 16-19. The first and third lessons are designed for 45 minutes. The second lesson will take place in the laboratory and it will last for 90 minutes.

Lesson 1: Knowledge Cafe (45 minutes)

Objectives of Lesson 1:

The students should be able to:

- Provide a definition on the bioeconomy: What is the bioeconomy? How does the bioeconomy influence our everyday life?
- Give sample for bio-based products and the raw materials, which are relevant for the production process.
- Learn about bio-based and non-bio-based building materials and their thermal insulation properties

Course of Activities in Lesson 1:

1. The teacher introduces the topic **of bioeconomy** and **bio-based building materials.** He/she explains the objectives of the lesson and the rules for the work in the flipped classroom (duration: 5-10 minutes).
2. The students are divided by the teacher into groups of 4-5 persons as each group will be working on a different issue. For example, the first group will watch the video on bioeconomy and read the document “The Fundamentals of Bioeconomy” (Lange, 2016) and answer questions such as:
   a. What is bioeconomy?
   b. How is bioeconomy linked to the conventional production process?
   c. What is the influence of bioeconomy on sustainable development?
   d. Is there a difference between bioeconomy and green economy?
2. Two groups will be dealing with various **bio-based products** and the raw materials needed for their fabrication. The teacher will provide each student with a bio-based product using the document “Bioeconomy in Everyday Life” (http://www.bio-step.eu). One group will answer the question “How does insulation work?” by watching the video provided by the teacher. The assigned activities should be worked out in the form of knowledge café and the results should be written down by creating a poster (duration: 25-30 minutes).
3. The lesson will be finished by **a round table discussion.** The teacher will play the moderator in the round table discussion (duration: 10-15 minutes).

The detailed description of the activity

4. **Homework for Lesson 2:** Each group should work on the same homework. Its exemplary content is written down in Annex 2.

Lesson 2: Experimental laboratory (90 minutes)

Objectives of lesson 2:

The students should be able to:

- Explain how thermal insulation works
- Undertake experiments to investigate thermal insulation of bio-based and non-bio-based building materials
- Outline testable hypotheses and verify them by collecting and analysing empirical data
- Communicate effectively the obtained experimental results in the appropriate scientific language

Course of Activities in Lesson 2:

1. The teacher starts the lesson by repeating the **learning materials**. He/she uses Kahoot as an introductory quiz about the bioeconomy and bio-based building materials. **The Kahoot quiz** is available under the link: https://play.kahoot.it/#/k/0d4b4f56-6899-4173-b9f5-ea07a734c39e (duration: 10-15 minutes).
2. The students are divided by the teacher into groups of three or four, as each group will be working on **building materials and testing its insulating properties**. Each group of students will carry out a **data logging experiment** while cooling a beaker of water insulated by either bio-based or non-bio-based building material. They will **collect empirical data** on temperature and time in order to verify the outlined hypothesis (see Annex 3). By the end of the lesson, the experiment should be completed and the collected data should be saved and shared (duration: 40-50 minutes).
3. The teacher closes the lesson by instructing the students to finish the experimental work and to clean up (duration: 5 minutes).

Lesson 3: Mathematical analysis in PC-lab (45 minutes)

Objectives of lesson 3:

The students should be able to:

- Conduct empirical analysis using suitable Mathematical techniques
- Analyse the data using Excel spreadsheet or GeoGebra
- Present the estimates and communicate them in the appropriate scientific language
- Communicate the meaning of the experimental results for future sustainable development in a global context

Course of Activities in Lesson 3:

1. The teacher starts the lesson by asking the students to continue the **experimental work** in their groups. He/she supports the groups by **analysing the collected data** (duration 5 minutes per group).
2. Students **analyse the empirical data by calculating descriptive statistics and conducting a regression analysis** (duration 20-25 minutes).

The detailed description of the activity

3. Each group presents the data analysis by creating a **PowerPoint presentation** (duration 3-5 minutes per group).

The teacher closes the lesson by a general discussion on the topic (duration: 5-10 minutes).

Learning Activities

Link to the Learning Activities created with Learning Designer (http://learningdesigner.org)

https://v.gd/TWRoSb (Full text available in Annex 4)

Annexes

Annex 1: Heat transfer

Heat Transfer

Heat transfer is a broad topic used in many branches of engineering. For example, mechanical engineers who design engines, from steam locomotives to modern internal combustion engines, rely on a detailed understanding of how heat moves through all types of matter. Industrial engineers use heat transfer concepts to design climate control systems for manufacturing facilities, such as foundries or refrigerated food production facilities, which integrate temperature-sensitive human workers with extreme temperature processes.

Newton's law of cooling is a complex topic that appears in physics and calculus. In this learning scenario, it is simplified to focus on the idea of applying the transformations learning during typical school laboratory investigations within a contextual situation. The mathematical practice in focus for this lesson could be combined with spreadsheet software such as Excel or with dynamic programmes such as GeoGebra.

Students get the possibility to observe an exponential trend demonstrated through the changing temperatures measured while heating a beaker of water insulated by three bio- and three non-bio-based materials utilising a data-logging equipment. This task is accomplished by first appealing to students' real-life cooling experiences, and second by showing an example for an exponential curve. After reviewing the basic principles of heat transfer, students make predictions about the cooling curves of a beaker of water in different environments. During a simple teacher demonstration or experiment, students gather temperature data while a beaker of water cools in an ice water bath (winter approximation), and while it cools in a hot water bath (summer approximation). They plot the data to create heating and cooling curves, which are recognized as having exponential trends, verifying Newton's result that the change in a sample's temperature is proportional to the difference between the sample's temperature and the temperature of the environment around it.

Students apply and explore how their new knowledge may be applied to real-world engineering applications. This engineering curriculum meets Next Generation Science Standards (NGSS). After completing the above-stated activities, students should be able to:

a) Record data displayed by a temperature probe

b) Plot data points to make graphs (manually and using appropriate software such as Excel or GeoGebra)

c) Identify an exponential trend in a heating or cooling curve

d) Verify the best insulating bio-based or non-bio-based material

Annex 2: Assignments

Homework: Building material timber as an insulator

Assignment 1

Observe a piece of wood and describe its structure in as much detail as possible!

____

____

____

Assignment 2

Try to explain why timber is a good insulator against heat and cold!

____

____

____

Assignment 3: Heating chamber

Build a heating chamber that consists of five walls. The walls should be heat insulating and fireproof. The front remains open. Position in the chamber an adjustable heat source, for instance heating plate. The open side is equipped with retaining clips to clamp different materials.

Clamp different wood panels (spruce, beech, etc.) of the same thickness (4 cm) into the heating chamber. Turn on the heating source and measure the amount of heat using an infrared camera. Repeat the experiment described above and double the thickness of the wood panels. Insert the measured values into the table pictured below.

Type of Wood	Measurement 4 cm			Measurement 8 cm		
	After 5 min	After 10 min	After 15 min	After 5 min	After 10 min	After 15 min

Repeat the experiment described above using different materials such as cork, coconut etc.

Type of Wood	Measurement 4 cm			Measurement 8 cm		
	After 5 min	After 10 min	After 15 min	After 5 min	After 10 min	After 15 min

Assignment 4: Heating chamber

Consider which insulating material is suitable for good thermal insulation. What would you recommend as insulating material if you are the specialist in this area?

Annex 3: Data logging experiment

Thermal insulation of building materials - Data logging experiment in groups

In this experiment you will examine the process of cooling to study properties of different building insulation materials (bio and non-bio-based). One of two beakers of hot water will be insulated. You will measure temperature changes and observe the cooling curves.

Equipment and materials (for 6 groups)

- different insulation materials (3 bio and 3 no bio-based)
- equipment for each group: interface and two temperature sensors, 2 beakers, clamps to hold the probes, stands, hot water, cold water, water bath.

Figure 1: Source: Own picture

Assignments

- Think about the thermal properties of the insulating materials. What is your hypothesis? Which of the beakers will cool faster?

____
____

- Connect two temperature sensors to the interface.
- Pour equal amounts of hot water into each beaker (e.g. 50 ml).
- Place the beakers in a hot water bath to get them to the same temperature.
- Set up your software to record for 15 minutes.
- Remove the beakers from the water bath, add the temperature probes and start recording.
- Wrap one beaker with insulating material (thickness 1 cm).
- Observe the temperature vs time graph

- Save your data.
- Repeat the experiment cooling the beakers in cold water.
- Share the collected data (in appropriate format) to the other groups and teacher for comments and further analysis.

Questions

a) Compare your hypothesis with the results of measurements. Does your hypothesis is correct?

b) How does insulation material affect the rate of cooling?

c) What do you think are the other possible factors that affect the rate of cooling?

(This experiment adapted from http://rogerfrost.com/exp/heat.htm).

Annex 4: Learning Design

Description	
Context	**Topic:** Bioeconomy **Total learning time:** 180 h **Number of students:** 25-30 students **Description:** The lessons are dedicated to students aged 16-19. Students learn about bioeconomy and bio-based products and materials. They take data-logging measurements with different insulating materials and analyse collected data.
Aims	Students explore experimentally the thermal properties of bio-based insulating materials, practice mathematical analysis of experimental data, cooperate with colleagues.
Outcomes	Knowledge (Knowledge): Students should know what is bioeconomy and how to check thermal properties of chosen insulating materials Application (Application): Students should know some application of bioeconomy products and materials Analysis (Analysis): Students should know how to analyse experimental data
Teaching-Learning activities	
Lesson 1: Laboratory work - data-logging experiment in groups	***Read Watch Listen 5 minutes 25-30 students Tutor is available*** Students get involve into basic concepts regarding the bio-based building materials at home. They watch videos: - Bio-Economy - https://youtu.be/2xvXkOMRTs4 - Different types of insulation/ fuel poverty - https://youtu.be/ZXPvaroR2AI - How does insulation work? - https://youtu.be/aaUz_SqOXnI The teacher introduces and motivates the students for the topic "Bio-Economy" and "Bio-based building materials". He/ She explains the objectives of the lesson and the rules for the work in the flipped classroom.
	Collaborate 25 minutes 4-5 students Tutor is not available The students are divided by the teacher into groups of 4-5 persons as each group will be working on different issue (the notes). The assigned activities should be worked out in form of knowledge café and the result should be written down by creating a poster.

	Discuss 10 minutes 25-30 students Tutor is not available The lesson will be fined by round table discussion. Each group is supposed to select a representative. The teacher will play the moderator in the round table discussion.
	Read Watch Listen 5 minutes 25-30 students Tutor is available The lesson will be summarized by teacher, the homework will be explained. For example, the first group will watch the video on bioeconomy and read the document "The Fundamentals of Bioeconomy" (Lange, 2016) and answer questions such as: What is the bio-economy? How is the bio-economy linked to the conventional production process? What is the influence of bio-economy on sustainable development? Is there a difference between bio-economy and green economy? Two groups will be dealing with various bio-based products and the raw materials needed for their fabrication. The teacher will provide each student with a bio-based product using the document Bio-Economy in Everyday Life (http://www.bio-step.eu). One group will frame the question how the insulation work by watching the video provided by the teacher.
Lesson 2. Laboratory work - data-logging experiment in groups	***Discuss 15 minutes 4 students Tutor is not available*** Reviewing the basic principles of heat transfer, bioeconomy and building materials - Kahoot quiz in groups. Discussion about the results of the home experiment. ***Read Watch Listen 10 minutes 12-16 students Tutor is available*** Description the task of each group, short presentation the data-logging experiment by teacher. ***Investigate 50 minutes 4 students Tutor is not available*** 1.Students prepare the experiment and set up the software. 2.They make predictions about the cooling curves of a beaker of water in different environments. 3.They register the cooling curve and compare their prediction with the result of their measurement. 4.They discuss the collected data. 5.They repeat the experiment using second insulation material. ***Collaborate 15 minutes 12-16 students Tutor is not available*** Students share the collected data. All groups present the results of their experiments.

Lesson 3. Mathematical Analysis in PC-lab	***Practice 30 minutes 4 students Tutor is not available*** The teacher starts the lesson by asking the students to continue the experimental group. He/ She supports the groups by analysing the collected data. The students analyse the empirical data by calculating descriptive statistics and conducting regression analysis
	Collaborate 10 minutes 4 students Tutor is not available Each group presents the data analysis by creating a Power Point presentation.
	Discuss5 minutes 25-30 students Tutor is available The teacher closes the lesson by a general discussion on the topic.

The BLOOM School Box

Future Classroom Scenario

Building a new environmental future

This scenario is part of the BLOOM School Box, which consists of a set of five Future Classroom Scenarios combining bioeconomy into science, technology, engineering and mathematics (STEM) subjects. These resources were developed and tested in classrooms by 20 BLOOM expert teachers from 10 different countries.
This Future Classroom Scenario has been developed as part of the BLOOM project, using the methodology of the Future Classroom Toolkit (http://fcl.eun.org/toolkit).

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European Schoolnet
Future Classroom Lab

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Ara / Subject

In which subject(s) or area of expertise can the scenario be used?

Subjects: Biology, Chemistry, Biochemistry, Geology, Natural Science

There are two version of scenario:

- for younger students (13 -15 years old)
- for older students (15 -17 years old)

The activity will take around 5 academic hours in class and around 6 academic hours out of the class environment.

Relevant Trends

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

Student-centred Learning: During most activities, students have an active role and the teacher guides them during their activities.

Collaborative Learning: A strong focus on group work.

Inquiry-based learning: Younger students will discover the issue and prepare a science exhibition.

Project-based Learning: students get fact-based tasks, problems to solve and they work in groups. This kind of learning usually transcends traditional subjects. In this learning scenario, older students will develop an inquiry-based learning project.

Lifelong Learning: Learning does not stop when leaving school.

Learning Objectives and Assessment

What are the main objectives? What skills will the learner develop and demonstrate within the scenario? (e.g. 21st Century Skills). How will the progress in achievement be assessed, ensuring the learner has access to information on their progress so they can improve?

Learning objectives

- Students will gain a basic insight into the topic of bioeconomy
- Students will be able to differentiate bioeconomy products from traditional industry products.
- Students will experience implementing the principles of bioeconomy on familiar products.

21st-century skills

Students will improve the following 21st-century skills:

- Learning Skills
- Critical Thinking
- Creative Thinking
- Collaborating
- Communicating

Literacy Skills:

- Information Literacy
- Media Literacy
- Technology Literacy

Life Skills:

- Initiative

- Social Skills
- Productivity

Assessment

- Students will be required to carry out presentations in the classroom (self-assessment; peer-assessment; assessment by the teacher)
- Formative evaluation in addition to summative evaluation (assessment by teacher)
- Assessment of the group work (group work skills are an important part of the project)
- Science exhibition/possible experiments/artefacts from the PBL (depends on the students age)

Learner's Role

What sort of activities will the learner be involved in?

The learners will be involved in student-centred activities:

- The learners will participate in debate activities.
- The learners will be involved in decision-making.
- The learners will be involved in inquiry-based learning and project-based learning.
- The learners will improve their presentation skills.

Tools and Resources

What resources, particularly technologies, will be required?

Computers, laboratory materials, virtual laboratory.

Learning Space

Where will the learning take place e.g. school classroom, local library, museum, outdoors, in an online space?

School classroom, outdoors, local business, school laboratory.

Future Classroom Scenario Narrative

The detailed description of the activity

This scenario consists of two chapters that are meant to be fully implemented in class. Part I and II should take around 5 academic hours (45 minutes per lesson). Part III should take around 6 academic hours (depending on the students´ project).

Part I

What is bioeconomy? - (90 min)

- The teacher introduces the theme by giving some facts about the consequences of using non-renewable resources and about the sustainability of our planet. Could there be a solution?
- The teacher shows a short film in class to introduce bioeconomy: https://www.youtube.com/watch?v=2xvXkOMRTs4 [in English]
- The teacher divides the class in groups of 3 or 4 students.
- The teacher gives each group a box with several items or pictures (e.g. usual plastic bottles and recycled or bio-based products; non-bio-based fuels and bio-based fuels resulting from bioeconomy; electronic pieces; cotton material and polyester material. For details, see Annex 1). If the teacher can find real products, that will be preferable.

The detailed description of the activity

- Each group, based only on what they know so far, has to divide their items into two groups: materials they think are produced as a result of bioeconomy and items produced by "traditional" industry. Then they have to find characteristics that distinguish them.
- The teacher promotes the debate between groups. The final objective is to demystify the idea that products obtained by bioeconomy are structurally less resistant and less durable and understand that the products obtained by the current industry can also be produced using biological resources.
- The teacher should now show a presentation with the solutions. Should also give more information about the raw material. For details, see Annex 2.
- In class, find a global definition of bioeconomy.

Part II

What can we do with this? (135 min)

- Add more information about bioeconomy by showing this video: https://www.youtube.com/watch?v=WEp3fFIeZc4 or this one https://www.youtube.com/watch?v=aiglinxb4XU [available in English]
- The teacher presents the driving questions to students:
    - For younger students: "What can we do with this fruit/vegetable besides eating it?"
    - For older students: "What can we do with this industry waste* besides putting it in the garbage?" (*it will depend on the local industries existent in the school region)
- The teacher gives each group an actual item:
  For younger students:
    - Apple, tomato, shrimp, clamshell, banana, nuts or cactus (depending on the resources existent in the school region).
    - Each group has to find examples of usage for as much of the mass of the products, so as to make the most of their potential with minimum waste.

  For older students:
    - It would be preferable if the class could make a visit to a local industry to find what kind of waste is produced. If this cannot done, the teacher should present an example of a type of industry waste to investigate potential uses connected to bioeconomy issues.
    - Each group has to make a presentation on the subject to the class.
    - Groups give feedback to each other about the presentations.
    - Students will produce a groups' reflection about the whole activity in collaborative electronic wall (through Padlet or Linoit platform).

Part III (270 min)

Yes we can change the world! (This part can take at least around 4 academic hours or even more, depending on out of class activity and the protocols designed by students)

- For younger students: plan a exhibition to show / explain what they've learned about bioeconomy to the whole school. If possible plan and develop a scientific project.
- For older students: plan and develop a scientific project.

Learning Activities

Link to the Learning Activities created with Learning Designer (http://learningdesigner.org)

https://v.gd/J6Xf1x (Full text available in Annex 3)

Annexes

Annex 1: Pictures for the boxes

BIO-BASED PRODUCTS	TRADITIONAL PRODUCTS
	
	

BIO-BASED PRODUCTS	**TRADITIONAL PRODUCTS**
	
	
	

BIO-BASED PRODUCTS	TRADITIONAL PRODUCTS
	
	
	

BIO-BASED PRODUCTS	TRADITIONAL PRODUCTS
	

Annex 2: Building a new environmental future presentation

Building a new environmental future

Bio-based products

Traditional based products

bloom

Boosting European Citizens' Knowledge and Awareness of Bio-Economy Research and Innovation

BIO-BASED PRODUCT

TRADITIONAL BASED PRODUCT

BIO-BASED PRODUCT

TRADITIONAL BASED PRODUCT

bloom
Boosting
European Citizens' Knowledge and Awareness of Bio-Economy Research and Innovation

BIO-BASED PRODUCT

BIO-BASED PRODUCT

TRADITIONAL BASED PRODUCT

BIO-BASED PRODUCT

BIO-BASED PRODUCT

TRADITIONAL BASED PRODUCT

bloom

Boosting European Citizens' Knowledge and Awareness of Bio-Economy Research and Innovation

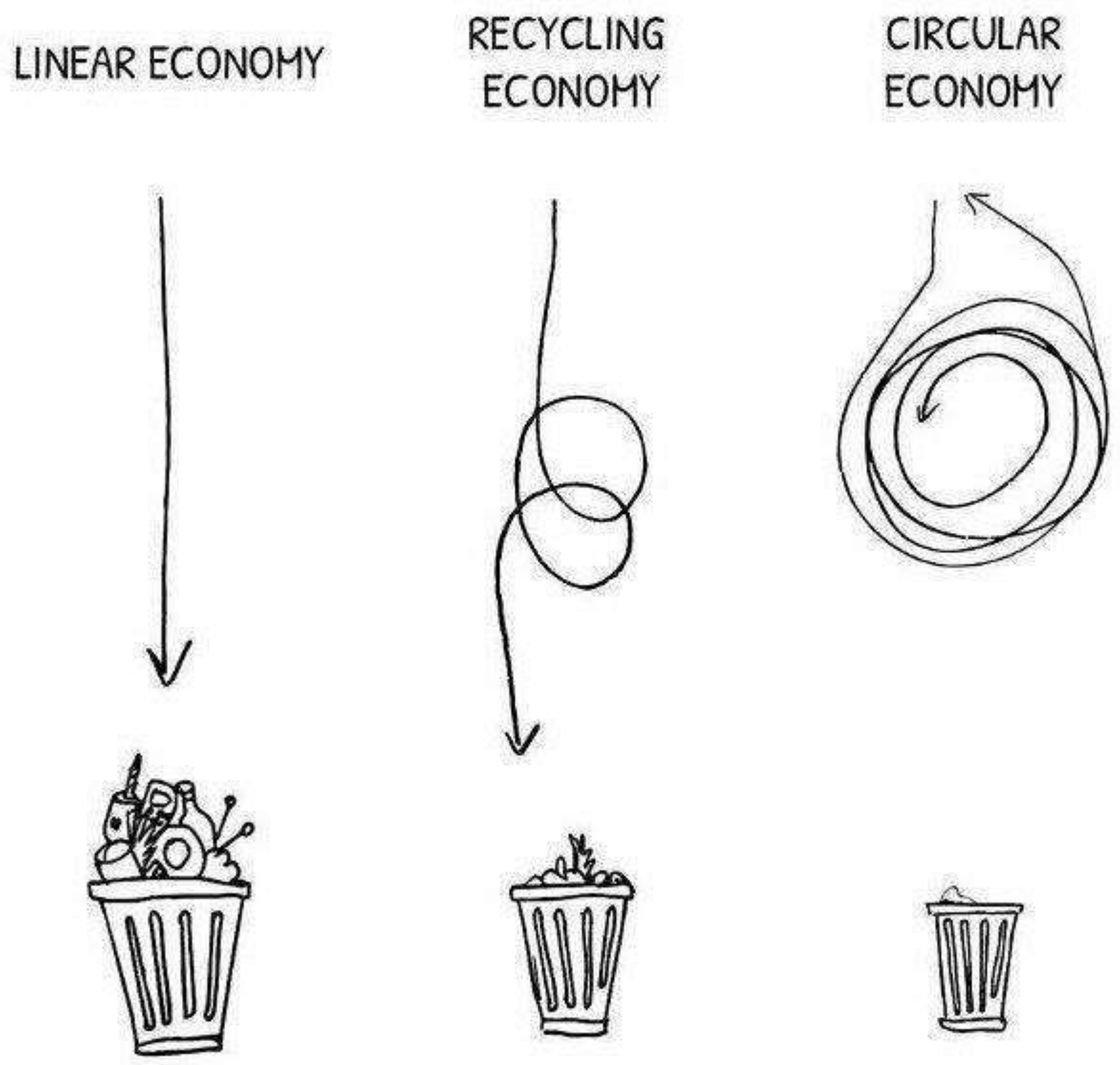
BIO-BASED PRODUCT

TRADITIONAL BASED PRODUCT

BIO-BASED PRODUCT

TRADITIONAL BASED PRODUCT

TRADITIONAL BASED PRODUCT


LINEAR ECONOMY
RECYCLING ECONOMY
CIRCULAR ECONOMY

Annex 3: Learning Design

Description	
Context	**Topic:** Bioeconomy **Total learning time:** 500 **Number of students:** 20/40 students **Description:** By viewing a short videos and analysing various materials, students will be able to define and understand the meaning of bioeconomics. In addition, they will be able to find more uses of certain living things, other than the usual and known ones, or to plan ways to increase the production of it, for example, microalgae. At the end, students will organize a Science Fair
Aims	1. Students will understand the meaning of the idea-bioeconomics. 2. Students will understand the difference between fossil and biomass resources. 3. Students will make a research about better implementations of bioeconomy for our future. 4. Students will gain a basic insight into the subject of bioeconomy 5. Students will be able to distinguish bioeconomy products from traditional industry products. 6. Students will experience implementing the principles of bioeconomy on familiar products.
Outcomes	Knowledge (Knowledge): Students will present their researches to their peers and do scientific projects with their outcomes.
Teaching-Learning activities	
What is Bioeconomy?	***Read Watch Listen 10 minutes 30 students Tutor is not available*** The group watches a small film to introduce the theme of bioeconomics. https://www.youtube.com/watch?v=2xvXkOMRTs4 At the end of the video, there will be a small discussion about new things that students learnt from this video and what else they would want to know
	Discuss 60 minutes 3 students Tutor is not available Each group will have a box with several materials or pictures (e.g.: usual plastic bottles and other, bio-based products; usual fuels and bio-based fuels; electronics pieces....). Each group has to divide their materials or pictures into two groups: materials resulting from fossil fuels and materials resulting from living beings.
	Discuss20 minutes 30 students Tutor is available The teacher promotes the debate between groups so that, at the end, the class has a global definition of bioeconomics.
What can we do with this?	***Read Watch Listen 6 minutes 30 students Tutor is available*** Show, to your class a video about bioeconomy (2 videos for younger and older students)

	Read Watch Listen 45 minutes 30 students Tutor is not available Teacher will present a presentation about bioeconomy at class
	Investigate 45 minutes 3 students Tutor is not available Give each group, a picture or a material (this will depend on the age of students): **For younger students** of 14 years old – in Israel and Portugal: give students materials such as an apple, a tomato, shrimp, clamshell, banana, etc. Each group has to find examples of usages for their material, so as to make the most of their potential. **For older students** of 15 or 17/18 years old: hand out to students sets of images (e.g.: a factory and microalgae, or dump and bacteria….) to investigate how they connect to bioeconomy issues.
	Produce 30 minutes 3 students Tutor is available Using ICT tools, students will present their work to the class.
	Collaborate 30 minutes students Tutor is available Peer-to-peer feedback for each groups of presenters (each group will provide their feedback and assessment to the other groups).
Yes, we can change the world!	***Produce 200 minutes 3 students Tutor is available*** **For younger students**: plan an exhibition to show/explain what they have learned about bioeconomy. The exhibition will be planned and prepared by students. Students can prepare posters, models, presentations in at order to show their researchers the exhibition. Also, there is a possibility that younger students will be asked to colour an activity book and will present through it their outcomes. **For older students:** plan and develop a scientific project, preferably using a local industry. The scientific project will include PBL steps, following the development of an idea into a product. Students can use materials in order to produce their projects. ***Collaborate 20 minutes 3 students Tutor is available*** Students will produce group reflections on a collaborative electronic wall (through Padlet or Linoit platforms).

The BLOOM School Box

Future Classroom Scenario

How poop will change the world

This scenario is part of the BLOOM School Box, which consists of a set of five Future Classroom Scenarios combining bioeconomy into science, technology, engineering and mathematics (STEM) subjects. These resources were developed and tested in classrooms by 20 BLOOM expert teachers from 10 different countries.
This Future Classroom Scenario has been developed as part of the BLOOM project, using the methodology of the Future Classroom Toolkit (http://fcl.eun.org/toolkit).

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Area / Subject

In which subject(s) or area of expertise can the scenario be used?

Subjects: Physics, Chemistry and Biology, both primary and standard level

Duration: This learning scenario contains 4 main parts and it takes 90 minutes to implement it.

Age of students: 13-15 years old.

Alternatively, it can be adapted to primary-school aged students, for 120 minutes. **Age of students:** 10-12 years old.

Relevant Trends

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

Project-based learning: Students get fact-based tasks, problems to solve and they work in groups. This kind of learning usually transcends traditional subjects.
Collaborative learning: A strong focus on group work.
Lifelong learning: Learning does not stop when leaving school.
Mobile learning: we get access to knowledge through smartphones and tablets. It is learning anytime, anywhere.
STEM learning: Increased focus on Science, Technology, Engineering and Mathematics.
Visual search and learning: Images and multimedia are more powerful than verbal stimuli.
Open source learning: Teachers copy, share, adapt, and reuse free educational materials.
BYOD (Bring your own device): Students bring their own mobile devices to the classroom.
Learning materials: Shift from textbooks to web resources and open source books.

Learning Objectives and Assessment

What are the main objectives? What skills will the learner develop and demonstrate within the scenario? (e.g. 21st Century Skills). How will the progress in achievement be assessed, ensuring the learner has access to information on their progress so they can improve?

The main objective of this scenario is to learn about energy and ways we can produce energy.

Skills that students develop:

- Analytic thinking - comparison of different types of energy production
- Communication and collaboration - working in groups to finish a task
- Creativity - making of their own brochures
- Digital citizenship - use of ICT and new technology

Progress will be **assessed** with an online quiz and with feedback from students.

Outcomes of this scenario:

- All learners will learn about the term 'bioeconomy' and implement this term in everyday life. All learners will learn about biomass, fossil fuel and renewable energy sources.
- All learners will discover, through practical work and worksheets, positive and negative facts about biomass, fossil fuel and renewable energy sources.
- Most learners will learn how to write a web brochure in pdf format.
- Some learners will present their web brochure about biomass, fossil fuel and renewable energy sources.

Learner's Role

What sort of activities will the learner be involved in?

Learners will be involved in the following activities: group work, reading, watching and listening, investigating, demonstrating and creating brochures.

Students will:

1. Discuss about energy, the ways of producing energy right now. Discuss about bioeconomy and ways of producing energy in the future (including human waste and animal waste), and how much people know about bioeconomy via a short video in which students interview by-passers about bioeconomy.

2. Listen and watch about bioeconomy and biomass.

3. Practice differentiating fossil fuels from biomass and renewable energy sources (investigate, practice, design brochure, present brochure).

4. Conclusion: Quiz about energy/bioeconomy.

Tools and Resources

What resources, particularly technologies, will be required?

To carry out this lesson, three laptops or PCs and, if possible, one printer are necessary to print out the prototype of brochures that each group will produce. Internet connection is desirable but the lesson can be implemented as an "offline" one.

For the online quiz, students will need their own device (smartphone) with internet connection.

Tools needed for the lesson (See in the Annexes):

- Introductory presentation
- Video: interviews
- Presentation on bioeconomy and biomass
- Useful notes about practical work
- Handouts for different groups (3): biomass, fossil fuels and renewable energy
- Handout (1): How to make a brochure?
- Kahoot quiz

Learning Space

Where will the learning take place e.g. school classroom, local library, museum, outdoors, in an online space?

Learning will take place in a school classroom.

Future Classroom Scenario Narrative

The detailed description of the activity

For students aged: 13-15

The earning scenario is divided in 4 main parts (90 min, age of students: 13-15)

1) INTRODUCTION (9 min)

The detailed description of the activity

For this part, use the introductory presentation from Annex 1.

- To start the lesson, the teacher asks the class a simple question: "What do you think will change world in next 50 years?" To which, most student will answer one of the following: technology, robots, cars, etc. The teacher answers: "Poop will change the world!"
- The teacher measures the knowledge of students about bioeconomy and biomass
- Optional: If possible, the teacher displays a video including interviews about the general knowledge of bioeconomy and explains main facts about it. The class discusses the content of the video. During the discussion, every student can state his or her opinion and say few words. Here are some leading questions:
    - Do people know enough about bioeconomy? Why is that so? What does that depend on?

2) BIOECONOMY 101 (15 min)

For this part, use the presentation about bioeconomy from Annex 2.

- The teacher gives a short lecture about bioeconomy, biomass and the ways we can use animal waste to produce energy.
- The class defines facts about bioeconomy.
    - Define biomass, what it can be used for and discuss its different types. Explain how to get energy from biomass. Explain positive and negative aspects of producing energy from biomass. Explain how to get new products from human and animal waste.

3) GROUP WORK (56 min)

- For this part, use the following resources, from Annex 3:
    - Handout about biomass -> for Group 1
    - Handout about fossil fuels -> for Group 2
    - Handout about renewable energy -> for Group 3
    - Useful notes about practical work
    - Handout: How to make brochures?
- The teacher divides students into 3 groups.
- Every group reads short learning materials the teacher provides about fossil fuels, renewable sources of energy and biomass (see Annex 3).
- Each group is given a topic: 1) fossil fuels as energy; 2) biomass as energy; 3) renewable energy sources. Each group is provided with materials for their research and a laptop for internet search.
- After carrying out the research, each group will carry out practical work, which is explained in their materials.
- Each group needs to produce brochure that represents key features about given topic and pros and cons about their source of energy. After that they need to present their work to others.

4) EVALUATION (10 min)

Last part is evaluation via online quiz. As a conclusion, the students will participate in an online Kahoot quiz. It is possible to use this Kahoot quiz [in English] or adapt it to fit your classroom.

For students aged: 10-12 (PRIMARY STUDENTS ADAPTATION)

The learning scenario is divided into 4 different parts (120 min, age of students: 10-12 years old).

1) INTRODUCTION

The detailed description of the activity

- To introduce the topic, the class creates a brainstorming mind map. With the help of the teacher, students elicit the information that they have about the topic. The main points could be: different types of energy, renewable energy, reduce, reuse, recycle.
- The teacher introduces the new vocabulary. First, students watch a short video [in English] about the dangers of wasting energy.
- The teacher introduces students to bioeconomy. Students will watch a video as well. [in English]
- For this section, use the presentation in Annex 4.

2) BIOECONOMY 101

- To practice the vocabulary about bioeconomy, students participate in an activity.
- For this, use the activity in Annex 5.

3) GROUP WORK

- Students are divided in heterogeneous groups of 4. In groups, they discuss and think about different questions:
  - What does it mean to "have treasures in the trash?"
  - What can we do to protect our environment?
  - What is the cycle of general waste?
  - What is the cycle of human waste?
- After students share their hypotheses, the teacher explains the cycle of general waste and human waste and how we can take advantage of them to take care of the environment.
- For this section, use the presentations in Annex 6.
- Show the following video to students: https://www.youtube.com/watch?v=mb9XdsxkIww [in Spanish]

4) EVALUATION

- Once students have learnt the vocabulary of the unit and the process and importance of biomass, the teacher helps them revise their knowledge with a Kahoot quiz:
  - https://goo.gl/JgtS48 [in English]
  - https://goo.gl/Wvuxc8 [in English]
- Optional activity: Students in groups of four create and advertisement video, explaining how important is to take advantage of the waste.

Learning Activities

Link to the Learning Activities created with Learning Designer (http://learningdesigner.org)

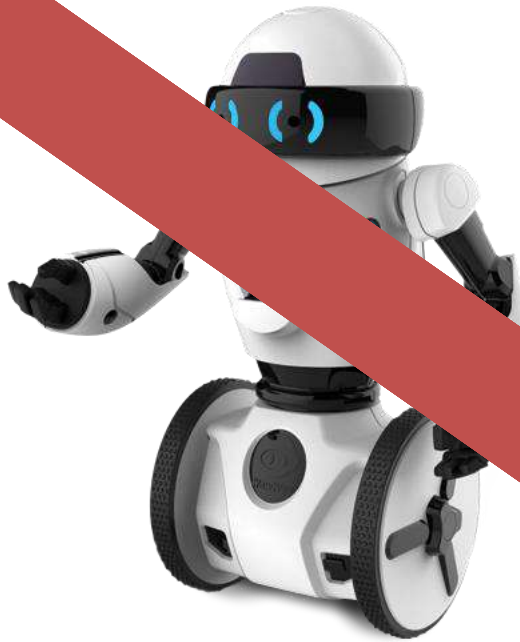
https://v.gd/OJQSfJ (Secondary school) (Full text available in Annex 7)

https://v.gd/q2AJAz (Primary adaptation) (Full text available in Annex 8)

Annexes

Annex 1: Secondary school implementation - Introductory presentation

WHAT DO YOU THINK WILL CHANGE THE WORLD IN NEXT 50 YEARS?



PICTURE CREDITS

- All pictures are open license
- https://bit.ly/2SiwqK7
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Annex 2: Secondary school implementation - Presentation about bioeconomy

What is biomass and bioeconomy?

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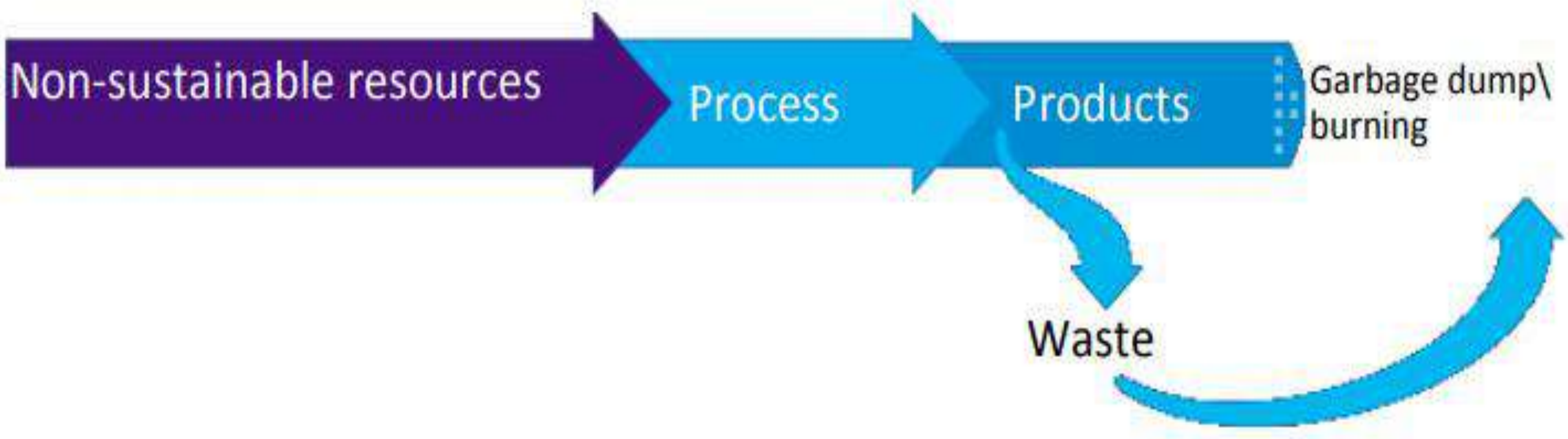
Today....

- We use fossil fuels as a most important resource
- Its not sustanable



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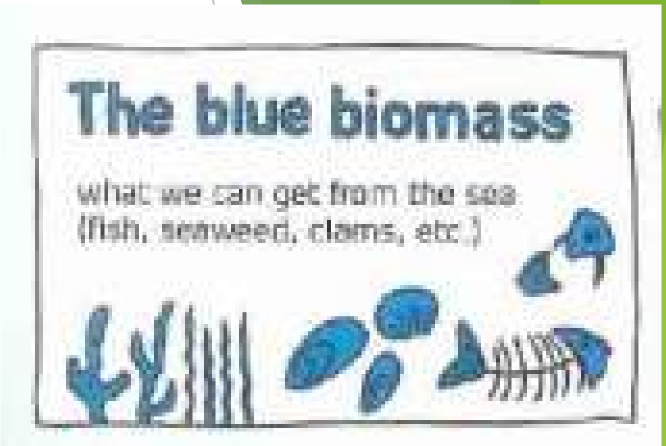
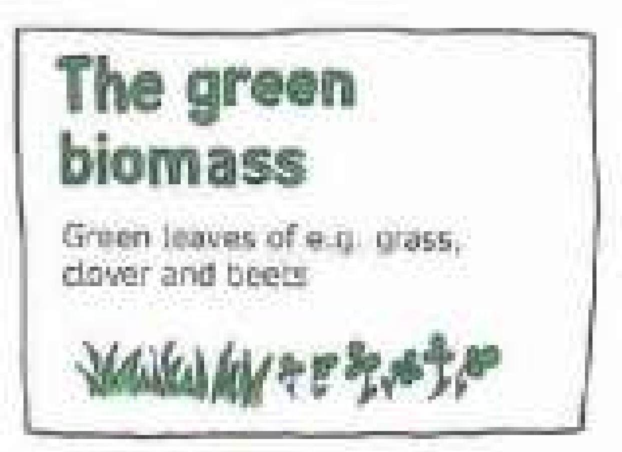
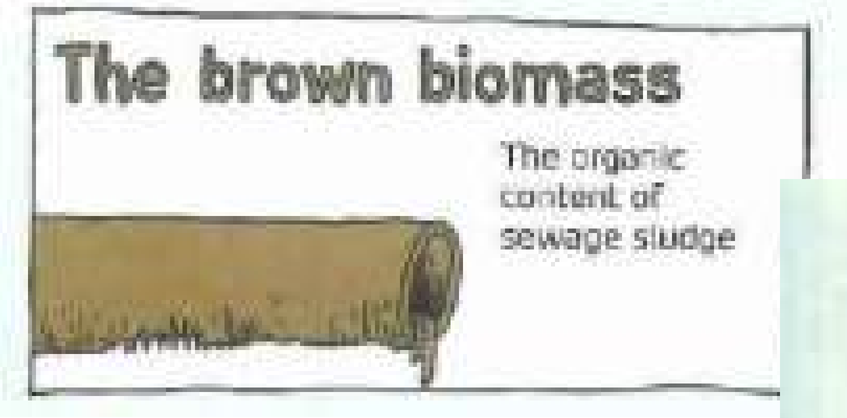
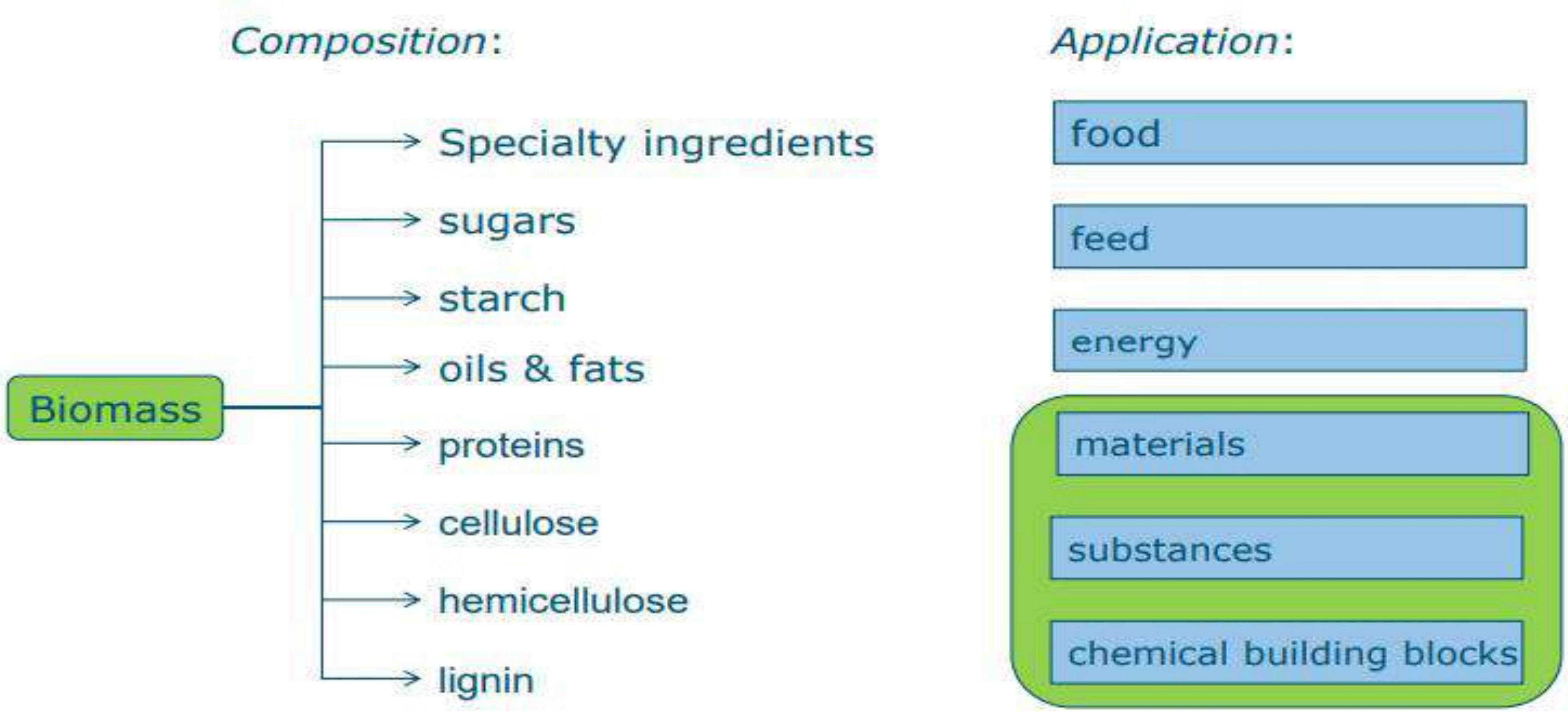


- The basis of Bioeconomy
- Crops, side streams wood, marine, etc





What can we do with biomass



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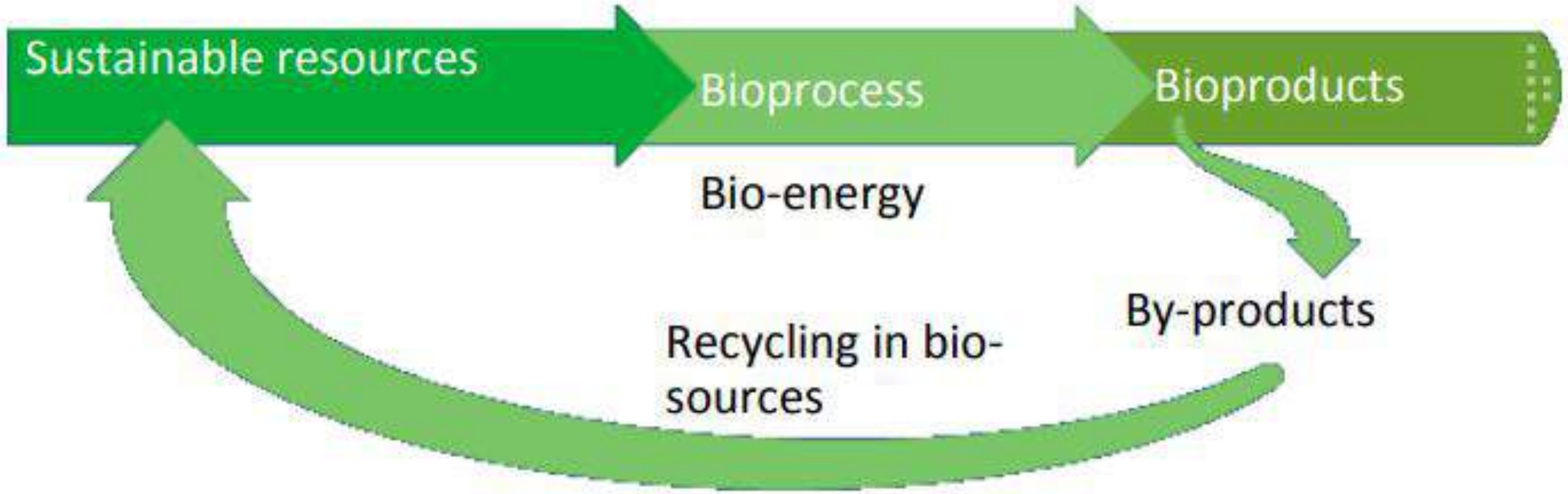
Modified wood
Bioplastics
Composteerbaar
Bioethanol
Natural fibre composites
Green plasticisers
Compostable packaging
Building materials
Paints, coatings and dyes
Insulation

bloom

Biobased Economy -



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How to get energy from biomass?

Thermal conversion – burning biomass (wood, briquettes, …)

Biofuel – fermenting biomass like sugar cane, whear or corn

Different chemichal process that produce methane

bloom

bloom

Keywords

Biomass - organic matter used as a fuel, especially in a power station for the generation of electricity

Bioeconomy - Economy which is based on using biomass as a renewable resources for the production of materials and energy

bloom

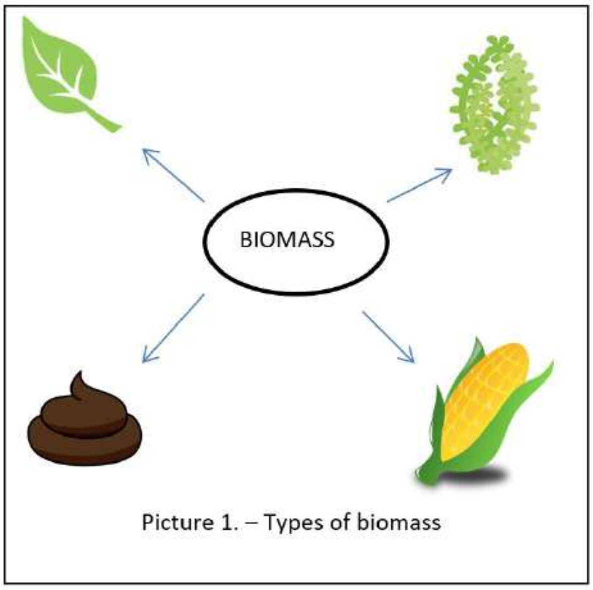
Annex 3: Secondary school implementation - Handouts

HANDOUT ABOUT BIOMASS

WHAT IS BIOMASS?

Biomass is organic material that comes from plants and animals, and it is a renewable source of energy. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel (eg methane). Crops such as corn and sugar cane are fermented to produce fuel for use in vehicles. Biodiesel, another transportation fuel, is produced from vegetable oils and animal fats.

TYPES OF BIOMASS



Picture 1: Types of Biomass

Biomass can come in many different forms. One of the most usual types of biomass is residues from crops of woods that is left after harvest. Another type of biomass we get from agricultural land such as corn or wheat and waste (poop) that animal and humans produce on daily basis. We can also use aquatic biomass from different type of seaweed to produce different materials and to produce energy depending on a need and composition of seaweed that we use.

Picture 2: Everyday products that are made from biomass

WHAT'S BAD ABOUT THEM?

Because we need a lot of biomass to produce energy and building materials we need a lot of space to produce biomass. That problem can lead to deforestation or using most of our agricultural fields for harvesting biomass for energy and not for food. If we wish to use biomass for building materials for different products we need to divide biomass to most simple components (proteins, fats, carbohydrates, etc.). That process can be expensive and it needs to be research more thoroughly.

HANDOUT ABOUT FOSSIL FUELS

WHAT ARE FOSSIL FUELS?

A fossil fuel is a fuel formed by natural processes, such as decomposition of buried dead organisms, containing energy originating in ancient photosynthesis. The age of the organisms and their resulting fossil fuels is typically millions of years, and sometimes exceeds 650 million years. The use of fossil fuels raises serious environmental concerns because burning fossil fuels produces carbon dioxide that is one of the biggest agent of greenhouse effect on our planet.

TYPES OF FOSSIL FUELS

There are three types of fossil fuels which can all be used for energy provision; coal, oil and natural gas. Coal is a solid fossil fuel formed over millions of years by decay of land vegetation. Coal is quite abundant compared to the other two fossil fuels. Oil is a liquid fossil fuel that is most widely used. It is applied in cars, jets, roads and roofs and many other. Natural gas is a gaseous fossil fuel that is versatile, abundant and relatively clean compared to coal and oil. Like oil, it is brought to the surface by drilling.

WHY DO WE USE IT?

Fossil fuels are cheap and reliable source of energy that we use on daily basis. Technology we need to harness the energy that is produced by fossil fuels is well developed and its used in every corner of the world. Anyone can use fossil fuels you just need a source of fire (a lighter or a match) and burn fossil fuels to release energy from it. Because technology we need to harness that energy is well developed, energy produced by fossil fuel is cheap in comparison with ones that are produced by renewable energy sources or biomass. Most of today’s products contain plastics, which are produced from fossil fuels – oil. Because plastics and other materials that are produced with fossil fuels are widely used, fossil fuel industry employs millions of people globally. One of the main reason so many countries use fossil fuels as their main energy sources is that fossil fuels are everywhere.

WHAT'S BAD ABOUT THEM?

The main disadvantage of using fossil fuels, of course, is the pollution that they cause. Carbon dioxide is released when fossil fuels are burned and he is one of the biggest reasons for global warming. Because fossil fuels needed millions of years to get from living organisms to fuels they are finite energy source that can be and will soon be depleted. We are using fossil fuels everyday more and more and because of that we need to find more sources of fossil fuel which is harder by the day. Some of the fossil fuels may contain some materials that are harmful for human health. By burning those fossil fuels we release smog into air that is poisoning us and living world around us.

a) b) c)

Picture 1. – Types of fossil fuels: a) coal; b) crude oil; c) natural gas

Picture 2. – Everyday products that are made with of from fossil fuels

HANDOUT ABOUT RENEWABLE ENERGY

WHAT IS RENEWABLE ENERGY?

Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale. Renewable energy resources exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Most of renewable energy sources produce electricity that can be converted into heat or mechanical energy with high efficiency depending on the necessity.

TYPES OF RENEWABLE ENERGY

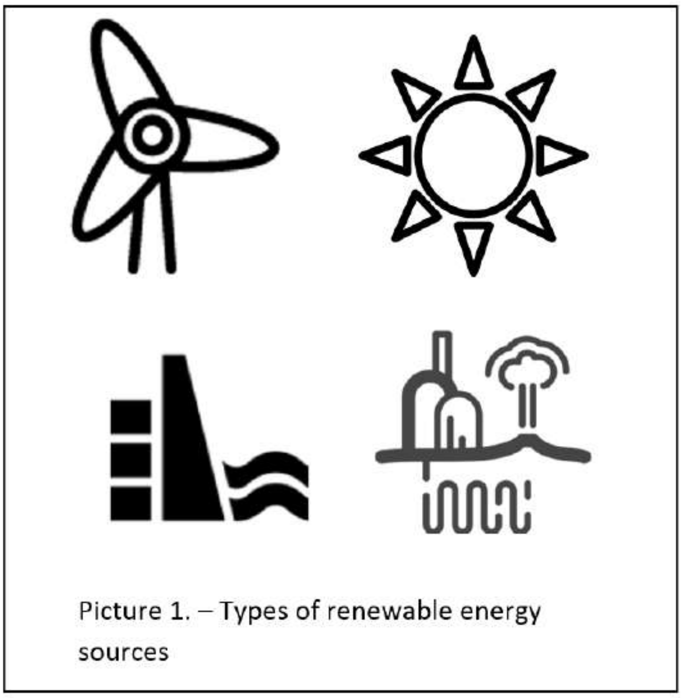
There are many forms of renewable energy such as sunlight, wind, tides, waves, and geothermal heat. Solar energy is the direct conversion of sunlight using panels or collectors. Wind energy can be used to produce electricity using large windmills. We can use tides and waves to harvest energy of the sea or rivers by building dams. Geothermal energy is based on using heat below Earth's surface for heating diverse heating purposes.

WHY DO WE USE IT?

Because we have less and less fossil fuels their price will go up eventually. That's the main reason we need to find another source of energy that will replace them. Because Sun will always rise and wind will always blow the reliability of renewable energy types can far exceed that of fossil fuels. Almost all of the renewable energy plans have lower carbon dioxide emission then those plan that include fossil fuels. That means renewable energy sources impact less on greenhouse effect. Once in place, most of renewable energy power plants have lower cost of operation then that of fossil fuels. We just need to change materials regularly and we will get electricity. Because of that there are a lot of job options in renewable energy sources. One of the main advantages is that anyone can place one of renewable energy generators in their home. We can place solar panels on our roof, or small windmill in our back yard.

WHAT'S BAD ABOUT THEM?

Because renewable energy is a new field more research is needed so we need to invest a lot of money in renewable energy to make it more efficient. Although we use renewable sources to make energy (e.g. Sun, wind, rivers) they can only produce so much energy in a given time. Because of that we need large area to set up large farms of energy to produce enough energy for towns. With that said we impact nature in another way. We need to clear forests and change river flows so we can use renewable energy sources properly.



Picture 1 - Types of renewable energy sources

Picture 2. – Example of renewable energy farm

Useful notes about practical work

1) Fossil fuels

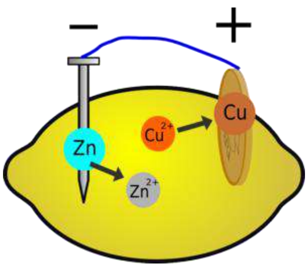
If you have you can use model of diesel engine as a example of turning fossil fuels into energy.

2) Renewable energy

You can use model of solar power plant or any toy that runs on solar power. Most of today calculators run on solar power so you can use that as an example of turning renewable energy into electricity. One of the best examples is hydro power plant. If you have one in your country you can use it as example.

3) Biomass as energy

You can use lemon to produce enough electricity to power LED light. Squeeze lemon and put few (3 or more) copper wires in it and few (3 or more) nails (preferable zinc nails) in it. Copper acts as a anode and zinc nail acts as a cathode of your battery that is lemon now.



HANDOUT: HOW TO MAKE BROCHURES?

You will need Office Word program 2013 or later on every device your students will be using.
After that go to: http://templatelab.com/brochure-templates/

From that web page chose any brochures template you like and save it as a Word file. You can edit it inside Word using your own pictures and text. After you edit it save it as a PDF file and print it if you want.

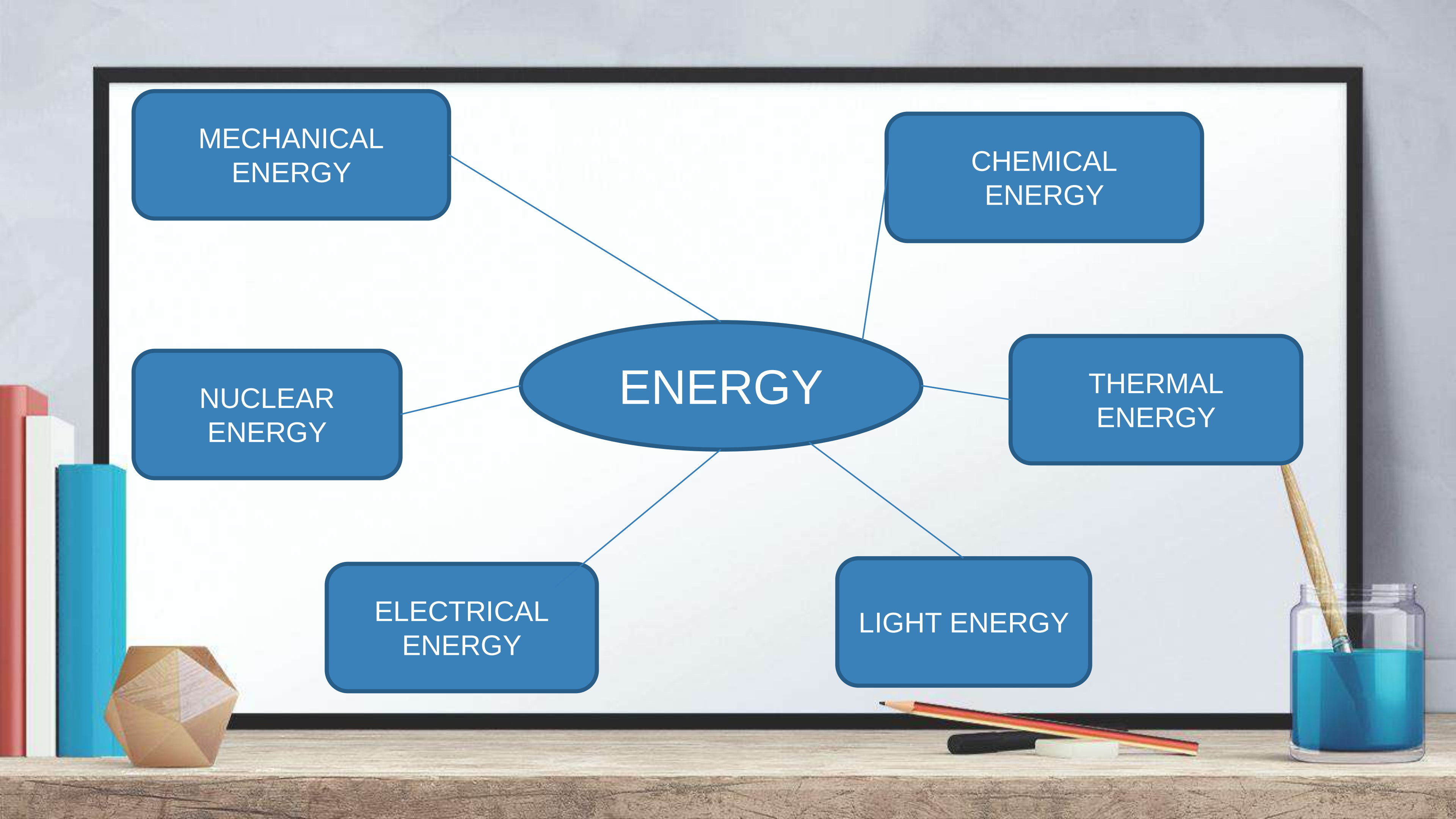
Annex 4: Primary school adaptation – introductory presentation

ENERGY

European Schoolnet
Transforming education in Europe

bloom

Future Classroom Lab
by European Schoolnet


ENERGY
MECHANICAL ENERGY
CHEMICAL ENERGY
NUCLEAR ENERGY
THERMAL ENERGY
ELECTRICAL ENERGY
LIGHT ENERGY

All living things need energy to live. Machines and tools use energy to work.

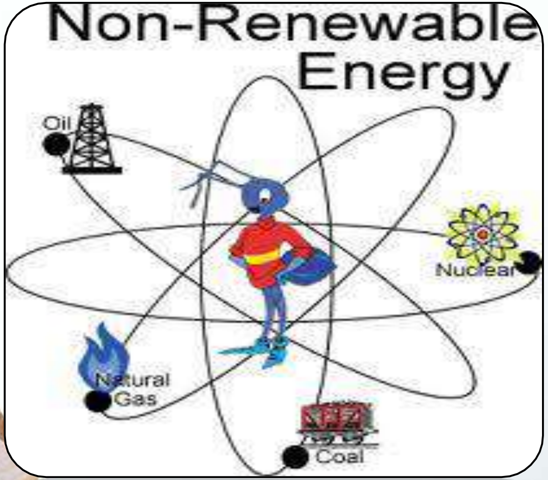
- All living things need energy from the Sun and food to live.
- Tools use energy from people or animals to work.
- Many machines use energy from electricity to work.
- Most means of transport use energy from burning fuel to move.

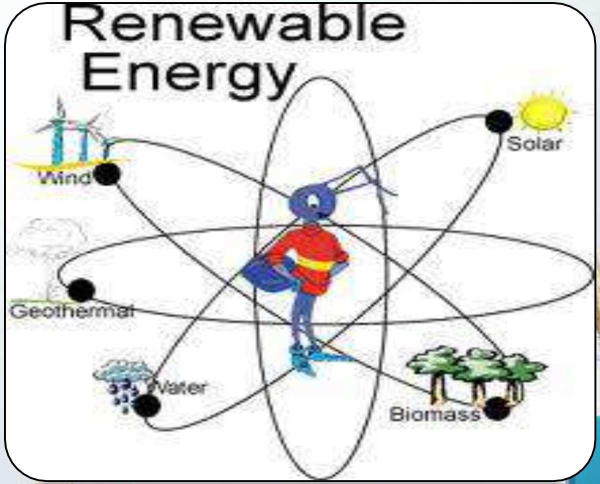
What happens to energy when it's used?

- Energy never disappears. It can be transformed from one type of energy into another, but it doesn't disappear completely.
- For example, energy can be stored inside batteries as chemical energy. When the batteries are put inside a torch, the torch transforms the chemical energy into light energy.

MAIN SOURCES OF ENERGY

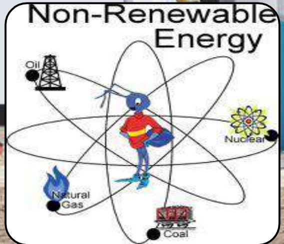
- NON – RENEWABLE ENERGY SOURCES
- RENEWABLE ENERGY SOURCES

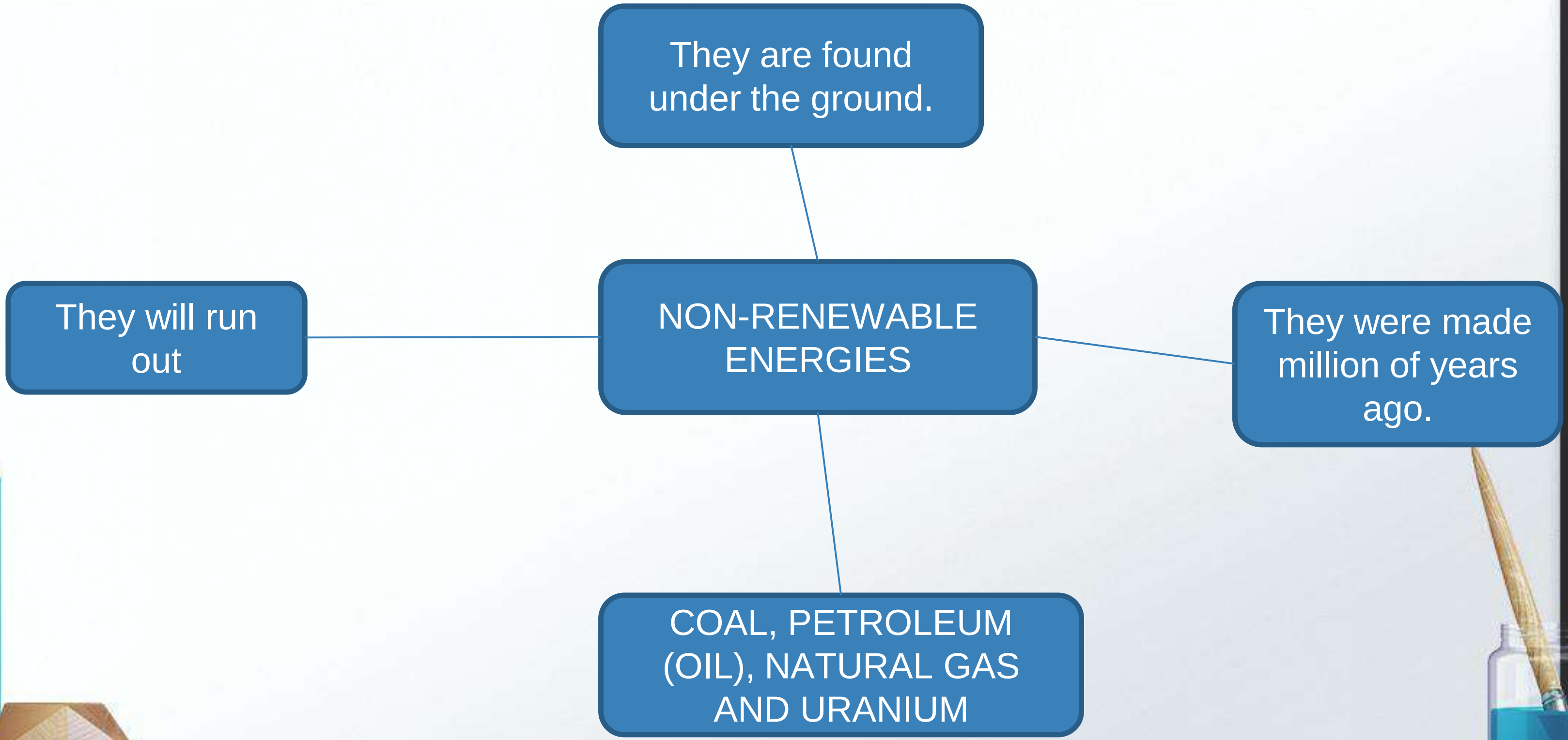




NON-RENEWABLE ENERGY SOURCES

- Non-renewable energy is energy from sources that are limited. If they are consumed faster that they are made , they will run out.
- These are fossil fuels: coal , petroleum, natural gas and uranium.
- They are found under the ground.
- They were made millions of years ago and millions of years are necessary to make more.




They are found under the ground.
They will run out
NON-RENEWABLE ENERGIES
They were made million of years ago.
COAL, PETROLEUM (OIL), NATURAL GAS AND URANIUM

COAL

- COAL is a solid. It is a black rock composed mainly of carbon. It is formed underground and extracted through mines.
- Coal is transported by train and boat.
- Coal is used mainly in power stations to make electricity and as fuel in some industries.

PETROLEUM (OIL)

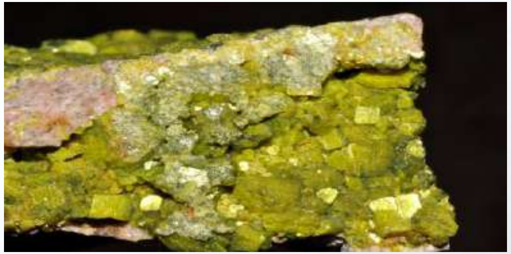
- PETROLEUM is a black liquid. It is formed underground and extracted through wells.
- Petroleum is transported to refineries by tanker and pipeline.
- It is the source of the fuel oil, diesel fuel and petrol that we use for heating and running vehicles
- Petroleum is used in industries , homes and vehicles.

NATURAL GAS

- NATURAL GAS is a mixture of gases. It is found underground and extracted through wells.
- Natural gas is transported by pipeline.
- Natural gas is used in homes for heating and cooking, and in industries.

URANIUM

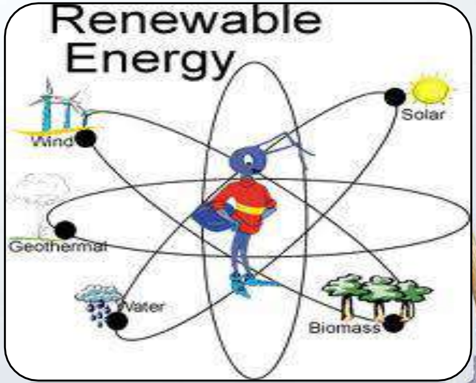
- It is a radioactive metal found in rocks.
- It is used in nuclear power stations to produce heat in nuclear reactions.
- Electricity is produced from this heat.



RENEWABLE ENERGY SOURCES

These are

- Hydroelectric energy (from water),
- Wind energy,
- Solar energy ,
- Geothermal,
- Biofuels .
- These energy sources are always avalaible.
- They will never run out.



RENEWABLE ENERGIES

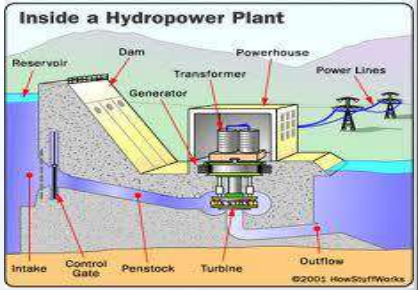
They will NEVER run out

They are always avalaible.

WIND, WATER, SUN, GEOTHERMAL, BIOFUELS

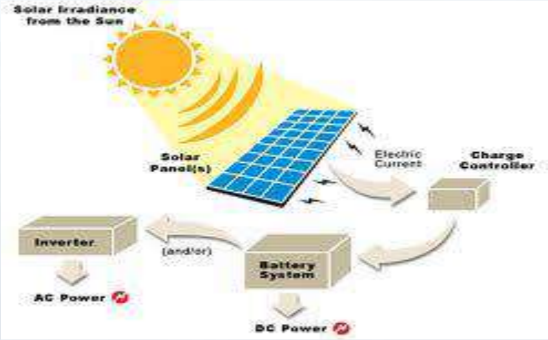
HYDROelectric ENERGY

- We get this energy from water that is moving or falling (from a dam).
- The water is collected in a reservoir. Then it passes through a turbine. As the turbine turns, it generates electricity.
- Hydro energy is transformed into electricity.



SOLAR ENERGY

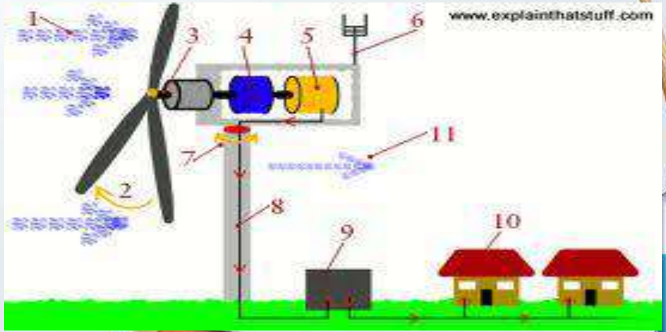
- Solar panels receive energy from the Sun.
- Solar energy is transformed into electricity that is used for light or heat.



CLICK ME

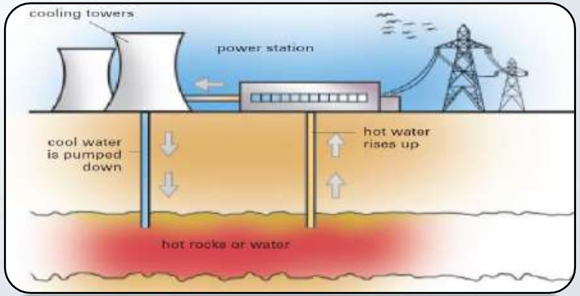
WIND ENERGY

- We get wind energy from the movement of the air.
- The kinetic energy of the wind turns a turbine and produces electrical energy.
- Wind energy is transformed into electricity.



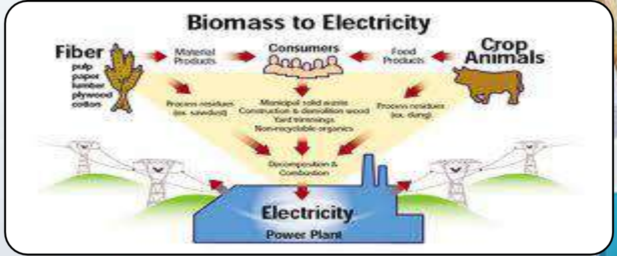
GEOTHERMAL ENERGY

- Geothermal energy is the heat from the Earth.
- It's clean and sustainable.
- Geothermal energy is the heat from the Earth. It's clean and sustainable.



Biofuels

- We get biofuels from plant and animal products.
- Biofuels can be solid (biomass), liquid (bioliquids) or gas (biogases).
- This energy is transformed into electricity and heat.

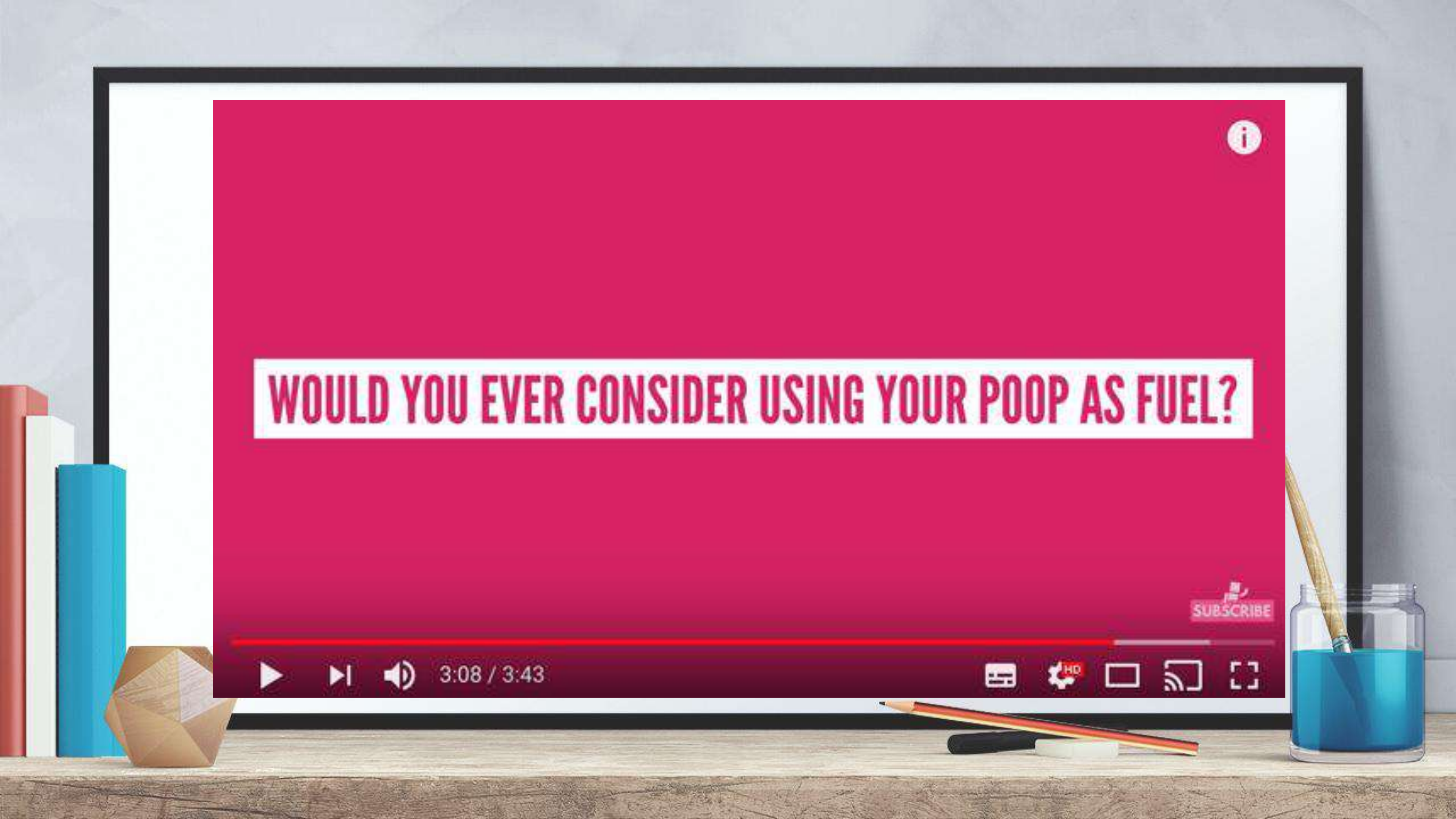



Biomass Sources
Sewage
Municipal Solid Waste
Agricultural Crops & Residue
Animal Residues
Forestry Crops & Residue
Industrial Residues

Towards a biobased society

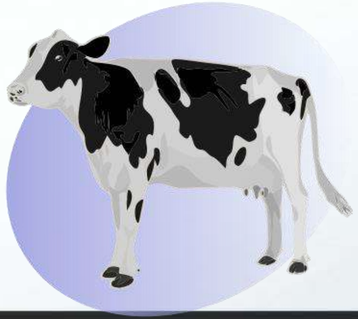
- **The population on Earth is growing** and we need more food. Climate change is both a reality and a threat. The answer is simple: We absolutely must use our biological resources better, so there will be food for more people with less environmental and climate impact per unit produced, and renewable biological material enough to produce the replacement for what we currently get from fossil crude oil (e.g. materials, chemicals and plastics).

Poop is Power


WOULD YOU EVER CONSIDER USING YOUR POOP AS FUEL?
SUBSCRIBE
3:08 / 3:43

Biomass Energy

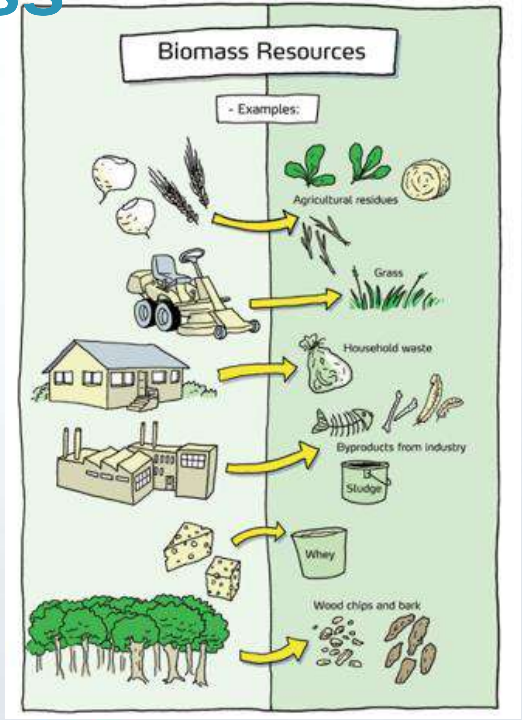
+ Did you know that poop can make power? It’s true.
+ Gas rising from the poop of 500 cows can create enough electricity to power 100 homes.
+ That’s some powerful poop!



SIMPLE energy

Poop is a form of biomass

+ Poop is a form of "biomass" which is the name for all living, or recently living materials coming from plants and animals that are a source of energy.

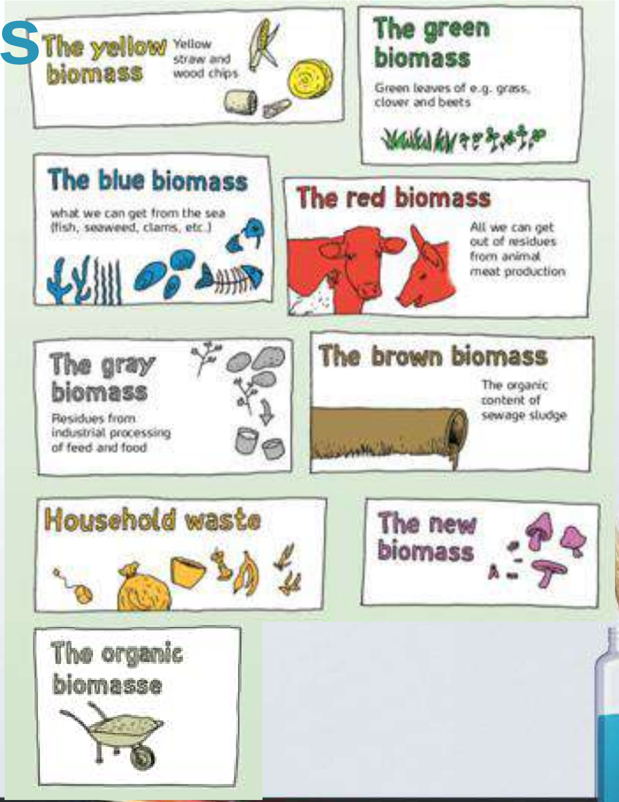


Poop is a form of biomass

- The most common form of biomass energy on Earth is burning wood. We burn wood in fireplaces to keep us warm, or in woodstoves to cook our food.

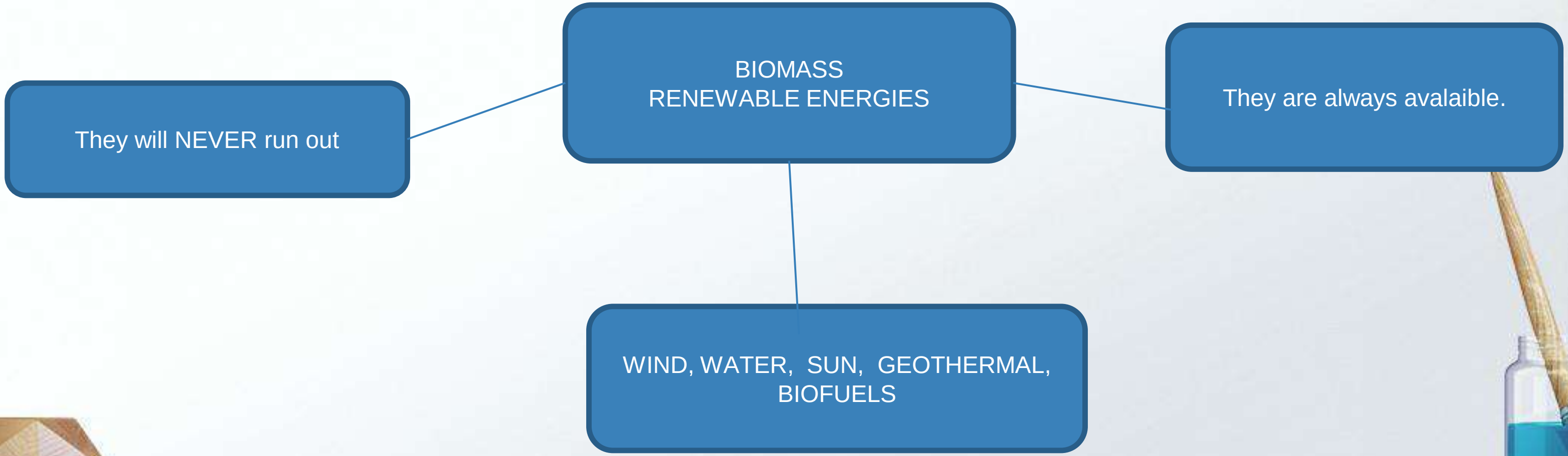
Poop is a form of biomass

+ Besides wood and poop, biomass fuels can come from stalks of wheat, corn or sugar cane. It can also come from rice hulls, cooking oil, and other forms of garbage and food waste.



Biomass vs. Fossil Fuels

+ Biomass materials can be grown over and over again, so they are considered renewable resources.



Biomass vs. Fossil Fuels

+ It takes them only months or years to grow and become fuel, unlike fossil fuels that take millions of years to become coal, oil, or gas.

COAL
OIL
GAS
1.000.000 years

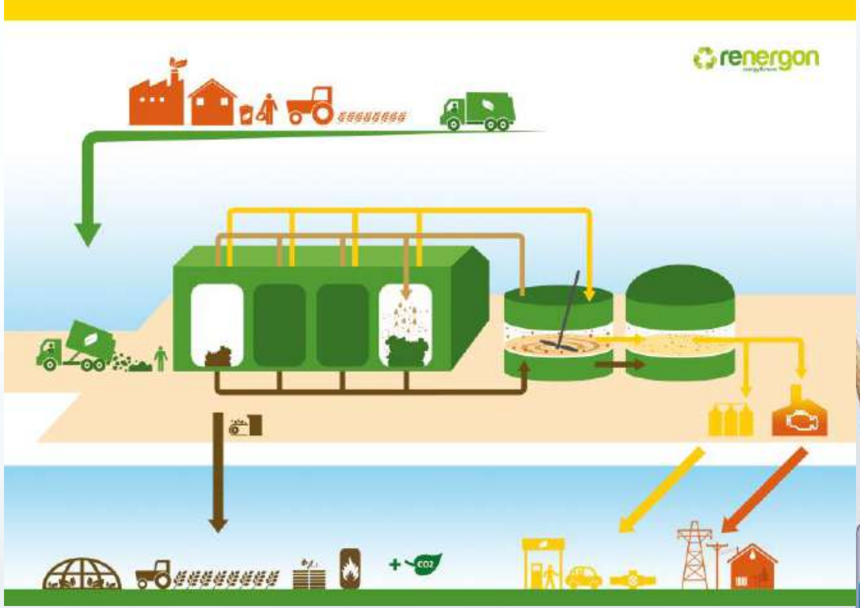
Biomass

Months or years

How does this happen?

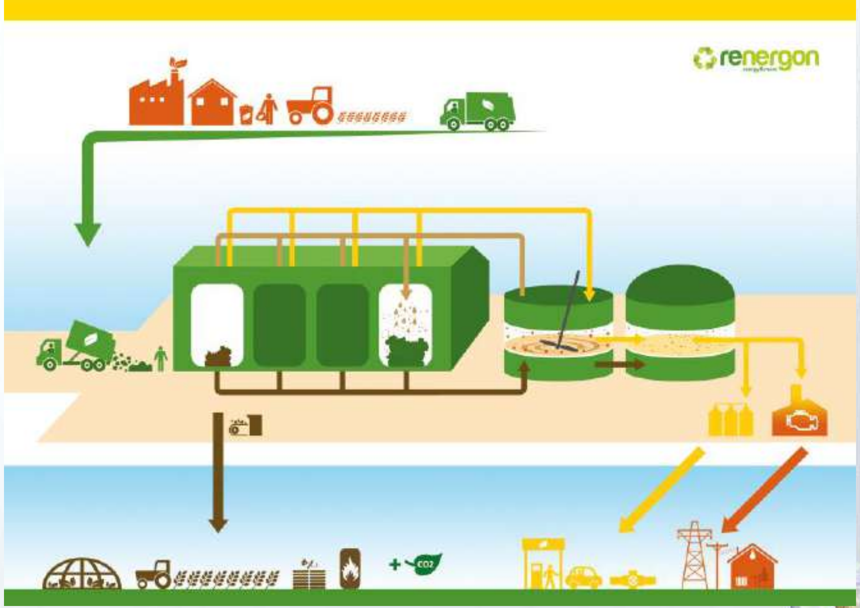
Biomass and Biogas

+ Biogas energy is created from burning the gas that comes off animal poop and rotting plants.



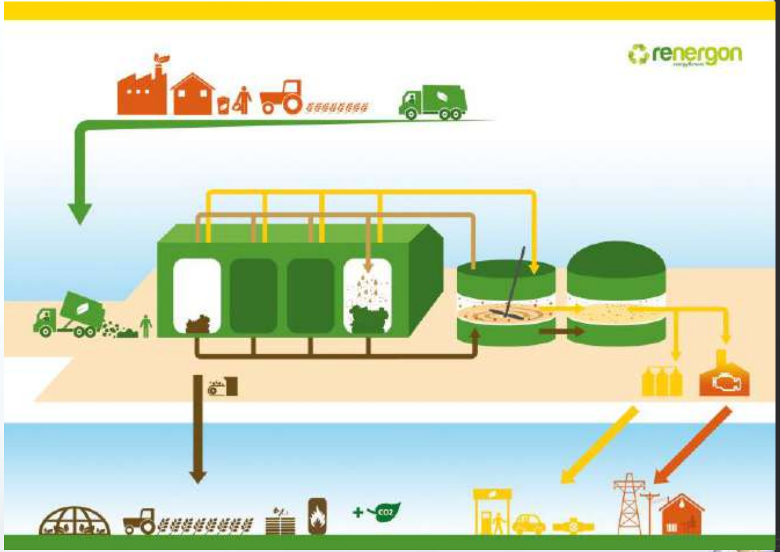
Biomass and Biogas

Rating stuff gives off methane and carbon dioxide gases. When burned in an airtight container, these gases are collected in a process called gasification, and are used to produce energy.



Biomass and Biogas

+ Biogas energy is used to heat water to create steam, which turns turbines, which generates electricity. The plant and animal waste that is left over is used as fertilizer for plants.



Keep Those Biomass Fires Burning

The best reasons for using biomass and biogas fuels are that they are sustainable; as long as people replant the fuel crops they harvest to create them.

Keep Those Biomass Fires Burning

- Also, plant and animal remains that were once considered waste and thrown in landfills are now being put to use as energy.
- The problem with biomass energy is that burning wood and garbage can still create air pollutants.

Keep Those Biomass Fires Burning

- Also, plant and animal remains that were once considered waste and thrown in landfills are now being put to use as energy.

Keep Those Biomass Fires Burning

+ Humans have used biomass energy for thousands of years. Today, nearly one third of the planet still uses some form of biomass energy, proving it remains a long-lasting, inexpensive alternative energy choice.

Any problem?

+ The problem with biomass energy is that burning wood and garbage can still create air pollutants.

WHAT PROBLEMS DO NON-RENEWABLE ENERGY SOURCES CAUSE?

+ Using non-renewable energy sources causes two problems.

1) These sources are limited. They can run out.
2) These sources produce pollution such as *carbon dioxide and other gases* that are harmful for people and the environment.

- Pollution is causing global warming and acid rain on our planet.
- *Gases from industries and vehicles goes up to the atmosphere and sometimes are condensed in clouds and when it rains it causes pollution. (sulfur dioxide and nitrogen oxides)*

SAVING ENERGY

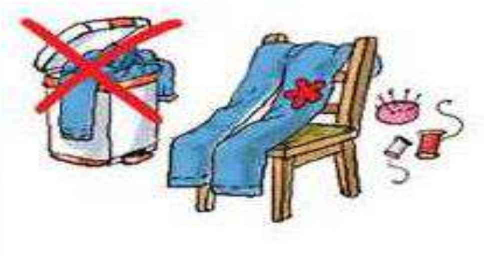
- Our lifestyle influences the amount of energy.
- We can save energy by making less waste.
- We must follow the 3 Rs:

+

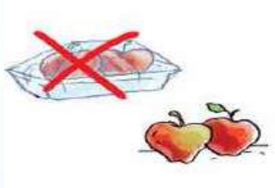
1ST R : REDUCE

+ It means BUYING LESS so that throw away less.

Don’t use dispposable items.



Repair things when
they break.



Avoid packaging

Buy large packs when possible.

2nd R: REUSE

+ It means USING THINGS AGAIN instead of throwing them away.

Take water to school in a reusable bottle.

Use paper on both sides

Make a pencil pot from a metal can

Give your old toys away.

3rd R: RECYCLE

- It means separating rubbish (or waste) and putting it in the correct bin.
- Recycling materials uses much less energy than making new ones.

Paper and cardboard

Glass

Metal and plastic

Thank you for your attention

Annex 5: Primary school adaptation – Vocabulary activity

ABOUT ENERGY

Session 1. Activity 3. Practice

1. Correct the false sentences and change the word underlined.
a) We can reduce pollution to protect our planet.
b) The four "Rs" are: reduce, reuse, recycle.
c) The non-renewable sources never run out.

2. Draw some objects that can be reduced, reused and recycled.

REDUCE **REUSE** **RECYCLE**

3. Fill in the missing verbs. Choose the correct option.
a) We can________________ energy to protect our planet. (save/waste)
b) A lot of the energy we___________ at home is non-renewable. (use/protect)
c) The three Rs______________________the environment. (damage/protect)
d) We can save energy if we__________________ off lights. (turn/take)

Annex 6: Primary school adaptation – group work presentation

Did you know that each one of us generates more than a kilo of waste per day?

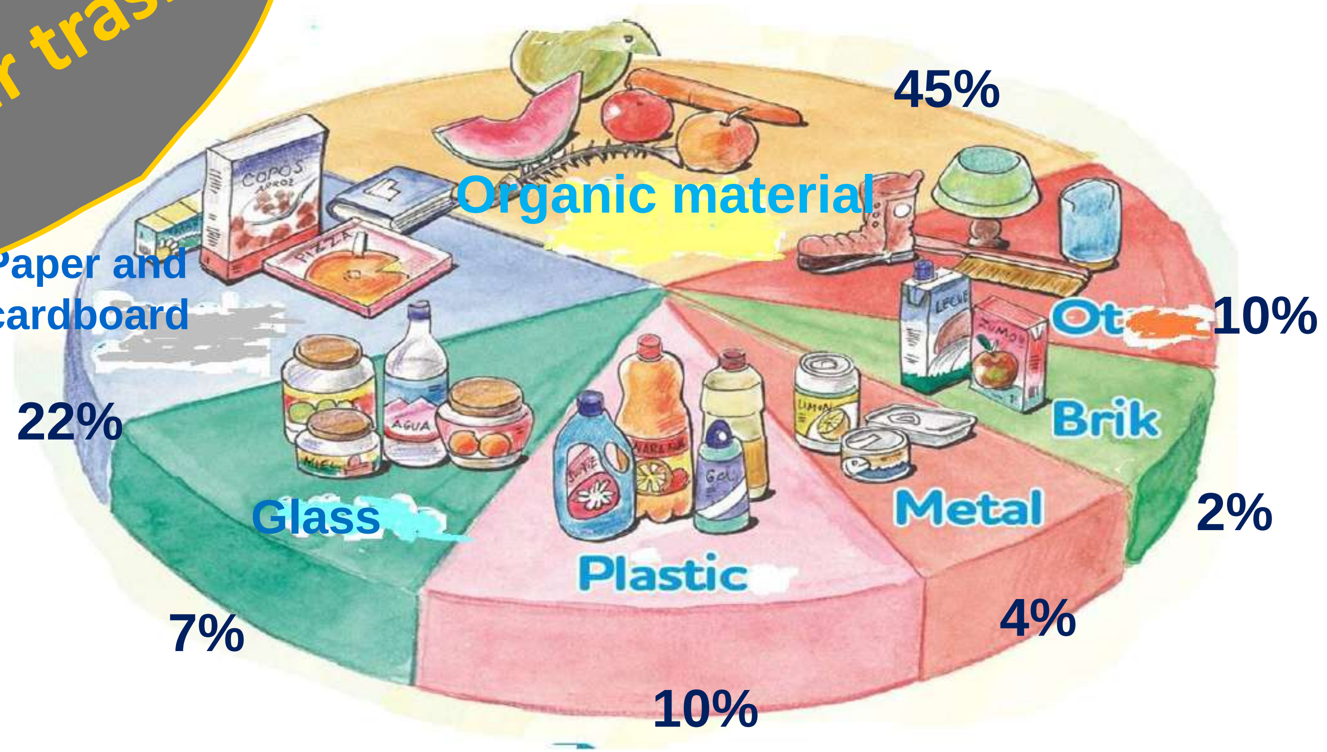
Treasures in the trash...

Urban hygiene, recycling and environment

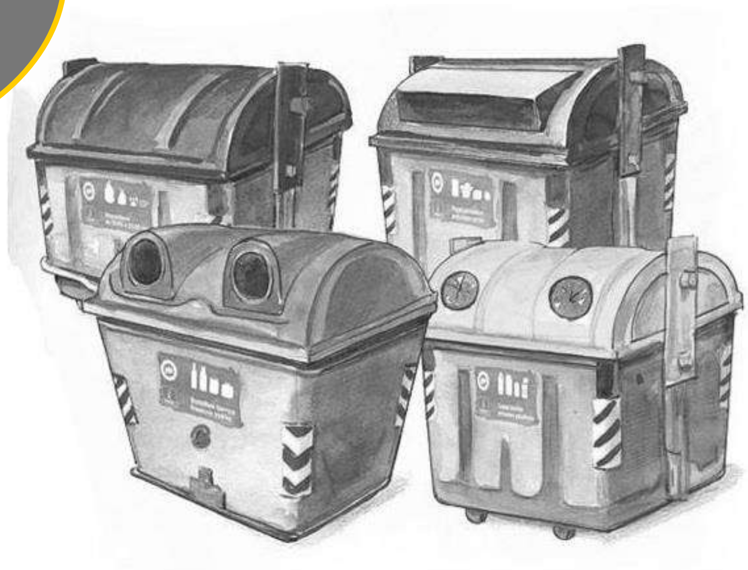
Did you know that each one of us generates more than a kilo of waste per day?

And that the majority of this waste can be used?

A treasure in your trash



The three-
Rs Rule



Reduce
Reuse
Recycle

For recycling you must learn to separate

Trees

Silica sand

Oil, trees, bauxite and iron

There is a urban waste treatment centre

WASTE TREATMENT PLANT

Rubbish that we can not recycle

What can we do with the rubbish that we can not recycle?

GREY BIN

ORGANIC MATERIAL

COMPOSTING PLANT
To make compost

THE REST GOES TO

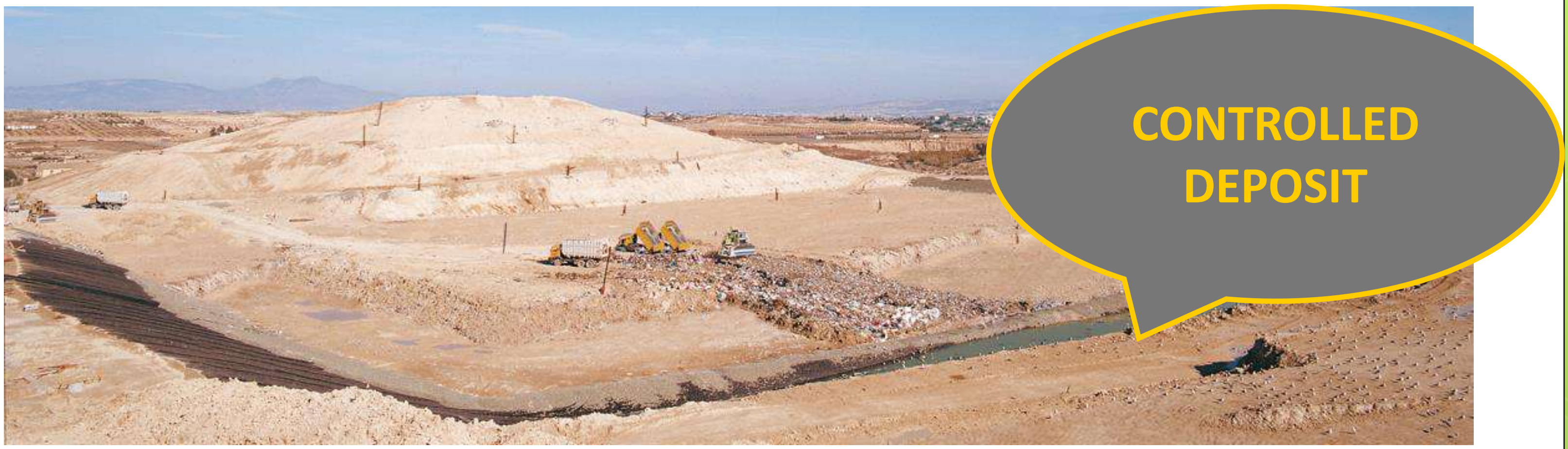
CONTROLLED DEPOSIT

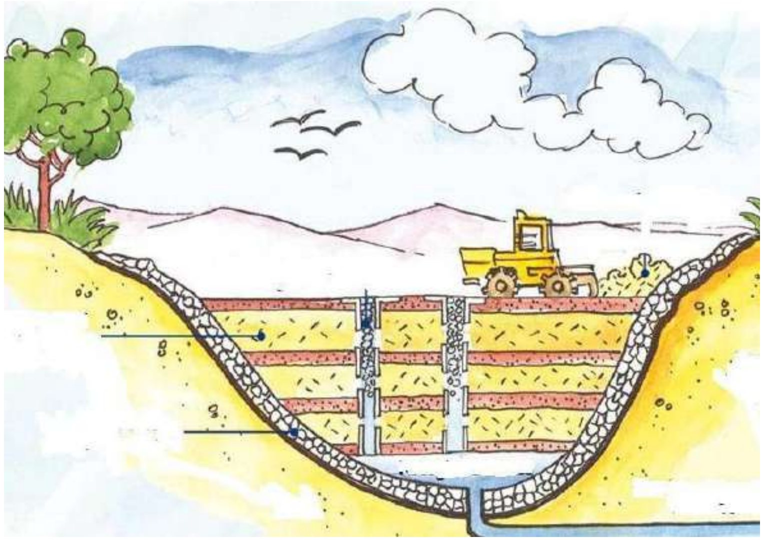
COMPOSTING PLANT

We use organic rubbish to make compost.

SLUDGE DRYING PLANT

First we dry the compost

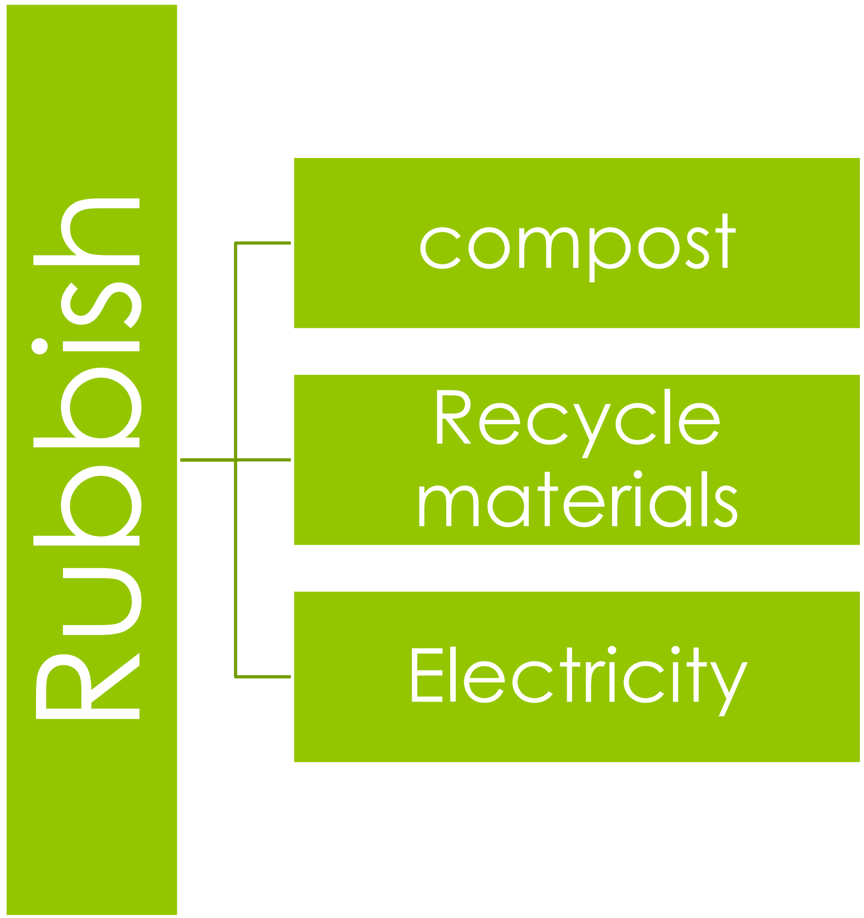




They make mountains!

The rubbish, that is buried in the controlled deposit, will decompose into a gas called BIOGAS and they use to make electricity!

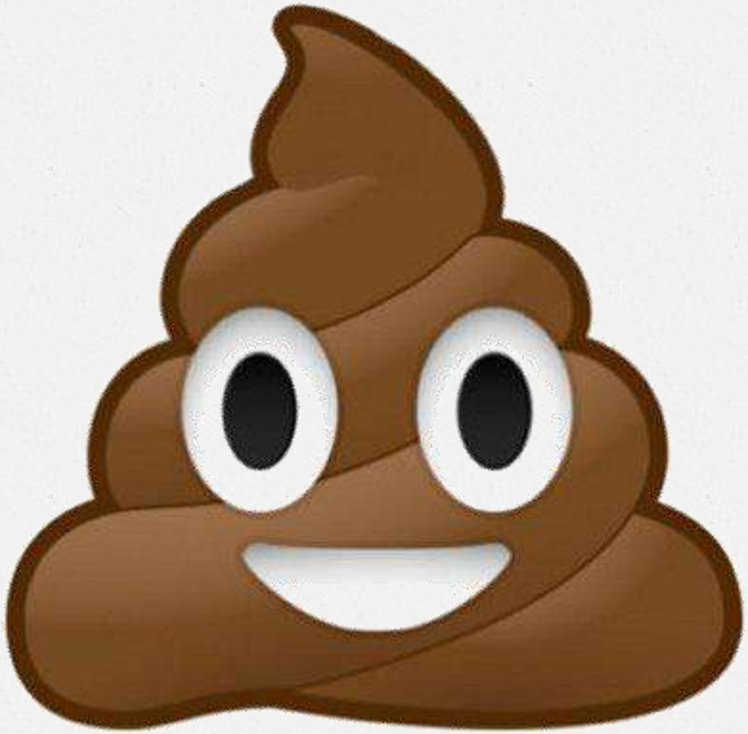
In the rubbish we can find treasures such us:



And finally they create a green area…

Thank you for your attention

THE CYCLE OF POOP



LET'S BEGIN THE JOURNEY…

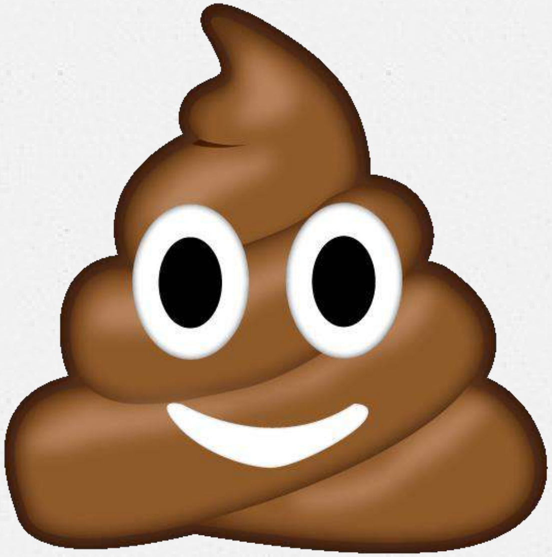
- YOUR POO SLIDES DOWN A PIPE INTO A SEWER (UNDERGROUND TUNNEL)
- WATER THEN WASHES IT AWAY TO A SEWAGE PLANT.

- IN THE SEWER, YOUR POO MIXES WITH WATER AND OTHER POO TO MAKE A THICK, BROWN UNDERGROUND RIVER.

- FLUSHING THE TOILET WASHES POO THROUGH THE PIPES TO THE SEWER, AND THE SEWER TAKES THE POO TO A SEWAGE TREATMENT PLANT.

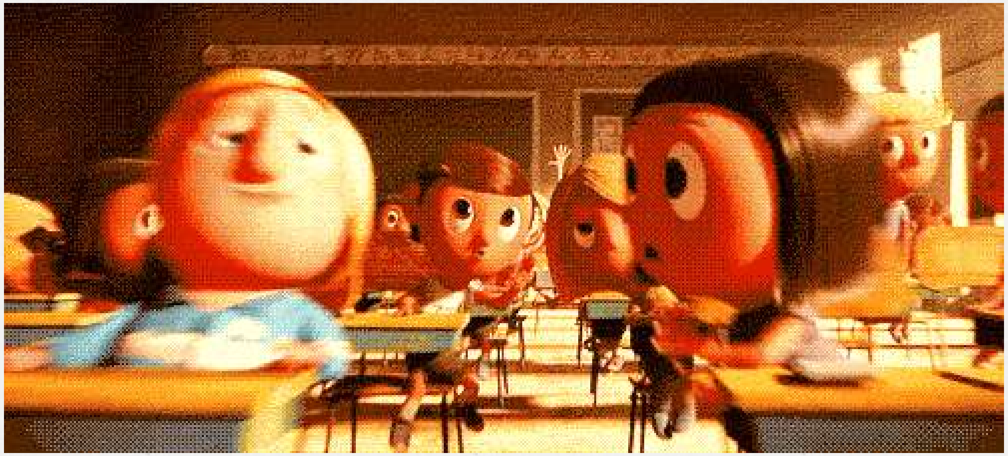
- THE DIRTY WATER IS SPRAYED ON TO STONES WICH HAVE GOOD BACTERIA. THE GOOD BACTERIA KILLS THE BAD BACTERIA (POO)
- WHEN THE GOOD BACTERIA DIE THEY ARE FLASHED TO THE SEDIMENTATION TANK AND THEN GOES TO THE RIVER

- But what can we do to take advantage of the poop?
- Can poop be a treasure too?



Let’s investigate

It is your turn!



Useful links

- http://www.poopower.com.au/uploads/files/poo_power_study_guide_v1.lowres.pdf
- https://energy.economictimes.indiatimes.com/news/power/chicken-poop-can-be-used-to-generate-electricity-study/61722818
- http://www.ecology.com/2011/10/10/poop-power-biomass-energy/
- http://www.funkidslive.com/learn/energy-sources/biomass-energy-source-fact-file-2/

Annex 7: Learning Design: Secondary School Implementation

Description	
Context	**Topic:** Energy/bioeconomy **Total learning time:** 90 minutes **Number of students:** 18 students **Description:** In this workshop, students will learn about bioeconomy, and how it can impact on everyday life. Trough discussion, practical work and the creation of a web brochure, all learners will learn about positive and negative facts about biomass, fossil fuel and renewable energy sources.
Aims	• implementation of the term bioeconomy in everyday life • compare energy producing from fossil fuels, biomass and renewable energy sources • importance of using biomass as a resource of producing energy • find new eco-friendly ways of energy production • design web brochure
Outcomes	**Define (Knowledge):** All leaners will learn about term bioeconomy and how it can impact on everyday life. All learners will learn about biomass, fossil fuel and renewable energy sources **Find out/discover (Knowledge):** All leaners will discover, through practical work and worksheets, positive and negative facts about biomass, fossil fuel and renewable energy sources **Design (Synthesis):** Most learners will learn how to write a web brochure in pdf format **Summarise (Synthesis):** Some students will present a web brochure about biomass, fossil fuel and renewable energy sources **Play (Psychomotor skills):** all leaners will play a quiz about energy/bioeconomy.
Teaching-Learning activities	
Discuss about energy, the ways of producing energy right now. Discuss about bioeconomy, producing energy in the future (include human waste and animal poop), and how much people know about bieconomy.	***Discuss 5 minutes 18 students Tutor is available*** Start the presentation and ask the following questions. What do you think will change the world in next 10 years? What is our future in producing energy! After that, state that you think human waste (poop) will change the world.
	Read Watch Listen 2 minutes 18 students Tutor is not available Now you will watch a video showing how much people know about bioeconomy.
	Discuss 2 minutes 18 students Tutor is available Discuss the content of the video. Do people know enough about bioeconomy? Why do you think that is? What does it depend on? In the discussion every student can state his opinion. Students are encouraged to create their own videos which represent knowledge of bioeconomy in their country.

<table>
<tr><td rowspan="1">Lecture - about bioeconomy and biomass.

Show the ways of gaining energy from biomass (PPT).

Explain positive and negative facts about producing energy from biomass.</td><td>Read Watch Listen 15 minutes Tutor is available
Define facts about bioeconomy.
Define what is biomass and what it can be used for, also define different type of biomass.
Explain how to get energy from biomass.
Show positive and negative facts about producing energy from biomass.
Explain how to get new products from human waste and animal poop.
Before this workshop, you can make your own power point presentation.</td></tr>
<tr><td rowspan="4">Exercise - Fossil fuels vs Biomass vs Renewable energy sources</td><td>Investigate 20 minutes 18 students Tutor is not available

Divide pupils in 3 groups (group size depends on the number of students). Each group is given a topic: fossil fuels as energy/ biomass as energy/renewable energy sources.
Each group is provided with materials for their research and a laptop for internet search.</td></tr>
<tr><td>Practice 10 minutes 18 students Tutor is not available
OPTIONAL!!!!!
After carrying out their research, each group will carry out practical work, which is explained in their materials.</td></tr>
<tr><td>Produce 20 minutes Tutor is not available
Students will work on designing a brochure to hhighlight the pros and cons for each type every energy resource.</td></tr>
<tr><td>Discuss 6 minutes 3 students Tutor is not available
One student from each group will present the results of their investigation included in their brochure.
They will conclude that biomass and renewable energy sources, which are new eco-friendly ways of energy production, are better than fossil fuels.</td></tr>
<tr><td>Conclusion: Quiz about energy/bioeconomy</td><td>Practice 10 minutes 18 students Tutor is available
As a conclusion, students will take a Kahoot quiz about everything they have learned during the lesson.</td></tr>
</table>

Annex 8: Learning Design: Primary Adaptation

Description	
Context	**Topic:** Science/ Energy/ Biomass **Total learning time:** 120 minutes **Number of students:** 24 **Description:** In this workshop, students will learn about bioeconomy, and how it can impact on everyday life. Trough discussion, practical work and the creation of a web brochure, all learners will learn about positive and negative facts about biomass, fossil fuel and renewable energy sources.
Aims	• Implementation of the term bioeconomy in everyday life • Compare producing energy from fossil fuels, biomass and renewable energy sources • Understand the importance of using biomass as a resource of producing energy • Find new eco-friendly ways of energy production • Design web brochure
Outcomes	**Comprehension (Comprehension): Learners** Students will learn about term bioeconomy and the implementation of this term in everyday life. All learners will learn about biomass, fossil fuels and renewable energy sources. **Application (Application): Find out/discover** All leaners will discover, through practical work and worksheets, positive and negative facts about biomass, fossil fuels and renewable energy sources. **Analysis (Analysis): Design** Most learners will learn how to classify renewable sources and they will set conclusion about their everyday life **Evaluation (Evaluation):** Students will present an advertisement encouraging citizens to use energy in a responsible way and presenting how we can change the world if we use biomass, bio-fuel and renewable energy sources. They will also take a quiz on the topic of energy/bioeconomy.
Teaching-Learning activities	
Session 1 **Brainstorming.** What do you know about energy and other concepts as: biomass and renewable resources?	***Discuss 10 minutes*** ***24 students*** ***Tutor is available*** To introduce the topic, we will start the lesson with a brainstorming mind map. With the help of the teacher, students will elicit the information that they already have about the topic. Their answer could be: different types of energy, renewable energy, reduce, reuse recycle.
	Read Watch Listen ***40 minutes*** ***24 students*** ***Tutor is available*** Introduction of the new vocabulary: First, kids will watch a short video about the consequences of energy waste, to make them reflect on the issue. Once we have elicited what students already know about energy, we will introduce to our students the contents

	of the topic. "Energy and other unusual Source Of Power..." Students will watch a video about the contents.
	Collaborate 10 minutes 24 students Tutor is available Once the kids have learnt about the contents of the topics, we will practice with a worksheet. They will work in groups of 4 and discuss the answers of activities in the worksheet. When they finish, they will have to explain their answers.
	**** DIVERSITY **** Our students with learning difficulties will take part in every activity with specific adaptations, depending on their difficulties. Some of these adaptations will be: having a classmate as a tutor, lots of visual support, do the activities orally instead of in writing, with lots of short and clear instructions. They will also have more time to finish the activities. To solve any difficult situation, our kids will be in groups of four in heterogeneous groups, where they will help each other to do the tasks.
Session 2	**Read Watch Listen 30 minutes 24 students Tutor is available** We will revise the contents of the previous day and we will start with the question: How can poop change the world? How can trash can change the world? We will explain how we really can find treasures in the trash... We will remember that the first thing we can do is to use the three “Rs”: reduce, reuse, recycle. After that, we will present a power point about how to take advantage of the trash in our city. We will also watch a video about how waste is turned into compost and electricity. The video is in Spanish, but we can turn the volume off to see the images and the teacher will explain the process.
	Investigate 30 minutes 24 students Tutor is available The teacher will present to the students the cycle of poop and after the teacher will ask them a question: Can poop be a treasure too? In groups, students will try to answer the question and they will sum up the information they learnt. After this, students can look for new information on different websites indicated in the power point to prepare their final task: an advertisement promoting good actions to protect the environment (a video). They will make their own presentations about the different advice that they can give to citizens to look after the environment.
Session 3	***Produce 40 minutes 24 students Tutor is available*** **Evaluation:** Once they know everything about the topic, and they have prepare their advertisements in groups of 4, students will present their final task and address questions to each team.
	Produce 20 minutes 24 students Tutor is available After their presentations, the tutor will check if students know the specific contents of the unit using a game

The BLOOM School Box

Future Classroom Scenario

Growing plastic & new life for plastic

This scenario is part of the BLOOM School Box, which consists of a set of five Future Classroom Scenarios combining bioeconomy into science, technology, engineering and mathematics (STEM) subjects. These resources were developed and tested in classrooms by 20 BLOOM expert teachers from 10 different countries.
This Future Classroom Scenario has been developed as part of the BLOOM project, using the methodology of the Future Classroom Toolkit (http://fcl.eun.org/toolkit).

Authors:

Costantina Cossu, Nele Deckx, Seppe Hermans, Caterina Mura

Table of contents

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Area / Subject

In which subject(s) or area of expertise can the scenario be used?

Subjects: Biology, Technology, Engineering, Environmental Education, Chemistry, Statistics

There are two subjects within which it is possible to implement this scenario:

- **Science:** including chemistry lab (Lesson 3)
- **Engineering:** including computer lab & 3D printer (Lesson 4)

It is possible to have an interdisciplinary lesson or just one of the two.

Curriculum: national secondary school 1st and 2nd level

Age of students: 11 to 18 years old

Relevant Trends

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

Project-based learning: students get fact-based tasks, problems to solve and they work in groups. This kind of learning usually transcends traditional subjects.

STEM learning: increased focus on Science, Technology, Engineering and Mathematics.

Edutainment: playful learning. Learning while having fun.

Flipped Classroom: students master basic concepts of the topic at home. Time spent in classroom is used to reflect, discuss and develop the topic.

Collaborative learning: a strong focus on group work.

Lifelong learning: learning does not stop when leaving school.

Mobile learning: students get access to knowledge through smartphones and tablets. It is learning anytime, anywhere.

BYOD (Bring your own device): Students bring their own mobile devices to the classroom.

Additional educational trends:

- Investigate
- Know-how
- Give new life to materials

Learning Objectives and Assessment

What are the main objectives? What skills will the learner develop and demonstrate within the scenario? (e.g. 21st Century Skills). How will the progress in achievement be assessed, ensuring the learner has access to information on their progress so they can improve?

Students will develop the following skills:

Collaboration: During group work, students have to collaborate.

Communication: During the discussions, students have to share ideas and learn to communicate.

Science & engineering: Students work in the science lab to “make plastic” and they have to draw a keychain for the 3D printer.

Civic competence: Students are encouraged to understand the problem of plastic pollution.

Entrepreneurship: Students create something new out of plastic.

Digital competence: Students analyse plastic and micro-plastic with a microscope and smartphone. They use an online software to design a keychain.

Assessment:

- Analyse and discuss in group
- Environmental activities at the beach: collect, classify and weigh the plastic
- Experimental laboratory:
  - Identify 7 types of plastics
  - Identify micro-plastics in cosmetics and make the statistical calculation by unit and by local population
- Create bio-plastics from potatoes and plant residues
- Recycle and give new life to plastic
- Print in 3D
- Assessment methods at the end of lesson or experiment: quiz, questionnaire, experimental log

Learner's Role

What sort of activities will the learner be involved in?

Investigate: Students are doing research on the topic
Collaborate: Students are involved in group work
Design: Students design their own keychain
Present: Students should present the outcome of their work
Discuss: Groups should discuss about the outcome of their investigations

Tools and Resources

What resources, particularly technologies, will be required?

Tools:

Internet: students should have Internet access to do research and to use Tinkercad to design their keychain.

- Smartphone: students will need a smartphone to analyse the plastics.
- Materials for the lab (lesson 4).
- Google Drive or another online application to share documents

Resources:

- Video "Bioeconomy start here": https://www.youtube.com/watch?v=2xvXkOMRTs4 [in English]
- "Plastic pollution and marine debris": www.marlisco.eu and http://malia.airicerca.org/ [in English]
- Micro-plastics: https://www.scienceinschool.org/content/microplastics-small-deadly [in Polish, English and Italian]
- Different kinds of biopolymers: https://polymerinnovationblog.com/biobased-or-biodegradable-polymers-whats-the-difference/ [in English]
- Bioplastics: https://www.european-bioplastics.org and https://www.youtube.com/watch?v=Dt8VoUShxPE [in English]

What resources, particularly technologies, will be required?

- Laboratory activity: http://www.rsc.org/Education/Teachers/Resources/Inspirational/resources/3.1.7.pdf [in English]
- What is 3D printing and how does it work?: https://www.youtube.com/watch?v=VxoZ6LplaMU [in English]
- To make a 3D Design in Tinkercad, follow instructions in the "Tinkercad Keychain" document in the Annexes.

Learning Space

Where will the learning take place e.g. school classroom, local library, museum, outdoors, in an online space?

- The research and discussions can be carried out in the classroom.
- For "making" plastic, the Chemistry lab is needed.
- For creating the keychain, a computer lab is needed.

Future Classroom Scenario Narrative

The detailed description of the activity

- The scenario enhances the following topics: pollution, organic solutions, biopolymers, making bioplastic, product design and 3D printing.
- Each part is a lesson of 45 minutes, except the part "Making bioplastic", which will take approximately 1 hour.
- The teacher may choose to implement both practical lessons to bring new life in plastic, or just one of them.
- The scenario can be done in class with students from age 11 until 18.

Breakdown of lessons:

- **Lesson 1:** Introduce students to the topic of plastic pollution.
- **Lesson 2:** Investigate and discuss about different kinds of plastic.
- **Lesson 3:** Practical Science: including carrying out experiments in the Chemistry lab.
- **Lesson 4:** Practical Engineering: including working in the computer lab and with the 3D printer.

Lesson 1: Plastic pollution (45 minutes)

- The teacher introduces the topic of plastic pollution. Take inspiration from the following article: http://coastalcare.org/2009/11/plastic-pollution/ [in English] or http://theconversation.com/we-are-guinea-pigs-in-a-worldwide-experiment-on-microplastics-97514 [in English]
- After the introduction, the teacher explains that the main idea is to know plastics well, catalogue them, and recycle them. It is possible to create creative objects from the plastic we collect.
- The class analyses the pictures and articles about the topic of plastic pollution and marine debris, recycling and bioeconomy. Take inspiration from [both in English]: www.marlisco.eu and http://malia.airicerca.org/
- The class discusses the topic in groups. Then, still in groups, students classify the type of plastic pollution at hand: micro-plastic, macro-plastic, etc.

The detailed description of the activity

- For the next activity, use the document "Identify 6 types of plastic" in the Annex 1
- After this, the class discusses possible reasons for plastic pollution in our seas. Students should formulate different hypotheses.
- Read this article [in English] again and find out why there is so much plastic in the sea. The class should check if their hypothesis is correct.

Lesson 2: Real labs (1 hour + exchanging results in the laboratory)

- **Aim of the lesson:** Investigate and discuss about different kinds of plastic and micro-plastics in the water.
- Students have one hour to experiment in three different groups. Each group receives a different resource (see below).
- After the 1 hour, they exchange their results.
- Resources (find all in the Annexes):
    - What's hidden in our sand? [Annex 2]
    - What's hidden in our laundry water? [Annex 3]
    - What's hidden in the water when you use cosmetics? Microbeads in cosmetics [Annex 4]
    - Resource to give to each group: "How to identify different types of plastic" [Annex 5]
    - To identify the collected marine litter, you can use with your students, this resource [in Portuguese] called "Marine Litter – Collected Litter": https://ambienteeuropeo.org/wp-content/uploads/2018/08/AAE-TARJETA-DE-DATOS_ESP.pdf

Lesson 3 : Organic solution - Bioplastics (45 minutes)

- During this lesson, students explore the possibilities of bioplastics and familiarize themselves with different terminologies. The world of bioplastic is very diverse.
- Read this article and watch this video (https://www.european-bioplastics.org and https://www.youtube.com/watch?v=Dt8VoUShxPE, both in English) to become familiar with bioplastics.
- Discuss in groups:
    - Why use bioplastics?
    - What is the difference between biodegradable and bio-based?
    - Which one would you use and why?
    - What are the consequences? (pros and cons)
    - Recycling
    - Bioeconomy
- Worksheet to use can be found in the Annex 6

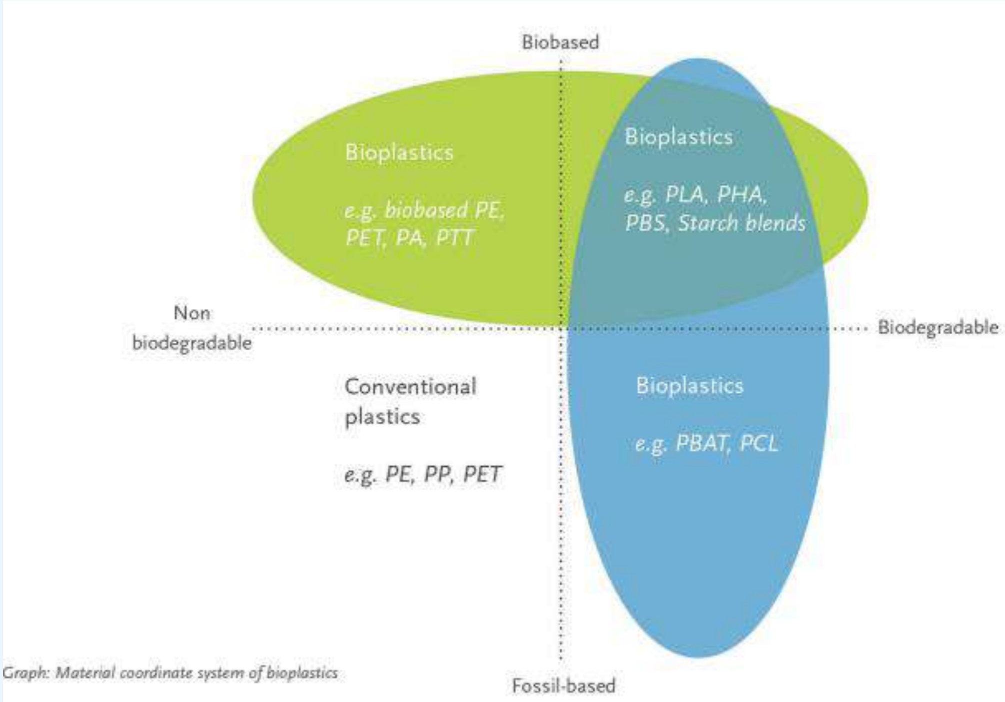


Figure 1: Source: FACT SHEET European Bioplastics / www.european-bioplastics.org

Lesson 4: Making bioplastic (1 hour)

- Investigation at home has to be done before doing the experiment:
  - 1st group: What is bioplastic?
  - 2nd group: What are the properties of bioplastic?
- Collect all the information in a document you can share (e.g.: google drive)
- The whole class then carries out the laboratory activity **for 45 minutes, using the following resource:** http://www.rsc.org/Education/Teachers/Resources/Inspirational/resources/3.1.7.pdf
- In this activity, students make a plastic from potato starch and other foods. They are divided into 3 different groups:
  - Group 1: make bioplastic from food residues that have starch.
  - Group 2: make bioplastic from potatoes
  - Group 3: make bioplastic from starch.
- Then students investigate the effect that adding a 'plasticiser' has on the properties of the polymer that they make.
- Finally, the class discusses recycling and bioeconomy together.

Lesson 5: Product design and 3D Printing (45 minutes)

- The class watches the following video to become familiar with 3D printing: https://www.youtube.com/watch?v=VxoZ6LplaMU [in English]
- The class discusses their thoughts on 3D printing. For the discussion you can use following worksheet about 3D printing from the Annex 7.
  - The teacher divides students into groups of 4 or 5 students.
  - Every group should have some sticky notes, so they can write down their opinions.
  - Students present their opinions to the class after the discussion.
- The class makes a 3D design for a keychain in Tinkercad, following instructions in Annex 8.

The detailed description of the activity
• If the schools has a 3D printer, it is possible to print the final product in class. If not, the teacher can maybe liaise with a fablab or with a company in the neighbourhood to print it.

Learning Activities

Link to the Learning Activities created with Learning Designer (http://learningdesigner.org)
https://v.gd/RcWp4L (Full text available in Annex 9)

Annexes

Annex 1: Identify 6 types of plastic

- Experimental Protocols
- How to identify 6 different types of plastic
- Target Audience
- Curricular Areas: Natural Sciences, Chemistry, Physic and Biology
- Age group: 11-18

Name of group: _________________________________ **date:** _________________________
Name of students ____

Background information: Types of plastic

The following table illustrates the most common types of plastics used and the symbol which is often used to identify them on forms of plastic packaging- European directive 94/62/CE.

Table 1. Plastic materials, symbols and acronyms.

Sostanza	Sigla
Poli(etilentereftalato)	PET
Polietilene ad alta densità	HDPE
Polivinilcloruro	PVC
Polietilene a bassa densità	LDPE
Polipropilene	PP
Polistirene	PS

The identification of the plastics allows separate collection and therefore the possibility of recycling them. Polymer recycling is part of the policy of saving energy resources and protecting the environment.

It is not easy to recognize the various types of plastic, even if the beverage containers are usually made of PET, the LDPE bags and the PVC pipes. Plastic is a polymeric material. The different molecular structure of the polymers involves different physical and chemical properties and for this reason it is possible to develop protocols for the recognition of these substances.

This laboratory activity is based on the recognition of 6 different types of polymers through the evaluation of their different density and through a flame test.

The purpose of the following experience is:

- building a density scale of the six polymers (Activity 1);
- identify a polymer using the flame test (Activity 2).

ACTIVITY 1: Which plastic floats and which sinks

The activity is based on the application of the Archimedes principle: "in the presence of a gravitational field, a body immersed in a fluid receives a thrust from the bottom upwards equal to the weight of the displaced fluid volume".
The result of the principle of Archimedes is that if we immerse a body in a fluid, the body sinks if its density is higher than that of the fluid, it floats if its density is lower, it is in indifferent equilibrium, that is, it does not sink and does not float , if its density is identical to that of the fluid.

Materials (required for each group)

- Graduated cylinder;
- Glass rod;
- Pasteur pipette;
- Solution of ethanol and water (60 parts of alcohol, 40 parts of water) density about 0.90 g / mL (The 96% ethyl alcohol has a density of about 0.80 g / mL, pure water has density 1 g / mL);
- Saturated solution of NaCl (the common kitchen salt), density about 1.2 g / mL;
- 6 types of plastic (PET, PVC, PS, PP, HDPE, LDPE).

The density of polymers and solutions are shown in Table 2.

Table 2. The density of polymers and solutions

Substance in italian	Substance in English	Symbol /n		Density g/mL
Poli(etilentereftalato)	Poly(ethylene terephthalate)	PET	1	1.38-1.39
Polivinilcloruro	Polyvinyl cloride	PVC	3	1.16-1.35
Polistirene	Polystyrene	PS	6	1.05-1.07
Polietilene alta densità	High density polyethylene	HDPE	2	0.95-0.96
Polietilene a bassa densità	Low density polyethylene	LDPE	4	0.92-0.94
Poliprolene	Polypropylene	PP	5	0.90-0.91
Acqua	Water			1.0
Etanolo in acqua	Ethanol:water (60:40)			ca. 0.9
Soluzione satura di NaCl	Saturated NaCl solution			ca. 1.2

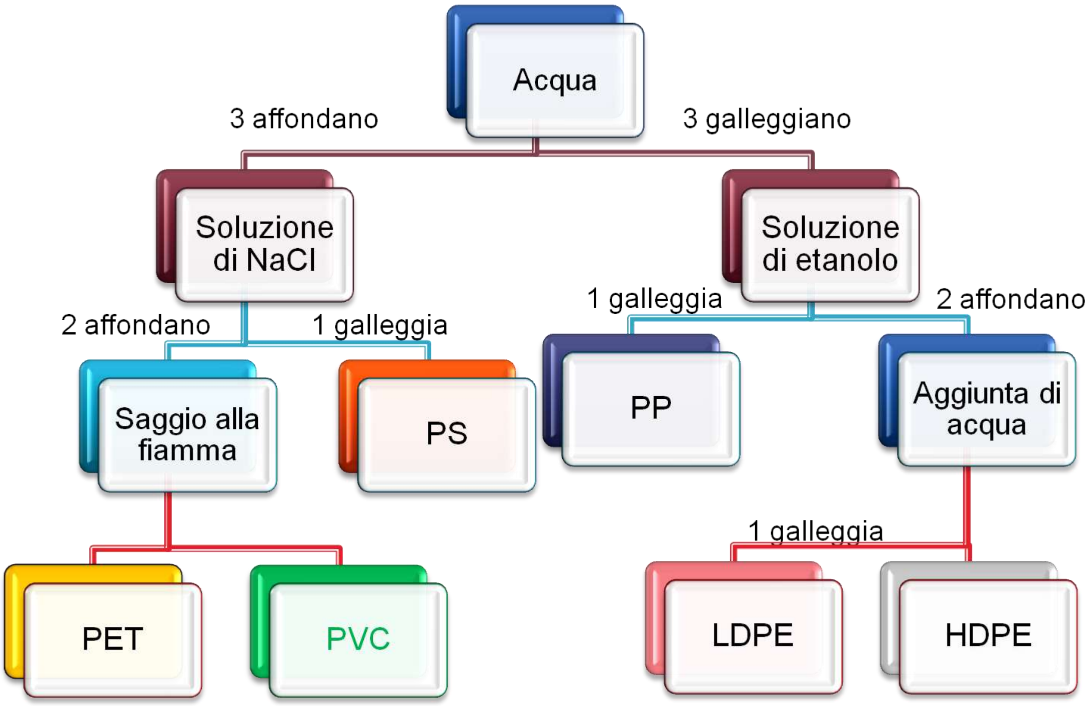
Method

In a 100 mL graduated cylinder, 70 mL of pure water are added and six pieces of plastic are introduced; three float (HDPE, LDPE and PP) and three sink (PET, PVC, PS).

The three samples that float in water recover, dry and insert into a 100 mL graduated cylinder containing 70 mL of ethanol / water solution. LDPE and HDPE sink, while the PP floats. By adding still pure water (half a millilitre at a time) the density of the solution is increased, until the LDPE floats. The HDPE remains on the bottom.

The three samples that sink into water, recover, dry and insert into another 100 mL graduated cylinder containing 70 mL of saturated NaCl solution.

The PS floats, the other two sink. The two remaining polymers (PVC and PET) are subjected to the flame test (because their density, due to the addition of additives and plasticizers, is very similar).


Acqua
3 affondano
3 galleggiano
Soluzione di NaCl
Soluzione di etanolo
2 affondano
1 galleggia
1 galleggia
2 affondano
Saggio alla fiamma
PS
PP
Aggiunta di acqua
1 galleggia
PET
PVC
LDPE
HDPE

ACTIVITY 2: Flame test

The flame test is based on the recognition of certain substances (metallic salts) based on the colour the flame takes when it is put in contact with the test compound. In fact, through thermal energy, the electrons of the metal are excited and reach a higher energy atomic orbital. However, they tend to return to the lower energy level, starting, the more stable energy, resulting in the emission of radiation. These are characteristics for each cation and are perceived as coloured light.

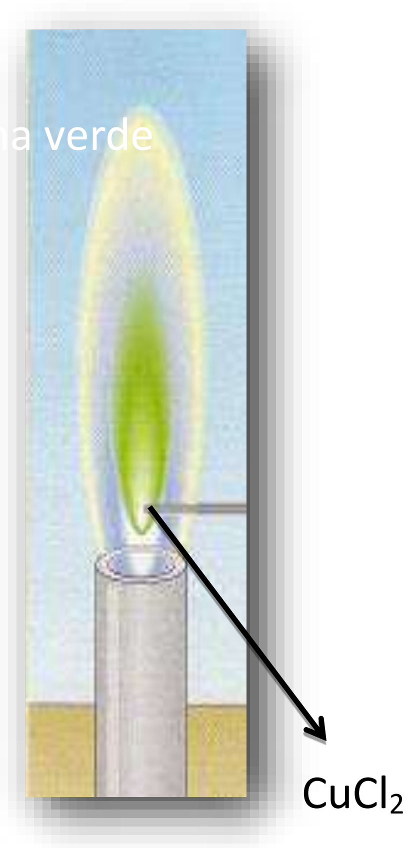
In the specific case, the recognition concerns the formation of CuCl2. When a copper wire is put in contact with the polyvinylchloride (PVC) and then placed in the flame, the latter takes on the characteristic green colour, typical of Cu2 +.

Materials (required for each group)

- Copper wire;
- PVC and PET;
- Bunsen burner;
- Wooden clothespin.

Method

You take the copper wire and heat up on the flame. Next, the copper wire is placed on the unknown plastic material which melts and deposits on the copper wire itself. At this point, the copper wire is exposed to the flame again. This is coloured green if the plastic material is PVC, remains unchanged in the other case (PET).



Annex 2: Experimental protocol: What's Hidden In Our Sand?

- Target Audience
- Curricular Areas: Natural Sciences and Biology
- Age group: 11-18

Name of group: ___________________________________ **date:** __________________________
Name of students ____

Background information

The multiple activities carried out daily in the coastal zones can lead to the presence of several pollutants in our sea.
Plastics account for 60-80% of marine litter and are currently considered one of the main pollutants responsible for marine pollution, together with petroleum hydrocarbons, ballast water and nutrients which, when at high levels, cause for instance eutrophication. Plastic can be carried by surface currents to sites far from the original ones having detrimental effects on both oceanic species and coastal ecosystems (US-EPA, 2002). Indeed, plastics pose a major threat to marine organisms such as fish, birds, turtles, mammals and zooplankton, mainly because of the risk of ingestion. About 400 marine species from around the world have already been found "stuck" to tons of plastic scattered across the ocean like plastic bags and fishing nets.
Microplastics are small particles (<5mm), that vary in composition (synthetic polymer), shape and colour. They are manufactured (primary microplastics) to fulfil certain functions, such as industrial abrasives, exfoliant micro-beads in personal care products or cosmetics, and pre-production plastic beads or pellets. They can also result from degradation or fragmentation of larger plastic particles (secondary microplastics) through mechanical, UV and microbial action which can result from larger plastic particles that have been degraded or from small dimensions purpose-built plastics. Since they have the capacity to absorb contaminants, namely Persistent Organic Pollutants (POPs), when ingested by marine species, they represent a route of entry of POPs to reach the marine food chain.

Aims

This activity aims to present microplastics, their origin and the consequences of their presence in the marine environment. This activity aims to raise awareness of the need to reduce the production and consumption of plastics. This activity is related with The Ocean Literacy Principles, namely Principle 6 –The Ocean and Humans are inextricably interconnected[1].

Material

- 1 Water bottle with a capacity of 5L or more
- 1 Bottle of 1,5L
- 0,5L Funnel
- Sieve
- 1 Kg of cooking salt

- Beach sand (1 bottle of 1,5L)
- Filtration glassware (i.e. Büchner flask, filtration glass, clamping device...)
- Vacuum pump with hose
- 2 filters ca. 0,2 µm porosity (1 for each 0,5L bottle)
- Stereomicroscope
- e Petri dishes
- Tweezers

Procedure

1. Collect sand from the high tide line, on the shallow side, up to about 5-10cm depth and sieve it to a 1.5L bottle. Discard large debris, or plastics, found into adequate recycling bins; Suggestion: students may be asked to collect and bring to the class sands from beaches under differing levels of human pressure and compare them
2. In the lab, prepare a ultra-concentrated saline solution with a concentration of approximately 360 g / L. To do this, in a 5 L capacity bottle, add 3 L of water and 1 kg of cooking salt. if there is no material for measuring 3L of water, a 1.5L bottle filled twice can be used;
3. Shake in 3 sets of 1 minute each;
4. Place the collected sand (free of large debris / debris), which is in the 1.5 L bottle, into the 5 L water bottle;
5. Close it and shake vigorously in 5 sets of about 30 seconds each;
6. Allow the mixture to stand for about 15 minutes;
7. Pass the water with the suspended particles to the 0.5 L bottle;
8. Prepare the filtration system and (vacuum pump + filtration glassware) and place the membrane filter in place;
9. Decant 250 ml of the salted with the sand into the filtration cup and connect the pump
10. At the end of the filtration, transfer the filter to a Petri dish with the tweezer and observe at with the with the stereomicroscope (repeat step 8 with the water in other 0.5L bottle);
11. Proceed to the research and identification of microplastics. If desired, they may also be separated into a petri dish to facilitate their counting.

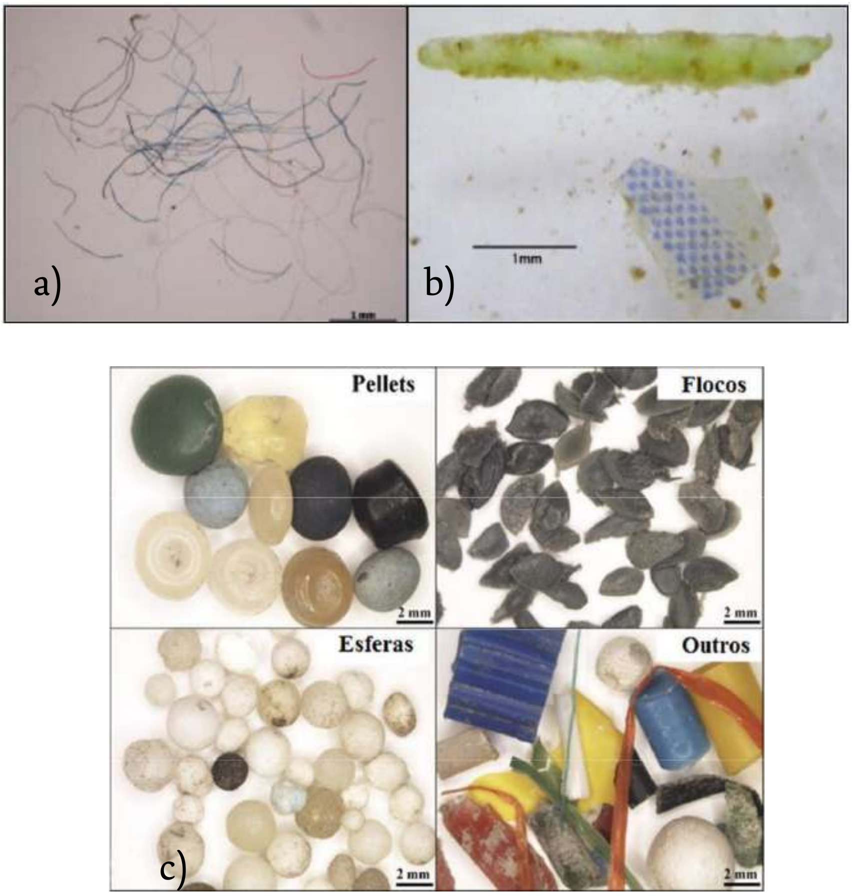


Figure 1: Examples of nylon fibres (a), rigid plastic (b[1]) and of different types of plastics (c[2]).

What's hidden in our sand?

Experimental log:

1. Indicates the hypothesis to be tested in this experiment.
2. What is the purpose of the NaCl used for in the experiment?
3. During the filtration of the sample where are the microplastics retained?
4. Is the sample analysed contaminated with microplastics? If yes, what kind of microplastics did you find (shape, colour, etc.)?
5. What measures should be taken in our daily life to avoid contamination of waters with microplastics?

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[1] Possatto, F.E.; Barletta, M.; Costa, M.F.; Ivar do Sul, J.; Dantas D.V. 2011. Plastic debris ingestion by marine catfish: an unexpected fisheries impact. Mar Poll Bull 62: 1098–1102

2 Lechner, A.; Keckeis, H.; Lamesberger-Loisl, F.; Zens, B.; Krusch, R.; Tritthart, M.; Glas, M.; Schludermann, E. 2014. The Danube so colourful: A potpourii of plastic litter outnumbers fish larvae in Europe's second largest river. Environmental Pollution 188: 177-

Annex 3: Experimental Protocol - What's Hidden In Our Laundry Water?

Background information

Multiple daily human activities carried on inland and in coastal zones directly and indirectly affect the marine ecosystem. According to the United Nations, about 80% of all litter at sea comes from land, with plastic waste as the most representative fraction (60-95%). Besides the 8 million tons of plastic thrown into the ocean every year, more and more personal hygiene products have microplastics (a facial cleanser can have about 330 thousand of microplastics) and many pieces of clothing have polyester fibres in their composition. It has been estimated that about 1,900 plastic microfibers are released from a single synthetic cloth every time it is washed in a laundry machine. Due to its small size, microfibers are not retained in the washing machine filter and end up in the marine environment. It has also been estimated that there are about 4 billion plastic microfibers per km2 of ocean floor.

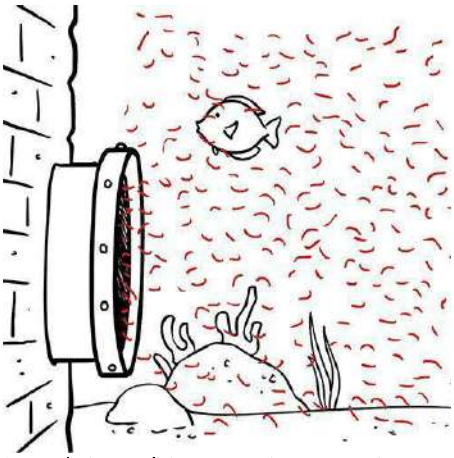


Figure 1: Polyester fibers (plastic) being release in the marine environment.
Source: http://storyofstuff.org/blog/microfibers-are-microplastics-1/

Target Audience

- **Curricular Areas**: Natural Sciences and Biology
- **Age group**: 11-18

Aims

The purpose of this activity is to raise awareness to the problem of microplastics, in particular polyester fibres, and the consequences they have to the marine environment. This activity aims to raise awareness of the need to reduce the production and consumption of plastics, as well as to warn about the need to change our daily activities that negatively affect the marine environment. This activity is related with The Ocean Literacy Principles[3], namely Principle 6: The Ocean and Humans are inextricably interconnected1.

Material

- 1.5L bottle
- Large bucket

[3] http://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework/ [in English]

- Funnel
- 100% polyester clothing
- Filtration glassware (i.e. Büchner flask, filtration glass, clamping device...) Vacuum pump with hose
- Six ca. 1.2µm membrane
- Filters Stereomicroscope
- Petri dishes
- Tweezers
- Dissection
- Needle
- Lighter
- Light microscope

Procedure

1. To perform this experiment it will be necessary to collect the water from the first wash of a washing machine;

2. Make sure the water outlet hose of the washing machine is in a visible and safe place (for example, inside a bucket);

3. Select 100 % polyester clothes (confirm on the label of each piece of clothing). Give preference to clothes with vibrant colours to facilitate the observation of microfibers with the magnifying glass;

4. Wash the polyester clothes the washing machine using the "economical" program. Do not use any type of detergent or soap;

5. Pay attention to the water outlet of the washing machine and, using a funnel, connect the hose to the mouth of the plastic bottle (do this in a bucket). After collecting 1.5L of water, the hose can be returned to the usual location;

6. Do not store water collected for many days (try to do the laundry the day before the experiment);

7. Before starting the filtration, close the bottle and shake it vigorously 3 times for about 3 seconds (repeat the process when necessary, the microfibers can stick to the wall of the plastic bottle);

8. Prepare the filtration system (vacuum pump + filtration glassware + clamping device) and fit the filter (for a more economical, and easy to find, option you can use round-cut coffee paper filters that fit the filter cup);

9. Turn on the vacuum pump and gradually pour the water from the bottle. Change filters whenever you feel you need;

10. At the end of each filtration, transfer the filter to a Petri dish with the tweezers and observe with the stereomicroscope;

11. The microfibers present in the filter may also be separated into categories (colours, sizes, texture) in order to facilitate their counting and logging;

12. Try to distinguish synthetic from cotton microfibers with the help of the light microscope. Polyester fibres are smooth tubes, usually translucent in their interior, with very well defined walls. Cotton fibres are flat, usually twisted, their interior may contain pigmentation and the walls have many imperfections and folds (Fig. 2 and 3);

13. To confirm you are observing a synthetic microfiber you may also do the "hot needle test", with the help of the stereomicroscope and of an adult to manipulate the lighter or another heat source. Heat the tip of a dissection needle with a lighter (or other heat source) and place the hot needle near the fibre under analysis. If the fibre quickly curls or melts on the needle, showing the behaviour of a burning plastic, it can be considered to be a plastic rather than a cotton microfiber.

Suggestion: The same procedure can also be carried out with 100% cotton clothing thus allowing making comparisons between microfibers of natural fabrics and synthetic.

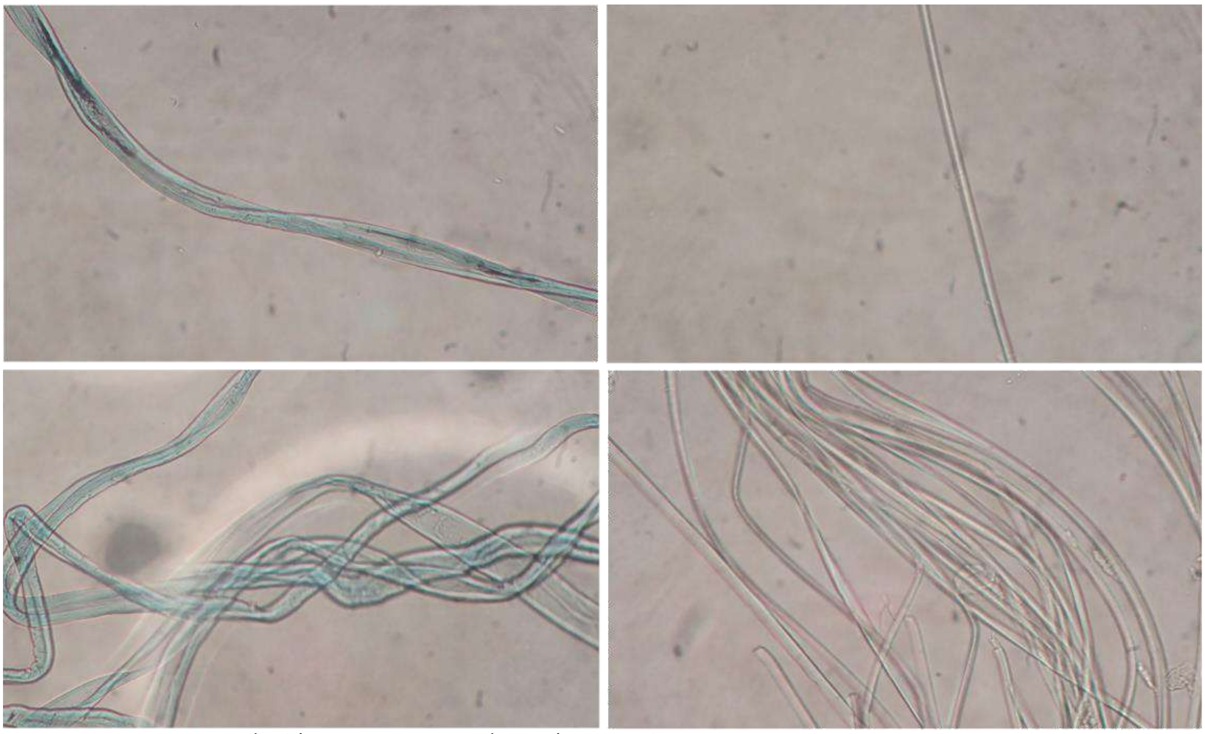


Figure 2: Cotton (left) and polyester (right) microfibers observed under the light microscope

What's hidden in our laundry water?

Experimental log

1. Indicate the hypothesis to be tested in this experiment.

2. What are microplastics?

3. Name three sources of the microplastics found in the environment

4. Where were the microfibers retained during the filtration of the sample?

- Is the analysed sample contaminated with microfibers? If so, how many fibres were found in 1.5L of water.
- Write down in the table the number of microfibers counted per colour and material (polyester or cotton) in the water sample. Write the table caption.

Table 1:

	Number of Microfibers	
	Polyester	Cotton
Colour 1:		
Colour 2:		
Colour 3:		
Colour 4:		
Colour 5:		
Colour 6:		
Colour 7:		
Colour 8:		
Total (in %)		

5. In the axes system below draw graphs for the number of polyester microfibers of each colour counted in the water sample (Figure 1) and for the total relative frequency (in %) of polyester and cotton microfibers found (Figure 2). Write the captions for the X and Y axes and the graphs you have drawn.

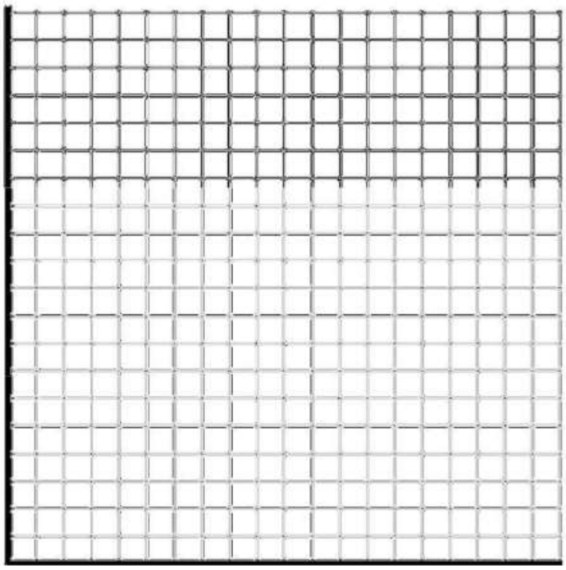


Figure 1.

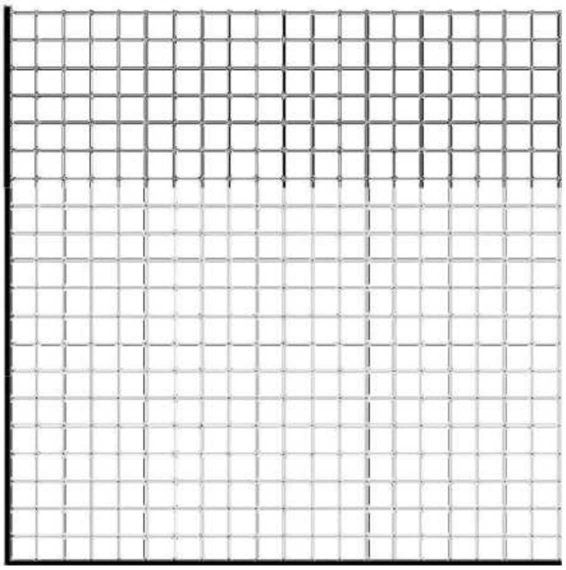


Figure 2.

6. What is the difference between a polyester and a cotton microfiber?

7. What type of clothing releases more fibres per litter of water?

8. Choose five classmates and write down on the table the material with which each T-shirt is made of (example: polyester, cotton, nylon ...). Write down the table caption.

Table2:

Class Colleague	T-shirt Material
Colleague 1	
Colleague 2	
Colleague 3	
Colleague 4	
Colleague 5	

9. What conclusions can you draw from Table 2 regarding the use of plastic in our clothing?
10. Right now, are you wearing any clothes or have any school supplies that do not contain plastic? If yes, indicate which.
11. What measures would you propose to be taken to prevent water contamination with polyester microfibers?
12. What can you do to reduce the use of plastic in your daily life? Give two examples.

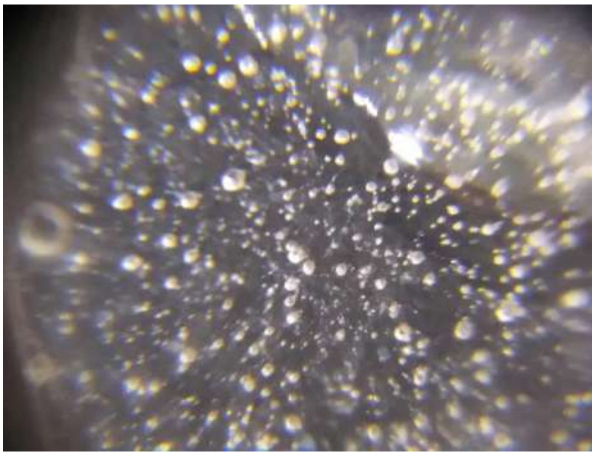
Annex 4: Experimental Protocol - Microbeads from cosmetics

- Target Audience
- Curricular Areas: Natural Sciences and Biology

Age group: 11-18
Name of group: _________________________________ **date:** _________________________
name students ____

Background information

Microbeads are another source of microplastics. These tiny plastic beads are used in cosmetics and personal care products (e.g. exfoliating and hand-washing creams, toothpastes). In this activity, students (aged 11–16) isolate and examine microbeads from such products, and consider their impact on the environment.



Picture n 1 : Microplastic in scrub cosmetics

Picture n2: Microplastic in toothpaste

Materials

- Some cosmetics and personal care products containing microbeads. Check the composition: if polyethylene is listed, the product contains microbeads.
- Clear acetate sheets
- Magnifying glasses or a microscope for smartphone
- Transparent plastic cups
- Tap water
- Dishwashing detergent
- Salt
- Spoons

Procedure

Using the materials above, ask the students to:
1. Read the composition of the product to confirm that it contains microbeads.
2. Examine the product by spreading it on an acetate sheet and looking at it with the magnifying lens (or a microscope), and also by touching it.

3. Test the microbeads for buoyancy in three different liquids, using the transparent cups:

- Tap water
- Water plus detergent (1/2 spoonful per cup)
- Water plus salt (1 spoonful per cup).

4. Based on the students' results, predict whether in the natural environment, microbeads will float or sink in freshwater (e.g. in a lake) and in saltwater (e.g. in the sea).

How many microbeads are we dumping in the sea?

This extension to the previous activity asks students aged 11–16 to make a rough estimate of how many microbeads are being dumped each year by people in their town, and to investigate and debate the environmental issues involved.

Materials

As for the previous activity, plus:

- Measuring spoons with a volume of 5 ml (like those used for cough syrups, etc.)
- Coffee filters

Procedure

Ask the students to:
1. Measure 5 ml of a product containing microbeads and dissolve it in a cup half-filled with tap water plus 5 ml of dishwashing detergent.
2. Stir the mixture for one minute, then filter the mixture with a coffee filter.
3. Transfer the microbeads from the filter paper to an acetate sheet. Now count the microbeads.
4. Using this result and the volume of the product's original container, calculate how many microbeads are contained in a whole tube or bottle.
5. Estimate how many containers of this product are used by a person in one year, and how many people in their town are likely to use this product.
6. Multiply these numbers together to calculate how many microbeads their town is dumping into the sewage system (and then into the sea) per year from this one product.

Picture n 3 Cosmetics in water, salad water, water with detergent

Finally, ask the students to research information about the problem of microbeads in the environment, and on current debates and actions limiting or banning their use in products[w4].

Acknowledgements

The activities described in this article were developed jointly by the author, Giuliana Candussio, Marinella Manià and Serenella Palamin. All four are members of *Scienza under 18 Isontina*[w2], an association that aims to inspire school students and teachers and to share good practice.

The "Exploring plastics" activity was adapted from materials developed as part of *progetto APQUA*, the Italian version of the Lawrence Hall of Science, University of California at Berkeley's Science Education for Public Understanding Program (SEPUP). The *progetto APQUA* materials were kindly provided by Federchimica-Assoplast, the association of Italian plastic manufacturers.

Annex 5: How to identify different types of plastic

Types of plastic

The following table illustrates the most common types of plastics used, their applications and the symbol which is often used to identify them on forms of plastic packaging.

Polymer Types	Examples of applications	Symbol
Polyethylene Terephthalate	Fizzy drink and water bottles. Salad trays.	
High Density Polyethylene	Milk bottles, bleach, cleaners and most shampoo bottles.	
Polyvinyl Chloride	Pipes, fittings, window and door frames (rigid PVC). Thermal insulation (PVC foam) and automotive parts.	
Low Density Polyethylene	Carrier bags, bin liners and packaging films.	
Polypropylene	Margarine tubs, microwaveable meal trays, also produced as fibres and filaments for carpets, wall coverings and vehicle upholstery.	
Polystyrene	Yoghurt pots, foam hamburger boxes and egg cartons, plastic cutlery, protective packaging for electronic goods and toys. Insulating material in the building and construction industry.	

Polymer Types	Examples of applications	Symbol
Unallocated References	Any other plastics that do not fall into any of the above categories - for example polycarbonate which is often used in glazing for the aircraft industry	

Materials

Density tests

- **5 beakers**: Water (Density=1.0 g/mL)
- **water, salt**: Salt Water -1200g salt per 1 L of water – (D= 1.2 g/mL)
- **corn syrup**: Corn Syrup (D= 1.36 g/mL)
- **isopropyl alcohol**: Isopropyl Alcohol (D=0.94 g/mL)
- **vegetable oil**: Vegetable Oil (D=0.90 g/mL)

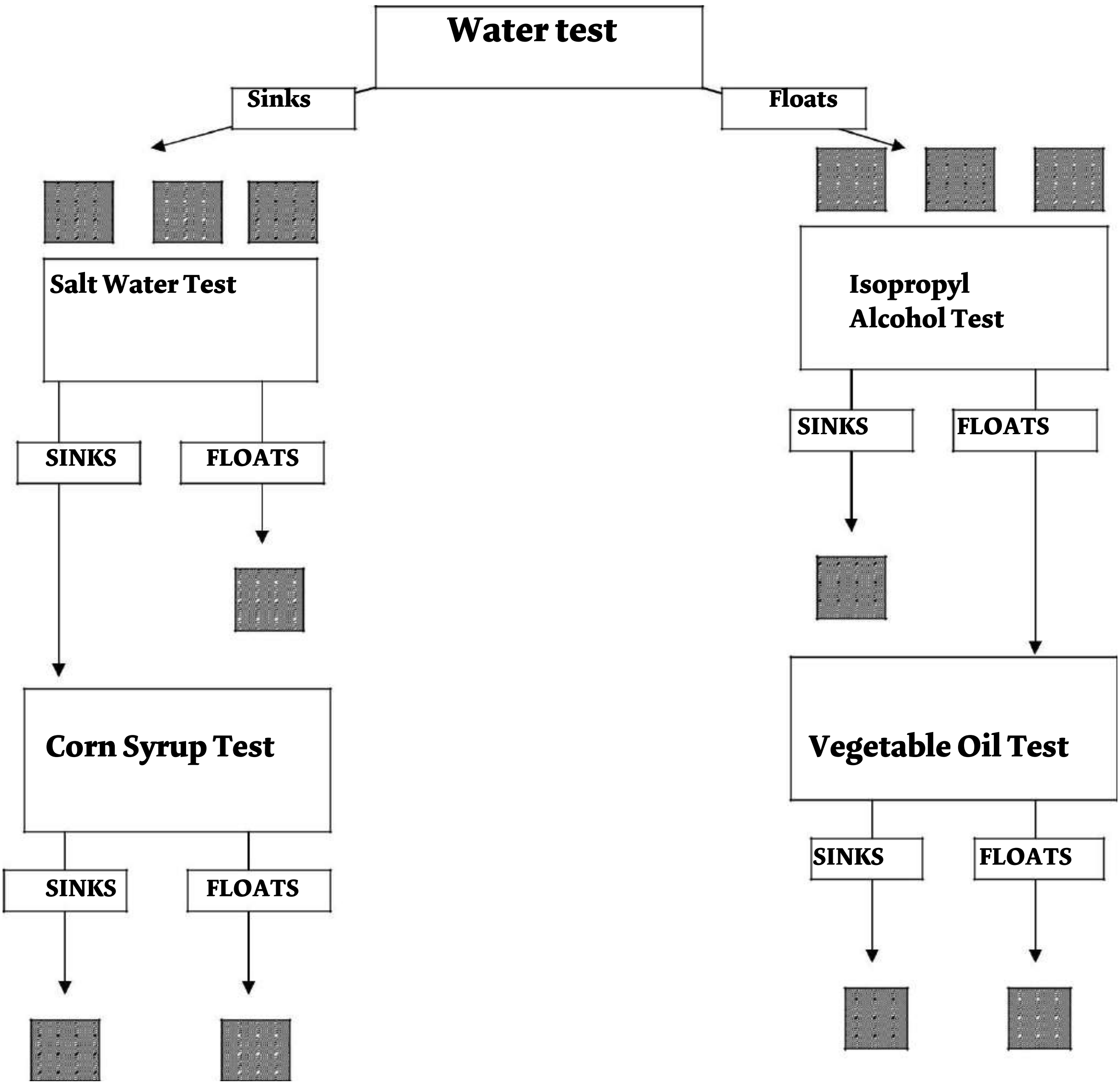
Several different samples of Plastics (6). Try to provide a density range value for Plastics.

Name ______________________________

Observations Worksheet

Plastics Type	Observations
☐	
☐	
☐	
☐	
☐	
☐	

- Have them try different variations of the density tests to find out if each 6 sample produces the same results. For example, did each 6 sample float in water? Sink?
- What about in the isopropyl alcohol?
- Follow the flow chart, performing each test as numbered in order. Please note that you will not use all 6 plastic samples for each test. After completing each test, determine which plastics (of the ones used for that particular test) sink and which float.



Questions

1. A lifeguard sees a young child fall into the neighbourhood pool. There are 6 plastic life preservers labelled 1, 2, 3, 4, 5, and 6. If the labels identify the type of plastic each is made of, which three would be the best to grab to save the child? Why?
2. A ship carrying empty milk jugs down the Mediterranean Sea has a spill, and the jugs go overboard. What will happen to the jugs when they hit the water?
3. What do you think would happen to the jugs when they reach the salt waters of the Mediterranean Sea? Explain your answer.
4. A local water park has a new ride. The slime used in the ride has a density of 1.15 g/mL. What type(s) of plastic would be best to use for making the floats for the ride?

Characteristics Of Plastics Information Sheet

Plastics Type	Name	Properties	Density	Common
	Polyethylene Terephthalate	Tough, rigid, shatter-resistant, softens if heated	**1.38-1.39 g/mL**	Soda, water, juice, and cooking oil bottles
	High Density Polyethylene	Semi-rigid, tough, flexible	**0.95-0.97 g/mL**	Milk and water jugs, bleach bottles
	Polyvinyl Chloride	Strong, semi-rigid, glossy	**1.16-1.35 g/mL**	Detergent bottles, shampoo bottles, shrink wrap, pipes
	Low Density Polyethylene	Flexible, not crinkly, moisture-proof	**0.92-0.94g/mL**	Garbage bags, sandwich bags, 6-pack rings
	Polypropylene	Non-glossy, semi-rigid	**0.90-0.91 g/mL**	Yogurt cups, margarine tubs, screw-on lids/caps
	Polystyrene	Often brittle, sometimes glossy, often has strong chemical reactions	**1.05-1.07 g/mL**	Styrofoam, egg cartons, packing pellets, take-out containers

Annex 6: Worksheet: Bioplastic

Biobased	●	●	Made from fuel such as coal, oil, or natural gas formed in the earth from plant or animal remains over millions of years.
Biodegradable	●	●	Materials or products (partly) derived from biomass (plants). e.g. corn, sugarcane, or cellulose.
Fossil-based	●	●	A chemical process during which microorganisms that are available in the environment convert materials into natural substances such as water, carbon dioxide, and compost.
Renewable	●	●	Materials or products that can be used repeatedly and replaced naturally.

Are all bioplastics bio-based? ☐ **Yes** ☐ **No**

Are all bioplastics biodegradable? ☐ **Yes** ☐ **No**

Look up these different types of plastics

Name	Made from:	Bio-based?	Biodegradable?
PLA **(polylactic acid)**		☐ Yes ☐ No	☐ Yes ☐ No
PHA **(Polyhydroxyalkanoates)**		☐ Yes ☐ No	☐ Yes ☐ No
PBS **(Polybutylene succinate)**		☐ Yes ☐ No	☐ Yes ☐ No
PBAT **(Polybutylene adipate terephthalate)**		☐ Yes ☐ No	☐ Yes ☐ No
PCL **(Polycaprolactone)**		☐ Yes ☐ No	☐ Yes ☐ No
PE **(Polyethylene)**		☐ Yes ☐ No	☐ Yes ☐ No
PET **(Polyethylene terephthalate)**		☐ Yes ☐ No	☐ Yes ☐ No
PA **(polyamide)**		☐ Yes ☐ No	☐ Yes ☐ No
PTT **(Polytrimethylene terephthalate)**		☐ Yes ☐ No	☐ Yes ☐ No

Knowing this, why do you think people still make Fossil-based plastics?

Which products would you replace with bioplastic?

Do they already exist? Look them up.

What would the benefit of replacing them with bioplastic be?

LEGO aims to make all its bricks from sustainable materials by 2030. Why would they do that?

http://legoexternal.23video.com/video/22467724/lego-plants-made-from-plants

Annex 7: Worksheet - What is 3D printing

PLA is used to produce plastic films, bottles, and biodegradable medical devices,..
It melts under heat so this makes it suitable for some interesting applications in 3D printing. The PLA material is melted in the head of the printer and hardens again when it's touching the colder plate.
But how does 3D printing works and what can we print?

Watch following YouTube video:

https://www.youtube.com/watch?v=VxoZ6LplaMU

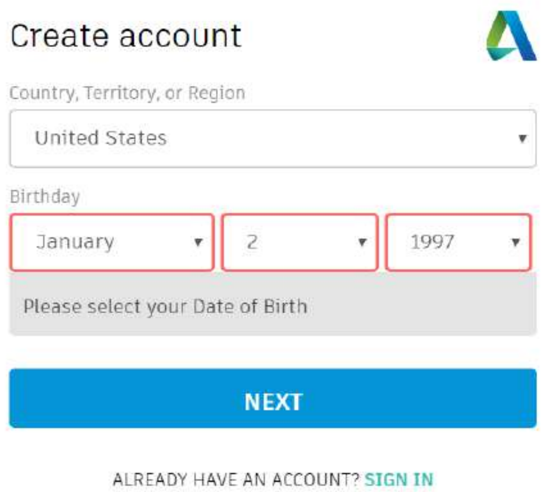
Discuss following topics in your group and write some opinions on the sticky notes

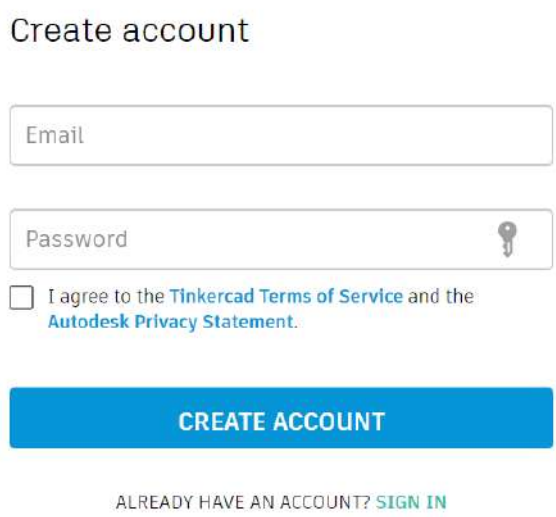
- What's your opinion about 3D-printing in general?
- Should students learn how to draw and use 3D-printing in school?
- Printing small plastic stuff is common use, but what do you think about printing parts of houses?
- 3D printing is still in the beginning stage, what do you think about the printing of bodyparts, organs,..
- What do you think the future can bring with 3D printing?
- Be creative : what will you like to print yourself if everything is possible?

Annex 8: Tinkercad tutorial - Tinkercad keychain

Login

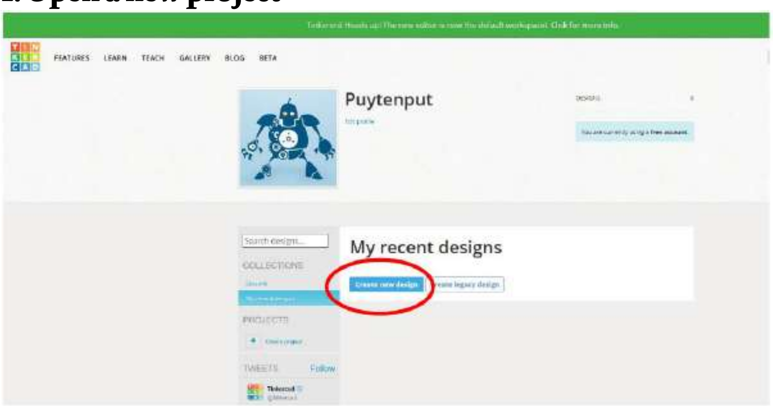
- Go to www.tinkercad.com
- Click "sign up" in the above right corner
- Select your country and fill in your Birthday, click NEXT
- Create account:
  - Fill in your Email address
  - Choose a password
  - Check on "I agree-box"
  - Click on "create account"





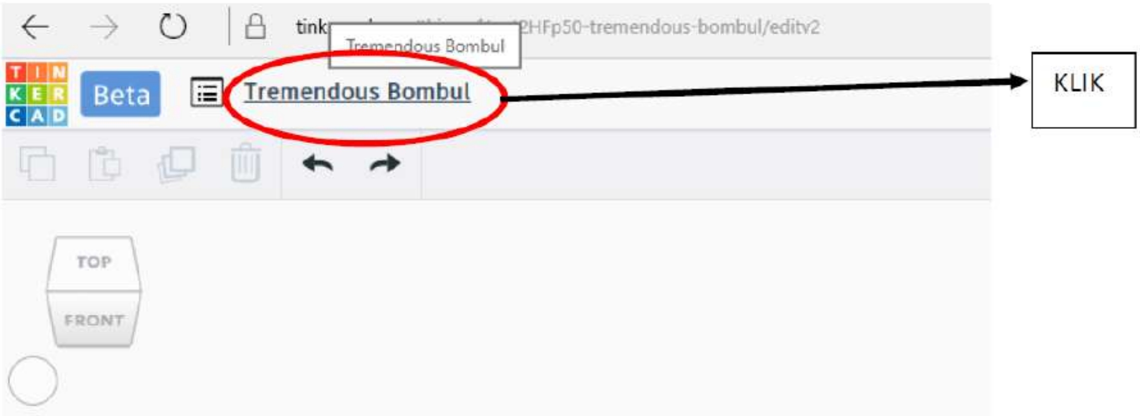
Making the keychain

1. Open a new project

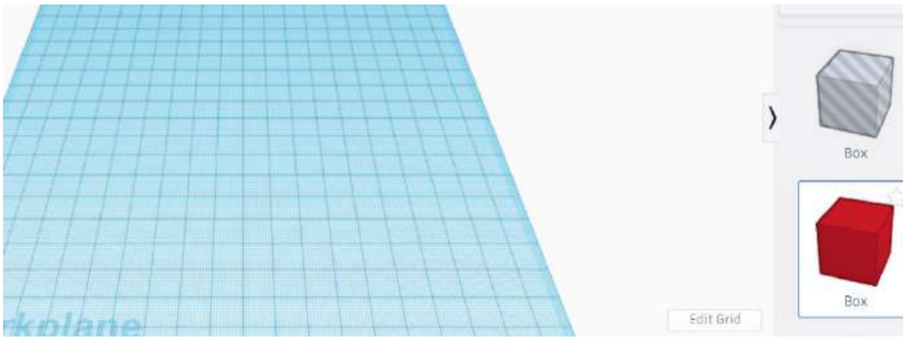


2. Rename your project

Click on the name above and type over your own project name

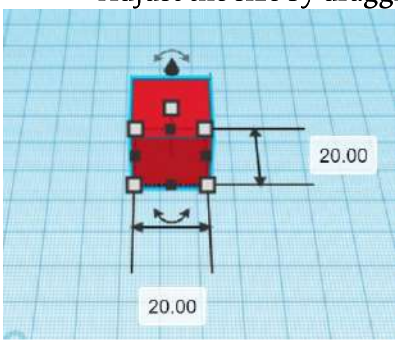


3. First, we make a square for our keychain.
Drag and drop a red cube to the middle of the workspace.



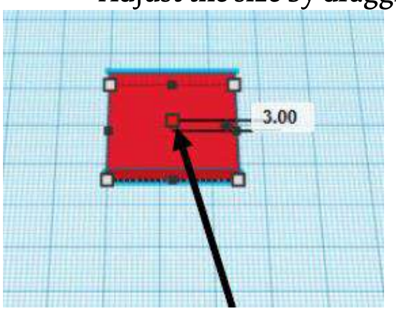
4. The standard size of a cube is 20mm X 20mm X 20mm
We are going to adjust the width and height to 25mm X 25mm

- Click on a corner
- Adjust the size by dragging OR by filling 25 in the white box

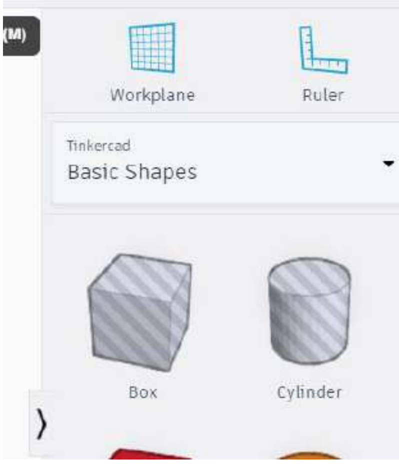


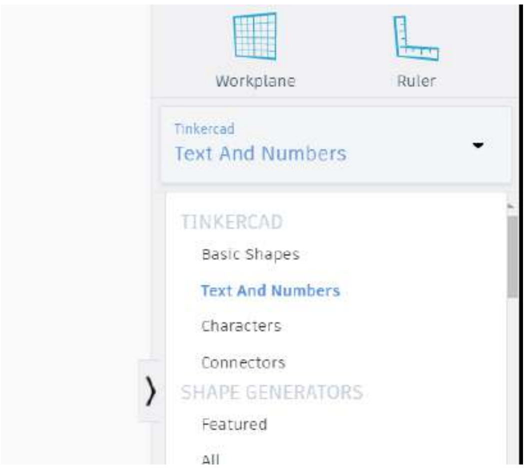
5. Adjust the height of the cube
The height of the keychain should be 3mm. So, we are going to adjust this one.

- Click on the white box in the middle of the square.
- Adjust the size by dragging or by filling “3” in the white box

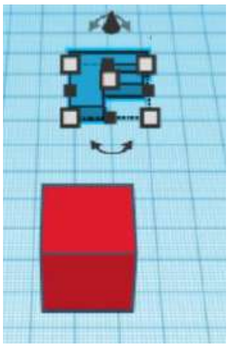


6. Select a letter for the keychain
In the menu at the right side you click on “basic shapes” and choose “Text and numbers”

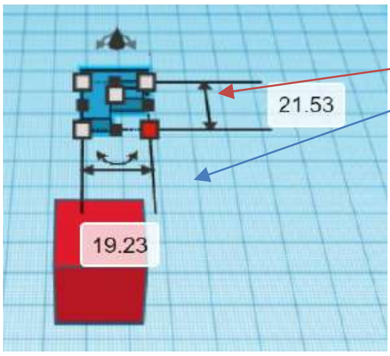




7. Drag the letter to the workspace above the square.
We drag this above the square, so we can adjust the size of the letter.

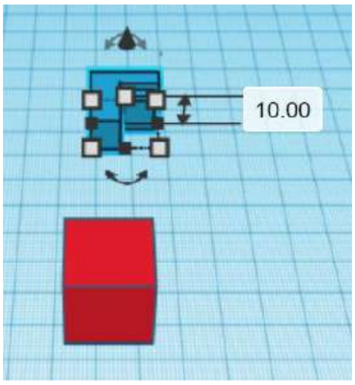


8. Adjust the size of the letter:
Click on a corner and change size to: 20mm X 20mm



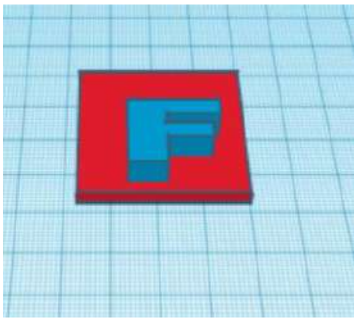
- Click on the corner
- Click on size
- Type the correct size

9. Adjusting the height of the letter:
Click on the square in the middle of the letter and change height to 10 mm

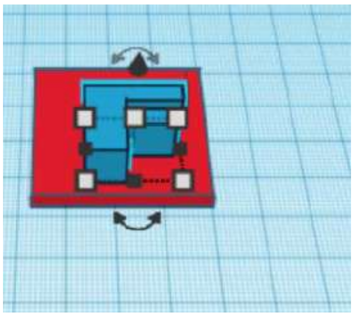


10. Put the letter on the square

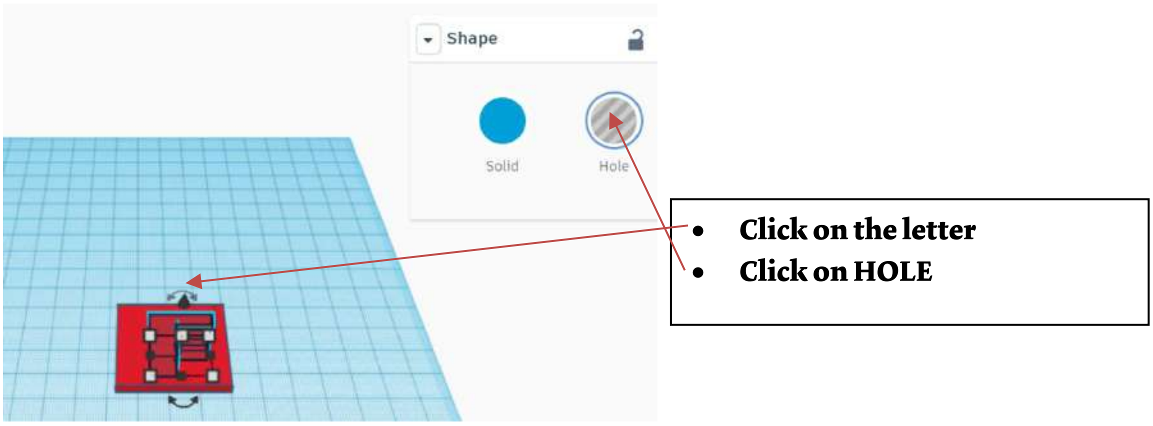
- Click on the letter and drag over the square
- Tip: if you want to turn the workspace: click on the right mouse button
- Zoom in - zoom out: scroll with your mouse wheel
- Check that the letter is in the middle of the square



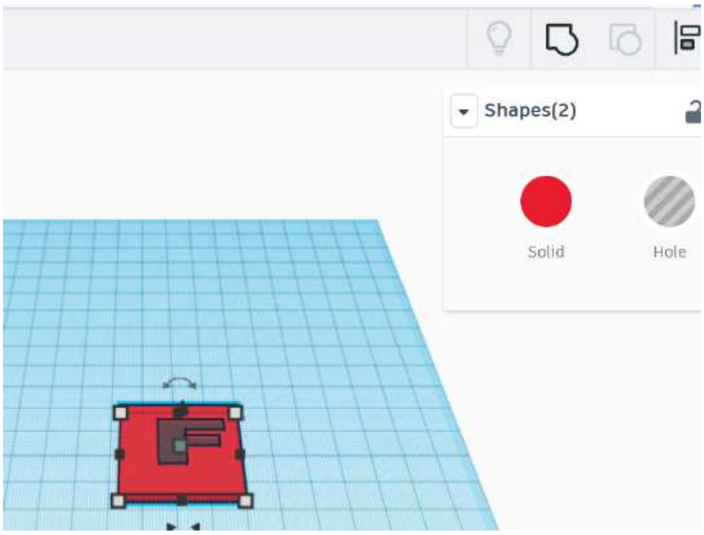
11. Lowering down the letter in the square by changing the height
Click on the back cone above the letter and drag this down until the letter goes through the square.



12. Change the letter in a "hole".
Click on the letter to select it, click afterwards on "hole"

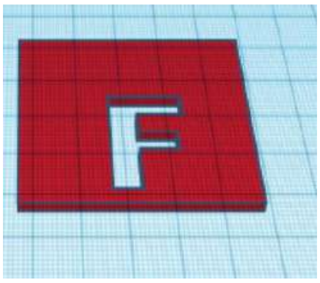


13. We have to make from the 2 different figures, one peace



- Select the complete figure.
- Click on the icon "MAKE GROUP"

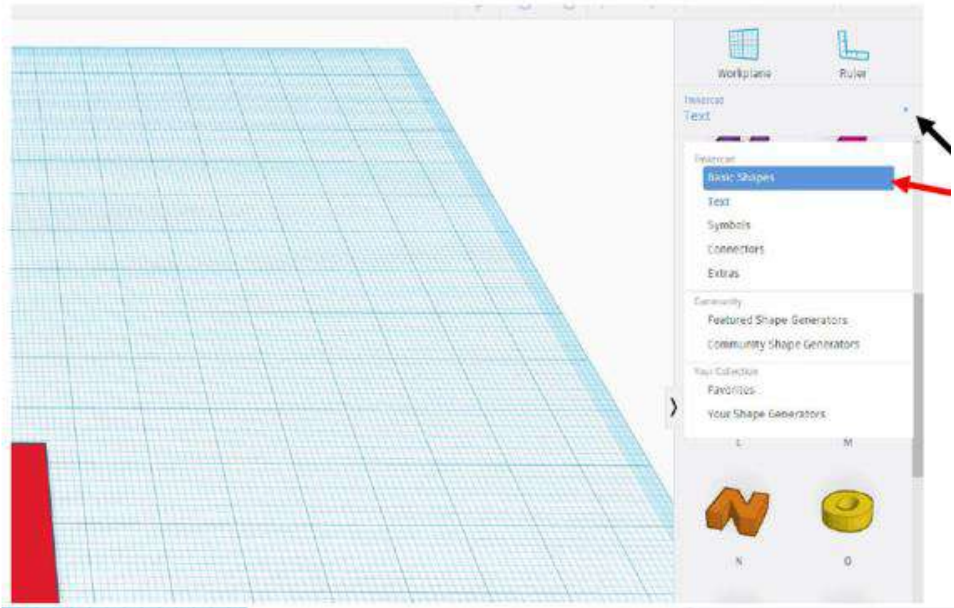
If everything is correct, your figure looks like this:



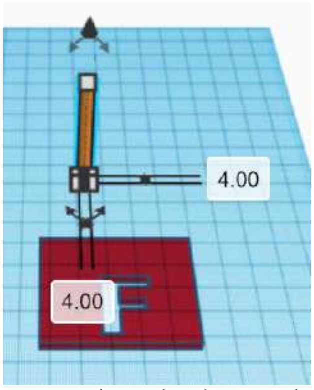
14. To finish, you have to make a hole for the key.

In which corner you have to make is, depends of your letter. Place it where you have some space left.

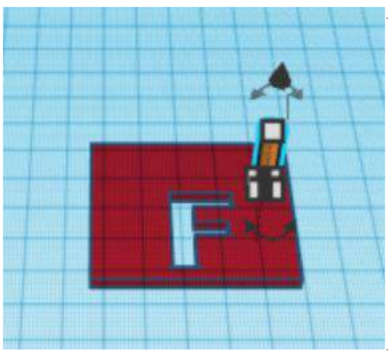
- Choose in the menu on the right "BASIC CHAPES"
- Drag a cylinder on the workspace

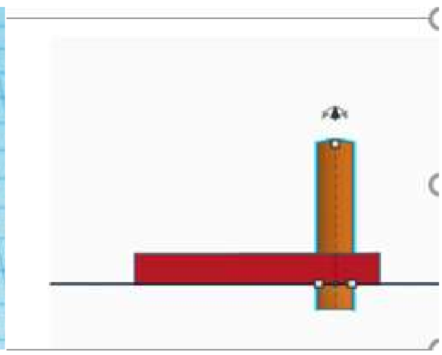


15. Adjust the diameter to 4mm



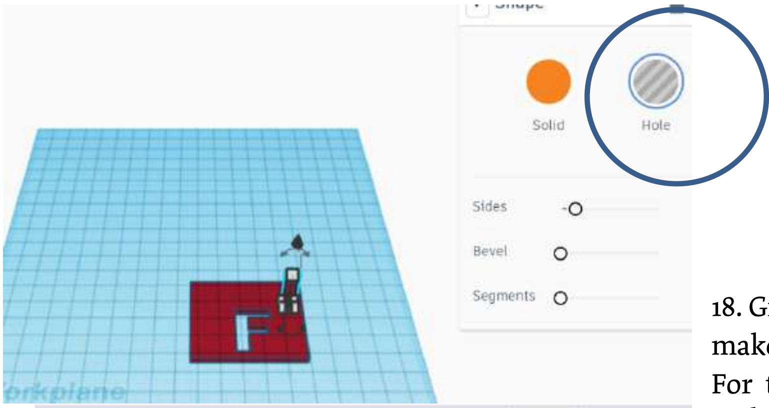
16. Drag the cylinder in the keychain, be careful that there is enough space left in the corner, else it will break while printing. Lower the cylinder until it's complete through the keychain.





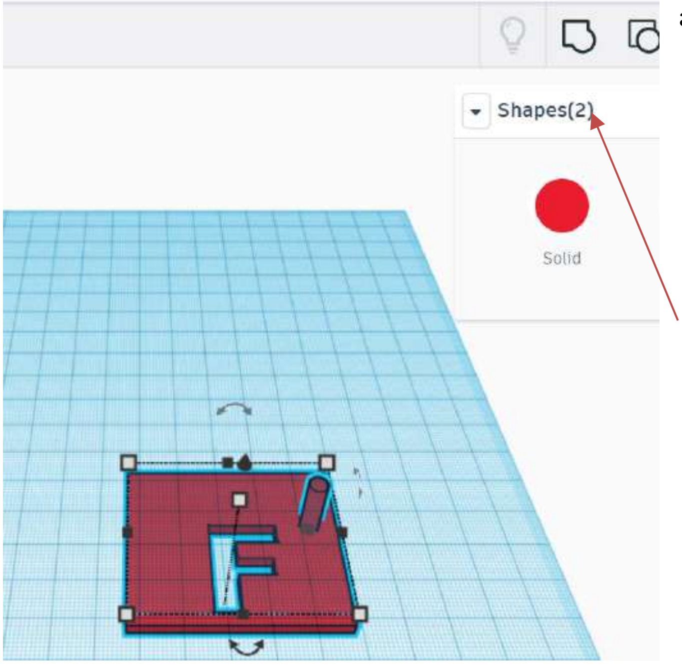
17. Make from the cylinder a "hole"

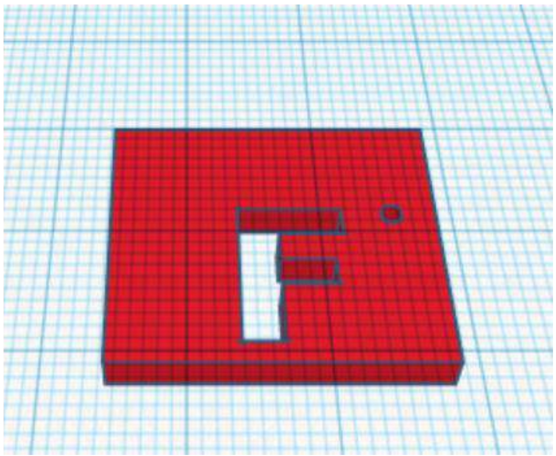
For this click on "hole"



18. Group your figure again to make it one.

For this, select your whole figure and click on "GROUP"

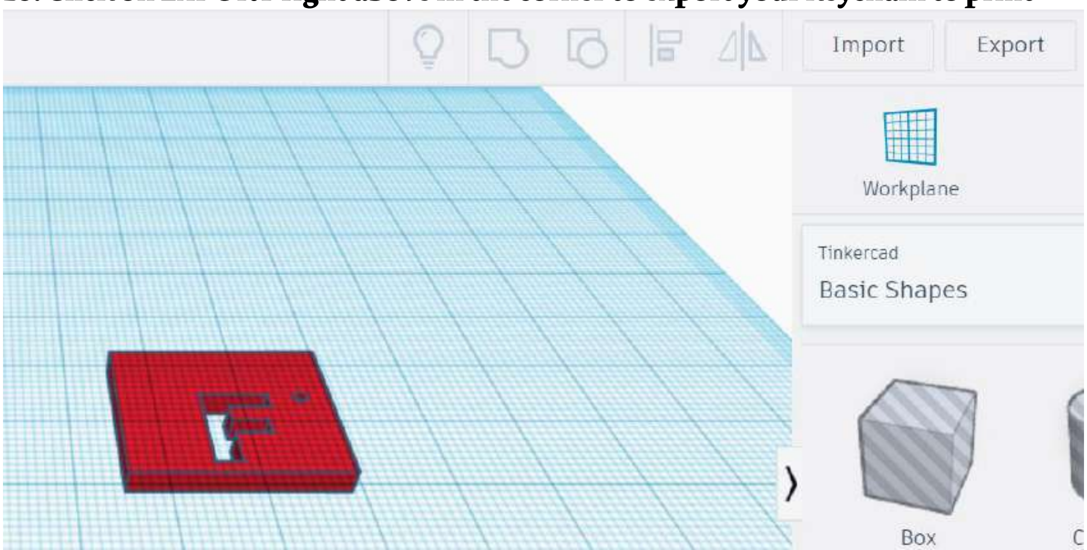




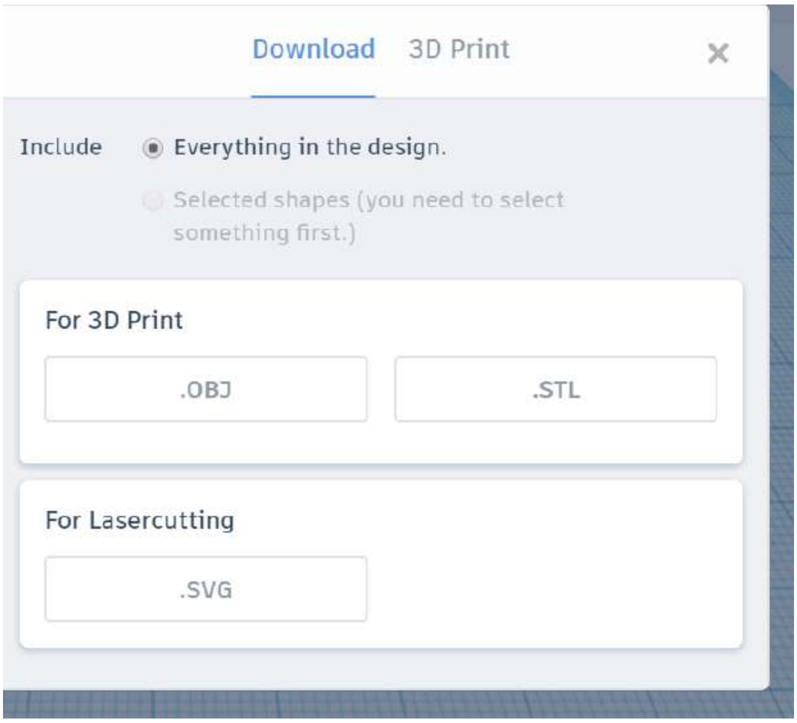
19. GREAT JOB! Your keychain is now ready for printing!!

The next page is only necessary when you are going to print it with the 3D printer!

20. Click on EXPORT right above in the corner to export your keychain to print



**21. Choose for format "stl" for downloading
(the format depends on your printer!! Check which format you need!)**



Annex 9: Learning Design

Description	
Context	**Topic:** Bioeconomy **Total learning time:** 220 minutes **Number of students:** 15-25 The world population is living, working, vacationing, along the coasts, and standing on the front row of the greatest, most unprecedented, plastic waste tide ever faced. Plastic is versatile, lightweight, flexible, moisture resistant, strong, and relatively inexpensive. Those are the attractive qualities that lead us, around the world, to such a voracious appetite and over-consumption of plastic goods. Our tremendous attraction to plastic, coupled with an undeniable behavioural propensity of increasingly over-consuming, discarding, littering and thus polluting, has become a combination of lethal nature. The future for the world is bioeconomy, recycle and use biodegradable material
Aims	Collaboration Communication Science & engineering civic competence entrepreneurship digital competence
Teaching-Learning activities	
Plastic pollution	***Investigate 30 minutes 20 students Tutor is available*** Analyse this pictures about "Plastic pollution and marine debris" http://www.marlisco.eu/
	Practice 50 minutes 20 students Tutor is available You work in group and make a table and classify the type of plastic pollution.
	Discuss30 minutes 20 students Tutor is available Why are there so many plastic pollution in the sea/beach ? To formulate different hypotheses.
	Read Watch Listen 50 minutes 20 students Tutor is available Read the document and find why there is so much plastic in the sea. Is it ok with your hypotheses?
Organic solution - Biopolymers	***Read Watch Listen 10 minutes Tutor is available*** "Know your plastics" Different kinds of biopolymers and their resources
	Discuss25 minutes students Tutor is available Why use bioplastics? Is this a good option? What are the consequences? (pros and cons)
	Investigate 25 minutes Tutor is available Investigate different bioplastics and their properties.
	Practice 15 minutes Tutor is available Exercise on biopolymers
	Read Watch Listen 20 minutes 20 students Tutor is available To search the internet at home.

Bioplastic-Making Bioplastic 3 lessons	**First group:** What is bioplastic? **Second group:** What are the properties of bioplastic? To communicate using drive docs.
	Produce ***30 minutes*** ***20 students*** ***Tutor is available*** **First group:** Make Bioplastic from food residues that have starch. **Second group:** Make bioplastic from potatoes **Third group:** Make bioplastic from starch
	Investigate ***30 minutes*** ***20 students*** ***Tutor is available*** Class practice: In this activity, students investigate the effect that adding a 'plasticiser' has on the properties of the polymer they make.
Product design/3D Printing	***Read Watch Listen*** ***15 minutes*** ***Tutor is available*** YouTube movie: What is 3D printing and how does it work?
	Discuss20 minutes ***20 students*** ***Tutor is available*** What do you think of 3D printing? Printing toys, parts of houses, or even ears, organs... PLA is bioplastic, what do you think of that?
	Produce ***45 minutes*** ***1 students*** ***Tutor is available*** 3D Design in Thinkercad, following instructions If you have a 3D printer in class, you can print it in class. Else you can maybe let it print in a fablab or in a company in the neighbourhood.