Fundación BBVA

2009 BBVA Foundation Frontiers of Knowledge Awards

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

PRESS RELEASE

Zare and Fisher win the BBVA Foundation Frontiers of Knowledge Award in Basic Sciences for rendering molecules visible and analyzing their collective behavior

- Richard N. Zare's work on the observation of individual molecules has contributed to the sequencing of DNA, and allowed us to see inside the flame
- Michael E. Fisher, of the University of Maryland, has explained phenomena ranging from why water evaporates to the functioning of molecular motors in the cell
- The eight categories of the Frontiers of Knowledge Awards address the great global challenges of the 21st century.
- The breadth of disciplines addressed and their monetary amount – a total of 3.2 million euros – place them among the world's foremost award schemes. Each category carries a cash prize of 400,000 euros.

January 26, 2010.- The 2009 BBVA Foundation Frontiers of Knowledge Award in the Basic Sciences category goes to physicist and chemist Richard N. Zare, of Stanford University, and physicist Michael E. Fisher, of the University of Maryland, for their independent, fundamental contributions to describing the world at molecular level. "One has unraveled secrets of nature's building blocks and the underlying interactions between them by enabling us to view what happens at the molecular scale. The other has developed theoretical approaches that help analyze what happens when a large assembly of such building blocks is brought together", in the words of the jury's citation.

Richard N. Zare (Cleveland, Ohio, 1939), shares the award for his introduction of laser-induced fluorescence, dating back to the decade of the 1970s, and other laser-based techniques "in order to address questions ranging from chemical reaction dynamics to ultra-sensitive chemical analysis down to the limit of single cells and single molecules".

In the case of Michael E. Fisher (born in Trinidad and Tobago in 1931, of British nationality), the jury singles out “his fundamental contributions to statistical mechanics. His work helps to interpret the vast diversity of the behaviors of bulk matter in terms of the characteristics of the component atomic or molecular parts and their interactions”.

The Frontiers of Knowledge Awards honor world-class research and artistic creation. The breadth of disciplines addressed and their monetary amount, an annual 3.2 million euros, place them among the foremost international award families. However their uniqueness lies in their close alignment with the scientific, technological, social and economic challenges of the present century. In this respect, they are the first to reserve dedicated categories for Climate Change; Development Cooperation; Information and Communication Technologies, and Ecology and Conservation Biology, alongside the awards going to outstanding contributions in Economics, Finance and Management; Basic Sciences; Biomedicine, and Contemporary Music.

The Basic Sciences award goes to honor outstanding contributions in Physics, Chemistry and Mathematics. In the inaugural 2008 edition, the award was shared by physicists **Ignacio Cirac** and **Peter Zoller**, authors of the first theoretical description of a quantum computer.

“I was fortunate to become a scientist at the same time when the laser was born”

The use of laser-induced fluorescence is what has won Zare’s work its international reputation. The method consists of exciting molecules by means of a laser beam with a determined wavelength. The excited molecule then interacts with other wavelengths allowing us to scrutinize its reactions and structure. “In many ways I was fortunate to be becoming a scientist at the same time when the laser was born”, remarks Zare, explaining the focus of his work on using radiation matter interaction, “how light interacts with solid objects, molecules, atoms and so forth”.

This ultra-sensitive technique meant molecules could be observed in isolation and their chemical reactions studied in detail. “I used the laser to be able to clock molecules and how fast they change in time”. Another application allowed him to examine this behavior in environments resistant to scientific observation, such as a flame. “Where you would not want to put your fingers, you can put a laser beam, and see very radical, very transient intermediates; those that take place in combustion”.

This American physicist and chemist also applied his discovery in observing what are known as separation processes, whereby a mixture of chemical elements is transformed into two or more substances, with physical and chemical properties at times differing from those of the original mixture. With the laser, he could then trace the path of the resulting molecules.

This, in turn, enabled him to look at single molecules in room-temperature solution. “When I was a graduate student, we all prided ourselves that we believed molecules but no one had ever seen one. Today with microscopy techniques and this fluorescence you can see individual molecules and you can follow what they do in time and space. Many hundreds of papers have come from there”. Indeed, Zare and his team were the first to succeed in counting all the molecules in a cyanobacterial cell.

But his work did not stop there. The ability to identify individual molecules and monitor their behavior meant they could be labeled (using fluorescence tags). And this tagging could be used to analyze more complex molecular structures like DNA. “We progressed from very small molecules to molecules and solutions, to questions of biology like the sequencing of the genome”. And certainly laser-induced fluorescence has been taken up by many scientific disciplines, from chemistry to biology by way of astrophysics (Zare’s work has enlarged our understanding of questions like the nature of life within a cell or the origins of the Solar System, comparing its chemical make-up to that of interstellar space).

In this journey from the simplest to the most complex, Zare has been spurred on by more than simple scientific curiosity: “There’s a common belief that what drives science is curiosity about the world. Yes, I’m a curious person, but I’m telling you personally that curiosity is not enough for me. What gives me the greatest joy is to tell others about something which is meaningful to them. How many people would compose music if they were told that the music they compose could only be heard by themselves? How many people would write poetry if only they were allowed to read it? In this respect, science is very much a humanistic endeavor”.

“Every little cell is like a whole city”

Molecules can be viewed as individual entities, but also as members of a group that exhibits a fascinating and often unpredictable ‘crowd behavior’: although we know a lot about water molecules, we are still unsure exactly what happens when water goes from liquid to gas. Michael E. Fisher’s work over five decades has been essential for interpreting this kind of behavior, which is present in countless phenomena from magnetism to superconductivity. The interdisciplinary Fisher – professor of Physics, Chemistry and Mathematics – takes his results as far afield as biology, his own ultimate frontier: “Every cell is like a whole, fascinating little city”, he enthuses.

Describing the ‘bulk’ behavior of molecules is the mission of statistical mechanics, an area which Fisher has taken to a new and unforeseen development stage. His contributions are essential to our understanding of the so-called phase transitions – when water changes state or the magnetization of a metal. The theory used to explain such phenomena for over a century was in fact wrong; Fisher not only corrected it, but realized that his model could serve for many different systems.

“When I put many molecules of water together, why do many of them freeze? And, most surprising, if I enclose them in a container and raise the pressure and the temperature, there will come a critical point above which the difference between liquid and vapor disappears; the water becomes dense but there is no interphase. Why does this happen? What exactly is going on in the vicinity of the interphase?” Fisher ponders. “Where one state of matter changes into another there is a very special point that has fascinated me for years”.

Fisher talks about indulging his passion for biology, an area that has attracted him since the start of his career, when he worked in the laboratory where the structure of DNA was determined (Kings College London, United Kingdom). Fisher sees the cell as a city, and has centered his analytical energies on the *molecular motors* that fulfill multiple functions in that city. To describe how it works, he insists, we need to call on statistical mechanics.

In the *city-cell* "you can start in politics, for instance, and there are all those things you have to worry about, like transportation or water supply. And then you realize that there is this little molecule that carries things around. In biology, you can conduct all kinds of incredible experiments, like hook a tag onto that molecule and see how it moves around within the cell. But how does it move? The theory you need to answer these questions is also statistical mechanics".

The jury in this second edition was chaired by **Theodor Hänsch**, Professor of Physics at LM Munich (Germany) with **Sandip Tiwari**, Charles N. Mellowes Professor in Engineering at Cornell University (United States), acting as secretary. Remaining members were **Douglas Abraham**, Professor of Statistical Mechanics at the University of Oxford (United Kingdom); **Martin Quack**, Professor of Physical Chemistry at ETH Zurich (Switzerland), **Hongkun Park**, Professor of Chemistry and Chemical Biology and of Physics at the University of Harvard (United States) and **Gerardo Delgado**, Director of the Instituto de Física Fundamental (Spanish National Research Council, CSIC).

WINNERS IN OTHER AWARD CATEGORIES

The Basic Sciences category is the third to be decided in this edition of the BBVA Foundation Frontiers of Knowledge Awards. The Climate Change award was granted to German physicist and mathematician **Klaus Hasselmann** for demonstrating that recent global warming trends are attributable to human activities. In Information and Communication Technologies, the award went to engineer and mathematician **Thomas Kailath** for a mathematical development enabling the production of increasingly small size chips.

The next award to be decided is Biomedicine whose winner will be announced tomorrow, January 27. The calendar of remaining award announcements can be consulted on www.fbbva.es.

The BBVA Foundation supports knowledge generation, scientific research and the promotion of culture, relaying the results of its work to society at large. This effort materializes in research projects; human capital investment; and specialization courses, grants and awards. Among the BBVA Foundation's preferred areas of activity are basic sciences, biomedicine, ecology and conservation biology, the social sciences and literary and musical creation.

For more information, contact the BBVA Foundation Communication Department (+34 91 374 5210/+34 94 487 4627 or comunicacion@fbbva.es) or visit www.fbbva.es