



Introduction

Modern telecommunications and space technologies provide us with stunning views of planet Earth. They also bring home to us the fragility of our planetary ecosystem and the effects of our lack of *stewardship* in the use of its limited resources.



Currently most developed countries obtain over 85% of their energy and much of their materials from *fossil fuels*. As fossil fuel reserves are depleted over the next 100 years or so we will need other energy and material sources.

Even if we had limitless fossil fuel reserves we have no option but to reduce our use of such fuels in order to lower the levels of carbon dioxide and other *greenhouse gases*.

For our long-term survival we must live more *sustainably* and become more responsible as citizens, as nations and as a global community in our use of Earth's resources. The bioeconomy addresses many of these issues through the production of bio-based materials and services.

What is the bioeconomy?

The term 'bioeconomy' refers to the *sustainable* use of biological resources and *waste streams* to produce value-added food, *feed*, bio-energy and bio-materials that can replace, for example, traditional plastics with biodegradable alternatives. The added value is usually obtained by producing intermediate products. For example, the residue of plants that are grown for food or feed may be used to produce higher-value materials (e.g. pharmaceuticals, oils, *ethanol*) and the final *residue* used as fuel or even as the raw material for another process. The potential benefit of this '*cascade*' model will depend on research and development of novel processes and on the *industrial scaling* of these processes.

What sectors are involved?

The bioeconomy covers all sectors and systems that rely on biological resources – animals, plants, micro-organisms and derived biomass, including organic waste. The bioeconomy relates particularly to:

- the environment (marine and land ecosystems and their services)
- agriculture (food, feed, oils, fibres and other raw materials)
- aquaculture (fish, seaweeds, algae, fish residues, fish oils)
- forestry (wood, fuel, ethanol, *butanol*, timber residues)
- water and waste management (landfill disposal, landfill mining, anaerobic digestion, composting, wastewater treatment, fertiliser)
- energy (*biomass*, using residues and waste as fuel)
- bioplastics and biopharmaceuticals (bio-chemicals, *enzymes*, *antibiotics*, biodegradable materials)
- ICT (process control, monitoring, programming).

"Europe is setting course for a resource-efficient and **sustainable economy**. The goal is a more innovative and **low-emissions economy**, reconciling demands for sustainable agriculture and fisheries, food security, and the sustainable use of renewable biological resources for industrial purposes, while ensuring biodiversity and **environmental protection**" (European Commission: <https://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy>)

What are key enabling technologies?

An EU expert group identified six technologies (called 'key enabling technologies') that can contribute to the bioeconomy and lead to the manufacture of innovative products and even to new industries.

1. Nanotechnologies (in electronics, medicine, solar cells, sensors, fuel cells, fabrics, space technology, air and water quality)
2. Advanced Materials (high-strength, composites, novel properties...)
3. Biotechnology (using microorganisms and enzymes to produce new biomaterials, fuels, basic chemicals and medicines...)
4. Advanced Manufacturing and Processing (3-D printed components, high performance materials, smart manufacture...)
5. Artificial intelligence and bioinformatics (as exemplified by the company www.nuritas.com)
6. Photonics (lasers, high speed communication, ecological and medical measurement and testing, astronomy...)

These technologies will play a key role in the production of high-value materials and commodities. What follows are four different examples to illustrate what is meant by the bioeconomy.

FungusChain

Monaghan Mushrooms sells 1800 tonnes of mushrooms every week. To deliver additional value to what they already produce, two European projects were created: FungusChain and BIOrescue.

FungusChain is a 4 year multi-partner European project that is developing the industrial infrastructure required to extract new products from the mushroom feedstock. FungusChain will use mushroom feedstock from the core business as input to its *bio-refinery* and release nutrient fractions to generate higher value products. www.funguschain.eu



BIOrescue

BIOrescue is focused on creating a novel bio-refinery process to extract valuable products, using *spent mushroom compost* as the feedstock. It is a multi-disciplinary project team working across Europe and looks to not only identify viable alternatives to fossil fuel based feedstocks but also deliver higher value for Europe's mushroom farmers. www.biorescue.eu



Monaghan Biosciences (MBio) is the bioscience arm of Monaghan Mushrooms, the western world's #2 mushroom producer employing 3,500 people across Ireland, UK, Europe & Canada. MBio has developed a range of nutritionally enhanced mushrooms (with vitamin D and *selenium*) and has a pipeline of future nutrient enhanced mushrooms under development. These nutrient enhanced mushrooms will directly feed a pipeline of mushroom powders that are protein rich, allergen free and completely sustainable. Using biotechnology MBio will also investigate the release of vegan nutrients including protein from the mushroom itself. Target markets for these products include food ingredients, sports nutrition and *nutraceuticals*.

AgriChemWhey

AgriChemWhey is an EU multi-partner research and innovation project led by Glanbia, that is seeking to develop the first of a kind integrated *biorefinery* for the conversion of dairy by-products ('sidestreams'), specifically *whey permeate*, into high value bio-based chemicals.

Cheese is produced by the action of *rennet* on acidified milk. The rennet causes *coagulation* of the milk protein (casein). When these solids (know as 'curd') are removed the remaining liquid is known as *whey*. Its volume is 80 – 90 % of the initial volume of milk and it contains about half the nutrients including soluble protein, *lactose*, vitamins and minerals.

The whey can be further processed to remove some of the lactose which has important uses in the food and pharmaceutical industries. The '*delactosed*' permeate has a high mineral content and can be used to enhance the nutritional value of many foods.

The AgriChemWhey project aims to convert the various sidestreams into added-value products – specifically *L-Lactic acid*, *polylactic acid*, minerals for human nutrition and bio-based fertiliser. It hopes to be an exemplar of sustainable development that can be replicated throughout Europe.

BioMarine Ingredients Ireland

Bio-Marine Ingredients Ireland (BII) is a marine bioeconomy company located in County Monaghan. It is a joint venture between Irish fishing vessel owners and Norwegian partners who are experts in marine ingredients. The company produces the highest quality marine ingredients from the large quantities of blue whiting located in Irish waters. BII is owned by fishermen who control the supply-chain and so can guarantee continuity of supply.

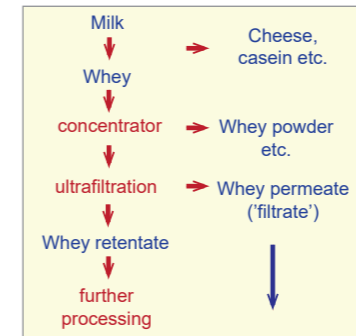
Products

Soluble Fish Protein Hydrolysate is a soluble high-protein powder with excellent *amino acid profile*. Applications for *bioactive* compounds that it contains include control of high blood pressure, inhibition of some types of breast cancer and lowering *cholesterol* levels.

Fish Oil that contains *polyunsaturated* fats that can lower the risk of coronary heart disease and heart failure.

Partly Hydrolysed Protein is a high-protein powder that can be used for animal feed or in pet-food. It has a higher protein content than traditional fish meal and has a typical shelf life of twelve months.

By integrating the supply chain and modern production facilities BII produces marine-based proteins, lipids and calcium for international markets.



Milk processing (simplified view)



An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine



Roinn Cumarsáide, Gníomhaíthe ar son na hAeráide & Comhshaoil
Department of Communications, Climate Action & Environment

The Irish Government published the **National Policy Statement on the Bioeconomy** on 12 March 2018 (pdf). Through this commitment the Government recognises that the bioeconomy is crucial for sustainability and low carbon and circular economic development whilst also providing an impetus to rural and regional development and employment. The Government has mandated a bioeconomy implementation group, jointly chaired by the Departments of Agriculture, Food and Marine and Communications, Climate Action and Environment, to take forward a number of major actions, in close collaboration with bioeconomy industries and other partners, and report back to Government.

Monaghan Biosciences, which is part of the Monaghan Mushrooms Group, has a team of research and development scientists working in state-of-the-art laboratory facilities in Tyholland, County Monaghan. Research areas include the production of cellulosic ethanol and the development of industrial enzymes for nutrition, cosmetic and other markets. It also develops custom enzymatic processes for partner industries. For more see: <http://monaghanbio.com/>



BEACON Bioeconomy Research Centre is developing sustainable novel processes and products using bio-based resources, creating clusters for new industry partnerships and delivering the expertise and trained workforce to translate new technologies into new sustainable products, processes, markets and industries. For more see: <http://www.beaconcentre.ie/>



You can find out more about the Irish bioeconomy at www.irishbioeconomy.ie/ Twitter #irishbioeconomy

Find this and other lessons on www.sta.ie



Syllabus References

The main syllabus references for the lesson are:

Leaving Certificate Geography

- Environmental impact: The use of renewable and non-renewable resources; ... fossil fuels and alternative energy; environmental pollution; sustainable economic development. (p. 26)

Leaving Certificate Biology

- Human impact on an ecosystem: Pollution, conservation, waste management; importance of waste minimisation. (p. 11)

Leaving Certificate Agricultural Science

- Macro and micro organisms. Interdependence of animals and plants. Decomposition of organic matter; carbon and nitrogen cycles. Improving soil fertility. (p. 1)

Leaving Certificate Business

- Entrepreneurs and enterprise skills... Identifying opportunities
- Marketing; Getting started; Expansion (p. 6)

Science and Technology in Action is also widely used by **Transition Year** classes.

Learning Outcomes

On completion of this lesson, students should be able to:

- Explain what is meant by the bioeconomy and give some examples of new bioeconomy businesses
- Outline the rationale for the bioeconomy with particular reference to climate change, environmental management, sustainability, industrial development and waste reduction
- Explain how the bioeconomy complements traditional practices in food production
- Outline the 'key enabling technologies' that contribute to the bioeconomy.

General Learning Points

These are additional relevant points which are used to extend knowledge and facilitate discussion.

- The current global use of fossil fuels is unsustainable. They will run out and we will need bio-based fuels and raw materials.
- Non-biodegradable materials, particularly plastics, are accumulating in landfills and are having a serious effect on marine life.
- In a bioeconomy non-renewable materials would be replaced by renewable materials derived from biological sources and would be used in a sustainable and circular way.
- Biological residues could be used to produce value-added food, feed, bio-based products and energy.
- Multiple uses can be made of many materials. When they have served one purpose they can be reprocessed to produce other materials in a 'cascade' effect.

Student Activities

1. Look up the list of new bio-based companies and partnerships in the EU on this website: <https://www.bbi-europe.eu/projects> (In the box above the SEARCH button on the left, enter 'Ireland' to limit the list to those with Irish partners, if you wish). Select one of the bio-based projects and make a poster or presentation describing what the project aims to produce and outlining how it will contribute to the bioeconomy.
2. Plastic bottles, cups and straws contribute significantly to landfill and to marine litter. Find out what biodegradable alternatives exist. How would you propose to encourage businesses and customers to switch to more sustainable materials?
3. What are the benefits of using biopesticides in place of conventional synthetic pesticides for control of crop pests? What are the main types of biopesticide?
4. Disposal of municipal waste is a major problem in most cities. How does PERCAL hope to address the problem? See <https://www.bbi-europe.eu/projects/percal>
5. Research the arguments for and against burning wood for electricity production and home heating. Consider particularly cost, land use, and pollution.
6. A new Bioeconomy Innovation and Piloting Facility is currently being developed at Lisheen, Co Tipperary. What are the expected benefits of this investment to the local and national economy?

True/False Questions

- | | |
|---|-----|
| a) Today most developed countries obtain over 85% of their energy from fossil fuels. | T F |
| b) Fossil fuels will last for hundreds of years. | T F |
| c) Biofuels can be produced in a sustainable way. | T F |
| d) Much of today's refuse is not biodegradable and may cause pollution of the oceans for centuries. | T F |
| e) Few materials we currently discard could be reprocessed to produce high value products. | T F |
| f) The bioeconomy is just another name for agriculture. | T F |
| g) Many agricultural and aquacultural residues can be used to produce high-value products. | T F |
| h) Bioplastics cannot replace synthetic plastics such as polythene for packing. | T F |
| i) The Irish mushroom industry produces 1000 tonnes of spent mushroom compost every week. | T F |
| j) Whey is used for making cheese. | T F |

Check your answers to these questions on www.sta.ie

Examination Questions

Leaving Certificate Geography (HL) 2018, Q. 15

Sustainability is a model for future development.

Discuss this statement with reference to three of the following: Resource use, Fair trade, Justice issues, Self-reliance.

Leaving Certificate Geography (HL) 2018, Q. 7 C

Economic Activities – Environmental Impact

Discuss how conflict may develop between economic interests and environmental interests as a result of the exploitation of resources, with reference to two examples that you have studied.

Leaving Certificate Business (OL) 2018, Q. 7 (part)

- (i) The product life cycle, product packaging and product design relate to the product element of the marketing mix.

Explain two functions of product packaging.

Leaving Certificate Biology (HL) 2008, Q. 10 c

- (i) Waste management is a matter of growing concern in Ireland as the population expands. Outline three problems associated with waste disposal.
- (ii) Give an example of waste produced in agriculture or fisheries or forestry and describe how it is managed.
- (iii) Suggest two methods of waste minimisation.
- (iv) Give one example of the use of micro-organisms in waste management.

Leaving Certificate Biology (OL) 2016, Q. 11 c

Humans can have many effects on an ecosystem, e.g. pollution.

- (i) Explain the term pollution.
- (ii) Give one effect of a named pollutant in agriculture, industry or the home.
- (iii) Give one specific way of controlling the pollution referred to in (ii) above.
- (iv) Give one example of good waste management from agriculture, fisheries or forestry.
- (v) Give two ways to minimise domestic waste.

Leaving Certificate Biology (HL) 2008, Q. 10 c

- (i) Waste management is a matter of growing concern in Ireland as the population expands. Outline three problems associated with waste disposal.
- (ii) Give an example of waste produced in agriculture or fisheries or forestry and describe how it is managed.
- (iii) Suggest two methods of waste minimisation.
- (iv) Give one example of the use of micro-organisms in waste management.

Leaving Certificate Geography (HL) 2010, Q. 9 c

Discuss the environmental and economic advantages of using renewable energy sources.

Did You Know?

What is the circular bioeconomy?

The term 'circular bioeconomy' refers to an economy that is largely independent of fossil fuels and in which waste materials are reused or recycled to extract the maximum benefit from them while eliminating the disposal of resources in non-renewable ways. Such an economy provides employment as well as sustainable products.

A circular bioeconomy would ensure that biomass is sustainably sourced, that its environmental impact is minimised and that products produced using biomass can be recycled sustainably.

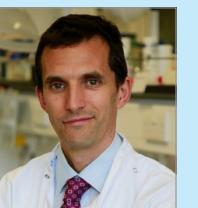
This is the only way human beings can survive long-term on this planet.

BEACON Bioeconomy Research Centre

BEACON Bioeconomy Research Centre, funded by Science Foundation Ireland, harnesses the wealth of Ireland's natural resources on land and in the sea for the development of a sustainable circular Irish bioeconomy.

It develops sustainable novel processes and products using bio-based resources, creating clusters for new industry partnerships and delivering the expertise and trained workforce to translate new technologies into new sustainable products, processes, markets and industries. It collaborates closely with industry across the agri-food and marine sectors to convert residues and waste streams created during primary production processes to higher value products. This creates new business opportunities and high value products while enabling partners to use resources efficiently.

BEACON is based in University College Dublin and the Director is Professor Kevin O'Connor. BEACON's partner institutions are Trinity College Dublin, National University of Ireland Galway, Teagasc and University of Limerick.



Revise The Terms

Can you recall the meaning of the following terms? Revising terminology is a powerful aid to recall and retention.

amino acid profile, bioactive, biomass, biorefinery, bio-refinery, butanol, cascade, cholesterol, coagulation, delactosed, enzymes, antibiotics, ethanol, feed, fossil fuels, greenhouse gases, industrial scaling, lactose, L-Lactic acid, polylactic acid, nutraceuticals, polyunsaturated, rennet, residue, selenium, spent mushroom compost, stewardship, sustainable, sustainably, waste streams, whey, whey permeate.

Check the Glossary of terms for this lesson on www.sta.ie