Scientific and Technological Achievements Which Contribute to Daily Life

Part 2 reported measures taken during FY2016 to promote science and technology. In this segment, we present scientific and technological achievements contributing to our daily lives.

We selected the following achievements contributing (or expected to contribute) to people's lives:

- Research and development (R&D) results produced by national R&D agencies, national research institutes and universities and
- R&D results produced in projects supported or commissioned by governments or national R&D agencies.

In this year's white paper, we mainly focus on R&D results produced by national R&D agencies. We also present other related R&D activities and R&D activities with similar goals.

Specifically, we selected the following 13 R&D topics.

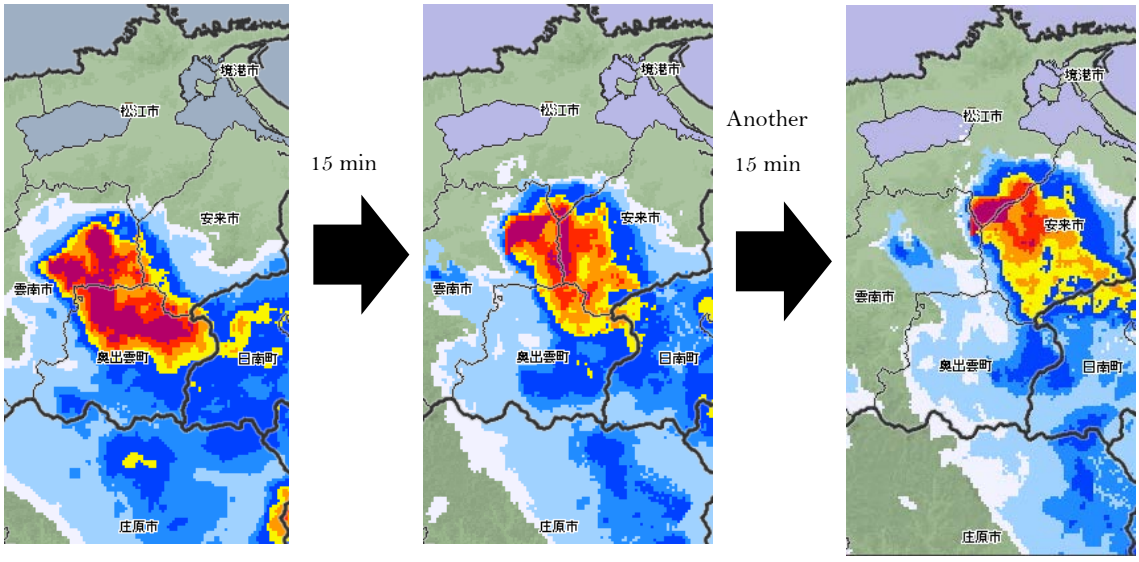
① Technologies to observe and forecast localized heavy rain
② R&D related to ingredients with health claims
③ Development of ergonomic products
④ Disaster response technologies
⑤ Satellite utilization
⑥ Insulation materials and solar power generation technologies
⑦ Technologies to alleviate the symptoms of Japanese cedar pollinosis
⑧ Technologies enabling early cancer detection
⑨ Aircraft materials
⑩ Technologies to protect people from heat waves
⑪ Display and screen technologies
⑫ Results of experiments performed in the KIBO module of the International Space Station
⑬ Automobile technologies

Scientific and technological achievements which contribute to daily life ①:
Technologies to observe and forecast localized heavy rain

Forecast of sudden heavy rain

Universities and public agencies that participated in R&D

JMA, NIED, Osaka University, NICT, RIKEN, JST, Meteorological Research Institute, NILIM



Images provided by the JMA

Current rain status (left) and forecasted rain statuses for 15 minutes (middle) and 30 minutes (right) later in vicinity of Matsue City. People often go out without an umbrella on a day forecasted to have unstable atmospheric conditions and a chance of sudden showers. The new forecast system may serve as a handy aid for people who are unprepared for inclement weather to avoid sudden heavy rain.

- Sudden pouring rain has been occurring more frequently in recent years. Although it is difficult to improve the precision of weather observation and forecast (e.g., predicting weather conditions 10 minutes later at specific locations), efforts to make these improvements are in progress.
- The High-Resolution Precipitation Nowcasts (HRPNs) (see ① below) are capable of forecasting weather for 250-square-meter areas at five-minute intervals up to 30 minutes ahead and transmitting the information to smartphones with a proper application installed. HRPNs can forecast sudden heavy rain and assist people in avoiding it.
- The HRPNs use data from X-band multi-parameter (MP) radars (see ② below). Work is underway to construct a radar rain gauge network consisting of X-band and C-band MP radars capable of recording rainfall changes virtually in real time. The network has been used, for example, for river management in which the change in downstream water levels is predicted based on rainfall measurements in upstream areas.
- The precision of weather forecast (numerical prediction) systems may improve by integrating the latest radar technologies, such as phased array weather radars (see ③ below), and supercomputers.

Detailed information on research results

① High-Resolution Precipitation Nowcasts (HRPNs): The HRPNs were developed by the Japan Meteorological Agency (JMA) when replacing previous radars from 2012 to 2013. The HRPNs use data including observation data from the JMA's radars, data from rain gauges operated by local governments, etc., upper-air observation data from radiosondes, etc., and data from the X-band multi-parameter radars operated by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

② X-band multi-parameter radars: The National Research Institute for Earth Science and Disaster Resilience (NIED) developed X-band multi-parameter radars in 2000 and has studied rainfall intensity estimation methodologies. The MLIT has been working to create the eXtended RAdar Information Network (XRAIN) using these radars since 2009.

③ Phased array weather radars: The National Institute of Information and Communications Technology (NICT), Osaka University, and Toshiba Corporation developed phased array weather radars in 2012. In 2016, a research group, which engaged in joint research supported by the Japan Science and Technology Agency (JST), succeeded in simulating the actual distribution of sudden torrential rains in detail by developing a weather forecast simulation system, which refreshes forecasts every 30 seconds by assimilating new observation data at 100-meter grid spacing, using observation data from phased array weather radars and data computed by RIKEN's supercomputer, the K computer. In addition, NIED conducts joint research for sophisticating predictions by using data including observation data from phased array weather radars. The Meteorological Research Institute has also engaged in research and development for full-fledged operation of and monitoring by phased array weather radars.

Scientific and technological achievements which contribute to daily life ②: R&D related to ingredients with health claims

Research and development related to health food products

Universities and public agencies that participated in R&D

National Institute of Advanced Industrial Science and Technology (AIST), Japan Science and Technology Agency (JST), Hirosaki University

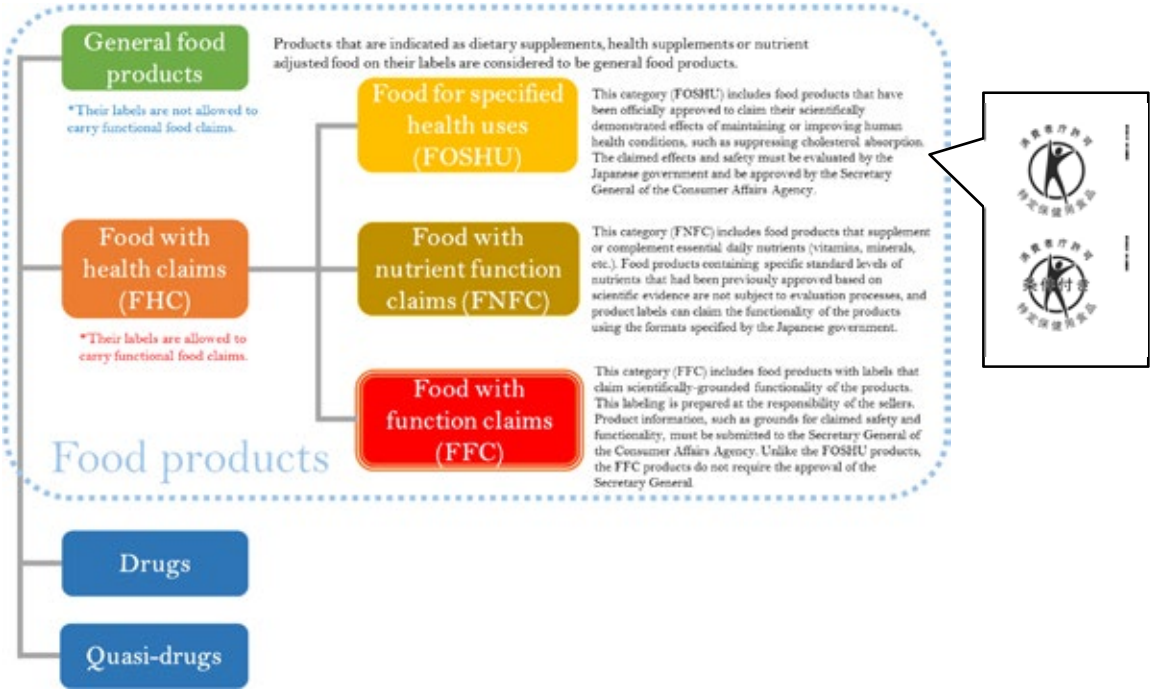


Diagram provided by the Consumer Affairs Agency

We commonly find a variety of food products with health claims at supermarkets, convenience stores and vending machines. Labels of these products claim various health effects, such as promoting body fat breakdown. Consumers can choose products according to their health concerns.

- Various R&D efforts resulted in the discovery of ingredients with biological effects—which are found in the FOSHU products and other food products with health claims—and the confirmation of beneficial effects of these ingredients.
- For example, "Casein DP Peptio Drink"—the first food product to claim its effect to lower cholesterol levels—contains an ingredient called casein dodecapeptide (see ① below). This ingredient was developed in research on active components of milk. The discovery of this ingredient later triggered the development of various food-derived ingredients with biological effects.
- Food products that claim to protect articular cartilage on their labels contain proteoglycans (see ② below) extracted from animal cartilage. Production of proteoglycans was initially very expensive, costing 30 million yen to produce one gram. A research group led by Hirosaki University developed a technology to extract proteoglycans from salmon nasal cartilage in 2000, which enabled production of proteoglycans at low cost and its commercialization. Aomori Prefecture is currently working to develop the proteoglycan-related industry.

Detailed information on research results

① Casein dodecapeptide was discovered by the Fermentation Research Institute (currently the National Institute of Advanced Industrial Science and Technology) in about 1980. In 1992, Kanebo, Ltd. (currently Kracie Holdings, Ltd.) published a research paper reporting the effectiveness of this substance in humans when administered orally, which led to the approval of this substance as an ingredient in food products with a "food for specified health uses" label in 1995. Kanebo, Ltd. launched Casein DP Peptio Drink in 1997.

② Proteoglycans: The possible existence of high concentrations of proteoglycans in salmon nasal cartilage was first reported by the Aomori Prefectural Industrial Technology Research Center in 1990. Hirosaki University—which had been researching and developing proteoglycans—was selected in 1998 to conduct a project on proteoglycans proposed by the Japan Science Foundation (currently Japan Science and Technology Agency). The university carried out the project in collaboration with a local company, Kakuhiro Corporation, and developed a technology enabling mass production of proteoglycans at low cost in 2000.

Scientific and technological achievements which contribute to daily life ③: Development of ergonomic products

Development of comfortable products using *kansei* engineering

Universities and public agencies that participated in R&D

Hokkaido University, Fukuyama University, Shinshu University, Hiroshima University, Japan Science and Technology Agency (JST)

Images and graphs provided by Unicharm Corporation

Unicharm Corporation released a new face mask product in 2016 with a claim that the mask gives users a more slender appearance. The intended effect has been verified in joint research between Hokkaido University and Fukuyama University (see ① below).

- *Kansei* (a Japanese word meaning sensitivity, sensibility and intuition) engineering—a relatively new type of engineering originated in Japan—is an approach to develop added-value products and services that offer comfort to users by applying the evaluation of human sensations to products. Collaborative research between universities and private companies has created a variety of products.
- For example, Shinshu University and AOKI Inc.—a men's apparel company—have been conducting joint research since 2003 (see ② below). They quantified the comfort levels of people wearing men's suits by analyzing the relationship between the level of comfort felt by people wearing suits or people moving in suits and the pressure of clothing on the human body (clothing pressure). Based on the research results, they developed new suits in 2007 that are comfortable to wear and easy to move in. The joint research is still continuing and produced comfortable textile products, such as suits, dress shirts and underwear.
- A joint research group led by Hiroshima University and Mazda Motor Corporation has been working to design products and systems that offer supreme comfort to various users by quantifying brain activities, including feelings of excitement (see ③ below). *Kansei* information may be applied to the development of a variety of products, such as automobiles that offer exciting driving experience and furniture that offers a luxurious feeling.

Detailed information on research results

① Joint research implemented by Unicharm Corporation: Hokkaido University and Fukuyama University jointly studied the effect of face masks designed to give users a more slender appearance in 2016. In addition, Hokkaido University and Chukyo University jointly studied the effect of mask color on users' facial attractiveness in 2015. These joint efforts led to the commercialization of new face mask products.

② Joint research between Shinshu University and AOKI Inc. has led to the development of 22 products between 2003 and 2016. Evaluation of various comfort criteria (e.g., wrinkles formed in clothing, the feel of clothing on the skin and the comfort of wearing) led to commercialization of various products.

③ Feelings of excitement have been quantified through industry-academia collaborative research led by Hiroshima University and Mazda Motor Corporation under the framework of the Center of Innovation (COI) Program implemented by the JST.

Scientific and technological achievements which contribute to daily life ④: Disaster response technologies

Response to the 2016 Kumamoto earthquakes

Universities and public agencies that participated in R&D

Geospatial Information Authority of Japan (GSI), NIED, JAXA

Image provided by GSI

The photo—taken by the GSI Land Bird team (see ① below) using an unmanned aerial vehicle—shows the collapse of the Great Aso Bridge in the aftermath of earthquakes in April 2016.

- It is very important in times of disasters to promptly collect various types of information (e.g., extent of damage), integrate them and use them to facilitate safe evacuation of the people in the affected area and effective rescue operations.
- When powerful earthquakes broke out in Kumamoto in April 2016, information transmitted from local disaster response headquarters and various administrative agencies was integrated on the NIED crisis response website (see ② below) and provided to the public. The website allowed the viewing of critical information, such as prompt report on the estimated extent of building damages, traffic regulation information, locations of emergency shelters and the restoration status of water supply systems. The information was also used for disaster relief activities.
- In addition, the establishment of the D-NET system (see ③ below) enabled fire, rescue and medical helicopters to operate efficiently through prompt information sharing.

Detailed information on research results

① The GSI Land Bird team was established in March 2016 to conduct land surveys using unmanned aerial vehicles (UAVs, commonly known as drones). The team trains GSI drone technicians and performs UAV photographing and surveys in a time of disaster.

② The NIED crisis response website (NIED-CRS) was launched immediately after the first earthquake, with a seismic intensity of 7 on the Japanese scale, struck Kumamoto on April 14. The website integrates and provides information on various disasters—such as earthquakes, volcanic eruptions, typhoons and avalanches—collected by various administrative agencies.

③D-NET, developed by JAXA, has been used by the Fire and Disaster Management Agency to manage its fire and rescue helicopters in action. Simulations of earthquakes anticipated to occur directly beneath the Tokyo metropolitan area estimate that the optimum operation management capability of D-NET will increase the mission achievement level by 1.8 times and reduce the risk of helicopters flying too close to each other by 90%. D-NET2 is currently under development to add information from UAVs and satellites to the current information system.

Scientific and technological achievements which contribute to daily life ⑤: Satellite utilization

Various satellite applications

Universities and public agencies that participated in R&D

Japan Aerospace Exploration Agency (JAXA)

Image provided by JAXA

The MICHIBIKI-1 satellite (see ① below) in this image was launched in 2010. A total of seven MICHIBIKI satellites are planned to be put in orbit to increase positional information accuracy, which may greatly transform services that rely on positional information.

- Do you know the types of services provided by satellites? The images of cloud movements shown in weather forecasts are taken by satellites orbiting 35,800 km above the ground. This is only one of the many benefits of satellite services.
- The global positioning system (GPS) via satellites enables us to use a variety of smartphone applications, such as interactive maps, and car navigation systems. The current GPS has a margin of error of about 10 m. The quasi-zenith satellite system (QZSS) Japan is planning to develop may reduce the margin of error to 1 m or less. If this is achieved, it might become easier, for example, to pinpoint the entrance to a store you are looking for on your interactive map display.
- In addition, satellites are used in addressing environmental issues. For example, forests' capability to absorb CO_2 is critical in considering measures against global warming. The DAICHI-2 satellite (see ② below) has been closely monitoring shrinking forests.

Detailed information on research results

① The quasi-zenith satellite system, MICHIBIKI, is a satellite positioning system under development to increase GPS accuracy and stability. JAXA launched the MICHIBIKI-1 satellite in 2010 and plans to launch three additional satellites by 2017.

② DAICHI-2 (advanced land observing satellite-2) was launched by JAXA in 2014, as a successor to the first DAICHI satellite, to be used for regional observation, disaster monitoring and forest distribution surveys. A global forest map was created in 2016 based on observation data from DAICHI-2.

Scientific and technological achievements which contribute to daily life ⑥: Insulation materials and solar power generation technologies

Universities and public agencies that participated in R&D

University of Tokyo, JST, NEDO, JAXA

Saving and generating energy using coating materials

Image provided by Mitsubishi Chemical Corporation

Do you notice the slight tint to these hallway windows?
These windows—coated with translucent thin-film solar cells—are capable of generating electricity (see ① below).

- Annual per household energy consumption is estimated to have increased by 10% over the last 40 years as of 2014. Although the energy efficiency of home appliances has dramatically increased, much more can be done to save energy at home.
- Heating accounts for a quarter of household energy consumption. Energy used for heat generation could be reduced by increasing the thermal insulation capacity of buildings. The nose cones of H-II rockets are coated with a low heat conductive material to protect the rocket's internal components from high heat during the launch. This material is available commercially to increase the thermal insulation capacity of buildings (see ② below).
- In addition, a building coating material capable of solar energy generation (see ① below) has been developed. Research to achieve practical application of this coating material is underway. It may become feasible in the future to generate power using a large proportion of building surfaces by integrating this material into windows, roofs, walls, curtains, etc.

Detailed information on research results

① Organic thin-film solar cells—which can be applied as a coating material—achieved an energy conversion efficiency of 5% in 2009 in JST-funded studies conducted by University of Tokyo researchers. Moreover, the University of Tokyo and Mitsubishi Chemical Corporation jointly succeeded in increasing the solar cells' energy conversion efficiency to 11.7% in 2012. The photo above shows translucent thin-film solar cells developed through NEDO-funded demonstration experiments conducted by Mitsubishi Chemical Corporation.[1]

② GAINA: The license for the coating material developed by JAXA to insulate rocket nose cones was transferred to Nisshin Sangyo Co., Ltd. in 2005. Nisshin Sangyo then commercialized and popularized the material as a home insulation material (GAINA).

1 2013 NEDO news release entitled "Experiments to demonstrate organic solar cells begin"

Scientific and technological achievements which contribute to daily life ⑦:
Technologies to alleviate the symptoms of Japanese cedar pollinosis

Attacking the root causes of pollinosis

Universities and public agencies that participated in R&D

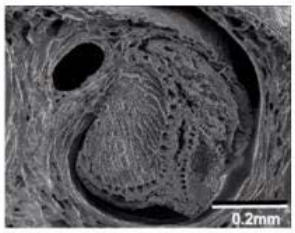
Forest Research and Management Organization, Tohoku University, National Agriculture and Food Research Organization (NARO)

Pollen-free Japanese cedar cultivar "Soshun"

This cultivar bears staminate flowers like ordinary Japanese cedar cultivars.

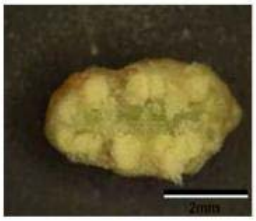
(Staminate flower cross-section)

(Electron micrograph)

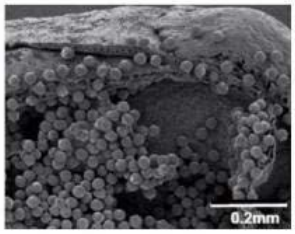


The anther contains no pollen.

Ordinary Japanese cedar cultivar



The anthers (round, yellow structures) are filled with pollen grains.



The spherical particles are pollen grains.

Images provided by the Forestry Agency

One in four Japanese people are believed to suffer from pollinosis. Japanese cedar pollinosis is the most prevalent type of pollinosis. To reduce the number of patients, a type of Japanese cedar has been developed which is incapable of producing pollen (see ① below).

- Many people wear face masks during the Japanese cedar pollen season in March and April. While wearing a mask can prevent the inhalation of pollen, more fundamental measures—such as reducing the amount of pollen dispersed in the air and curing pollinosis itself—are also being pursued.
- Japanese cedar cultivars have been developed that produce little or no pollen (see ① below). Efforts are underway to plant seedlings from these cultivars across a wide area.
- Sublingual immunotherapy is a pollinosis treatment technique in which allergens (antigens) are introduced into a patient's body through the mucosa under the tongue, thereby allowing the body to become accustomed to the allergens and suppressing overactive immune responses. This technique has been adopted in recent years to treat pollinosis patients. While it takes several years to completely cure pollinosis with this technique, progress is being made in improving it in clinical studies and research on the mechanisms of pollinosis (see ② below).
- Oral administration of antigens into a patient's body via ordinary food has also been pursued as a technique for suppressing overactive immune responses. Clinical studies of transgenic rice that expresses modified Japanese cedar pollen allergens (see ③ below) are ongoing.

Detailed information on research results

① The first pollen-free Japanese cedar was discovered at the Forest Research Institute of the Toyama Prefecture Agricultural, Forestry & Fisheries Research Center in 1992. Improvement of this cultivar resulted in the development of the new cultivar "Haruyokoi" in 2004. The Forestry and Forest Products Research Institute (currently the Forest Research and Management Organization) also developed a different pollen-free Japanese cedar cultivar called "Soshun" in 2005.

② Sublingual immunotherapy is a technique for the treatment of Japanese cedar pollinosis. Insurance coverage for this technique was approved in 2014. Tohoku University identified the mechanisms of dendritic cells and regulatory T cells capable of preventing allergies in the oral mucosa in 2016.

③ Transgenic rice that expresses modified Japanese cedar pollen allergens: The National Agriculture and Food Research Organization (NARO) began researching and developing this technology in 2000 to ease the symptoms of Japanese cedar pollinosis. Clinical studies of the technology started in 2016.

Scientific and technological achievements which contribute to daily life ⑧: Technologies enabling early cancer detection

Early cancer detection

Universities and public agencies that participated in R&D

AMED, NEDO, Kyoto University, NCC, NCGG, National Institutes for Quantum and Radiological Science and Technology (QST), Gunma University

Image provided by Shimadzu Corporation

This bed, on which an adult can recline, is a breast cancer screening device (see ① below). An examinee is first administered a radioactive drug (a radioisotopic agent) and then lays down on the bed. The device can detect breast cancer by measuring the radiation emitted by cancerous lesions. This technique is called radiation positron emission tomography (PET). Unlike mammography, the device does not cause pain and may enable early cancer detection.

- Early detection of certain types of cancer is known to greatly increase a patient's chances of survival. Simple cancer examination methods are under development to detect and treat early stage cancer.
- The potential of cancer diagnosis techniques which use blood and other bodily fluid samples (e.g., X-ray diagnostic imaging and endoscopic tumor tissue sampling) to resolve critical diagnostic issues, such as increased accuracy and speed and cost reduction, is very promising.
- For example, the method used to detect microRNA from cancer cells (see ② below) may enable the detection of 10 types of cancer from a single drop of blood. Research in this field is underway.
- A new radioisotopic agent was developed to increase the cancer detection sensitivity of PET technology (see ③ below). The agent has enabled the detection of very small amounts of cancer cells. Application of this agent as a cancer treatment is being pursued.

Detailed information on research results

① Elmammo is a PET device dedicated to breast cancer diagnosis. The device was developed by Shimadzu Corporation through a NEDO-funded research project initiated in 2006. Shimadzu Corporation conducted joint clinical research on the device with Kyoto University and introduced it into the market in 2014. Elmammo is capable of examining both breasts in about 15 minutes.

② MicroRNA-based cancer diagnosis systems have been developed by National Cancer Center (NCC), National Center for Geriatrics and Gerontology (NCGG) and seven other organizations through research projects commissioned by NEDO (since 2014) and AMED (since 2015).

③ Cancer diagnosis using radioisotopic (RI) agents: The Japan Atomic Energy Agency (currently the National Institutes for Quantum and Radiological Science and Technology) and Gunma University jointly succeeded in the PET imaging of a trace amount of cancer cells in 2010 using an RI agent they developed. They also demonstrated in experiments on mice in 2016 that the RI agent may be used for cancer treatment in addition to cancer diagnosis. The agent may enable early stage cancer treatment.

Scientific and technological achievements which contribute to daily life ⑨: Aircraft materials

Universities and public agencies that participated in R&D

Evolution of aircraft materials

NIMS, AIST, JAXA, ATLA, QST, JST

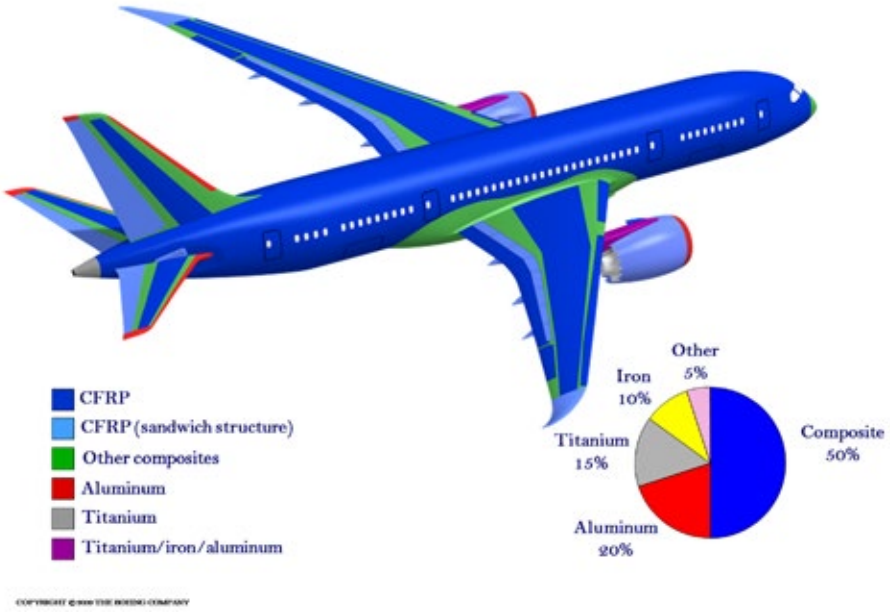


Diagram provided by Boeing Japan Co., Ltd.

The figure shows the types of materials constituting the airframe of the Boeing 787 which began operation around the world in 2011. Did you know that many of these materials were developed in Japan?

- Aircraft materials must meet various requirements, such as being strong to ensure safe flight, being heat-resistant to allow engines to run at high temperatures for fuel efficient operation and being lightweight to reduce airframe weight.
- A highly heat-resistant alloy capable of withstanding temperatures up to 1,100°C (see ① below) is used in engine parts of the Boeing 787. It is known that the higher the temperature at which fuels are burned, the better the fuel efficiency of the airplane. The use of these alloys is estimated to save fuel cost of as much as 100 million yen for each international airplane annually.
- A large amount (50% of airframe by weight) of a carbon fiber material called CFRP (see ② below) is used in wings, fuselage, etc. The use of CFRP—which is as strong as and lighter than aluminum alloys conventionally used in airframes—has greatly reduced airframe weight, thereby increasing cruising range. The Boeing 787 is the first passenger airplane to adopt CFRP as its wing material.
- A silicon carbide fiber material called CMC (see ③ below) is attracting attention as an engine material for next-generation aircraft. Only Japanese companies currently have the techniques necessary to manufacture CMC. The use of CMC in an engine may dramatically reduce its weight while maintaining its strength and heat-resistance ability. For example, the XF5-1 engine which was made in Japan using CMC achieved among the world's highest thrust-to-weight ratios.

Detailed information on research results

① Highly heat-resistant alloy: The National Research Institute for Metals (currently the National Institute for Materials Science) initiated research on the alloy in the 1970s. The material demonstrated resistance to temperatures up to 1,120°C in the 2000s.

② PAN-based carbon fibers: The basic principles of producing these fibers were discovered at Osaka National Research Institute (currently AIST) in 1959. The National Aerospace Laboratory of Japan (currently the Japan Aerospace Exploration Agency) developed basic technologies to design and manufacture CFRP (carbon fiber reinforced plastic). CFRP was first used in the STOL research aircraft "Asuka" (first flight in 1985). The Japan Defense Agency's Technical Research and Development Institute (TRDI) (currently the ATLA) then developed CFRP-forming technology, which enabled the world's first practical application of CFRP as wing parts of the F-2 fighter.

③ A silicon carbide (SiC) fiber was invented at Tohoku University in 1975. The Japan Atomic Energy Research Institute (currently QST) then studied the methods of producing heat-resistant SiC fibers. These research achievements were transferred to the private sector for technological development, which was mediated by the Research Development Corporation of Japan (currently JST). The TRDI began research on the XF5-1 engine in 1995. The engine was installed in the Advanced Technological Demonstrator-X aircraft which made its first flight in 2016.

Scientific and technological achievements which contribute to daily life ⑩: Technologies to protect people from heat waves

Beat the heat using science and technology

Universities and public agencies that participated in R&D

Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Nagoya University, Nagoya Institute of Technology, Tohoku University

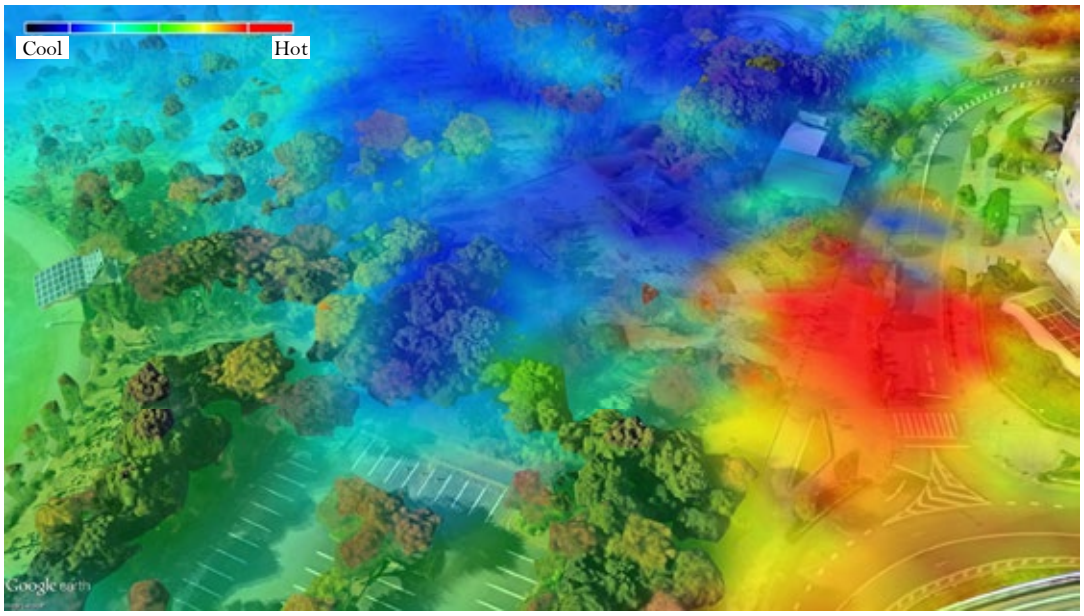


Image provided by JAMSTEC

The 2020 Tokyo Olympic games will be held in the Tokyo Bay area.
The above image shows simulated temperature distributions over the area surrounding an urban green space produced using wind and thermal environment projections.
The red and blue areas represent hot and cool areas, respectively.

- The 2020 Tokyo Olympics and Paralympics will be held in very hot summer conditions between July and September. Various measures are being planned to enable visitors who are not accustomed to hot Japanese summers to cope with the weather and enjoy the games comfortably.
- One such measure is establishing urban green spaces to lower ambient temperatures. The estimated effect of this measure by 2020 was quantified using the Earth Simulator supercomputer (see ① below). A data-based approach may facilitate the formulation of effective heat-coping measures.
- Projects are underway to establish so-called "cool spots"—sites at which people can cool off on hot days—in areas around train stations and city centers where green spaces are scarce. Dry mist generators (see ② below) capable of lowering temperatures in small areas will operate in these cool spots.
- Heatstroke prevention is an important issue. The risk of heatstroke varies depending on various factors, such as age group (the elderly and infants are particularly vulnerable) and environmental conditions (e.g., ground surface characteristics). A heatstroke risk assessment system (see ③ below) which takes account of these factors is under development.

Detailed information on research results

① JAMSTEC's Earth Simulator (ES) supercomputer began operating in 2002. Updated in 2009 and 2015, ES has been used for research in various industrial fields in addition to earth science. Simulation images generated by ES were released in 2016.
② Dry mist generators were jointly developed by Nagoya University, Shimizu Corporation, Nohmi Bosai Ltd., Chubu Electric Power Co., Inc., Kawamoto Pump Mfg. Co., Ltd. and Tokin Corporation (currently Kyoritsu Air Tech Inc.) starting in 2003 in a project funded by the Ministry of Economy, Trade and Industry. The product was experimentally demonstrated at the 2005 Aichi Expo.
③ A heatstroke risk assessment system is being jointly developed by the Nagoya Institute of Technology, Tohoku University and the Japan Weather Association. The system links weather data with various risk assessment factors. These include individual characteristics such as age group (elderly, infants, etc.) and ground conditions (asphalt, playgrounds, etc.).

Scientific and technological achievements which contribute to daily life ⑪: Display and screen technologies

Upcoming display and screen technologies

Universities and public agencies that participated in R&D

Japan Science and Technology Agency (JST), Tokyo Institute of Technology, Tohoku University

Images provided by JST

The display shown above (see □ below) has been used as digital signage in train stations and for other purposes. This display technology has a special feature—one screen can simultaneously display multiple images depending on the viewing angle. In addition, the technology is highly energy-efficient because light emitted from the screen is projected only to the limited areas around the viewers.

- You probably often see digital and computer-created images via various types of display technologies, such as smartphones, advertisement displays in the city and projection mapping, where images are projected onto the walls of buildings. Among the latest R&D achievements is a technology that offers new types of viewing experiences.
- A liquid crystal display is equipped with transistors that switch on and off an electric current flowing into individual pixels. An IGZO-TFT (see ② below), a type of transistor, is already in practical use in smartphones and other devices to make their displays energy-efficient and high-resolution. In addition, the IGZO-TFT technology has enabled fabrication of a low-temperature, large-area, thin-film transistor with high electron mobility, which in turn allowed for the production of the world's first large-screen, organic, electroluminescent 4K televisions (55 and 65 inches). Future research may enable the development of displays with even higher resolution, transparent displays and flexible, bendable display devices.
- It is a challenge to project images onto the surfaces of transparent materials such as glass. A film to be attached to such surfaces (see ③ below) was developed to make the surfaces compatible with image projection technology without affecting their transparency. The film can be attached, for example, to the surfaces of aquarium tanks to allow blending of projected images with aquatic life, creating magical effects.

Detailed information on research results

① A screen capable of simultaneously displaying multiple images depending on the viewing angle: Tohoku University developed a spatial imaging iris-plane screen technology in a research project funded by the JST. The university and NTT Media Intelligence Laboratories then jointly developed the technology into a commercial display product in 2015.

② An IGZO-TFT (In-Ga-Zn-O-based thin-film transistor) is one of the transparent oxide semiconductors developed by Tokyo Institute of Technology in a JST-funded research project. There are crystal and amorphous IGZO-TFTs. The first amorphous IGZO-TFT prototype was fabricated on a plastic substrate in 2004, and the first commercial product was introduced into the market in 2012.

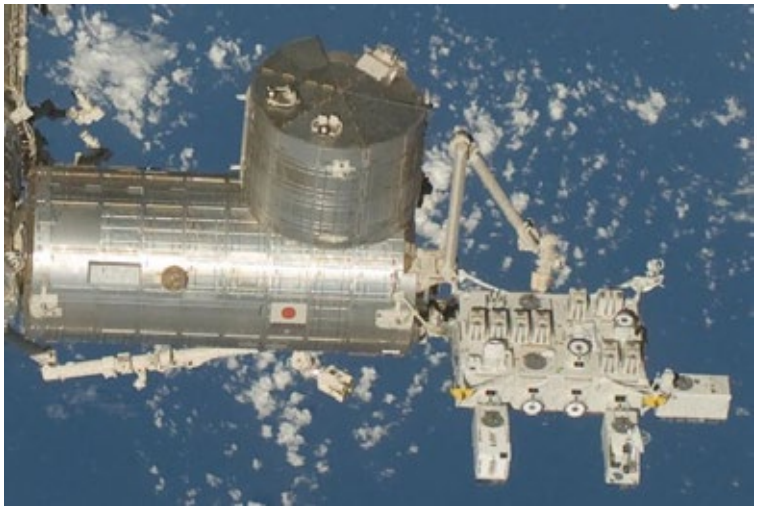
③ Transparent screen film: Tokyo Institute of Technology and JX Nippon Oil & Energy Corporation (currently JXTG Nippon Oil & Energy Corporation) jointly developed a technology to fabricate films using dispersed inorganic nanoparticles in a JST-funded research project. JX Nippon Oil & Energy Corporation then used this technology to develop a commercial film product called "KALEIDO SCREEN," which was introduced into the market in 2016.

Scientific and technological achievements which contribute to daily life ⑫: Results of experiments performed in the KIBO module of the International Space Station

Universities and public agencies that participated in R&D

Outer space experiment facilitates periodontal disease research

Japan Aerospace Exploration Agency (JAXA), Iwate Medical University, Nagaoka University of Technology, Showa University



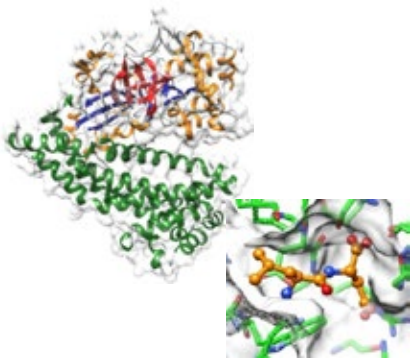


Image provided by JAXA

The photo shows Japan's KIBO module of the International Space Station orbiting 400 km above the ground. Scientific experimental results produced in the unique outer space environment may vary from those produced on the ground. For example, higher-quality protein crystals were produced in space, which facilitated the determination of detailed protein structures as shown in the image on the right.

- Periodontal diseases are said to be the most prevalent infectious diseases in the world. They are not mere oral conditions; they have a known link to systemic illnesses, such as diabetes and arteriosclerosis. Various types of experiments have been conducted in Japan's KIBO module of the International Space Station (see ① below), which offers a unique outer space environment. One such experiment led to a key discovery contributing to periodontal disease treatments.
- High-quality protein crystals were produced in in experiments conducted in the KIBO module. This achievement led to the world's first determination of a detailed three-dimensional structure of DPP11 (see ② below), a peptide-degrading enzyme vital to the growth of periodontal disease-causing bacteria. The structural determination enabled scientists to identify a mechanism by which the bacteria convert external energy-source materials using DPP11 into a form that can be absorbed by the bacteria.
- Knowledge on the mechanism of DPP11 is important in developing periodontal disease treatment drugs (see ③ below) because the information may facilitate the production of enzyme-inhibiting compounds—potential antibacterial drugs. Such drugs may be applicable not only to periodontal disease-causing bacteria but also to non-fermenting bacteria which obtain their nutrients from proteins and peptides.

Detailed information on research results

① The KIBO module of the International Space Station was completed in 2009 as Japan's first manned experiment module. JAXA has been promoting utilization of the module.

② DPP11 is a peptidase produced by periodontal disease-causing bacteria. It was discovered in 2009 by Dr. Hiroshi Haraga of Iwate Medical University and others. Iwate Medical University, Showa University, Nagaoka University of Technology and JAXA jointly produced a high-quality DPP11 crystal and analyzed its structure using X-rays in experiments conducted in the KIBO module. A DPP11 crystal produced in space had higher quality than that produced on the ground, because the three-dimensional structure of the former had a higher resolution (2.46 Å) than that of the latter (1.66 Å). This achievement in space subsequently enabled determination of the three-dimensional DPP11 crystal structure at high resolution, which allowed the joint research group to estimate terminal bonding sites of substrate amino acids.

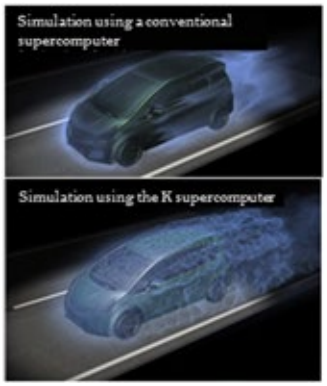
③ Drug development: A joint research team consisting of Iwate Medical University, Nagaoka University of Technology and Showa University is working to select effective drug candidates with relatively few side effects from compound databases.

Scientific and technological achievements which contribute to daily life ⑬: Automobile technologies

Development of new automobile technologies using public facilities

Universities and public agencies that participated in R&D

RIKEN, Japan Atomic Energy Agency (JAEA), High Energy Accelerator Research Organization (KEK), University of Tokyo, etc.



Images (left) and diagrams (right) were respectively provided by RIKEN (along with Honda Motor Company and Hokkaido University) and Sumitomo Rubber Industries.

The two images on the left compare computer-based, automobile aerodynamic simulations. With its exceptional computational power, the K supercomputer is capable of reproducing detailed air swirl structures which influence automobiles' wind resistance by dividing the space into small segments.

The photo at the center shows a new automobile tire product released in 2016. The use of multiple, world-class research facilities enabled the development of a product meeting three high-quality tire requirements which are difficult to achieve simultaneously.

- Automobile manufacturers continuously strive to develop new technologies to satisfy consumers' requests to enhance automobile performance, increase fuel efficiency, create safe automobiles and create environmentally friendly automobiles. Recent utilization of world-class, large research facilities has enabled developing new technologies that have resolved conventional technical issues.
- Air passing over automobiles in motion was recently simulated at high resolution using the K supercomputer. These simulations have enabled designing aerodynamic automobiles with reduced wind resistance, thereby increasing both fuel efficiency and driving stability. In addition, the simulation approach may replace wind tunnel tests to reduce time and cost for automobile design and boost international competitiveness of the Japanese auto industry (see ① below).
- In addition, research efforts were recently made to improve the performance of automobile tires using SPring-8, J-PARC and the K supercomputer. The use of these facilities enabled analyzing the molecular structure of the rubber component of tires at micro and nano-levels. Simulations of molecular movement facilitated the development of new tires that increase automobiles' fuel efficiency and improve their gripping performance, despite the fact that the tires are highly wear-resistant (see ② below).

Detailed information on research results

① Automobile aerodynamic simulations: Automobiles' wind resistance affects fuel efficiency, ride comfort, driving stability, etc. Computer-based aerodynamic simulations to estimate air flow patterns have been performed previously in combination with wind tunnel tests in which air is blown on a model automobile. However, this type of simulation was incapable of reproducing detailed air flow patterns. Aerodynamic simulations performed by the K supercomputer are as accurate as those based on wind tunnel tests. In addition, the supercomputer is capable of performing aerodynamic simulations under actual driving conditions.

② Techniques to develop high-quality tire materials: A research group led by Sumitomo Rubber Industries developed these techniques through coordinated utilization of the World's largest synchrotron radiation facility (SPring-8), the Japan Proton Accelerator Research Complex (J-PARC) and the K supercomputer. These techniques were used to design a material that prevents damage occurring in the rubber component, a cause of tire wear. The material was introduced into the market in 2016.