MATERIALS 4 A SUSTAINABLE FUTURE

Research lab educational visits

Suggestions for exploiting www.materialsfuture.eu

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About this guide

This guide consists of three parts and suggests activities before, during and after a visit to a Research Lab where Advanced Materials are being developed and tested. Parts A and C are aimed towards teachers and part B towards the staff of the hosting lab. The products from the "STIMULATE" project are designed in order to spark the interest of visitors before the visit, and also keep them involved for a long time after the visit; they are freely available, in all official EU languages, at the website: www.materialsfuture.eu.

We recommend that the hosts provide the teachers with a table listing the available research topics and labs before the visits, so that teachers can choose their preferences and build up interest among their students. At the end of this guide, we provide two tables with the main topics and equipment shown in the films and the game from the website. The hosts can indicate on these tables which technologies they will be able to show during any visit, and return them to the visitors in advance.

A Before the visit

Suggested duration 1.5 – 2 hours

The motives for researching Advanced Materials are not easy to comprehend because the role of new materials is usually hidden behind the technological innovations (consider for example, the role of semiconductors in LEDs).

Therefore, a visit to an Advanced Materials Research Lab should be prepared carefully. Visitors must have at least a general idea of why they are there and what there is to see, in order to develop a positive attitude towards the upcoming visit. The reason for choosing such a Lab for the visit should be explained during a discussion in class.

A topic that could initiate a discussion is *sustainability*. Sustainability is about meeting the needs of the present without compromising the ability of future generations to meet their own needs. We have been using renewable, plant-derived materials like wood, cotton and rubber for a long time. However, in the last century we have been using such materials at such a rate that the plants or animals cannot replenish themselves in time (e.g. overfishing!). We have also become increasingly dependent on resources such as coal, gas and petroleum oil, and have been depleting them at a rapid rate. Oil is used not only as fuel, but also as a source of raw material to create products such as plastics, dyes, medicines and textiles.

The challenge for scientists is to find ways to use natural resources efficiently, to exploit renewable energy resources more effectively, and to create sustainable products. Encourage students to consider such issues as: What are advanced materials? In what ways do they enter our lives? Material in the encyclopedia page on the website could also be used to prompt students, such as: What is a nanomaterial? What is a photovoltaic cell and why we use it?

At this point, the discussion could be enriched with the trailer of the film “The secret life of materials”. If time permits, we recommend the screening of the complete film “The Secret Life of Materials” (60 min). If there is not enough time, we recommend the screening of one or more of the film's 10 stand-alone segments:

Segment	Mins	Content
Teaser	00:56	View online
Intro, Trailer	02:03	View online
Violin	14:34	The process of 3D printing a plastic violin, from its initial design, to its demonstration at a concert.
Bionic Limbs	07:01	A prosthetic hand controlled from the brain. Can a prosthetic hand sense its surroundings?
Carbon Nanomaterials	07:36	Graphene and its amazing properties; used in conductive invisible inks that make paper responsive.
Clean Water	07:59	An innovative desalination method that uses certain proteins (aquaporins) as water filters. A demonstration of the process takes place in Crete, where seawater is filtered and used to water plants.
Living Materials	06:14	The concept of creating materials that interact with their environment; imagine sport shoes that respond to certain movements!
Materials Library	03:11	A tour at a materials library that hosts some of the most exciting materials on earth, e.g. the lightest solid ever created.
Mimicking Nature	05:15	Structural colour; how can we create colourful materials without using chemicals?
Solar Energy	06:15	The fabrication of a photovoltaic cell by simple means. Michael Grätzel describes the importance of photovoltaic technologies.

Involve the students in the decision process for choosing the labs / research topics that are available for the visit. The visitors can use the forms provided by the hosts in order to choose the labs that are most interesting to them.

B During the visit

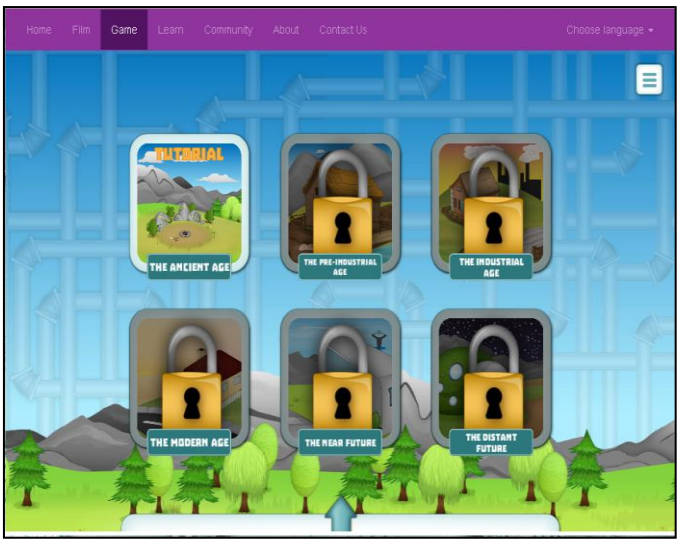
Suggested duration 3 hours

A place where research takes place is, by itself, a motivating environment and can easily attract students' attention. It is good to start with a short presentation before the lab tour. Depending on the time available, one or more of the segments described above could be screened. The selection of segments could be based on the topics that will be demonstrated later, as it will be very good to allow the students to make the connection between what they have seen in the film and what they see in the real world.

At the end of the visit, the students should be encouraged to follow up by visiting not only the lab's web site and social media, but also www.materialsfuture.eu (where the films and game are freely available), and its Facebook page.

They will be encouraged to play the game "Materials Hunter" on this site, where the player "creates" advanced materials to make a small society evolve in a sustainable way, from prehistoric times into the far future. The technologies that appear range from simple brick manufacturing to nano-robot assembly; as the player completes each level, new technologies are unlocked (e.g. glass, paper, steel, batteries, p-n junction, sensors, drug delivery devices). The player sells his technologies and so is able to create new ones; a better score is achieved for sustainable solutions.

The game play may last many hours, therefore it is not recommended for use during the visit, and only a short introduction should be given (e.g. viewing of the game's trailer). The game and game trailer can be downloaded from the project's web site and played on most platforms (PCs, smartphones or tablets).



Screenshot of the different ages that the player has to unlock in the game "Materials Hunter"

C After the visit

There are many activities that can be organised after the visit in order to build on the trip and further explore the field of Advanced Materials. Activities such as playing the game or additional discussions on what were seen are a good way to revisit the lab tour. The "Materials Hunter" game could be also part of a homework exercise. Teachers may organise a game competition where students compete with each other. In this way, students will get more involved themselves and discover more technological innovations where Materials Science plays an important role. Teachers may also distribute a questionnaire to the students, encouraging them to search for the answers which are found in the game or films. Keep in mind that the game is relatively addictive and that it may need time to complete it with a high score.

For a deeper insight on the topics that are presented in the main film "The Secret Life of Materials", we recommend screening the short educational films, which are also be found at www.materialsfuture.eu (they are named "Enhanced shorts"):

Enhanced Short	**Length**
Mimicking Nature	02:50 minutes
Nanomaterials Graphene	03:12 minutes
Solar Energy	03:31 minutes
3D Printing	03:08 minutes
Adaptive Materials	04:17 minutes
Bionic Bodies	03:47 minutes

A complete educational pack is available on the website for teachers to download with ideas on topics of discussion. It also contains worksheets that can be distributed to the students.

Appendix 1: Content and technologies featured in the Secret Life of Materials films

Please tick which topics or equipment below are available to see during a visit

Segment name	Main Topic	Topics/Materials/Equipment	✓
Living materials	Adaptive Materials	Red oil "protocells" / Chemistry lab	
Bionic limbs	Brain-machine interface	Biocompatible materials / Iridium platinum contacts, advanced polymers, Titanium	
Clean water	Desalination	Water desalination systems, membranes / Aquaporins	
Materials library	Exciting materials	Shape memory alloys, synthetic skin, diamonds, aerogel	
Carbon nanomaterials	Graphene	Graphite, graphene / optical microscope, TEM, CVD, spin coater,	
Mimicking nature	Structural Colour	"Polymer Opals", plastic spheres, holograms, natural structurally coloured objects such as butterfly wings / Press, SEM, TEM, optical microscope	
Solar energy	Solar cells	p-n junction solar cells, silicon solar cells, pigments, titanium oxide, glass, electrolyte, light source, optical characterisation equipment	
3D printing violin	3D printing	ABS polymer, plastics, ceramics, metals, 3D printed objects / 3D printer, X-ray equipment	

Appendix 2: Content and technologies featured in the Materials Hunter game

Please tick which topics or equipment below are available to see during a visit

		✓			✓
Solar Panel	Solar cell		Photo reduction of CO2	Jar lamp reactor	
	Thin film solar cell			Optical fibre reactor	
	Organic solar cell			Natural light reactor	
Battery	Alkaline battery		Glass	Normal glass	
	Lithium-ion battery			Durable glass	
	Lithium iron phosphate battery			Eco-friendly glass	
Paper	Low strength paper		Targeted drug delivery	Advanced drug delivery	
	High strength paper			Smart drug delivery	
	Recycled paper			Biofeedback drug delivery	
Lab on a chip	Lab on a chip		Steel	Construction steel	
	Polymer lab on a chip			Cable steel	
	Paper lab on a chip			Stainless steel	
Display	LED display		Brain computer interfaces (BCI)	Headband BCI	
	OLED display			Full scalp BCI	
	IGZO display			Invasive BCI	
Brick	Light-coloured clay brick		Carbon Nanotubes	Carbon nanotubes (CNT)	
	Dark clay brick			CNT's/Polymer composites	
Transient Electronics	Paper solar cell		Semiconductor	Semiconductor	
	Transient battery			PN-junction semiconductor	
Artificial Photosynthesis	Artificial leaf		Water Desalination	Reverse osmosis desalination	
	Super artificial leaf			Aquaporins	
Fuel cells	Alkaline fuel cells		Printable Prosthetics	Prosthetic limbs	
	Pem fuel cells		Internet of things	Internet of things	
Nanorobots	Nanorobots				