THE JAPAN PRIZE FOUNDATION
ARK Mori Building, East Wing 35th Floor, 1-12-32
Akasaka, Minato-ku, Tokyo, 107-6035, JAPAN
Tel: +81-3-5545-0551 Fax: +81-3-5545-0554
www.japanprize.jp

Japan Prize News
No. 63 Feb. 2020

JAPAN PRIZE

2020 Japan Prize Laureates Announced

Prof. Robert G. Gallager
Professor Emeritus, Massachusetts Institute of Technology
USA

Dr. Svante Pääbo
Professor, Max Planck Institute for Evolutionary Anthropology
Sweden

Eligible Field: "Electronics, Information, Communication"

Pioneering contribution to information and coding theory

From general communication devices such as TVs, personal computers and mobile phones to cutting-edge researches utilizing big-data, such as particle physics and astronomy, digital information communication is one of the fundamental technologies that support today's society. However, when performing data communication, errors can occur due to external noise, and for many years, a lot of research was conducted on developing detection and correction schemes for such errors.

Among them, LDPC codes (Low-Density Parity-Check Codes), invented by Prof. Robert G. Gallager, is an extremely reliable and practical scheme.

Starting with its adoption in the fifth-generation mobile communication system (5G), LDPC codes are expected to support the coming generations of high-speed and large-capacity communications.

Eligible Field: "Life Science"

Pioneering contributions to paleoanthropology through decoding ancient human genome sequences

Where did we humans come from?

Elucidating "the origin and evolution of modern humans" is one of the biggest challenges in paleoanthropology. Traditionally, the evolution and classification of humans had been approached by analyzing the shape of excavated bone and teeth fossils. However, from the mid-1980s, Dr. Svante Pääbo adopted the "genetic approach", which involves extracting and analyzing DNA, and made series of discoveries that have enabled us to understand modern human evolution at much greater depth.

In particular, the DNA analysis of Neanderthals revealed that the ancestors of modern humans interbred with Neanderthals. Furthermore, the DNA from a fossilized bone fragment excavated from the Denisova cave in Russia revealed the existence of a previously unknown species of humans called the Denisovans.

By analyzing the DNA of ancient humans, Dr. Pääbo has shed new light on the fundamental question of where modern humans came from.

JAPAN PRIZE

The creation of the Japan Prize was motivated by the Japanese government's desire to "express gratitude to international society by establishing a prestigious international award in the fields of science and technology". Supported by numerous donations, the Japan Prize was established in 1983 with a cabinet endorsement.

The Japan Prize honors those who have made significant achievements that contribute to the peace and prosperity of mankind, based not only on contributions to the advancement of science and technology but also on social contributions to our lives.

The award covers all fields of science and technology and takes into consideration the developments in science and technology. Every year, the foundation designates two fields for the award presentation.

One award is given for each field as a general rule. Each laureate receives a certificate of merit and a prize medal. A cash prize of 50 million yen is also presented to each prize category.

“Electronics, Information, Communication” Field

Achievement : Pioneering contribution to information and coding theory

Prof. Robert G. Gallager (USA)
Born: May 29, 1931 (Age: 88)
Professor Emeritus, Massachusetts Institute of Technology

Error correction schemes in digital information communication

To realize remote surgeries and autonomous driving, it is indispensable to use low-latency error-free data transmission. In digital data transmission, however, errors may occur in both wired and wireless communications due to noises caused by problems in communication equipment or radio noise interference. Since most of these noises cannot be removed, it is necessary to devise a framework to detect and correct these errors.

One of the easiest ways to achieve this is to send duplicate data. If the data “01” is repeated three times and sent as “01 01 01”, even if an error occurs and becomes “11 01 01” at the receiving end, the correct data “01” can be recovered by the majority rule. The process of adding extra data in such circumstances is called “coding”, and the process of correcting errors and recovering the original data is called “decoding”.

Principle and features of LDPC codes

This approach is, however, very wasteful of data and not very reliable. A better approach, familiar to communication engineers in the 1950's, was to arrange a block of data into rows and columns. A parity check digit is added to each row and to each column, as illustrated in Fig. 2. The parity check digit is 1 if the number of ones in that row or column is odd and is 0 otherwise. Then if an error occurs in transmission in a particular row and column, the check digit for that column and row would indicate the location of the error, and it could be corrected.

Much research in the 1950's was devoted to improving this approach, including the Hamming codes, the BCH codes, the RS codes, and LDPC codes. All these schemes replace the rows and columns of data above with an arbitrary collection of subsets of data. A parity check is then appended to each subset and errors are corrected according to the parity check digits which have the wrong parity after transmission.

In the LDPC codes invented by Prof. Gallager, the overall block of data was chosen to be very large, but each of the above subsets were chosen to be quite small, a choice made to simplify the implementation of error correction. He showed that these subsets could be kept at a fixed small size while increasing the length of the overall block so as to approach channel capacity with highly reliable transmission.

LDPC codes became mainstream after 2000

LDPC codes were proposed by Prof. Gallager during the 1960s. However, because processing capability of computers were limited at that time, his ideas were neglected for the next 30 years.

From the 1990s, computer processing capability rapidly enhanced, and research into its practical implementation became active. In 1998, it was proven to be the most theoretically superior scheme, and its adoption into the large-capacity information communication systems advanced drastically.

Since the 2000s, LDPC codes have been rapidly adopted in digital communication systems and digital storage systems. These include digital TV satellite broadcasting, 10 Gigabit Ethernet, WiMAX high-speed data communication, and the 5th generation mobile communication system (5G), as well as hard disks and solid-state drives. It has become an extremely important basic technology that supports our modern digital society.

Figure 1 Error correction schemes in digital information communication

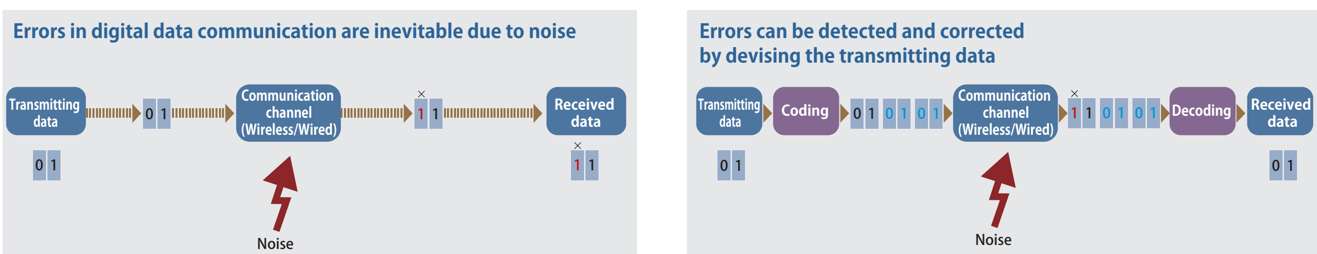


Figure 2 A simple example of using parity checks to correct errors

Using the method of grouping and checking data

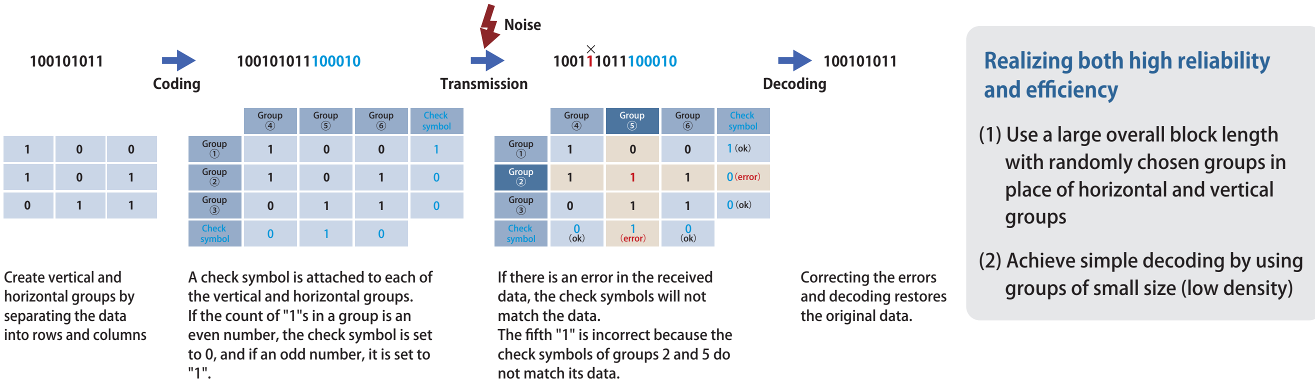
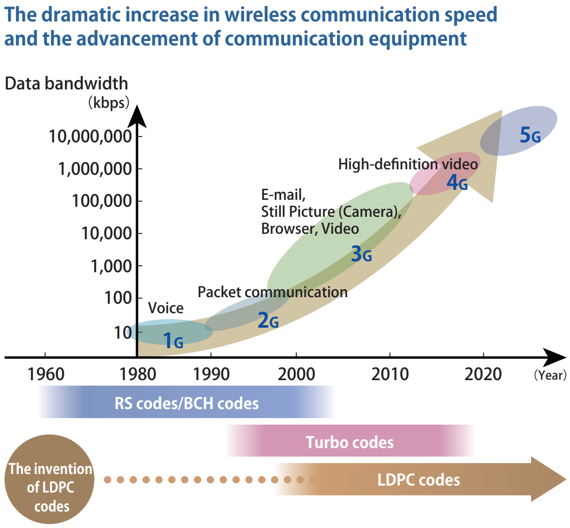


Figure 3 LDPC codes became mainstream after 2000

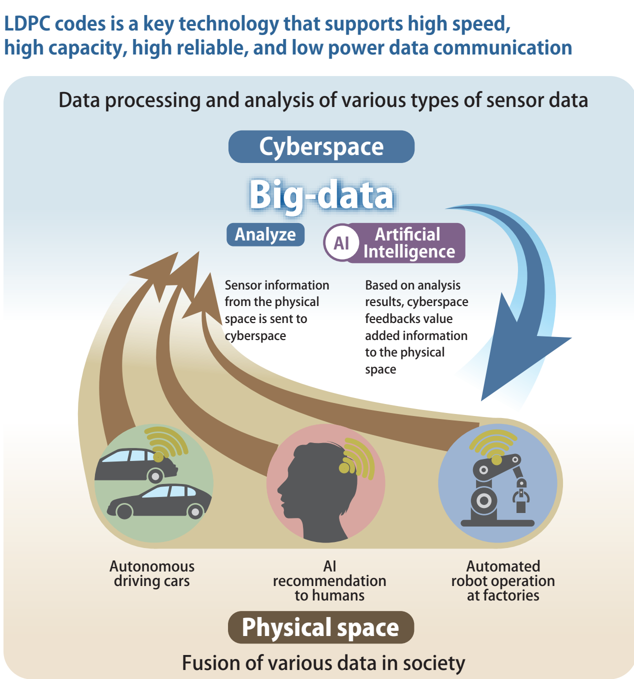


Technologies that contribute to the realization of a Super Smart Society (Society 5.0)

Currently, there are no other practical codes that can outperform LDPC codes. As computer processing capability continues to rapidly improve in the future, the application of LDPC codes is expected to further expand in scope.

Super Smart Society (Society 5.0), which is envisioned to be the future of our society, will require the cyberspace and the real world to be highly integrated. LDPC codes are expected to contribute significantly to this goal by playing an essential and fundamental role in solving the various challenges of information communication, such as demands for higher speeds, capacity, and reliability, and lower power consumption.

Figure 4 Technologies that contribute to the realization of a Super Smart Society (Society 5.0)



"Life Science" field

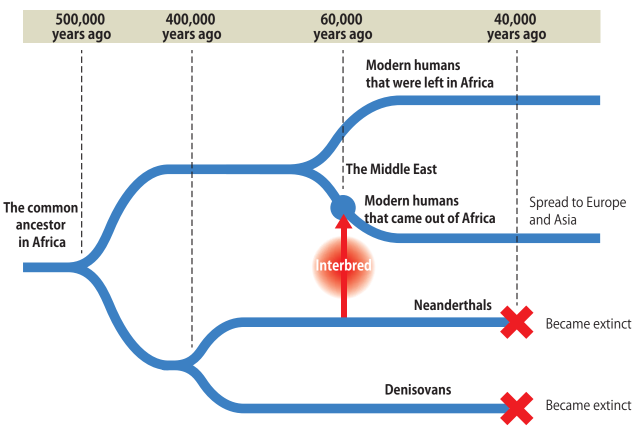
Achievement : Pioneering contributions to paleoanthropology through decoding ancient human genome sequences

Dr. Svante Pääbo (Sweden)
Born: April 20, 1955 (Age: 64)
Professor, Max Planck Institute for Evolutionary Anthropology

The ancestors of modern humans interbred with Neanderthals

Neanderthals are a species of archaic humans that once existed. They left Africa around 500,000 years ago and spread across Europe and the Middle East, but became extinct about 40,000 years ago. For this reason, it was long thought that Neanderthals were unrelated to modern humans. However, when Dr. Pääbo analyzed the DNA of excavated Neanderthal bones, he discovered that modern humans had in fact inherited Neanderthal DNA.

Figure 1　The ancestors of modern humans interbred with Neanderthals



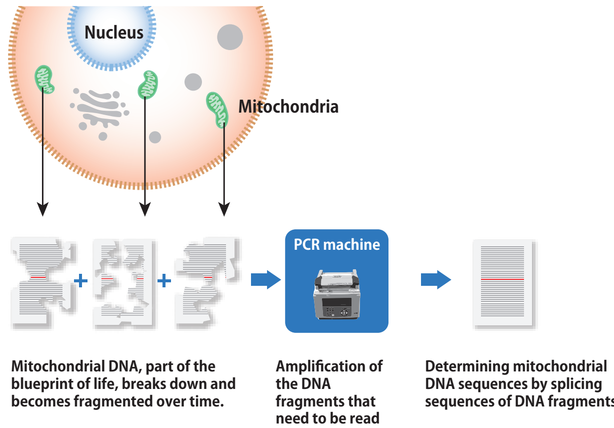
Achievements (1): Analysis of mitochondrial DNA (1997)

The difficulty of studying ancient DNA is that DNA, the blueprint of life, breaks down and becomes fragmented over time, therefore, it is difficult to obtain enough quantity required for proper analysis. In order to increase the small number of DNA fragments, Dr. Pääbo employed a newly developed DNA amplification method called the "Polymerase chain reaction" (PCR). There was, however, a limitation to this method. Modern DNA contaminated by airborne dust or human sweat could be mistakenly be amplified if the sequence was similar to ancient human DNA. Because the handling of ancient DNA requires great care, Dr. Pääbo devised new research methods, including a new method of DNA extraction and the use of a cleanroom.

In 1997, a portion of Neanderthal mitochondrial DNA was first sequenced, followed by the entire mitochondrial DNA. Mitochondria are a type of organelle that has DNA different from that of the nucleus.

Mitochondrial DNA is only 16,000 base pairs long and can easily be obtained in large quantities because a single cell alone contains several thousand of them. The sequence was able to be determined using the PCR method and the DNA analysis technology that was available at the time.

Figure 2　Achievements (1): Analysis of mitochondrial DNA (1997)



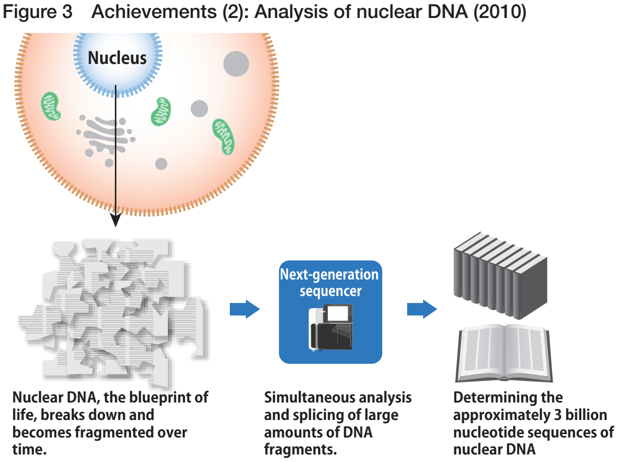
Ancient DNA fragments are like pieces of a torn-up document. By the same analogy, a mitochondrial DNA, composed of approximately 16,000 base pairs, is a single-page document. The various DNA fragments were amplified using PCR, analyzed and fitted together, and in 1997, the hyper-vari-able region of the mitochondrial DNA was sequenced.

When the sequenced mitochondrial DNA was compared with that of modern humans, no commonalities were found, thus, proving the theory that Neanderthals were not the direct ancestors of modern humans as some had suggested.

Achievements (2): Analysis of nuclear DNA (2010)

Dr. Pääbo hypothesized that analysis of mitochondrial DNA alone was not enough to unravel the mysteries of modern human evolution. Beginning in the 2000s, a next-generation sequencer capable of simulta-neously sequencing large quantities of DNA became available. In 2010, it was used to sequence the entire Neanderthal nuclear DNA for the first time in the world. He analyzed large quantities of DNA fragments,

Figure 3　Achievements (2): Analysis of nuclear DNA (2010)



Ancient DNA fragments are like pieces of a torn-up document. By the same analogy, the 3 billion base pairs long nuclear DNA, is the equivalent to a collection of books. A large number of DNA fragments were analyzed and fitted together using next-generation sequencers to restore the reconstruct book collection.

mapped them on a modern human reference sequence, and reconstructed the nuclear DNA sequence consisting of 3 billion base pairs.

The analysis of Neanderthal nuclear DNA showed that 1 to 4% of the total DNA of modern humans, excluding the people of Africa, had Neanderthal origins. It was thus proven that the ancestors of modern humans interbred with Neanderthals. Furthermore, Dr. Pääbo sequenced the nuclear DNA from a bone fragment of an unknown group of hominins, excavated from the Denisova Cave in Russia, and named them "Denisovans".

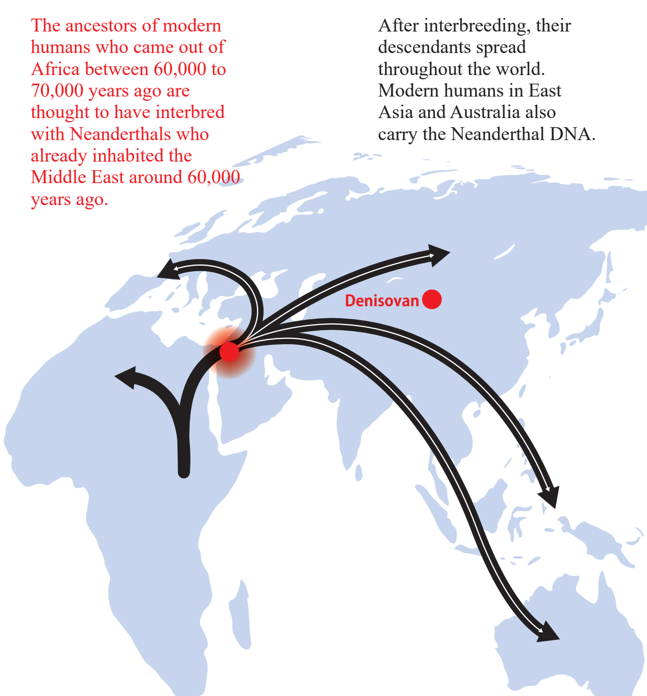
Significant contributions to paleoanthropology

The fact that Neanderthal DNA is present in modern humans, excluding the people of Africa, illustrates a scenario of modern human migration in which "the ancestors of modern humans who left Africa between 60,000 to 70,000 years ago are thought to have interbred with Neanderthals who already inhabited the Middle East around 60,000 years ago and spread around the world".

In this manner, Dr. Pääbo's DNA analysis using ancient bones has revolutionized the paleoanthropological research of exploring "the origin of modern humans". His research methods and achievements have also significantly impacted all disciplines related to the study of modern human species, including anthropology, archeology, and history, thereby contributing tremendously to the advancement of these disciplines.

Dr. Pääbo, who has contributed significantly to the field of paleoanthropology, is currently a professor at the Max Planck Institute for Evolutionary Anthropology. There, he continues to lead many projects on ancient human genomes, expand the horizons of paleoanthropological genomic research, and nurture the next generation of researchers.

Figure 4 Significant contributions to paleoanthropology



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 16,000 nominators, strictly comprised of prominent scientists and researchers from around the world invited by the Foundation, to nominate the candidates through the web by Web System. The deadline for nominations is the end of January 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 two years from the time that the fields are decided. Every January or February, the winners of that year's Japan Prize are announced. The Presentation Ceremony is held in April in Tokyo.

July - October, 2018	November		End January, 2019		November	February, 2020	April
Consider the fields eligible for the 2020 Japan Prize	Determine the fields eligible for the 2020 Japan Prize Electronics, Information, Communication Life Science	Invite the nominations →	Closing of the nominations →	Selection Subcommittee for Electronics, Information, Communication Selection Subcommittee for Life Science ↑ Selection Committee →	Board of Directors →	Announce the Laureates of the 2020 Japan Prize	The 2020 Japan Prize Presentation Ceremony

Members of the 2020 Japan Prize Selection Committee

Chairman

- **Makoto Asashima**
  Research Professor, Academic Advisor, Teikyo University
  Academic Advisor, Japan Society for the Promotion of Science
  Professor Emeritus, The University of Tokyo

Vice Chairman

- **Yoshinao Mishima**
  Professor Emeritus and Former President
  Tokyo Institute of Technology

Members

- **Yoshinori Fujiyoshi**
  Distinguished Professor
  TMDU Advanced Research Institute
  Tokyo Medical and Dental University
- **Yoshihiro Hayashi**
  President/Director General
  National Museum of Nature and Science
- **Hiroto Ishida**
  Director
  The Japan Prize Foundation
- **Kazunori Kataoka**
  Professor, The University of Tokyo
  Vice President, Kawasaki Institute of Industrial Promotion
  Director-General, Innovation Center of NanoMedicine
- **Yoichiro Matsumoto**
  President
  Tokyo University of Science
- **Masayuki Matsushita**
  Director
  The Japan Prize Foundation
- **Shojiro Nishio**
  President
  Osaka University
- **Tadatsugu Taniguchi**
  Professor Emeritus, Advisor to the Office of President
  The University of Tokyo

Selection Subcommittee for the "Electronics, Information, Communication" field

Chairman

- **Shojiro Nishio**
  President
  Osaka University

Deputy Chairman

- **Hiroto Yasuura**
  Executive Vice President
  Kyushu University

Members

- **Makoto Ando**
  Senior Executive Director
  National Institute of Technology
- **Hiroki Arimura**
  Professor
  Graduate School of Information Science and Technology
  Hokkaido University
- **Michiko Inoue**
  Professor
  Graduate School of Science and Technology
  Nara Institute of Science and Technology
- **Yoshiharu Ishikawa**
  Professor
  Graduate School of Informatics, Nagoya University
- **Michihiko Minoh**
  Executive Director
  RIKEN
- **Hiroyuki Morikawa**
  Professor
  Graduate School of Engineering, The University of Tokyo
- **Yasuo Okabe**
  Professor
  Academic Center for Computing and Media Studies
  Kyoto University
- **Takao Onoye**
  Executive Vice President
  Osaka University
- **Naonori Ueda**
  Deputy Director
  RIKEN Center for Advanced Intelligence Project
- **Shigeaki Zaima**
  Professor
  Graduate School of Science and Technology
  Meijo University

Selection Subcommittee for the "Life Science" field

Chairman

- **Yoshinori Fujiyoshi**
  Distinguished Professor
  TMDU Advanced Research Institute
  Tokyo Medical and Dental University

Deputy Chairman

- **Shigeo Koyasu**
  Executive Director
  RIKEN

Members

- **Junken Aoki**
  Professor
  Graduate School of Pharmaceutical Sciences
  Tohoku University
- **Hiroo Fukuda**
  Executive Vice President
  The University of Tokyo
- **Akinori Kimura**
  Executive Senior Vice President
  Tokyo Medical and Dental University
- **Tomoko M. Nakanishi**
  President, Hoshi University
  Professor, Graduate School of Agricultural and Life Sciences
  The University of Tokyo
  Commissioner, Japan Atomic Energy Commission
- **Sumio Ohtsuki**
  Professor
  Faculty of Life Sciences, Kumamoto University
- **Shigeo Okabe**
  Professor
  Graduate School of Medicine
  The University of Tokyo
- **Yasushi Okamura**
  Professor
  Graduate School of Medicine
  Osaka University
- **Atsuko Sehara**
  Professor Emeritus
  Kyoto University
- **Masahide Takahashi**
  Trustee and Vice President
  Nagoya University
- **Toichi Takenaka**
  Chairman
  Japan Health Sciences Foundation

(alphabetical order, titles as of February, 2020)

Eligible Fields for the 2021 Japan Prize

Area of Physics, Chemistry, Informatics, Engineering

Resources, Energy, Environment, Social Infrastructure

Background and Rationale:

Today's lifestyle is supported by various infrastructure, created from the systematization of technologies. The dissemination and advancement of infrastructure technologies that support our society are crucial for realizing the goal of "eradicating poverty in all its forms and dimensions", which has been defined by the United Nations' Sustainable Development Goals (SDGs) as the "greatest global challenge".

Meanwhile, the effects of climate change are becoming more apparent, and there is a growing awareness that not only mitigation measures, but also adaptation measures are required. Amid mounting concerns of greater disasters in the future, the creation of a resilient society is also an urgent issue.

Thus, we are in serious need of further innovation in such areas as development and recycling technologies for resources including urban mines, water usage/treatment systems, energy management, the prediction of environmental changes and its countermeasures, as well as in social infrastructure technologies relevant to urban and transportation systems.

Eligible Achievements:

The 2021 Japan Prize in the field of "Resources, Energy, Environment, Social Infrastructure" is awarded to an individual(s) who has achieved breakthroughs in the creation, innovation or dissemination of science and technology, thereby contributing significantly to the sustainable development of human society.

Area of Life Science, Agriculture, Medicine

Medical Science, Medicinal Science

Background and Rationale:

The field of medical science and medicinal science has been undergoing remarkable progress in recent years. Genomic medicine, regenerative medicine and medical robotics have been making rapid progress. Also, revolutionary medicines such as cancer immunotherapy drugs and antiviral agents are being developed one after another.

Nonetheless, the need for new measures against emerging infectious diseases and diseases associated with aging and changes in lifestyle, as well as the emergence of drug-resistant pathogens and cancers, have all come to the fore as major global issues.

Today's medical science and medicinal science are expected to contribute even more to people's health and well-being. This is being sought through the creation and dissemination of new medical care that integrates other disciplines such as engineering and informatics, the development and production of new drugs, and new drug delivery systems.

Eligible Achievements :

The 2021 Japan Prize in the field of "Medical Science, Medicinal Science" is awarded to an individual(s) who has achieved scientific and technological breakthroughs, such as new discoveries or the development of innovative technologies on the "prevention", "diagnosis", "treatment" or "prognosis" of diseases, thereby contributing towards the health and well-being of humankind.

Fields Selection Committee for the 2021 Japan Prize

Chairman

- **Michiharu Nakamura**
  Counselor to the President, Japan Science and Technology Agency
  Director, The Japan Prize Foundation

Vice Chairman

- **Kazuhito Hashimoto**
  President
  National Institute for Materials Science
- **Kohei Miyazono**
  Professor
  Department of Molecular Pathology
  Graduate School of Medicine, The University of Tokyo

Members

- **Yozo Fujino**
  Distinguished Professor
  Institute of Advanced Sciences
  Yokohama National University
- **Ken Furuya**
  Professor, Graduate School of Engineering
  Soka University
  Professor Emeritus, The University of Tokyo
- **Mariko Hasegawa**
  President
  SOKENDAI
  (The Graduate University for Advanced Studies)
- **Masaru Kitsuregawa**
  Director General, National Institute of Informatics
  Professor, Institute of Industrial Science
  The University of Tokyo
- **Kazuo Kyuma**
  President
  National Agriculture and Food Research Organization
- **Eiichi Nakamura**
  Endowed Professor
  Office of the President and Department of Chemistry
  The University of Tokyo
- **Yuichi Sugiyama**
  Head
  Sugiyama Laboratory, RIKEN Baton Zone Program
- **Mariko Takahashi**
  The Science Coordinator
  The Asahi Shimbun
- **Masayuki Yamamoto**
  Professor Emeritus, The University of Tokyo
  Professor Emeritus, National Institute for Basic Biology

(alphabetical order, titles as of November, 2019)

Schedule (2021-2023)

The eligible fields for the Japan Prize (2021 to 2023) have been decided for the two research areas, respectively.
These fields rotate every year in a three year cycle.
Every year the Fields Selection Committee announces the eligible fields for the next three years.

Area of Physics, Chemistry, Informatics, Engineering

Year	Eligible Fields
2021	Resources, Energy, Environment, Social Infrastructure
2022	Materials, Production
2023	Electronics, Information, Communication

Area of Life Science, Agriculture, Medicine

Year	Eligible Fields
2021	Medical Science, Medicinal Science
2022	Biological Production, Ecology/ Environment
2023	Life Science