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Japan Prize News
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JAPAN PRIZE

2011 Japan Prizes Awarded to : Dr. Dennis Ritchie and Dr. Ken Thompson for the development of UNIX, Dr. Tadamitsu Kishimoto and Dr. Toshio Hirano for the discovery of interleukin-6

"Information and Communications" field

Dr. Dennis M. Ritchie
Distinguished Member of Technical Staff Emeritus,
Bell Labs
United States

Dr. Ken L. Thompson
Distinguished Engineer,
Google Inc.
United States

"Bioscience and Medical Science" field

Dr. Tadamitsu Kishimoto
Emeritus Professor,
Osaka University
Japan

Dr. Toshio Hirano
Professor,
Osaka University
Japan

It has been decided that The Japan Prize Foundation will award the 2011 Japan Prizes to Dr. Dennis Ritchie, Distinguished Member of Technical Staff Emeritus at Bell Labs, Dr. Ken Thompson, Distinguished Engineer at Google Inc., Dr. Tadamitsu Kishimoto, Emeritus Professor at Osaka University, and Dr. Toshio Hirano, Professor at Osaka University.

Dr. Ritchie and Dr. Thompson will be awarded in the field of "Information and Communications" for their contributions to the development of the operating system, UNIX.

Dr. Kishimoto and Dr. Hirano will be awarded in the field of "Bioscience and Medical Science" for their discovery of interleukin-6 and its application in treating diseases.

The laureates deserve the utmost honor for contributing to the peace and prosperity of mankind through their significant roles in the advancement of science and technology.

They will be formally honored at the Presentation Ceremony to be held in Tokyo on April 20, 2011.

JAPAN PRIZE

The Japan Prize is awarded to scientists throughout the world who have been credited with original and outstanding achievements and have made major contributions to the advancement of science and technology, thereby manifestly furthering the cause of peace and the 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 commemorative medal. A cash award of 50 million yen is also made for each prize field.

"Information and Communications" field

Achievement: Development of the operating system, UNIX

Dr. Dennis M. Ritchie
Born : September 9, 1941 (Age 69)
Distinguished Member of Technical Staff Emeritus, Bell Labs

Dr. Ken L. Thompson
Born : February 4, 1943 (Age 67)
Distinguished Engineer, Google Inc.

Summary

With present computer systems, basic software called operating systems are used in addition to application software to perform word processor, spreadsheet tasks, and so on. Dr. Dennis Ritchie and Dr. Ken Thompson developed an advanced operating system called UNIX in 1969. The operating systems in those days were increasing in scale but becoming complex and disorderly. With UNIX, stability and high-speed performance could be attained by combining modularized programs. UNIX's superior design concept has been carried on by many computer technicians, and has supported the development of an advanced information society including the Internet.

Operating systems which make user-friendly computers possible

With present computers, multiple software usually functions hierarchically (Figure 1). For example, application software works closest to the user in operating a spreadsheet or in processing photographs. The operating system works in between the application software and hardware (machine). The role of the operating system is to make the hardware which includes the hard disk constituting the computer abstract and present it to the application software. Thanks to it, the application software can simplify such commands as "record data" or "print." In addition, the operating system can execute multiple tasks concurrently and also perform basic tasks such as connecting to the network.

The early computers which appeared on the scene in the 1940's did not, in fact, have an operating system. In the 1950's, programs came to be used as tools to simplify hardware usage, which established the concept of an operating system. Then in the 1960's, computer developers were competing to upgrade the operating system functions. In those days, large-scale and high-speed computers were rapidly being developed, and a time sharing system was achieved where one high performance computer was used concurrently by multiple persons. In order to improve the user-friendliness of these computers, the development of an operating system became indispensable.

In the U.S. in 1964, Massachusetts Institute of Technology (MIT), in collaboration with Bell Labs and General Electric (GE), began a joint research project to develop a time sharing operating system called Multics. Multics aimed to use the capacity of high performance computers to the full, in order to achieve an interactive user interface that could be used like a telephone or electricity, which was a breakthrough system back then.

Dr. Ritchie and Dr. Thompson, both of whom were then in their 20's, were among those who participated in the project as researchers of Bell Labs. Dr. Ritchie was developing an efficient programming language for Multics, and Dr. Thompson came up with the idea of a hierarchical filing (document management) system which later became the core technology for UNIX. However, between 1968 and 1969, Bell Labs decided to withdraw from Multics development. The verdict reached by Bell Labs was that Multics, in pursuing ideals, had become too massive and complex, and not much hope could be held for the overall system performance.

In want of making their own operating system

The development of Multics at Bell Labs was discontinued, but Dr. Thompson and his colleagues were deeply involved in the development carried on independent research. They felt they did not want to lose the convenient user interface which Multics provided at its development stage, and began to search for an alternative system. In particular, Dr. Thompson was very fond of an interactive computer game called "Space Travel" that he programmed himself.

Figure 1 Software hierarchical diagram

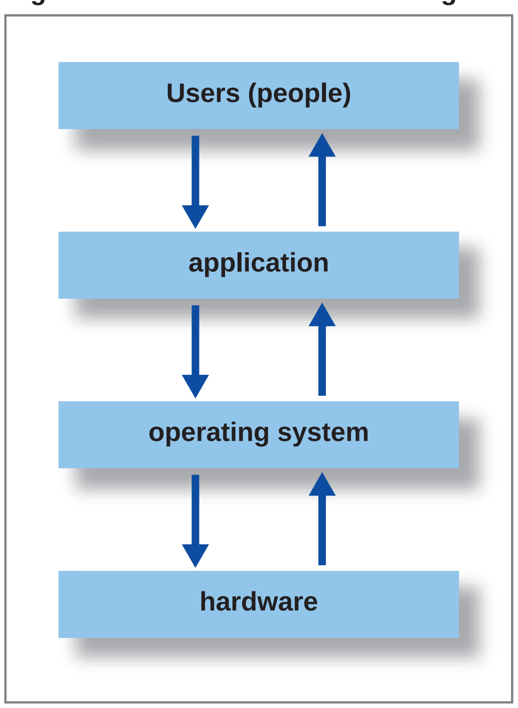


Figure 2 UNIX philosophy

(1) Small is beautiful:
Small things have advantages that large things do not have. By separating the programs into small modules as much as possible, they can be used in combinations.

(2) One program with one function:
Programs separated into small modules should each have one definite and reliable function.

(3) More emphasis on portability than efficiency:
Rather than having maximum capabilities on one particular hardware, by maximizing functions on as many computers as possible, the computer environment is enhanced.

(4) Emphasis on data portability:
Even if the program is portable, information cannot be shared. All number data should be stored in ASCII flat files.

(5) Avoid excessive interactivity:
Data flow is disrupted during the time users are interacting. Aim to achieve a moderately interactive interface.

(6) Design all programs as filters:
The basis of software is not to generate data but to process it. The programs should be designed as filters.

Thus, he ported the computer game into an old computer (DEC's PDP-7) which was lying idle at the laboratory . With Dr. Ritchie's help, he gradually added functions in Multics which were thought to be particularly important. Dr. Thompson's filing system which was left in limbo was also ported, and by 1969, it came to have an appearance of a new operating system. In the process, this operating system came to be known among the staff as UNICS. The name was supposedly given to emphasize its compact and single layer (UNIplex) image in contrast to Multics' massive and multilayer (Multiplex) image.

In time, the spelling of UNICS became UNIX, and its superior functions became known to researchers as well. In addition to having a hierarchical filing system that enables a quick search of desired information, because its basic parts were developed by a handful of people, it was a simple yet relatively trouble-free, solid operation system. In 1970, it was ported to a higher performance computer (PDP-11), and Bell Labs' patent department became one of its users.

The next issue which the now highly-evaluated UNIX faced, was the improvement of the programming language. From his experience with Multics, Ritchie felt the need for a "high-level language" programming with a higher abstraction level of commands. Dr. Ritchie along with Dr. Thompson were jointly developing B language, but they completed the improved version, the C language, and in 1973, UNIX was rewritten in the C language. Through this development, it became possible for UNIX to be used in computers around the world. In 1974, both doctors published their long-awaited UNIX article, and UNIX became known worldwide.

An open culture achieved by UNIX

Both UNIX and the C language which were developed by both doctors greatly influenced the information science in later years. In those days, Bell Labs provided free-of-charge UNIX and the source code (number sequence indicating basic commands to the hardware) to universities and research institutes; thus they were used proactively by researchers around the world. UNIX has created an open culture where researchers share ideas among themselves, which in turn, leads to new developments. As bamboo shoots after the rain, design concepts which sprung up one after the other has been handed down as UNIX philosophy. Many improvements have also been made to the C language, and many operating systems today have been written in the C language from the beginning.

In retrospect, many basic technologies in the information field have been conceived with UNIX as the basis. Noteworthy of them is the Internet. University of California, Berkeley developed BSD UNIX, which is the extended version of the Version 6 UNIX functions. From this, Internet protocol (TCP/IP)-mounted UNIX originated, greatly contributing to the realization of the Internet.

At present, there is a license system where certain regulations are applied to UNIX usage. However, "open source," which is a method where the source code is disclosed while protecting the copyright of the software producer, is also under parallel development. Operating systems carrying on the UNIX philosophy are now being used widely from mobile phones to supercomputers.

"Bioscience and Medical Science" field

Achievement: Discovery of interleukin-6 and its application in treating diseases

Dr. Tadamitsu Kishimoto
Born: May 7, 1939 (Age 71)
Emeritus Professor, Osaka University

Dr. Toshio Hirano
Born: April 17, 1947 (Age 63)
Professor, Osaka University

Summary

Our bodies detect external invasions of bacteria and viruses and eliminate them. This mechanism is called "immunity." Immunity is a complex system consisting of various cells such as lymphocytes (T-cells, B-cells) and macrophage, but the substance which plays an important role in transmitting information between cells is called interleukin. Dr. Tadamitsu Kishimoto and Dr. Toshio Hirano have purified interleukin 6 (IL-6), which plays a vital part in the production of antibodies, and also succeeded in gene cloning in 1986. In addition, the two doctors have identified a wide range of functions of IL-6 and their research results have contributed to the progress of bioscience and the development of therapeutic drugs for inflammatory diseases.

In quest of a substance which transmits immune cell commands

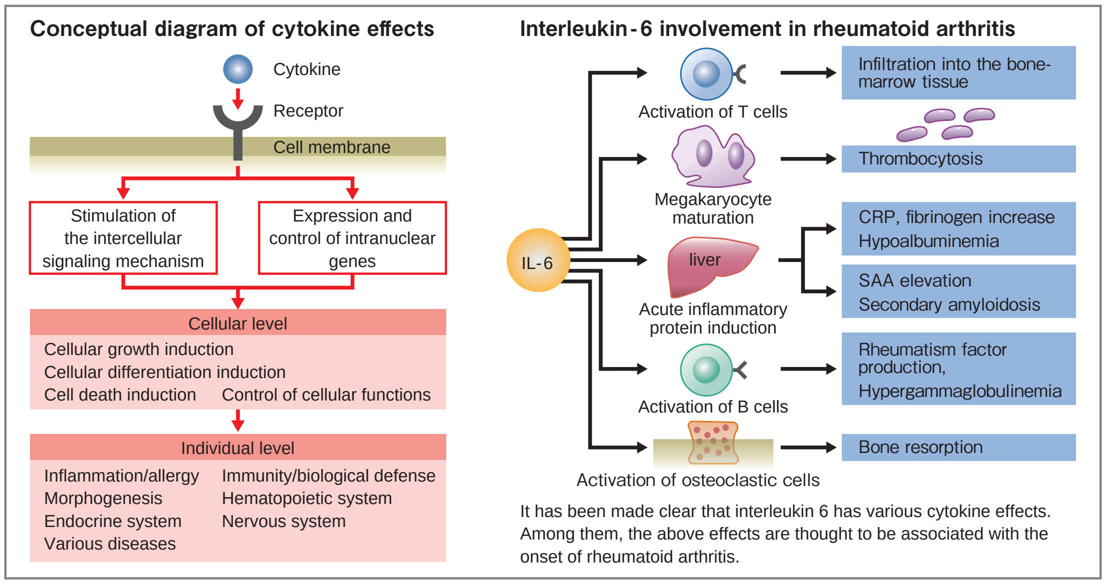
The knowledge that the human body has an immune system which, once exposed, builds in us resistance to a certain illness, has been long-established. Modern medicine started off with researchers confronted with the challenge of revealing what the immune system is. At the end of the 19th Century, Shibasaburo Kitazato and German physician Behring conducted research on the serum therapy of tetanus and diphtheria and discovered that a substance which attacks the pathogen is formed within the body once we are exposed to such infectious diseases. Thus, the concept of the immune system where the antibodies recognize and eliminate antigens was established. Around the same period, Russian microbiologist Mechnikov claimed that leukocytes within the blood attack pathogens such as bacteria in a mechanism called "phagocytosis," thus establishing the foundations of immunology.

Coming into the 20th Century, the characteristics of antibodies as substances were clarified and in a wider sense, the immune system came to be identified as a complex system made up of a wide variety of cells including companions of leukocytes such as lymphocytes, macrophage and dendritic cells. It was not until the late 1960's that the research regarding the essence of the immune system proceeded rapidly. It was then discovered that there were two types of lymphocytes, namely T-cells and B-cells, and that it was by mutual transmission of information between these two cell types that enabled the various antibodies to be produced efficiently. By defining the signaling mechanism, knowledge about the complex immune system can be acquired. The protein used to transmit information among the cells is called cytokine, and among these, interleukin is the substance most closely connected to the immune system. It was the study of interleukin which researchers around the world were competing to undertake.

It was immunology, a field in which cutthroat competition was already underway, that Dr. Kishimoto who graduated from Osaka University, Graduate School of Medicine, in 1969, decided to aim for. The catalyst for his decision was in his 5th year of medical school when he heard the lecture by the late Yuichi Yamamura, a pioneer in immunological research in Japan. He was intrigued by the discourse about autoimmune disorders where the immune system, which should protect our bodies from pathogens, revolts and attacks our bodies.

Dr. Kishimoto studied for 4 years from 1970 at the Johns Hopkins University in Baltimore, U.S., under Professor Kimishige Ishizaka (the 2000 Japan Prize Laureate), who discovered immunoglobulin E. After returning to Japan, he became an assistant at Osaka University, Faculty of Medicine, and in 1975, he was able to do research for 3 months under Robert Good, the Director of Laboratory at the Memorial Sloan-Kettering Cancer Center, who was closely following Dr. Kishimoto's research. During that short period, he discovered a new interleukin candidate substance which generates from T-cells and creates antibodies within B-cells. The research results thereof were posted and published in a British science magazine "Nature."

Figure Functions of lymphocyte-produced interleukin-6



It has been made clear that interleukin 6 has various cytokine effects. Among them, the above effects are thought to be associated with the onset of rheumatoid arthritis.

Success in gene cloning after much hardship

All seemed smooth sailing, but it was only the beginning of research for Kishimoto. The characteristic of cytokine is that one type has many combined functions, and there are many companions with overlapping functions. Even if the biological activities of the discovered substance were studied, it would be difficult to prove whether it was really a new substance. The academic society only acknowledged a new substance if the gene which creates a substance is extracted singularly (cloning).

What provided a boost to Dr. Kishimoto who was in search of the gene of the discovered substance, was the establishment of the Institute for Molecular and Cellular Biology at Osaka University in 1982, which became the center of bioscience. In the following year, Dr. Kishimoto, who became a professor at the above institute, welcomed Dr. Hirano as his research partner. Dr. Hirano graduated the Faculty of Medicine at Osaka University and went on to study immunology at the National Institute of Health (NIH) at Baltimore, U.S., so they had been acquaintances from their days in the U.S. Moreover, Dr. Hirano, after returning to Japan, had been continuing his research at Habikino Hospital and the School of Medicine at Kumamoto University, and had independently discovered interleukin and was working on the cloning.

Both doctors adopted the leading-edge genetic engineering techniques and continued in their gene hunt. They were unable to obtain the desired results, and continued in their low-profile experiments for days and then for years, often struggling with frustration. However, in May, 1986, they finally succeeded in capturing a particular gene. In 1988, at the international conference, the name interleukin 6 (IL-6) which meant that this was the 6th interleukin that the two professors cloned, was given.

Application of research results to the therapeutic drug for rheumatoid arthritis

After the success of gene cloning, by means of the genetic modification technique, a highly pure IL-6 was obtained, and progress was also seen in the clarification of its mechanism. The research group with both doctors as core members also identified the structure of the IL-6 receptor. In addition, they explained the intracelluar signals which transmit IL-6 information to the cell nucleus. By publishing various articles about the IL-6 mechanisms one after another, they became the world's leading researchers in this field.

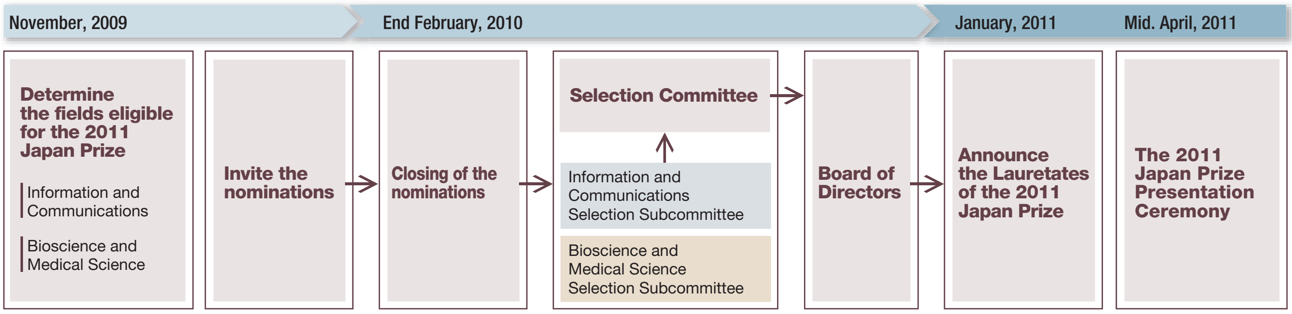
What proved fortunate for both doctors was that as the research progressed, it became evident that IL-6 not only enhances antibody production, but also has a wide variety of functions. For example, it has a mechanism for stimulating the production of protein within the liver (CRP) when an acute inflammation occurs in the body. It also has a mechanism for increasing platelets within the blood components which coagulate blood in the event of an injury. There is also a mechanism for thickening heart muscles. The more research is done, the more functions are discovered, thus contributing to the progress of medicine.

Particularly noteworthy was the discovery that IL-6 is involved in the onset of rheumatoid arthritis, which is representative of autoimmune disorders. The two doctors had already noted from an early stage of their research that IL-6 is deeply involved in the inflammatory reactions within the body, but it was newly discovered that a large quantity of IL-6 exists in the joint fluid of rheumatoid arthritis patients. From this discovery, an important result was obtained about its pathogenic mechanism.

Both doctors are currently involving themselves diligently in research activities. Dr. Kishimoto, based on basic research, has jointly developed, with a pharmaceutical company, an antibody drug Tocilizumab which inhibits IL-6 action. After being approved in Japan in 2008, the drug has become approved in 70 countries worldwide including Europe and U.S. Dr. Hirano defined the mechanism of the onset of autoimmune diseases in addition to discovering that IL-6 plays a vital role in the initial stage of the emergence of fish. Research originating from the discovery of IL-6 has broadened its horizons from leading-edge medicine to bioscience.

Nominations and Selection Process

- Every November the Fields 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 following year.
- For each field, a Selection Subcommittee conducts a rigorous evaluation of the candidates' academic achievements. The conclusions are then forwarded to 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 mid-April in Tokyo.



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Professor, Graduate School of Medicine, The University of Tokyo

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Associate Professor, Institute of Molecular and Cellular Biosciences, The University of Tokyo

Advisor Chikashi Toyoshima
Professor, Institute of Molecular and Cellular Biosciences, The University of Tokyo

(alphabetical order, titles as of December, 2010)

Fields for the 2012 Japan Prize Selected

Area of Studies Ⅰ
mathematics, physics, chemistry and engineering

Fields eligible for the award: Environment, Energy and Infrastructure

Background and rationale:

In recent years, the increase in resource and energy consumption and the destruction of the natural environment caused by various human activities have reached a level that is no longer ignorable, prompting negotiations for environmental protection measures on a global scale.

A strong need has thus been reaffirmed for innovation in fundamental technologies that profoundly influences the global environment. They include technologies for energy production and utilization, material production, water resource management, urban development, physical distribution and transportation. Particular importance lies in the promotion of energy saving across civil life and industry, exploitation of alternative energy resources and new production technology under resource and environmental constrains. Moreover, scientific advancement and innovation in disaster mitigation and safety measures is another important target for the development of the social infrastructure.

Achievement eligible:

The 2012 Japan Prize in the fields of “Environment, Energy, and Infrastructure” is awarded to individuals who have made significant contributions to society by achieving momentous scientific and technological breakthroughs in creation, innovation and propagation of technologies that are related to environmental protection, energy, environmentally benign production and social infrastructure, thereby improving and protecting the global environment.

Area of Studies Ⅱ
biology, agriculture and medical science

Fields eligible for the award: Healthcare and Medical Technology

Background and rationale:

Over the past few decades, dramatic progress has been made in diagnostic accuracy of diseases and physical functions. This has been due to the advancements of science and technology in the field of diagnostic imaging instrument, information based medical technology, and moreover, the medical diagnostic technology and biochemical-based diagnosis methods based upon the study of genetics.

In addition to the advancements in diagnosis technology, innovations in medical treatment technique including minimally invasive surgery and radiation therapy have improved the curability rate of many diseases, thereby significantly contributing to the well-being of people. Furthermore, even greater developments are being anticipated in the field of medicine, such as diagnostic technology for early detection of diseases, epoch-making drug discovery and regenerative medicine.

With a rapidly aging population, maintaining and improving health and disease prevention has become increasingly important for the preservation of social vitality. As a result, there are high expectations for further development and advancement of the science and technology in this field.

Achievement eligible:

The 2012 Japan Prize in the fields of “Healthcare and Medical Technology” is awarded to individuals who have made significant contributions to society by achieving momentous scientific and technological breakthroughs in creating and promoting new technologies for medical diagnosis and treatment, and those contributing to maintenance and furtherance of our health and disease prevention.

Fields Selection Committee for the 2012 Japan Prize

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Editorial writer, The Asahi Shimbun

(alphabetical order, titles as of December, 2010)

Schedule (2013-2015)

The fields eligible for the Japan Prize (2013 to 2015) 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 fields for the next three years.

Areas of Physics, Chemistry and Engineering

Year	Eligible Fields
2013	Materials, Production
2014	Electronics, Information, Communication
2015	Resources, Energy, Social Infrastructure

Areas of Life Science, Agriculture and Medicine

Year	Eligible Fields
2013	Biological Production, Biological Environment
2014	Life Science
2015	Medical Science, Medicinal Science

※ As of October 1, 2010, The Science and Technology Foundation of Japan changed its name to “THE JAPAN PRIZE FOUNDATION”.