The Shaw Prize

The Shaw Prize is an international award to honour individuals who are currently active in their respective fields and who have recently achieved distinguished and significant advances, who have made outstanding contributions in academic and scientific research or applications, or who in other domains have achieved excellence. The award is dedicated to furthering societal progress, enhancing quality of life, and enriching humanity's spiritual civilization.

Preference is to be given to individuals whose significant work was recently achieved and who are currently active in their respective fields.

Founder of The Shaw Prize

Mr Shaw, born in China in 1907, was a native of Ningbo County, Zhejiang Province. He joined his brother's film company in China in the 1920s. During the 1950s he founded the film company Shaw Brothers (HK) Limited in Hong Kong. He was one of the founding members of Television Broadcasts Limited (TVB) launched in Hong Kong in 1967. As an established figure in the film and media industry, Mr Shaw gained insight into the needs of the people, and as a visionary he saw how, in addition to the fleeting escapism of entertainment, the more substantial benefits of education and healthcare would greatly impact lives for the better. He established two charities: The Shaw Foundation Hong Kong and The Sir Run Run Shaw Charitable Trust, both dedicated to the promotion of education, scientific and technological research, medical and welfare services, and culture and the arts.

The Shaw Foundation quickly gained momentum in a wide range of philanthropic work: supporting educational institutions as well as hospitals and clinics in Hong Kong, the rest of China and beyond. Expanding his vision into new areas convinced him that the quest

Mr Run Run Shaw

for knowledge is key to sustaining the advancement of civilization, and strengthened his belief that scientists focussed on unmasking the mysteries of nature are pivotal to the well-being of mankind. He decided to use his modest influence, by establishing the Shaw Prize, to inspire and recognize imaginative individuals committed to scientific research and to highlight their discoveries. The Award continues to gain in stature, casting a beam of recognition on outstanding scientific achievements, and firing the imagination of pioneers who follow him in spirit and in deed, sustaining the continued success of the Shaw Foundation and the Shaw Prize Foundation as lasting tributes to his wisdom and generosity.

Messsage from the Chief Executive

My congratulations to this year's Shaw Laureates for their groundbreaking achievements in astronomy, life science and medicine, and the mathematical sciences.

Five extraordinary individuals are being honoured this year: two share The Shaw Prize in Life Science and Medicine, two receive the Mathematical Sciences award; and one has been awarded The Shaw Prize in Astronomy. Together, they extend our frontiers of knowledge. The explanatory research on quorum sensing, the development of fundamental tools in number theory, and the continuing discovery of earth-like planets orbiting stars outside our solar system have far-reaching impact on the advancement of humanity and civilisation in general.

The Shaw Prize, one of the world's most prestigious awards for scientific accomplishment, is now in its 12th year. It was established by entrepreneur and philanthropist Run Run Shaw, whose far-sighted commitment to research excellence, innovation and quality of life continues through The Shaw Prize.

The Honourable C Y Leung

I wish the five Shaw Laureates of 2015 all the best in their research and professional pursuits. And I look forward to more trailblazing progress from them, and from those inspired by their work, in the years to come.

C Y Leung
Chief Executive
Hong Kong Special Administrative Region

Message from Chairman of the Board of Adjudicators

Welcome to the twelfth annual Shaw Prize Award Presentation Ceremony. The three scientific fields covered by The Shaw Prizes, namely, Astronomy, Life Science and Medicine, and Mathematical Sciences, have all made spectacular progress in recent years. Tonight we honour five scientists in these three fields for their distinguished contributions.

The Shaw Prize was established in 2002 under the auspices of Mr Run Run Shaw to honour individuals, regardless of race, nationality, gender and religious belief, who have achieved significant breakthroughs in academic and scientific research or applications and whose work has resulted in a positive and profound impact on mankind.

The first Shaw Prize Award Presentation Ceremony took place in 2004. Since that time, including this year's awards, there have been altogether thirty-seven Shaw Prizes awarded to sixty-five scientists in these three fields.

The Shaw Prize is proud to play a role in recognizing revolutionary advances in these vibrant and productive areas of modern scientific research.

Chen-Ning Yang
Chairmen, Board of Adjudicators
Shaw Prize 2015

The Shaw Prize Medal

The front of the medal displays a portrait of Run Run Shaw, next to which are the words and Chinese characters for the title of "The Shaw Prize". On the reverse, the medal shows the award category, the relevant year and the name of the prizewinner. A seal of imprint of the Chinese phrase "制天命而用之" (quoted from Xun Zi – a thinker in the warring states period of Chinese history in 313 – 238 BCE) meaning "Grasp the law of nature and make use of it" appears in the upper right corner.

AGENDA

Arrival of Officiating Guest and Laureates

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Welcome Speech by Professor Kenneth Young

Member of the Council

Vice Chairman of the Board of Adjudicators, The Shaw Prize

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Speech by Professor Peter Goldreich

Member of the Board of Adjudicators

Chairman of the Selection Committee for the Prize in Astronomy

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Speech by Professor Yuet-Wai Kan

Member of the Board of Adjudicators

Chairman of the Selection Committee for

the Prize in Life Science and Medicine

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Speech by Professor Peter C Sarnak

Member of the Board of Adjudicators

Chairman of the Selection Committee for

the Prize in Mathematical Sciences

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Award Presentation

Grand Hall

Hong Kong Convention and Exhibition Centre

24 September 2015

AWARD PRESENTATION

(Category listed in alphabetical order)

Astronomy

Mr William J Borucki

Life Science and Medicine

Professor Bonnie L Bassler

and

Professor E Peter Greenberg

Mathematical Sciences

Professor Gerd Faltings

and

Professor Henryk Iwaniec

Professor Peter Goldreich

Member of the Board of Adjudicators
Chairman of the Selection Committee for the Prize in Astronomy

Professor Peter Goldreich is the Lee A DuBridge Professor of Astrophysics & Planetary Physics Emeritus at the California Institute of Technology in Pasadena, California.

He received a PhD from Cornell University in 1963. After spending one year as a postdoc at Cambridge University and two as an Assistant Professor at the University of California, Los Angeles, he joined the Caltech faculty as an Associate Professor in 1966. He was promoted to Full Professor in 1969 and remained at Caltech until he retired in 2002. Subsequently, he was appointed Professor in the School of Natural Sciences at the Institute for Advanced Study in Princeton from which he retired in 2009. Professor Goldreich is a Member of the US National Academy of Sciences and a Foreign Member of the Royal Society of London. His awards include the Henry Norris Russell Lectureship of the American Astronomical Society, the US National Medal of Science, the Gold Medal of the Royal Astronomical Society, the Grande Medaille of the French Academy of Sciences, and the Shaw Prize. Professor Goldreich's research involves the application of physics to the understanding of natural phenomena, in particular those revealed by astronomical observations.

The Prize in Astronomy 2015

William J Borucki

for his conceiving and leading the Kepler Mission, which greatly advanced knowledge of both extrasolar planetary systems and stellar interiors

An Essay on the Prize in Astronomy 2015

Thirty years ago, William Borucki and Audrey Summers published a paper assessing the potential for detecting extrasolar planetary systems by transit photometry. The key concept is to simultaneously monitor the brightness of a large number of stars with a high-precision photometer. Planets are revealed by the dips in brightness they produce when they pass in front of (transit) their host stars. Successive transits by a planet are spaced by its orbit period, which helps to distinguish transits from other sources of stellar variability. Transit depths determine the ratio of the planet's surface area to that of its host star. Borucki and Summers emphasized that detection of Earth-size planets would require observations from above the atmosphere.

Subsequently, Borucki began a long quest to develop a suitable photometer and to convince the astronomical community and the US National Space and Aeronautics Administration (NASA) that a modest space mission could discover planets potentially capable of harbouring life. Four proposals submitted between 1992 and 1998 were rejected before the fifth was selected in December 2001 as Discovery Mission #10. Mission development began in 2002 and launch occurred in March 2009.

Five years after launch, the Kepler Mission has detected over four thousand planet candidates and confirmed more than one thousand. Analysis of these data shows that most stars have planets and that small Earth-size planets are common.

An important milestone in gaining acceptance for the Kepler Mission was the demonstration that photometry from space would be precise enough to detect Earth-size planets transiting Sun-size stars. Since Earth's radius is about one hundredth of Sun's radius, this requires measuring brightness variations smaller than one part in ten thousand. Kepler routinely achieves higher precision and as a result has discovered planets even smaller than Earth.

Kepler also accomplished an important secondary goal, the precise measurement of photometric variations due to stellar oscillations. Determination of oscillation frequencies informs us about stellar ages, masses, radii, and internal rotation rates.

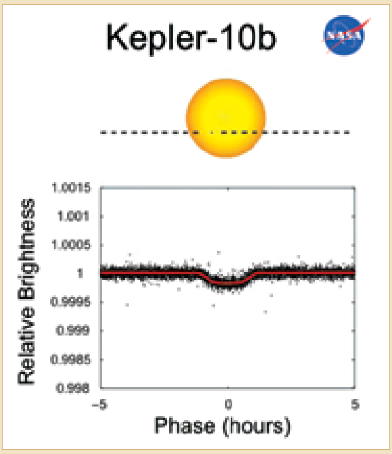


Fig 1: Transit geometry of Kepler 10b, the first rocky planet Kepler discovered. Planet parameters: $P = 0.84$ d, $M_P \approx 4.6M_{\oplus}$, $R \approx 1.4R_{\oplus}$. The gravitational acceleration on the surface of this planet is similar to that on Earth but the temperature is much too high for liquid water to exist.

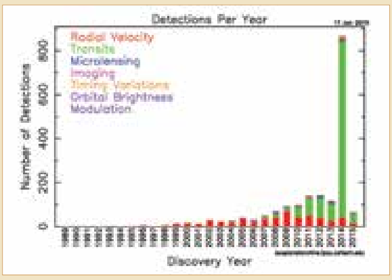


Fig 2: Pace of Exoplanet Discoveries. Early discoveries made by radial velocities measured from the ground mainly found giant planets. Transits detected from space discovered planets with a wide range of sizes, including some even smaller than Earth. To a considerable extent, the peak rate of discovery in 2014 is due to the introduction of a statistical method that validates large groups of candidates identified in previous years.

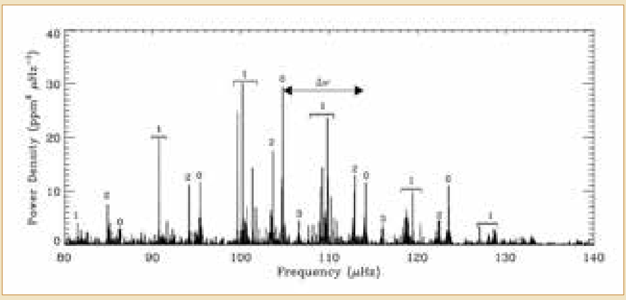
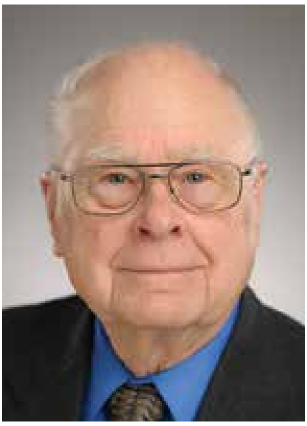


Fig 3: Asteroseismology Spectrum of HD 186355 (Modeling Kepler Observations of Solar-like Oscillations in the Red Giant Star HD186355. C Jiang et al. 2011, ApJ, 742, 120, 2011): The discrete peaks at particular frequencies are akin to the individual notes a piano can play. Knowledge of these frequencies provides information about the interior of the star that otherwise is hidden from our view.

William J Borucki
Laureate in Astronomy



I was born in Chicago, Illinois in 1939 to Steven and Anna Borucki. When I was two years old, we moved to Delavan Wisconsin where I grew up enjoying starry skies, the freedom to build things, and a great nearby library. As a boy, I built model airplanes, launched homemade rockets, built radios, and became a radio amateur. My brother and friends were interested in astronomy. We sometimes visited nearby Yerkes Observatory to look at Mars through its giant refractor.

My graduate and undergraduate studies were conducted at the University of Wisconsin, Madison. After receiving a BSc and MSc degrees in physics in 1960 and 1962, I joined the Hypersonic Free Flight Branch at the NASA Ames Research Center in California to participate in the great race to the Moon.

At Ames I helped develop the heat shield for the Apollo missions to the Moon. From 1962 through 1972, I conducted laboratory and theoretical studies of the radiation and plasma environments of entry vehicles. During this period, I developed spectroscopic instrumentation to determine the plasma properties of hypervelocity shock waves. The use of a large grating and a state-of-the-art reconnaissance lens allowed the derivation of the state properties of plasmas to be derived from line broadening and intensity ratios of atomic lines with only a 200 nanosecond exposure.

After the successful Moon landings, I transferred to the Theoretical Studies Branch where I developed mathematical models of the Earth's stratosphere to predict the effects of nitric oxides and chlorofluoromethanes on the ozone layer. I also used the opportunity to investigate the effects of lightning activity in the atmospheres of Earth, Venus, and Jupiter. I also conducted laboratory measurements and developed instrumentation to determine the optical efficiency of lightning in each type of atmosphere and used these in conjunction with spacecraft observations to deduce the lightning-energy available to produce molecular species. At the invitation of the Principal Investigator for the Huygens-Cassini Mission to Saturn and Titan, I was appointed a co-investigator on the Atmospheric Structure Experiment carried by the Huygens entry probe. During this period I found time to earn a MSc degree in meteorology from San Jose State University.

In 1983, I began advocating the development of a space mission that could detect Earth-size planets and determine the frequency of Earth-size planets in the habitable zone of Sun-like stars. My first paper (1984) showed that a space-based photometer should be able to detect Earth-size planets if a photometer could be developed that was a 1000 times more precise than any previous photometer and if it could observe tens of thousands of stars simultaneously. The second paper showed that all stars must be regarded as variable at the precision required to detect Earth-size planets. In the succeeding years I visited observatories to determine the capabilities of their photometers and what processes limited the precision of their photometry. I also held workshops to investigate the most promising approaches to building a photometer with the required precision. In conjunction with scientists at the National Institute of Science and Technology, several multi-channel photometers were built and tested. Tests of CCD detectors proved that they had the necessary precision if the systematic errors were measured and corrected. To demonstrate that high precision, automated photometry of thousands of stars could be done simultaneously, my team built an automated photometric telescope and installed it at a small, unused dome at Lick Observatory on Mount Hamilton, California. Nightly observations were radio-linked to Ames where a data analysis pipe-line was developed to do automated photometry. Science team members analyzed the results and conducted follow-up observations at other ground-based telescopes; just as they would do in the future for the Kepler Mission results.

To complete the demonstration that the technology needed to accomplish the detection of Earth-sized transits was sufficiently mature to start the development of a space mission, a $1M end-to-end simulation testbed was built. It used currently-available CCD detectors (not those imagined to exist in the future), vibrated a miniature telescope at the frequencies that the actual instrument would experience when in orbit, and demonstrated the detection of 80 part-per-million transits associated with Earth-size transits. The demonstrations showed that appropriate detectors existed and that a photometer could be built that monitored many thousands of stars simultaneously with the precision to detect Earth-size planets. In 2001, my proposal to the NASA Discovery Program for the Kepler Mission was competitively selected from a group of 26 proposals for funding and I was appointed its Principal Investigator. During the four years of its operation, the Kepler Mission discovered over 4,600 planetary candidates, confirmed more than 1000 as planets, and made numerous contributions to stellar astrophysics, especially with respect to asteroseismic investigations of evolving stars. Worldwide, over 1,000 scientists are involved in analyzing, interpreting, and publishing the Mission results. Currently I am doing research on exoplanets at the Ames Research Center as an Ames Associate.

Professor Yuet-Wai Kan

Member of the Board of Adjudicators
Chairman of the Selection Committee for the Prize in Life Science and Medicine

Professor Yuet-Wai Kan is currently the Louis K Diamond Professor of Hematology at the University of California, San Francisco and he focuses his research on the use of gene and cell therapy to treat sickle cell anemia and thalassemia. Professor Kan was born in Hong Kong, graduated from the Faculty of Medicine at the University of Hong Kong and trained at Queen Mary Hospital, Hong Kong, before going to the United States for further studies.

Professor Kan's contributions led to the innovation of DNA diagnosis and the discovery of human DNA polymorphism that have found wide application in genetics and human diseases. For his work, he has received many national and international awards including the Albert Lasker Clinical Medical Research Award, the Gairdner Foundation International Award and the Shaw Prize. He is the first Chinese elected to the Royal Society, London, and is a Member of the US National Academy of Sciences, Academia Sinica, the Third World Academy of Sciences and the Chinese Academy of Sciences. He has received honorary degrees from The University of Caglieri, Italy, The Chinese University of Hong Kong, The University of Hong Kong and The Open University of Hong Kong.

The Prize in Life Science and Medicine 2015

Bonnie L Bassler

and

E Peter Greenberg

for elucidating the molecular mechanism of quorum sensing, a process whereby bacteria communicate with each other and which offers innovative ways to interfere with bacterial pathogens or to modulate the microbiome for health applications

An Essay on the Prize in
Life Science and Medicine 2015

As implied in the term *single-cell organisms*, bacteria used to be regarded as lonely individual cells that act independently from their neighbouring cells. Research in the past four decades has painted a completely different picture. Bacteria survive and thrive in communities in every imaginable habitat. In each community, bacteria communicate with each other and with other species to coordinate functions that are difficult or impossible to achieve by individual cells. These include uptake and processing of nutrients, coping with environmental stresses, and mounting attacks on host organisms. A ubiquitous bacterial communication strategy is *quorum sensing*, whereby bacterial cells sense and respond to changes in their local densities by the production and sensing of small, diffusible molecules. Bonnie L Bassler and E Peter Greenberg elucidated many of the molecular mechanisms underlying quorum sensing as well as the implications of the mechanism in controlling bacterial physiology in the context of infectious diseases. Understanding quorum sensing is of fundamental significance for explaining how bacteria interact with each other or with their physical environment. It points to innovative ways to interfere with bacterial pathogens or to modulate the microbiome for health applications, and establishes a technological foundation for precisely controlling bacterial dynamics using artificial gene circuits.

The recognition of quorum sensing and the elucidation of its underlying mechanism are one of the most fascinating developments in microbiology. The notion of bacterial cells communicating within and between species has transformed the way we think of bacteria or interpret the implications of gene regulatory mechanisms. While numerous quorum sensing systems have been discovered, they share the same fundamental architecture. Each cell produces a small molecule that is released into the environment by diffusion or excretion. The concentration of the molecule then reflects the density of the producing cells and can trigger gene expression in cells able to respond to this molecule, through a cognate receptor protein. This incredibly simple yet elegant mechanism enables bacteria to sense changes in their local densities or the physical confinement, and to coordinate behaviour within a population or between populations of the same or different species. It plays a critical role in controlling diverse functions, including generation of bioluminescence, formation of biofilms, and development of virulence. In addition to their roles in bacterial physiology, the molecular components underlying quorum sensing have been widely used in synthetic gene circuits to program dynamics of one or multiple bacterial populations in time and space.

Building on early work of Hastings, Nealson, Eberhard, Silverman, Engebrecht, Iglewski and others, both Greenberg and Bassler contributed to the development of this important concept and the establishment of quorum sensing as a vibrant research field today. The Greenberg group provided definitive evidence that quorum sensing in *Vibrio fischeri*, a marine bacterium, is indeed mediated by diffusion of a chemical signal (J Bact 163, 1210–4, 1985). His group refined understanding of the details of the conserved molecular components and the mechanism underlying this process (J Bact 178, 5291–4, 1996; PNAS 93, 9505–9, 1996; J Bact 179, 557–62, 1997; Mol Microbiol 31, 1197–204, 1999; J Bact 183, 382–6, 2001) and coined the term "quorum sensing" (J Bact 176, 269–75, 1994) that crystalized the field. From the 1990's, Greenberg and colleagues elucidated the mechanism of quorum sensing in *Pseudomonas aeruginosa* and its role in controlling the physiology and biofilm development of this pathogen (PNAS 91, 197–201, 1994; J Bact 176, 3076–80, 1994; Science 280, 295–8, 1998; Nature 407, 762–4, 2000; J Bact 185, 2066–79, 2003). Recent work from Greenberg has integrated concepts from evolution and ecology to provide novel insights into quorum-sensing mediated cooperation (Science 338, 264–6, 2012; PNAS 112, 2187–91, 2015).

Bassler began her venture in quorum sensing after she joined Silverman's laboratory in 1990. From the mid 1990's and building on earlier work by a number of groups on *V fischeri*, Bassler and her colleagues mapped details of the molecular mechanisms underlying quorum sensing in *Vibrio harveyi*, another marine bacterium (Mol Microbiol 4, 773–86 1993; Cell 118, 69-82, 2004; EMBO J, 22, 870–81, 2003; Genes & Dev 20, 2754–67, 2006; Genes & Dev 21, 221–33, 2007; Mol Cell 37, 567–79, 2010). Meanwhile, her laboratory elucidated the mechanism underlying quorum sensing in a different pathogen, *Vibrio cholerae*, and their implications in biofilm formation and virulence development (Cell 110, 303–14, 2002; PNAS 99, 3129–34, 2002; Nature 450, 883–886, 2007; J Bact 190, 2527–36, 2008). Bassler elucidated the mechanism allowing bacteria to communicate across species (J Bact 179, 4043–45, 1997) and defined its molecular mechanism (Mol Microbiol, 42, 777–93, 2001; Nature, 415, 545-549, 2002; Mol Cell 15, 677–87, 2004). Cross-species communication adds another dimension to the concept of bacterial communication: the same bacterial population can use different chemicals to distinguish themselves from other populations. Bassler's recent work has adopted a quantitative perspective in analyzing quorum-sensing mediated gene expression and the resulting evolutionary dynamics (PNAS 108, 14181–5, 2011; Curr Biol 24, 50–55, 2014; Cell 160, 228–40, 2015).

The research by the two investigators has progressed in parallel. Both started with bioluminescence in marine bacteria and then moved on to pathogens. Both have demonstrated incredible focus in using well-defined model systems to establish the mechanistic basis of quorum sensing. Their studies have established the conceptual framework of our view of bacterial communication today and inspired fundamentally new ways to control bacterial dynamics for medical applications.

Bonnie L Bassler

Laureate in Life Science and Medicine

I have always been delighted by critters. When I was 13, my parents arranged for me to work as a veterinarian's assistant at the Miami Zoo and later at a local dog and cat clinic. When I started college at the University of California at Davis, I wanted to be a vet, like my early mentors, but I dreaded anatomy demonstrations and memorizing names and locations of bones and muscles. By contrast, in biochemistry and molecular biology courses I could use logic to solve puzzles, and I was thrilled by the wondrous, miniature building blocks that made life possible: DNA, RNA, and proteins. I changed my major to biochemistry and my Grade Point Average soared.

In my junior year of college, my mom was diagnosed with colon cancer, and she died four months later. Her early death made my life's work clear: to make meaningful contributions to medicine. With a sense of purpose and urgency, I joined Rick Troy's research lab, and his postdoc, Eric Vimr, became my mentor. Eric introduced me to the power of bacteria as model systems to discover fundamental principles about life. I have studied bacteria ever since.

My graduate research in Saul Roseman's lab at Johns Hopkins University focused on bacterial chemotaxis: how bacteria detect nutrients and swim to food sources. Near the end of my graduate studies, Mike Silverman came to speak at a local conference, and I was in the audience. Silverman introduced his topic by describing Nealson and Hastings' 1970's work showing how the symbiotic bacterium, *Vibrio fischeri*, emitted light as a collective. Nealson and Hastings had found that *V fischeri* produced, released, and responded to the accumulation of a small molecule signal which they called an "autoinducer". Silverman told how Anatol Eberhard identified the signal molecule: it was a homoserine lactone.

Silverman went on to describe his own work, reported in a series of six, now landmark papers published between 1983–1987. Silverman, with graduate student Joanne Engebrecht and collaborator Ken Nealson, discovered, and cloned the genes underpinning the *V fischeri* cell-cell communication mechanism as well as the luciferase genes required for light production. Engebrecht and Silverman went on to sequence the genes, map their arrangement, characterize the protein functions involved, and show how the components interacted to yield density dependent bioluminescence. Silverman named the autoinducer synthase protein "LuxI", and the autoinducer response protein "LuxR". This was the first molecular description of a "quorum-sensing" circuit, a decade before the process received that name. Mesmerized by his seminar, I rushed to the podium immediately afterward and begged to become his postdoc.

I joined Silverman's lab in 1990 to study *Vibrio harveyi*, a free-living bioluminescent bacterium. We showed that *V harveyi* had two autoinducers, two cognate receptors, and a protein linking the two systems. To our surprise, we found that the *V harveyi* quorum-sensing components did not resemble LuxI and LuxR of *V fischeri*. In 1993–94, we reported that a bacterium could have multiple quorum-sensing systems, and that distinctly different mechanisms had evolved to enable cell-cell communication. We did not know the identity of the second autoinducer, which we called "AI-2", but we had hints that it was not a homoserine lactone.

I joined Princeton University's Department of Molecular Biology in 1994. My lab identified LuxS, the AI-2 synthase. We showed that LuxS and AI-2 are broadly conserved in bacteria and that AI-2 is a universal signal that allows bacteria to communicate across species boundaries. We determined the biosynthetic pathway and structure of AI-2 and found that it was a five-carbon molecule containing boron, an element with surprisingly few roles in biology. We discovered quorum sensing in *Vibrio cholerae* and showed that the process controls virulence and biofilm formation. Later, we found that small non-coding RNAs lie at the heart of quorum-sensing circuits and they drive the internal quorum-sensing process. More recently, we developed quorum-sensing-modulating molecules that inhibit virulence in *V cholerae* and in *Pseudomonas aeruginosa*. We now study quorum sensing and its inhibition in scenarios mimicking those encountered by bacteria in the wild.

At Princeton, I have collaborated with exceptional students, postdocs, and faculty spanning physics, structure, chemistry, and engineering. I have been a Howard Hughes Medical Institute Investigator since 2005, and I am currently Chair of Princeton's Department of Molecular Biology.

I am committed to teaching, service, and outreach aimed at informing non-scientists about the beauty and relevance of science. I have led efforts at Princeton and beyond to increase diversity within the scientific community. Some roles include: President of the American Society for Microbiology and Member of the Board of Governors of the American Association for the Advancement of Science. Nominated by President Obama in 1999, I serve on the National Science Board, which oversees the National Science Foundation and determines the nation's research and educational priorities in science, math, and engineering.

In 2002, I married my long-time partner, Todd Reichart, who shares my love of nature and candid self-expression. I highly value his reliably unconventional and comical point of view. He is my biggest advocate, and I am his.

E Peter Greenberg
Laureate in Life Science and Medicine

The customary beginning — I was born just outside of New York City on November 7, 1948. My mother and father have both passed away. I can feel their pride and likely stunned disbelief about the Shaw Prize. The first relevant moment for this short story came around age 15. By then my family had moved first to San Francisco and then Seattle. I was a disengaged student with no academic interests. My biology teacher announced an optional overnight fieldtrip to the Pacific Coast; something about tide pools. Signing up meant escaping Friday classes. Off I went with the class "smart kids". Exploring the tide pools was life changing. The creatures I could find by turning over a rock were fascinating in their form and function. Over that weekend biology became my life long passion.

After floating the rest of the way through high school, engaged much more in my rock and roll band than in academics, except for biology, I eventually went to college. Upon careful consideration I decided that the University of Washington, my hometown university and my current employer, was too big. I opted to attend the smaller Western Washington University where I graduated in 1970. My decision was sound. Entering college I was focused on marine invertebrates. As a small liberal arts college Western offered a degree in general biology and I obtained a very broad background in the subject including my introduction to microbiology during my final year.

I once again was thinking of attending the University of Washington as a graduate student in biochemistry, but at the 11th hour I decided to follow what had become my passion — the microbial world. This led to a last minute switch to the University of Iowa where in 1972 I obtained a MS in Microbiology, and then on to the University of Massachusetts where I could work on marine bacteria with my PhD mentor the late Ercole Canale–Parola who sent me to Woods Hole summer microbiology course. This was yet another life-changing experience. There I learned from the late JW Hastings, Ken Nealson and Anatol Eberhard about how luminescent marine bacteria make light in response to something they produce themselves. I also came under the spell of EO Wilson the famous social ant biologist. To me it seemed like the luminescent bacteria were using chemical signals to communicate and coordinate light production, an expensive collective behavior. This was a social activity.

I received my PhD in 1977 and then moved to a postdoctoral with Hastings at Harvard. It was during my postdoctoral that a romance began with my wife of now 31 years, Carrie Harwood, a microbiologist herself. I moved to the Cornell Microbiology faculty in 1979, and Carrie to Yale shortly thereafter. The romance survived separation, we married in 1984 and she moved to Ithaca. I continued to build a head of steam on what was then called autoinduction of bacterial luminescence. In 1986 Barbara, our first-born arrived, another life-changing experience but more difficult than anticipated. Barbara lives with the genetic disease cystic fibrosis. This reality prompted us to consider moving from Cornell, a place I love and where I thrived, to a microbiology programme at a major medical school.

After considering our options it was back to the University of Iowa in 1989. Carrie was the first woman faculty member ever in the Department of Microbiology — arriving eight months pregnant with our soon-to-be son Ted. I am sure some of our new colleagues were wondering about us. Barbara received world-class medical care and our careers advanced. I became involved in the cystic fibrosis "community" in many ways but not in my own research until colleagues working on the virulence of *Pseudomonas*, the most common pathogen in the lungs of people with cystic fibrosis, discovered genes like the genes controlling light production in my marine bacteria. These colleagues did not know about bacterial communication. As one of the very few "experts" on this regulatory mechanism I had to wade in and work on *Pseudomonas*, which became a major focus of my team. My fascination with microbes, and basic rather than applied research approach had taken an interesting and personal twist. This was an exciting time — the early 1990's. Our luminescent bacteria were teaching us things well beyond what was anticipated. In 1994 Clay Fuqua, Steve Winans and I introduced the term quorum sensing and response to the scientific world. Quorum sensing controls virulence in *Pseudomonas* and many other pathogens. Life in a small scientific discipline populated by me, my co-awardee Bonnie Bassler and a few others changed to become a large, active, competitive area of research.

For several reasons in 2005 it was time to move home to Seattle, and finally to the University of Washington where I am now a Professor of Microbiology. As is customary, I will add information about other honors. I am an elected Fellow of the US National Academy of Sciences, the American Academy of Arts and Sciences and the American Academy of Microbiology. I am a recipient of the American Society for Microbiology DC White Award for excellence in research and mentoring among other honors.

I am honored, humbled and surprised that the work of my students and colleagues has been recognized with the Shaw Prize. In particular, my inquisitive and open-minded students and also my colleagues, have made our corner of the scientific world both interesting and important.

Professor Peter C Sarnak

Member of the Board of Adjudicators
Chairman of the Selection Committee for the Prize in Mathematical Sciences

Professor Peter C Sarnak is currently the Eugene Higgins Professor of Mathematics at Princeton University and Professor of the Institute for Advanced Study.

He has made major contributions to number theory, and to questions in analysis motivated by number theory. His interest in mathematics is wide-ranging, and his research focuses on the theory of zeta functions and automorphic forms with applications to number theory, combinatorics, and mathematical physics.

Professor Sarnak received his PhD from Stanford University in 1980. In the same year, he became Assistant Professor of Courant Institute of Mathematical Sciences of New York University and an Associate Professor in 1983. In 1987 he moved to Stanford University. He joined Princeton University as Professor in 1991, became the Henry Burchard Fine Professor of Mathematics in 1995 and the Chair of the Department of Mathematics from 1996 to 1999. From 2001 to 2005, he was Professor of Courant Institute of Mathematical Sciences of New York University.

He has received many awards, including the Frank Nelson Cole Prize, American Mathematical Society (2005) and Levi L Conant Prize, AMS (2003). He was elected as a Member of the US National Academy of Sciences and Fellow of the Royal Society of London in 2002.

The Prize in Mathematical Sciences 2015

Gerd Faltings

and

Henryk Iwaniec

for their introduction and development of fundamental tools in number theory, allowing them as well as others to resolve some longstanding classical problems

An Essay on the Prize in Mathematical Sciences 2015

The theory of numbers is one of the oldest branches of mathematics, going back more than two thousand years in China, Greece, and India. It is concerned with the study of whole numbers, prime numbers, and polynomial equations involving them. The third of these goes by the name Diophantine equations after the Alexandrian/Greek mathematician Diophantus. Gauss, who laid many of the foundations of modern number theory, called it the "Queen of Mathematics". At the time, and for many years after, it was considered as very much on the theoretical and pure side of mathematics. However, in our modern digital/discrete world the deeper truths and techniques that have been developed to study whole numbers play an increasingly significant role in applications.

Many of the central problems in the theory of numbers are elementary and easy to state; but the experience of generations of mathematicians shows that they can be extraordinarily difficult to resolve. Success, when it is achieved, often relies on sophisticated tools from many fields of mathematics. This is no coincidence, since aspects of these fields were introduced and developed in efforts to resolve classical problems in number theory.

Faltings and Iwaniec have developed many of the most powerful modern tools in algebra, analysis, algebraic and arithmetic geometry, automorphic forms, and the theory of zeta functions. They and others have used these tools to resolve longstanding problems in number theory.

Gerd Faltings

A polynomial equation of degree n in one variable with coefficients which are rational numbers has just n complex numbers as solutions. Such an equation has a symmetry group, its Galois group, that describes how these complex solutions are related to each other.

A polynomial equation in *two* variables with rational coefficients has infinitely many complex solutions, which form an algebraic curve. In most cases (that is, when the curve has genus 2 or more) such a Diophantine equation has only finitely many solutions whose coordinates are rational numbers. This statement was for over sixty years a famous conjecture of Mordell, until Faltings finally proved it. His unexpected proof provided fundamental new tools in Arakelov and arithmetic geometry, as well as a proof of another fundamental finiteness theorem — the Shaferavich and Tate Conjecture — concerning polynomial equations in many variables. Later, developing a quite different method of Vojta, Faltings established a far-reaching higher dimensional finiteness theorem for rational solutions to systems of equations on Abelian varieties (the Lang conjectures). In order to study rational solutions of polynomial equations by geometry, one needs arithmetic versions of the tools of complex geometry. One such tool is Hodge theory. Faltings' foundational contributions to Hodge theory over the p-adic numbers, as well as his introduction of other related novel and powerful techniques, are at the core of some of the recent advances connecting Galois groups (from polynomial equations in one or more variables) and the modern theory of automorphic forms (a vast generalization of the theory of periodic functions). The recent striking work of Peter Scholze concerning Galois representations is a good example of the power of these techniques.

Henryk Iwaniec

Iwaniec's work concerns the analytic side of Diophantine analysis, where the goal is usually to prove that equations do have integral or prime solutions, and ideally to estimate how many there are up to a given size.

One of the oldest techniques for finding primes is sieve theory, originating in Erastosthenes' description of how to list the prime numbers. Iwaniec's foundational works and breakthroughs in sieve theory and its applications form a large part of this active area of mathematics. His proof (with John Friedlander) that there are infinitely many primes of the form X^2+Y^4 is one of the most striking results about prime numbers known; the techniques introduced to prove it are the basis of many further works. The theory of Riemann's zeta function — and more generally of L-functions associated with automorphic forms — plays a central role in the study of prime numbers and Diophantine equations. Iwaniec invented many of the powerful techniques for studying L-functions of automorphic forms, which are used widely today. Specifically, his techniques to estimate the Fourier coefficients of modular forms of half-integral weight and for estimating L-functions on their critical lines (the latter joint with William Duke and John Friedlander) have led to the solution of a number of longstanding problems in number theory, including one of Hilbert's problems: that quadratic equations in integers (in three or more variables) can always be solved unless there is an "obvious" reason that they cannot.

In a series of papers remarkable both in terms of their concept and novel techniques, Iwaniec together with different authors (Étienne Fouvry and then Enrico Bombieri and John Friedlander), established results about the distribution of primes in arithmetic progressions which go beyond the notorious Riemann hypothesis. This opened the door to some potentially very striking applications. Yitang Zhang's much celebrated recent result on bounded gaps between primes relies heavily on the works of Iwaniec *et al*. Iwaniec's work mentioned above, together with his many other technically brilliant works, have a central position in modern analytic number theory.

Gerd Faltings
Laureate in Mathematical Sciences

I was born July 28, 1954 in Gelsenkirchen, an industrial town in the then coal mining region of Germany called "Ruhrgebiet". My parents originate from the Hamburg region and had PhD's in Physics and in Chemistry. After primary school I attended the Max-Planck-Gymnasium, a high school, in Gelsenkirchen which I finished in 1972 with my Abitur. During my last years in high school I participitated twice successfully in the "Bundeswettbewerb Mathematik", a competion for high school students interested in mathematics. As a result I became a member of the "Studienstiftung des deutschen Volkes", a foundation dedicated to the support of talented students.

In the fall of 1972 I started to study mathematics at the University of Münster near Gelsenkirchen. Interrupted by 15 months of obligatory military service I finished my studies in 1978 with a diploma (in local cohomology) and a PhD (in Macaulayfication). My advisor was Professor H J Nastold who was specialising in commutative algebra, and so the topics are from that field. He co-organised a regular Oberwolfach meeting (together with Berger, Kunz, Szpiro) on commutative algebra.

The PhD enabled me to obtain a stipend from the Deutsche Forschungsgemeinschaft (a German NSF) to spend one year at Harvard University. My host was Professor Hironaka, to whom I was recommended by Professor Matsumura, an old friend of Professor Nastold. At Harvard I first learned about toroidal embeddings, a subject which became important to me later. Returning to Münster I became assistant to Professor Nastold and got my Habilitation in 1981. This allowed me to apply for professorships and to my surprise, the first application was successful. From 1982–84 I was a full professor at the University of Wuppertal. There I managed to prove the Mordell conjecture over number fields, and this success changed my personal circumstances considerably. For example, I received my first prize, the Dannie–Heinemann award from the Academy in Göttingen. It involved a considerable amount of cash. Usually, such prizes are only given to established researchers who do not need the money anymore, so this was a pleasant exception. Also, at Wuppertal I met my future wife Angelika, and we got married in December 1984.

The Mordell conjecture was an old open problem and had been solved for function fields by (among others) Parshin and Arakelov. Szpiro had extended their theory to positive characteristics and tried to use Arakelov theory (another invention by Arakelov) to extend this to number fields. Unfortunately, one ingredient (the Kodaira-Spencer class) was missing. I was very fortunate to find that it could be replaced by a tool from the theory of Galois representations. Also, I profited very much from an Oberwolfach meeting (Arbeitsgemeinschaft) on the paper by Harris–Mumford proving that the moduli space of curves is usually of general type. So far, my knowledge of the theory of moduli spaces covered only the construction, after which everybody seemed to be exhausted. That they could be used for something was new to me.

From 1985–1994 I was full professor at Princeton University. In 1986 I was awarded a Fields Medal at the ICM in Berkeley, and especially recently this has been followed by quite a number of awards. Also, during my stay at Princeton my two daughters Christina and Ulrike were born (1985 and 1988). My mathematics at Princeton centred around two topics where an ad hoc solution was sufficient for the Mordell, but the full picture required more work. These were toroidal compactifications of the Siegel moduli space, and p-adic Hodge theory. On the first topic I wrote a book jointly with C L Chai, and on the second I extended ideas of J Tate to define "almost étale coverings". In addition, I learned about a new idea of Vojta leading to a new proof of Mordell via diophantine approximation. Everybody talked highly about it but nobody seemed to be ready to declare it correct. Out of a sense of duty I studied it, found it to be correct, and as a reward also realised that the method allowed a vast generalisation (via the "product theorem"). At Princeton I also heard lectures from E Witten about string theory. As a result, I concluded firstly that physics is not a branch of mathematics, and secondly, was inspired to study moduli spaces of vector bundles on curves where I could show some new results. At Princeton I also was awarded a fellowship from the Guggenheim Foundation (1988).

In 1994 I accepted an offer from the Max Planck Society to become one of the directors of the Max Planck Institute for Mathematics in Bonn, and I am stll there. Shortly after resettling I was awarded a Leibniz-Preis (1996). I continued my work and watched my daughters grow up. Unfortunately, my wife died in 2011 so I am a widower. In recent years I have been honoured with a number of awards: von Staudt Preis 2008, Heinz Gumin Preis 2010, honorary degree from Münster 2012, King Faisal Prize 2014, and finally the Shaw Prize 2015.

Henryk Iwaniec
Laureate in Mathematical Sciences

I was born on October 9, 1947 in Elblag, Poland, eight hours before my identical twin brother Tadeusz. We grew up close in a loving family with no academic tradition.

Our interest in mathematics began in a technical high school (which focused on steam turbines) where we were successful in mathematical olympiads. Instead of continuing our education in engineering we entered the Mathematics Department of Warsaw University in 1966. However, we no longer shared our ideas in mathematics as we wished to be more independent intellectually.

At the end of my first undergraduate year I was fortunate to attract the attention of Professor Andrzej Schinzel, who invited me to attend and to give talks in his number theory seminar at the Mathematics Institute of the Polish Academy of Sciences. Early on I was fascinated by analytic number theory because of the large variety of tools, which are used to establish results of an arithmetical flavour. I was particularly impressed by the work of Yu V Linnik. I started alone on sieve methods while Professor Schinzel provided general advice, and also helped with editorial matters.

A year before I graduated in 1971 I had two papers accepted for publication, one of which became my master thesis and the other my PhD thesis, which I defended in the spring of 1972 without entering graduate school (the requirement of passing an exam on Marxism philosophy delayed my thesis defense!).

From 1971 to 1983 (the year I left Poland with my family for the United States) I was employed at the Mathematics Institute of the Polish Academy of Sciences in Warsaw, at which time I was promoted to Professor and elected corresponding member of the Polish Academy of Sciences.

During this period I spent one year in Pisa (1976/77) at the Scuola Normale Superiore where I had the opportunity to expand my interest in sieve methods under the influence of Enrico Bombieri and in collaboration with John Friedlander. Later in the USA my collaboration with John evolved into many other topics in number theory (exponential and character sums, distribution of prime numbers, etc.). Our numerous joint results constitute the essential bulk of my total work.

Next, my time spent at the University of Bordeaux in 1979/80 and the subsequent visits during 1980–82 were critical for directing my interest to the field of automorphic forms. There began my collaboration with Jean–Marc Deshouillers. We developed new estimates for the Fourier coefficients of cusp forms in the spectral aspect and for sums of Kloosterman sums. All of these are basic tools in modern analytic number theory; they open doors for using non-abelian harmonic analysis to study natural numbers.

At the same time in Bordeaux I worked with Ètienne Fouvry on primes in arithmetic progressions. We succeeded in establishing equidistribution results over residue classes, which surpass those implied by the Riemann hypothesis. Later we improved the range of these results jointly with Bombieri and Friedlander at the Institute for Advanced Study (IAS) at Princeton.

My first years in the USA (September 1983–December 1986) were spent at the IAS with two semester breaks for visits to the University of Michigan and as a Distinguished Ulam Visiting Professor to the University of Colorado at Boulder. I also made a few trips to Stanford University to work with Peter Sarnak. At the Institute it was like being in paradise to have free time to think of mathematics, to discuss and to share ideas with members of the School of Mathematics, distinguished visitors, as well as with the faculty of Princeton University. Such an atmosphere easily boosts the aspirations of everybody. I was driven to the uncharted waters of the Riemann hypothesis for varieties (Deligne's result) directing some of it into powerful tools for analytic number theory. Jointly with Friedlander and Fouvry, and with assistance from Birch, Bombieri and Katz, crucial improvements were made in asymptotic formulas for some arithmetic functions, which are fundamental to the theory of prime numbers. The Riemann hypothesis for varieties is also used later in my work on L-functions (jointly with Brian Conrey) and on Hecke eigenvalues (jointly with William Duke). It is gratifying that my mathematical "children", Ètienne Fouvry, Emmanuel Kowalski and Philippe Michel travel much further conceptually in their "Theory of Trace Functions", and produce very strong results which unify many applications.

I love working in collaboration with others. Peter Sarnak and I established (among many other things) statistical results concerning the central values of families of automorphic L-functions, which shed new light on the Riemann hypothesis. Moreover, we revealed new connections with the notorious exceptional character issues. Brian Conrey, Kannan Soundararajan and I established that a large percentage of zeros of L-functions rest on the critical line. John Friedlander and I developed extra axioms for sieve theory which allows one to break the parity barrier, and hence to produce prime numbers in sparse sequences. Algebraic and analytic number theory coexists beautifully in my recent work with John Friedlander, Barry Mazur and Karl Rubin on the spin of prime ideals.

In January 1987 I moved from the IAS to Rutgers University accepting the position of New Jersey State Professor of Mathematics. Teaching graduate students at Rutgers is a great pleasure; it relaxes me from the more intense pursuit of research, and it convinces me that the future of my beloved subject, analytic number theory, is bright.

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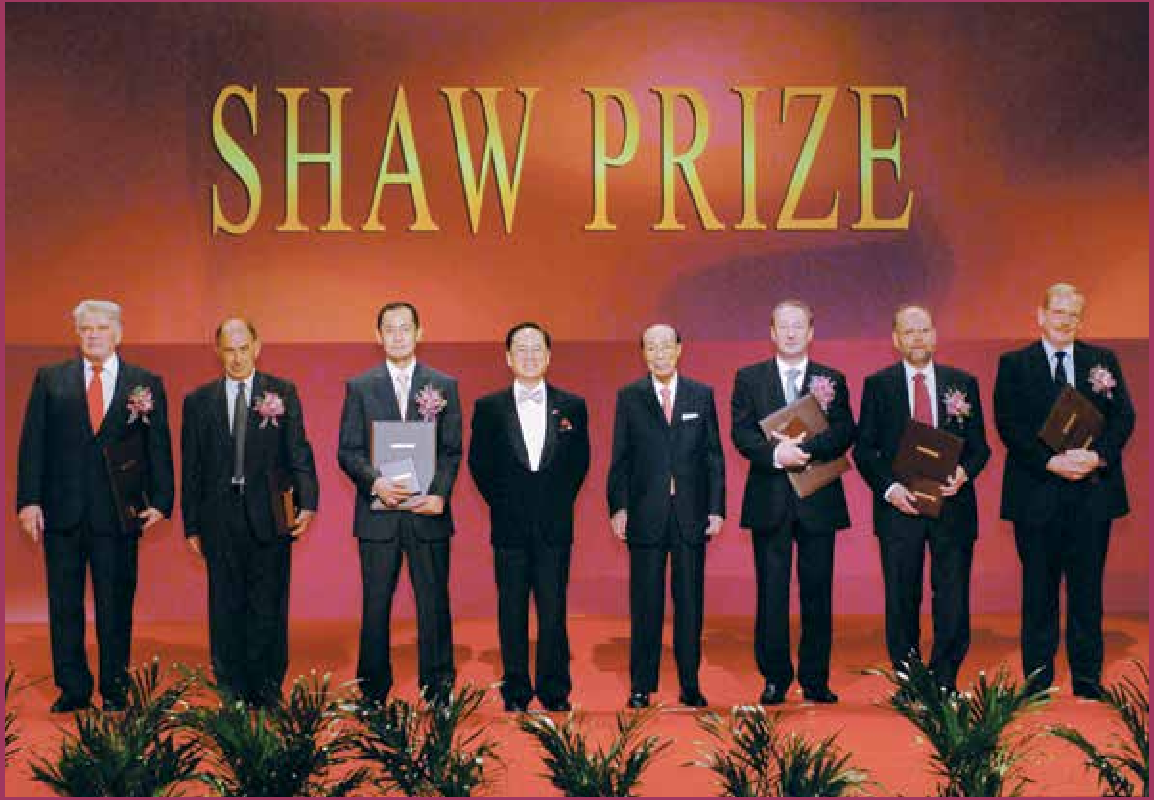

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Mrs Mona Shaw

Mrs Mona Shaw, wife of the founder, the late Sir Run Run Shaw, is Chairperson of The Sir Run Run Shaw Charitable Trust, The Shaw Foundation Hong Kong Limited and The Shaw Prize Foundation. A native of Shanghai, China, she is an established figure in the Hong Kong media and entertainment industry and Chairperson of the Shaw Group of Companies. She was Deputy Chairperson and Managing Director of Television Broadcasts Limited until her resignation in March 2012, and is now a Non-Executive Director of the company.

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Professor Chen-Ning Yang

Professor Chen-Ning Yang, an eminent physicist, was Albert Einstein Professor of Physics at the State University of New York at Stony Brook until his retirement in 1999. He has been Distinguished Professor-at-large at The Chinese University of Hong Kong since 1986 and Professor at Tsinghua University, Beijing, since 1998.

Professor Yang has received many awards: Nobel Prize in Physics (1957), Rumford Prize (1980), US National Medal of Science (1986), Benjamin Franklin Medal (1993), Bower Award (1994) and King Faisal Prize (2001). He is a Member of the Chinese Academy of Sciences, the Academia Sinica in Taiwan, the US Academy of Sciences, the Royal Society of London, the Russian Academy of Sciences and the Japan Academy.

Since receiving his PhD from the University of Chicago in 1948, he has made great impacts in both abstract theory and phenomenological analysis in modern physics.

Council Member

Professor Kenneth Young

Professor Kenneth Young is a theoretical physicist, and is Master of CW Chu College and Professor of Physics at The Chinese University of Hong Kong. He pursued studies at the California Institute of Technology, USA, 1965–1972, and obtained a BS in Physics (1969) and a PhD in Physics and Mathematics (1972). He joined The Chinese University of Hong Kong in 1973, where he has held the position of Chairman, Department of Physics and later Dean, Faculty of Science, Dean of the Graduate School and Pro-Vice-Chancellor. He was elected a Fellow of the American Physical Society in 1999 and a Member of the International Eurasian Academy of Sciences in 2004. He was also a Member of the University Grants Committee, HKSAR and Chairman of its Research Grants Council. He served as Secretary and then Vice-President of the Association of Asia Pacific Physical Societies. His research interests include elementary particles, field theory, high energy phenomenology, dissipative systems and especially their eigenfunction representation and application to optics, gravitational waves and other open systems.

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Professor Pak-Chung Ching

Professor Pak-Chung Ching is Director of Shun Hing Institute of Advanced Engineering and Choh-Ming Li Professor of Electronic Engineering of The Chinese University of Hong Kong. He received his Bachelor in Engineering (First Class Honours) and PhD degrees from the University of Liverpool, UK, in 1977 and 1981 respectively. Professor Ching is a Fellow of IEEE, IEE, HKIE and HKAES. He is Chairman of the Hong Kong Council for Testing and Certification, Chairman of the Veterinary Board of Hong Kong and Member of the Advisory Committee on Innovation and Technology of the HKSAR. He also sits on the boards of a number of research and development organizations in Hong Kong. Professor Ching was awarded the IEEE Third Millennium Award in 2000, and the HKIE Hall of Fame and the Bronze Bauhinia Star by the Government of HKSAR in 2010. His research interests include adaptive digital signal processing, time delay estimation and target localization, blind signal estimation and separation, automatic speech recognition, speaker identification/verification and speech synthesis, and advanced signal processing techniques for wireless communications.

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Professor Wai-Yee Chan

Professor Wai-Yee Chan is Professor of Biomedical Sciences and Director of School of Biomedical Sciences, The Chinese University of Hong Kong (CUHK), Hong Kong. Professor Chan obtained his BSc (First Class Honours) from CUHK in 1974 and PhD from the University of Florida, Gainesville, Florida, USA in 1977. Prior to assuming his current position in June of 2009, he was Professor of Pediatrics, Georgetown University, Washington, DC, and Head and Principal Investigator, Section on Developmental Genomics, National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, MD, USA.

His expertise is in developmental genomics and molecular genetics of endocrine disorders. He received the 1988 Merrick Award for Outstanding Biomedical Research and the 2008 Presidential Award from the Association of Chinese Geneticists in America. He serves on the editorial board of a number of international scientific journals and on review panels of regional and international research funding agencies.

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Professor Reinhard Genzel, Born in 1952 in Germany, is the Director and Scientific Member at the Max Planck Institute for Extraterrestrial Physics, Garching, Germany, Honorary Professor at the Ludwig Maximilian University, Munich since 1988 and Full Professor of Physics, UC Berkeley since 1999.

He received his PhD from the University of Bonn in 1978. He was a Postdoctoral Fellow at Harvard-Smithsonian Center for Astrophysics, Cambridge, Massachusetts (1978–1980), an Associate Professor of Physics and Associate Research Astronomer at Space Sciences Laboratory (1981–1985) and a Full Professor of Physics at UC Berkeley (1985–1986).

Professor Genzel received many awards, including Newton Lacy Pierce Prize, Leibniz Prize, Janssen Prize, Balzan Prize, Petrie Prize, the Shaw Prize in Astronomy, Jansky Prize, Karl Schwarzschild Medal, Crafoord Prize in Astronomy and Tycho Brahe Prize, Herschel Medal of RAS, Great Cross of Merit of Germany, Honorary Doctorate of Paris Observatory OPSPM, Harvey Prize in Science and Technology.

He is a Member of the European Academy of Sciences, the German Academy of Natural Sciences Leopoldina, the Bavarian Academy of Sciences. He is also a Foreign Member/Foreign Corresponding Member/Associate of the Academy of Sciences of France, the US National Academy of Sciences, the Royal Spanish Academy, and the Royal Society of London.

Selection Committee Member

Professor
Douglas N C Lin

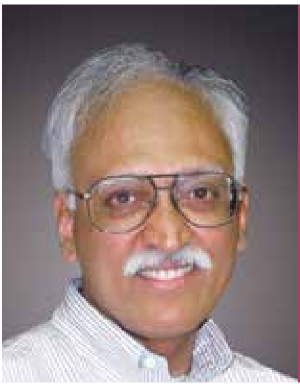
Astronomy Committee

Professor Douglas Lin is the Founding Director of the Kavli Institute for Astronomy and Astrophysics at Peking University and Professor of Astronomy and Astrophysics at the University of California, Santa Cruz.

He obtained his PhD at the Institute of Astronomy, Cambridge University. He held post-doctoral fellowships at Cambridge and Harvard University. He joined the faculty at the Department of Astronomy and Astrophysics, University of California, Santa Cruz in 1979, became a Full Professor in 1985, served as its Chair in 1998, and was elected as a Distinguished Faculty in 2009. For his research, he has won awards from the US, Germany, UK, and Russia. He was elected to the American Academy of Arts and Sciences in 2002 and an Honorary Fellow of the Royal Astronomical Society in 2010.

He is the author or co-author of over 200 research papers, mainly on astrophysics and planetary sciences and several science articles for the general public. He has frequent television and newspaper interviews and lectures widely, and has held visiting professorships at many universities around the world.

Selection Committee Member



Professor Ramesh Narayan

Astronomy Committee

Professor Ramesh Narayan is the Thomas Dudley Cabot Professor of the Natural Sciences at Harvard University.

Professor Narayan received a BSc in Physics from Madras University (1971), and an MSc (1973) and a PhD (1979) from Bangalore University. After a few years as a Research Scientist at the Raman Research Institute, Bangalore, he went in 1983 to Caltech, where he was a Senior Research Fellow. He joined the faculty at the University of Arizona in 1985, and moved to Harvard University in 1991.

Professor Narayan has carried out research in a number of areas of theoretical astrophysics, including accretion disks, gravitational lensing, gamma-ray bursts, neutron stars and black holes.

Professor Narayan is a Fellow of the Royal Society (London), a Fellow of the American Association for the Advancement of Science, and a Member of the US National Academy of Sciences.

Selection Committee Member

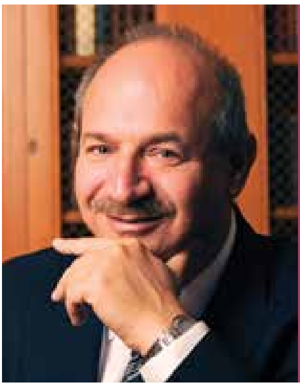
Professor Adam G Riess

Astronomy Committee

Professor Adam G Riess is a Professor of Physics and Astronomy at Johns Hopkins University and a Staff Astronomer at the Space Telescope Science Institute. He received his bachelor's degree from MIT in 1992 in Physics and his PhD from Harvard in 1996. He leads the Higher-Z SN Search program, which uses the Hubble Space Telescope to discover distant supernovae. In 1998, he led the study for the High-Z Supernova Search Team which first reported evidence that the Universe is accelerating. Science Magazine named this the 1998 "Breakthrough of the Year".

In 1999 Professor Riess received the Trumpler Award from the ASP, the Bok Prize from Harvard University in 2001, the Warner Prize from the AAS in 2003 and the Sackler Prize in 2004. In 2006, he shared the Shaw Prize in Astronomy with Professors Schmidt and Perlmutter and the 2007 Gruber Prize with members of the High-Z team and the Supernova Cosmology Project. Professor Riess won a MacArthur Fellowship in 2008, was elected to the US National Academy of Sciences in 2009 and received the Einstein Medal in 2011. Last but not least, he was awarded the Nobel Prize in Physics 2011 together with Professor Saul Perlmutter and Professor Brian Schmidt.

Selection Committee Member



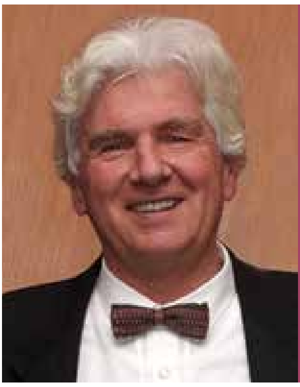
Professor
Bruce A Beutler

Life Science and Medicine Committee

Professor Bruce A Beutler is a Regental Professor and Director of the Center for the Genetics of Host Defense at UT Southwestern Medical Center in Dallas, Texas. He received his medical training at the University of Chicago, graduating in 1981. As a postdoctoral fellow at The Rockefeller University (1983–1986), he isolated mouse tumor necrosis factor (TNF) and discovered its importance as a mediator of inflammation. Subsequently, at UT Southwestern, he analyzed mammalian responses to bacterial lipopolysaccharide. This work culminated in the identification of Toll-like receptors as key sensors of the innate immune system, used to detect infection. In further studies, Professor Beutler employed a forward genetic strategy to elucidate many aspects of mammalian immunity.

He has received numerous awards for his work including the Balzan Prize (2007), the Albany Medical Center Prize (2009), the Shaw Prize (2011), and election to both the US National Academy of Sciences and the Institute of Medicine (2008). In 2011, he shared the Nobel Prize in Physiology or Medicine for “discoveries concerning the activation of innate immunity”.

Selection Committee Member

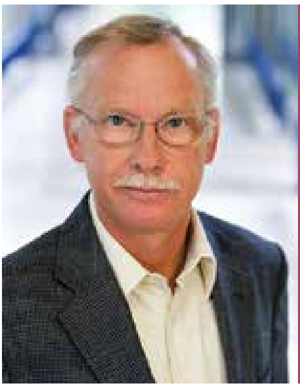


Professor
Günter Blobel

Life Science and Medicine Committee

Born in Germany, Professor Günter Blobel earned an MD degree from Tübingen, Germany and a PhD degree in Oncology from Madison, Wisconsin. Following postdoctoral training, he became Full Professor of Cell Biology at Rockefeller University in New York in 1976. Since 1986 he is also Investigator of the Howard Hughes Medical Institute. He received numerous awards, among them the 1993 Lasker Award and the 1999 Nobel Prize in Medicine. He donated the entire proceeds of the Nobel Prize of one million USD to the reconstruction of the Frauenkirche and the Synagogue in Dresden, Germany. His research has focused on how proteins translocate across or integrate into membranes and on bidirectional traffic between the cytoplasm and the nucleus. A recent research objective is to piece together the atomic structure of the 100 MDalton nuclear pore complex by crystallographic and cryo electron microscopic analyses.

Selection Committee Member



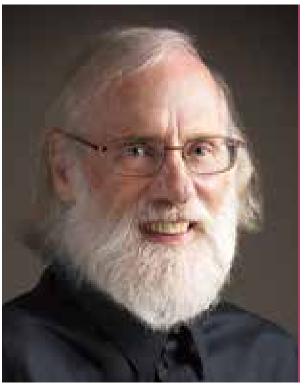
Professor
Franz-Ulrich Hartl

Life Science and Medicine Committee

Professor Franz-Ulrich Hartl is a Director at the Max Planck Institute of Biochemistry in Martinsried, Germany. After completing his medical studies he earned a D med degree in Biochemistry from the University of Heidelberg and then worked as postdoctoral fellow and group leader at the University of Munich. From 1991 to 1997 he was a Professor at Memorial Sloan-Kettering Cancer Center in New York where he was appointed HHMI Investigator in 1994. Professor Hartl's laboratory has elucidated the role of molecular chaperones in protein folding and discovered that the chaperonins — a class of ATP-driven chaperones — function as nano-cages for single protein molecules to fold unimpaired by aggregation. His recent research has focused on understanding the mechanisms underlying the toxicity of protein misfolding in neurodegenerative disease.

Among Professor Hartl's honors are the Gairdner International Award, the Louisa Gross Horwitz Prize, The Rosenstiel Award, The Wiley Prize, the Albert Lasker Award for Basic Medical Research, the Heineken Prize and the Shaw Prize in Life Science and Medicine. He was elected as a Foreign Associate of the US National Academy of Sciences in 2011.

Selection Committee Member



Professor Tony Hunter

Life Science and Medicine Committee

Professor Tony Hunter was born in Ashford, Kent, England. He received his BA in 1965 from the University of Cambridge, and his PhD in 1969 for work on mammalian protein synthesis under Asher Korner in the Department of Biochemistry, University of Cambridge. He was a Research Fellow in the Department from 1968 to 1971, and a Postdoctoral Fellow at the Salk Institute from 1971 to 1973 working under Walter Eckhart on polyoma virus DNA replication. He rejoined the Salk Institute as an Assistant Professor in 1975 in the Molecular and Cell Biology Laboratory, where he is currently the Renato Dulbecco Chair in Cancer Research and Director of the Salk Institute Cancer Center.

In 1979, he discovered that polyomavirus middle T antigen and the RSV v-Src oncoprotein both exhibit a previously unknown protein kinase activity that phosphorylates tyrosine. He has spent most of the last thirty years studying protein kinases and phosphatases, and the role of protein phosphorylation in cell growth, the cell cycle, and cancer.

He has received many awards for his work on tyrosine phosphorylation. He is a Fellow of the Royal Society of London, an Associate Member of EMBO, a Member of the US National Academy of Sciences, the Institute of Medicine, and the American Philosophical Society.

Selection Committee Member

Professor
Robert J Lefkowitz

Life Science and Medicine Committee

Professor Robert J Lefkowitz, MD is James B Duke Professor of Medicine and Professor of Biochemistry at the Duke University Medical Center. He has been an Investigator of the Howard Hughes Medical Institute since 1976. He has received numerous awards and honours for his research, including the National Medal of Science, the Shaw Prize, the Albany Prize, and the 2012 Nobel Prize in Chemistry. He was elected to the US National Academy of Sciences in 1988, the American Academy of Arts and Sciences in 1988, and the Institute of Medicine in 1994.

He is best known for his studies of G protein coupled receptors, a field which he has pioneered for more than forty-five years.

Selection Committee Member

Professor Eve E Marder

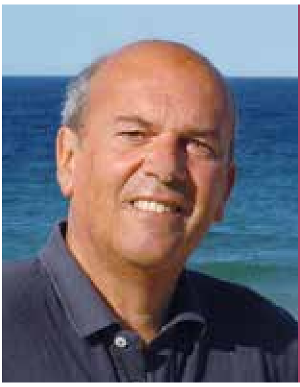
Life Science and Medicine Committee

Professor Eve E Marder received her PhD from UCSD in 1974 and did postdoctoral work at the Ecole Normale Superieure, Paris. She is the Beinfield Professor of Neuroscience at Brandeis University. In the year 2007–2008, she served as President of the Society for Neuroscience, USA.

Her honours include membership in the US National Academy of Sciences, the American Academy of Arts and Sciences, the Salpeter Award from WIN, the Gerard Prize from the SfN, the George A Miller Award from the Cognitive Neuroscience Society, the Karl Spenser Lashley Prize from the American Philosophical Society, an Honorary Doctorate from Bowdoin College, and the 2013 Gruber Prize in Neuroscience. She served on the NIH Director's BRAIN Working Group.

Professor Marder's studies in the dynamics of small neural circuits was instrumental in demonstrating that neuronal circuits are not "hard-wired" but can be reconfigured by neuromodulatory neurons and substances. Her lab pioneered studies of homeostatic regulation of intrinsic membrane properties, and stimulated work on the mechanisms by which brains remain stable while allowing for change during development and learning. Professor Marder now studies how similar network performance can arise from different sets of underlying network parameters, opening up rigorous studies of the variations in individual brains of normal healthy animals.

Selection Committee Member



Professor Corrado De Concini

Mathematical Sciences Committee

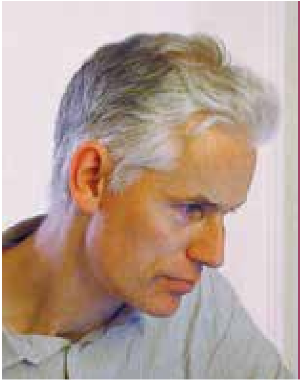
Professor Corrado De Concini was born in Roma, Italy, in 1949. He obtained his Laurea in Matematica at La Sapienza, Università di Roma in 1971 and his PhD at Warwick University under the direction of G Lusztig.

After having been a professor at the Universities of Pisa, Roma Tor Vergata and at the Scuola Normale Superiore of Pisa, he is currently a Professor of Algebra at the Università La Sapienza in Roma.

Professor De Concini is mainly an algebraist. He has worked on the study of the so-called wonderful compactifications of semisimple groups and symmetric varieties, the Schottky problem, hyperplane arrangements, and, recently, on the determination of the values of the index for transversally elliptic operators.

He is a Member of the Accademia dei Lincei, of the Accademia delle Scienze detta dei XL and of the Istituto Lombardo. He received the gold medal of the Accademia dei XL and the Caccioppoli Prize in Mathematics. He has been a speaker at the International Congress of Mathematics (Berkeley 1986) and at the European Congress of Mathematics (Paris 1990).

Selection Committee Member



Professor W Timothy Gowers

Mathematical Sciences Committee

Professor Timothy Gowers was born in Marlborough, England, in 1963. From 1973 to 1976 he was a chorister in the choir of King's College, Cambridge, after which he went as a scholar to Eton College. He studied mathematics at Trinity College, Cambridge, where he also did his PhD, under the supervision of Bèla Bollobàs. In 1989 he became a research fellow at Trinity, moving to University College London two years later as a Lecturer. In 1995 he returned to Cambridge, and Trinity, where he was first a Lecturer and then a Professor. He is currently a Royal Society Research Professor and also holder of the Rouse Ball Chair in Mathematics. In the early part of his career he solved some old problems in Banach space theory, including two of Banach himself. He then discovered the first quantitative proof of Szèmèrèdi's theorem and has subsequently worked in additive combinatorics. For this work he was awarded a Fields Medal in 1998.

Selection Committee Member

Professor John W Morgan

Mathematical Sciences Committee

Professor John W Morgan is a Professor of Mathematics and Director of the Simons Center for Geometry and Physics at Stony Brook University. His work is in the areas of geometry and topology. He has concentrated study of manifolds and smooth algebraic varieties. His most recent work includes a book, joint with Gang Tian, explaining in detail the proof of the Poincaŕe Conjecture.

Professor Morgan received his PhD from Rice University in 1969. He was an instructor at Princeton from 1969 to 1972, an Assistant Professor at MIT from 1972 to 1974, and was Associate Professor and then Professor at Columbia University from 1974 to 2009. In 2009, he joined Stony Brook University.

His awards include the Levi L Conant Prize of the AMS (2009). He is a Member of the AMS, a Fellow of the AMS (2013), and a Member of the US National Academy of Sciences.

Selection Committee Member

Professor
David A Vogan, Jr

Mathematical Sciences Committee

Professor David Vogan Jr is Norbert Wiener Professor of Mathematics at the Massachusetts Institute of Technology.

His work concerns representations of Lie groups, particularly unitary representations. Since 2003 he has worked with Jeff Adams' group "Atlas of Lie groups and representations" looking for light that computers can shed on these questions.

He received the BA and SM degrees from the University of Chicago in 1974, and the PhD from MIT in 1976 under the direction of Bertram Kostant. He continued as an Instructor at MIT, and a Member of the Institute for Advanced Study, before joining the MIT mathematics faculty in 1979. He served as Head of the department from 1999 to 2004.

In 2011, he received the AMS Levi L Conant Prize. He was elected as a Fellow of the American Academy of Arts and Sciences and a Member of the US National Academy of Sciences.

Presenter

Ms
Do Do Cheng

Award-winning Actress
Versatile TV Performer
Programme Host

Award-winning actress, versatile TV performer and programme host Ms Do Do Cheng has starred in many TVB classic dramas and won film awards, local and international. Her hosting of the Hong Kong version of "The Weakest Link" and starring in Television Broadcasts Limited's (TVB) sit-com "War of the Genders" became talk-of-the-town. Ms Cheng's success in hosting the TVB game show on legal knowledge "Justice for All" brought her career to a new height. In addition to the 2008 Beijing Olympics for TVB, she has also been hosting many yearly events of the Company namely TVB Anniversary Gala, TV Award Presentation and Miss Hong Kong Pageant. She has also been a popular talk show host at Hong Kong Commercial Broadcasting Corporation Ltd since September 2011. From its inception in 2004, Ms Cheng has been one of the presenters for the Shaw Prize Award Presentation Ceremony.

Presenter

Mr
Leon Ko

Theatre and Film Composer

Mr Leon Ko received a Richard Rodgers Development Award in the US for his musical "Heading East". His musical "Takeaway" was the first major British Chinese musical to premiere in London in 2011. His music for the movie "Perhaps Love" won him a Golden Horse Award and a Hong Kong Film Award. He won Best Original Film Song for the movie "The Last Tycoon" at the 32nd Hong Kong Film Awards, and received another Best Song nomination for the movie "Insanity" at this year's Hong Kong Film Awards. For the stage, he won five Best Score awards for his musicals in Hong Kong. Mr Ko was the musical director of Jacky Cheung's 2004 world tour of "Snow, Wolf, Lake". Recent works include music for the play "Tonnochy" in Hong Kong as well as the score for the live action movie "Monster Hunt". Besides music, Mr Ko launched "Time In A Bottle", the first-ever perfume bottle exhibition in Hong Kong in 2010, showcasing the artistry of vintage bottles in the context of theatre. Mr Ko is currently a council member of the Hong Kong Arts Development Council, as well as the Theatre Panel of the Leisure and Cultural Services Department.

Special Acknowledgement

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Harkima Shiu
Administration Advisor

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Systems Administrator

10th Floor, Shaw House
Lot 220, Clear Water Bay Road
Kowloon, Hong Kong

Tel: (852) 2994 4888
Fax: (852) 2994 4881
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