Table 2-3-8/ Principle measures for conservation of basis of the nation's existence (FY 2011)

Ministries and agencies	Conducting organization	Measures
MIC	MIC	R&D of quasi-zenith satellite system
		R&D of technology to predict and promptly respond against cyber attacks through international cooperation
		R&D of cloud-shifting promotion security technology prepared for disasters
	National Institute of Information and Communications Technology (NICT)	R&D of network platform technology
MEXT	MEXT	Establishment of Innovative High-performance Computing Infrastructure (HPCI)
		Ocean-resource use promotion technology development program (advance exploration technique of marine mineral resources)
	JAXA	Upgrading platform rocket
		Solid rocket
		Hayabusa-2
		Mercury exploration project "Bepi Colombo"
		X-ray astronomy satellite "ASTRO-H"
		Satellite observation and monitoring system
		International Space Station Program
		R&D of an unmanned cargo transfer spacecraft, H-II Transfer Vehicle, with the capability of returning to Earth (HTV-R)
	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Verification of an ocean-resource exploration system
		Oceanic-Earth Drilling Program
METI	METI	Project to promote measures for the information security of enterprises and individuals
		R&D of an advanced space system with downsizing
		R&D of a transportable integrated small ground system
		R&D of oil resources via remote detection
		R&D of a hyper spectrum sensor
		R&D of a next-generation earth observation satellite use platform
	National Institute of Advanced Industrial Science and Technology (AIST)	Consolidation of satellite image information and geological information, and the expansion of its use
		geological survey of land and oceans, and improvements in the precision of earth-science basic charts
	Information-technology Promotion Agency, Japan	Government subsidies for the Information-technology Promotion Agency, Japan
MLIT	Japan Coast Guard (JCG) Hydrographic and Oceanographic Department	Promotion of ocean surveys in the territorial waters and exclusive economic zone (EEZ) of Japan

5 Enhancement and Strengthening of the S&T Common Platform

In order to effectively and efficiently promote R&D that will respond to the various problems faced by Japan and the world, it is necessary to promote the R&D of S&T that is used across multiple areas. Furthermore, regarding the common and fundamental facilities and the equipment needed for a large variety and wide range of R&D, it is important to promote the connection of these facilities and equipment so as to create a mutual network that will further enhance and strengthen them.

Therefore, the government focuses on and promotes policies related to R&D for critical problems.

(1) Strengthening cross-disciplinary S&T

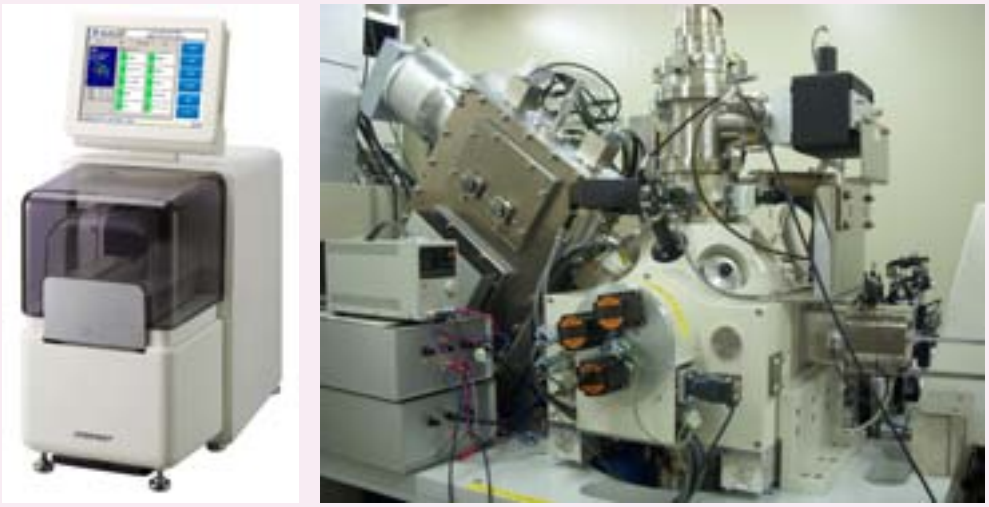
The government promotes R&D on S&T that can be practically used across disciplines and in multiple fields, for example, the use of leading-edge measurement and analysis technology and nanotechnology, light/quantum science technology, advanced information and communication technology, and technology related to the mathematical sciences.

(Development of leading-edge measurement and analysis technology and equipment)

The leading-edge measurement and analysis technology and equipment are a common platform that supports the creation of unique, world-class, cutting-edge results in R&D—the type of results that can be awarded Nobel Prizes, and therefore key technologies indispensable to progress in S&T.

Within MEXT, the Japan Science and Technology Agency conducts "Industry-Academia Collaborative R&D Programs (leading-edge measurement and analysis technology and equipment development program)" and makes efforts on strengthening R&D platforms by promoting the development of one-and-only, leading-edge measurement and analysis technology and equipment that originate in Japan and can meet the needs of world leading researchers and the demands of manufacturing sites (Figure 2-3-9). In FY 2011, in an effort to overcome obstacles in the creation of excellent results, and in order to contribute to green innovation, MEXT started the development of measurement and analysis technology and equipment so as to generate excellent R&D results aimed at a dramatic improvement in performance and so as to lower the cost of fuel cells and storage batteries. Furthermore, MEXT started to make efforts on the formation of a measurement and analysis technology platform that supports the further advancement and diffusion of equipment by providing development teams with feedback about various knowledge gained through users' actual experiences after they have deployed newly developed, cutting-edge prototypes at the actual research sites. The number of cases that developed prototypes which became commercial products exceeded twenty as of the end of FY 2011.

Figure 2-3-9/ Example of the fruits of leading-edge measurement and analysis technology and equipment



Left: Protein analyzer (This equipment enables the full automation of two-dimensional gel electrophoresis for the analysis of mixtures of proteins. The product was awarded for "The 54th 2011 Best 10 New Product Prize" selected by Nikkan Kogyo Shimbun, Ltd.)
Right: Super-sensitive, Infinitesimal-mass spectrometry system (This equipment is practically used for the analysis of samples that the asteroid explorer "Hayabusa" brought back from the asteroid "Itokawa.")
Courtesy of Japan Science and Technology Agency

(R&D of nanotechnology)

The nanotechnology and materials field contributes to the progress of S&T and to problem solving in field such as life sciences, information and telecommunications, and environmental sciences. The R&D of this field is also necessary for society to realize the growth of industry and to make people's lives more safe, secure, comfortable and convenient.

MEXT promotes fundamental R&D to realize breakthroughs in environmental technology using a "Elements Science and Technology Project" to develop technology for the replacement or reduction of rare-elements and a "Development of Environmental Technology Using Nanotechnology" (refer to 1(1) and (3) in Part 2 Chapter 2 Section 1).

The National Institute for Materials Science (NIMS) develops advanced technologies that are commonly required including 1) world-class, leading-edge measurement technology for complete material measurement from the surface to the core, 2) simulation technology for high-precision analysis and evaluation of physical properties, and 3) development of design methods and new manufacturing processes, in order to generate material from material elements (particles, organic molecules, etc.). NIMS also creates new substances and materials by taking advantage of physical properties that are unique to nano-sized substances—either organic or inorganic—by manipulating and controlling atoms and molecules on the nano-level (one billionth or 10^{-9} meter). In addition, NIMS promotes the R&D of materials that provide advancement, high-reliability and a high safety environment for energy related materials as a response to common challenges faced by human beings, and in order to solve environment/energy/resource problems and to establish a safe and secure social platform (refer to 1 in Part 2 Chapter 2 Section 2).

Within MIC, the Institute of Information and Communications Technology (NICT) promotes the R&D of platform technologies, such as advanced quantum-control technology and photon-level, signal-control technology, unused-frequency band technology, and atom/molecular-level structure control technology; NICT does so by using new materials including atoms, molecules and superconductors in order to overcome technical and performance limits and to realize dramatic progress in the areas of future information and communication technology.

MAFF makes efforts on development of process and evaluation techniques for the development of new food materials through the practical use of nanotechnology.

METI conducts 1) the development of nanoelectronics technology whose operating principle is based on near-field light to realize optical elements such as lower loss and multifunctional polarization control components and 2) the development of molecular imaging equipment that contributes to super early detection of cancer by detecting functional change in cells. METI also conducts the development of processing-platform technology related to welding techniques and forging technology that control elements in nano order for further improvement in reliability, strength and lightness that are leveraged with the characteristics of high-quality steel materials whose structure are controlled in nano order. Furthermore, METI makes efforts for the establishment of safety evaluation techniques in order to smoothly promote the development and application of nanomaterials that are the foundation of nanotechnology.

In addition, an industry, academia and government integrated and cooperated center "Tsukuba Innovation Arena" (TIA) has been formed with four organizations as its core, and with support from MEXT and METI at Tsukuba, where a leading-edge nanotechnology research facility and talented personnel are combined: the four organizations are Tsukuba University, NIMS, National Institute of Advanced Industrial Science and Technology (AIST), and Nippon Keidanren (Japan Business Federation).

(R&D of light/quantum S&T)

Many quantum beams, including light, neutron beams and ion beams are practically used for precision observation, precision machining and substance creation, all of which are leveraged with their excellent properties. For example, a laser is used for precisely machining semiconductors, and synchrotron radiation is used for structure analysis at the atom level.

Due to dramatic progress in S&T, nowadays, it is required to process at the atom/molecule level and to examine the structure and capability of substances in detail, which was previously impossible. Therefore, the S&T of light and quantum science support a wide spectrum of S&T, from academic research to industrial applications, as an extremely important, key technology.

MEXT promotes the R&D of light/quantum S&T through cooperation with and interaction among various researchers in industry, academia and government by linking the potentials in Japan's light/quantum S&T with needs in other areas. MEXT also has been conducting the "Development of platform technology for the formation of a light/quantum science center" since FY 2008, with the aim of promoting the development of human resources who will continue to make contributions in this area in the future.

(R&D of advanced information and communication technology)

Information and communication technology is a common platform technology that will play a key role in terms of contributions by S&T to overcome various social problems in the future.

As a necessary platform for innovation in S&T, it is necessary to effectively and efficiently upgrade systems for information gathering, information aggregation, information consolidation, information management, information analysis, information circulation and information sharing by practically using the information gleaned from S&T. Therefore, MEXT conducts activities to strengthen an S&T platform that enables the efficient use of large-scale data. These activities include both an "R&D of system consolidation/cooperation software to realize E-SCIENCE," and the "R&D of Web society analysis platform software." MEXT also conducts the establishment of an Innovative, High-performance Computing Infrastructure (HPCI) in order to respond to the requirements of upgrading precise scientific analysis/understanding/prediction and by practically using information gleaned from S&T (refer to 4(1) in Part 1 Chapter 2 Section 1). Furthermore, MEXT conducted a "Feasibility study for the realization of problem-solving based IT consolidated technology R&D" in FY 2011 because a purpose-driven-based, IT consolidated system (a highly cooperative and integrated IT system used to summarize society's real information, and to determine optimum solutions and a direction for solving problems, and to provide society with feedback) will be required in the future. In regard to super-low energy consumption and the improvement of reliability in IT systems, MEXT conducts the "R&D of a device system platform technology for high-function and ultra low-power consumption computing" and a "Highly reliable software technology development program."

(Creation of innovation by taking advantage of mathematical sciences)

In order to establish a framework where various problems in the areas of science and industry can be solved and where new values (mathematical innovation) can be created by practically using mathematics and mathematical scientific knowledge, MEXT supports researchers in the areas of mathematics and mathematical science, as well as supporting researchers in various areas of science and industry, so that they can cooperate as they work together on R&D.

(2) Upgrading and networking of common and basic facilities and equipment

Facilities and equipment for R&D are platforms necessary for the promotion of S&T, and it is essential to support all S&T activities through basic research and the creation of innovation. Therefore, it is important to plan for the enhancement and effective use of these facilities and equipment. And in the "R&D Enhancement Act[1]," it is stipulated that the government shall take necessary measures to promote sharing of R&D facilities and sharing of equipment owned by Independent Administrative Legal Institutes and universities.

Therefore, regarding common/platform facilities and equipment used in a wide range of S&T, and at the various research institutions of industry, academia and government, the government makes efforts to promote networking between these facilities, and promotes sharing of equipment and aims to improve the usability, mutual complementarities, and the ability to respond in the case of an emergency in addition to

1 "Act of Strengthening R&D Capability and Efficient Promotion of R&D with Promotion of R&D System Reform" (2008, Law number 63)

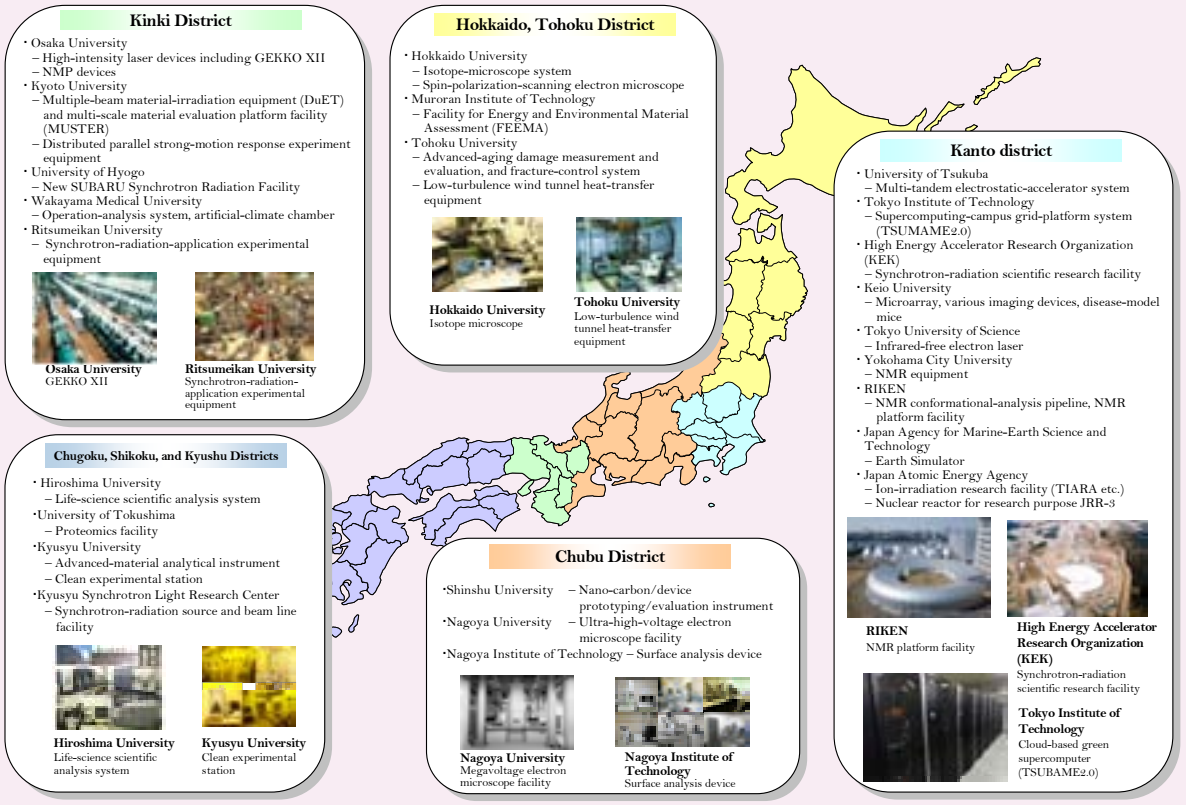
the promotion of their effective and practical use.

MEXT promotes sharing among researchers from industry, academia and government through large, specified, leading-edge research facilities[1] and provides subsidies for sharing pursuant to the "Act on Promotion of Shared Use of Specified, Large-Scale, High-Technology Research Facilities" (1994 Law No. 78) (referred to as hereinafter "Sharing Act"). (This will be discussed later in this paper.)

Regarding R&D facilities and equipment owned by other independent administrative institutions and universities, and regarding specified, large-scale, high-technology research facilities, "The Program for Strategic Use of Advanced Large-scale Research Facilities" was performed, and thirty facilities were supported in FY 2011 (Figure 2-3-10). "Sharing NAVI" (Composite navigation site of sharing research facilities) was established as a comprehensive portal website for basic information (location, usage application, available time etc.) regarding its use in order to promote sharing of these facilities and equipment for creation of results. Furthermore, MEXT promotes sharing advanced research facilities and equipment owned by research institutions such as universities and independent administrative institutions through the "Nanotechnology Network" in an effort to promote research field integration that will produce achievement and spawn innovation. Furthermore, having the supercomputer, K computer, as its core, MEXT promotes the establishment of an Innovative, High-performance Computing Infrastructure (HPCI) that realizes a computing environment that supports the various needs of users by networking the major supercomputers installed at universities and research institutes across the nation. MEXT has also fully conducted an "HPCI Strategic Program" to enhance R&D in strategically important areas, and has operated Japan's computing S&T system since FY 2011.

[1] The Sharing Act defines specified synchrotron radiation facility (Super Photon ring-8 GeV (SPring-8) and X-ray free electron laser facility (SACLA) (The long shaped building on the left is SACLA. The round building on the right is Spring-8.)) , specified high-speed commuter facility (supercomputer "K computer), and specified neutron facility (Japan Proton Accelerator Research Complex (J-PARC)).

Figure 2-3-10/ Organization that conducts "Program for Strategic Use of Advanced Large-scale Research Facilities."



Source: Created by MEXT

With the progression of globalization and the increased mobility of talented personnel due to a strong international competition for excellent minds, it is important to increase the number of opportunities available to Japanese researchers who have studied abroad, so they can work and actively contribute upon their return to Japan. It is also necessary to realize an international "brain circulation" that allows excellent foreign researchers to actively work in Japan.

Therefore, MEXT conducted an "Advanced research infrastructure project" in order to attract domestic and overseas researchers early in their careers and to enhance research facilities that can create cutting-edge research results. MEXT supported thirteen such projects in FY 2011.

(Specified, large-scale, high technology research facilities)

Particularly important, large-scale research facilities are defined as a "Specified, Large-Scale, High-Technology Research Facility," pursuant to the Sharing Act, in which planned enhancement and fair and impartial sharing are stipulated, in order to promote innovation in Japan's S&T and to practically use investment for R&D in an effective and efficient manner.

○Super Photon ring-8 GeV (SPring-8)

The Super Photon ring-8 GeV (SPring-8) is the world's best performance research platform facility; it enables scientists to analyze the structure and function of substances at the atomic and molecular levels by using "synchrotron radiation," which is an extremely bright light that is generated when the light beam,

which contains electrons that are travelling close to the speed of light, is bent. The facility started its service in 1997, and has contributed to innovative R&D in the areas of life innovation and green innovation, both of which lead Japan's economic growth.

○X-ray free electron laser facility (SACLA)

The X-ray free electron laser facility (SACLA) is a world-leading research platform facility that enables analysis that was impossible with previous methods by oscillating an ultimate light beam that has both laser and synchrotron radiation characteristics. The facility enables the instantaneous measurement and analysis of both super-fine structures moving at super high speeds and the change of chemical reactions on an atomic level. As a result, innovative results are expected to be created in a wide range of research fields, such as those involving the development of medicine, fuel cells and the understanding of photosynthetic mechanisms. The facility succeeded in generating the world's shortest wavelength X-ray laser in June 2011, and started its service in March 2012.

Super Photon ring-8 GeV (SPring-8) and X-ray free electron laser facility (SACLA) (The long shaped building on the left is SACLA. The round building on the right is Spring-8.)
Courtesy of RIKEN

○Supercomputer "K computer"

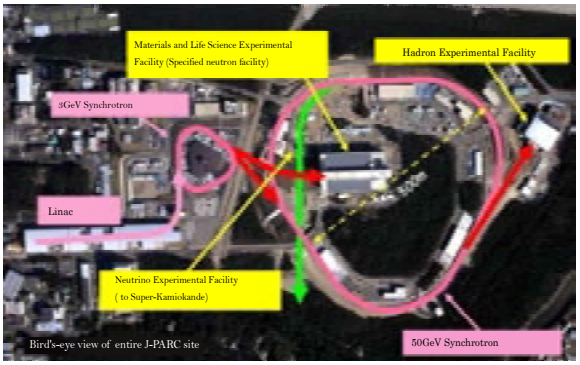
Nowadays, simulation with a supercomputer is indispensable as a third method, in addition to theory and experiment. A supercomputer can perform a large-scale simulation at high speed and can be used for the mitigation of damages caused by an earthquake or tsunami, and can be used for the development of new energy-saving semiconductor materials. MEXT is currently conducting the development and enhancement of the computer with the aim of achieving full completion by June 2012 and beginning service in fall of the same year.

Supercomputer "K computer"
Courtesy of RIKEN

In November 2011, "K computer" achieved its performance goal of 10 PFLOPS, and was ranked as the world's best performing supercomputer according to the TOP500 ranking conducted in June and November of that year.

○Japan Proton Accelerator Research Complex (J-PARC)

The Japan Proton Accelerator Research Complex (J-PARC) contributes to a wide range of areas including the life sciences, substance/material sciences, and atomic nucleus/particle physics; it does so by using various secondary particles such as a neutron and a neutrino[1] that are generated by the proton accelerator having world-class beam intensity. Although the facility stopped operation due to the damage caused by the GEJE in March 2011, efforts were made for an early recovery, and it was able to resume operations and neutron-facility services in January 2012.



Japan Proton Accelerator Research Complex (J-PARC)
Courtesy of J-PARC center

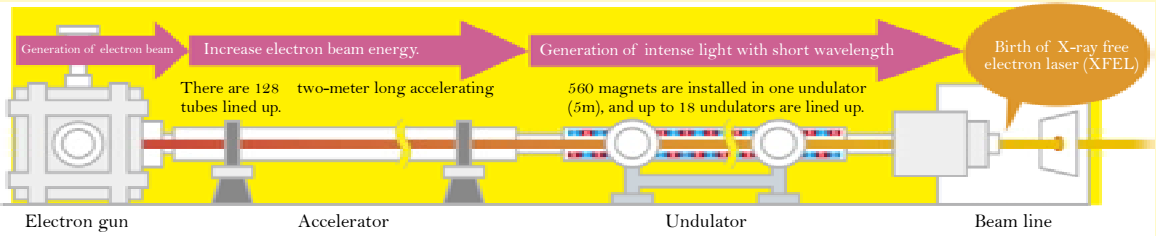
[1] This is one of the smallest elementary particles that compose a substance. A neutrino is difficult to detect because it is electrically neutral and can penetrate substances. Therefore, many properties, including its mass, are unknown.

Column 2-6

Future brought by X-ray free electron facility SACLA

SALCA is an ultimate laser facility that can oscillate an extremely intense x-ray that is 10^{19} times" stronger than the sun's x-rays.

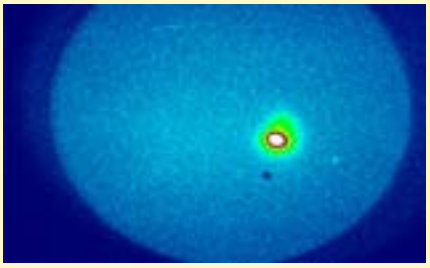
This new light enables the observation of atoms and molecules that are moving with super high speeds at a resolution of less than one trillionth of second (the time that the light propagates for just a few mm) allowing for frame-by-frame observation and is therefore expected to play a key role in the development of fuel cells and new medicine.



Configuration of SACLA apparatus

Courtesy of RIKEN and Japan Synchrotron Radiation Research Institute

While the X-ray free electron laser (XFEL) facility "LCLS" that already operates is 3.7 km long, Japan's "SACLA" has higher performance, yet is only 700 m long. This compact and energy-saving "SACLA" was constructed by gathering the world's leading technology and the wisdom of engineers, researchers and enterprises throughout Japan, from 2008 through 2010. Finally, in March 2012, it made the service available to all researchers.



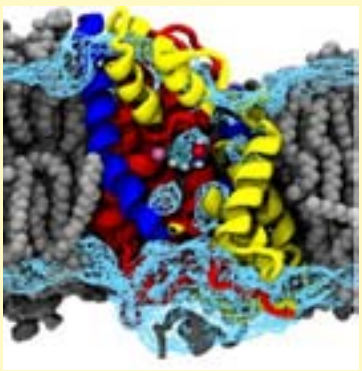
X-ray free electron laser at initial oscillation

Courtesy of RIKEN

It is said that Newton discovered universal gravitation by seeing an apple fall from a tree and that Galileo discovered that gravitational acceleration is consistent regardless of mass by dropping a ball from the Leaning Tower of Pisa. Centuries ago, scientists developed science by thoroughly investigating the daily phenomena around them. Modern science, however, is extremely advanced and has reached to the stage where new findings and innovative products can hardly be achieved without analyzing and manipulating substances on the atom/molecular level.

In such a modern scientific age, what might SACLA's innovative light provide us with?

For example, if we can easily understand the structure and function of a "membrane protein" with which the medicines in our body work, it may become possible to quickly design and develop a medicine that works perfectly. It might also be possible to generate fuel with sun light, water and carbon dioxide if we could understand the dynamic mechanisms of photosynthesis and artificially generate the same process. It is also expected we might develop innovative fuel cells, storage batteries, and solar cells through the detailed analysis of the status of atoms and electrons.



Understanding of membrane protein structure on the atom level

Courtesy of Kyoto University

The light generated with SACLA is the "light of the dream" that enables an ultimate science that allows researchers in Japan, as well as the rest of the world, to understand the function and structure of substances on the atom/molecule level and to thus design and control useful substances and materials on the atom/molecule level based on that understanding.

Table 2-3-11/ Major measures to enhance and strengthen common platform for science (FY 2011)

Ministries and agencies	Conducting organization	Measures
MIC,	National Institute of Information and Communications Technology (NICT)	R&D of future ICT platform technology
MEXT	MEXT	Establishment of Innovative High-performance Computing Infrastructure (HPCI)
		R&D for establishment of a next-generation IT platform
		The Program for Strategic Use of Advanced, Large-scale Research Facilities
		Development of platform technology to form a light/quantum science research center
		Elements Science and Technology Project
		Nanotechnology Network
		Development of Environmental Technology Using Nanotechnology
	Japan Science and Technology Agency	Industry-Academia Collaborative R&D Programs (Advanced measurement and analysis technology and equipment development program)
	RIKEN, Japan Synchrotron Radiation Research Institute (JASRI)	Sharing of Super Photon ring-8 GeV (SPring-8)
		Enhancement and sharing of an X-ray free electron laser (XFEL) facility
	Japan Atomic Energy Agency High energy accelerator research organization	Enhancement and sharing of a Japan Proton Accelerator Research Complex (J-PARC)
	National Institute for Materials Science (NIMS)	Advanced R&D that aims breakthrough with creating innovative materials
		R&D for advanced materials responding to social needs
MLIT	Port and Airport Research Institute	Study to protect regional society against large-scale earthquakes and tsunamis
		Study on the evaluation of and measures against the influences of climate change to high-wave, high-tide and geomorphic change
		Research on the functional improvement of ports and airports to strengthen international competitiveness
		Study on the strategic maintenance and management of port and airport facilities
		Research on the effective use of oceans, space and energy