NOBEL LAUREATES OF JAPAN

BIMAN BASU

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MOSAI

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Mombusho Scholars Association of India (MOSAI) is a registered society for prompting educational and academic contacts between India and Japan. Its select membership consists of specialists with first hand experience of years of research and academic assignments at Japanese universities, research institutions and industry. Members occupy senior positions in various India Universities, Research Institutions and Government agencies. MOSAI works in close cooperation with the Embassy of Japan, the Japan Foundation and other India-Japan related organizations. The association is the recipient of commendation from Minister of Foreign Affairs, Government of Japan.

For details: www.mosai.org.in

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Preface

The Nobel Prize is widely regarded as the most prestigious award in the fields of physics, chemistry, medicine, peace, literature, and economics. The set of annual international awards are bestowed by Swedish and Norwegian institutions in recognition of academic, cultural, or scientific advances. The will of the Swedish scientist Alfred Nobel established the prizes in 1895. According to his will, Alfred Nobel's enormous fortune was to be used to establish prizes to award those who had done their best to benefit mankind in the fields of physics, chemistry, medicine, literature and peace.

The first Nobel Prizes were awarded in 1901, five years after Nobel's death. Till date 26 Japanese individuals or persons of Japanese birth have been awarded the Nobel Prize – 11 in Physics, 7 in Chemistry, 4 in Physiology or Medicine, 3 in Literature, and 1 in Peace.

This booklet brings a brief account of the laureates' life and work.

Message From Dr. Ashok Jain

In a research opinion survey on image of Japan amongst Indians 'More than 60% responded affirmatively to the suggestion that more young people should study in Japan in order to gain a higher education.'

Source: Ministry of Foreign Affairs, Government of Japan

http://www.mofa.go.jp/announce/announce/2009/5/1191566_1134.html

Indeed with 780 world-class universities, Japan provides excellent opportunities to bright Indian students who wish to go abroad for higher studies in frontier areas that too at a cost less other advanced countries.

In addition with expanding economic and industrial cooperation between India and Japan increasing number of Indian and Japanese companies are offering bright careers to young people who have studied in Japan and imbibed not only good education but also Japan's universally acclaimed 'work culture'.

In this scenario, MOSAI and RethinkIndia have launched 'EduJapan' to inform students, teachers and school mangers to know about excellent education ecosystem of Japan and to help them realise bright career opportunities through studying in Japan.

The publication 'Nobel Laureates' of Japan is part of the EduJapan programme. Knowing the Nobel Laureates, we believe, is the most appropriate entry point for appreciating the excellence of education ecosystem of Japan.

Dr. Ashok Jain
Fellow National Academy of Sciences, India
President

April 2018 Mombusho Scholars Association of India (MOSAI)

1

Hideki Yukawa

Japanese physicist Hideki Yukawa was awarded the Nobel Prize in Physics in 1949 for his prediction of the existence of subatomic particles called mesons on the basis of theoretical work on nuclear forces. He was the first Japanese scientist to be awarded a Nobel Prize.

Yukawa had theoretically predicted the existence of mesons in 1935. He predicted that this particle should have a mass about 200 times that of an electron. He had theorised that the meson acts as glue, holding various other particles together to form the nucleus of the atom. The existence of meson was confirmed in 1947 by a team led by the English physicist Cecil Frank Powell with the discovery of particles called pi-meson, or pion, in cosmic-rays coming from space. Scientists have discovered more than 200 mesons since then and most of them were created in high-energy particle-accelerator experiments.

Yukawa was born in Tokyo, Japan, on 23 January, 1907. He was brought up in Kyoto and graduated from the local university in 1929. Since that time he has been engaged on investigations in theoretical physics, particularly in the theory of elementary particles.

The learned societies of Japan have recognised his ability. He was a member of the Japan Academy, the Physical Society and the Science Council of Japan, and was Emeritus Professor of Osaka University. As Director of the Research Institute for Fundamental Physics in Kyoto University he had his office in the Yukawa Hall, which is named after him. He was also a Foreign Associate of the American National Academy of Sciences and a Fellow of the American Physical Society. The Imperial Prize of the Japan Academy was awarded to Yukawa in 1940; he received the Decoration of Cultural Merit in 1943. An honorary doctorate of the University of Paris and honorary memberships of the Royal Society of Edinburgh, the Indian Academy of Sciences, the International Academy of Philosophy and Sciences, and the Pontificia Academia Scientiarum are among the significant acclaims he had earned in world scientific circles.

Yukawa had published a large number of scientific papers and written many books, including Introduction to Quantum Mechanics (1946) and Introduction to the Theory of Elementary Particles (1948), both in Japanese. He had edited a journal in English, Progress of Theoretical Physics, since 1946.

Yukawa died on 8 September 1981 in Tokyo.

Notes

2

Sin-Itiro Tomonaga

The Japanese physicist Sin-Itiro Tomonaga was awarded the Nobel Prize in Physics in 1965, jointly with the American physicists Julian Schwinger and Richard P. Feynman for their fundamental work in quantum electrodynamics. Quantum electrodynamics is a field of physics that studies the interaction of electromagnetic radiation with electrically charged matter within the framework of relativity and quantum mechanics. It basically describes how light and matter interact. More specifically it deals with the interactions between the electrons, positrons and photons.

Tomonaga was born in Tokyo, Japan, on 31 March 1906. In 1913 his family moved to Kyoto when his father was appointed a professor of philosophy at Kyoto Imperial University. From that time he was brought up in Kyoto. He is a graduate of the Third Higher School, Kyoto, a renowned senior high school which has educated a number of leading personalities in pre-war Japan.

Tomonaga completed work for bachelor's degree in physics at Kyoto Imperial University in 1929, with Hideki Yukawa, Nobel laureate. He stayed in Leipzig, Germany, from 1937 to 1939, to study nuclear physics and the quantum field theory in collaboration with the theoretical group of Werner Heisenberg, where he published a paper, which was chosen as the thesis for Doctor of Science at Tokyo Imperial University in December 1939.

In 1940, he directed his attention to the meson theory and developed the intermediate coupling theory in order to clarify the structure of the meson cloud around the nucleon. He joined the faculty of Tokyo Bunrika University (which was absorbed into the Tokyo University of Education in 1949) as Professor of Physics in 1941.

Tomonaga was invited to the Institute for Advanced Study, Princeton, USA, in 1949 where he was engaged in the investigation of a one-dimensional fermion system. Thus he first succeeded in clarifying the nature of collective oscillations of a quantum-mechanical many-body system and opened a new frontier of theoretical physics, modern many-body problem. In 1955, he published an elementary theory of quantum mechanical collective motions.

Tomonaga took the leadership in establishing the Institute for Nuclear Study, University of Tokyo, in 1955. From 1956 to 1962 he was appointed President of the Tokyo University of Education and since 1963 he has been President of the Science Council of Japan and Director of the Institute for Optical Research, Tokyo University of Education. He was a member of the Japan Academy, the Deutsche Akademie der Naturforscher “Leopoldina”, and a foreign member of the Royal Swedish Academy of Science. Japan Academy Prize (1948), the Order of Culture (1952), and the Lomonosov Medal, USSR (1964).

Sin-Itiro Tomonaga died on 8 July 1079.

Notes

3

Yasunari Kawabata

Japanese novelist and short story writer Yasunari Kawabata was awarded the Nobel Prize in Literature in 1968 “for his narrative mastery, which with great sensibility expresses the essence of the Japanese mind”. He was the first Japanese to be awarded the Nobel in Literature.

Kawabata was born in Osaka, Japan, on 11 June 1899. His father, a physician, was interested in Chinese poetry, and Kawabata himself was at first more drawn to painting than to literature in his youth. But in middle school, he decided to be a writer and had some pieces published in magazines and local newspapers while still a schoolboy. He entered Tokyo Imperial University in 1920, and was first enrolled in the English literature department and then moved to the Department of Japanese Literature. He graduated from there in 1924.

One aspect of aspect of Kawabata’s early years that was often reflected in his writings was the tragic loss of so many members of his family. When Kawabata was three, his father died; the next year his mother died, and Kawabata went to live with his grandparents. When he was eight, his grandmother died, and in 1914 his grandfather died. The child was thus constantly confronted with the death of members of his family, and it is thought that this experience left its mark on Kawabata, who often dwelt on the problem of death, or loneliness of life.

Kawabata was one of the founders of the publication *Bungei Jidai* (The Artistic Age), the medium of a new movement in modern Japanese literature. He made his debut as a writer with the short story, ‘Izu dancer’, published in 1927. After several distinguished works, the novel *Snow Country* in 1937 secured Kawabata's position as one of the leading authors in Japan. In 1949, the publication of the serials *Thousand Cranes* and *The Sound of the Mountain* was commenced. He became a member of the Art Academy of Japan in 1953 and four years later he was appointed chairman of the P.E.N. Club of Japan. At several international congresses Kawabata was the Japanese delegate for this club. Of his novels, *The Old Capital* is the one that made the deepest impression in the author's native country and abroad. In 1959, Kawabata received the Goethe-medal in Frankfurt, Germany.

Throughout his life, Kawabata wrote very short stories which he referred to as "stories that fit into the palm of one's hand." These 146 stories, written intermittently from 1921 to 1972, were for Kawabata the essence of his art. They show his "preference for the miniature and for the half-spoken wisp of a plot."

Kawabata ended his life by committing suicide on 16 April 1972.

Notes

4

Leo Esaki

Japanese physicist Leo Esaki was awarded the Nobel Prize in Physics in 1973, jointly with the Norwegian-born American physicist Ivar Giaever and Welsh theoretical physicist Brian David Josephson "for his discovery of the phenomenon of electron tunnelling". Tunnelling effect is a quantum-mechanical process by which a particle can pass through a potential energy barrier that is higher than the energy of the particle, similar to a train or a car crossing a mountain through a tunnel cut through it. The train or the car does not have to climb over the mountain to cross it. Esaki was honoured for his 1957 pioneering work in electron tunnelling in semiconducting materials, which led to his creation of the Esaki diode, or tunnel diode. This tunnel diode allowed electrons to pass through junctions that were only a hundred atoms thick. Tunnelling was possible using wave equations of quantum mechanics, rather than approaching the phenomenon using classical theories of physics, in which electrons are thought of as particles.

Esaki was born in Osaka, Japan on 12 March 1925. He completed work for a BS in Physics in 1947 and received his PhD in 1959, both from the University of Tokyo. In 1956, he became chief physicist at Tokyo Tsushin Kogyo, a forerunner of what is today Sony Corporation, where his research on heavily-doped germanium (Ge) and silicon (Si) resulted in the discovery of the Esaki tunnel diode – the first quantum electron device. The knowledge of tunnelling in semiconductors was useful in practical applications, as electrons that could cross barriers would be useful for high-speed circuits. Esaki used his discovery and research for his graduate thesis which earned him a PhD in Physics from Tokyo University in 1959.

In 1960, Esaki was invited to work as a resident consultant at International Business Machines (IBM) in New York, in the United States. His one-year visit soon extended to a 32-year stay after IBM awarded him a fellowship to continue his research in semiconductor physics at the IBM Thomas J. Watson Research Centre. Since 1969, Esaki has, with his colleagues, pioneered "designed semiconductor quantum structures" such as man-made superlattices, exploring a new quantum regime in the frontier of semiconductor physics. A superlattice is a periodic structure of layers of two materials. Typically, the thickness of one layer is several nanometres.

Many international organisations named Esaki as a foreign member, including the Russian Academy of Sciences, Korean Academy of Science and Technology, Italian National Academy of Science, Max-Planck Gesellschaft, and American Philosophical Society. Esaki was named a Sir John Cass Sr. Visiting Research Fellow at London Polytechnic in 1981. In 1992, Esaki retired from IBM and returned to Japan, where he had retained his citizenship. He accepted a position as president of Tsukuba University in Ibaraki, Japan. He was the first person outside of academia to lead a national university in Japan.

Notes

5

Eisaku Sato

Eisaku Sato, a Japanese politician and the 39th Prime Minister of Japan, was awarded the Nobel Peace Prize in 1974, jointly with an Irish government minister Sean MacBride "for his efforts on behalf of human rights, among other things as one of the founders of Amnesty International". In 1974 he was also Chairman of the International Peace Bureau and Assistant Secretary-General of the United Nations. The reasons the Nobel Committee gave for awarding the Peace Prize to Eisaku Sato were that as Japanese Prime Minister he represented the will for peace of the Japanese people, and that he had signed the nuclear arms Non-Proliferation Treaty (NPT) in 1970.

Sato was born into an old samurai family on 27 March 1901 in Tabuse, Japan. He was trained as a lawyer. In 1923, he passed the senior civil service examinations, and in the following year, after studying German law, he joined the Ministry of Railways. Immediately after the War, Sato was named general director of the Railway Administration and was soon promoted to deputy minister of transportation, the highest rank a civil servant could aspire to. At this juncture he made a decisive departure from his bureaucratic career and started pursuing a political career and in 1964 he was in charge of the Olympic Games in Tokyo. He became Prime Minister the same year.

During his tenure as Prime Minister, the crisis in the universities and continuing problems of Japanese-American relations were two of the major challenges that confronted Sato. To deal with campus disorders, which wracked nearly all the universities in Japan, Sato's government passed a bill that allow the Ministry of Education to take over a school if the disruption persisted more than nine months. It was evident in elections that Sato's party benefited from a hard line on student disorders.

Sato supported the US war in Vietnam, while at the same time urging the United States to return the island of Okinawa to Japan. In November 1969 Sato flew to Washington, USA, seeking to conclude negotiations for the reversion of Okinawa to Japanese sovereignty by 1972. Upon returning to Japan, he dissolved the House of Representatives, and in the general elections held in December his party won a resounding victory. In June 1971 the United States and Japan signed a treaty to restore Okinawa and the other Ryukyu Islands to Japanese sovereignty in 1972; the accord was ratified by both countries in March 1972. In July 1972, the 71-year-old Sato resigned as Prime Minister.

Sato died on 2 June 1975, in Tokyo.

Notes

6

Kenichi Fukui

Japanese chemist Kenichi Fukui was awarded the Nobel Prize in Chemistry in 1981, jointly with American theoretical chemist Roald Hoffmann "for their theories, developed independently, concerning the course of chemical reactions". It has been known that in chemical reactions, molecules composed of atoms interact and form new compounds in which electrons orbiting around the atoms' nuclei play an important role.

The two laureates' work aims at theoretically anticipating the course of chemical reactions. It is based on quantum mechanics (the theory whose starting point is that the smallest building blocks of matter may be regarded both as particles and as waves), which attempts to explain how atoms behave. Their theories were developed via close interaction with the empirical findings of experimental chemists.

More than 25 years ago, Fukui showed that certain properties of the orbits of the most loosely bound electrons and of the "most easily accessible" unoccupied electronic orbits had great significance for the chemical reactivity of molecules. He called these orbits "frontier orbitals". Fukui's earlier frontier orbital theory attracted only little attention at first. In later, more developed theories, Fukui and Hoffmann proved independently of one another how the symmetrical properties of electron orbitals explain the course of chemical reactions.

In the mid-1960s, Fukui and Hoffmann discovered – almost simultaneously and independently of each other – that symmetry properties of frontier orbitals could explain certain reaction courses that had previously been difficult to understand. These observations are collectively termed the theory of conservation of orbital symmetry in chemical reactions. Fukui's and Hoffmann's theories are milestones in the development of our understanding of the course of chemical reactions. This development has, however, by no means been brought to a halt by the prizewinning work. This work has provided inspiration for new lines of development.

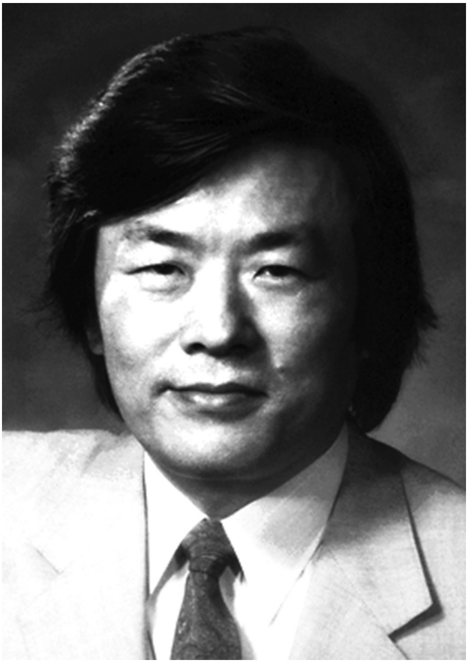
Fukui was born on 4 October 1918, in Nara, Japan. In his high school years, chemistry was not his favourite subject, but a great change in his educational career came when his father sought the advice of Professor Gen-itsu Kita of Kyoto Imperial University concerning the course his son should take. It was on suggestion of Prof. Kita that Fukui joined the Department of Industrial Chemistry at Kyoto Imperial University. For a few years after his graduation from Kyoto Imperial University in 1941, he was engaged in experimental research on synthetic fuel chemistry in the Army Fuel Laboratory. He became lecturer in the Fuel Chemistry Department of Kyoto Imperial University in 1943, assistant professor in 1945, and professor in 1951.

Kenichi Fukui died on 9 January 1998 in Kyoyo, Japan.

Notes

7

Susumu Tonegawa



Japanese scientist Susumu Tonegawa was awarded the Nobel Prize in Physiology or Medicine in 1987 "for his discovery of the genetic principle for generation of antibody diversity". He is Japan's First Nobel Laureate in Physiology or Medicine. His research explained how the immune system can produce a vast diversity of antibodies, each of which reacts with and counteracts the effects of a separate antigen (a foreign molecule or microbe). He demonstrated how only a limited number of genes could be rearranged to produce millions of different antibodies in an individual, thus revealing a fundamental mechanism in the immune system.

Tonegawa was born on 6 September 1939, in Nagoya, Japan. He spent his early in his life in several small rural towns as the family moved to accommodate his father's jobs. When he was an adolescent, Tonegawa and his brother were sent to Tokyo to live with relatives so that they could receive a better education. He attended the prestigious Hibiya High School in Tokyo, from which he graduated in 1959.

In 1959, Tonegawa entered the Imperial University of Kyoto, from where he received a BS degree in chemistry in 1963. While at the Imperial University, he became interested in molecular biology. To further his education, Tonegawa went to the United States in 1963 to study at the University of California, San Diego. For four years (1964–1968), he taught and pursued graduate work, earning a PhD degree in molecular biology in 1968. Thereafter he accepted a postdoctoral position at the Salk

Institute in San Diego, where he worked for two years (1968–1970). Because his visa expired in 1970, Tonegawa was required by law to leave the United States for two years before he could receive another visa. In 1971, he received a Fulbright travel grant, which enabled him to go to Switzerland, where he became a member of the Basel Institute of Immunology. Instead of returning to the United States after two years, he remained in Switzerland until 1981. It was in Basel that he performed most of the work for which he received the Nobel Prize.

Tonegawa returned to the United States in 1981 and joined the faculty of the Massachusetts Institute of Technology in Cambridge, Massachusetts. There he became a professor of molecular biology at the Centre of Cancer Research, conducting research and teaching in the Department of Biology.

Besides the Nobel Prize, Tonegawa has received many honours and awards, one of which was the Albert Lasker Medical Award (1987). He was honoured on a stamp issued by Gambia in 1995, on a sheet of stamps honouring Nobel laureates.

Notes

8

Kenzaburo Oe

Kenzaburo Oe, a Japanese writer and a major figure in contemporary Japanese literature, was awarded the Nobel Prize in Literature in 1994. The Nobel Committee described him as one "who with poetic force creates an imagined world, where life and myth condense to form a disconcerting picture of the human predicament today".

Oe was born on 31 January 1935 in Ose village in Ehime Prefecture, Japan. He attended high school in Matsuyama. At the age of 18, he made his first trip to Tokyo. Although he loved science and mathematics, he nonetheless chose French as his major, specialising in Sartre and French humanism at Tokyo University under the tutelage of Kazuo Watanabe. Oe was the only sibling in his family to receive a college degree. Oe lost his father in World War II and says the Japanese defeat is what made him a novelist. He wrote a cycle of books about his relationship with his autistic son. He has been involved with pacifist and anti-nuclear campaigns and has written books regarding the atomic bombings of Hiroshima and Nagasaki and the Hibakusha.

Soon after his admission to the University in 1954, Oe began to submit stories to the All-Japan Student Fiction Contest, for which he twice received honourable mention. Then in 1957, *A Strange Job* won the University's prestigious May Festival Prize, and the following year, *Prize Stock* was given the coveted Akutagawa Prize, establishing Oe as the most innovative writer of the young generation. Oe's unflinching portrayals of the human condition, with its experiences of vulnerability, despair, outrage, compassion, tenderness, hope, and moments of joy, are, in short, stories of everyman and everywoman.

Oe's writings were influenced by the contradictions inherent in Japan's defeat in the Pacific War and the underlying ideology of the Emperor system that enabled it. From 1931 onward, Japan pursued totalitarianism and military expansionism in the name of the Emperor: the takeover of Manchuria, the invasion of China proper, aggression toward Europe's Asian colonies, and the attack on Pearl Harbour. On 15 August 1945, Emperor Hirohito made two unthinkable radio announcements: Japan's unconditional surrender and the renunciation of his divinity. Japan's surrender released conflicting emotions that began to grow and take deep root in Oe – a sense of both humiliation/subjugation and liberation/renewal. The democratic principles in Japan's new Constitution were to become central to his humanist beliefs. Through the catalytic medium of humanism, Oe conjoined his own fate of having to accept a handicapped child into the family with that of the stance one ought to take in contemporary society, and wrote Hiroshima Notes (1965), a long essay which describes the realities and thoughts of the A-bomb victims. Oe's writings have been described as a gift to humanity that springs from the deepest recesses of his soul.

Notes

9

Hideki Shirakawa

Japanese chemist Hideki Shirakawa was awarded the Nobel Prize in Chemistry in 2000, jointly with American chemist Alan J. Heeger and New Zealand-born American chemist, Alan G. MacDiarmid "for the discovery and development of conductive polymers". Plastics are polymers and have been routinely used as insulation because they do not allow electrical current to pass. So Shirakawa's finding, in collaboration with Heeger and MacDiarmid, was startling. The practical applications of his work have included the bright display screens on cell phones and anti-static coating on photographic film.

Shirakawa was born on 20 August 1936 in Tokyo. After he was born, his family moved many times, following his father's work, but they finally settled in Takayama, in 1944 toward the end of World War II. He had his higher education in Tokyo Institute of Technology where he mainly studied applied chemistry during his undergraduate course. He received the degree of Doctor of Engineering in March 1966.

Shirakawa primarily worked on polymer synthesis, particularly on polyacetylene, the work for which he shares the Nobel Prize. The initial purpose of this study was to determine the polymerisation mechanism of polyacetylene using the Ziegler-Natta catalysts. Conventional method of polymerisation, produces polyacetylene in the form of black powder; however, one day, when a visiting scientist tried to make polyacetylene in the usual way, he only produced some ragged pieces of a film. In order to clarify the reason for the failure, Shirakawa inspected various polymerisation conditions again and again and finally found that the concentration of the catalyst used was a thousand-fold higher than he had planned, which apparently accelerated the rate of the polymerisation reaction about a thousand times.

By chance, the glittering, silvery film of polyacetylene caught the eyes of MacDiarmid, one of the co-recipients of the prize, who invited Shirakawa to work with him in the USA. In September 1976, Shirakawa went to the University of Pennsylvania, where Heeger, another co-recipient, was also working, and spent one year there. In November 1976, while measuring the electrical conductivity of polyacetylene on addition of bromine, Shirakawa observed that at exactly the moment bromine was added, the conductivity jumped to ten million times higher than before adding bromine; it behaved like a conductor. After returning to Japan, he continued to work on polyacetylene. In November 1979, he moved from Tokyo Institute of Technology to the Institute of Materials Science, University of Tsukuba, where he was appointed Associate Professor. In October 1982, he was promoted to full professor and worked on polyacetylene and other conducting polymers. He retired from University of Tsukuba at the end of March 2000.

Notes

10

Ryoji Noyori

Japanese chemist Ryoji Noyori was awarded the Nobel Prize in Chemistry in 2001, jointly with American chemists Karl Barry Sharpless and William Standish Knowles for their work on chirally catalysed chemical reactions.

Many molecules are chiral; that is, they exist in two structural forms called enantiomers that are non-superimposable mirror images, in the same way as we cannot superimpose our two palms, which are like mirror images of each other. Likewise, the receptors, enzymes, and other cellular components made from these molecules are chiral and tend to interact selectively with only one or two enantiomers of a given substance. When drugs are synthesised, a mixture of enantiomers is usually produced of which one form usually has the desired effect while the other form may be inactive or even cause undesirable side effects. To avoid this problem, scientists are going for chiral catalysts, which lead to the production of only one of two possible enantiomers.

Noyori was born on 3 September 1938 in a suburb of Kobe, Japan. Except for a short period at the end of World War II, he attended an elementary school affiliated to Kobe University from ages six to twelve, and then moved on to Nada Middle and High School from ages twelve to eighteen.

In 1957, at the age of 18, Noyori entered Kyoto University, which was known to be the most active institution in the research of polymer chemistry. Incidentally, this was the year when the USSR launched into space for the first time an artificial satellite, the Sputnik, thereby demonstrating the power of science-based technology. He started to study organic chemistry, rather than polymer chemistry and obtained his Bachelor's degree in 1961. He received his Master's degree in 1963 and doctorate (DEng) in 1967.

Noyori went to Harvard in 1969 and worked on asymmetric hydrogenation of organic compounds and organic synthesis using organometallic chemistry, which then comprised a branch of inorganic chemistry. It marked the beginning of his three-decade-long work on hydrogenation. The fruitful Harvard experience, coupled with earlier asymmetric cyclopropanation (a chemical process which generates cyclopropane rings) in 1966, led to Noyori's life-long research on asymmetric hydrogenation. After returning to Nagoya in 1970, he began to study organic synthesis and homogeneous catalysis via organometallic chemistry. In 1980s, building on the work of Knowles, Noyori began developing more general asymmetrical hydrogen catalysts. His catalysts had broader applications, could produce larger proportions of the desired enantiomer, and were suitable for large-scale industrial applications. They found wide use in the synthesis of antibiotics and other pharmaceutical products.

Notes

11

Masatoshi Koshiba

Japanese physicist Masatoshi Koshiba was awarded the Nobel Prize in Physics in 2002, jointly with Italian astrophysicist Riccardo Giacconi and American physicist Raymond Davis Jr., for their detection of neutrinos. Neutrinos are elementary subatomic particles with no electric charge, very little mass, and ½ unit of spin. There are three types of neutrino, one each associated with the subatomic particles electron, the muon, and the tau, which are given the corresponding names electron-neutrino, muon-neutrino, and tau-neutrino. Each type of neutrino also has an antimatter component, called an antineutrino.

Koshiba's award-winning work centred on neutrinos the elusive particles produced in certain nuclear reactions, including those where hydrogen atoms combine to form helium, as happens in the Sun. Neutrinos interact weakly with matter and are therefore the most penetrating of subatomic particles, capable of passing through an enormous number of atoms without causing any reaction. Only 1 in 10 billion of these particles, travelling through matter for a distance equal to Earth's diameter, reacts with a proton or a neutron. For this reason it was long believed that neutrinos are undetectable.

By proving the existence of neutrinos in cosmic radiation, Davis had shown that the Sun's energy originates from such nuclear reactions. In rare cases, neutrinos react with atomic nuclei in water, creating an electron and thus a flash of light that can be detected. Davis had succeeded in capturing a total of 2,000 neutrinos from the Sun over a period of 30 years using a gigantic tank filled with 600 tonnes of fluid in a mine.

Drawing on the work done by Davis, Koshiba constructed an underground neutrino detector in a zinc mine in Japan. Called Kamiokande II, it was an enormous water tank surrounded by electronic detectors to sense flashes of light produced when neutrinos interacted with atomic nuclei in water molecules. Koshiba was able to confirm Davis's results – that the Sun produces neutrinos and that fewer neutrinos were found than had been expected. After building a larger, more sensitive detector named Super-Kamiokande, which became operational in 1996, Koshiba found strong evidence for what scientists had already suspected – that neutrinos, of which three types are known, change from one type into another in flight. The work of Davis and Koshiba has led to unexpected discoveries and a new, intensive field of research called neutrino-astronomy.

Koshiba was born on 19 September 1926 in Toyohashi, Japan. After first studying at Tokyo University he later earned his PhD from the University of Rochester in New York in 1955. After several years spent working at the University of Chicago, Koshiba returned to Tokyo in 1963, where he continues to work and where he conducted his Nobel Prize-winning research.

Notes

12

Koichi Tanaka

Japanese chemist Koichi Tanaka was awarded the Nobel Prize in Chemistry in 2002, jointly with American chemist John Fenn and Swiss chemist Kurt Wüthrich "for the development of methods for identification and structure analyses of large biological molecules".

Tanaka's prizewinning work expanded the applications of mass spectrometry, an analytic technique used in many fields of science since the early 20th century. Mass spectrometry can identify unknown compounds in minute samples of material, determine the amounts of known compounds, and help deduce molecular formulas of compounds. Scientists had long employed mass spectrometry on small and medium-sized molecules, but not on large molecules such as proteins. After the genetic code was deciphered and gene sequences were explored, the study of proteins and their interaction inside cells took on great importance.

The problem with mass spectrometry is that for study, samples must be in the form of a gas of ions, or electrically charged molecules. Molecules such as proteins presented a problem because existing ionisation techniques broke down their three-dimensional structure. Tanaka developed a way to convert samples of large molecules into gaseous form without such degradation. In the late 1980s he reported a method, called soft laser desorption, in which the sample, in solid or viscous form, is bombarded with a laser pulse. As molecules in the sample absorb the laser energy, they form a cloud of ions suitable for mass spectroscopy. Tanaka's soft laser desorption is a highly versatile technique and has proved particularly useful in the early detection of malaria and certain types of cancer.

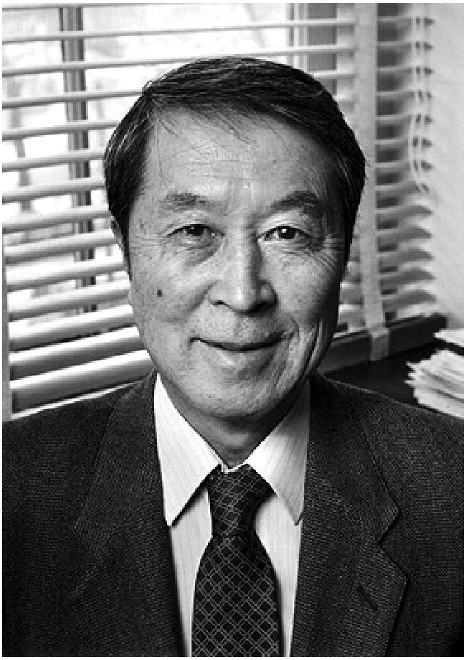
Tanaka was born on 3 August 1959 in Toyama City, Japan. He was enrolled in the Hachininmachi Elementary School in Toyama City in 1966. He enrolled in Toyama Municipal Shibazono Middle School in 1972. In 1975, he moved to Toyama Chubu High School, which was known for its competitive first or second ranking in Toyama Prefecture as a school for sending graduates on to "first-class" universities.

In 1978, Tanaka entered Tohoku University, in the Department of Electrical Engineering, Faculty of Technology and received an engineering degree from the same University in 1983. Later that year he joined Shimadzu Corporation, a maker of scientific and industrial instruments. He was immediately assigned to the Central Research Laboratory, a new department which had been established in 1980. At that time, there were three laboratories, for mechanical-, chemical- and electrical-related research, respectively. Tanaka was assigned to the laboratory for electrical systems-related research, and joined a team charged with developing component technology for analytical instruments. In 2002 he was appointed fellow of the corporation, a position comparable to executive director.

Notes

13

Yoichiro Nambu



Japanese-born American physicist Yoichiro Nambu was awarded the Nobel Prize in Physics in 2008, jointly with Japanese physicists Toshihide Maskawa, and Makoto Kobayashi, "for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics". Nambu received half of the prize money.

For a long time, physicists assumed that various symmetries characterised nature. In a kind of "mirror world" where right and left were reversed and matter was replaced by antimatter, the same physical laws would apply, they postulated. However, symmetries had been proven to be violated at times. In 1960, Nambu formulated a mathematical theory for understanding spontaneous symmetry violations, providing a basis for better understanding elementary particles and their interactions. Nambu received half of the prize for his discovery of spontaneous broken symmetry in subatomic physics, which explained why matter is much more common in the universe than antimatter.

Nambu's work on spontaneous symmetry breaking, for which he received the Nobel Prize, started around 1959. The BCS theory of superconductivity in 1957 led him to the idea of spontaneous symmetry breaking as a general phenomenon in physics. His work on its specific application to particle physics as a mechanism for generation of the nucleon mass and the pion was first published in 1960. Since then he has pursued the subject in various areas. Nambu also was a pioneer in quantum chromodynamics, a field in which he first suggested that the gluon is the intermediary in carrying the strong force between quarks in nucleons.

Nambu was born on 18 January 1921 in Tokyo, Japan and grew up in the provincial city of Fukui. He studied physics at the Imperial University of Tokyo from 1940 to 1942, graduating at the level of MS. He received a doctorate in physics from the University of Tokyo in 1952, and that same year he went to the United States on the invitation of the Institute for Advanced Study in Princeton, New Jersey. In 1954 he became a research associate at the University of Chicago. He became associate professor in 1956, professor in 1958, and Distinguished Service Professor in 1971. From 1973 to 1976 he served as chairman of the department of physics. In 1976 Nambu became Henry Judson Distinguished Professor, from which position he retired in 1991 and became Emeritus.

Nambu became a US citizen in 1970. He received many awards, including the U.S. National Medal of Science (1982) and the Dirac Medal of the International Centre for Theoretical Physics (1986). He was a member of both the U.S. National Academy of Sciences and the American Academy of Arts and Sciences and an honorary member of the Japan Academy.

Notes

14

Makoto Kobayashi

Japanese physicist Makoto Kobayashi was awarded the Nobel Prize in Physics in 2008, jointly with Japanese-born American physicist Yoichiro Nambu and Japanese physicist Toshihide Maskawa. Kobayashi and Maskawa shared half the prize money for their discovery of the origin of broken symmetry, which created at least six quarks moments after the big bang.

Kobayashi was born on 7 April 1944 in Nagoya, Japan. After completing schooling, he entered the Physics Department of Nagoya University. When he was in high school, he read *The Evolution of Physics* by Albert Einstein and Leopold Infeld, sparked his interest in physics. As a graduate student, he began his research in particle physics. As a graduate student, he began his research in particle physics. He met Maskawa at Nagoya University and began conducting joint research with him. He received his doctoral degree in physics from Nagoya University in March 1972. At that time, it was not easy for post-doctoral researchers to find positions. Fortunately, he was hired as a research associate in the Physics Department of Kyoto University and resumed joint research with Maskawa, who had transferred to Kyoto University. They worked on CP violation. CP violation, in particle physics means violation of the combined conservation laws associated with charge conjugation (C) and parity (P) by the weak force, which is responsible for reactions such as the radioactive decay of atomic nuclei.

In 1979 Kobayashi became an assistant professor at the High Energy Accelerator Research Organization (KEK) in Tsukuba Science City, and in 1989 he was appointed professor and designated as the head of Physics Division II. In 1979 Kobayashi became an assistant professor at the High Energy Accelerator Research Organization (KEK) in Tsukuba Science City, and in 1989 he was appointed professor and designated as the head of Physics Division II. He became the director of the Institute of Particle and Nuclear Studies at KEK in 2003, and he was named professor emeritus in 2006.

He spent three months at CERN (the European Organisation for Nuclear Research) from November 1982. While he was there, the W particle was discovered, which was a very exciting experience for him. During his tenure as director of the Institute, KEK was converted from a government organisation to an independent research corporation. He became very busy in carrying out this reorganisation. He was able to steadily improve the performance of the B-factory accelerator during that period. Its experimental results showed their 6-quark theory to be virtually accurate.

In 1985, Kobayashi shared with Maskawa the J.J. Sakurai Prize, instituted in that year by the American Physical Society. The same year he received the Japan Academy Prize. He received the Japanese Person of Cultural Merit Award in 2001.

Notes

15

Toshihide Maskawa

Japanese physicist Toshihide Maskawa was awarded the Nobel Prize in Physics in 2008, jointly with the Japanese-born American physicist Yoichiro Nambu and Japanese physicist Makoto Kobayashi. Maskawa and Kobayashi shared half the prize money for their discovery of the origin of broken symmetry, which predicts the existence of at least three families of quarks in nature. Maskawa received a PhD in 1967 from Nagoya University in Japan. In 1972, only four quarks were known with four 'flavours' – up, down, charm, and strange. Kobayashi and Maskawa proposed that if CP violation (the violation of the combined conservation laws associated with charge conjugation C and parity P by the weak force) is an inherent property of the standard model of subatomic particles, then there have to exist at least two additional quarks. These two new quarks were experimentally confirmed in 1977 (bottom quark) and 1995 (top quark).

Maskawa was born on 7 February 1940 in Nagoya, Japan. He graduated from Nagoya University in 1962 and received a PhD in Physics from the same university in 1967. At that time at Nagoya University, the campus for freshmen and sophomores was separated from that for juniors and seniors. The campus for the general education course for the students in the first two years of study had previously been a high school in the old system of education. The theoretical physics course at Nagoya University made Maskawa pay attention to field theory, which no one took any notice of in the 1960s. He got interested in theoretical problems related to weak interactions. When the importance of field theory was later appreciated, the situation had turned full circle and the curriculum of theoretical physics at the graduate school of Nagoya University was again at the forefront of world physics.

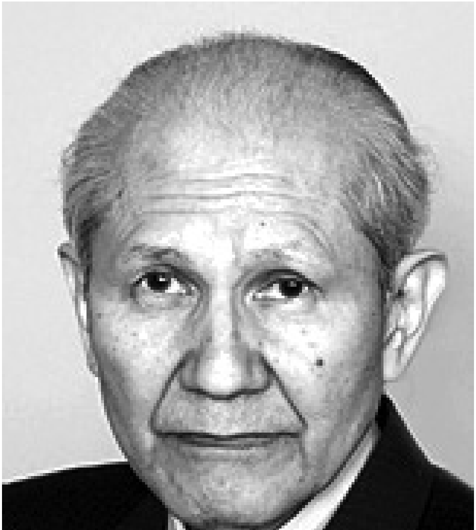
Maskawa spent three years at Nagoya University as an assistant professor and then moved to Kyoto University where he had a fateful encounter with Makoto Kobayashi, a co-recipient of the Nobel Prize in Physics in 2008. Since then, he has also showed enthusiasm for social activities and nowadays is also famous as an anti-war activist. In 1997, he became a professor at the Yukawa Institute for Theoretical Physics at Kyoto University and held a directorship at the institute. He carried out his Nobel Prize-winning work at Kyoto University. Since that time, he has been affiliated with both Nagoya and Kyoto universities. After 2003, he moved to Kyoto Sangyo University as a full professor and established the Maskawa Institute for Science and Culture. He has been a university professor at Nagoya University since 2009, as well as a director at the Kobayashi-Maskawa Institute for the Origin of Particles and the Universe, Nagoya University. Since 2010, he has been a member of the Japan Academy.

In 1985, Kobayashi shared with Maskawa the J.J. Sakurai Prize, instituted that year by the American Physical Society.

Notes

16

Osamu Shimomura



Japanese organic chemist and marine biologist Osamu Shimomura was awarded the Nobel Prize in Chemistry in 2008, jointly with American chemist Martin Chalfie and American biochemist Roger Y. Tsien "for the discovery and development of the green fluorescent protein, GFP".

Green fluorescent protein (GFP), which emits a shimmering light, is found in some marine organisms such as the jellyfish. The formation of GFP is regulated by a gene that can be incorporated into the genomes of other organisms. Because GFP can be linked to other proteins using genetic engineering, it has become an important tool for studying biological processes in cells. The first steps in achieving this were taken by Shimomura, who isolated GFP from the jellyfish *Aequorea victoria* in the 1960s and found that the protein glowed green when illuminated with ultraviolet light.

The visual signal that GFP provides allows scientists to probe protein activity, such as when and where proteins are produced and how different proteins or parts of proteins move and approach each other within a cell. Subsequent discoveries by his co-recipients opened a vast set of opportunities for the utilisation of GFP in studying biological processes at the molecular level.

Shimomura was born on 27 August 1928 in Kyoto, Japan. In March 1951, he graduated from Nagasaki Pharmacy School, at the top of his class. The school was reorganised as the Department of Pharmacy, Nagasaki University. In 1955 he became a research assistant at Nagoya University, where he earned a PhD in organic chemistry in 1960. That same year, he travelled to the United States on the invitation of Princeton University. It was as a researcher there that he made the discovery that would win him the Nobel Prize.

In August 1962, he visited Bermuda to study the famous fireworm *Odontosyllis enopla* at the Bermuda Biological Station. The fireworms are very small but they show a spectacular bioluminescence display that is correlated with the lunar cycle. In February 1965, he went to New Zealand to study two kinds of bioluminescent organisms: the cave worm Arachnocampa and the freshwater limpet Latia. Between 1965 and 1978, he also did research on the bioluminescence of various luminous organisms, various coelenterates, and luminous bacteria.

In 1982 he moved his studies to the Marine Biological Laboratory in Woods Hole, Massachusetts, USA, from which he later retired as professor emeritus. He also worked at Boston University Medical School.

Notes

17

Ei-ichi Negishi

Japanese chemist Ei-ichi Negishi was awarded the Nobel Prize in Chemistry in 2010, jointly with American chemist Richard F. Heck and compatriot Akira Suzuki for their work on “palladium-catalysed cross couplings in organic synthesis”.

Nature is full of organic substances – a multitude of chemical compounds that contain the element carbon. Using chemical methods to combine or synthesise organic substances is important in both scientific and industrial contexts. In the mid-1970s, Negishi began developing chemical reactions in which carbon atoms are bound together so that new compounds are created. Using the metal palladium as a catalyst, the reactions create cross couplings between carbon atoms. Palladium facilitates the reaction without becoming incorporated in the final product.

Negishi was born on 14 July 1935 in Xinjing, Manchukuo (now Changchun, China). He received a bachelor’s degree from the University of Tokyo in 1958. He was a research chemist at the Japanese chemical company Teijin from 1958 to 1960. At Teijin, he was assigned to be a research chemist at the Iwakuni Research Laboratories, then the main research facility of Teijin, which was located near Hiroshima in the Inland Sea area. After passing two-stage Fulbright Examination on written and conversational English, he won a Fulbright Smith-Mund All-Expense Scholarship to go to the US in 1960 and study for his PhD degree in synthetic organic chemistry, which turned out to be the single most important turning point in his professional career. After 8 weeks of English orientation classes at the University of Hawaii in August and September, 1960, he went to the University of Pennsylvania in Philadelphia. From 1960 to 1963 he studied at the University of Pennsylvania in Philadelphia, USA, where he received a doctorate. As a first-year graduate student at Pennsylvania he earned 8 consecutive grades of excellence in the Organic Cumulative Examinations, a feat essentially unheard of back then, which gave him the confidence about potential his research capability. He returned to Teijin as a research chemist from 1963 and stayed there till 1966. In 1966 he became a postdoctoral associate at Purdue University in West Lafayette, Indiana, USA, where he was an assistant to American chemist Herbert C. Brown. Negishi was an assistant professor and later an associate professor at Syracuse University in USA from 1972 to 1979.

In 1977, Negishi further developed palladium catalysis by using a zinc atom to transfer a carbon atom to the palladium atom. The carbon atom then joins to another carbon atom to form a new molecule. This became known as the Negishi reaction. He returned to Purdue as a professor in 1979.

Notes

18

Akira Suzuki

Japanese chemist Akira Suzuki was awarded the Nobel Prize in Chemistry in 2010, jointly with American chemist Richard F. Heck and compatriot Ei-ichi Negishi for their work on "palladium-catalysed cross couplings in organic synthesis".

In the mid-1970s, Suzuki began developing chemical reactions in which carbon atoms are bound together so that new compounds are created. Using the metal palladium as a catalyst, the reactions create cross couplings between carbon atoms. Palladium facilitates the reaction without becoming incorporated in the final product. In 1979 Suzuki modified the technique of palladium catalysis of organic molecules by using a boron atom to transfer a carbon atom to the palladium atom. The carbon atom then joins to another carbon atom to form a new molecule. This became known as the Suzuki reaction.

Suzuki was born on 12 September 1930 in Mukawa – a small town in Hokkaido, Japan. He attended primary school there and entered a secondary school in Tomakomai. At high school, he was interested in mathematics, but his interest turned to organic chemistry after reading the *Textbook of Organic Chemistry* by L.F. Fieser and M. Fieser and he decided to major in organic chemistry. The title of his doctoral thesis was 'Synthesis of the Model Compounds of Diterpene Alkaloids'. In the study, he used organometallic compounds, Grignard reagents and organozinc compounds as synthetic intermediates and realised that organometallic compounds are interesting and versatile intermediates for organic synthesis.

After completing the PhD program at Hokkaido University's Graduate School of Science in 1959, he was employed as a research assistant in the Chemistry Department. Two years and six months later in October 1961, he was invited to become an assistant professor of the Synthetic Organic Chemistry Laboratory at the newly founded Synthetic Chemical Engineering Department in the Faculty of Engineering.

Including nine years as a student, he spent the major part of his life at Hokkaido University. In total, he spent 35 years at Hokkaido University as a staff member – two and a half years in the Faculty of Science, and the other 32½ years in the Faculty of Engineering. Other than about two years of study in USA and a few months in other places overseas, most of his life has been spent at the Faculty of Engineering. After his retirement from the university in 1994, was a professor at the Okayama University of Science in Okayama prefecture until 1995. From 1995 to 2002 he was a professor at Kurashiki University of Science and the Arts, in nearby Kurashiki before retiring from university work in 2002.

Notes

19

Shinya Yamanaka

Japanese stem-cell researcher Shinya Yamanaka was awarded the Nobel Prize in Physiology or Medicine in 2012, jointly with English developmental biologist John Gurdon "for the discovery that mature cells can be reprogrammed to become pluripotent". It was long thought that a mature or specialised cell could not return to an immature embryonic state, but Yamanaka's work proved it to be incorrect. In 2006, Yamanaka succeeded in identifying a small number of genes within the genome of mice that proved decisive in this process. When activated, skin cells from mice could be reprogrammed to immature stem cells, which, in turn, could grow into different types of cells within the body. Yamanaka's method involved inserting specific genes into the nuclei of adult cells (such as skin cells cells), a process that resulted in the reversion of cells from an adult state to a pluripotent state like embryonic stem-cells, which endowed them with the capacity to differentiate into any cell type of the body. Thus, the reverted cells became known as induced pluripotent stem (iPS) cells.

Yamanaka was born on 4 September 1962 in Osaka, Japan. He received an MD from Kobe University in 1987 and a PhD in pharmacology from the Osaka City University Graduate School in 1993. After spending several years at the Gladstone Institute at the University of California, San Francisco, USA, he returned to Osaka in 1996, where he remained till 1999, when he took a position at the Nara Institute of Science and Technology where he began his Nobel Prize-winning research. During this period his research became increasingly focussed on stem cells. In 2004 he moved to the Institute for Frontier Medical Sciences at Kyoto University, where he began his landmark studies on finding ways to induce pluripotency in cells.

In 2006 Yamanaka announced that he had succeeded in generating iPS cells. The cells had the properties of embryonic stem cells but were produced by inserting four specific genes into the nuclei of mouse adult tissue cells. The following year he reported that he had derived iPS cells from human adult fibroblasts (cells from which connective tissue develops). This was the first successful attempt at generating human versions of these cells. This discovery marked a turning point in stem cell research, because it offered a way of obtaining human stem cells without the controversial use of human embryos.

Yamanaka received several awards for his contributions to stem-cell research, including the Robert Koch Prize (2008), the Shaw Prize in Life Science and Medicine (2008), the Gairdner Foundation International Award (2009), the Albert Lasker Basic Medical Research Award (2009), and the Millennium Technology Prize (2012).

Notes

20

Shuji Nakamura

Japanese-born American materials scientist Shuji Nakamura was awarded the Nobel Prize in Physics in 2014, jointly with Japanese materials scientists Hiroshi Amano and Isamu Akasaki "for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources".

Lighting plays a major role in our quality of life. The development of light-emitting diodes (LEDs) has made more efficient light sources possible. Creating white light that can be used for lighting requires a combination of red, green, and blue light. Green and red LEDs have been available for many years, but blue LEDs proved to be much more difficult to create than red and green diodes. During the 1980s and 1990s the three Nobel laureates successfully used the difficult-to-handle semiconductor gallium nitride to create efficient blue LEDs that made white LEDs possible.

Nakamura was born on 22 May 1954 in Oku, a tiny fishing village on the Pacific coast of Shikoku, the smallest of Japan's four main islands. He received bachelor's (1977) and master's (1979) degrees in electronic engineering from the University of Tokushima. In 1979 he went to work for a small company called Nichia Chemical in Tokushima. He initially worked on growing gallium phosphide and gallium arsenide crystals for LEDs. However, sales of those products proved disappointing. In the mid-1980s Nichia decided to produce complete LEDs. Nakamura taught himself the necessary techniques to produce high-quality red and infrared LEDs, but those also were not commercially successful.

Nakamura felt that Nichia had to develop a product that would not be competing with those of other, larger companies. That product would be the blue LED. Scientists had produced LEDs that emitted red or green light, but attempts to make blue LEDs were unsuccessful. If developed, the blue LED could be combined with red and green LEDs to produce white light for a fraction of the cost of incandescent and fluorescent lighting. Nakamura's supervisor discouraged him by noting that the blue LED had been sought after for decades by much better-funded researchers.

But Nakamura was determined. He got funds and spent a year at the University of Florida, in USA to learn metallorganic chemical vapour deposition to produce the semiconductors for the blue LED. After his return from Florida in 1989, Nakamura decided on gallium nitride (GaN) as the material he would use for the blue LED, mainly because most other researchers used zinc selenide, which was easier to work with. High-quality GaN crystals were very difficult to grow. But Nakamura succeeded in 1992. Working independently at the same time, Akasaki and Amano also developed blue LEDs using different techniques. In 1994 Nakamura received a doctorate in engineering from the University of Tokushima.

Notes

21

Hiroshi Amano

Japanese materials scientist Hiroshi Amano was awarded the Nobel Prize in Physics in 2014, jointly with Japanese-born American materials scientist Isamu Akasaki and Japanese materials scientist Shuji Nakamura, "for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources". The development of light-emitting diodes (LEDs) has made more efficient light sources possible. In an LED, light is emitted when current flows across a p-n junction, the interface between a p-type (positive) and an n-type (negative) semiconductor. LEDs are very energy-efficient light sources compared to filament and fluorescent lights. Before the work of Amano, Akasaki, and Nakamura, red and green LEDs existed but, because attempts to make blue LEDs were unsuccessful, LEDs could not be used as a source of white light, which requires a combination of blue, red, and green light. Blue LEDs proved to be much more difficult to create than red and green diodes. During the 1980s and 1990s Akasaki, Amano, and Nakamura successfully used the difficult-to-handle semiconductor gallium nitride (GaN) to create efficient blue LEDs.

Amano was born on 11 September 1960 in Hamamatsu, Japan. He spent elementary school, junior high school, and high school at Hamamatsu. He moved to Nagoya in 1979 to enter Nagoya University to study electrical engineering. In 1982, when he was in the third year of university, he joined Akasaki's group as an undergraduate. He had to choose a dissertation research topic. He chose GaN-based blue LEDs as his dissertation topic. At that time, cathode-ray tubes were used as the monitors of PCs and also in television systems. Because cathode-ray tubes were so large, he thought that if he could develop blue LEDs, he could change the world by improving people's lives by providing the means to develop smarter PC and TV systems. But at that time, he did not know how difficult it would be to develop blue LEDs.

Amano received his bachelor's (1983), master's (1985), and doctoral degrees (1989) in engineering from Nagoya University and was a research associate from 1988 to 1992. In 1986 Amano and Akasaki created high-quality GaN crystals by placing an aluminium nitride layer on a sapphire substrate and then growing the crystals on that. In 1989 they made p-type GaN, which glowed much brighter when under an electron microscope, thus showing that electron beams would improve the material. The p-type and n-type layers were combined to form blue LEDs in 1992. They also worked on blue GaN laser diodes, which have applications ranging from medicine to laser projectors and which form the heart of Blu-ray disc players. In 1992 he and Akasaki moved to Meijo University, where Amano became an assistant professor. Amano returned to Nagoya University as a professor in 2010.

Notes

22

Isamu Akasaki

Japanese materials scientist Isamu Akasaki was awarded the Nobel Prize in Physics in 2014, jointly with Japanese-born American materials scientist Shuji Nakamura and Japanese materials scientist Hiroshi Amano “for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources”.

Light-emitting diodes (LEDs) are one of the most efficient sources of light that has revolutionised lighting throughout the world. The combination of blue, green, and red LEDs produces a light that appears white to the eye and that can be produced for much less energy than that from incandescent and fluorescent lamps. In an LED, light is emitted when current flows across a p-n junction, the interface between a p-type (positive) and an n-type (negative) semiconductor. Before the work of Amano, Akasaki, and Nakamura, red and green LEDs existed but, because attempts to make blue LEDs were unsuccessful, LEDs could not be used as a source of white light, which requires a combination of blue, red, and green light. Blue LEDs proved to be much more difficult to create than red and green diodes.

A major breakthrough was Akasaki and Amano’s discovery in 1986 that high-quality gallium nitride (GaN) crystals could be created by placing an aluminium nitride layer on a sapphire substrate and then growing the crystals on that. The second breakthrough in Akasaki and Amano’s work came in 1989 when they discovered that p-type GaN could be formed by doping GaN crystals with magnesium atoms. That p-type material was then used with existing n-type material to form blue LEDs in 1992. (Working independently at the same time, Nakamura made blue LEDs with slightly different techniques.)

Isamu Akasaki was born on 30 January 1929 in Chiran, Japan. After studying electrical engineering at the University of Kyoto, he began working at the electronics company Kobe Kogyo Corporation (later named Fujitsu) until 1959. He then attended Nagoya University, where he held several teaching positions while obtaining a doctorate in engineering (1964). He subsequently served as the head of a basic research laboratory at the Matsushita Research Institute Tokyo, Inc. After having worked many years at the electronics company Matsuhita, in 1981 he became a professor at Nagoya University. In 1992, when Akasaki left Nagoya University, he was made professor emeritus; he then joined the faculty of Meijo University in Nagoya. Nagoya University gave Akasaki the title of distinguished professor in 2004 and named the Akasaki Institute, completed in 2006, in his honour. Blue LEDs became commercially available in 1993 and Akasaki's work helped lead to the development of blue semiconductor lasers, which proved useful for high-capacity optical-media devices such as Blu-ray disc players.

Notes

23

Satoshi Omura

Japanese biochemist Satoshi Omura was awarded the Nobel Prize in Physiology or Medicine in 2015, jointly with Irish and American biologist William C. Campbell and Chinese pharmaceutical chemist Tu Youyou for "discoveries concerning a novel therapy against infections caused by roundworm parasites".

A number of serious infectious diseases are caused by parasites spread by insects. River blindness is caused by a tiny worm that can infect the cornea and cause blindness. Lymphatic filariasis or elephantiasis is also caused by a worm and produces chronic swelling. Omura cultured bacteria, which produce substances that inhibit the growth of other microorganisms. In 1978 he succeeded in culturing a strain from which Campbell purified a substance, avermectin, which in a chemically modified form, ivermectin, proved effective against river blindness and elephantiasis.

Omura was born on 12 July 1935 in Nirasaki, Japan. He earned a bachelor's degree in 1958 from the University of Yamanashi. It took him 5 long years to obtain his MS degree, but the extensive knowledge and technical skills acquired during that period became an invaluable foundation for all his later research work. He got his master's degree in 1963 from the Tokyo University of Science. From the mid-1960s, Omura's research centred on the discovery and isolation of naturally occurring bioactive chemical compounds from microorganisms, particularly from bacteria living in the soil. Omura developed novel techniques that facilitated the growth of soil bacteria in laboratory cultures and enabled the characterisation of the substances they produced. Among his first major discoveries was the identification in the mid-1970s of cerulenin, an antibiotic produced by a species of fungus. Omura found that cerulenin worked by inhibiting the biosynthesis of fatty acids. The compound subsequently became an important research tool. Also in the mid-1970s, Omura discovered and successfully cultured new strains of Streptomyces soil bacteria, including *S. avermitilis*.

In 1968 Omura completed a PhD in pharmaceutical sciences at the University of Tokyo, and two years later, having returned to the Tokyo University of Science, he also earned a PhD in chemistry. From 1963 to 1965, he worked as a research associate at the University of Yamanashi, and afterward served as research associate at the Kitasato Institute, then one of the world's leading microbiology research facilities. While completing his PhD studies and carrying out research at the institute, he took a position as an associate professor at nearby Kitasato University. Between 1968 and 2007, when Omura was named professor emeritus at Kitasato University, he served variously as director and president of the Kitasato Institute as well as a professor and director of the university. In 2013 he was given the title distinguished emeritus professor at Kitasato.

Notes

24

Takaaki Kajita

Japanese physicist Takaaki Kajita was awarded the Nobel Prize in Physics in 2015, jointly with Canadian astrophysicist Arthur B. McDonald "for the discovery of neutrino oscillations, which shows that neutrinos have mass".

The neutrino is an elusive particle that is extremely difficult to detect because it interacts very feebly with matter. There are three types of neutrinos: electron neutrino, muon neutrino, and tau neutrino. Each 'flavour' of neutrino has a corresponding charged particle from which it gets its name. Although it was postulated first by Wolfgang Pauli in 1930 to explain beta of radioactive atoms, it was not discovered till 1959. Three types of neutrino are known. But, for a long time physicists were not sure whether neutrino has mass. The Standard Model of of particle physics used by modern physics has three types of neutrino. In 1998, Kajita detected neutrinos created in reactions between cosmic rays and the Earth's atmosphere in the Super-Kamiokande detector, an experimental facility in a mine in Japan. Measurements showed deviations, which were explained by the neutrinos switching between the different types, which meant that they must have mass.

Kajital was born on 9 March 1959, in Higashi-Matsuyama, a small city north of Tokyo, Japan. He went to Kawagoe High School, a typical small-town school, and decided to learn physics in the undergraduate course at Saitama University, a local university near Tokyo from where he received a bachelor's degree in 1981 and a doctorate from the University of Tokyo in 1986. He was particularly interested in experimental particle physics.

Kajita joined the University of Tokyo's Institute for Cosmic Ray Research in 1988 as a research associate and continued his work at the Kamiokande-II neutrino experiment, a tank containing 3,000 tons of water located deep underground in the Kamioka mine near Hida. He became an associate professor at the institute in 1992. That same year he and his team published results confirming the deficit of atmospheric muon neutrinos. They suggested that neutrino oscillations in which the "missing" muon neutrinos changed into the third neutrino flavour, tau (which could not be observed by Kamiokande-II), could be the culprit.

In 1996 Kamiokande-II was replaced by Super-Kamiokande, which contained 50,000 tons of water After years of planning and construction, the Super-Kamiokande experiment started taking data precisely on schedule on 1 April 1996. Since then Kajita had worked as a convener of the atmospheric neutrino analysis. After two years of observations, his team definitively confirmed the existence of neutrino 'flavour' oscillations and thus neutrino mass, which meant neutrinos have mass.

Notes

25

Yoshinori Ohsumi

Japanese cell biologist Yoshinori Ohsumi was awarded the Nobel Prize in Physiology or Medicine in 2016 "for his discoveries of mechanisms for autophagy". Autophagy is a process by which cells degrade and recycle proteins and other cellular components. Autophagy has been known for over 50 years but its fundamental importance in physiology and medicine was only recognised after Ohsumi's path-breaking research in the 1990's, when Ohsumi conducted a series of ground-breaking experiments with yeast, where he detected autophagy and identified genes important for the process. Ohsumi's discoveries laid the foundation for a better understanding of the ability of cells to manage malnutrition and infections, the causes of certain hereditary and neurological diseases, and cancer. His discoveries opened the path to understanding the fundamental importance of autophagy in many physiological processes, such as in the adaptation to starvation or response to infection.

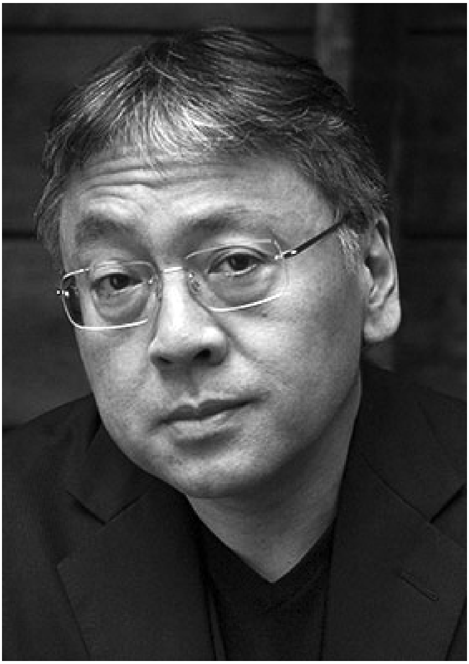
Ohsumi was born on 9 February 1945 in Fukuoka, Japan. He was interested in the natural sciences from an early age. After receiving a BS degree in 1967 and a PhD in 1974 from the University of Tokyo, he went to Rockefeller University in New York, USA, where he studied as a postdoctoral researcher with American physical chemist Gerald Maurice Edelman. Ohsumi initially worked on a system for *in vitro* fertilisation in mice. As he was unfamiliar with mammalian embryonic development, he later switched to the study of DNA in yeast and became interested in vacuoles (membrane-bound fluid-filled cavities in cell), which were easily obtained from yeast cells and in which Ohsumi had observed various transport systems for moving molecules across the vacuole membrane.

Thanks to Ohsumi and others following in his footsteps, we now know that autophagy controls important physiological functions where cellular components need to be degraded and recycled. Autophagy can rapidly provide fuel for energy and building blocks for renewal of cellular components, and is therefore essential for the cellular response to starvation and other types of stress. After infection, autophagy can eliminate invading intracellular bacteria and viruses. Autophagy contributes to embryo development and cell differentiation. Cells also use autophagy to eliminate damaged proteins and organelles, a quality control mechanism that is critical for counteracting the negative consequences of aging. Disrupted autophagy has been linked to Parkinson's disease, Type 2 diabetes and other disorders that appear in the elderly. Mutations in autophagy genes can cause genetic disease. Disturbances in the autophagic machinery have also been linked to cancer. Intense research is now ongoing to develop drugs that can target autophagy in various diseases.

Notes

26

Kazuo Ishiguro



Kazuo Ishiguro, a Japanese-born English novelist, screenwriter, and short story writer, was awarded the Nobel Prize in Literature in 2017. The Swedish Academy described him as one "who, in novels of great emotional force, has uncovered the abyss beneath our illusory sense of connection with the world".

Ishiguro is considered one of the most celebrated contemporary fiction authors in the English-speaking world, having received four Man Booker Prize nominations and winning the 1989 award for his novel *The Remains of the Day*. His 2005 novel, *Never Let Me Go*, was named by *Time* as the best novel of 2005 and included in its list of the 100 best English-language novels from 1923 to 2005. His seventh novel, *The Buried Giant*, was published in 2015.

Ishiguro was born on 8 November 1954 in Nagasaki, Japan. His family moved to England in 1960 when he was five. He attended Stoughton Primary School and then Woking County Grammar School in Surrey. After finishing school, he took a gap year and travelled through the United States and Canada, while writing a journal and sending demo tapes to record companies. In 1974, he began studies at the University of Kent at Canterbury, graduating in 1978 with a Bachelor of Arts (honours) in English and Philosophy. Growing up in a Japanese family in the UK was crucial to his writing, as he says, enabling him to see things from a different perspective to many of his British peers.

After spending a year writing fiction, he resumed his studies at the University of East Anglia and gained a Master of Arts in Creative Writing in 1980. His thesis became his first novel, A Pale View of Hills, published in 1982. He became a British citizen in 1983.

Except for *A Pale View of Hills* and *The Buried Giant*, all of Ishiguro's novels and his short story collection have been shortlisted for major awards. Most significantly, *An Artist of the Floating World*, *When We Were Orphans*, and *Never Let Me Go* were all short-listed for the Booker Prize. He received the Booker Prize for *The Remains of the Day* in 1989. After this, Ishiguro became one of the best-known European novelists at just 35 years of age. His next novel, *The Unconsoled* (1995) – a radical stylistic departure from his early, conventional works that received passionately mixed reviews – focusses on lack of communication and absence of emotion as a concert pianist arrives in a European city to give a performance.

Ishiguro also wrote screenplays for British television as well as for the feature films *The Saddest Music in the World* (2003) and *The White Countess* (2005). He was appointed Officer of the Order of the British Empire (OBE) in 1995.

Notes