Press release
March 25, 2025

In the Basic Sciences category

The Frontiers of Knowledge Award goes to Avelino Corma, John Hartwig and Helmut Schwarz for their founding work on the catalysts that are enabling a more efficient, sustainable chemistry

- **The combined work of the three scientists has achieved fundamental advances** in the catalysis field that have made it possible to "control and accelerate chemical reactions" and obtain products in multiple industrial sectors, "improving efficiency and reducing energy consumption," in the words of the award committee

- **Corma spearheaded the development of solid catalysts from porous materials** and holds more than 100 patents with applications now being used to improve the efficiency of chemical processes and cut back on pollutant emissions in the production of fuels, plastics, cosmetics and food

- **The metal-based catalysts created by Hartwig, active in the liquid phase, have proved key** in the manufacture of drugs against a wide range of conditions, from leukemia to HIV and depression, and new applications are now being sought for plastic waste recycling

- **Schwarz has analyzed gas-phase chemical reactions atom by atom**, elucidating their function down to an unprecedented level of detail, a fundamental advance that has reduced waste production in industrial processes and opened the door to new catalysis applications in multiple domains

The BBVA Foundation Frontiers of Knowledge Award in Basic Sciences has gone in this seventeenth edition to Avelino Corma (Institute of Chemical Technology, Universitat Politècnica de València-CSIC, Spain), John F. Hartwig (University of California, Berkeley, United States) and Helmut Schwarz (Technical University of Berlin, Germany) for fundamental advances in the catalysis field, in the words of the committee, that have made it possible to

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"control and accelerate chemical reactions" and obtain products across multiple industrial processes, thereby "improving efficiency and reducing energy consumption."

Working independently, the new laureates "have led global thinking in the three main research areas devoted to understanding and applying catalysis, covering the entire spectrum of this fundamental field," said committee member Hongkun Park, Mark Hyman Jr Professor of Chemistry and Professor of Physics at Harvard University (United States). Their combined output has paved the way for a more efficient, sustainable chemistry.

Corma spearheaded the development of solid catalysts from porous materials and holds more than 100 patents with applications that are now being used to improve the efficiency of chemical processes and cut back on pollutant emissions in the production of fuels, plastics, cosmetics and food.

The metal-based catalysts developed by Hartwig, active in the liquid phase, have been game changers in the manufacture of drug treatments for numerous conditions ranging from leukemia to HIV or depression. And new applications are now being sought for plastic waste recycling.

Schwarz has succeeded in analyzing gas-phase chemical reactions atom by atom, elucidating their function with an unprecedented level of detail, a fundamental advance that has already served to cut back on waste production in industrial processes while opening the door to new catalysis applications in multiple domains.

"Avelino Corma is a researcher who starts from fundamental, basic science, then works outwards to apply his results to social challenges like sustainability. The fact that the committee considers him deserving of an internationally prestigious award like the Frontiers of Knowledge is a testament to his scientific stature. And in truth he fits perfectly with the name of the scheme, because his foremost concern is to move the frontiers of knowledge," said José Capilla, the Rector of the Universitat Politècnica de València (UPV), who nominated the Valencian researcher.

"They say that science is full of researchers who do good things, but very few who actually do new things. John Hartwig not only does new things but he does so time and time again. He is one of those people who carve out paths the rest can only follow," said his nominator Pedro Pérez

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Rodríguez, Professor of Inorganic Chemistry at the University of Huelva and Head of the Center for Research in Sustainable Chemistry (CIQSO). "I believe the committee made the right decision in distinguishing him alongside professors Corma and Schwarz. Bringing the three together extends this recognition to the whole field of chemistry, and catalysis in particular."

"This award is extremely well judged given the importance of catalysis research, which accounts for 90 percent of all chemical industry production processes and 30 percent of the world's GDP. Helmut Schwarz has done real basic science, but has also proved it experimentally. It is to him we owe the insight of incorporating elements of quantum mechanics into basic knowledge of catalytic reactions," said Jesús Ugalde, Professor of Physical Chemistry at the University of the Basque Country and a collaborator of Professor Schwarz's.

Porous materials for the production of greener fuels

Avelino Corma has pioneered the field of heterogeneous catalysis, so called because the catalyst is in a different phase of matter from the agents of the chemical reaction the researcher is seeking to accelerate. In his work, concretely, as he explains it, "the catalyst is a solid and the reactants could be gases or liquids." In the last 35 years, since co-founding the Institute of Chemical Technology (ITQ) at the Universitat Politècnica de València back in 1990, Corma has led the conception and synthesis of microporous materials that act as solid catalysts, where the reactions unfold inside molecule-sized cavities. "We found that by controlling the size of these cavities and channels, we could select not only what molecules penetrated and therefore reacted, but those whose access and reaction we wanted to avoid," he explains.

His breakthroughs in this field were described in two papers published in *Nature* in 1998 and 2006, and a later one published in *Science* in 2017, where he demonstrated the potential of these microporous materials to efficiently accelerate and control chemical reactions, opening the door to a more sustainable, less polluting chemistry. "In these studies, we showed that by controlling the cavities in these solid catalysts, we could control the reactions that ensued. So we could, for instance, reduce their acidity and thus achieve a lower environmental impact."

Corma's influence, as the committee remarked, stretches even further than these basic research findings, which have had a major international impact in the catalysis field. He is also the inventor of over 100 patents with industrial applications that are now being rolled out to improve efficiency and sustainability in the production of fuels, plastics, cosmetics and food.

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For example, "more than 22 plants around the world now produce gasoline more efficiently, with greater energy efficiency, thanks to a catalyst developed in my research." In addition, many industrial chemical processes are starting to replace fossil fuels with biomass – obtained, for example, from municipal, agricultural or forestry organic waste – through reactions achieved with solid catalysts derived from advances led by Corma. "We are making great strides towards a more sustainable chemistry thanks to this technology, with catalysts that allow us to reduce the use of fossil hydrocarbons and also prevent the release of pollutants through vehicle combustion and factory chimneys."

For the laureate, moreover, this is just the start of a technological revolution that in coming years could be a powerful transformative tool in the fight against climate change: "I believe catalysts will enable us to capture CO_2 from the atmosphere or biomass on the way to developing fuels and chemical processes with far less environmental impact."

Catalysts to produce medicines against cancer, HIV and hepatitis

The metal-based catalysts developed by John Hartwig have changed the way drugs are manufactured for conditions ranging from leukemia to HIV or depression. He has excelled in the development of homogeneous catalysis, in which both the catalyst and the molecules undergoing the chemical reaction are in the liquid phase, dissolved in a solution. This enables reactions to occur at relatively low temperatures and at very precise sites within the molecule. "There's a whole series of medicines approved by the Food and Drug Administration (FDA) for diseases like hepatitis C, HIV, depression, psoriasis and leukemia, that rely on the availability of molecules created from reactions developed in my lab," the new laureate explains.

Hartwig has spent much of his career working on organometallic catalysts, formed by molecules containing both an organic carbon fragment and a transition metal such as platinum. It is precisely the metal-carbon bond that supports chemical reactions by providing a platform on which they can occur.

The awardee has also modified certain enzymes – which, within biological organisms, act as catalysts – by exchanging the naturally occurring metal for another, in order to change their reactivity. Recently, Hartwig was able to insert these "bionic enzymes" into a microorganism and have it make the reagents, the chemicals that react with that enzyme. The chemical reaction, in other words, takes place inside the cells, creating artificial products through a biosynthetic pathway.

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Among the reactions Hartwig has focused on most are those occurring at the site of carbon-hydrogen bond cleavage. "These are very strong bonds that are mostly unreactive," explains the Berkeley chemist, who has developed catalysts that can help break the bond so it accommodates the desired chemical reaction. These catalysts have already been put to work in the production of a key compound for anti-cancer pharmaceuticals and another two against HIV. "It's really exciting to watch things progress from the very, very fundamental discovery of cleaving a carbon-hydrogen bond to being able to develop large-scale reactions, with thousands of pounds of molecules."

Another of the awardee's lauded contributions concerns the formation of the carbon-nitrogen bond; "a reaction – he explains – that doesn't occur in the absence of a catalyst." The catalyst he and his team developed to create this bond has led to drugs for depression, HIV and hepatitis C.

Hartwig has since turned his attention to the polymers making up the plastics we use daily, trying to deconstruct their bonds and isolate their components so that they can serve to make new plastic. "Right now plastic is recycled mechanically," he points out, "but this new method would be chemical recycling, perhaps a future solution to manage the huge amount of plastic waste we generate."

"The smallest test tube in the world" to observe chemical reactions atom by atom

"My contribution is in many ways unusual," remarks Helmut Schwarz, "because I have been concerned mainly with basic research but have employed quite unorthodox techniques." The combination of advanced experiment with advanced computational tools has allowed him to elucidate the functioning of chemical reactions atom by atom, with an unprecedented level of detail. "In most cases there are millions of atoms involved in bringing about a reaction. But what we need to know is which of them are actually doing the business – the aristocratic atoms as we call them."

Methane, for instance, is known for being very unreactive, but why it is so difficult to activate remains among the big unanswered questions in chemistry. "Millions of tons of methane are released into the atmosphere yearly, and it is a major greenhouse gas. So the question is, can't we find a better use for it?" The key would lie in finding a way to selectively cleave the carbon-hydrogen bond, a fundamental problem in chemistry which Schwarz set out to probe using the instruments of catalysis.

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"Conventional catalysis research is usually done in the condensed phase. But we decided to run our experiment in the gas phase, to avoid uncontrolled side effects that might influence the outcome," the awardee recalls. They accordingly isolated the atoms one at a time, controlling the reaction environment in such a way that each result could be traced to a single atom rather than the collective effort of thousands – "something people thought for decades was impossible to achieve."

The means to isolate atoms to observe their individual behavior was provided by the mass spectrometer, a tool invented over 100 years ago but never before used for this purpose. "The mass spectrometer gives us a microscopic view of details which is not available when you look at the average behavior of millions of atoms. It is the world's smallest test tube."

Despite his basic science approach, Schwarz's discoveries have ended up transforming major industrial processes. A case in point is the German factory Degussa, a precious metal refinery that produces a hydrogen, carbon and nitrogen compound used in a large number of industrial applications. The factory developed a way to produce the compound, coupling methane with ammonia by means of a catalyst. But the coal by-product fouled the catalyst and eventually deactivated it. Schwarz was able to uncover key details of how the reaction worked and propose a modification to the catalyst to prevent soot from forming. "So there we have a practical example of how basic research ended up helping a company to substantially improve a process," says Schwarz.

Having had the experience of his research being dismissed by the more orthodox currents in academia, the awardee's advice to the new generations is: "Don't give up too early. Spot where the truly challenging problems are and have the courage to tackle them. Above all, try to excite your co-workers to join the field and see what can be achieved with an enthusiasm for basic research."

Laureate bio notes

Avelino Corma (Moncófar, Castellón, Spain, 1951) earned a BSc in Chemistry from the University of Valencia in 1973, and just three years later completed his doctorate at the Complutense University of Madrid (UCM). He began his professional career as a scientific researcher for the Spanish National Research Council (CSIC) and is currently a Research Professor at the Institute of Chemical Technology (CSIC/UPV), a mixed center which he co-founded in 1990. For the last fifty years he has researched in heterogeneous catalysis. Author

of more than 1,400 papers in international journals, he has also written three books and numerous reviews and served on the editorial boards of leading titles in the catalysis field. Corma holds over 200 invention patents, over 20 of them applied industrially in commercial processes.

John Hartwig (Elmhurst, Illinois, United States, 1964) completed a degree in chemistry at Princeton University, then went on to earn a PhD from the University of California, Berkeley in 1990. That same year he began a postdoctoral fellowship for the American Cancer Society at the Massachusetts Institute of Technology. He moved to Yale University in 1992, rising through the ranks to become Professor of Chemistry and finally Irénée DuPont Chair in Chemistry. In 2006, he joined the faculty at the University of Illinois-Champaign, where he was Kenneth L. Rinehart Jr. Professor of Chemistry until 2011. He then returned to U.C. Berkeley, where he is currently Henry Rapoport Professor of Chemistry. The author of over 400 papers, he has also garnered more than 98,000 citations, holds more than 20 patents and in 2010 published the book *Organotransition Metal Chemistry – From Bonding to Catalysis.*

Helmut Schwarz (Nickenich, Rhineland-Palatinate, Germany, 1943) graduated in chemistry in 1971 after working in industry. He received his PhD degree a year later from the Technical University of Berlin (Germany), which would become his academic home and where he was appointed Professor of Chemistry in 1978. A member of the German Academy of Natural Sciences Leopoldina, serving as its president from 2010 to 2015, the Academia Europaea, and the Göttingen Academy of Sciences, among others, Schwarz was also a co-founder of the Berlin-Brandeburg Academy of Sciences, where he was vice-president from 1998 to 2003. He holds honorary doctorates from several universities, including the Israel Institute of Technology, the University of Innsbruck and ETH Zurich. As well as authoring over 1,000 papers, he has participated in over 1,000 conferences and served on the editorial boards of various journals. From 2001 to 2007 he was vice-president of the German Research Foundation (DFG).

Nominators

A total of 94 nominations were received in this edition. The awardee researchers were nominated by **José E. Capilla,** Rector and Professor of Applied Physics at the Universitat Politècnica de València (UPV) (Spain); **Pedro J. Pérez,** Professor of Inorganic Chemistry at the University of Huelva (Spain); and **Geraldine Rauch,** President and Professor of Medical Biometry at the Technical University of Berlin (Germany).

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Basic Sciences committee and evaluation support panel

The committee in this category was chaired by **Theodor Hänsch**, Emeritus Director of the Division of Laser Spectroscopy at the Max Planck Institute of Quantum Optics (Germany) and the 2005 Nobel Laureate in Physics, with **Aitziber López Cortajarena,** Ikerbasque Research Professor, Scientific Director and Biomolecular Nanotechnology Group Leader at CIC biomaGUNE, Center for Cooperative Research in Biomaterials (Spain)**,** acting as secretary.

Remaining members were **Emmanuel Candès**, Barnum-Simons Professor of Mathematics and Statistics at Stanford University (United States); **María José García Borge**, Research Professor at the Institute for the Structure of Matter (IEM), CSIC (Spain): **Nigel Hitchin**, Emeritus Savilian Professor of Geometry in the Mathematical Institute at the University of Oxford (United Kingdom); **Hongkun Park,** Mark Hyman Jr. Professor of Chemistry and Professor of Physics at Harvard University (United States); **Martin Quack**, Professor and Head of the Molecular Kinetics and Spectroscopy Group at ETH Zurich (Switzerland); and **Sandip Tiwari**, Charles N. Mellowes Professor in Engineering, Emeritus at Cornell University (United States) and Distinguished Visiting Professor at the Indian Institute of Technology, Kanpur (India).

The **evaluation support panel** charged with nominee pre-evaluation was coordinated by **Dr. Elena Cartea**, Deputy Vice-President of Scientific-Technical Areas at the Spanish National Research Council (CSIC,) and organized into three groups. The Physics Group was coordinated by **María José Calderón Prieto**, Deputy Coordinator of the Materia Global Area and Scientific Researcher at the Institute of Materials Science of Madrid (ICMM, CSIC) and formed by **Alberto Casas González**, Research Professor at the Institute for Theoretical Physics (IFT, CSIC-UAM); **Pere Colet Rafecas**, Research Professor at the Institute for Cross-Disciplinary Physics and Complex Systems (IFISC, CSIC-UIB); **Lourdes Fábrega Sánchez**, Tenured Scientist at the Institute of Materials Science of Barcelona (ICMAB, CSIC); and **Alejandro Luque Estepa**, Tenured Scientist at the Institute of Astrophysics of Andalusia (IAA, CSIC). The Chemistry Group was coordinated by **José M. Mato**, General Director of CIC bioGUNE and CIC biomaGUNE, and formed by **Miguel Ángel Bañares González**, Research Professor at the Institute of Catalysis and Petrochemistry (ICP, CSIC); **Antonio Chica Lara**, Coordinator of the Materia Global Area and Scientific Researcher at the Institute of Chemical Technology (ITQ, CSIC-UPV); **Jesús Jiménez-Barbero**, Scientific Director of CIC bioGUNE and Ikerbasque Research Professor in the Chemical Glycobiology Lab; **Gonzalo Jiménez-**

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Osés, Principal Investigator in the Computational Chemistry Lab at CIC bioGUNE; **Luis Liz-Marzán**, Principal Investigator in the Bionanoplasmonics Lab at CIC biomaGUNE; **Aitziber López Cortajarena**, Ikerbasque Research Professor, Scientific Director and Principal Investigator in the Biomolecular Nanotechnology Lab at CIC biomaGUNE; and **María Luz Sanz Murias**, Scientific Researcher at the Institute of General Organic Chemistry (IQOG, CSIC). The Mathematics Group was coordinated by **José María Martell Berrocal**, CSIC Vice-President for Scientific and Technical Research, and formed by **María Jesús Carro Rosell**, Professor of Mathematical Analysis at the Complutense University of Madrid (UCM); **Alberto Enciso Carrasco**, Research Professor at the Institute of Mathematical Sciences (ICMAT, CSIC); **Francisco Martín Serrano**, Professor of Differential Geometry at the University of Granada; and **Rosa María Miró Roig**, Professor in the Department of Algebra and Geometry at the University of Barcelona.

About the BBVA Foundation Frontiers of Knowledge Awards

The BBVA Foundation centers its activity on the promotion of world-class scientific research and cultural creation, and the recognition of talent.

The BBVA Foundation Frontiers of Knowledge Awards, funded with 400,000 euros in each of their eight categories, recognize and reward contributions of singular impact in basic sciences, biomedicine, environmental sciences and climate change, information and communication technologies, social sciences, economics, humanities and music. The goal of the awards, established in 2008, is to celebrate and promote the value of knowledge as a global public good, the best instrument to confront the great challenges of our time and expand individual worldviews. Their eight categories are congruent with the knowledge map of the 21st century.

The BBVA Foundation is partnered in these awards by the Spanish National Research Council (CSIC), the country's premier public research organization. CSIC appoints evaluation support panels made up of leading experts in the corresponding knowledge area, who are charged with undertaking an initial assessment of candidates and drawing up a reasoned shortlist for the consideration of the award committees. CSIC is also responsible for designating each committee's chair across the eight prize categories and participates in the selection of remaining members, helping to ensure objectivity in the recognition of innovation and scientific excellence. The presidency of CSIC also has a prominent role in the awards ceremony held each year in Bilbao, the permanent home of the BBVA Foundation Frontiers of Knowledge Awards.

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