EDITORIAL

The rewards of crystallography: The 2014 Gregori Aminoff Prize in the International Year of Crystallography

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Editorial

The rewards of crystallography: The 2014 Gregori Aminoff Prize in the International Year of Crystallography

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On 31st March 2014, the Gregori Aminoff Prize was awarded to Professor Yigong Shi at the Concert House in Stockholm by HRH King Carl XVI Gustaf. This occasion was noteworthy, not only as the 275th anniversary of the year in which the Royal Swedish Academy of Sciences was founded, but also as a year of consequence for the Gregori Aminoff Prize, an award presented annually for a documented contribution in the field of crystallography made by an individual or, on occasion, by individuals.

The current year, 2014, has been designated the 'International Year of Crystallography' and will be marked in *Physica Scripta* by a series of publications celebrating the diversity of crystallography and the achievements that have been made through the application of crystallographic techniques.

A considerable number of Aminoff Prize winners have kindly agreed to contribute a personal account of their research achievements and, considered chronologically according to the year of the award, these papers commence with a manuscript by Professor Jack Dunitz, who received the accolade in 1990. I have been overwhelmed by the gracious acceptance of the invitation to contribute to this series by almost all previous prizewinners, but I would especially like to express my gratitude to every author who has made an effort to step out of a sometimes lengthy (official) retirement to produce articles to enrich the reading material available on crystallography to the benefit of us all.

In terms of the publication dates, however, the first of these autobiographical tales to be published in 2014 is that of Professor Shi, which appears in this issue [1]. Professor Shi begins his article with poignant stories of his childhood and culminates with technical descriptions of the work that led to him receiving the prize (see figure 1). As his account unfolds, he passes through his years of education and development, gives praise for outstanding examples and leadership, and provides evidence of the perseverance required to reach the top of his field. His account will surely inspire many ambitious young scientists embarking on their careers.

Professor Roland Allen has tackled the issue of how to provide an overview of the extraordinarily broad range of subjects studied by crystallography in an article intended to introduce the subject to undergraduate students [2]. His paper begins with the discovery of x-rays, and ends with the powerful x-ray free-electron laser facilities currently under development around the world. Structural biology largely starts with Dorothy Hodgkin, who determined the structures of cholesterol, penicillin, vitamin B12 and insulin, and continues through Rosalind Franklin, whose x-ray diffraction pattern provided the basis for understanding the structure of DNA. Recently the Cambridge Crystallographic Data Centre announced that the anti-convulsant drug Lamotrigine had become the 500 000th structure in its database. Thousands of complex protein structures have now been determined, and this application of x-ray crystallography has led to major breakthroughs in structural biochemistry and drug discovery. The 2014 Gregori Aminoff Prize,

Figure 1. Professor Yigong Shi receives the Gregori Aminoff Prize at the Concert House in Stockholm on the occasion of the Royal Swedish Academy of Sciences' annual award ceremony and dinner. From left to right, prizewinners: Yigong Shi, Gregori Aminoff Prize; Eva Björklund, Ingvar Lindqvist Prize; Daniel Barker; Anja Eklund; Patrik Lundqvist; and Anna Stilby. Second from right, HRH King Carl XVI Gustaf and, on the far right, the President of the Royal Swedish Academy of Sciences, Barbara Cannon. Copyright: Royal Swedish Academy of Sciences/Markus Marcetic.

discussed above, and the 2012 Nobel Prize in chemistry demonstrate the power of crystallographic techniques for understanding the functioning of important biological macromolecules. Structure is also a key to understanding the electronic properties of thousands of important materials, such as graphene, carbon nanotubes and high-temperature superconductors.

Explanatory accounts of the use of crystallography in a wide range of subjects have been requested and will be published to ensure that the power of crystallography as a tool in a variety of fields, including those in which we are not active, is made apparent to us all. I look forward to learning about the biological and medical applications that are common knowledge to many, but unfamiliar to me. In addition, for completeness, as the scientists who had their work recognized by receipt of the Gregori Aminoff Prize in the 1970s and 1980s are no longer with us, their tales will be told by other authors and researchers in their place. The early days of crystallography are also covered in a paper by Professor Tamir Dattar intended to provide historical context, and the fascinating life of Professor Gregori Aminoff, artist and scientist, forms the subject of another.

All of the aforementioned publications, overviews, historical accounts and biographical and autobiographical articles will appear in regular issues of the journal, whereupon the published papers will be gathered together to form a virtual issue. For completeness, this latter will also include our first personal accounts by Gregori Aminoff Prize winners, those of Professors Gatti and Spackman, who received the award in 2013 [3, 4].

Since the occasion on which the first Aminoff prize was awarded in 1979, it has been presented on an almost annual basis to crystallographers in a variety of fields. Table 1 contains a full listing of the prizewinners, also displaying the countries in which they were active. In those initial years, the formative work of developing the scientific methods was recognized, and the majority of prizes were awarded to physicists and structural chemists. Subsequent years saw a

Table 1. The complete list of recipients of the Gregori Aminoff prize since the instigation of the award in 1979. Where no English translation of the citation for the nomination existed, I have provided one.

Prizewinner	Year[a]	Country of residence	Nomination
Paul Peter Ewald	1979	USA	For fundamental contributions to the development of the science of crystallography.
Charles Frank	1981	UK	For fundamental contributions to the development of the science of crystallography.
Gunnar Hägg	1982	Sweden	For pioneering application of x-ray crystallography in inorganic chemistry.
J M Robertson	1983	UK	For fundamental contributions to the development of the science of crystallography.
David Harker	1984	USA	For fundamental contributions to the development of methods in x-ray crystallography.
André Guinier	1985	France	For fundamental experimental and theoretical studies of the dispersion of x-rays with application to the study of structures of condensed systems.
E F Bertaut	1986	France	For fundamental contributions to theoretical and experimental crystallography, in particular in relation to magnetic structures.
Otto Kratky	1987	Austria	For the development of the small angle scattering method and x-ray studies of the structure of macromolecules.
Isabella L Karle	1988	USA	For outstanding crystallographic investigations of complicated natural products.
Arne Magnéli	1989	Sweden	For epoch-making crystallographic studies of the building principles of oxide compounds, which have changed the view of the relations between stoichiometry and structure in inorganic chemistry decisively.
Jack D Dunitz	1990	Switzerland	For the preeminent way of using structural analysis as a tool for studying different chemical problems.
David Phillips	1991	UK	For fundamental results on the catalytic mechanism of enzymes.
Michael M Woolfson	1992	UK	For the development of direct methods for statistical phase determination of crystal structures.
Clifford G Shull	1993	USA	For the development and application of neutron diffraction methods for studies of atomic and magnetic structures of solids.
Michael G Rossmann	1994	USA	For the fundamental methodological work on the utilization of non-crystallographic symmetry, with its especially important applications within protein and virus crystallography.
Hugo M Rietveld	1995	The Netherlands	In recognition of the development of profile refinement methods for the analysis of powder diffraction data.
Philip Coppens	1996	USA	In recognition of outstanding methodological and structural chemical achievements in crystallography, especially the studies of electron distribution in different types of chemical bonds.
Wayne A Hendrickson	1997	USA	For contributions to the phase angle determination of macromolecular crystals using anomalous dispersion and measurements at multiple wavelengths.
Aloysio Janner	1998	The Netherlands	For contributions to the theory and practise of modulated structure refinements.
Ted Janssen	1998	The Netherlands	For contributions to the theory and practise of modulated structure refinements.
Pietro Marten de Wolff	1998	The Netherlands	For contributions to the theory and practise of modulated structure refinements.
Richard Henderson	1999	UK	For the development of methods for structural determination of biological macromolecules using electron diffraction.
Nigel Unwin	1999	UK	For the development of methods for structural determination of biological macromolecules using electron diffraction.
Dan Schechtman	2000	Israel	For the discovery of quasicrystals.
Kenneth C Holmes	2001	Germany	For pioneering development of methods to study biological macromolecules, in particular muscle proteins, by synchrotron radiation.
Meir Lahav	2002	Israel	For fundamental studies of crystal growth and application to the separation of enantiomers and for studies of surface structures by synchrotron radiation.
Leslie Leiserowitz	2002	Israel	For fundamental studies of crystal growth and application to the separation of enantiomers and for studies of surface structures by synchrotron radiation.

Table 1. (Continued.)

Prizewinner	Year[a]	Country of residence	Nomination
Axel Brünger	2003	USA	For the development of refinement techniques for macromolecules.
T Alwyn Jones	2003	Sweden	For pioneering development of methods to interpret electron density maps and to build models of biological macromolecules with the aid of computer graphics.
Ho-Kwang Mao	2005	USA	For pioneering research of solid materials at ultrahigh pressures and temperatures.
Stephen Harrison	2006	USA	For remarkable contributions in virus crystallography.
David Stuart	2006	UK	For remarkable contributions in virus crystallography.
Sumio Iijima	2007	South Korea	For structural studies of carbon nanotubes.
Hans Eklund	2008	Sweden	For crystallographic studies of ribonucleotide reductase.
George Sheldrik	2009	Germany	For contributions to theoretical development and methodological implementation in crystallography.
Gerard Bricogne	2009	UK	For contributions to theoretical development and methodological implementation in crystallography.
So Iwata	2010	UK	For seminal crystallographic studies of membrane proteins—the elucidation of vital biological functions within the fields of cellular respiration, photosynthesis and molecular transport using state-of-the-art crystallographic methods.
Stephen Weiner	2011	Israel	For crystallographic studies of biomineralization processes, which have led to an understanding of mechanisms of mineral formation.
Lia Addadi	2011	Israel	For crystallographic studies of biomineralization processes, which have led to an understanding of mechanisms of mineral formation.
Gulnara Yusupova	2012	France	For crystallographic studies on ribosomes, translators of the code of life.
Marat Yusupov	2012	France	For crystallographic studies on ribosomes, translators of the code of life.
Harry B Noller	2012	USA	For crystallographic studies on ribosomes, translators of the code of life.
Carlo Gatti	2013	Italy	For developing experimental and theoretical methods to study electron density in crystals, and using these methods to determine molecular and crystalline properties.
Mark Spackman	2013	Australia	For developing experimental and theoretical methods to study electron density in crystals, and using these methods to determine molecular and crystalline properties.
Yigong Shi	2014	China	For groundbreaking crystallographic studies of proteins and protein complexes that regulate programmed cell death.

[a] No prize was awarded in 1980 or 2004.

considerable broadening of the applications of the techniques and an accompanying increase in the complexity of the materials being studied. Biological and medical applications came to the fore, and these have been recognized by several prizes in more recent decades. Physicists and chemists do still have a role to play, however, and even amongst the recent prizewinners, contributions from the so-called hard sciences continue to be recognized.

Other changes are apparent simply from a sweeping glance at the list: from 1979 to 2006, all of the prizewinners performed their work in the USA or Western Europe. However, as the subjects diversified, so the use of crystallographic techniques spread. Many nations then started to contribute significantly to advances in crystallography, and in 2007 Sumion Iijima of South Korea became the first recipient of the Gregori Aminoff Prize to work primarily outside the USA and Europe. He received the award for his crystallographic studies of membrane proteins. Subsequent years have seen Australia and China added to this list. Changing demographics and a substantial increase in the number of women in the sciences alters the probabilities that more women will continue to feature amongst the prizewinners, although physics still has progress to make in this respect.

Future developments in crystallography will inevitably be accompanied by greater precision and even more complex structures will be studied, but it is the dynamics of processes that are likely to attract considerable interest in the coming years. It is exciting to witness new developments, such as the free electron laser, continuing to open up new avenues of research.

References

[1] Shi Y 2014 Life, career and structural biology *Phys. Scr.* **89** 068004
[2] Allen R 2014 From crystallography to life *Phys. Scr.* **89** 068005
[3] Gatti C 2013 Challenging chemical concepts through charge density of molecules and crystals *Phys. Scr.* **87** 048102
[4] Spackman M A 2013 Molecules in crystals *Phys. Scr.* **87** 048103