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Synopsis

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TOWARDS A GREEN BASED INDUSTRY

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THE SCIENCE OF PLANTS: TOWARDS A GREEN INDUSTRY

One of the greatest challenges facing the industry and the economy is how to be sustainable. **Due to climate change, it is now a pressing need that we move towards what has been dubbed the "post-oil" society**: a society that prioritizes renewable energy and minimizes the use of contaminating plastics. A society that, moreover, has the challenge of feeding a growing population with little-to-no margin for expanding croplands.

Plants are the heart of all of these challenges. Science and new technology seeks to optimize the way energy and materials are obtained from them. Even improving crops to make them more efficient and higher yield. At the heart of each of these mechanisms lies what is called **proteostasis**, or the balance of proteins. As everything builds on top of this, understanding the basics of how it works will give us access to more and better tools.

To discuss and share the main news in all of these fields, national and international experts met on 27 and 28 September 2016 for the debate 'Plant Proteostasis. Towards a Green Based Industry' organized by B·Debate ─an initiative of Biocat and the "la Caixa" Foundation to promote scientific debate─ along with the Center for Research in Agricultural Genomics (CRAG) and COST Proteostasis.

CONCLUSIONS

- Plants are the heart of many global challenges, including the need to feed a growing population and obtain renewable energy to fight climate change.
- Some of the applications scientists are working on include improving biomaterials, developing more resistant, higher-yield crops, and modifying plants and processes to extract more power.
- Basic research is essential to these improvements. In this area, two terms seem to be key: proteostasis and autophagy (focus of the latest Nobel Laureate in medicine).
- One constant concern among scientists is how to make transfer from the laboratory to the "real world" faster and more effective.

TOWARDS A BIOECONOMY: ENERGY, MATERIALS, CLIMATE CHANGE, FOOD

"Plants are at the heart of the global challenges we are facing. There is no doubt about that." This conclusive statement was made by José Pío Beltrán, president of the European Plant Science Organization (EPSO). Some of these challenges were discussed by Luisa M. Trindade, associate professor at Wageningen University, in the Netherlands. These include transcendental aspects such as feeding a global population that is growing incessantly and obtaining the power we need sustainably, while mitigating climate change and the current loss of biodiversity.

According to Beltrán, "**With today's technology we can't solve the challenges we are facing**." At the same time, one thing seems clear: "**The only way to do so is by investing in research**." Some of what is being done today was presented during the debate, and the applications can be divided into several areas: biofuel, materials, climate change and food.

Biofuel

Bioethanol made from plants is a promising alternative energy source to gasoline, and is undoubtedly much more eco-friendly. To make it, you must follow a series of steps that change cellulose –found in plant cell walls– into sugars that can be fermented. But there are problems yet to be solved: right now one of the main sources is corn, which is not only not as efficient as it should be but also raises ethical questions, as crops that could be used for food are diverted to energy production. So, scientists are **working on alternative sources and altering the make-up of plants to make them higher yield**.

One of these alternatives are trees like **poplars**, as they are found naturally in abundance and their use doesn't cause any ethical dilemmas. The problem is that they have large amounts of lignin in their cellulose. Lignin is a polymer that makes them hard and rigid, but interferes with the process leading up to fermentation. Hannele Tuominen, associate professor at the Umeå Plant Science Centre in Sweden, is working with them through genetic engineering. "Our aim is to modify the chemistry of wood to make it easier to process lignin-cellulose," she said. This research has identified several genes involved in their composition and, so far, they've reached a point where they get "a lot more sugar, but also much slower tree growth."

This difficult balance is also the focus of work being done by the group led by Luisa M. Trindade, in this case trying to redesign and improve corn crops. By researching different genetic variants focusing on lignin and cellulose, they've created options that break down more easily and are more efficient, but also warned, "**We must take into account that these variants can have an**

effect on crop yield."

Materials

There are many reasons to bank on biomaterials. The main one has to do with the environmental damage caused by using plastics, which has recently led to laws in France and New York prohibiting their use in various products. In fact, **some plant fibers are already being used in bicycles and rackets, and there are also prototypes for cars and motorcycles based on these materials**. "The carbon footprint (the amount of greenhouse gases emitted during manufacturing) for natural fibers is much smaller than other materials," explained Aart Willem van Vuure, professor at the University of Leuven, in Belgium. In fact, "Mechanically they have better properties than fiberglass," and aren't far behind carbon fiber. The problem lies in the fact that they don't last as long and in the variability of the raw material, aspects scientists are working on. In this regard, Simon Hawkins, professor at Lille University, refers to one of the problems researchers run into: "**We need the industry to come work on plant-fiber biology**."

The possibilities for using plant fibers vary widely. They can even be applied in areas like construction. This has been demonstrated by Ana María Lacasta, professor at the Polytechnic University of Catalonia, with examples like **transparent wood**, fiber used as thermal insulation and projects that aim to replace steel-based construction with bamboo. Based on its properties and possibilities, Lacasta does not hesitate to say that, on many occasions, "Nature does our job for us."

Climate change

One of the main causes of global warming is industrial emissions of greenhouse gases, including carbon dioxide. This is the gas that plants use in photosynthesis, helping mitigate its effects while obtaining the energy they need. In this regard, Production Director at AlgaEnergy Federico Witt presented some of the projects the company is working on, which are based on massive microalgae farms. "**One hectare of microalgae," he explained, "absorbs the same amount of carbon dioxide as 22 hectares of trees (approximately 33,000 units), and they can do so right at the source**."

AlgaEnergy has several pilot plants where they are testing different types of algae and growth techniques, with the plus that the resulting product is higher value: algae can be used for agriculture, animal food and cosmetics. They can even be used to make biodiesel, although Witt recognizes, "At least for now, obtaining energy from microalgae isn't a good business opportunity."

Food

Rice is the most commonly consumed food in the world, **but an estimated 75% of all crops are lost**, mainly due to drought or high salt content. In order to tackle the challenge of feeding an incessantly growing population, researchers are looking to design varieties that are much more resistant.

One of these studies is led by Ari Sadanandom, professor at Durham University, in the United Kingdom. His group is working on untangling the mechanisms of a transgenic variety that over-expresses the OTS1 gene, making it overly tolerant to salt. Understanding these mechanisms would allow them to improve on them, reproducing their effects through added compounds and expanding them into other varieties.

What they've seen so far is that the resistance seems to be based on proteins called DELLAs, and specifically on the mechanisms that lead them to be eliminated or preserved. It is the **crossroads between applied and basic research**, with concepts like balance of proteins, autophagy and proteasomes. The other, extremely necessary, starts from debate.

AT THE CORE OF GREEN INDUSTRY: PROTEINS, AUTOPHAGY AND CONTROL

DNA contains the instructions, but in the end the building blocks of life are the proteins dictated by the genome. Uncovering the secrets of how they are regulated and work is key to creating applications for a greener industry.

Noteworthy among these secrets is the concept of proteostasis, or the way in which a cell strikes the perfect balance between production, function and elimination of its proteins. And two words related to this and to each other: **ubiquitination and autophagy**. The first is a protein-marking system that signals them to be eliminated by cell compounds called proteasomes. The second is a **broad term that literally implies "eating one's self" and refers to the process through which cells destroy their own components** (one of the people that discovered this, Japanese scientist Yoshinori Ohsumi, has just won the 2016 Nobel Prize in medicine). But as explained by Diane Bassham, Professor at the University of Iowa, “Autophagy isn't death, it’s recycling and defense." Some of its functions are to eliminate toxins and even obtain energy in times of scarcity and stress.

Part of the B·Debate was used to present new data on the complex mechanisms involved in each of these terms. And also to share approaches that are a first leap from basic to more applied research. One of these was presented by Peter Bozhkov, professor at the University of Uppsala, in Sweden,

whose group is working on "**manipulating autophagy to improve plant yield**." Bozhkov showed that by increasing the expression of two genes associated with the process, they can boost the growth and production of Arabidopsis seeds, one of the plants most commonly used in research. The problem is that it seems to be at the expense of decreasing its resistance to bacterial infections.

Additionally, the group led by Nico Dissmeyer, researcher at Leibniz Institute of Plant Biochemistry, in Germany, has developed a technology that allows scientists to introduce a sort of switch into plants. This biological mechanism is temperature controlled and indicates whether or not the cell should eliminate certain proteins. This is not only highly valuable for research, but Dissmeyer also says, "It will allow us to generate **phenotypes on demand**" and could even be used in the future, for example, to design specific in vivo bioreactors, cells that produce the desired molecules that wouldn't do so naturally.

THE GREAT DEBATE: HOW TO BRING RESEARCH TO LIFE

On the final day of this B·Debate, there was a free wrap-up session open to the public, discussing the importance of transferring this research to everyday life and how to do so.

"We have the tools, we already have very good biological products: why aren't we already manufacturing them on a large scale?" asked Hannele Tuominen at this debate.

For van Vuure —at least in the field of biomaterials — it is a question of markets, because they are "highly conservative. It takes years for people to become familiar with the new product and generate demand for it."

– "But isn't that in part due to price?" responded Tuominen.

- "I don't think so. I think it's more a question of education. In fact, agriculture prices are more stable than oil prices, which is what most current technology is based on."

According to Núria Sánchez Coll, CRAG researcher and one of the scientific leaders of this B·Debate along with L. Maria Lois , "**There is a problem. In the laboratory, it seems like the applications we are working on are very far off**." Tuominen doesn't think that is so important. The "line between basic and applied research is artificial: you never know what can be applied." However, participants in general referred to the gap between researchers and industry. In this regard, Federico Witt recognized that the industry "resolves specific problems, but basic researchers won't change the line of research to offer it to a company."

Tuominen brought up another problem: isolationism. "It seems like research is more concerned about biomedical issues: **as scientists we have to take responsibility for calling attention to what we do, even in the media**."