KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Chemistry for 2013 to **Martin Karplus, Michael Levitt** and **Arieh Warshel** "for the development of multiscale models for complex chemical systems".

The Nobel Prize 2013 **in Chemistry**

They launched chemistry into virtual space

Chemists once created models of molecules using plastic balls and sticks. Today, the modelling takes place inside computers, *in silico*. In the 1970s, Martin Karplus, Michael Levitt and Arieh Warshel laid the foundation for the powerful programs that are now used to understand and predict chemical processes. Computer models that mirror real life have become crucial for most advances made in chemistry.

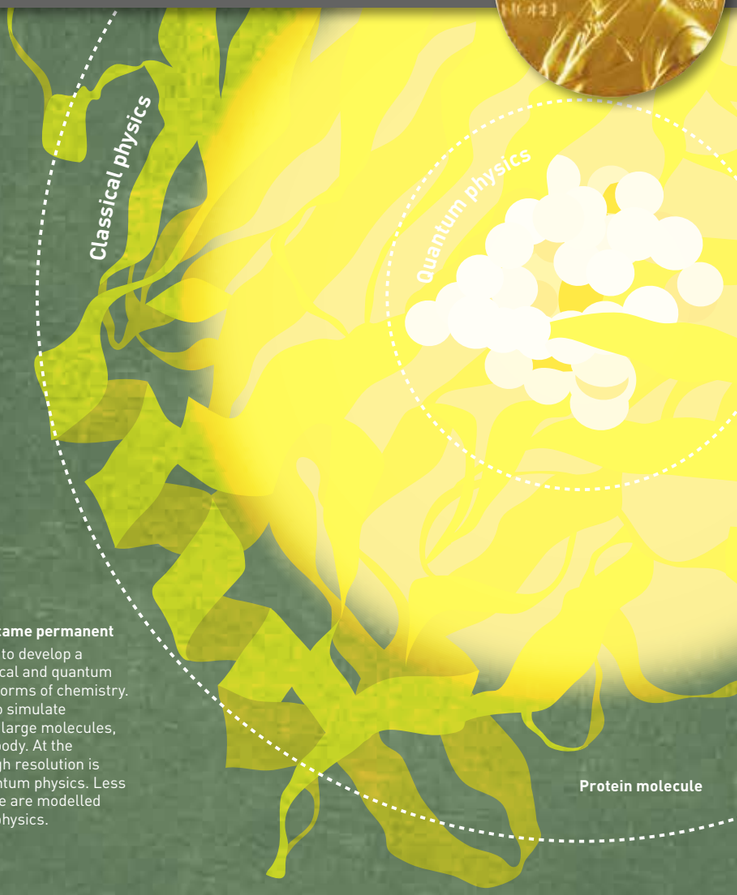
Today, virtual calculations of molecules often reveal the pathway of a chemical reaction, showing exactly how each and every little electron, proton and atom behave during otherwise lightning-fast processes. Using computers, chemists map reactions at an extremely detailed level: for example, how a drug molecule couples to its target protein in the body; how photosynthesis unfolds in green leaves; or how cells generate energy in the mitochondria, their internal power plants.

The significance of the work of Karplus, Levitt and Warshel is that they managed to open a door between two of the big master theories of physics: Newton's classical physics and Schrödinger's quantum mechanics. Before, those two theories competed. Now, chemists get the best of both worlds in their computer models.

1975 – A simplification of classical physics
Instead of treating each and every atom separately during calculations, Levitt and Warshel merged several atoms together in classical calculations. This simplification saved computer power, without losing the precision of the models.

The past –
Newtonian physics for big molecules at rest
Scientists could always use Newton's classical physics to model really big molecules. The equations are so simple that even computers in the 1970s had enough power to solve them. But Newton's physics cannot describe the making and breaking of chemical bonds. Molecules therefore always were modelled in a resting state.

The present –
Computers predict chemical reactions
The merging of the two worlds revolutionized chemistry. Now, chemists gain as much knowledge from virtual experiments in computers as they do from laboratory experiments. Computers give an idea of probable reaction pathways. The hypotheses are tested through real experiments, which result in new knowledge that can improve the simulations.



1976 – The collaboration became permanent
Warshel and Levitt managed to develop a collaboration between classical and quantum physics, which works for all forms of chemistry. It thereby became possible to simulate chemical processes in really large molecules, for example, proteins in the body. At the heart of the action, where high resolution is needed, scientists apply quantum physics. Less important parts of a molecule are modelled using less precise classical physics.

1972 – A first tentative meeting
Karplus and Warshel modelled molecules for the first time using both classical and quantum physics. It was a big step, but the method they developed had a limitation: it could only be applied to so-called symmetrical molecules.

The past – Quantum physics for reactions
When scientists wanted to simulate chemical reactions or other processes, they used quantum physics, the dualistic theory in which Schrödinger's cat can be both dead and alive inside its box. However, solving equations for quantum physics demands enormous computer power. Therefore, only small molecules could be simulated, which was a drawback.

Michael Levitt
U.S., British and Israeli citizen. Born 1947 in Pretoria, South Africa. Robert W. and Vivian K. Cahill Professor in Cancer Research at Stanford University School of Medicine, Stanford, CA, USA.

Arieh Warshel
U.S. and Israeli citizen. Born 1940 in Kibbutz Sde-Nahum, Israel. Distinguished Professor at University of Southern California, Los Angeles, CA, USA.

Martin Karplus
U.S. and Austrian citizen. Born 1930 in Vienna, Austria. Professeur Conventionné at Université de Strasbourg, France, and Theodore William Richards Professor of Chemistry, Emeritus, at Harvard University, Cambridge, MA, USA.

FURTHER READING! More information on the Nobel Prize in Chemistry 2013: http://kva.se/nobelprizechemistry2013 and http://nobelprize.org **REVIEW ARTICLES:** ● **Levitt, M.** (2001) *The birth of computational structural biology*, Nature structural biology 8, 392–393. ● **Karplus, M.** (2006) *Spinach on the Ceiling: A Theoretical Chemist's Return to Biology*, Annu. Rev. Biophys. Biomol. Struct. 35, 1–47. **ORIGINAL ARTICLES:** ● **Warshel, A. and Karplus, M.** (1972) *Calculation of Ground and Excited State Potential Surfaces of Conjugated Molecules. I. Formulation and Parameterization.* J. Amer. Chem. Soc. 94, 5612 ● **Levitt, M. and Warshel, A.** (1975) *Computer Simulation of Protein Folding.* Nature 253, 694 ● **Warshel, A. and Levitt, M.** (1976) *Theoretical Studies of Enzymatic Reactions: Dielectric Electrostatic and Steric Stabilization of the Carbonium Ion in the Reaction of Lysozyme.* J. Mol. Biol. 103, 227-249 **LINKS:** ● **Johnson, P.** (2012) *Warshel Fêted by Royal Society of Chemistry*: http://news.usc.edu/#!/article/44708/warshel-feted-by-royal-society-of-chemistry ● **More references can be found in the Scientific Background:** http://kva.se/nobelprizechemistry2013

Editors: Gunnar Karlström and Sven Lidin, The Nobel Comittee for Chemistry, The Royal Swedish Academy of Sciences; Ann Fernholm/Katalys Media, Science Writer; Victoria Henriksson, Editor, and Linnéa Wallgren, Nobel Assistant, The Royal Swedish Academy of Sciences. **Graphic design:** Ritator **Illustrations:** Johan Jarnestad/Swedish Graphics **Print:** Åtta45

Printing and distribution made possible by VOLVO

Box 50005, SE-104 05 Stockholm, Sweden
Phone: +46 8 673 95 00
e-mail: info@kva.se, http://kva.se
Posters may be ordered free of charge at http://kva.se/posters or by phone.