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Japan Prize News
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JAPAN PRIZE

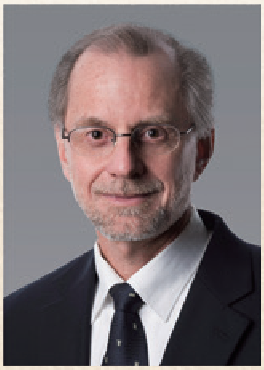
2016 Japan Prize Laureates Announced

Dr. Hideo Hosono, who has opened new horizons in material science and immensely contributed to the advancement of basic science and industry, and Dr. Steven D. Tanksley, who has transformed intuition and experience based traditional crop breeding into science and made significant contributions to stable food production in the world

"Materials and Production" field

Dr. Hideo Hosono
Professor, Materials and Structures Laboratory,
Founding Director, Materials Research Center for Element Strategy,
Tokyo Institute of Technology
Japan

"Biological Production and Biological Environment" field



Dr. Steven D. Tanksley
Professor Emeritus,
Cornell University
USA

The Japan Prize Foundation has decided to award the 2016 (32nd) Japan Prize to Dr. Hideo Hosono of Japan and Dr. Steven D. Tanksley from the United States.

Dr. Honoso, the winner in the "Materials and Production" field, was recognized for his "creation of unconventional inorganic materials with novel electronic functions based on nanostructure engineering." Dr. Hosono invented a series of novel materials that defy traditionally-held ideas about elements and compounds and helped open up new horizons in material science, from basic science to industrial applications. Among many of his achievements, energy-efficient liquid crystal displays used in personal and tablet computers and large organic light-emitting diode (OLED) displays for televisions are just a few of the notable examples of commercial applications found in our daily life.

In the "Biological Production and Biological Environment" field, Dr. Tanksley was recognized for his "contribution to modern crop breeding through research on development of molecular genetic analysis." He introduced molecular genetic analysis to crop breeding that had depended on the intuition and experience of researchers, and led to the development of crop breeding technology based on science. Dr. Tanksley's highly original approach inspired researchers around the world and led to the development of new varieties that are, for example, resistant to pests or have higher yields, and further contributed to the stable production of food crops in the world.

An award-presentation ceremony will be held in Tokyo on April 20, 2016 to honor the two distinguished scientists.

JAPAN PRIZE

The Japan Prize came into being after the late Mr. Konosuke Matsushita, the founder of Matsushita Electric Industrial Co., Ltd. (now known as Panasonic Corporation), responded in 1982 with a personal donation to the then government's wish for creating a prestigious international prize for scientists around the world as a token of gratitude for the international society. With a Cabinet endorsement, the Prize was first awarded in 1985.

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.

"Materials and Production" field

Achievement : Creation of unconventional inorganic materials with novel electronic functions based on nano-structure engineering

Dr. Hideo Hosono (Japan)
Born: September 7, 1953 (Age 62)
Professor, Materials and Structures Laboratory,
Tokyo Institute of Technology

Summary

Discovery of new materials is a major driving force that transforms industry and our society. Dr. Hideo Hosono endeavored to create new functional materials in areas where others had not yet achieved success. For example, it was said that "transparent oxides" like glass are unsuitable as electrofunctional material because of their electrical nonconductivity, but Dr. Hosono studied their nano-structure and developed the "transparent amorphous oxide semiconductor." Today, it is extensively used in technologies such as liquid crystal displays (LCDs) and organic light-emitting diode (OLED) displays, contributing enormously towards our society.

Furthermore, he has developed a series of unconventional inorganic materials with electronic functions. In the field of superconductivity research, he focused on iron compounds, which nobody had been paying attention to, and achieved high superconducting transition temperature. He also developed "electrically conductive cement" by modifying the nano-structure of what had been considered an archetypal insulator material.

Focusing on the behavior of electrons, and striving for the development of materials that meet the needs of society

"I want to pursue the kind of materials development that could solve issues faced by our society", felt Dr. Hideo Hosono, who was deeply impressed by reading "Discovery of Nylon" by Minoru Imoto (published by Tokyo Kagaku Dojin) during his years at a technology college. Dr. Hosono went on to major in chemistry at Tokyo Metropolitan University, and in 1982, began his research career as a research associate at Nagoya Institute of Technology.

His research themes at the time were the elucidation of the optical properties and the microstructure of high purity silica glass (silicon dioxide), and the creation of ceramics from glass. He later took up the challenge of "creating a range of materials with electronic functions solely from oxides, such as glass."

The color and electrical characteristics of inorganic materials are determined by the behavior of their electrons. Oxides such as glass are transparent or white because their electrons have what experts call the "wide-bandgap" property. They were also thought to lack electronically active functions, since oxides are generally insulators.

However, with discoveries such as superconducting material made with copper oxides in 1986, huge potential in materials research was starting to emerge. Dr. Hosono too was seeing great potential in transparent oxides. Around this time, he announced his experiment results and demonstrated that when the nano-structure of oxides, which normally only turn white in color, is modified, they exhibit light-induced coloration.

The key to Dr. Hosono's research was the electron. In a later interview for a professional journal, he said, "My focus has solely been on the property of electrons in solids. It may lead to semiconductors, superconductors or catalysts, but it ultimately comes down to the ingenious utilization of electrons in solids."

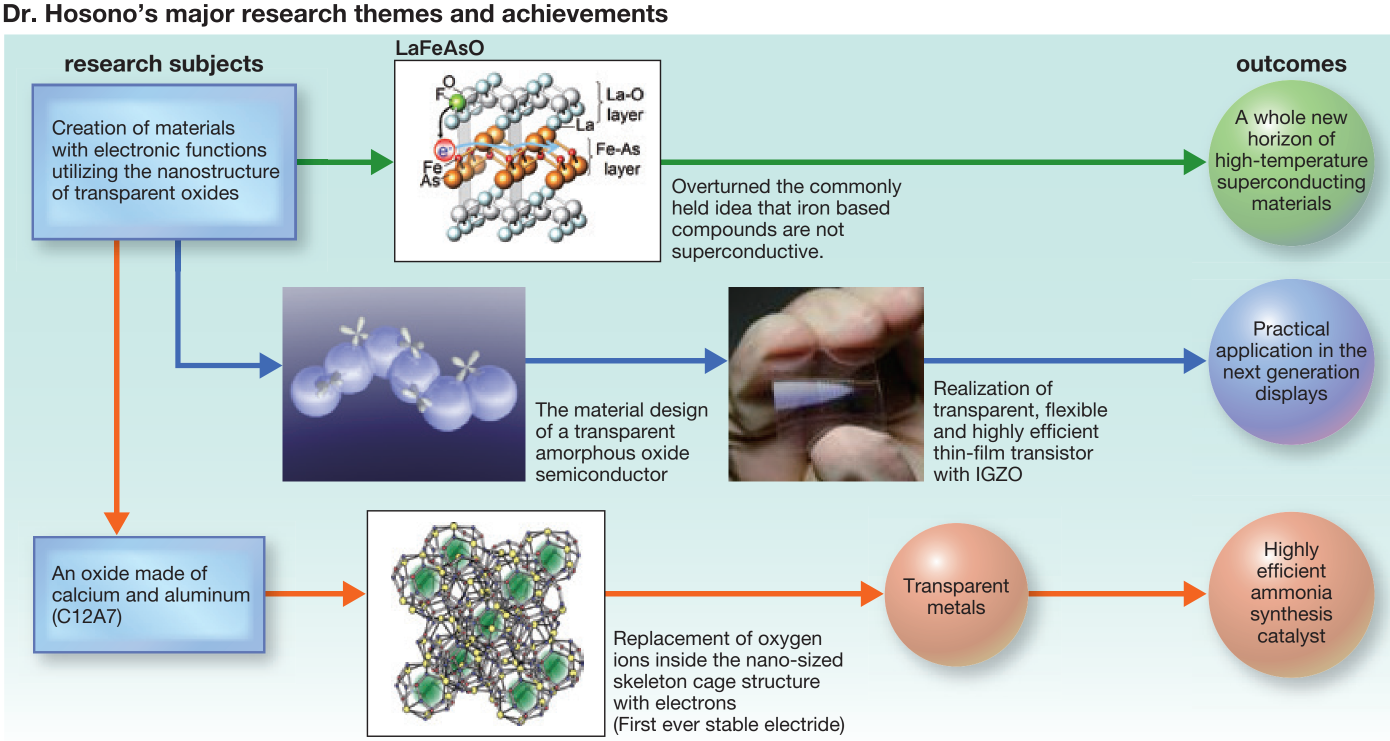
Creating materials with superior electronic properties from common elements

In 1993, Dr. Hosono assumed the post of associate professor at the Research Laboratory of Engineering Materials (present day Materials and Structures Laboratory), Tokyo Institute of Technology. Here, his underlying research theme was the "creation of electrofunctional materials with transparent oxides such as glass".

At the time, it was commonly believed that "transparent oxides" were unsuitable as electrofunctional materials because of their electrical nonconductivity. Dr. Hosono, however, intentionally chose glass, a "transparent oxide," as the subject of his research, in part because of his aspiration to "challenge unexplored frontiers," but also in response to the large societal need for such materials.

For example, transistors used in LCDs and solar cell development require semiconductors with not only superior electronic properties but also to allow light to pass through. At the time, indium oxide containing a small amount of tin was known to meet this requirement. Indium, however, is a scarce rare-metal that is very expensive, as well difficult

Dr. Hosono's major research themes and achievements



to secure in sufficient quantities.

Dr. Hosono's strategy was to create materials that could meet the needs of society from commonly available materials by modifying the nano-structure of transparent oxides. In 1994, he began the research and development of transparent conductive materials. By studying the oxides' nano-structure and the behavior of the electrons within, he revealed that "in transparent conductive oxides, there is a spatial spread of the metal ion orbitals that carry electron conduction."

Using this as a design guideline, he undertook the development of numerous oxide semiconductors. In 1997, Dr. Hosono, together with his mentor Dr. Hiroshi Kawazoe, successfully developed the world's first "p-type transparent oxide semiconductor." This research was later applied to the creation of the world's first p-channel oxide thin-film transistor.

Before long, Dr. Hosono's work drew attention both within and outside Japan. Subsequently, Japan's research grant program "ERATO (Exploratory Research for Advanced Technology/ Strategic Basic Research Program)" selected Dr. Hosono's proposal of "transparent electro-active materials project." Prompted by this project, he successfully went on to achieve his goals one by one. Among the wide range of themes Dr. Hosono undertook, "transparent amorphous oxide semiconductors (TAOS) with high electron mobility" is an example of practical technology that has since been adopted worldwide.

Set off by Dr. Hosono's research, TAOS became one of the major fields of semiconductor research. In particular, Dr. Hosono developed the world's first In-Ga-Zn-O thin film transistor (IGZO-TFT), which saw practical application as an energy-efficient device, due to its high electron mobility despite lacking the highly ordered atomic arrangement seen in crystal, and its high transparency. Today, it is beginning to replace amorphous silicon semiconductors in LCDs on devices such as PC monitors and tablet PCs. Most recently, it is also starting to be implemented in large-sized OLED televisions.

The challenge of electrically conductive cement and iron-based superconductors

Beside the development of transparent oxide semiconductors and luminescent materials, Dr. Hosono had another theme he wanted to pursue, namely, "the research on the electronic functions of a calcium aluminate C12A7", an ingredient of cement. Cement is made up of several compounds, all of which are typical insulators. Dr. Hosono noticed that C12A7 was made up of nano-sized cage structures. He then replaced the oxide ions held gently inside the "cages" with electrons and created a new material called the electride, which has excellent electrical conductivity like a metal, as well as superconductivity at low temperatures.

The discovery of electrides completely transformed the image of cement as a new material with great potential. Other unique properties of electrides, including greater electron emission ability and chemical stability, opened up the possibility of their application as catalysts for various chemical reactions.

From there on, Dr. Hosono demonstrated that ammonia synthesis, which had theretofore required high temperature and high pressure, could efficiently be achieved under ambient pressure using the electride as a catalyst. From fertilizer to gunpowder, ammonia is a chemical substance of universal applications that is used to create numerous indispensable materials for mankind. Therefore, its potential in contributing towards the building of a sustainable society is seen with great anticipation.

Through the modification of the nano-structure, Dr. Hosono created electrically conductive cement. In other words, he "turned cement into metal." These challenges towards the characteristics of materials led to broadening his research area still further. One of his researches that astonished the world was the discovery of iron-based high temperature superconductors.

Until then, iron, a typical magnetic element, was thought to be unfavorable for superconductivity. However, by forming a layered crystal structure through the reaction of iron with phosphorus and arsenic, Dr. Hosono achieved control over electrons, and in 2006, discovered that an iron-based compound (LaFePO) is superconductive. In 2008, he drew attention from around the world with the announcement of LaFeAsO, which has a superconducting transition temperature of 26 K.

Dr. Hosono's research has pioneered a new frontier in the exploration of superconducting materials by discovering iron-based superconductors in addition to the already known copper-based superconductors. Because iron-based superconductors have a high critical magnetic field and exhibit small anisotropic properties, applied research is under way to explore their potential for practical use in materials, such as for superconducting magnets.

It is greatly anticipated that Dr. Hideo Hosono's successful research, which focuses on the behavior of electrons in substances from an original perspective, will continue to give rise to materials that will transform our society.

"Biological Production and Biological Environment" field

Achievement : Contribution to modern crop breeding through research on development of molecular genetic analysis

Dr. Steven D. Tanksley (USA)
Born: April 7, 1954 (Age 61)
Professor Emeritus, Cornell University

Summary

Since the beginning of agriculture, mankind has practiced selective breeding in search of crops with enhanced traits. For most of that time, the methods practiced relied on experience and intuition. From the 1980s, however, rapid advancements in genomic analysis techniques brought about significant changes. The pioneering figure who continuously led this field was Dr. Steven Tanksley.

Dr. Tanksley created chromosomal maps of crops by molecular genetic analysis and went on to identify genes that are related to agricultural productivity, such as fruit size, thereby developing a genomic analysis technique that is instrumental for selective breeding. His research, which combines genetic information and breeding techniques, has contributed enormously to increasing selection accuracy and reducing the amount of time required to breed new crop varieties.

Selective breeding, from reliance on experience and intuition to application of molecular genetics

It is believed that agriculture began 10 to 20 thousand years ago. Humans took their staple wild plants and began intentionally cultivating them as crops. Through a long course of trial and error, humans bred diverse varieties of "crops" by selectively cultivating those individual crops that had higher yields and were more resistant to diseases and pests. "Selective breeding," in which superior individuals are crossbred, was also developed.

Most traditional selective breeding relied on experience, intuition and luck, but in the 19th century, a "scientific perspective" was brought into this field. Gregor Johann Mendel revealed that when two strains of pea plants were crossbred, traits (properties and characteristics of an organism) inherited by the offspring followed a certain fixed pattern. It's famously known as "Mendel's laws of inheritance."

Mendel's laws led to the adoption of a scientific approach to selective breeding. His laws, however, only applied to traits related to genes that determine "qualitative" differences amongst individuals, such as "the color of the peas being green/yellow" and "the peas being round or wrinkled," most of which were caused by single genes.

In contrast, many of the traits we desire in crops, such as "larger size," "greater yields" and "faster flowering," cannot be determined in the "black and white" manner of qualitative traits. These traits are determined by a complex interaction of multiple genes on the chromosome and environmental factors. Genes of this nature are called "Quantitative Trait Loci (QTL)."

Even into the 20th century, traits determined by QTL were being selectively bred based only on experience and intuition. However, following the discovery of restriction enzymes which cut double-stranded DNA containing the genes, selective breeding entered a new era in the 1980s with rapid advancements in the molecular genetic analysis of crops.

Creation of the tomato chromosomal map Elucidation of QTL genes responsible for fruit size

During the 1980s, Dr. Steven Tanksley was the first to make a major breakthrough in this field. He was involved in research on plant molecular genetics and selective breeding at New Mexico State University (1981-1985) and Cornell University (1985 onwards). Using the Restriction Fragment Length Polymorphism (RFLP) method, which had been developed at the time, Dr. Tanksley undertook the challenge of creating "chromosomal maps" for the tomato and rice crops, which mark the location of important genes on DNA.

The RFLP method enables the analysis of a chromosome's characteristics on the "individual level" by the fragment length of DNA when it is cut using a restriction enzyme. This method centered on the fact that when the base sequence is identical, the fragment length is also identical, and when the gene differed, the fragment length also differed.

First, Dr. Tanksley successfully created a chromosomal map of tomato plant by the RFLP method. He then analyzed the location of fragments where length differed across individual plants (gene mapping) and discovered six QTLs related to the fruit size of tomatoes.

When his research achievements were published in the "Nature" in 1988, a ripple of excitement ran through researchers around the world engaged in the study of selective breeding, whether for animals or plants. His research paper revealed that, by regarding QTLs related to important traits as "DNA markers," the selection of individuals during selective breeding could now be backed by scientific evidence. In recognition of his innovative research, Dr. Tanksley was elected a member of the U.S. National Academy of Sciences in 1995.

Application of DNA markers leads to realization of efficient selective breeding

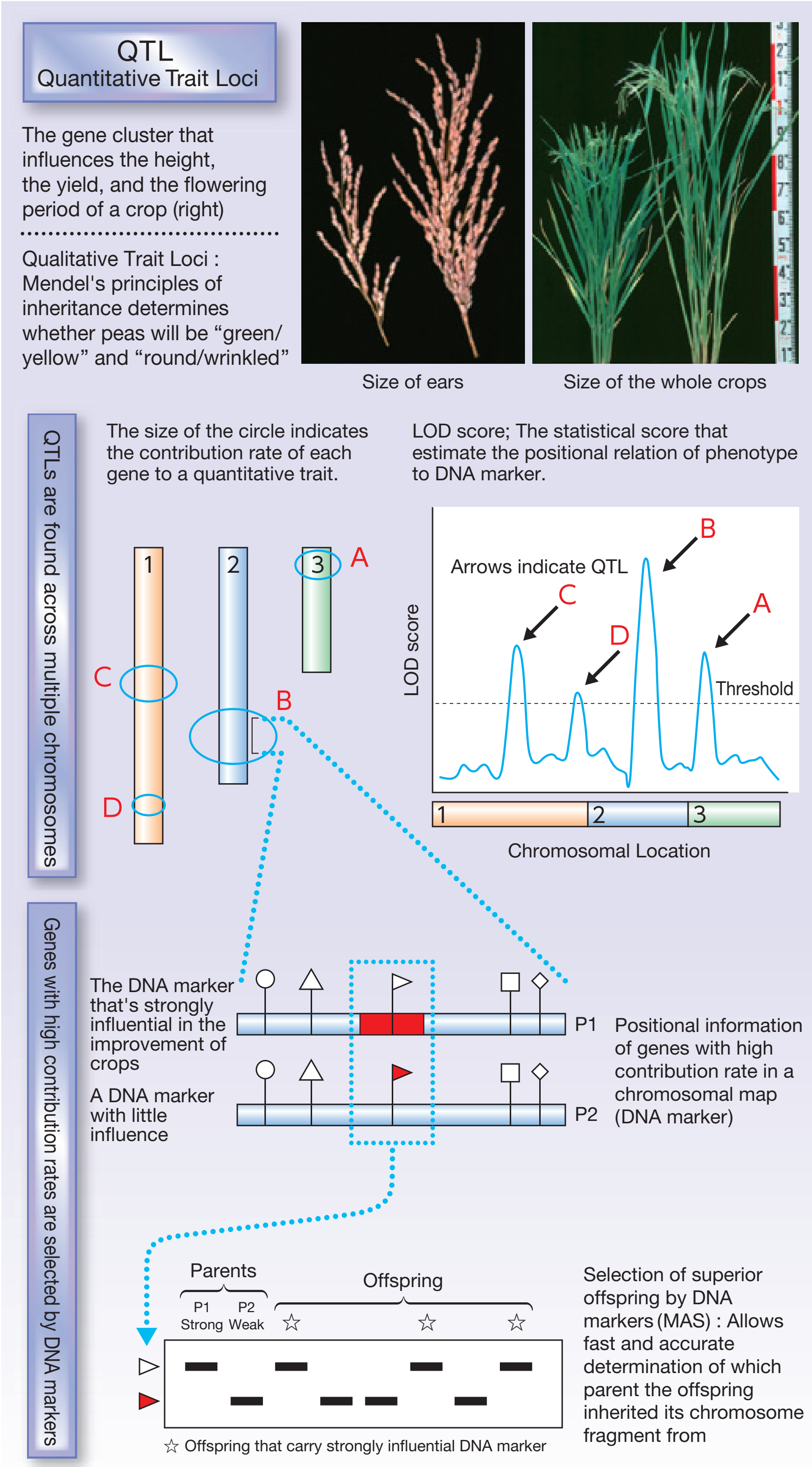
Throughout the 1990s to 2000s, Dr. Tanksley continues to lead the field of selective breeding and plant genetics. One of his research themes was to elucidate which genes of wild plant species mankind had taken advantage of in order to create the modern species.

For example, Dr. Tanksley points out in his paper that when comparing the wild ancestor of tomatoes, which originated in South America, with the modern species, fruit size has increased several hundred-fold. Dr. Tanksley conducted research in which he crossbred tomatoes that differed in fruit size and mapped out the major QTLs that determine tomato fruit size. As a result, he revealed that the modern species with larger fruit size had a decreased amount of transcription in certain genes, whereas the wild species of tomatoes with smaller fruit size had a large amount of transcription. He believes that such variation occurred during the process of cultivation by humans and was accelerated by intentional selection of larger fruit. Dr. Tanksley's research also covers a wide variety of themes such as the elucidation of genes for increased resistance to diseases and pests.

Led by Dr. Tanksley's research, selective breeding using DNA markers began to spread around the world. In Japan, where rice is the staple crop, new varieties have been developed using DNA markers that influence agriculturally important traits, such as "resistance to diseases and pests like the rice blast fungus," "cold tolerance," "variations of heading time (early or late)" and "taste," some of which have turned out to be exceptionally successful breeds.

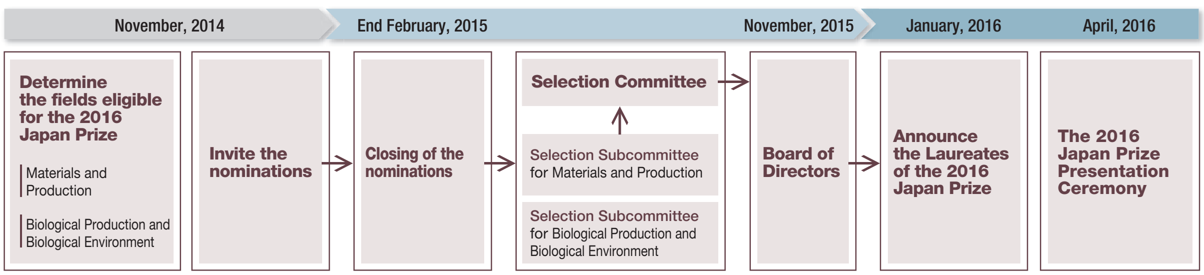
Today, one of the most important themes surrounding selective breeding is the challenge of adapting to global warming. Mankind will face serious food shortages if agriculture is unable to adapt to the rapidly changing climate. Therefore, the prompt and precise development of species adapted to the warming climate is essential. In facing this challenge, the "development and application of DNA markers for breeding" (Marker Assisted Selection), led by Dr. Tanksley, is playing a crucial role.

In this manner, Dr. Steven Tanksley's research has brought us to a new age in breeding techniques, which are contributing towards solutions such as the realization of a stable and increased production of food, and have become one of the most important technologies for mankind in building a prosperous future.


QTL
Quantitative Trait Loci
The gene cluster that influences the height, the yield, and the flowering period of a crop (right)
Qualitative Trait Loci : Mendel's principles of inheritance determines whether peas will be “green/yellow” and “round/wrinkled”
Size of ears
Size of the whole crops
QTLs are found across multiple chromosomes
The size of the circle indicates the contribution rate of each gene to a quantitative trait.
LOD score; The statistical score that estimate the positional relation of phenotype to DNA marker.
1
2
3
A
B
C
D
Arrows indicate QTL
Threshold
LOD score
Chromosomal Location
Genes with high contribution rates are selected by DNA markers
The DNA marker that's strongly influential in the improvement of crops
A DNA marker with little influence
P1
P2
Positional information of genes with high contribution rate in a chromosomal map (DNA marker)
Parents
Offspring
P1 Strong
P2 Weak
Selection of superior offspring by DNA markers (MAS) : Allows fast and accurate determination of which parent the offspring inherited its chromosome fragment from
☆ Offspring that carry strongly influential DNA marker

Nomination 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 recipients.
- 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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Kyoto University

(alphabetical order, titles as of December, 2015)

Fields Eligible for the 2017 Japan Prize

Area of Physics, Chemistry and Engineering

Electronics, Information and Communication

Background and rationale:

In recent years, we have seen new waves of technological development from devices to systems, in various fields of electronics, information and communication, such as artificial intelligence, big data, IoT, next generation network, robotics and energy utilization. In particular, innovation derived from the rapid and efficient utilization of large data generated across broad areas is anticipated to spawn new cultures, lifestyles and types of manufacturing, thereby contributing enormously to the advancement of our society.

Meanwhile, the various incidental phenomena that are threatening the safety and security of our lives can no longer be ignored, making the development of technological solutions an urgent matter.

Achievement eligible:

The 2017 Japan Prize in the field of "Electronics, Information and Communication" will be awarded to an individual(s) who has achieved scientific and technological breakthroughs, such as development of essential technologies or systems that contribute significantly and widely to the creation of new industries, to the innovation of manufacturing technologies, to the advancement of information and knowledge driven society, and to the assurance of our society's safety and security, as well as basic research and development that is highly likely to drive the future advancement of our society.

Area of Life Science, Agriculture and Medicine

Life Science

Background and rationale:

The field of life science has been increasingly expanding and deepening in recent years, leading to remarkable advances in our understanding of life itself.

For example, genome and epigenome analysis using next-generation sequencing, OMICs analysis using mass spectrometry, molecular and morphological analysis using super-resolution microscopy or three-dimensional electron microscopy, and various analyses using genome editing techniques are progressing at an incredible pace. Such innovative analysis technologies have contributed to numerous revolutionary discoveries.

While we must respect bioethics and handle personal information very carefully, the advancement of our understanding of the life phenomenon will be of tremendous benefit to humanity and lead to the creation and spread of new fields of medicine in the future.

Achievement eligible:

The 2017 Japan Prize in the field of "Life Science" will be awarded to an individual(s) who has achieved scientific and technological breakthroughs, such as the discovery of new life phenomena and innovation in analysis techniques that facilitate the elucidation of biological functions, thereby contributing significantly to our society.

Fields Selection Committee for the 2017 Japan Prize

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Staff Writer
Op-Ed Section, The Asahi Shimbun

(alphabetical order, titles as of December, 2015)

Schedule (2017-2019)

The fields eligible for the Japan Prize (2017 to 2019) have been decided for the two research areas, respectively.
These fields rotate every three years, basically.
Every year the Fields Selection Committee announces the eligible field for the next three years.

Area of Physics, Chemistry and Engineering

Year	Eligible Fields
2017	Electronics, Information and Communication
2018	Resources, Energy, Environment, Social Infrastructure
2019	Materials, Production

Area of Life Science, Agriculture and Medicine

Year	Eligible Fields
2017	Life Science
2018	Medical Science, Medicinal Science
2019	Biological Production, Biological Environment