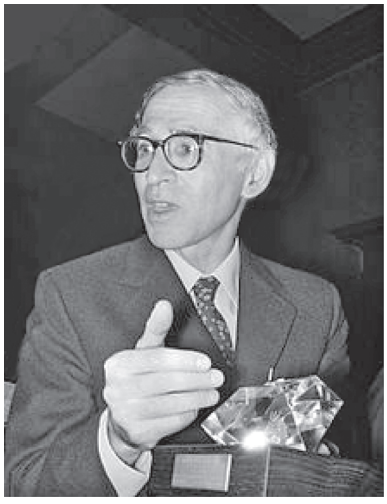
Notes and News

Sir Aaron Klug, NL, The Discoverer of Crystallographic Electron Microscopy, Passes Away

Dubbed 'one of the mildest, most broad-minded and most cultured of scientists', Aaron Klug, who was awarded the Nobel Prize in Chemistry in 1982 for "*his development of crystallographic electron microscopy and his structural elucidation of biologically important nucleic acid-protein complexes*," died on November 20, 2018 at the age of 92 years.

Klug was born on 11th August, 1926 in •elva, Lithuania to Jewish parents Lazar Klug, a cattleman, and Bella (née Silin) Klug. His family moved to South Africa when he was two years old. He had his early education in Durban High School. He received his B.Sc. degree with a first class Honours from the University of the Witwaterstrand and his M.Sc. degree in Physics from the University of Cape Town.



Sir Aaron Klug, NL (1982)
(11.08.1926-20.11.2018)

In 1949, Klug moved to England with his newly married (1948) wife, Liebe (née Bobrow) with a '1851 Research Fellowship from the Royal Commission for the Exhibition of 1851' to join the Cavendish Laboratory, Department of Physics, Cambridge University. Having worked on a theoretical project on how transitions occur in the microstructure of steel when it cools, he received his Ph.D. degree in Physics in 1953 from the Trinity College, Cambridge.

In late 1953, he moved to the Birkbeck College, University of London where he started collaborating with the X-ray crystallographer Rosalind Franklin on her studies on tobacco mosaic virus. The combined commendable technical skill of Franklin in producing X-ray diffraction images and deep theoretical understanding of matter by Klug led to the determination of the general outline of the structure of this virus just before the untimely demise of Franklin from cancer in 1958. Klug always acknowledged the help that he received from Rosalind in this domain of research.

In 1962, Klug joined the newly founded MRC Laboratory of Molecular Biology (LMB) in Cambridge where he used X-ray diffraction methods, microscopy and structural modelling to develop 'crystallographic electron microscopy' (CEM) in 1968. Electron microscopy (EM) produces two-dimensional images that do not reveal detailed structural information. In CEM, a sequence of two-dimensional images of crystals, taken from different angles, are combined to produce three-dimensional images of a target. Using this technique, he studied the structure of 'transfer RNA' (a type of RNA that decodes the message for producing a protein) and chromatin (that holds the long strands of DNA within a nucleus), discovered (1985) 'zinc fingers' (molecular motifs that can bind to specific DNA sequences) and studied neurofibrils (tangles of proteins) associated with Alzheimer's disease. It was this work on the application of CEM to unravel complexes of protein and nucleic acid in viruses and chromosomes (that carry genetic information) that brought Klug the Nobel Prize in Chemistry in 1982.

Klug was the Director of the LMB in Cambridge during 1986-1996 when he played a key role in establishing the Wellcome Sanger Institute, England which completed nearly one-third of the sequencing of the Human Genome Project. He was knighted in 1988. He was the President of the Royal Society during 1995-2000 where he encouraged the science community to engage in public debates on topics of public concern like embryonic stem cell research, genetically modified food and climate change.

Three Vice-presidents admired Klug: "*Aaron Klug brings to the Presidency intellectual rigour and integrity, penetrating insights and knowledge of a staggering array of fields, both scientific and cultural*."

In a tribute, Venki Ramakrishnan, Nobel Laureate (2009) and President of the Royal Society (since November, 2015), called Aaron Klug a "*giant of 20th-century molecular biology who made fundamental contributions to the development of methods to decipher and thus understand complex biological structures*." Klug also served on the Advisory Council for the Campaign for Science and Engineering and on the Board of Scientific Governors at the Scripps Research Institute.

In essence, Klug was the pioneer in what is currently known as structural biology. The demise of this great scientist, who was a gifted teacher with a phenomenal memory and an encyclopaedic knowledge, is deeply mourned among the scientific community in general and the global community of structural biologists in particular.

Klug is survived by his wife, a son (David; another son Adam died in 2000) and four grandchildren. ❐

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Demise of Thomas A. Steitz, NL Who Mapped Ribosome

Thomas Arthur Steitz, who shared the Nobel Prize in Chemistry for 2009 with V. Ramakrishnan (MRC Laboratory of Molecular Biology, Cambridge) and Ada E. Yonath (Weizmann Institute of Science, Rheovot, Israel) for elucidating the structure and function of ribosome, died of pancreatic cancer on October 9, 2018 at his home in Branford, Connecticut, U.S.A.

Steitz was born in Milwaukee, Wisconsin, U.S.A. on the 23rd August, 1940. At the age of 9, his family moved to Wauwatosa, a suburb of Milwaukee. He had his early education at Wauwatosa High School. With a scholarship he then moved to Lawrence College, Appleton, Wisconsin, from where he graduated in 1962. He then studied at Harvard University, from where he received his Ph.D. degree in Biochemistry and Molecular Biology in 1966. At Harvard, Steitz worked under the supervision of Wiilliam N. Lipscomb who later got the Nobel Prize in Chemistry for 1976. Steitz spent a year there as a postdoc.

At Harvard two consequential events took place in the life of Steitz. Firstly, he heard in 1963 a lecture by Max Perutz (NL 1962 for Chemistry) on his discovery of how to determine the positions of all the atoms in large protein molecules. This lecture 'changed his life'. Secondly, it was at Harvard where Steitz met Joan Argetsinger, whom he married, while they were both graduate students in biochemistry and molecular biology. Joan was also a celebrated biochemist and biophysicist. Pertinently, an article published later in 2015 in *Hartford-Courant* marked Thomas and Joan Steitz as "*one of the great power couples of science*."

T.A. Steitz, NL (2009)
(23.08.1940-09.10.2018)

He then pursued postdoctoral research (1967-1970) at the Laboratory of Molecular Biology at Cambridge, England where he had the company of giant molecular biologists and biophysicists like Francis Crick (NL 1962 for physiology or medicine), Sydney Brenner (NL 2002 for physiology or medicine), Frederick Sanger (NL 1958, 1980 for chemistry) and Richard Henderson (NL 2017 for chemistry). Daily discussion with these stalwarts was a '*transforming experience*' for Steitz.

In 1970, Steitz became an Assistant Professor at the University of California, Barkeley. But he resigned shortly thereafter. In the same year, he moved to the Yale University where both he and his wife Joan became Faculty Members. He continued to work on cellular and structural biology. It was in Yale where he, along with Peter Moore, used X-ray crystallography to determine the large 50S ribosomal subunit and published their findings in *Science* in 2000. For this work, Steitz was awarded the Nobel Prize. His co-sharers of the Nobel Prize, Venki Ramakrishnan and Ada Yonath, solved the structures of ribosome's small subunit.

The structure of ribosome tells you how a protein is made, since ribosome converts the DNA sequences of genes into a sequence of amino acids, the building blocks of proteins. One immediate application of Steitz's discovery was in understanding how a major set of antibiotics (that poison bacterial ribosomes) work, thus offering clues to finding antibiotics that can evade drug-resistant bacteria.

Steitz made many other significant contributions, for which, according to a fellow biophysicist in Yale, "*he could have been given three Nobels. Even if he had never done the ribosome, if there was something called the career Nobel prize he would have been a winner*."

Dr. Steitz is survived by his wife, a son, two grandchildren and four siblings. ❐

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Demise of Osamu Shimomura, NL, The Discoverer of Green Fluorescent Protein

Osamu Shimomura, who shared the 2008 Nobel Prize in Chemistry with Martin Chalfie (Columbia University) and Roger Y. Tsien (University of California, San Diego), for "*for the discovery and development of the green fluorescent protein (GFP)*", passed away on Friday, the 19th October, 2018 at his residence in Nagasaki, Japan.

O. Shimomura
(27.08.1928-19.10.2018)

Shimomura was born on the 27th August, 1928 in Fukuchiyama, Kyoto-Fu, Japan. His childhood in Japanese-occupied Manchuria, China (since 1933) and later in Osaka, Japan and his school education were severely affected by World War II especially because his father was an Army Captain. He completed his school education at the age of 16 when he was living with his grandparents in Isahaya near Nagasaki. He was a witness to the dropping of atom bomb on August 9, 1945 at Nagasaki. He described his own experience of this incidence in his Nobel autobiography. His grandmother made him take a quick bath after the bomb was dropped, which, he believed, saved him from the short and long term radiation effects of the resulting black rain.

Shimomura graduated from Nagasaki Pharmacy College (which later became the Pharmacy Department of Nagasaki University) in 1951 securing the top position and then worked as an Assistant in the Analytical Chemistry Department of Nagasaki University. In 1955, he moved to Nagoya University where his mentor, Professor Yoshimasa Hirata, assigned to him a seemingly difficult task – to crystallise luciferin, a fluorescent (under UV light) metabolite of *Cypridina* sp., a small crustacean found in shallow coastal waters of Japan. But Shimomura accomplished the task in ten months, thus ending a twenty year-old failed attempt by E.N. Harvey, a renowned zoologist at Princeton. Shimomura earned his Ph.D. degree in 1959 on his work on luciferin.

He married Akemi Okubo, a graduate of the Pharmacy Department, in August, 1960 and moved to Princeton University, U.S.A. where he studied bioluminescent jelly fish. In the 1960s and mainly in the 1970s, Shimomura collected a large amount of the floating jelly fish, *Aequoria* sp., from which he was able to isolate and purify the photoproteins 'aequorin' and the 'Green Fluorescent Protein' (GFP). In 1979, he elucidated the chromophore of GFP. In 1981, he moved to the Marine Biological Laboratory (MBL) at Woods Hole, Massachusetts as a Senior Scientist. Pertinently, MBL is the oldest (established in 1888) marine laboratory in the western hemisphere.

Shimomura retired from the MBL in 2001. Thereafter he moved all his laboratory equipment and chemicals to his home where he set up his Photoprotein Laboratory. His retirement symposium, "GFP and Aequorin," was held at the MBL in 2002, where Chalfie and Tsien, his would be co-winners of the Nobel Prize, were also present. He received, *inter alia*, the Pearse Prize (2004), the Asahi Prize (2006) and the Nobel Prize (2008) for Chemistry, and published a book, *Bioluminescence: Chemical Principles and Methods* (World Scientific Press, 2006).

Other scientists subsequently determined the gene that produces GFP and were able to incorporate it into the DNA of other organisms so that these fluorescent proteins can be seen under a microscope. Since its discovery, GFP has been used to visualise many different processes within cells to study everything from embryonic development to cancer. In 2017, Shimomura published an autobiography, *Luminous Pursuit: Jellyfish, GFP, and the Unforeseen Path to the Nobel Prize*. Shimomura will always be remembered not only for his work on GFP but also for "*his intense dedication and masterful work on a fundamental problem in biology — how can different organisms generate light?*"

Dr. Shimomura is survived by his wife, a brother, a sister, a son, a daughter and two grandchildren. ❐

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From Chidambaram to Cambridge: A Life in Science

Dr Venkatraman Ramakrishnan, the 2009 Nobel Laureate structural biologist from MRC Laboratory of Molecular Biology, Cambridge, UK gave a lecture at Presidency University (PU), Kolkata on 22/1/2019. It was organized by Department of Life Sciences, PU and his lecture entitled 'From Chidambaram to Cambridge: A Life in Science'. Dr Ramakrishnan briefly focused on his Book 'Gene Machine - The race to decipher the secrets of ribosomes' and discussed his journey and work on elucidation of atomic structure and function of ribosomes.

Audience were provided a detailed understanding of ribosomes, which, in words of Dr Ramakrishnan, are large translating machine that reads information in one type of biological polymer and makes the large protein polymer that gene codes for. He further explained that ribosomes as chemical units construct the products that genes specify to develop every life form. Almost every molecule in our cells is made up of ribosomes or made by enzymes which were themselves made by ribosomes. He explained the concept of DNA; estimated number of genes and genome size in sequenced organisms; how order of amino acids (aa) in polypeptide chain orders its falling up into different structures; bonding pattern between bases leading to correct shape of aa; how 20 types of aa in protein is formed from 4 types of bases; transformation of language of genes to proteins; specific functions of mRNA, tRNA and rRNA; salient aspects of Central Dogma. He explained the function of three types of proteins, *viz.* collagen that makes up our skin cartilage; haemoglobin that carries O_2 from lungs to blood and different tissues and rhodopsin, which sits in cell membrane of our retina and senses light. Each of many proteins, carrying out different functions of life, is made by following instructions encoded in our genes.

Dr Ramakrishnan spoke about initial interest in studying 30S subunit of ribosomes; presence of 50 proteins and 3 large RNA in bacterial ribosomes; his journey to USA to do PhD in Physics; spending five years at Ohio University (1971-1976); going to UG School at University of California, San Diego to study cell biology, genetics and biochemistry. He went through every issue of Scientific American (SA) during his PhD, which reported breakthrough in biology. At time of his starting over to biology, he gained enthusiasm after reading article of D. Engelman and P. Moore on ribosomes in SA. He spoke about his initial conversation with them at Yale University when he was Graduate student; his opportunity to work as post-doctoral researcher in ribosome project; interest to find out arrangement of proteins in ribosomes by macromolecular crystallography, *i.e.*, recombination of rays scattered from crystal to form an image in computer, its measurement and data collection; going to the 'mecca' of crystallography at MRC Laboratory of Molecular Biology in Cambridge, England in 1991 and his correspondence with Sir Aaron Klug; starting the 30S project (it contained 1,50,000 atoms) at University of Utah aiming at high-resolution (hr) structure of 30S subunit and his return to MRC laboratory in 1999.

In order to study on how ribosomes (containing 0.5 million atoms) work, he started tackling the structure of the small 30S ribosomal subunit, studying individual structures of pieces of ribosomes separately and mapping the location of proteins in it. According to him, hr structures of entire ribosome were required in many states to understand the underlying mechanisms of translation in protein synthesis. He focused on work of Ada Yonath in revealing atomic structure of 50S crystal of ribosome; absence of expert crystallographic colleague and powerful sources of X-rays called synchrotrons as limitations on working on whole ribosome structure; use of X-ray crystallography to solve increasingly hr structures of different ribosomes; working of crystallography that comprised pieces of image of helical stretch of RNA, arriving at its chemical structure and interpretation; functional sites of ribosomes made of RNA; seeing antibiotics bound to 30S subunits and investigations on how antibiotics work against bacteria. Many antibiotics kill

bacteria by blocking the bacterial version of ribosomes but not affecting the human version.

At last, the nature of 30S subunit of ribosome was established and studies on mapping of its hr atomic structure, also that of 50S subunit, was published in 2000. Dr Ramakrishnan stated that scientists are motivated by curiosity, ambition, vision, desire to succeed and self-interest; emphasized on commitment to science, importance of working on a problem, taking care of our interests; spoke about great Indian scientists who studied at PU and fondly remembered people who gave him technical advice and helped preparing reagents. ❐

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100 Years of IUPAC: Celebrations in 2019

The word 'IUPAC' is almost synonymous with 'IUPAC nomenclature' to the school students of science. But many of them are not fully aware of many facets of IUPAC, viz. its full form, when was it established, what is its purpose, what are its contributions, what are its promises for the chemists and the society. Since IUPAC is going to celebrate its 100th year of existence this year (2019), it is time to briefly reiterate the aforesaid details about IUPAC.

The full form of IUPAC is International Union of Pure and Applied Chemistry. In the early part of the 20th century, communication across the global chemical communities was becoming increasingly troublesome primarily because multiple names appeared for many single compounds, which posed severe problems. The initial objective of the IUPAC was, therefore, to develop a universally accepted norm of naming chemical compounds, hence 'IUPAC nomenclature'. The second goal of the IUPAC was 'to develop standards and norms for the calibration and normalisation of chemical substances'.

In order to materialise these objectives, a group of visionary chemists from Belgium, France, Italy, U.K. and the U.S.A. created IUPAC which was formally registered on July 28, 1919. The post-World War I era created a third objective of the IUPAC, viz. 'to address the peacetime role of chemistry and the societal benefits that it is likely to offer'. Since creation, IUPAC has indeed 'nurtured an international community that has dealt with all aspects of pure and applied chemistry'. Every two years, the members of the IUPAC assemble together to find out solutions to the then existing problems in chemistry and chemical industries. The results are published in the journal *Pure and Applied Chemistry*.

Logo of IUPAC Centenary Celebrations

IUPAC is going to celebrate its centenary in its 47th World Chemical Congress (WCC) (July 7-12, 2019) and its 50th General Assembly (July 5-11, 2019) at the Palais des Congrès, Paris. The anniversary theme is '**Creating a Common Language for Chemistry**'. The International Advisory Board comprises reputed chemists from Brazil, China, France, Germany, India, Israel, Japan, New Zealand, Russia, Switzerland, Taiwan, U.K. and the U.S.A. The main themes of the WCC are (i) Chemistry for Life, (ii) Chemistry for Energy and Resources and (iii) Chemistry for Environment. Professor Adriano Andricopulo of IFSC/USP, Brazil, and Professors K.D.P. Nigam, I.I.T., New Delhi and C.N.R. Rao, JNCASR-Bangalore from India are, *inter alia*, members of the International Advisory Board.

In his welcome address, Professor Clément Sanchez, Chair of IUPAC-2019 WCC and Centenary Events, informed that special events during the celebration will comprise a Celebration Special Session, a celebratory Evening, a Celebration Gala Dinner and an official Ceremony at the Sorborne. Some 30 symposia and a Young Scientists programme are planned. Nearly 260 Invited Lectures, 900 Oral Presentations and 2/3 sessions covering 1,000 Poster Presentations will be there. Five Nobel Laureates are scheduled to grace the celebrations by their presence.

IUPAC is also going to undertake various other events (https://iupac.org/100/). (1) Since the year 2019 has also been declared the International Year of The Periodic Table (IUPT-2019), a worldwide online competition for young students centred on the Periodic Table and IUPAC is going to be held. IUPAC will honour 118 winners who will be profiled on 'IUPAC100'. (2) '*Empowering Women in Chemistry: A Global Networking Event'* – To highlight the contribution of women to chemistry during the last 100 years, a Global Women's Breakfast event was launched in the University of Auckland, New Zealand on Feb. 12, 2019. It is scheduled to progress through the Asia-Pacific region into Europe, Africa and finally onto the American

region. (3) A series of stories highlighting the essential IUPAC tools, developed during the last 100 years, have already been launched. Seven stories have been released so far. (4) A '*Post Graduate Summer School in Green Chemistry*', with a focus on teaching Green Chemistry and its role in sustainable development, is going to be held in Tanzania, Africa in May, 2019. (5) IUPAC members and chemists worldwide will create a virtual handshake using social media on an '*IUPAC International Day*'. (6) Following a worldwide competition ending on Feb. 1, 2017, a logo for the IUPAC centenary celebrations (shown above) has been chosen.

The IUPAC Centenary celebrations are aimed not only to commemorate its past contribution to the society, but also to advocate the importance of science literacy to students worldwide, inspire younger generations to become involved in innovative futuristic chemistry, and to have a positive influence on the public's perception of science in general and chemistry in particular.

IUPAC will continue to be an indispensable resource for chemistry. ❐

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Seminar on "Presidency, Jagadish Chandra and X-rays"

The Department of Physics of Presidency University organizes weekly lectures by eminent scientists on every Wednesday. Prof. S.C. Roy, Editor-in-Chief, Science and Culture, Indian Science News Association, delivered a lecture on "*Presidency, Jagadish Chandra and X-rays*" at the Amal Kumar Raychaudhuri Lecture Theatre of Presidency University on January 30, 2019. Prof. Roy started his lecture with the historical introduction of development of modern science education and research in Bengal and the role played by the Presidency University starting from its establishment as Hindoo College. He also spoke about Acharya Jagadish Chandra Bose and his work on X-ray research which he had done in Presidency College itself.

Prof. Roy presented the history of Hindoo College which was established in 1817 by the influential Hindus of Calcutta, after the approval obtained from East India Company government. Hindoo was later spelt as 'Hindu' and the Hindoo College was renamed Presidency College in 1855 and finally Presidency University in 2010. Hindu College was started with only 20 students and at that time the college charged a fee of Rs.5/- per month! During his talk Prof. Roy also provided many interesting facts about science education in colonial India. One of which was that John Mack of Serampore College actually wrote the first book on chemistry in Bengali in 1894 under the title 'Kimiya Vidya Sar'.

Prof. Roy also addressed the establishment of research institutes in India, starting from the Asiatic Society in 1784 by William Jones. The first research paper of J.C. Bose titled "On polarisation of electric rays by double-refracting crystals" was published in this journal in 1895. According to Prof. Roy, Jagadish Chandra was a life-ling warrior who fought against colonial bureaucracy, against unjust treatment received from scientific peers abroad and from his own scientific compatriots. His struggle started as soon as he joined the Presidency College, where he was given one-third salary compared to what was given to a European professor. He protested and refused to accept salary for a few years. Later, in 1903, after a knighthood and other honors, he was admitted to the European scale of pay. J.C. Bose established his own institute after retiring from Presidency to do research independently but continued to receive resistance from different quarters, even from his own friends and colleagues.

In the next part of his lecture Prof. Roy spoke about the discovery of X-rays and the history of X-ray research in India. However, his emphasis was on J.C. Bose's work on X-ray research, which was not fully known to many of us. Wilhelm Conrad Roentgen has been credited with the discovery of X-rays in 1895 while he was experimenting with a discharge tube. However X-rays were produced even before the discovery of X-rays! This is not surprising because anyone involved in studying discharge of gases unknowingly produced X-rays. Philipp Lenard in fact went very close to the discovery of X-rays, and both Lenard and Roentgen were nominated for the Nobel Prize in Physics for the year 1901, and the Committee recommended that the prize should be divided equally between the two. However, the Royal Academy of Science did not follow the recommendation of the Committee and decided to award the prize to Roentgen. Lenard was given the Nobel Prize in 1905 for his work on cathode rays.

Within six months of the discovery of X-rays, Mahendralal Sircar, the founder of the Indian Association for the Cultivation of Science, imported an X-ray tube and within ten days he made all arrangements to use the machine. He took the first successful X-ray photograph on June 23, 1896. It was amazing to note how the science-

loving people of India even at that time were interested in new discovery. We all know about J.C. Bose's work on microwave and plant physiology. But very few people know about his work on X-rays. He was the first person in India who built an improved Roentgen's apparatus at Presidency College in 1897. The first recorded evidence of this X-ray apparatus was obtained from a letter written in 1898 to Rabindranath Tagore. A Press Report published in the May 5, 1898 edition of the Amrita Bazar Patrika also vividly reported the demonstration Jagadish Chandra exhibited. It is to be noted that the apparatus developed by Jagadish Chandra was not the replica of the apparatus used by Roentgen. This was an improved apparatus capable of producing higher voltage yielding good picture. Prof. Roy also spoke about the X-ray diffraction research by C.V. Raman, Ramanathan, Krishnamurti and Bidhubhusan Ray. It was also interesting to know that S.N. Bose also worked on X-rays. He established X-ray research laboratory at Dhaka University and later joined Calcutta University and took charge of the X-ray laboratory after the premature death of B.B. Ray.

During his presentation Prof. Roy also showed few rare X-ray photographs. The lecture was presented in a very simple way to make it interesting to the audience. ❐

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