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Japan Prize News
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JAPAN PRIZE

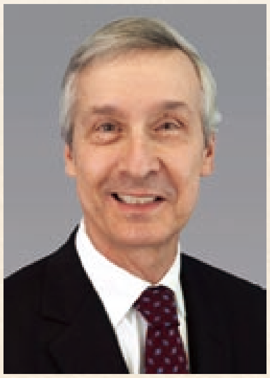
2014 Japan Prize Laureates Announced

Dr. Yasuharu Suematsu whose research has led to the establishment of optical fiber communication technology indispensable for today's information society, and Dr. C. David Allis whose discovery has deciphered epigenetic changes in genes

"Electronics, Information and Communication" field

Dr. Yasuharu Suematsu
Honorary Professor
Tokyo Institute of Technology
JAPAN

" Life Science" field



Dr. C. David Allis
The Joy and Jack Fishman Professor
The Rockefeller University
USA

The Japan Prize Foundation has decided to award the 2014 (30th) Japan Prize to Dr. Yasuharu Suematsu of Japan and Dr. C. David Allis of the United States. Dr. Suematsu, Honorary Professor of Tokyo Institute of Technology, was recognized in the "Electronics, Information and Communication" field for his "pioneering research on semiconductor lasers for high-capacity, long-distance optical fiber communication." His research led to a major breakthrough in optical fiber communication technology that supports global information networks such as the Internet.

In the "Life Science" field, Dr. Allis, the Joy and Jack Fishman Professor at The Rockefeller University in New York City, was given credit for his world-first "discovery of histone modifications as fundamental regulators of gene expression." His discovery has elucidated how chemical modifications of histone proteins, around which DNA wraps itself in the cell' s nucleus, affect gene expression, and contributed significantly to the progress of life science.

An award-presentation ceremony honoring the laureates will be held in Tokyo on April 23, 2014.

JAPAN PRIZE

The Japan Prize is awarded to scientists and researchers, regardless of nationality, who have made significant contributions to the progress of science and technology as well as society to serve the cause of peace and prosperity of mankind.

While the prize encompasses all categories of science and technology, two fields of study are designated for the prize each year in consideration of developments in science and technology. Each Japan Prize laureate receives a certificate of merit and a prize medal. A cash prize of 50 million yen is also awarded to each prize field.

"Electronics, Information and Communication" field

Achievement : Pioneering research on semiconductor lasers for high-capacity, long-distance optical fiber communication

Dr. Yasuharu Suematsu

Born: September 22, 1932 (age 81)
Honorary Professor, Tokyo Institute of Technology

Summary

Optical communication network using optical fiber is the pillar of present information society. Dr. Yasuharu Suematsu, Honorary Professor of Tokyo Institute of Technology, has been undertaking the study of optical communication since the early 1960s, the dawn of the optical electronics age. Dr. Suematsu was also a forerunner in taking a "problem-solving approach" in research. In this approach, levels of performance required by society are projected first, and theory and experiments are combined to achieve the goal. In the early 1980s, Dr. Suematsu gave shape to his idea of dynamic single-mode laser, which emits light in the wavelength range where the minimum loss is achieved and has a stable wavelength even with high-speed light modulation when transmitting information. His research on semiconductor lasers has greatly contributed to the realization of a high-capacity, long-distance optical fiber communication.

Semiconductor laser innovation: The driving force behind the achievement of the optical fiber network

The term "information society" was coined in the 1960s when the world was entering a new phase after World War II. The term refers to a society where information technology permeates and revolutionizes various facets of our lives such as economic activity, culture, education and daily lives. In order to realize this information society, scientists and engineers have taken on the challenge of innovation in communication technology. For example, owing to the development in wireless communication technology using microwaves and millimeter waves, Japan and the United States succeeded in launching satellite transmission in 1963. In 1979, a car phone service, which was the forerunner of mobile phones, started in the Tokyo Metropolitan area.

Another technology which contributed to the sophistication of the information society is optical communication using optical fiber. Optical fibers enabled transmission of a large amount of data by sending laser light modulated with high speed to carry information over light waves through optical fibers.

In the early 1960s, Dr. Yasuharu Suematsu, Honorary Professor of Tokyo Institute of Technology, undertook the development of a semiconductor laser which oscillates light used for optical transmission. In 1981, he succeeded in developing a semiconductor laser that uses a wavelength band that minimizes loss of the light signal in an optical fiber (essential to long-distance communication), while maintaining a stable wavelength during a high-speed modulation (essential to large-capacity transmission). This technology greatly contributed to realizing a high-capacity, long distance optical fiber network.

Surpassing millimeter waves in one leap, taking on the challenge of the new frontier of optical communication technology

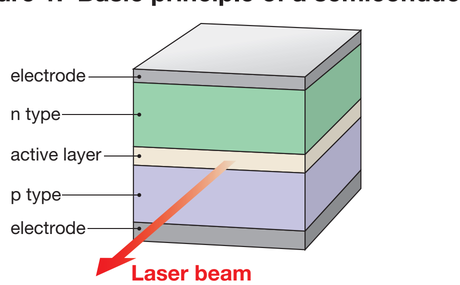
Dr. Suematsu was born in Gifu Prefecture, central Japan, in 1932. From childhood, he was one of the so-called "Radio Boys," creating vacuum-tube radios with his own hands. He went on to go to Tokyo Institute of Technology, heeding his uncle's advice, "If you want to study technology, TIT is the place to go."

At the university, he was deeply impressed by his mentor Professor Kiyoshi Morita's experiments with microwave communication, and was spurred on to carry out studies in communication himself. However, as he proceeded with his postgraduate research, he came to wonder if microwaves and millimeter waves can handle high-capacity communication. He thought: "According to Shannon's theorem, with electromagnetic waves, the limit in information volume is half the number of frequencies. However, using a shorter wavelength, it may be possible to transmit several thousand times the information millimeter waves can carry." When he became an assistant professor in 1961 after completing his postgraduate studies, he surpassed millimeter waves and chose optical communication as his research theme.

However, it was not an easy decision for him to make as prevailing opinions in the university at that time were that one should tackle the task at hand, rather than engaging in research on a technology that seemed to be far away from practical use. Yet what served as a tailwind was that element technologies that led to the realization of optical communication sprang up one after another. In 1964, Professor Junichi Nishizawa of Tohoku University proposed a "self-focusing optical fiber" which made possible a wide-area signal transfer. Then, in 1966, Charles Kao (1996 Japan Prize Laureate) theoretically forecasted that low-loss optical fiber is feasible. Thus, expectations mounted toward a digital communication network using optical fiber.

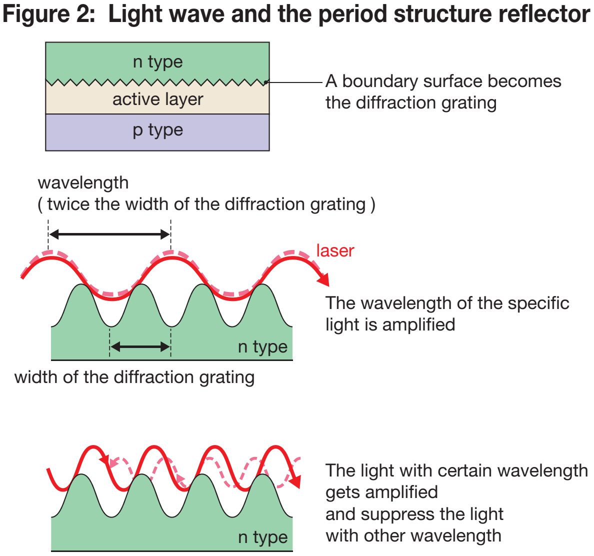
The main challenge was to develop an optimum laser for optical

Figure 1: Basic principle of a semiconductor laser



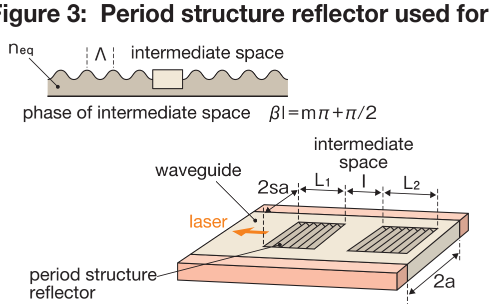
A semiconductor laser has structure in which matter called the active layer is sandwiched between two types of semiconductors, namely the n type and the p type. When voltage is applied to these two semiconductors, oscillation of light with wavelength according to the changes in energy takes place.

Figure 2: Light wave and the period structure reflector



When a "zigzag cut" diffraction grating is inserted onto the surface of the semiconductor at half the interval of the wavelength, light with a fixed wavelength is amplified, and the other wavelengths are cancelled. Thus, the wavelength of the light oscillated becomes uniform.

Figure 3: Period structure reflector used for the integrated laser



The period structure reflector used for the proposed single-mode laser by Dr. Suematsu. By creating an intermediate region between the two reflectors place in the waveguide, light with a more uniform wavelength was achieved.

fiber communication. In order for information to be passed without attenuation through such scales as several tens of kilometers or several hundreds of kilometers of fiber, a laser with adequate wavelength and direction was necessary. At the time, various types of lasers had been developed; however, with optical fiber digital communication where information is transmitted in combination of 0s and 1s, information could not be transmitted long distance with precision when various types of lights are mixed. A high-precision laser with stable oscillation of a fixed wavelength was required.

Dr. Suematsu's choice was semiconductor lasers, which were invented in 1962. A semiconductor laser has a structure in which matter called an "active layer" is sandwiched between two types of semiconductors, namely the n type and the p type. By applying voltage to the semiconductor, the electrons are transferred between both semiconductors, light with wavelength corresponding to changes in energy (photon) results. The resultant light continues to be amplified within the active layer in order to induce the transfer of the next electron, and when it exceeds a certain strength, it oscillates as a laser light (Figure 1).

However, the issue with semiconductor lasers is that the wavelength changes with high-speed modulation, and specialists use such expression as "oscillation mode hopping" or "multimode oscillation" to describe this phenomenon. In order to transmit digital data, an unchanging mode (single mode) even with high-speed modulation of light to carry high-capacity information was required.

Dynamic single-mode laser achieved - long-distance optical fiber communication becomes a reality

Dr. Suematsu's research style of tackling a challenge was unique for a university professor. His research stance was to achieve the performance demanded by the society and university researchers were to thoroughly pursue a basic theory to arrive at an "optimum solution."

For example, there exists a technology in which a period structure of a light reflector is used in order to align the light wavelength. When inserting a "zigzag cutting" into the surface or inside the semiconductor at half the interval of the wavelength, the target light of the wavelength strengthens one another and cancels the others (Figure 2). Dr. Suematsu not only pursued the theory of this technology, but also applied this technology by introducing a device which could actually be used for optical communication, thereby stabilizing the laser motion.

Afterwards, he undertook research of an integrated laser. In a semiconductor laser, there is an "active region" which strengthens the laser light, a "waveguide" which leads the light in a fixed direction, and a "reflective part" which reflects light. By using a period structure reflector on the reflective part, and integrating it with the other parts, Dr. Suematsu anticipated that this would become the foundation of next-generation technology such as the "optical integrated circuit." Thereafter, in 1974, 13 years after beginning his research at the university, he proposed a single-mode laser which oscillates light with uniform wavelength by placing two periodic structure reflectors within the integrated "waveguide," and creating an intermediate region between the respective reflectors so that half of the wavelength phase is deviated (Figure 3).

Furthermore, when it was discovered in the 1970s that light loss within the optical fiber is minimal when the wavelength band is 1.5 micrometers, Dr. Suematsu began an independent study of semiconductors and succeeded in the room-temperature continuous-wave operation of 1.5 micrometer wavelength using an InGaAsP laser. In the fall of 1980, by means of an integrated laser using with a unique period structure reflector, he succeeded in creating a prototype for a 1.5 micrometer wavelength band laser. It was verified that light oscillation was stable even under high-speed modulation in order to transmit data, and in the following year (1981), at the academic conference in Europe, this invention was presented as a "dynamic single-mode laser."

The dynamic single-mode laser proved to be an indispensable technology in the field of optical fiber communication in the years that followed. In the mid-1980s, technology using optical fiber for long distance communication was established and began to be used as inter-city and international communication infrastructure. It can be said that the Internet, which has become widespread to the general public from 1995 onwards, would not have been possible without this technology.

Dr. Suematsu has also contributed toward the sophistication of the integrated laser technology. In 1983, Dr. Suematsu et al. became the first in the world to achieve a variable wavelength semiconductor laser which can electrically control the oscillation wavelength. Coming into the 2000s, a new technology, namely, wavelength division multiplexing was introduced into the optical fiber field to achieve an even faster communication network, and the technology pioneered by Dr. Suematsu has greatly contributed to this development.

The integrated laser technology pioneered by Dr. Suematsu will continue to evolve our information society in the future.

"Life Science" field

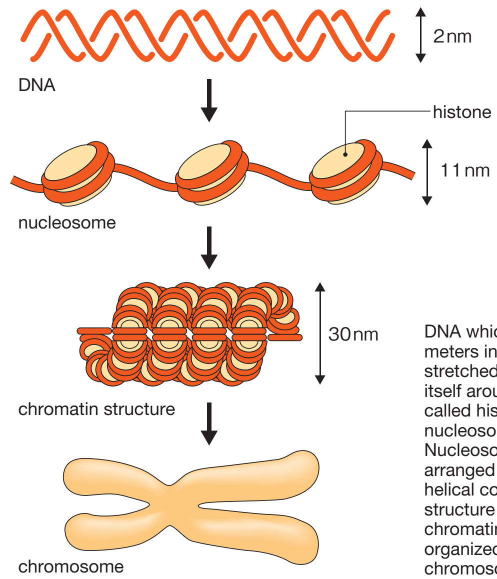
Achievement : Discovery of histone modifications as fundamental regulators of gene expression

Dr. C. David Allis
Born: March 22, 1951 (Age 62)
Joy and Jack Fishman Professor
Head, Laboratory of Chromatin Biology and Epigenetics
The Rockefeller University

Summary

A human body consists of approximately 60 trillion cells, and most of them have the same genetic information in DNA (deoxyribonucleic acid). How can cells with the same DNA develop into many different types of cells to make up the different organs in the body with different forms and functions, such as skin, liver and cranial nerves? A biochemist from the U.S., Dr. David Allis, tackled this question and discovered from his research in the 1990s that enzymes that chemically modify histones, proteins found in chromosomes, play a vital role in the regulation of gene activity. His findings have greatly contributed to the understanding of the generation mechanism in which an organism grows from a fertilized egg, as well as to the development of drugs to treat cancer related to abnormalities in histone modifications.

Figure 1 : DNA folding structure



DNA which extends to 2 meters in length when stretched out, wraps itself around proteins called histones to form a nucleosome. Nucleosomes are further arranged in a stacked helical complex to form a structure called chromatin, which is organized to form a chromosome.

How do various organs result from cells with the same genetic information?

DNA, which is found within the cell nucleus of living organisms, is called "the blueprint of life." Ever since the double helical structure of DNA was discovered by James Watson and Francis Crick in 1953, scientists have been endeavoring to explain how life phenomena are brought about by means of the information written in the DNA. In the 1990s, the Human Genome Project commenced with the goal of decoding the entire base sequence (genome) of the human DNA and was completed in 2003, 50 years after the discovery by Watson and Crick.

Is it possible to understand all about life phenomena if the base sequence of DNA is defined? Unfortunately, the answer is "no." While the Human Genome Project was in progress, it was becoming clear that, in addition to the genetic information of the DNA, there exists a mechanism in which a part of the genetic information is selectively expressed at each cell level and that this system is extremely vital in life phenomena.

For example, in the human body, there are approximately 300 types of cells, and with the exception of a small fraction, most have the same DNA. Despite having the same DNA, they develop into different types of cells with different forms and functions, such as skin cells and hepatic cells. The characteristics of these cells carry on even after cell division.

The academic field which studies chromosomes controlling mechanisms without changes in DNA sequences is called epigenetics. Epigenetics has several research themes, such as a phenomenon known as "DNA methylation." Dr. David Allis was the first to clarify in 1996 that a chemical modification known as acetylation occurs on histones, proteins which constitute the chromosomes in eukaryotes (organisms having a nucleus within the cell), and that such modifications are relevant to the controlling of gene expression. His discovery has made a significant contribution to the development of the emerging science of epigenetics.

Fascinated by Real Lab's appeal, taking on the challenge of the mechanism of the genetic expression control

Dr. Allis was born in Cincinnati, a major city in southwestern Ohio, the United States, in 1951. After graduating from high school, he entered the University of Cincinnati. He majored in biology in preparation for medical school. However, his advisor suggested that he experience basic research (Dr. Allis refers to this as the Real Lab), which is another forefront indispensable to the development of medicine. He ended up becoming engrossed with this basic research, in particular embryology, and acquired a doctorate degree in biology at the postgraduate school of the University of Indiana in 1978.

He then moved on to the University of Rochester and made the University of Virginia Health System his research base. There, he conducted research on the functions of chromosomes using various organisms such as drosophila, but eventually focused his research subject on a unicellular organism called tetrahymena. The cell nucleus of tetrahymena is divided into a micronucleus and a macronucleus. The micronucleus is not active normally, but carries on through cell division similar to a reproductive cell of a higher organism, and cell activity is carried on based on the DNA of the macronucleus.

In the 1990s, Dr. Allis chose histones, proteins that constitute the chromosomes of tetrahymena, as the essential study theme of his research group. What, then, is a histone? The DNA in our cells becomes approximately two meters in length when stretched out. Histones organize "long strands" of DNA into a cell nucleus just 10 micrometers in diameter in a compact and orderly fashion. DNA coils itself around granular histones approximately two times to form a nucleosome. Nucleosomes are further arranged in a stacked helical complex to form a structure called chromatin, which is organized to form a chromosome (Figure 1).

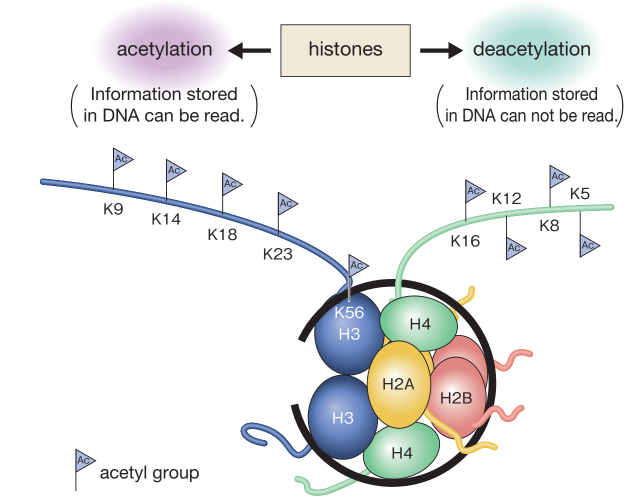
What the researchers particularly paid attention about histones was that the region within the DNA which is not used in cell activity is bound strongly to histones. Conversely, when the base sequence information is being used, the DNA distances itself from histones, in a loosely unbound state. What substance regulates the bond between the DNA and histones? Dr. Allis' research team continued to undertake the challenge of clarifying the difference between chemical modifications in the macronucleus and the suspended action in the micronucleus when tetrahymena is active.

There proved to be stiff competition developing among research groups worldwide. Finally, in 1996, it was clarified that with histones in the region where genetic information could be read, histone acetyltransferase which binds itself to the acetyl group is active. In addition, through the balance between the histone acetyltransferase and the histone deacetylase, genetic expression is regulated, thus proving for the first time that changes in the chromatin structure through histone modifications are actually regulating gene activity.

Study of histone modifications contributes to the development of next-generation medicine

The discovery by Dr. Allis' research group served as a catalyst for the rapid development of studies related to chromosome functions.

Figure 2 : Histone tails and acetylation



Histones form a structure known as a histone octamer in which eight small proteins are bound together. Several proteins have a tail, and when an acetyl group is attached to the tail, DNA binding to histones is regulated.

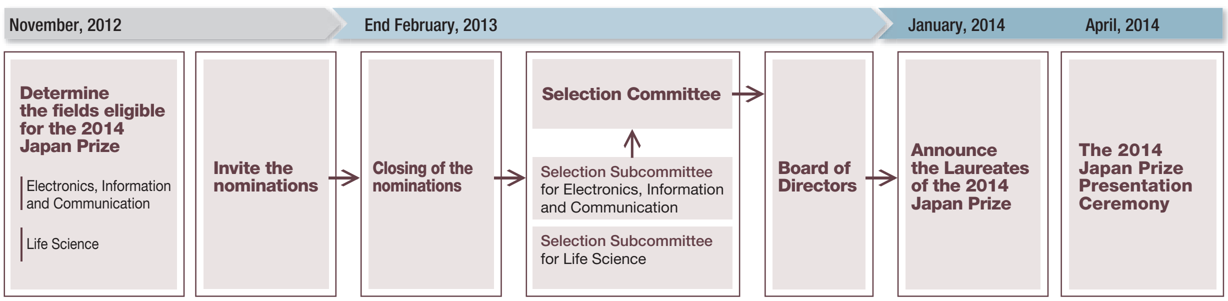
It also clarified that not only the acetyl group but several other substances such as the methyl group also attach themselves to histones (chemical modification). When probing into the histone structure, there are eight small ball-like proteins connected together in a form called a histone octamer, with some proteins having a "tail" extension. A "histone code hypothesis," in which it is thought that multiple chemical modification patterns connected to the tail function as a "code," controlling the gene expression, has been proposed, and studies thereof are ongoing (Figure 2).

Dr. Allis' research is also contributing to the progress of medicine. For example, it has come to light that not only gene abnormalities but also abnormalities in epigenetics such as histone modifications contribute to the occurrence of cancer. There has been one report after another of histone acetylation decrease in certain types of cancer, and molecular-target drug named HDI (histone deacetylase inhibitor) which repairs the balance between histone acetylase and histone deacetylase has been proposed. With "Vorinostat," the first HID for cutaneous T-cell lymphoma approved in the U.S. in 2006, studies of several new drug candidates are underway.

In addition, histone modifications play a major role in governing the occurrence of organisms, contributing to the progress of regenerative medicine using iPS cells. The research into histone chemical modifications pioneered by Dr. Allis, will continue to be a vital field in the future development of life science.

Nominations and Selection Process

- Every November, the Field Selection Committee of The Japan Prize Foundation designates and announces two fields in which the Japan Prize will be awarded two years hence. At the same time, the Foundation calls for over 13,000 nominators, strictly comprised of prominent scientists and researchers from around the world invited by the Foundation, to nominate the candidates through the web by JPNS (Japan Prize Nomination System). The deadline for nominations is the end of February of the following year.
- For each field, a Selection Subcommittee conducts a rigorous evaluation of the candidates' academic achievements. The conclusions are then forwarded to the Selection Committee, which conducts evaluations of candidates' achievements from a wider perspective, including contributions to the progress of science and technology, and significant advancement towards the cause of world peace and prosperity, and finally the selected candidates are recommended for the Prize.
- The recommendations are then sent to the Foundation's Board of Directors, which makes the final decision on the winners.
- The nomination and selection process takes almost one year from the time that the fields are decided. Every January, the winners of that year's Japan Prize are announced. The Presentation Ceremony is held in April in Tokyo.



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Member Yoshiko Takahashi — Professor, Division of Biological Science, Graduate School of Science, Kyoto University

(alphabetical order, titles as of December, 2013)

Fields Eligible for the 2015 Japan Prize

Area of Physics, Chemistry and Engineering

Resources, Energy and Social Infrastructure

Background and rationale:

As global population continues to grow, the biggest challenge of this century is guiding human society towards balanced development while overcoming environmental and resource constraints, and reducing inequalities.

In order to achieve this, innovative base technology is required in such areas as resource and energy utilization, water resources management, material circulation, urban development, and traffic and transportation.

Particularly important are issues such as the creation of new technology for resource development and utilization, promotion of household and industrial energy conservation, and development of alternative energy technology, as well as renovation of social infrastructure technology such as disaster mitigation and safety measures.

Achievement eligible:

The 2015 Japan Prize in the field of “Resource, Energy and Social Infrastructure” will be awarded to an individual(s) who has made significant contributions to society by improving the sustainability of human society and the global environment through scientific and technological breakthroughs, such as the creation, innovation and dissemination of resource utilization technology, energy technology and infrastructure formation technology.

Area of Life Science, Agriculture and Medicine

Medical Science and Medicinal Science

Background and rationale:

Advancement of modern science has brought about tremendous progress in the field of medical and medicinal sciences. Elucidations of various diseases and their pathological mechanisms have led to continuous development in the establishment of new prophylaxes, diagnostic methods and treatments.

Amid such circumstances, developed countries are experiencing a rise in diseases brought about by increased longevity and lifestyle changes. In contrast, many regions around the world still have little or no access to adequate medical care. Furthermore, emerging and re-emerging infectious diseases are becoming a major issue worldwide with the onset of globalization.

Therefore, it is anticipated that medical and medicinal sciences will further contribute towards the well-being of people in today's changing times. Those contributions include the creation and dissemination of new medical care in fusion with other discipline such as engineering and information science, development and production of new drugs, and development of drug delivery systems.

Achievement eligible:

The 2015 Japan Prize in the field of “Medical Science and Medicinal Science” will be awarded to an individual(s) who has made significant contributions to society by achieving scientific and technological breakthroughs in improving people’s health through new discoveries and development of innovative technologies for prevention, diagnosis, treatment, and prognostic prediction of diseases.

Fields Selection Committee for the 2015 Japan Prize

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(alphabetical order, titles as of November, 2013)

Schedule (2015-2017)

The fields eligible for the Japan Prize (2015 to 2017) have been decided for the two research areas, as shown below. These fields rotate every three years, basically. Every year, the Fields Selection Committee announces the eligible fields for the next three years.

Area of Physics, Chemistry and Engineering

Year	Eligible Fields
2015	Resources, Energy, Social Infrastructure
2016	Materials, Production
2017	Electronics, Information, Communication

Area of Life Science, Agriculture and Medicine

Year	Eligible Fields
2015	Medical Science, Medicinal Science
2016	Biological Production, Biological Environment
2017	Life Science