

Teacher Preparation Guide

Bio-packaging	Module 1: The Circular Economy
Aim:	Understand the concepts of the circular economy and how to transition towards one in the current economic climate
Learning Objectives:	<p>Upon completion of this module participants will:</p> <ul style="list-style-type: none"> - Understand the 5 core messages of Agenda 2030 and the 17 goals of sustainable development - Know the 5 main reasons circular business models should be considered by entrepreneurs - Understand the 9 principles of circular economy - How to transition from a linear economy to a circular economy - Know the benefits of a circular bioeconomy - Know the EU action plan for transition towards a circular economy - Understand the circular economy in Bio-packaging production - Importance and benefits of bio-packaging in circular bio-economy
Key words	Circular economy, bio-economy, principles, Agenda 2030, entrepreneurship, EU action plan, Bio-packaging
Downloads / Videos / Learning Resources:	<p>Re-thinking Progress: The Circular Economy - www.youtube.com/watch?v=zCRKvDyyHml</p> <p>#17 goals https://www.youtube.com/watch?v=0XTBYMfZyrM)</p> <p>Eurostat interface https://ec.europa.eu/eurostat/web/sdi/key-findings</p> <p>5 Reasons to Think About Circular Economy for Entrepreneurs https://www.bioazul.com/en/5-razones-para-considerar-la-economia-circular-siquieres-emprender-2/</p> <p>9 Principles of Circular Economy https://www.umweltbundesamt.de/publikationen/9-principles-for-a-circular-economy</p> <p>EU Circular Economy Action Plan https://ec.europa.eu/environment/circular-economy/pdf/report_implementation_54_actions.pdf</p> <p>Circular Economy: It's the Way Forward (http://www.switchtogreen.eu/?p=846)</p>
Further Reading / Resources:	<p>Circular Economy... it's the way forward: www.youtube.com/watch?v=IK00v_tzkCI&feature=emb_logo</p> <p>Circular Economy Explained: https://www.youtube.com/watch?v=7b9R82vrA40</p> <p>Circular Economy: definition & examples Sustainability Environment https://www.youtube.com/watch?v=X6HDcubgxRk</p> <p>Circular Economy: https://www.youtube.com/watch?v=9mHi93n2AI</p>

Bio-packaging	Module 2: Introduction
Aim:	Understand what is packaging, the connected environmental problems and how bio-packaging could be an alternative solution
Learning Objectives:	<p>Upon completion of this module participants will:</p> <ul style="list-style-type: none"> - Understand the main functions of packaging

	<ul style="list-style-type: none"> - Know the main connected environmental problems - Understand the concept of bio-packaging in the framework of the Circular and Biobased economy - Comprehend what is bio-packaging in general terms - Know the main different categories of biobased materials that can be used for bio-packaging
Key words	Packaging, functions, biobased materials, environmental problems
Downloads / Videos / Learning Resources:	<p>Food packaging and the connected problems: https://www.youtube.com/watch?v=aTcMPy6L88E</p> <p>Main features of packaging: https://europen-packaging.eu/sustainability/what-is-packaging.html</p> <p>The need for sustainable food packaging: Bio-packaging https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits https://ec.europa.eu/environment/topics/waste-and-recycling/packaging-waste_en https://sustainablebiomaterials.org/ https://www.plasticseurope.org/en/about-plastics/what-are-plastics/large-family/biodegradable-plastics</p> <p>Biobased materials suitable for biopackaging: https://bioplasticsnews.com/2013/12/31/bio-based-pet/</p>
Further Reading / Resources:	<p>Food packaging and the connected problems: https://youtu.be/HQTUWK7CM-Y; https://youtu.be/ju_2NuK5O-E https://www.youtube.com/watch?v=1h-nQgmRLpE; https://youtu.be/cwTDvqaqPIM https://www.youtube.com/watch?v=Yomf5pBN8dY; https://www.youtube.com/watch?v=vZTL1aE3oFs; https://www.youtube.com/watch?v=1qT-rOXB6NI; https://www.youtube.com/watch?v=d3WYoSJ8wHo</p> <p>Bio-packaging and Bioeconomy: - Cruz-Romero M. and J. P. Kerry. 2008. Crop-based biodegradable packaging and its environmental implication. CAB Review - Miller R. The Landscape for Biopolymers in Packaging. National Non-Food Crops Centre (NNFCC) Publication, Heslington, York, UK; 2005. - Van crevel, R. 2016. Bio-based food packaging in sustainable development, Forestry Policy and Resources Division, Food and Agriculture Organization of the UN. https://ec.europa.eu/environment/topics/waste-and-recycling/packaging-waste_en https://plasticpollutionblogsite.wordpress.com/2016/10/31/solution-technology-1/ https://www.alpagro.be/en/support/material-types/bioplastic/</p>

Bio-packaging	Module 3: Ecological benefits of bio-packaging
Aim:	Understand the principles of assessing environmental impact, the main method used (life cycle assessment) and the difference between bio-packaging and conventional packaging
Learning Objectives:	<p>Upon completion of this module participants will:</p> <ul style="list-style-type: none"> - Understand the main principles of assessing environmental impact - Know the main method used (lifecycle assessment)

	<ul style="list-style-type: none"> - Understand the main steps of the LCA - Comprehend the main difference of the bio-packaging versus conventional packaging - Identify the main ecological benefits of bio-packaging
Key words	Lifecycle assessment, process, biodegradable, fossil-fuel, footprint, ecological
Downloads / Videos / Learning Resources:	<p>Plastic and the connected environmental problems: https://www.youtube.com/watch?v=vgl3et8KK_o&t=27s</p> <p>Life cycle assessment to evaluate the environmental impact: https://en.wikipedia.org/wiki/Life-cycle_assessment#</p> <p>Compare bio-packaging vs conventional packaging: https://ec.europa.eu/info/food-farming-fisheries/sustainability/economicsustainability/bioeconomy/agricultural-biomass_en https://plasticpollutionblogsite.wordpress.com/2016/10/31/solution-technology-1/</p> <p>-Molenveld, K., Oever, M.V.D. and Bos, H. Biobased Packaging Catalogue. Wageningen: Wageningen UR Food & Biobased Research.</p> <p>-Rexam. 2011. <i>Packaging Unwrapped</i>. [PDF] Available at: --- https://www.rexam.com/files/pdf/packaging_unwrapped_2011.pdf</p> <p>-SBC.2009.<i>Sustainable Biomaterials Collaborative</i> [online] Available at: - EIPRO 2006 Technical Report EUR 22284 EN</p>
Further Reading / Resources:	<p>Further resources for plastic and the environmental problems: https://www.youtube.com/watch?v=HQTUWK7CM-Y</p> <p>Life cycle of materials: https://ec.europa.eu/info/food-farming-fisheries/sustainability/economic-sustainability/bioeconomy/agricultural-biomass_en https://www.european-bioplastics.org/bioplastics/environment/ https://www.european-bioplastics.org/bioplastics/materials/ http://www.sustainablebiomaterials.org/ https://www.europarl.europa.eu/thinktank/infographics/circulareconomy/public/index.html https://en.wikipedia.org/wiki/Life-cycle_assessment# https://immago.com/biodegradable-plastic-bags/</p>

Bio-packaging	Module 4: Biomass production in Biobased context
Aim:	Understand the basic principles of the biomass production, the role of agriculture as sustainable source of biomass, important crops that are suitable for biomass resource and the types of residues that can be used in a biobased context
Learning Objectives:	<p>Upon completion of this module participants will:</p> <ul style="list-style-type: none"> - Understand the value of Agriculture as a biomass source - Recognize sustainable biomass production - Know the different systems for sustainable biomass production and the main parameters involved - Recognize appropriate harvest stages and methods

	<ul style="list-style-type: none"> - Know example of important crops that can serve as biomass source for biobased materials - Identify other sources of biomass and connected products
Key words	Biomass, agriculture, open field, greenhouse, residues, agro-based feedstock
Downloads / Videos / Learning Resources:	<p>Discover the new EU Rural: https://www.youtube.com/watch?v=w3KRjnOarnQ</p> <p>-Allen, B., Cavicchi B., Jalasjoki L., Keenleyside C., Medyna G., Potter, J. and Wills T. 2019. EU rural review No 28. 2019. Mainstreaming the bioeconomy. European Union, 2019, Luxembourg: publications office of the European Union, 2019.</p> <p>Introduction to biomass production: https://www.youtube.com/watch?v=CL9A8YhwUjs</p> <p>-Garcia-Condado, S., Lopez-Lozano, R., & der, van Velde, M. (2018). Brief on agricultural biomass production. Luxembourg: European Commission's Knowledge Centre for Bioeconomy, Publications Office of the European Union. www.mdpi.com/2071-1050/10/6/1745</p> <p>-H. Hoff, F.X. Johnson, B. Allen, L. Biber-Freudenberger, J.J. Förster (2018) Sustainable bio-resource pathways towards a fossil-free world: the European bioeconomy in a global development context, Policy paper produced for the IEEP Think2030 conference, Brussels, October 2018.</p> <p>-Imadi S.R., Shazadi K., Gul A., Hakeem K.R. (2016) Sustainable Crop Production System. In: Hakeem K., Akhtar M., Abdullah S. (eds) Plant, Soil and Microbes. Springer, Cham. https://doi.org/10.1007/978-3-319-27455-3_6</p> <p>Examples of a growing crops (e.g. tomato/corn): https://www.youtube.com/watch?v=V_ZXBSD_7XQ https://www.youtube.com/watch?v=-rgdcVsF12g https://www.youtube.com/watch?v=-n8dJrqeL88 https://futureoffood.org/insights/the-global-importance-of-maize-diversity/ http://www.tomatonews.com/en/background_47.html</p> <p>Biomass production and the biobased Economy: -Biobased Economy – Sustainable Use of Agricultural Resources By S. Kulshreshtha, B. G. McConkey, T. T. Liu, J. A. Dyer, X. P. C. Vergé and R. L. Desjardins Submitted: November 5th 2010Reviewed: March 25th 2011Published: September 6th 2011 DOI: 10.5772/19989 -Peelman, N., Ragaert, P., De Meulenaer, B., Adons, D., Peeters, R., Cardon, L., Van Impe, F., Devlieghere, F. Application of bioplastics for food packaging, Trends in Food Science & Technology, Volume 32, Issue 2, 2013, 128-141, ISSN 0924-2244, https://doi.org/10.1016/j.tifs.2013.06.003</p>
Further Reading / Resources:	<p>Further reading on the importance of Agriculture and the biobased economy: https://ec.europa.eu/research/bioeconomy/index.cfm; https://www.biobasedeconomy.eu/</p> <p>Further resources for biomass production:</p>

	https://www.youtube.com/watch?v=3pD68uxRLkM https://www.youtube.com/watch?v=CL9A8YhwUps Sustainable production of Agricultural biomass: http://www.fao.org/land-water/overview/covid19/circular/fr/ https://sustainablebiomaterials.org/
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Bio-packaging	Module 5: Production of biobased materials
Aim:	Understand the principles of the production of types of biobased materials, their origin according to the initial biomass source (feedstock), useful definitions and innovative concepts connected with the biobased economy
Learning Objectives:	<p>Upon completion of this module participants will:</p> <ul style="list-style-type: none"> - Know the main types of biobased materials the main principles of assessing environmental impact - Recognize the initial source and production process of these materials - Recognize the different classification according to the end-of-life of the biobased materials. - Know the key characteristics of biodegradable packaging - Demonstrate the main types of processing methods and outputs - List the main biobased materials
Key words	Biobased material, processes, biodegradable, PLA, cellulose, PHA, fermentation, polymerization
Downloads / Videos / Learning Resources:	<p>Use of renewable feedstock for biobased material production: https://www.youtube.com/watch?v=wFXXtO58H5M JRC-IES and Imperial College expert workshop, 2013 Types of biobased materials: -Molenveld, K., Oever, M. V.D. and Bos, H. Biobased Packaging Catalogue. Wageningen: Wageningen UR Food & Biobased Research. -Van den Oever, M., Molenveld, K., van der Zee, M., Bos, H. 2017. Bio-based and biodegradable plastics – Facts and Figures, Wageningen Food & Biobased Research number 1722. Key characteristics of biodegradable packaging: https://www.naturespath.com/en-us/blog/whats-difference-biodegradable-compostable/ https://immago.com/biodegradable-plastic-bags/ https://plasticpollutionblogsite.wordpress.com/2016/10/31/solution-technology-1/</p>
Further Reading / Resources:	<p>Types of biobased materials-Innovative concepts: -Karan, H., Funk, C., Grabert, M., Oey, M., and B. Hankamer. 2019. Green Bioplastics as Part of a Circular Bioeconomy. Trends in Plants Science, 24, 237-249. https://doi.org/10.1016/j.tplants.2018.11.010 https://www.european-bioplastics.org/pla-in-the-waste-stream/ -Resource efficiency of biobased industries, Notes from an expert workshop, in support to the JRC activities in the field of resource efficiency, bioeconomy and set-up of an EU Bioeconomy Observatory; organised by European Commission – Joint Research Centre, Institute for Environment and Sustainability, Sustainability Assessment Unit and Imperial College London, Centre for Energy Policy and</p>

	<p>Technology (in the framework of the IEE 12 835 Biomass Policies project) https://ec.europa.eu/jrc/en/event/workshop/resource-efficiency-biobased-industries https://link.springer.com/chapter/10.1007/978-981-13-1909-9_4 Bioplastics: innovative concepts https://www.european-bioplastics.org/pla-in-the-waste-stream/ https://www.wikihow.com/Make-Bioplastic https://www.european-bioplastics.org/bioplastics/environment/</p>
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Bio-packaging	Module 6: Technical characteristics of food bio-packaging
Aim:	Recognize basic characteristics of bio-packaging materials make them suitable for food packaging
Learning Objectives:	<p>Upon completion of this module participants will:</p> <ul style="list-style-type: none"> - Understand the main technical characteristics of food packaging materials - Recognize basic legislation that regulate the technical characteristics of materials suitable for food packaging - Identify the main quality standards of the products and uses - Demonstrate an example of measurements
Key words	Physical and chemical characteristics, properties suitable for food packaging, thickness, thermoplastic, hydrophobic
Downloads / Videos / Learning Resources:	<p>Principles regarding the technical characteristics of packaging materials: -Nilsen-Nygaard J, Fernandez EN, Radusin T, et al. Current status of biobased and biodegradable food packaging materials: Impact on food quality and effect of innovative processing technologies. <i>Compr Rev Food Sci Food Saf.</i> 2021;20:1333–1380. https://doi.org/10.1111/1541-4337.12715 -Briassoulis and Giannoulis 2018 Evaluation of the functionality of bio-based packaging films polymer testing 69 (2018) 39-51. www.practcialaction.org Examples of measuring some technical characteristics: https://chem.libretexts.org/Courses/ https://www.campdenbri.co.uk/services/packaging-plastics-testing.php https://www.bizongo.com/blog/flexible-packaging-testing-methods Testing procedures: https://www.youtube.com/watch?v=Pmyu_8jiUZs&list=RDCMUcPrcG3gGtWqieJe-LGmi93w</p>
Further Reading / Resources:	<p>Technical characteristics of bio-packaging materials: https://www.pkgbranding.com/blog/5-characteristics-of-smart-packaging https://ift.onlinelibrary.wiley.com/doi/10.1111/j.1750-3841.2007.00301.x Examples of Testing procedures-innovative concepts: https://www.youtube.com/watch?v=eO8Doh4wFCg https://www.youtube.com/watch?v=pVioKtzn1u8 https://www.youtube.com/watch?v=ta53DwOJdhw</p>