

Presentation ceremony of the 16th edition

The Frontiers of Knowledge Awards celebrate the value of science and culture as a means to broaden society's horizon of opportunities and deliver effective tools to confront the great challenges of our time

- **The gala of the 16th edition of the BBVA Foundation's international awards** honored 17 world leaders in scientific research and artistic creation
- **The event at Euskalduna Bilbao celebrated the intrinsic value of knowledge**, along with its potential to find solutions to the problems of today's world, plotting a "route map" that orients society towards "the best decisions on both the individual and collective plane," in the words of Carlos Torres Vila, President of the BBVA Foundation
- **The President of the Spanish National Research Council (CSIC), Eloísa del Pino, remarked in her speech** that the Frontiers of Knowledge Awards "have always understood the complexity of our world as an object of research," their message being that "only through the diversity of scientific disciplines can we hope to apprehend the extraordinary universe in which we live"
- **Among the awardees are the researchers** who opened up new avenues for the treatment of multiple diseases through their discoveries on protein function, and the computer vision pioneer who brought us robotic surgery, autonomous cars and facial recognition
- **Recognition was also extended to key contributions in tackling the environmental crisis**, like the discovery of the linkage between CO2 and global warming enclosed in the polar ice; the quantification of the scale of the sixth mass extinction of species; the grounding of the fields of environmental economics and the economics of biodiversity; and the definition of the motivating levers for action against climate change

The ceremony of the 16th edition of the Frontiers of Knowledge Awards celebrated the value of leading-edge research and culture as a means to expand society's cognitive capacities and plot a "route map" to tackle the key challenges of our time. This was the message conveyed by the President of the BBVA Foundation, Carlos Torres Vila, at the event held in Euskalduna Bilbao to recognize 17 world leaders in scientific research and artistic creation. In the face of such complex challenges as the environmental crisis and technological disruption, "we have to articulate a coordinated global response based on research, innovation and education." These and no other, said Torres Vila, are the instruments that can guide us to "the best decisions on both the individual and collective plane."

"Science and culture are global activities, without borders, and with the potential to benefit us all," continued the BBVA Foundation President. "Through the Frontiers of Knowledge Awards we have been able to contribute, year after year, to highlighting the decisive role of research and artistic creation as the best compass we have to understand the world around us." In this respect, the BBVA Foundation's international accolades celebrate both the intrinsic value of knowledge and its potential to deliver "the most effective tools at society's command to solve the problems we confront."

This is the fifth time that the Bizkaia capital has welcomed the Frontiers Awards presentation events, following the Foundation's decision in 2019 to make Bilbao their permanent home. Torres Vila stressed in his speech that "a hallmark of BBVA's identity is that it does not see its purpose as to operate transitorily in different world geographies, but to put down deep roots in each, building dialogue and commitment with the communities it serves, made up of businesses, individuals, families and public institutions, and respecting each region's economic, social, cultural and institutional singularity. Undoubtedly, Bilbao and the Basque Country as a whole are especially expressive of the bank's roots, and the innovating spirit that presided its founding in the mid-19th century."

Co-chaired by the BBVA Foundation President and the President of the Spanish National Research Council (CSIC), Eloísa del Pino, the ceremony also featured a welcome address by the Mayor of Bilbao, Juan Mari Aburto, and a closing speech from the General Deputy for Bizkaia, Elizabete Etxanobe.

CSIC President Eloísa del Pino said of the Frontiers of Knowledge Awards that "they have always understood the complexity of our world as an object of research." Their message, as such – one reflected in their eight categories – is that "only through the diversity of scientific disciplines can

we hope to apprehend the extraordinary universe in which we live.” For Dr. Del Pino, the achievements distinguished in this 16th edition show that “when scientists look beyond the security we get from the hyperspecialization of our knowledge fields and start venturing into other areas or disciplines, we not only achieve a wider-reaching and more disruptive science, but also a more empathetic science, better able to understand and engage with citizens at a time when it is most needed.”

The ceremony also welcomed a sizable representation of the international committees deciding the eight award categories, which draw their members from some of the top universities in Europe and North America. Among the more than 1,000 people in attendance were eminent researchers, artists and academics from the Spanish scientific and cultural community, as well as executives from the worlds of business and the media.

Protein folding, a key discovery to combat multiple diseases

The awardees in Biology and Biomedicine – F. Ulrich Hartl, Arthur Horwich, Kazutoshi Mori and Peter Walter – have shown how an initially curiosity-led finding can end up exerting a transformative impact. The four share the award for identifying the mechanisms that regulate protein function, “one of the most fascinating problems in biology,” as Professor Hartl described it in his speech at the ceremony.

Working with Arthur Horwich, Hartl discovered that proteins fold within the cell thanks to another protein that acts as a chaperone. “This finding was unexpected,” the laureate continued, “and contradicted the prevailing dogma that protein folding is a spontaneous process, independent of cellular machinery.”

As well as advancing basic knowledge on how proteins work, the awardee contribution has proved key to clarifying the origin of numerous diseases, aiding in the search for new therapeutic targets. “The molecular chaperone field has connections to almost every other aspect of biology,” Hart explained. “The medical relevance of molecular chaperones has become abundantly clear, especially in understanding neurodegenerative conditions such as Alzheimer's and Parkinson's disease, which are linked with the formation of protein aggregates.” It is for this reason, he finished, that “the chaperone story exemplifies the importance of basic, curiosity-driven research in generating insights of far-reaching significance.”

Kazutoshi Mori and Peter Walter, their co-awardees, identified another key component of protein folding: the mechanism cells turn to when the process goes wrong, to either fold them correctly or, failing this, eliminate them. In his speech, Walter recalled how they persevered despite the unexpected hurdles encountered in their research – “Walking on, undeterred, we deciphered one of the most unusual cell-internal communication pathways” – before alluding also to the clinical impact of their work. “To top it off, the salient features of what we learned from simple, single-celled brewer’s yeast held true for human cells. These features now emerge as impacting players in a plethora of devastating human diseases, including cancer, diabetes, and neurodegeneration.”

Walter also talked about the role of chance in any research, especially when its object consists of the “inherently unpredictable machines” that are living cells. “We are explorers who face the chaotic randomness of evolution,” he said in closing. “The journey required radical thinking and fearless experimentation. But only in the end did it all combine, serendipitously, into a story of unexpectedness and, we hope, lasting significance.”

Computer vision, a transformative technology omnipresent in our society

Takeo Kanade received the award in Information and Communication Technologies for developing the mathematical foundations for machine vision and robotics perception, two areas that he helped found in the 1970s and that today form part of multiple technologies in everyday use.

“Human beings are superb vision machines,” he said in his acceptance speech, explaining that early approaches to computer vision sought to mimic the functions of human eyes. What Kanade proposed was a “more rigorous” approach focused on underlying mathematical models, one that would successfully lead him to several foundational computer-vision algorithms.

In the course of his career, the ICT laureate has created software that recognizes facial features and expressions with a high level of accuracy, driving new functionalities that have transformed the world we live in: “In the 1990s, I demonstrated reliable face detection by using neural net machine learning algorithms, a technology omnipresent in our cellphones,” he recalled. He has also developed algorithms for vision-based autonomous driving capable of following lanes and detecting cars, pedestrians and other obstacles, and even a system known as EyeVision offering 360-degree televised replays of sporting event highlights.

Always with one eye on practical problems, Kanade stated his belief that the great advances made to date in computer vision could be amply surpassed in the not too distant future: “Computer vision is now used everywhere; from our daily lives to space exploration to factory floor to medicine,” he observed. “Yet we have only scratched the surface of its potential. Far better capabilities and more applications are possible. We could even make the invisible visible. With advanced sensors, high-performance computers, and AI-learning algorithms, the computer vision field is in the middle of a ‘perfect storm’, in a good sense, of course.”

The cultural value of mathematics, where nothing is true until it is proven

The Basic Sciences award went to Claire Voisin and Yakov Eliashberg for their contributions to algebraic and symplectic geometry, with particular mention of the bridges they built between the two disciplines. Working independently, the awardee scientists have broken down barriers between these mathematical areas, applying tools from each to study problems routinely assigned to the other.

Algebraic geometry is a classical mathematical discipline that starts from a variety of simple equations, those defined by polynomials, and studies their solutions from the standpoint of geometry. Symplectic geometry is concerned with the geometric objects that describe motion in physics. The two fields have come to prominence in recent years through their links with theories of quantum physics, which explores the fundamental properties of matter and energy on the subatomic scale. Yet for the awardees themselves, as Voisin remarked in her speech, a greater motivation is to understand the mathematical objects they are drawn to for their “beauty.”

“The question of what mathematics is useful for is different, and is a matter of personal taste and appreciation,” she explained. “Mathematical theories and objects appear through an abstract extrapolation of the real world. After a long detour that requires audacity, freedom and creativity, they help to understand, describe, and interpret our physical and intuitive experience.”

That said, the mathematician chose to highlight the cultural usefulness of mathematics over and above its practical applications, especially in the context of today’s society. Inundated with screens and instant messages that reach us via multiple channels, it may be hard to separate the true from the false, and it is here that Voisin stakes a claim for her discipline as an aid to discernment: “In these difficult times, it would be totally unrealistic to claim that mathematicians doing research in the field of pure mathematics work for the welfare of humanity. Nevertheless, I do believe that mathematical knowledge is essential to knowledge and intellectual life in general,

because it is built on the universal principle that every statement has to be proved in order to be considered true.”

Climate change, a dangerous “experiment” we are all “trapped inside”

The scale of the climate change challenge was laid bare in the speech delivered by Dorthe Dahl-Jensen, the Danish scientist who shared the award in this category with her colleagues Jean Jouzel, Valérie Masson-Delmotte, Jakob Schwander and Thomas Stocker. “Right now,” she warned, “humans are playing with the global climate system in an experiment where we are all trapped inside.” The danger of this “experiment” is patent in the fact that in the last 800,000 years atmospheric greenhouse gas concentrations have never approached today’s human-driven levels. An insight that owes to the work of the five awardee researchers, who discovered the vital linkage between increased CO₂ levels and global warming concealed within the polar ice.

“It is truly fascinating to look into ice cores and see millions of small trapped air bubbles of the past atmosphere,” Dahl-Jensen observed. These bubbles are like an open book that takes us back through time to reconstruct the Earth’s atmospheric conditions. As early as the 1960s, climate models were showing that increased atmospheric concentrations of CO₂ would lead to higher temperatures. But to validate this finding, what was missing was hard data on the composition of the atmosphere throughout Earth history. The needed confirmation came with the contributions of the five awardees, demonstrating the anthropogenic origin of present-day climate change.

For Dahl-Jensen, “understanding and extracting the wealth of climate information from 3 km long and crystal-clear majestic ice cores drilled from the surface to bedrock of the large ice sheets in Greenland and Antarctica has been an innovative and challenging journey.” Thanks to the work done by the laureates, we know that not only are CO₂ concentrations 35% higher than at any point in the past 800,000 years, but also that our planet has witnessed past instabilities in the climate system; abrupt changes that could happen again due to man-made perturbations.

The scientist closed her speech with some considered words of warning: “As the lifetime of carbon dioxide in the atmosphere is more than 100 years, we have programmed the world to warm over many years to come.”

The human species, a destructive “meteorite” that threatens “Earth’s biological wealth”

Professor Rodolfo Dirzo, co-laureate with Gerardo Ceballos in the Ecology and Conservation Biology category, devoted his speech to the other key environmental challenge of our time: the impact of human activity on “the Earth’s biological wealth,” a threat he described as “of no less importance than the threat of climate change.” The two Mexican researchers were honored for their contributions to the study of “defaunation,” a term coined by Dirzo to describe both the disappearance of animals and how their loss alters the structure and function of ecosystems. Their studies have shown that the elimination of a single species can trigger pernicious cascading effects by disrupting its web of interactions with other organisms. This, in turn, impacts negatively on human wellbeing through the reduction of the goods and services these organisms provide.

Dirzo recalled that throughout Earth’s history there have been “five mass extinction events.” The latest of these biological catastrophes took place 66 million years ago, when a meteorite crashing into what is now the Yucatán Peninsula in Mexico “brought the reign of the dinosaurs to an end,” and opened a space for “the evolutionary flourishing of mammals,” including the primate lineage to which *Homo sapiens* belongs.

What the laureates have concluded from their studies is that the sixth great extinction is already upon us, only this time the meteorite is our own species. As Dirzo stated, “human action has come to exert a counteracting force on the diversification trajectory of the biosphere, becoming the agent of what increasingly looks like a new mass extinction.” Indeed their research has shown that vertebrate extinction rates are from 100 to 1,000 times greater than those prevailing in the past few million years.

The seriousness of this “anthropogenic pulse” demands that we adopt “an ethical commitment to conserve as much as possible of the biological wealth that accompanies us, which we all depend on and with which we form an indissoluble whole,” in view of the Stanford professor. For only if we act now to stop the sixth mass extinction can we hope to prevent our descendants “being denied a future.”

Decision-making in the face of the global environmental crisis

The fight against global and transversal threats like climate change or biodiversity loss must be mounted through multiple responses on the same scale: planetary and multidisciplinary. It is this conviction that has guided the work of Elke Weber, recognized in the Social Sciences category for

her decisive role in the emergence of a new scientific discipline: the study of environmental decision-making. “The international attention garnered by this prize will help to correct the misperception that the absence of adequate climate action is just an information deficit,” she said on collecting the award, since “understanding the cognitive, motivational, and political deficits that contribute to inaction” is among the first steps to addressing the problem.

The environmental psychology that Weber helped shape emerged at the end of last century as an offshoot of decision theory, and draws its tools and methods from social psychology, neuroscience, behavioral economics, sociology and environmental science. A key focus of the discipline is the deficits or biases that, on many occasions, override rational thinking and lead citizens to adopt behaviors that are actually harmful to their long-term interests. “This is true in many domains,” she observed, “from insufficient pension savings to unhealthy eating.” But with the aggravant in the case of the environment that the benefits of combating climate change or the accelerated loss of animal and plant species will not be seen for decades; it is a bet on the future whose winnings will come back to future generations. And this sacrificial aspect, said Weber at the ceremony, “makes protective action even more daunting.”

And yet the Princeton professor believes there is still room for hope. “People’s psychological needs (like feeling safe and being confident in their decisions) provide us with a much larger set of incentives to motivate action than those provided by economics and the law.” It also helps to know, she added in closing, that “we make decisions not just with our heads (calculating consequences), but also with our hearts (responding to feelings of guilt or pride) and by the book (following moral rules of conduct or standard operating procedures). And this knowledge allows us to design decision environments that make foresightful decisions more likely.”

The economics of biodiversity and the two sides of global progress

“For some four decades now, I have tried to introduce nature into economic reasoning.” These words by Partha Dasgupta, laureate in the Economics, Finance and Management category, provide an apt summary of the contribution that earned him the award.

This economist with a background in physics and math points out that the words ‘economics’ and ‘ecology’ not only have the same etymological root (*oikos* or home in Ancient Greek) but the same origin: “Humanity is part of nature and human economy is embedded deep within it,” he insisted in his speech. Yet still today “biodiversity is absent from official economic reckoning.”

Hence his decision to devote a research career of almost half a century to propounding a new formula for measuring wealth; an indicator that goes beyond traditional measures like GDP to depict the real situation of the stock of goods and services (processes in his terminology) and tell us how much that stock is depreciating, so we can arrive at a true calculation of global wealth. Not only that, continued the Cambridge professor, applied systematically what this yardstick shows is that the progress of the global economy in the past 75 years is best described as a two-sided coin: “one side displaying skyscrapers, plantations, agricultural fields, animal farms, and highways in all parts of the world; the other side depicting shrunken lakes, dead oceanic zones, desiccated forests, bleached coral reefs, and infertile watersheds.”

Dasgupta also warned in his speech that “our global success has come with an increasingly impoverished biosphere and species extinction rates currently at 100-1,000 times the average rates in the previous several million years,” and referred in closing to *The Dasgupta Review*, released in 2021, a commission from the UK Treasury to take stock of the current state of the world’s natural resources, which has successfully spurred debate in academic and policy circles on how to measure wealth in an inclusive way that fully factors nature. Its publication, he said, “has enabled me to put all those decades of work together into a comprehensive whole.”

The music of George Benjamin: an extraordinary impact in contemporary creation

“Nothing is more exciting in the world than music. Music indeed defines beauty, and light and truth reside in harmony as nowhere else in existence. And I now realize that several lives would not begin to be sufficient to serve and explore this wondrous medium.” Sir George Benjamin summed up in these words what music means to him, as a composer whose expressive power and mastery of his craft won him the 16th Frontiers of Knowledge Award in the Music and Opera category.

In his speech, the British composer looked back at his infancy when he visited Spain for the first time, going on to converse rhetorically with his eleven-year-old self – “with his enthusiastic though as yet restricted knowledge of Beethoven, Berlioz, Mahler and Stravinsky.” He recalled being shocked at the news of the latter’s death as an already fanatical fan of the Rite of Spring. And how that young boy, “despite his youth, was already determined to devote his life to music and ardently hoped to be one thing and one thing alone: a composer.” Wondering why this was so, he could only conclude: “I would find it hard to respond today, as I have pursued this vocation throughout my adult life and cannot begin to imagine doing anything else.”

His connection with Spain traces back “to the first half of the 17th century when my Marano antecedent Isaac Abendana fled the Inquisition in Cantabria and traveled through Germany and the Netherlands before finally settling in England. I accordingly have deep Hispanic roots, something which has meant ever more to me over the years as I have got to know this beautiful country and admire its wonderfully diverse and rich culture.”

George Benjamin received the award, in the words of the committee, for modernizing the operatic language and for his extraordinary impact in contemporary musical creation, achievements clear to anyone present at the June 19 concert in honor of the 16th edition laureates, at which the Orquesta Sinfónica de Madrid under conductor Santiago Serrate performed his *Concerto for Orchestra* (premiere in Spain) and *Dance Figures*.

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 Frontiers of Knowledge Awards, established in 2008, recognize and reward contributions of singular impact in science, art and the humanities, privileging those that significantly expand the frontiers of the known world, open up new fields, or emerge from the interaction of various disciplinary areas.

The goal of the awards is to celebrate and promote the value of knowledge as a public good without frontiers, the best instrument at our command to take on the great challenges of our time. Their eight categories are congruent with the knowledge map of the latter half of the 20th century and the present day, according a differential weight to areas of particular relevance and dynamism in recent decades, such as the environment, information and communication technologies or biomedicine, alongside other areas like basic sciences, economics, social sciences, the humanities and, in the world of the arts, contemporary music and opera.

The international committees deciding the Frontiers Awards are formed by reputed experts in their respective fields, who deliberate independently applying the indicators and metrics of excellence proper to the subject area. Nominations come in from many of the world’s most prestigious academic, research and artistic institutions. The BBVA Foundation is aided in candidate evaluation in the eight award categories 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 disciplinary domain, 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 and participates with the BBVA Foundation in the selection of its members, thus helping to ensure the objectivity and merit of the selection process.

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