MS Wissenschaft 2020 – Bioeconomy

Exhibitlist and -texts

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2	Fossil Resources	beier+wellach projekte gbr, Berlin / Wissenschaft im Dialog gGmbH, Berlin
3	Everything out of Oil?	beier+wellach projekte gbr, Berlin / Wissenschaft im Dialog gGmbH, Berlin
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9	New Materials from Wood	Technische Hochschule Nürnberg Georg Simon Ohm, Fakultät Verfahrenstechnik
10	Expedition Earth	Wissenschaftsjahr + BonaRes-Zentrum für Bodenforschung c/o Helmholtz-Zentrum für Umweltforschung GmbH – UFZ, Department Bodensystemforschung, Halle/S.
11	Making new Products out of Organic Waste	Universität Hohenheim, Fachgebiet Konversionstechnologien nachwachsender Rohstoffe, Stuttgart
12	The Value of Soil	BonaRes-Zentrum für Bodenforschung c/o Helmholtz-Zentrum für Umweltforschung GmbH – UFZ, Department Bodensystemforschung, Halle/S.
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19	Multi-talented Popcorn	Hochschule für Künste - Bremen, Studiengang Integriertes Design, Lehrgebiet Produktdesign / CAD Georg-August-Universität Göttingen, Büsgen-Institut, AG Chemie und Verfahrenstechnik von Verbundwerkstoffen
20	A Place for Ideas to Grow	beier+wellach projekte gbr, Berlin / Wissenschaft im Dialog gGmbH, Berlin
21	Indoor Farming	Innovationsraum NewFoodSystems (Koordination: Max Rubner-Institut, Bundesforschungsinstitut für Ernährung und Lebensmittel, Karlsruhe; Innovationsmanagement: Fraunhofer-Institut für Verfahrenstechnik und Verpackung IVV, Freising)
22	Food of the Future	Universität Osnabrück, Abteilung Biologiedidaktik

23	Agricultural Systems of the Future	Agrarsysteme der Zukunft (Koordinierungsstelle: Leibniz-Institut für Gemüse- und Zierpflanzenbau (IGZ) e. V., Großbeeren und Leibniz-Zentrum für Agrarlandforschung (ZALF) e. V., Müncheberg)
24	Plant Research	Leibniz-WissenschaftsCampus-Halle, Pflanzenbasierte Bioökonomie, Halle/S.
25	Aquaculture Ecosystem	Fraunhofer-Einrichtung für Marine Biotechnologie und Zelltechnik EMB, Lübeck
26	Clean Water thanks to Algae	Forschungszentrum Jülich, IBG-2: Pflanzenwissenschaften und Bioeconomy Science Center
27	Your Piece of the World's Field	beier+wellach projekte gbr, Berlin / Wissenschaft im Dialog gGmbH, Berlin
28	Green Genetic Engineering in Focus	Leibniz-WissenschaftsCampus-Halle, Pflanzenbasierte Bioökonomie, Halle/S.
29	Between Industry and Environmental Protection	FernUniversität Hagen, Lehrgebiet Politikfeldanalyse und Umweltpolitik Otto-von-Guericke-Universität Magdeburg, Lehrstuhl für Politikwissenschaft mit Schwerpunkt Nachhaltige Entwicklung
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1 Earth Overshoot Day

Earth Overshoot Day is the day when humanity has used up all the natural resources created by the Earth's ecosystems over the course of one year. From an ecological point of view, from this day onwards we are living beyond our means. We are overshooting the limits of the planet and thus endangering the resources of future generations. The organisation Global Footprint Network reminds us of this fact on Earth Overshoot Day, which in 2019 fell on 29 July. Since the volume of natural resources we use is increasing all the time, Earth Overshoot Day occurs earlier every year.

2 Fossil Resources

Fossil resources are natural carbon deposits stored in the earth which were formed over long periods of time from the decomposed remains of plants and animals. They occur in the form of oil, gas or coal. They are found underground and are exploited via open-cast or underground mining.

A distinction is drawn between reserves and resources. Reserves are known deposits of raw materials that can be commercially exploited using known technologies. Resources, on the other hand, refers to raw materials that are currently not being exploited for reasons of cost or speculative deposits as yet unconfirmed. This is why it is difficult to predict how long oil, gas and coal will last. What we do know is that fossil resources are finite and in the case of oil and gas will probably last only for another few decades.

Currently, we are still reliant on fossil resources, both in industry and in our everyday lives. We use gas and coal for heating, for example, and oil to make plastics. When fossil resources are used, the carbon bonds with oxygen to form the greenhouse gas carbon dioxide (CO_2). CO_2 is a primary component in global warming caused by human activity.

Oil
Oil is used for a wide range of purposes: for heating, for fuel and also to make plastics, paint and medicines. Extracting oil involves deep drilling – on land or in the sea – and then pumping it up to the surface. There is always the danger that the oil will leak and contaminate the soil or the sea. When oil is burned, carbon dioxide (CO_2) is released.
Uranium
Uranium is used for the fuel rods in nuclear reactors. It is also a non-renewable fossil fuel. Extracting uranium out of the rock consumes a great deal of energy. Before it can be used, it usually needs to be chemically enriched and converted into a solid. Uranium is poisonous and the radioactivity it emits can causes genetic damage.
Coal

Currently, we still use coal to generate electricity and heat and to make steel. Most of the coal used in Germany today comes from Australia. When we burn coal, the concentration of carbon dioxide (CO_2) released is particularly high.

Lignite

Lignite is used to generate electricity and heat in power stations. In Germany lignite is extracted mainly from open-cast mines. To gain access to the lignite, large areas of countryside have to be cleared and even villages often have to make way for open-cast mines. The fuel value of lignite is less than that of coal, but when it is burned carbon dioxide (CO_2) is likewise released.

Gas

Gas is used to generate electricity and heat and as fuel for vehicles. It consists mainly of methane and hydrocarbons. When it is burned a mixture of carbon dioxide (CO_2) and steam is released. This means that gas emissions contain less CO_2 than those from coal.

Fracking

Gas and oil deposits can also be found in rock. In order to extract them from these sources, deep drilling is used. Chemicals and pressure are used to widen cracks in the rock and extract the gas or oil stored there. This process is known as fracking. There is a risk that the chemicals used to extract the oil and gas will end up in the groundwater.

3 Everything out of Oil?

Washing agents

We throw our dirty clothes into the washing machine. The active substances in the washing agents we use are called tensides. They ensure that the fat and dirt on our clothes dissolves in the water. But most tensides are made from oil. They are not biodegradable and can damage water organisms.

T-shirt

Many of the clothes we wear are made from materials like polyester, elastane, nylon or acrylic. All of these artificial fibres are made from oil. They are not biodegradable.

Shoes

Shoes also contain synthetic materials. The heels are often made from polypropylene, and synthetic leather contains polyurethane. Neither of these materials can be recycled. If the shoes containing these materials are burned, dangerous chemicals are released and if they decompose in rubbish dumps this produces toxic substances.

Ballpoint pen

We all know the synthetic material polystyrene from Styrofoam. But did you know that it is also used to make ballpoint pens? Because it is such a durable material the pens rarely break. The downside is that it takes 2,500 litres of oil to produce a ton of polystyrene.

PET bottles

We take our empty plastic bottles to the bottle deposit machine. Experts call these returnable bottles PET bottles. PET stands for polyethylene terephthalate, which is made from oil. It takes as much as 0.3 litres of oil to make one 75 ml PET bottle.

Toothbrushes

Cleaning your teeth is a good and healthy thing to do. But are toothbrushes good for the environment? Not really. The polyamides used to make a toothbrush contain 0.2 litres of oil. Germans buy 190 million toothbrushes a year, which uses up 38 million litres of oil.

Plastic plates and cups

At parties and festivals we often use disposable plates. These are usually made of various synthetic products. When we have finished eating and drinking we simply throw the plastic cups and plates away. Because this kind of waste is usually not recyclable, it has to be burned. That's why plastic plates and cups are increasingly being banned.

Plastic toy bricks

Interlocking toy bricks are made of very stable plastic, which means that it doesn't break easily. It is made of a substance called acrylnitrile butadiene styrene, which is derived from oil. In 2014, the Lego company used 1.5 million litres of oil to make its toy bricks.

4 Glossary

Aquaponics
Aquaponics is a compound word formed from aquaculture and hydroponics. Aquaculture is the controlled breeding of water organisms like fish and algae, while hydroponics refers to the cultivation of plants without soil. In aquaponics fish and plants are bred in the same cycle. The fish excretions supply the fertiliser for growing plants, which in turn purify the water for the fish. One of the best-known examples of aquaponics is the "Tomato Fish" project being conducted by researchers in Berlin. It combines the breeding of cichlids with growing tomatoes.
[Quelle: Glossar bioökonomie.de]

Bioeconomy
In a bioeconomy the latest scientific findings are used to develop new products and processes based on renewable resources. The aim is to end dependency on oil and shift to a bio-based economic system. The concept embraces all sectors that farm, process or trade in plants, animals and micro-organisms. These include agriculture and forestry, fisheries and aquaculture, the timber and textiles industries and parts of the chemical and pharmaceutical industries as well as the energy sector.
[Quelle: https://museumfrankfurt.senckenberg.de]

Biomass
The term biomass is not clearly defined in ecology. It refers to the entirety of the organic substance stored in plants, animals and micro-organisms. In the context of renewable energy, biomass means all organic substances of plant or animal origin that can be used as energy sources.
[Quelle: bioökonomie.de]

Bioreactor
A bioreactor is a container in which specially grown micro-organisms or animal or plant cells are cultivated in a nutrient medium. The aim is to harvest either the cells themselves (or parts of them) or one of their metabolic products. Enzymes may be used for this purpose. Bioreactors are sometimes also called fermenters.
[Quelle: Pflanzenforschung.de]

Carbon Cycle
Carbon is a special element because it occurs in all spheres of the Earth: in rocks, soil, the air, water and living beings. It is involved in numerous chemical reactions and physical processes and is exchanged between the different spheres. Together, these processes make up the global carbon cycle. The natural carbon cycle is a system in equilibrium. Through the combustion of fossil carbon reserves (such as coal or oil) carbon that was previously bound is released. An excess of carbon dioxide makes the oceans more acidic and intensifies the natural greenhouse effect in the atmosphere, which leads to global warming.
[Quelle: www.simplyscience.ch]

Circular Economy
The idea of a circular economy is that no materials or resources should be lost as waste. To start with, materials are designed to have as long a life as possible and bring maximum use. When materials are used once or several times through recycling and then burned to generate energy this is called cascade use.
[Quelle: bioökonomie.de]

Efficiency, Consistency, Sufficiency
The terms efficiency, consistency and sufficiency refer to three different strategies for sustainable development.
Efficiency aims to obtain a greater yield from raw materials and natural resources, often via technical innovations. One example is a company that uses the warmed-up cooling water generated during production processes to heat a factory hall.
Consistency denotes technologies and materials that protect nature and are more environmentally friendly than those previously used. Cycles that run from production to reuse with intermediate phases of use and recycling should be circular as far as possible, one example being a company that sells drinks in returnable bottles rather than in TetraPak cartons.

Sufficiency aims to reduce use of resources and materials by decreasing human consumption and use of services. Companies assess their products in terms of their durability and "reparability", so that a broken vacuum cleaner, for instance, need not simply be thrown away.
[Quelle: www.bund.net]

Energy Crops
Energy crops are plants grown specifically to supply energy. Alongside maize, these include rape, sunflowers, oil palms, poplars and wild plants. In most cases these crops are used to produce biogas or biofuel. Maize has the highest yield. The German government's sustainability regulations stipulate that biofuels can only be categorised as sustainable if they save at least 35 per cent in greenhouse gases compared with fossil fuels. Moreover, they may not be grown on land with a high level of biodiversity or where a lot of carbon is stored. Energy crops grown on fertile arable land pose direct competition to food and animal feed production.
[Quellen: bioökonomie.de; www.umweltbundesamt.de]

Enzyme
An enzyme is a protein that accelerates specific biochemical reactions. That is why enzymes are also called biocatalysts. They have a central role to play in all metabolic processes in organisms, from bacteria to human beings. Enzymes also have a wide range of technological applications. They are present, for example, in washing and cleaning agents, in toothpaste and in many foods. They are also used in the production of drugs.
[Qulle: biooekonomie.de; www.transgen.de]

Genome Editing
Genome editing is a bit like editing a text or a film, only in this case it means modifying the genome of micro-organisms or of plant, animal or human cells. One of the most important editing methods is CRISPR-Cas, which works like genetic scissors. Tools like these from molecular biology can be used to switch genes off or on or to insert new sequences. They can be used in fields such as medicine or animal and plant breeding.
[Quelle: www.pflanzenforschung.de; bioökonomie.de]

Sustainability
Sustainability or sustainable development means satisfying present needs in a way that does not limit the options of future generations. Three dimensions are given equal weight here: sustainable activity should be economically efficient, socially just and ecologically viable. The term sustainability originated in forestry and means that trees should be felled for timber only at the rate that they can be replaced.
[Quelle: www.bmz.de]

Waste
Waste denotes substances that are generated during product manufacture and consumption and are not reused. Bioeconomy regards them as raw materials from which reusable materials can be extracted. Waste thus becomes the starting point for new products. The EU's Waste Framework Guidelines from 2008 contain clear provisions for how to deal with waste: avoidance should take priority over repair, and recycling should take priority over other use such as incineration or energy generation. Waste disposal is the very last option.
[Quelle: www.bmu.de]

5 Forum

Let's talk bioeconomics!

The discussion about sustainable economies is not new. The study *The Limits to Growth,* published by the Club of Rome think tank in 1972, triggered a worldwide debate on sustainability. This study on the future of humanity concluded that increasing consumption, production and economic growth would bring about large-scale environmental destruction and resource depletion and ultimately destroy the basis for life for current and future generations.
As food for thought, the Forum presents quotations from this study and a range of opinions on it. Where do we stand now, almost fifty years after the study was published? Can greater sustainability be achieved by technology alone? Or do we need to adapt the economic system and our way of life? How can we stop using more resources than the planet produces and at the same time feed the world's growing population?

6 Green Resources

What are the alternatives to fossil resources?

To make the economic system climate-neutral and sustainable, bioeconomy is looking for alternatives to fossil resources. Plants and fungi play the main role here. But they are not just important as suppliers of food and animal feed. They can also be used in the construction industry and in medicine. Even if the demand for renewable resources is growing, it is important not to overburden agricultural land and forests. This is why researchers are trying to find new cultivation methods. One option might be vertical farming whereby crops are grown in vertically stacked layers in closed indoor spaces.

Fungi

Mould generally has a bad name in households, since mouldy food is inedible. In the laboratory, on the other hand, fungi are prized specimens on account of their complex metabolisms. To produce them on a large scale, researchers are trying to find the optimal growing conditions.

Moss

Mosses' ability to adapt to extreme environments makes them very interesting for bioeconomic research. They do not have roots but instead obtain nutrients from the air. Scientists are studying the extent to which they can, for example, filter fine dust particles and carbon dioxide out of the air. Growing moss indoors improves the indoor climate and provides thermal insulation.

Grass

Grasses play a big role in bioeconomic research. Most areas of grass can be easily cultivated and can be left untended for a long time. This reduces the risk of erosion. Grass is efficient, low-maintenance and high-yield. It will also grow on less fertile soil, which is an additional advantage in the era of climate change with longer periods of drought.

Bamboo

Bamboo grows quickly, is extremely robust and at the same time very light. The height of this grass species ranges from a few centimetres to forty metres. Its stems supply large amounts of wood, which can be used as a construction material or as an alternative to plastic. Scientists are trying to cultivate bamboo in Europe so as to avoid long delivery routes, which damage the environment.

Russian Dandelion

Russian dandelion is similar to our native dandelion and is relatively hardy. The milky substance found in all parts of the plant contains rubber. It can therefore be used to make tyres. The demand for rubber is growing, yet the number of rubber trees is dwindling. The plan is therefore to cultivate Russian dandelion in Germany on a large scale. This will also make delivery routes shorter.

7 Sustainable Materials for Flooring

Cork flooring

We all know cork from wine bottles. But did you know that cork comes from the bark of a species of oak tree? These cork oaks are primarily grown in Portugal and absorb and store CO_2. Cork has many uses. Much of it ends up as bottle corks, but the rest is used to make flooring or furniture. Cork is a highly durable material and insulates against heat and cold. It also benefits the indoor climate in rooms where it is used.

Terrace tiles made of grass

This terrace tiling is synthetic – but 75 per cent of it is actually grass. The material is produced in a circular system using grass supplied by local farmers: the remaining vegetal components that are not used for the plastic end up in a biogas facility where, together with food waste, they are fed to the bacteria that generate biogas. This in turn is converted into electricity in a cogeneration unit.

Parquet flooring from bamboo

Bamboo is a popular garden plant in Germany. In Asia, where it grows extremely tall, it has long been used for construction and scaffolding. Nowadays it is also used as a building material in Europe. Bamboo is as solid as wood; it grows very fast and therefore produces twice as much oxygen as an ordinary tree. Bamboo is able to protect itself against bacterial and fungal infestations so no pesticides are needed to grow it. It can also be harvested in an ecologically friendly way.

Floorboards from hemp fibres
In the laboratory for sustainable raw materials at the Bingen University of Applied Sciences, hemp fibre is being produced from biomass. Hemp fibre can be used to replace carbon fibre, an extremely hard and lightweight material used for making cars and tennis rackets, for example. However, its production releases CO_2 into the atmosphere, which is harmful for the climate. Hemp fibre is equally durable and versatile.

Click flooring made from hay
Hay, herbs and flowers harvested on mountain pastures can be used to make durable hay flooring. The natural materials are mixed with an ecological binding agent and then compressed into a hard coating, which is applied to a supporting board. No synthetic materials are used in the entire production process.

8 Plastic made from Plants

How to create biodegradable plastic from sustainable resources?

Our world is full of plastic products. But the damage caused by this versatile material is becoming increasingly evident. Plastic is generally made from oil, which releases carbon dioxide stored in the earth. Moreover, most of it is not biodegradable. Plastic waste thus contaminates the natural world and is a danger to human and animal health. Science has developed ways to replace ordinary plastic with products made from sustainable materials. One option is plastic from a plant starch called polylactic acid (PLA). Like wood, it is biodegradable. This 3D printer uses PLA to print environmentally friendly products.

The "TUM Campus Straubing for Biotechnology and Sustainability", which is part of the Technical University Munich (TUM), focuses its sustainability-oriented research and teaching on replacing fossil fuels with renewable resources to generate energy and as raw materials for the chemical industry. A further focus is bioeconomics, whose key aim is a sustainable economy.

9 New Materials from Wood

How can we process and use wood more efficiently and sustainably?

Wood is a renewable resource consisting primarily of a mixed substance called lignocellulose. Demand for its main components is high, as they can be processed into biofuels and chemicals. But the production process is lengthy and costly: the wood is shredded several times in biorefineries and chemically broken down into its components. Researchers are working on new techniques to streamline the process and make it more cost and energy efficient.

The Nuremberg Institute of Technology is one of the largest universities of its kind in Germany, with over 13,000 students. It develops ideas for the world of today and tomorrow and conducts research into the key issues facing our society. The broad array of practice-oriented courses address the technological, economic, societal and design challenges of our time.

10 Expedition Earth

How can we use teabags to investigate the soil?

Soil has many talents. It provides a habitat for animals and plants. It is used to cultivate food and animal feed as well as renewable resources. It stores carbon and is therefore invaluable for climate protection. And on top of all that, it filters harmful substances out of our drinking water. With the shift to a bioeconomy, there is increasing emphasis on maintaining healthy soil. During Expedition Earth you will conduct some experiments to find out about the state of the soil. One of the methods you will use is the so-called Teabag Index. To take part in this experiment you will need to bury some teabags in the soil. When you send the data you have collected to www.**expedition-erdreich.de**, researchers will help you to evaluate it. Become a citizen scientist and play an active part in global soil research!

Expedition Earth is a joint project of the German Federal Ministry for Education and Research, the Helmholtz Centre for Environmental Research and the BonaRes Centre for Soil Research (BonaRes). The goals of BonaRes are to broaden scientific understanding of soil ecosystems, increase soil productivity and develop strategies for sustainable soil use.

11 Making new Products out of Organic Waste

How can products be made out of renewable resources without compromising food production?

We are now able to make many products out of plants instead of oil or coal. However, if we manufacture clothing, food storage containers, computer casing, furniture parts, medicines or battery materials out of biological substances, a new problem arises: the land used to grow these raw materials will no longer be available for food production. Luckily we are able to solve this problem by making these things out of the non-edible by-products generated from food production. This means that the more food we produce, the more organic waste we have. As long as the products are in use, they store carbon. When they are eventually burnt, the amount of carbon dioxide (CO_2) released is the same as that used by the plants to grow in the first place – they are CO_2-neutral, in other words.

The University of Hohenheim has chosen bioeconomics as a central research focus. The department "Conversion Technologies of Biobased Resources" develops technical solutions for material cycles so that when products are made out of plants, the nutrients end up back in the soil. Students can learn how material cycles function in the study courses "Biobased Products and Bioenergy".

12 The Value of Soil

What role does soil play in the shift to a bio-based economy?

Soil is far more than the surface on which we move and on which we build our houses and roads. It is an exciting three-dimensional system that fulfils many functions, such as storing water and nutrients and providing a habitat for all manner of organisms. Without soil, life on earth as we know it would be impossible. It has a particularly important role to play in the shift to a bio-based economy. Replacing fossil resources with sustainable ones will require even more intensive soil use, since we will have to grow not only food for ourselves and our animals but also plants for energy production and as raw materials for industry. We must therefore be careful not to exhaust the soil.

BonaRes is the short name of the funding initiative "Soil as a sustainable resource for the bioeconomy". The BonaRes Centre for Soil Research supports decision-making for sustainable soil use and management in agriculture.

13 Peatland must be Wet!

How can peatlands protect the climate and be used sustainably?

The world's peatlands store twice as much carbon as all forests. This makes them a key component in attempts to limit global warming. They also filter our water and provide habitats for rare species. But they can only fulfil these functions if they are wet. Many peatlands have been drained, or are threatened with drainage to make way for agriculture. Draining peatlands causes major emissions of greenhouse gases. It also results in soil degradation. The solution to this problem is to rewet the peatlands. Reeds, bulrushes and peat moss may be cultivated there. These plants can provide raw materials for building and heating, animal feed, and peat substitute for horticulture. This sustainable wet cultivation is called paludiculture and is a good example of the bioeconomy.

The Greifswald Mire Centre is an interface between science, policy and practice for all peatland-related questions – both locally and globally. Here fifty peatland experts from various disciplines work at a single location. It offers science-based, targeted solutions for social challenges such as the climate crisis, ecosystem services, biodiversity protection and sustainable management.

14 The Benefits of Biodiversity

How can we discover and apply useful natural products?

How does the industry benefit from biodiversity? This is a key question, particularly for the food and the pharmaceutical industry, and materials research. Many animals, plants and fungi produce substances with interesting commercial

applications. Scientists are working to identify these substances and to find out how the organisms produce them. Then they try to recreate this production process so that it also succeeds in the laboratory or in a production chain. The genetic analysis of the organisms provides fundamental knowledge for this. The aim is to develop substances with natural origins. By mimicking these processes in the laboratory, it is possible to use natural products without exploiting the environment.

The LOEWE Centre for Translational Biodiversity Genomics is a joint venture initiated by four institutes: the Senckenberg Nature Research Society, the Goethe University Frankfurt, the Justus-Liebig University Gießen and the Fraunhofer Institute for Molecular Biology and Applied Ecology IME. It is financed by the federal state of Hessen as part of its campaign to promote scientific and economic excellence (LOEWE).

15 Bioeconomy Adventure

What approaches are researchers taking to replace our dependence on fossil resources with a bio-based economy?

Many people are willing to change their behaviour and thinking for the sake of environmental protection and sustainability. But for this to happen in practice, we need new products, ideas and processes. Only if scientists develop these it will be possible to shift to bio-based ways of life and production methods. The game “Bioeconomy Adventure” uses various applications to illustrate how important science is for this shift. It highlights the research that the Fraunhofer Institutes are doing to further the transition from an oil-based to a bio-based market economy.

The Fraunhofer Academy is the provider of continuing education of the Fraunhofer-Gesellschaft, the leading application-oriented research organization in Europe. The game is based on the expertise and the research currently being conducted by UMSICHT, EMB, IBP and IKTS, Fraunhofer Institutes with a focus on environment, energy, sustainability, process engineering and marine biotechnology.

16 Clean Laundry thanks to Fungi

How can we use surfactants from renewable raw materials to wash and clean in an environmentally compatible way?

Most soaps, or surfactants, used in washing agents are made from oil. But these will soon be replaced with bio-based surfactants made from renewable raw materials. This will reduce CO_2 emissions. Many bio-based surfactants are produced chemically today, but an alternative option is to use fungi. The advantage is that bio-based surfactants are more easily biodegradable than their synthetic competitors. Biosurfactants can be made using the corn smut fungus *Ustilago maydis*. Researchers are trying to optimise the production process to increase yields and reduce the high costs. Currently, biosurfactants made by fungi cannot fulfil the market demand, since Europe still lacks the facilities required to produce them.

The Fraunhofer Institute for Interfacial Engineering and Biotechnology develops technologies for health, sustainable chemistry and the environment. It has been working in the field of bioeconomy for many years now. In the research field Industrial Biotechnology scientists are investigating how chemical resources can be produced using biotechnological methods. The goal is to put organic waste and renewable resources to good use.

17 Electricity from Bacteria

How can we use microbes to generate energy?

Bacteria are among the many micro-organisms that live in the soil. Some of them can emit electrons. We can use this property to generate electricity. At the carbon anode, the minus pole, bacterial activity produces a surfeit of electrons. The cathode, the plus pole, attracts these electrons. The flow of electrons causes the lamp to light up. We call this kind of system “bioelectrochemical”. It is, for example, possible to use bacteria to generate energy out of waste water. Researchers are trying to find out which bacteria are involved in transmitting electrons, so that they can be used in the laboratory as catalysts for chemical reactions. Biocatalysers of this kind are cheaper than conventional ones and can be used for many different purposes.

The Leibniz Institute for Natural Product Research and Infection Biology – Hans Knöll Institute – is studying the enormous potential of microbes such as bacteria and fungi, to produce natural compounds. This may pave the way for developing new

drugs and also has an important role to play in biotechnology. The MudWatt earth battery is produced by the US company Magical Microbes.

Alternative plastic from microorganisms

Many bacteria produce biopolymers as storage materials, for example polyhydroxybutyric acid (PHB). PHB is non-toxic and biodegradable; it is processed into films or surgical suture material, among others. In the future, it might partially replace petroleum-based plastics.

18 Scents instead of Pesticides

How can we use insect attractants to protect fields and forests against pests without harming the environment?

Many living creatures communicate using chemical messengers or scents. Researchers can analyse these substances, recreate them and use them for a range of applications. An excellent example of this is pest control. Harmful insects can be trapped using scents (such as attractants and sex pheromones) without causing harm to other creatures. Such traps can be used against bark beetles, for example, which cause widespread damage to forests. This approach would drastically reduce the need for environmentally harmful pesticides or make them entirely unnecessary. People can also understand nature's chemical language. We can even differentiate between the spatial structures of otherwise identical molecules, "smell" differences in the concentration of chemical messengers and comprehend the complexity of mixed scents.

Interdisciplinary research into chemical communication in nature is the focus of the collaborative research centre ChemBioSys of the German Research Foundation (DFG). This research into the chemical messengers of complex biological systems provides the basis for innovative and promising approaches in ecology, agriculture, biotechnology and medicine.

19 Multi-talented Popcorn

What are the benefits of developing new lightweight material from popped maize?

The idea popped into his head while he was eating it: the scientist Alireza Kharazipour wondered whether popcorn could have other uses, as a lightweight material for example. Even the initial experiments proved promising. Milled industrial corn can be made into popcorn granulate. This is then mixed with a natural binding agent to form a composite material that can be processed into stable yet lightweight panels. These can be used for making furniture, for example, or to replace polystyrene products known as Styrofoam. These include insulation boards and packaging. Popcorn panels dampen sound; they have a low flammability, a very minimal thermal conductivity and are extremely light – which saves on transport costs.

In a cooperation project between the Working Group on the Chemistry and Process Engineering of Composite Materials at the Buesgen Institute at the Georg August University of Göttingen headed by Prof. Dr. A. Kharazipour, the doctoral student C. Pertsch and the University of the Arts Bremen headed by Prof. A. Kramer, students from the Integrated Design course developed new products out of popcorn.

20 A Place for Ideas to Grow

What do you think about the new world of bioeconomy?

You are standing in front of the Tree of Ideas. It is surrounded by all kinds of new, sustainable products, most of which have been made without using oil or any other fossil resources. On the tree itself you will see a number of raw materials used in the bioeconomy. What they all have in common is that they are renewable, they have a very broad range of uses and, in many cases, require few resources to exploit. We can use them to feed and clothe ourselves, to move from A to B, to take care of our bodies, to make everyday objects and to build houses. Bioeconomy is a key concept in designing a sustainable future. Many of its ideas are still in the early stages of research, but some have already been realised and are commercially available. Take time to discover the many facets of bioeconomy and share your ideas and wishes with us.

GRASS

Grasses, especially grass fibres, can be used as a raw material for making paper. They require less water and nutrients than wood. Silos have an important role to play in processing grass, because this is where the grass ferments. Researchers are working on using silage to develop biodegradable plastic. Grass silage can also be used to generate gas – in biogas facilities.

Adhesive tape
Packaging generates a lot of waste. But a completely recyclable adhesive tape has now been developed. It is manufactured using extremely stiff paper made out of grass and natural rubber adhesive. The cardboard and adhesive tape no longer need to be separated before the packaging is disposed of in the paper bin.

Paper
Paper is usually made out of wood. But it takes 6,000 to 8,000 litres of water to produce one ton of conventional paper. Making paper out of grass uses far less water and only a tenth the amount of energy.

Plastic
Until now the plastic for ballpoint pens and crates was produced using oil. Now, however, we can use meadow grass instead. Although 25 per cent of the new product is still made from plastics, these can be recycled and are biodegradable.

WOOD
Wood is one of the most important renewable resources and it offers a whole range of applications for the bioeconomy. Examples include paper composite systems and high-tech products such as nano-cellulose or wood-based materials for 3D printing. Nevertheless, we still need to find a strategy that protects the forests while meeting the higher demand for wood.

T-shirt
Four T-shirts can be made from one kilo of wood. To do this, wood shavings are mixed with a non-toxic solvent in order to dissolve the cellulose. This produces a honey-like mass that is spun to produce fibres. These, in turn, are used as yarn to make clothing as an alternative to oil-based polyester.

Coffee capsules
However good it tastes and however easy it is to make, the fact is that coffee brewed using aluminium capsules produces large amounts of non-biodegradable waste. It does not have to be this way, though. Bio coffee capsules made from lignin, a waste product from wood processing, already exist. These capsules are completely biodegradable.
Plastic toy bricks
Plastic toy bricks are not environmentally friendly. A Japanese manufacturer has come up with a robust and hygienic alternative that fits onto conventional interlocking toy bricks. They are made from the waste products from processing Japanese cherry, magnolia, maple, hornbeam, birch and elm wood.

CORK
Cork is robust, flexible and highly versatile. It is made from the bark of cork oaks. After twenty years the cork oaks are large enough for their bark to be peeled. The bark from the first harvest is very hard and particularly suitable as an insulation material. The soft material used to make bottle corks comes from subsequent harvests.

Trainers
Sports shoes need to fulfil many demands, including lightness. Until now this was achieved using an oil-based material, but cork makes a good alternative. It is obtained from the renewable bark of cork oaks and is just as lightweight and breathable.

BAMBOO
How can bamboo be made into a building material? First, the stems are split into pieces (slats) and the green bamboo skin is planed off. Then the bamboo is boiled, dried and compressed using high-pressure technology. It can then be used for many products including parquet flooring.

Toothbrush
Plastic toothbrushes have been a standard household item for eighty years now. But they can’t be recycled. A renewable, biodegradable alternative to plastic is bamboo. The bristles of a bamboo toothbrush are made out of nylon, an artificial fibre, so they need to be removed before the brush can be thrown on the compost heap.

Sunglasses
Bamboo sunglasses make a robust alternative to plastic. To date, however, only a few certification processes for responsible cultivation of bamboo exist, so the development of sustainable bamboo products is still in its infancy.

Cotton buds
As of 2021, cotton buds made from disposable plastic will be banned in the EU. Bamboo is an alternative material for disposable products. Currently there are a number of untreated bamboo products on the market as well as those made from bamboo plastic, but its sustainability is disputed.

ALGAE
Algae are grown in so-called photobioreactors where they receive the optimal amount of sunlight, carbon dioxide and water. Unlike energy plants such as rape or maize, algae do not require arable land or fertiliser. Yet they are still able to yield a large volume of biomass in a short time. Algae are promising candidates for biofuel and biodegradable plastics.

Barefoot shoes
Shoes can be made without using oil. One suitable material is a foam, between 15 and 60 per cent of which is made from algae. The shoes are lightweight, breathable and flexible. Although the foam is not biodegradable, it is more environmentally friendly than oil.

FUNGI
Fungi have long been used to make antibiotics and cheese, but we can also use them to produce renewable resources. Because fungi have such varied metabolisms they can be used to make a very diverse range of products.

Bicycle helmet
The tinder fungus can be grown in moulds to take on any shape or form. The Institute for Biotechnology of the Technical University Berlin has made use of this property, growing tinder fungi in the shape of bicycle helmets, for example. However, in the current state of research, the fungus helmet would continue to grow and would also decay in the rain, so the project continues.

“Leather” bag
Everyone knows what vegan food is. But what is vegan leather? Tinder fungus is one material that can be used to make vegan leather and fashioned into bags. As its name suggests, the fungus grows on trees.

Washing agents
In order to avoid using chemical tensides in cleaning agents, the company Ecover uses plant-based ingredients instead, for example, sugar-based tensides. Product development is continuing with the goal of making all cleaning agents out of sustainable plant-based tensides.

HEMP
Hemp fibres are so tear-resistant that they have been used for centuries to make textiles. The strong hemp leaves suppress weed growth, so no herbicides are required to grow it. New applications are being sought for this versatile plant. However, because certain types of hemp can also be used to make drugs, its cultivation is strictly regulated.

Tray
Trays have to be very robust to withstand regular cleaning of tea, coffee and food stains, so they are usually made of plastic. The biogenic workshop at the Technical University Bingen has developed trays made from hemp bast that are stable and can be wiped easily. They have already been successfully tested in a canteen.

Plant pot
Most plants are initially grown in greenhouses using millions of plastic pots. This plant pot is made from 98 per cent hemp fibres, the rest from minerals. It will decompose without residues and can be planted in the earth together with the plant or else reused.

COFFEE GROUNDS

Every day we throw huge amounts of coffee grounds in the rubbish. But coffee grounds are actually an important raw material. They can be converted into chemical intermediate products, which can then be further refined in a variety of ways. As a result, coffee grounds can be used as a bio-based substitute for oil-based plastics or other resources in short supply.

Coffee cups
What a crazy idea – making coffee cups out of coffee grounds! But it really is possible: the coffee grounds from ground coffee beans are dried and mixed with natural fibres and natural binding agents into a composite material. In this way, waste is used to make a cup that is as robust as wood.

T-shirt
T-shirts made from cold coffee – how cool is that? Dried coffee grounds are ground down to a powder and then mixed with recycled polyester fibres to produce sustainable textiles used to make sports and leisure-wear.

21 Indoor Farming

How can growing plants in closed systems help supply us with healthy and sustainable food?

Food can be grown not just in fields but also in buildings. Indoor farming entails growing plants in closed systems. One advantage of this promising technology is that farming is no longer climate-dependent, so it can be done anywhere in the world on a domestic or industrial scale. Tropical plants can be grown in Germany, for instance, reducing transport distances and protecting arable land. Optimal conditions and technology mean high-quality plants can be grown using less water and without pesticides, ideally yielding several harvests a year. The downside is that indoor farming is still very energy-intensive, but researchers are developing new concepts to save energy and optimise yields.

Some fifty scientific, economic and societal institutions are working together in the research consortium NewFoodSystems to develop new, commercially viable methods for sustainable food production. As well as indoor farming, NewFoodSystems is also working on extracting sustainable proteins from plants, algae and insects for use in food and animal feed.

Sustainable protein ingredients

The NewFoodSystems project “Sustainable Protein Ingredients” is investigating how protein from plants, algae and insects might offer a sustainable alternative to animal protein. Characteristics like taste and how the food feels in the mouth are modelled on conventional foods.

22 Food of the Future

Are insects and in vitro meat sustainable alternatives to conventional meat?

Meat production and consumption are contributing to climate change and biodiversity loss. Some meat alternatives might be food made from insects or in vitro meat, produced from cell cultures. Their production releases less carbon dioxide and requires less water and arable land. Major food companies have already recognised the economic potential of insects and in vitro meat. Whether these meat alternatives sell successfully depends on public acceptance. Many people feel fear or disgust towards novel foods of this kind. Reasons are they don’t know precisely how they are produced and whether they are sustainable.

The Department of Biology Didactics at the University of Osnabrück is researching the psychological factors that persuade people to eat a more sustainable diet. A particular focus here is the German public’s acceptance of novel foods made from insects and in vitro meat.

23 Agricultural Systems of the Future

How can we produce food in a sustainable and resource-friendly way?

Amid the effects of climate change, a shortage of arable land and the need to protect the key environmental resources of air, water, soil and biodiversity, the agricultural industry faces the major challenge of producing sufficient food for a

growing global population. In a bid to reconcile these conflicting demands, scientists in the research programme “Future Agricultural Systems” are working on new solutions. Find out about these projects and the food production of the future.

The “Future Agricultural Systems” research programme of the Federal Ministry of Education and Research funds eight international and transdisciplinary research consortia across Germany in the field of sustainable and resource-friendly agriculture. They are networked by a coordination centre, which also maintains a dialogue with the public.

24 Plant Research

How can we measure the ability of crop plants to adapt to different environmental conditions?

Population growth, limited arable land and climate change are challenges for the global food supply. Plants with higher yields and more robust plants may help find a solution. This is why scientists are researching how crop plants react to environmental changes. To that end, they measure traits such as overall size, leaf surface, weight and reactions to pathogens. This approach is called “phenotyping”. It uses imaging techniques that enable researchers to precisely document plant characteristics without damaging the plants. It enables to automatically determine the expression of particular plant characteristics throughout their growth cycle. These large-scale experiments will help scientists to develop plants for the future.

The Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) focuses on revealing the underlying principles of evolution, development and adaptation in leading crop plants. The IPK is a member of the ScienceCampus Halle – Plant-based Bioeconomy (WCH), which promotes research, teaching and knowledge and technology transfer in the field of plant-based bioeconomy.

25 Aquaculture Ecosystem

How can we farm fish in a way that is sustainable and environmentally compatible?

The seas are overfished, yet the demand for fish and seafood continues to grow. Fish farming facilities on land offer a solution. But how can we make them sustainable? Recirculating systems, what we might call natural recycling, can help. The waste products from the fish are filtered by shellfish and recycled. Algae then use the soluble nutrients to grow. This produces additional biomass and also purifies the water. All the animals and plants involved can be used as resources for products. This ensures not only a high level of environmental compatibility but also makes the farming facility more efficient.

The Fraunhofer Research Institution for Marine Biotechnology and Cell Technology (EMB) conducts research in the fields of bioeconomy, food technology, pharmaceuticals and diagnostics sectors, working closely with the industry. In the field of marine biotechnology it develops aquaculture facilties. This involves technical testing of new recirculating systems and the co-cultivation of different species. The EMB is also studying how these marine resources can be utilised as foodstuffs.

26 Clean Water thanks to Algae

How can we purify our wastewater in an environmentally friendly way and gain valuable biomass at the same time?

Phosphate is an important nutrient for plants, but it can cause ecological damage to bodies of water. The phosphate in cleaning agents and fertiliser is removed from the wastewater in sewage treatment plants. The phosphate that remains in the sewage sludge is in a form that cannot be used by plants. The algae flipper shows how wastewater can be purified ecologically using algae, while keeping the phosphate in a form that plants can absorb. Sunlight and carbon dioxide cause the algae to grow into an algal turf, absorbing nutrients such as phosphate from the wastewater in the process. The result is clean water on the one hand, but also a biomass by-product that can be used as a fertiliser or in biogas facilities. This simple and cost-efficient system can be used in a wide range of locations.

The IBG-2 Plant Sciences at Forschungszentrum Jülich develops integrated concepts for the sustainable production and use of plants. The institute coordinates the research network Bioeconomy Science Center (BioSC), where several disciplines from plant sciences to biotechnology and economics work together. The BioSC is supported by the Ministry for Culture and Science of the state of North Rhine-Westphalia.

27 Your Piece of the World's Field

How much arable land do we need to cover our daily needs?

More than 7.5 billion people currently live on our planet, and the number is increasing every day. Being able to feed the world's growing population depends among other things on how much land is available. If we divide the world's total arable land of 1.5 billion hectares by the global population, we get an area of 2,000 square metres per person. Divided by the number of days in the year, that makes 5.5 square metres per person per day. If we then subtract food that is thrown away and arable land that is not used to cultivate food crops, we are left with 4.2 square metres to cover the needs of each of us for one day. Everything we eat has to grow in that area – including the feed for the animals whose meat, milk and eggs we consume. In the EU we currently use an average of 2,700 square metres per person and day.

The 2,000 m² World's Field is a project initiated by the Agriculture of the Future Foundation, which is committed to supporting sustainable agriculture. The World's Field is located in the Botanischer Volkspark in the Berlin district of Blankenfelde. It allows us to see in practice how much land is available to each person per year and what can be grown on it. The project offers tours followed by a "meal from the field".

28 Green Genetic Engineering in Focus

How can we have an objective discussion about genetic engineering in plant breeding?

Genetically engineering plants is a controversial issue. Particularly in Europe there is a lot of resistance to use genetic engineering in food production. Many people fear that genetically modified organisms (GMOs) will have unforeseen effects on humans and nature. Many scientists dispute this fear. They consider genetically engineered foods largely safe. Their goal is to make crop plants pest-resistant and fit for climate change. But public scepticism makes it difficult for policy-makers to take decisions about GMOs. Researchers do their best to understand the differing perceptions and they support an objective discussion about the use of "green genetic engineering".

The Leibniz ScienceCampus Halle – Plant-based Bioeconomy (WCH) promotes research and teaching. It also promotes knowledge and technology transfer to industry, politics and the public. The exhibit is based on the findings of the WCH research project AgriMyths, which examines the arguments surrounding genetic engineering from an ethical and economic point of view.

29 Between Industry and Environmental Protection

How do policymakers take decisions involving conflicts over resources?

A sustainable lifestyle and economy protect the environment and secure good economic opportunities at the same time. In its national bioeconomic strategy the German government outlines a number of goals, among them guaranteeing supplies and protecting the climate. Yet some of the goals present obstacles to others. One such example is biofuels and food, which have to compete for arable land. Ultimately it is the policymakers who decide whether petrol tanks or plates get filled. We present three examples of conflicting goals. The researchers weigh up the factors at play in making such decisions and show how reasonable solutions can be found.

The exhibit came out of the research project "Political processes of bioeconomy between economy and ecology – BIO-ECOPOLI", which has funding from the Federal Ministry of Education and Research until the end of 2020. The project is a joint venture between the FernUniversität in Hagen and the Otto-von-Guericke University Magdeburg.

30 The World in Equilibrium

Can bioeconomy help to guarantee good living conditions for humanity and protect nature and the environment at the same time?

The United Nations works to ensure a decent existence for the global population and at the same time to preserve natural resources in the long term. To this end seventeen Sustainable Development Goals have been agreed. These include eliminating hunger and poverty, improving health and reducing the burden on the natural world. But since natural resources are limited, the achievement of one goal can impede another. A bio-based economy can contribute to reconciling the objectives so they can all be achieved. At the Helmholtz-Centre for Environmental Research scientists are

working to find a balance between the growing demand for natural resources and a sustainable supply of material and energy. This ranges from improvement of bio-based technologies for biogas plants to supporting global strategies.

The Helmholtz-Zentrum für Umweltforschung GmbH UFZ is one of the world's leading research centres in the field of environmental research. It demonstrates ways in which a sustainable use of our natural resource base is possible for the benefit of both humankind and the environment. To this end it also records and analyses the potential and impact of bioeconomy on the natural world, industry and society.