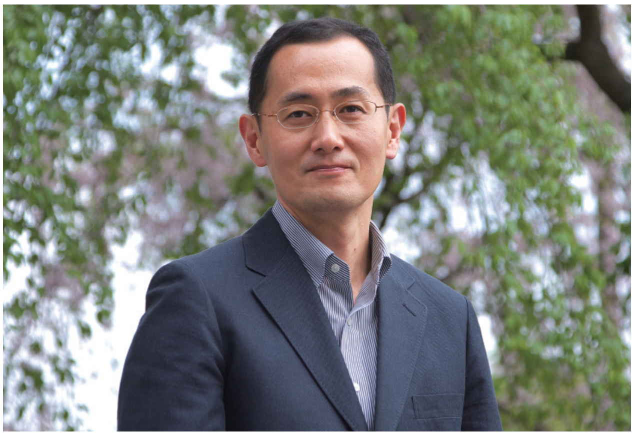
Dr. Shinya Yamanaka was awarded the 2012 Nobel Prize in Physiology or Medicine jointly with Sir John B. Gurdon

"for the discovery that mature cells can be reprogrammed to become pluripotent"

Dr. Shinya Yamanaka and his research team reported the world's first generation of mouse iPS cells in 2006 and the generation of human iPS cells in 2007. The team also reported the establishment of mouse iPS cells using plasmid DNA vectors in 2008, one of the first methods to generate such cells without requiring gene insertion. Many researchers around the world are now working on studies with the use of iPS cells, which may one day find applications in regenerative medicine and as a research tool in drug discovery. In order for such applications to become a reality, however, it will be necessary to establish optimal protocols for the generation of iPS cells by deepening our understanding of the mechanisms that underlie the reprogramming of differentiated cells into an undifferentiated state.

Dr. Yamanaka commented that he is particularly happy to have been awarded the prize jointly with Sir John B. Gurdon, a Fellow of the Royal Society and professor at and founder of the Wellcome Trust/Cancer Research UK Gurdon Institute at the University of Cambridge. In 2009, Dr. Yamanaka and Sir Gurdon were jointly awarded the Albert Lasker Award for Basic Medical Research "for discoveries concerning nuclear reprogramming, the process that instructs specialized adult cells to form early stem cells — creating the potential to become any type of mature cell for experimental or therapeutic purposes."



Dr. Shinya Yamanaka

Director and Professor
Center for iPS Cell Research and Application (CiRA)

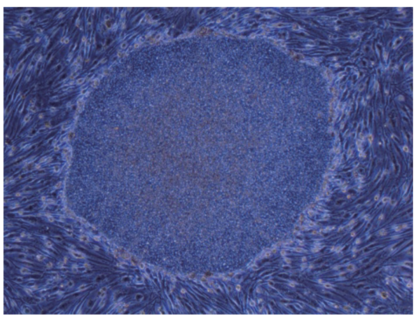
Principal Investigator,
Institute for Integrated Cell-Material Sciences (iCeMS)

Dr. Shinya Yamanaka received his M.D. from Kobe University in 1987 and his Ph.D. from Osaka City University in 1993. After working as a postdoctoral fellow at the Gladstone Institute of Cardiovascular Disease in San Francisco, he became an assistant professor at Osaka City University in 1996. He was appointed as an associate professor at Nara Institute of Science and Technology in 1999, and a professor in 2003. He moved to Kyoto University in 2004, and since 2008 has served as the director of the university's Center for iPS Cell Research and Application (CiRA). In addition to the Nobel Prize in Physiology or Medicine, he has received several other awards including the Albert Lasker Award for Basic Medical Research, the Canada Gairdner International Award, the Imperial Prize, the Japan Academy Prize, and the Kyoto Prize.

Key Research Paper by Dr. Yamanaka Now Available Online

Induction of Pluripotent Stem Cells from Mouse Embryonic and Adult Fibroblast Cultures by Defined Factors, a groundbreaking research paper by Dr. Yamanaka, is now available for free public download via the Kyoto University Research Information Repository (KURENAI). Dr. Yamanaka was awarded the Nobel Prize for Physiology or Medicine on the basis of this key publication.

repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/159777/1/j.cell.2006.07.024.pdf



Nobel Laureates at Kyoto University

Dr. Shinya Yamanaka's award is the eight Nobel Prize to be garnered by researchers affiliated with Kyoto University. Beginning in 1949 with theoretical physicist Hideki Yukawa, Japan's first Nobel laureate, this string of honors serves as a concrete testament to Kyoto University's status as one of the most dynamic and accomplished research universities in Asia.

Since its foundation in 1897, Kyoto University has been dedicated to cultivating a liberal and vibrant academic environment conducive to quality education, interdisciplinary dialogue, and groundbreaking research. That rich academic culture is continually refined and refreshed by the university's lineage of outstanding scholars, and continues to provide fertile ground for award-winning innovation and creativity.

The following section features introductions to the seven Nobel laureates who preceded Dr. Yamanaka, and the remainder of the booklet highlights selected endeavors by Kyoto University's current generation of pioneering researchers.

8 Nobel Laureates associated with Kyoto University

Hideki Yukawa
1949

Sin-Itiro Tomonaga
1965

Kenichi Fukui
1981

Susumu Tonegawa
1987

Ryoji Noyori
2001

Makoto Kobayashi
2008

Toshihide Maskawa
2008

Shinya Yamanaka
2012

Hideki Yukawa

Nobel Prize in Physics, 1949

The bronze bust of Dr. Yukawa, in front of the building of Research Institute for Fundamental Physics

Dr. Hideki Yukawa, a theoretical physicist, was a student at Kyoto Imperial University and became a professor at Kyoto University in 1939.

Dr. Yukawa proposed a theory in 1935, with regard to the coupling between protons and neutrons, which constitute an atomic nucleus. In such couplings the proton has a positive charge, whereas the neutron is changeless. Therefore, the coupling between them cannot be explained by electric forces. Dr. Yukawa's theory proposed that the proton and the neutron absorb and emit a certain particle by which the coupling between them is held. He predicted that the mass of this particle, which was later called a meson, is 200 times that of the electron.

In 1937, a new particle with the predicted meson mass was discovered. Moreover, Cecil Powell, a British physicist, experimentally discovered a meson mediating the nuclear force in 1947, which demonstrated Dr. Yukawa's theory. The Nobel Prize in Physics was awarded to Dr. Yukawa for his theory in 1949. His receipt of the award gave a great deal of encouragement to the Japanese people in the period just after the Second World War.

Sin-Itiro Tomonaga

Nobel Prize in Physics, 1965

Dr. Sin-Itiro Tomonaga was a physicist and a classmate of Hideki Yukawa, also a Nobel Laureate, at Kyoto Imperial University.

Force does not directly and instantaneously act on a remote object, but is transmitted through an intervening field. This viewpoint is important in constructing a theory consistent with the theory of relativity.

In 1943, Dr. Tomonaga formulated the theory of quantum fields in a relativistically covariant form to establish the “super-many-time theory,” completing the quantum field theory.

In the 1930s to 1940s, researchers of the quantum mechanics of fields faced a serious problem: Theoretical calculation of the electron mass gave infinity, inconsistent with the measurement. In 1946, Dr. Tomonaga solved this problem by the “renormalization theory.” In 1965, Dr. Tomonaga was awarded the Nobel Prize in Physics for his fundamental work in quantum electrodynamics, which greatly enhanced understanding of the physics of elementary particles.

Kenichi Fukui

Nobel Prize in Chemistry, 1981

Dr. Kenichi Fukui, a chemist, was a professor at Kyoto University from 1951 to 1982. Dr. Fukui strived to theoretically elucidate chemical reactions using quantum mechanics. Classical theory of chemical reactions based on electrical attraction between a positively charged atom and a negatively charged atom cannot explain all chemical reactions. Quantum mechanics dictates the existence of orbitals, which represent the energy and distribution of electrons in a molecule. Dr. Fukui discovered that some of these orbitals play critical roles in chemical reactions, and then provided a perfect description of the essence of chemical reactions. In 1952, he published this description, which he called the frontier electron theory (later renamed the frontier orbital theory).

The frontier orbital theory is useful in understanding and predicting numerous chemical reactions, and remains essential in today’s chemistry. In 1981, Dr. Fukui was awarded the Nobel Prize in Chemistry for his achievement.

Susumu Tonegawa

Nobel Prize in Physiology or Medicine, 1987

Dr. Susumu Tonegawa, a biologist, received his bachelor's degree from Kyoto University in 1963. He is currently a professor at the Massachusetts Institute of Technology.

Lymphocytes play a major role in the immune system, which protects an organism against pathogens. Lymphocytes can express a vast variety (over one trillion) of receptors, which recognize and react with pathogens and other foreign substances. Since an organism has only 20,000 to 30,000 genes at the most, how these genes can create over one trillion lymphocyte receptors, called antibodies, was one of the greatest mysteries of life science in the 20^{th} century.

Dr. Tonegawa discovered the mechanism for producing this enormous antibody diversity. With regard to antibodies, a child inherits only the components of the genes from his or her parents, and those components are then combined. This mechanism of producing the diversity allows organisms to fully respond to the invasion of extraneous substances and environmental changes that occur over tens of thousands of years. Dr. Tonegawa was awarded the Nobel Prize in Physiology or Medicine in 1987 for this discovery.

Ryoji Noyori

Nobel Prize in Chemistry, 2001

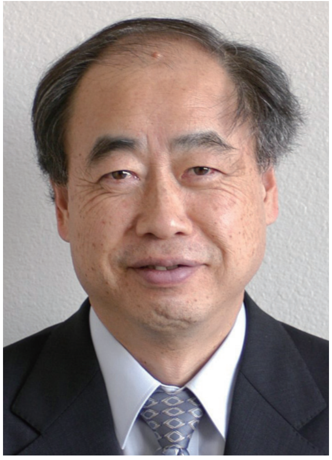
Dr. Ryoji Noyori, a chemist, received his Ph.D. degree from Kyoto University in 1967. He is currently a professor at Nagoya University and president of RIKEN, a large natural sciences research institute in Japan founded in 1917.

A pair of "left" and "right" molecules that mirror each other are called enantiomers (optical isomers), which have different properties. For example, one is advantageous, but the other is harmful. It is desirable to separately produce and use only the advantageous one of the left and right molecules. Unfortunately, however, artificial production without subtle ingenuity results in an equal amount of left and right molecules.

Dr. Noyori tackled this problem, and developed a catalyst bearing BINAP ligand in 1986. This enabled separate production of left and right substances. This reaction, called asymmetric synthesis, has been applied to a variety of industrial products and medicines, and produced useful substances. In 2001, he was awarded the Nobel Prize in Chemistry for his work on chorally catalyzed hydrogenation reactions.

Makoto Kobayashi

Nobel Prize in Physics, 2008



Toshihide Maskawa

Dr. Makoto Kobayashi is a physicist who worked at Kyoto University after receiving his Ph.D. degree from Nagoya University in 1972. Dr. Toshihide Maskawa, also a physicist, received his Ph.D. degree from Nagoya University in 1967. He was director of the Yukawa Institute for Theoretical Physics at Kyoto University from 1997 to 2003, and is currently director of the Maskawa Institute for Science and Culture at Kyoto Sangyo University.

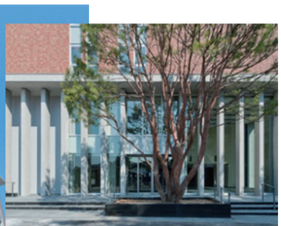
At the beginning of the universe the Big Bang produced equal amounts of matter and anti-matter through pair-creations. As the universe expanded and cooled, much of this matter and anti-matter was annihilated. If perfect symmetry between matter and anti-matter (CP symmetry) exists, then all the matter and anti-matter in the universe would have been completely annihilated, and consequently matter could not have survived. However, this is not the case. The symmetry between matter and anti-matter is, in fact, imperfect and slightly broken (CP violation). This asymmetry has resulted in only matter surviving to form the universe which we observe today. This slight violation of CP symmetry was first confirmed by a particle physics experiment at Brookhaven National Laboratory in 1964.

In 1972, Dr. Kobayashi and Dr. Maskawa, proposed a new mechanism (Kobayashi-Maskawa theory) to explain CP violation in the framework of a unified gauge theory of the electroweak interaction, which had just been established at that time. They predicted that the number of quarks should be at least six in order for this mechanism to work. However, at this time only three quarks were known. The remaining three quarks that they predicted have subsequently been found experimentally (six quarks have been found in total). Furthermore, by 2002, two precision experiments using B-mesons, which were conducted in Japan and the US, confirmed that CP violation can consistently be explained by the Kobayashi-Maskawa theory.

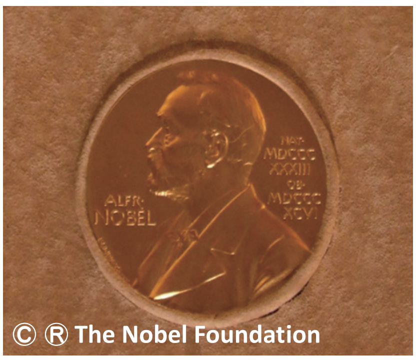
The Kobayashi-Maskawa theory is an important part of the standard model of elementary particles, which is based on the current gauge theory. In 2008, these two physicists were jointly awarded the Nobel Prize in Physics for this work.

Kobayashi-Maskawa Memorial Room

[right]
North Comprehensive Education and Research Building, established in 2011, also called the Maskawa Memorial Hall in commemoration of Dr. Maskawa's award.



Entrance



Dr. Maskawa's Nobel Medal