Promoting New Innovation and Industry

Tsukuba International Strategic Zone

http://www.tsukuba-sogotokku.jp/en/

Tsukuba International Strategic Zone

From Science City to a focal point of innovation
In December 2011, the Japanese Prime Minister officially designated Tsukuba City and parts of Ibaraki Prefecture as a Comprehensive Special Zone. Today, in the Tsukuba International Strategic Zone, leading research and development projects are being undertaken in order to create new industries within a global vision.
In March 2017, a change to the plan, related to the extension of the period, was approved by the National Government. (The new period is four years, starting in 2017, which coincides with the final year of the National Government's Basic Policies on Comprehensive Special Zones.)

What are Comprehensive Special Zones?

Comprehensive Special Zones are one of Japan's economic growth strategies, designed to strengthen the country's industrial competitiveness within the global community. Tsukuba is currently one of seven regions in Japan to have received this designation. In special zones, research and development projects (and related activities) that have been approved may be given various types of assistance or special treatment. For example, a project might receive government funding or benefit from relaxed regulations that may otherwise impede their progress. Consequently, one advantage of a special zone is that it facilitates making a project practical and commercially feasible more quickly and easily than when a project is located in areas outside of such zones.

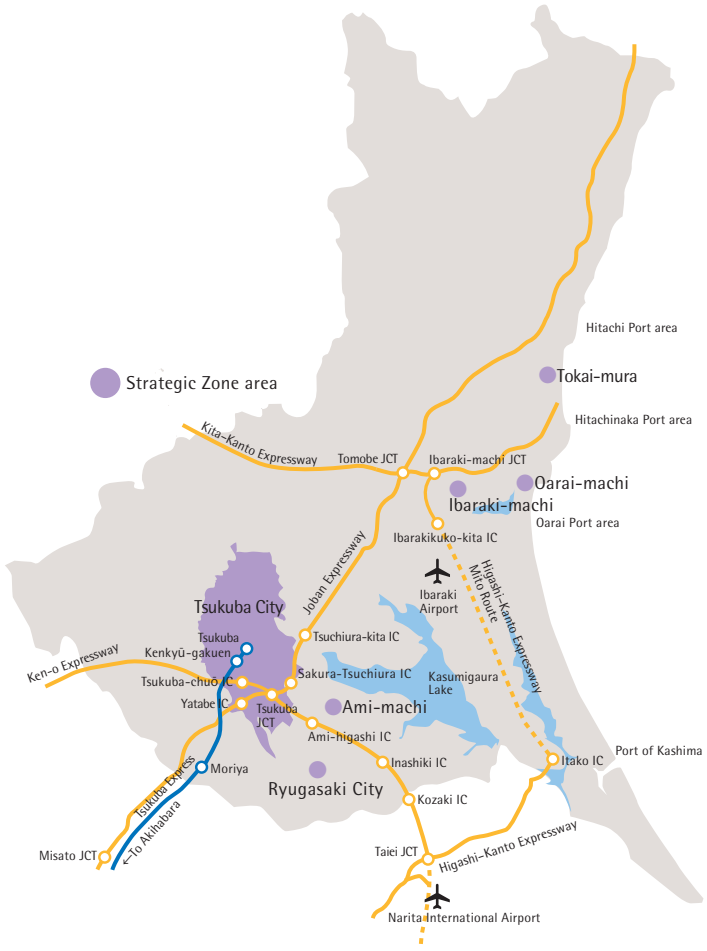
Construction of the new industry–government–academia collaboration system that is changing Tsukuba

Nine pioneering projects

The Strategic Zone

- Entire Tsukuba City (total area)
- Tsukuba-no-sato Industrial Park in Ryugasaki City
- Tokai-mura Hospital, Japan Atomic Energy Agency, and Ibaraki Neutron Medical Research Center in Tokai-mura, Naka-gun
- Ibaraki Prefectural University of Health Sciences, and its University Hospital in Ami-machi, Inashiki-gun
- Part of Oarai-machi, Higashiibaraki-gun
- Part of Ibaraki-machi, Higashiibaraki-gun

* The strategic zone will be revised in a flexible manner based on the progress of the respective projects.



onal Strategic Zone

Initiatives in the Tsukuba International Strategic Zone

1. Objectives

Promote industrialization by promoting life and green innovation that uses scientific technologies accumulated in Tsukuba.
* This objective aims to resolve issues in the field of life and green innovation effectively by using each zone's preferred legal, tax, and financial measures.

2. Construct a new industry–government–academia collaboration system in order to develop Tsukuba

- Establish the Tsukuba Global Innovation Promotion Agency to serve as a new core for the industry–government–academia collaboration
- Create systems that enable researchers to use the leading-edge research facilities of other organizations, produce tangible results, publish study resources, and support projects on a common platform
- Create new projects

3. Nine pioneering projects

Project 1 — Life-Innovation
Development and Implementation of Boron Neutron Capture Therapy (BNCT)

Project 2 — Life-Innovation
Living with Personal Care Robots

Project 3 — Green-Innovation
Commercialization of Algal Biomass Energy

Project 4 — Life-Innovation / Green-Innovation
TIA, Creating a Global Innovation Platform

Project 5 — Life-Innovation
Development of Innovative Pharmaceuticals and Medical Technologies Using Biomedical Resources in Tsukuba

Project 6 — Life-Innovation
Domestic Production of Medical Radioisotope (Technetium-99m) in Japan

Project 7 — Life-Innovation
Achieving Practical Use of Revolutionary Robot Medical Equipment and the Formation of a Global Focal Point

Project 8 — Green-Innovation
Practical Development of a Recycling System for Strategic Urban Mining

Project 9 — Life-Innovation
Development and Commercialization of a Plant -based Useful Material Production System that Promotes Human Health

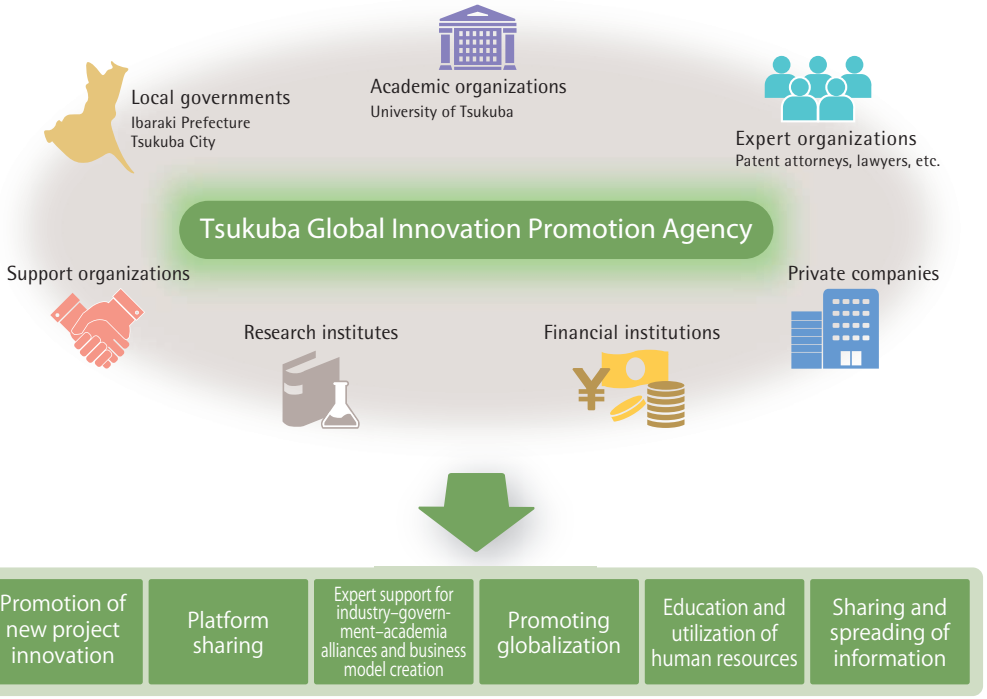
Developing Tsukuba by constructing a new industry–government–academia collaboration system

To become a new core organization of Tsukuba

To further strengthen regionwide collaboration, the Tsukuba International Strategic Zone has established the Tsukuba Global Innovation Promotion Agency (TGI) as the core of a new industry–government–academia collaboration system. This system operates a matching business and strategically transmits information (among other activities) in order to promote commercialization and industrialization. Taking advantage of Tsukuba's strengths, Ibaraki Prefecture, Tsukuba City, University of Tsukuba, the National Research and Development Agency, and private companies collaborate to promote the creation of new businesses and industries.

Tsukuba Global Innovation Promotion Agency

The TGI aims to create sustainable outcomes that have a significant impact on economic and social systems from Tsukuba. This is achieved by the industry–government–academia collaboration, taking advantage of the intellectual resources of Tsukuba Science City, creating new businesses by matching the technological seeds of research institutes and the needs of industry, fostering venture businesses, and so on.



System for promoting the Tsukuba International Strategic Zone

· Application for approval of a special zone plan
· Application for deregulation, tax support, etc.
*Application through deliberation by the Regional Council

National Government
(Window of Comprehensive Special Zone Applications)

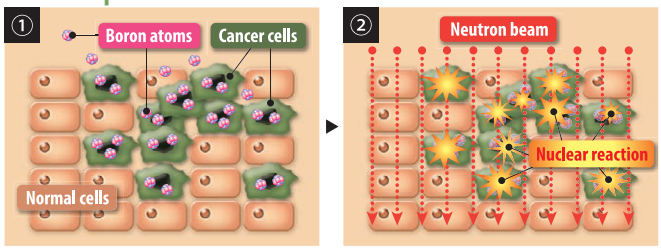
Universities and research institutes, private companies

Development and Implementation of Boron Neutron Capture Therapy (BNCT)

This outstanding medical engineering collaboration is a world leader in the treatment of refractory cancer

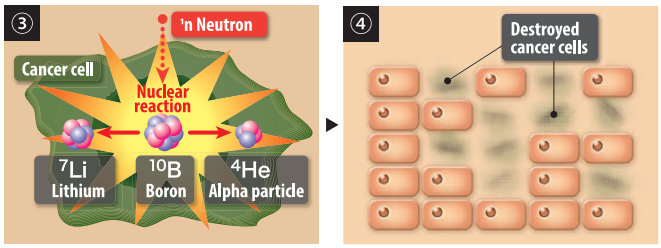
Boron neutron capture therapy (BNCT) is a treatment that selectively attacks tumors without causing significant damage to normal tissue, and is expected to be an effective treatment for the refractory cancers such as invasive and recurrent cancer. Since the 1980s, clinical studies on BNCT have been conducted by the University of Tsukuba, using a nuclear reactor. The project is developing a small, easy-to-use treatment device that can be installed at a hospital as a substitute for the nuclear reactor. It is also developing peripheral devices, such as treatment planning system, etc. As such, a cutting-edge package for cancer therapy is being created in Tsukuba by experts on medicine, physical engineering, accelerator development, and pharmacy.

Principles of BNCT



A boron-containing drug that accumulates selectively in cancer cells is administered.

Energy-controlled neutrons are irradiated at the focal point.



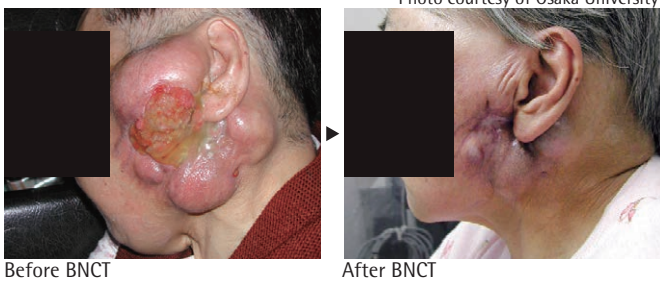
The nuclear reaction between neutrons and boron atoms emits alpha particles and lithium ions and destroys cancer cells.

Both alpha particles and lithium ions penetrate only as far as the diameter of one cell (10 μm), enabling cell-level therapy.

Remedial example

Head and neck cancer

Photo courtesy of Osaka University



Before BNCT

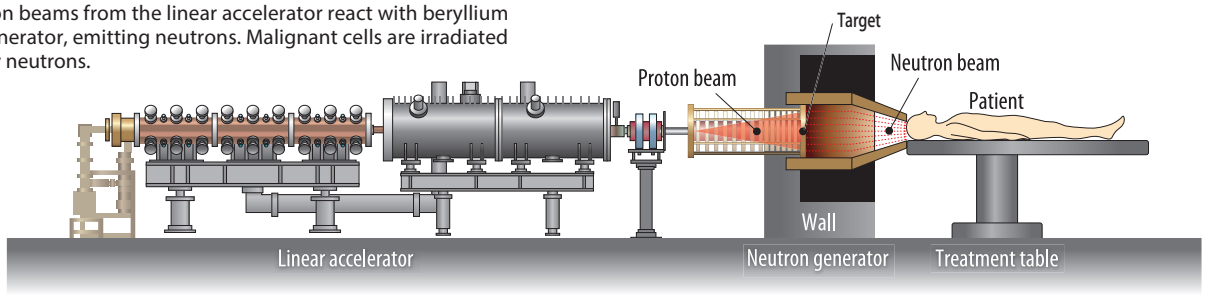
After BNCT

Characteristics of BNCT

- Effective against refractory cancers (invasive cancers, multiple cancers, cancers not treatable by surgery, etc.)
- Reduced physical burden on the patient and higher quality of life (QOL)
- Pinpoint targeting of individual cancer cells

Schematic diagram of a therapeutic device

Accelerated proton beams from the linear accelerator react with beryllium in the neutron generator, emitting neutrons. Malignant cells are irradiated by the low-energy neutrons.



Overview of activities

[Results obtained so far]

- The development of versatile medical equipment, and so on, for hospitals and clinics (since FY 2010)
- The development of a treatment planning system, equipment to control a patient's posture, equipment that automatically synthesizes chemicals for PET diagnoses, a comprehensive control system, and so on (since FY 2010)
- The development of the Ibaraki Neutron Medical Research Center as a focal point of joint research (FY 2011–2012)
- The generation of neutron beams (since FY 2016)
- Irradiation experiments using cells and animals (since FY 2017)
- Tests of the performance of the neutron beam (since FY 2018)

[Future topics]

- Clinical research and trials (treatment of actual patients)

Main institutes involved

University of Tsukuba Hospital/High Energy Accelerator Research Organization (KEK)/Japan Atomic Energy Agency/Toshiba Energy Systems & Solutions Corporation

Living with Personal Care Robots

Robots developed in Tsukuba are setting international standards

Personal care robots are designed to assist people with their physical motion and mobility. As Japan's society ages, these robots are expected to provide a variety of uses. As a result, numerous research organizations and companies are conducting research and development in this field. Safety is crucial to promoting the full-scale practical use of robots. As such, the Robot Safety Center determines the technical safety of the robots and verifies effects and issues through corroborative experiments. With the goal of introducing personal care robots in both Japan and other countries, the center is creating a seamless system that covers everything from robot development to safety approval.

Robot Safety Center

The Robot Safety Center is equipped with apparatus that it uses to conduct safety tests on robots developed by research organizations and companies. The Center also conducts tests requested by other organizations.

Corroborative experiments in various fields

Tsukuba includes a designated area where boarding-type mobility robots can be tested on public pathways. Corroborative experiments are also conducted in care facilities, hospitals, and so on, in order to determine the effectiveness and safety of the robots in practical scenarios.

RT.1 is a robot designed to assist elderly people and others with walking. Corroborative experiments are currently being conducted to introduce these robots in care facilities in Ibaraki Prefecture.

Corroborative experiment at the Ibaraki Prefectural University of Health Sciences to determine the restorative effects of physical functions and the safety of users.

The safety, etc., of users and surrounding areas are being verified.

Overview of activities

[Results obtained so far]

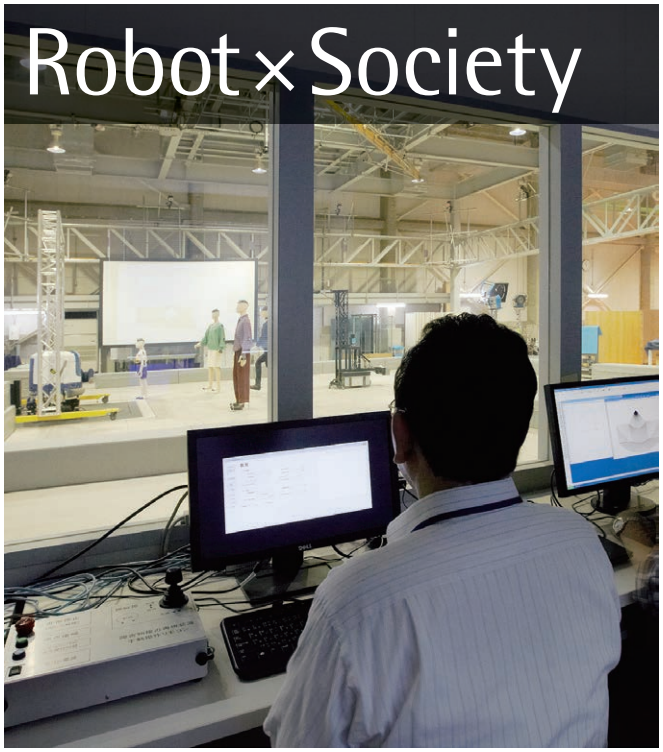
- The opening of the Robot Safety Center (FY 2010)
- Corroborative experiments designed to bring personal care robots into practical use (FY 2010–2012)
- Corroborative experiments with robots on public pathways in the "Tsukuba Mobility Robot Experiment Zone" (FY 2012–2015)
- The development and introduction of personal care robots, as well as related equipment (since FY 2013)
- The establishment of safety evaluation standards, and the proposal and issue of the ISO13482 international standard (FY 2013)
- The opening of the safety approval facility and the launch of certifications for robots (since FY 2014)
- The full-scale market entry of safety-certified robots (since FY 2015)
- The Connected Innovations Grand Awards under the 13th Industry-Academia-Government Collaboration Contributors Awards Program (Project name: Development and standardization of new testing methods for verifying the safety of service robots) (FY 2015)

[Future topics]

- The diffusion of safety-certified robots to the market
- The creation and transmission of new methods of using robots and model systems in public spaces

Main institutes involved

National Institute of Advanced Industrial Science and Technology (AIST) / Japan Automobile Research Institute (JARI) / related companies / University of Tsukuba



Contribution to the establishment of international safety standards

In February 2014, ISO13482 was officially issued as the international safety standard for personal care robots. It incorporates results from the safety testing technologies and verification methods used at the Robot Safety Center, and was created based on proposals submitted from Japan. As it acquires more data and results, the center is aiming to serve as an international robot certification organization.

ISO13482 certified products of companies participating in the project:

- "Robot Assist Walker RT.1" and "Robot Assist Walker RT.2" by RT. Works Co., Ltd.
- "HAL® for labor support" (lumbar type), "HAL® for care support" (lumbar type), and "HAL® for well-being" (lower limb type) by Cyberdyne, Inc.
- "Surveillance Robot" (Sharp SV-S500) by Sharp Corporation
- "Area Management System" by Daifuku Co., Ltd.
- "Guidance Robot LIGHBOTTM" by NSK, Ltd.
- "Rishone®" by Panasonic Corporation
- "Honda Walking Assist Device" by Honda Motor Co., Ltd.
- "Robohelper SASUKE" by MUSCLE Corporation

Commercialization of Algal Biomass Energy

Algal oil contributing to solve energy problems

Microalgae are widely regarded as a promising source of alternative biofuel, owing to its high productivity of oil, and non-competitiveness with food production. The aim of this project is to develop technologies for microalgae oil production to contribute on solving the global energy problem as well as to build the momentum necessary for creation of a new algal industry by discovering useful functions from algae and inventing applied technologies for expanding algal business.

Oil production capacity of microalgae

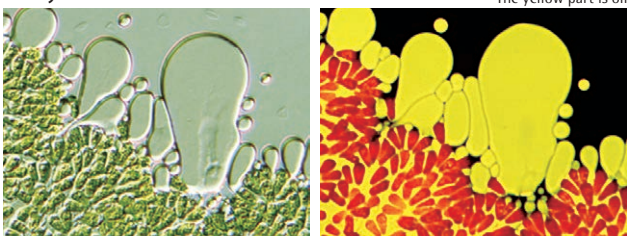
Microalgae have high potential for producing biofuels. Their oil productivities are tens to several hundred times higher than those of terrestrial oil crops.

Types of crops	Corn	Soybeans	Safflower	Sunflower	Rapeseed	Palm	Microalgae
Annual oil production volume per hectare of cultivated land (t)	0.2	0.5	0.8	1.0	1.2	6.0	47~140

Hydrocarbon-producing algae

Botryococcus

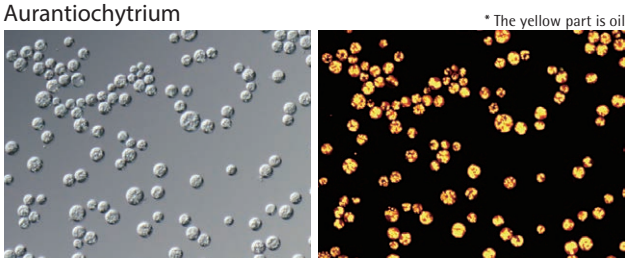
* The yellow part is oil



- Freshwater photosynthetic green alga
- Fixes carbon dioxide
- Accumulates hydrocarbon oil in its cell and colony (20–75% of dry cell weight)

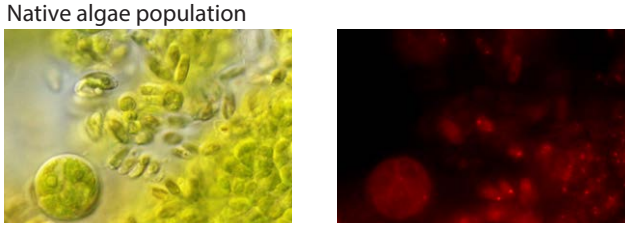
Aurantiochytrium

* The yellow part is oil



- Marine and brackish-water heterotrophic alga
- Grows using organic matter and oxygen, and produces a hydrocarbon called squalene
- Contains hydrocarbon in the cell (20–30% of dry cell weight)

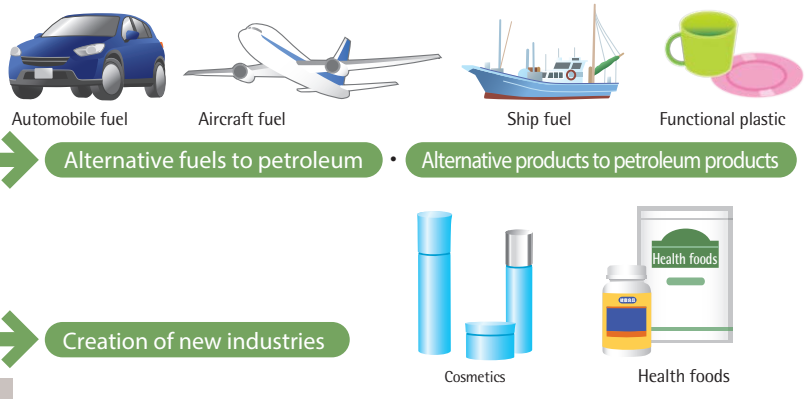
Native algae population



- Contains less oil than oil-producing algae do
- Can be converted to crude oil through hydrothermal liquefaction
- High biomass productivity

Development of large-scale production technology for algal oil

Outdoor culture demonstration facility (Kurihara, Tsukuba City)



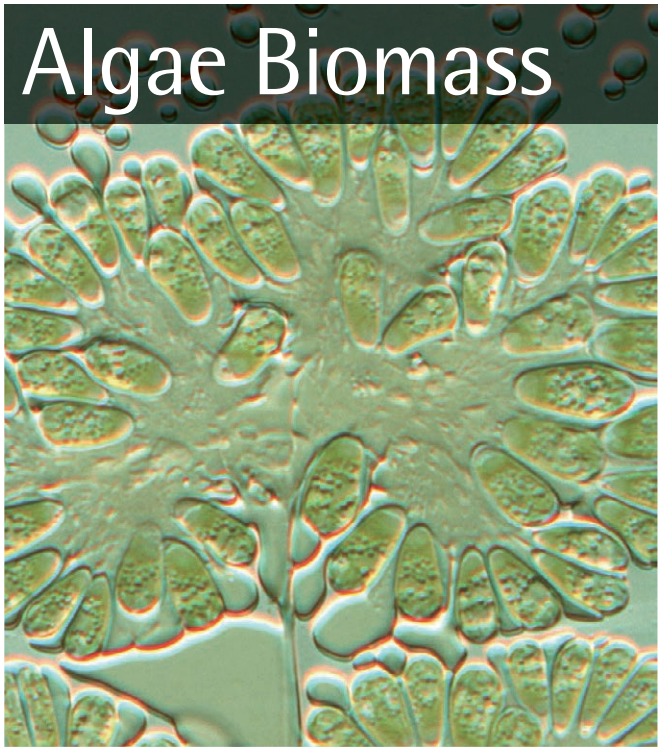
Overview of activities

[Results obtained so far]

- The construction of an outdoor demonstration plant for mass cultivation (FY 2013)
- The test operation of an official vehicle fueled by composite fuel containing algal hydrocarbon fuel (since FY 2013)
- Demonstration project on fuel production using algae native to Fukushima Prefecture (since FY 2013)
- The development and commercialization of functional products by joint R&Ds with private companies (since FY 2014)
- The development and commercialization of advanced aquaculture technologies using DHA-rich microalgae (since FY 2014)
- The opening of the Algal Biomass Energy R&D Center of the University of Tsukuba (FY 2015)
- Development of low carbon technologies based on collaboration between efficient productions of algae biomass and their conversions to high performance plastics (since FY 2017)

[Future topics]

- The promotion of R&D toward the creation of an algae industry



Main institutes involved

University of Tsukuba / Sobio Technologies Inc. / Algae Industry Incubation Consortium

TIA, Creating a Global Innovation Platform

Open innovation platform to bring transformative changes in Japan's industry

"TIA" is an open innovation hub operated by five institutes in Tsukuba, Kashiwa and Tokyo: the National Institute of Advanced Industrial Science and Technology (AIST), the National Institute for Materials Science (NIMS), the University of Tsukuba, the High Energy Accelerator Research Organization (KEK), and The University of Tokyo. Managed by those core organizations and the Japan Business Federation (Keidanren) with the support of the Cabinet Office, the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the Ministry of Economy, Trade and Industry (METI), TIA has been promoting various integrated fields of R&D to encourage diverse industry-academia collaborations and the program of nurturing the next generation of human resources.

Overview of activities

[TIA's results]

- Progress of R&D based on the open innovation model (since FY 2012).
- The promotion of the Nanotech Career-up Alliance (CUPAL) and TIA Graduate School (since FY 2011).
- Over 1,000 scientists and engineers are concentrating in Tsukuba as a user of TIA's facilities in every year.
- Cumulative funding allocated for the industry–academia–government collaboration project: JPY 129 billion (FY 2010–2017)
- The total number of enterprises participating in the industry–academia collaboration program: 1147 (FY 2010–2017)
- The promotion of the TIA collaborative research program "Kakehashi" to play a role in fostering the seeds of research (since FY 2016).

The five core organizations promoting the main projects

National Institute of Advanced Industrial Science and Technology (AIST) / National Institute for Materials Science (NIMS) / University of Tsukuba / High Energy Accelerator Research Organization (KEK) / The University of Tokyo

Open Innovation Platform

– Creating knowledge and bridging the industry-academia gap –

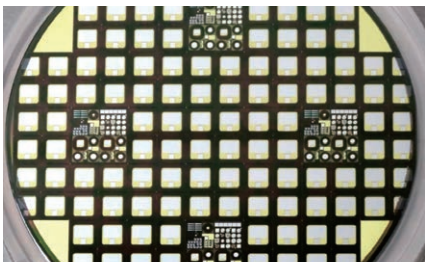
- TIA started in 2009, originally named as the Tsukuba Innovation Arena for Nanotechnology (TIA-nano). Until now, TIA has performed R&D bases of 44 national projects and consortiums. 200 companies in total have participated in the R&D projects and over 6,000 researchers from industry and academia have utilized the TIA programs. Since it was renamed to "TIA" in 2016, TIA has been advancing R&D with its new member of the University of Tokyo to expand its research focus into biotechnology, healthcare, computer science, and the internet of things (IoT), keeping the plural core research arears in nanotechnology.
- TIA exerts itself to promote "open innovation" aiming to create new global businesses through close collaboration with industry, academia and government based on the strengths of each individual organization as well as the shared basic infrastructures. TIA provides a useful environment appropriate to R&D at the TIA platforms based on the accumulated knowledge of the TIA core institutes. Those TIA platforms are backed by the over 400 state-of-the-art equipment for open use in the leading-edge facilities, e.g. the Super Cleanroom (SCR) in AIST, the Photon Factory (PF) in KEK, with user-friendly systems.
- TIA's long-term activities have achieved the results of practical application such as NanoBridge-FPGA, CNT mass production plant, commercialization, and the laying of the foundation of venture companies. Tsukuba Power-Electronics Constellations (TPEC) founded in 2012 as a new industry-funded consortium has developed the mass production plant for SiC power device and in operation now. AIST, NIMS, KEK, and the University of Tsukuba from TIA, and Kyoto University are in charge of providing education and training to young-generation researchers in the Nanotech Career-up Alliance (CUPAL). Supplemented by cutting-edge expertise and equipment, CUPAL offers Nanotech Research Professional courses and Nanotech Innovation Professional courses.

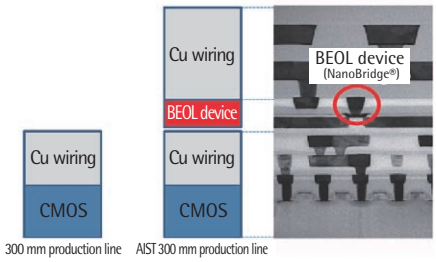
Shared use of advanced nanotechnology


AIST Super Clean Room (SCR)

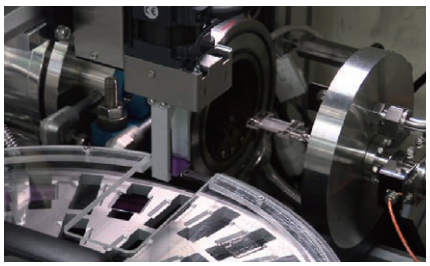

KEK Photon Factory (PF)

From "Tsukuba" for future industry – bridging the industry-academia gap


Mass production plant for SiC power device
Fuji Electric Co., Ltd. developed the component technology necessary for the practical application of SiC power devices using a mass-production line for prototypes at AIST. As a result, Fuji Electric Co., Ltd. built 6-inch wafer process lines of the SiC power devices at Matsumoto Factory in Nagano Prefecture.



Commercialized NanoBridge-FPGA
NanoBridge-FPGA has remarkably high radiation tolerance and tenfold higher power efficiency compared with conventional FPGAs based on static random-access memory (SRAM). NEC is expanding the device's application for communication and IoT equipment in which low power performance is important.


Commercialized CNT (carbon nanotubes) mass production plant
AIST and the Zeon Corporation jointly promoted the development of the world's first mass production plant of CNT based on the super-growth (SG) method developed by AIST. The mass production plant for SGCNTs is currently operating at Zeon Corporation's Tokuyama Plant. SGCNTs are applicable to various materials such as high-performance thermal interface materials (TIMs).

Development of Innovative Pharmaceuticals and Medical Technologies Using Biomedical Resources in Tsukuba

Utilization of a world-class repository of biomedical resources

Research institutes and pharmaceutical companies in Tsukuba are cooperating closely to develop innovative pharmaceuticals and medical technologies related to cancer, infectious diseases, and cell therapy, among others. To do so, they are using the world's largest collection of biomedical resources, located in Tsukuba, to develop and market functional foods that prevent lifestyle diseases and have anti-aging effects.

Seeds of drug discovery meeting the needs of society

Tsukuba Biomedical Resources Consortium

- ○ Disease Control Business Promotion Department
  - ● Pharmaceuticals that work against complex carbohydrates that occur specifically in cancer stem cells
  - ● "Autovaccine" that fights brain tumors
  - ● Cancer treatment using nanoparticles
  - ● Anti-influenza and test drugs
- ○ Cell Therapy Promotion Department
  - ● Recombinant cell therapy
- ○ Healthcare Business Promotion Department
  - ● Product development based on research findings related to diet, exercise, and sleep
  - ● The development of next-generation physiologically functional materials for a long and healthy life
  - ● Genomic medicine, cell regeneration, and regenerative engineering
- ○ Subgroup for Genomic Medicine and Regenerative Medicine Promotion utilizing a Biobank
- ○ Precision Medicine Business Promotion Department

Collaborative systems for early implementation of results

Tsukuba Life Science Promotion Association (TLSK)

TLSK was founded in April 2012 by pharmaceutical companies and academic research institutes located in the Tsukuba area, and presently (as of May 2019) consists of approximately 60 organizations. TLSK promotes the following activities:

● **Master's/Doctoral Program in Life Science Innovation**

This program is designed to produce engineers and researchers who can play key roles in international R&D of innovative food and pharmaceutical products. It aims to develop human resources who can produce new findings using multi-faceted analyses and research, which includes molecular biological techniques (whole genome analysis, proteome analysis, metabolome analysis, etc.) and environmental studies related to biological resources and geography, among other fields. The instructors include individuals invited from private companies and who have had success in life science.

● **Tsukuba Human Tissue Biobank Center**

Some countries have their own national biobanks, as well as specific and relevant laws. In Japan, universities, hospitals, and research institutes are at the forefront of establishing biobanks. However, while they collect and manage human tissue, few biobanks currently provide such tissue to external organizations. Biobanks of other countries are often difficult to use, because their tissue does not include sufficient clinical information for researchers. Therefore, considering the needs of society, TLSK has established a biobank that provides researchers with human tissue, including detailed clinical information.

● **TLSK Pitch Meetings**

At TLSK, (mainly young) researchers pitch their ideas for a seeds/needs system. Such meetings have produced many successful cases of joint research and commercialization.

● **TLSK Young Researchers Exchange Meetings (Life Science Café)**

Younger researchers (40 years old, or younger) of the member research institutes meet to discuss topics in groups, after which the groups compete against one another by means of presentations based on their discussions. Presentations that are deemed to hold potential value are reviewed by TLSK. This is a forum in which life science researchers can share information and ideas, and where new innovations are created ("sowing for the future").

Overview of activities

[Results obtained so far]

- ● The establishment of the Tsukuba Life Science Promotion Association (TLSK) (FY 2012)
- ● The construction of a joint-use platform for biomedical resources (FY 2012–2013)
- ● The establishment of the Tsukuba Biomedical Resources Consortium (since FY 2013)
- ● Clinical research; promotion of R&D
- ● The marketing and selling of products in the fields of food/exercise and health function assessment (FY 2016)

[Future topics]

- ● The commencement of clinical trials for innovative pharmaceuticals, and applying for pharmaceutical approval
- ● The rapid commercialization of functional foods, and so on.

Main institutes involved (as of December 2017)

● Tsukuba Biomedical Resources Consortium

University of Tsukuba / National Institute of Advanced Industrial Science and Technology (AIST) / Eisai Co., Ltd. / iLAC Inc. / Riken / Cell-Medicine, Inc.

● TLSK

Astellas Pharma Inc. / Eisai Co., Ltd. / Ono Pharmaceutical Co., Ltd. / Biotherapy Institute of Japan, Inc. / Hitachi, Ltd. / Kyowa Hakko Bio Co., Ltd. / Kirin Company Limited. / JSR Life Sciences Corporation / Cell-Medicine, Inc. / Sobio Technologies, Inc. / Taiho Pharmaceutical Co., Ltd. / NOF Corporation / NH Foods, Ltd. / Charles River Laboratories International, Inc. / GlycoBiomarker Leading Innovation Co., Ltd. / MC Food Specialties Inc. / GlaxoSmithKline K.K. / Personal Lifepath Book, Inc. / RORZE Lifescience, Inc. / Oriental Giken, Inc. / Foundation for Advancement of International Science / National Institutes of Biomedical Innovation, Health and Nutrition Research Center for Medicinal Plant Resources / National Institutes of Biomedical Innovation, Health and Nutrition Tsukuba Primate Research Center / Japan Aerospace Exploration Agency / National Institute for Environmental Studies / National Institute of Advanced Industrial Science and Technology (AIST) / National Agriculture and Food Research Organization (NARO) / National Institute for Materials Science (NIMS) / RIKEN / University of Tsukuba / The High Energy Accelerator Research Organization (KEK) / National Museum of Nature and Science / Ibaraki University / Tokyo University of Science / Government agencies, financial institutions, etc.

Domestic Production of Medical Radioisotope (Technetium-99m) in Japan

For stable supply of the essential tracer for a detailed examination

The tracer used in nuclear medicine examinations (e.g., bone scintigraphy, SPECT) is made by combining an agent that characteristically accumulates in lesion areas and radioisotopes (RIs). Being able to visualize the gamma rays emitted from the RIs helps with diagnoses of various diseases. Technetium-99m is most widely used to diagnose cancers and to examine the blood flow in the brain, bones, and myocardia. Technetium-99m is generated from molybdenum-99 (^{99}Mo). Although Japan is the third largest consumer of ^{99}Mo, it depends on imports for its overall supply of ^{99}Mo. As a result, Japan risks a supply shortage if there are problems with, for example, the foreign nuclear reactors producing the materials or the transportation of materials (e.g., owing to a volcanic eruption). Thus, in order to ensure a stable supply, Japan needs to produce its own ^{99}Mo as soon as possible. We aim to develop the technologies necessary for practical use using the Japan Material Testing Reactor (JMTR) of the Oarai Research & Development Center of the Japan Atomic Energy Agency. We are certain that such technologies will reinforce the international competitiveness of Japan's medical industry.

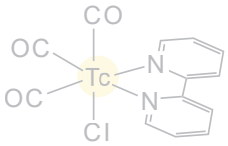
Clean booths installed at the JMTR hot lab

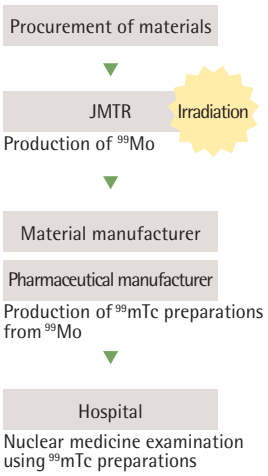

Testing equipment for isolating, extracting, and measuring the concentration of ^{99m}Tc in a lead cell installed in a clean booth


Remote operation of test equipment in clean booths

Schematic flow from development to supply of ^{99}Mo

A consistent system is being constructed for the entire process, from material production to product supply.





Preparation method of ^{99}Mo

Currently, ^{99}Mo is produced mainly via the nuclear fission of uranium. Here, it is difficult to avoid the diffusion of fissionable materials and to maintain safety while using and disposing of such materials. In this project, ^{99}Mo will be prepared via activation, without using uranium. However, it is difficult to generate ^{99}Mo, which has a high specific activity when using the neutron activation method rather than the nuclear fission method. Therefore, practical production technologies are now being developed.

Neutron activation method ((n,γ) method)

- Smaller amount of radioactive waste
- Reduced production costs

Overview of activities

[Results obtained so far]
- Neutron irradiation tests with the research and test reactor (since FY 2013)
- Separation, extraction, and condensation tests of technetium-99m (since FY 2013)
- The construction of a clean room inside a hot cell (FY 2014)

[Future topics]
- The production of molybdenum-99 using the test reactor
- Testing the quality of the technetium-99m solution
- Nonclinical research using experiments on animals
- Technical feasibility for practical applications

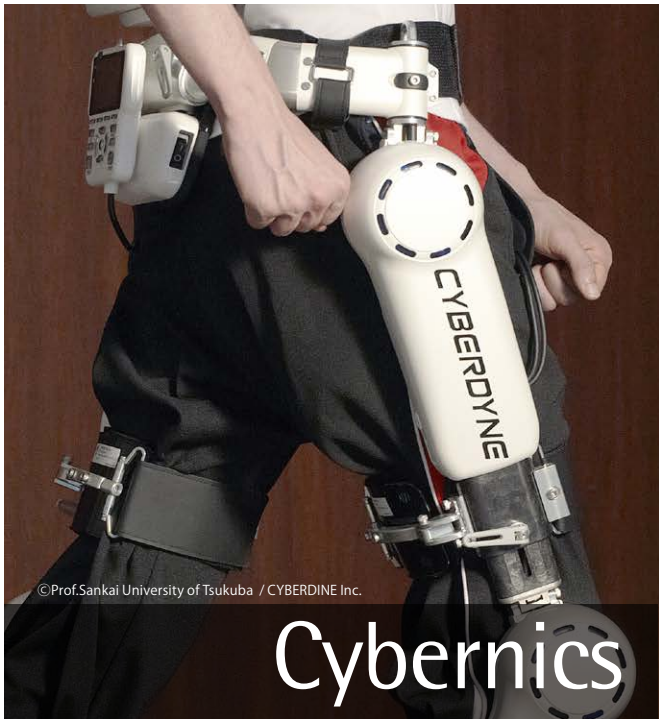
Main institutes involved

Japan Atomic Energy Agency / Chiyoda Technol Corporation / Metal Technology Co., Ltd. / Art Kagaku Co., Ltd. / Taiyo Koko Co., Ltd. / University of Tsukuba

Achieving Practical Use of Revolutionary Robot Medical Equipment and the Formation of a Global Focal Point

Global development of revolutionary HAL® robot medical equipment

Efforts are being made to put innovative medical equipment and technologies into practical use, based on the technologies of the new field "Cybernics" (fusion of man, robots, and information systems). Environments are being established in which new industries are created and the human resources necessary for future innovation are developed. Such environments also support R&D, clinical trials, and social implementations. We aim to become an international frontrunner that can continue to create revolutionary robot-based medical equipment and medical technologies (The International Center for Medical Cybernics [tentative name]).



Overview of activities

[Results obtained so far]

- The development of HAL® for Medical Use, the world' s first robotic remedial device. HAL® was introduced to Japan, Europe, and the United States as a medical device, covered by public workers' compensation insurance in Germany, covered by health insurance in Japan, and approved by the US FDA as a medical device (2017)
- The development of international standards on robots in health care, wellbeing, and living for the International Organization for Standardization (ISO) (since FY 2014)
- A keynote speech delivered at the G7 Science and Technology Ministers' Meeting on AI robots, AI vital sensing technology, and big data, among other topics, as innovative cybernics technologies that have originated in Japan; this included an outline of our efforts at ministerial conferences (2016)
- Accommodating and collaborating with Germany-led Industry 4.0, we presented our cybernics-based efforts for Society 5.0 to Prime Minister Abe and Chancellor Merkel under the leadership of the Japanese government. We also played a role in the adoption of the Japan–Germany joint declaration on the promotion of innovation (2016)

[Future topics]

- Cybernics innovation: Creation of a "cybernic city" (The International Center for Medical Cybernics [tentative name]), an implementation of Society 5.0, a future society where humans and technology coexist
- The development of compound therapies, with pharmaceutical products and regenerative medicines, and using Robot Suit HAL®
- The development of a cybernic interface (e.g., ALS and AI robot technology) between the brain and nerve system activities of a patient with severe neuromuscular disease
- The development and social implementation of AI vital sensors for health monitoring
- The establishment of Cybernics Excellence Japan (CEJ), a consortium for creating new and innovative industries

Main institutes involved

University of Tsukuba / Cyberdyne, Inc. / Other research institutes and companies

HAL® for Medical Use, the world's first cyborg-type robotic remedial device

HAL® for Medical Use is a cyborg-type robot worn by patients with reduced brain, nerve, and muscle functions due to illness, as they receive treatment from doctors or other medical practitioners. HAL® establishes interactive biofeedback between the brain/nerve system and the musculoskeletal system of the wearer. As a result, even people who have difficulty exerting the muscle strength necessary for movement, owing to functional disorders or other conditions, can repeat movements that are synchronized with the intentions of the wearer. This takes place without overworking the brain, nerve, and muscle systems, thus promoting the improvement or reproduction of functions.

Practical application of medical equipment and technologies

Functional improvement treatment at CCR in Germany

Medical care system for examining, diagnosing, and preventing circulatory diseases

As the world's first robotic remedial device, HAL® for Medical Use has already obtained medical device certification throughout Europe, and is covered by public workers' compensation insurance in Germany. In November 2015, it was approved as a medical device in Japan under the new definition. Since September 2016, it has been covered by public health insurance for patients with a progressive and intractable neuromuscular disease. In addition, in December 2017, the US FDA approved it as a medical device. To increase the use of HAL® for Medical Use in Japan, Europe, and the United States, we continue to globally promote the "cybernics treatment," a new medical technology that helps improve and reproduce brain, nerve, and muscular functions.

The International Center for Medical Cybernics (Tsukuba Medix) (tentative name)

The International Center for Medical Cybernics (tentative name) is being built to serve as a focal point for the global development of innovative technologies for robot medical equipment and medical treatment. The center will be engaged in R&D of compound medical treatments consisting of, for example, pharmaceutical products, regenerative medicine, and HAL®, as well as new medical equipment and treatment technologies. The center will also use the results of the R&D to conduct clinical trials and social implementations, as well as to nurture human resources in an integrated manner.

Practical Development of a Recycling System for Strategic Urban Mining

Aim: to realize a recycling society based on the concept of strategic urban mining

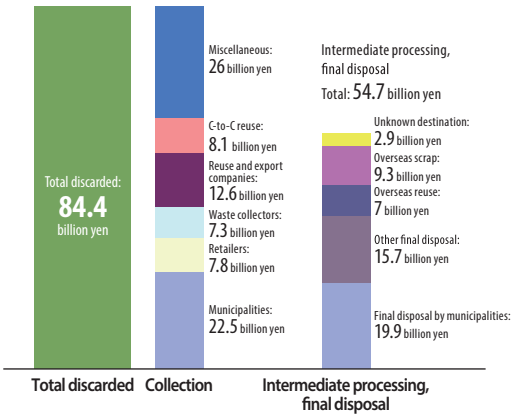
Urban mines, which contain small home appliances and other discarded electronic and electrical devices that can be recycled for their metals, are mostly undeveloped or are buried underground. Therefore, efforts are being made to be a world leader in integrating the development of revolutionary recycling technologies with educating the public about their potential, the environment, and so on. This will help ensure a stable supply of various metals necessary for manufacturing, promote the development of recycling industries, and realize a recycling society based on the concept of strategic urban mining.

Development of innovative recycling technologies

New technologies and techniques for recovering rare metals and other useful metals from discarded appliances in an economic and effective way include:

(1) the development of equipment and systems that automatically disassemble home appliances and other electronic devices and sort substrates; this work has hitherto been done by hand.

(2) the development of systems for sorting useful metals into single materials that can be recycled easily.



Annual value of useful metals contained in small discarded home appliances
(based on materials presented by the Central Environment Council, 2011)

Outlook, economic effects, and so on

- Economic effect of about JPY 5.2 billion: About four plants are expected to be built in Japan
- Market scale of about JPY 18 billion: Estimated from the recovery target of 140,000 tons, based on the Act on Promotion of Recycling of Small Waste Electrical and Electronic Equipment (about 20% of the total annual amount produced in Japan)

Discarded home electronics | Disassembling/crushing | Sorting metals into single materials

Educating the public to help realize a recycling society

Efforts are being made to enlighten the public and provide environmental education in order to effectively promote the Act on Promotion of Recycling of Small Waste Electrical and Electronic Equipment. These include the following:

- Associating with the SURE Consortium, including manufacturers, resource industries, and so on, and examining social systems based on the concept of strategic urban mining
- Meeting places, research groups, and so on, are being established in municipalities to investigate ways of improving the recovery rate from discarded products. In addition, public relations campaigns are being undertaken to educate the public.

The development of systems that automatically disassemble and sort discarded products

Equipment and systems are being developed that can safely disassemble discarded products (e.g., home appliances, etc.) without destroying their shape; this has hitherto been done by hand.

- The development of products that can be crushed (while maintaining the shape of, for example, secondary batteries) and crushing machines for disassembly
- The development of systems that automatically sort secondary batteries, and so on, after disassembly by creating and utilizing databases

The development of systems for high-grade sorting

The development of systems that sort useful metals, and so on, into single materials that can be recycled easily.

- The development of systems that can remove metals from mixed plastic–metal materials and sort according to the way the plastic is used
- The development of a "fine-particle sorting system" that can sort substrates, mixed metals, and other composite materials into single materials

Development of a liberation crusher (conceptual image) | Development of a "fine-particle sorting system" (conceptual image) | Recovery by type of metal (copper, precious metal, rare metal, etc.)

Overview of activities

[Results obtained so far]

- The establishment of the Strategic Urban Mining Research Base (SURE) at AIST (FY 2013)
- The establishment of the SURE Consortium at AIST (FY 2014)
- Start of the NEDO project (2017)

[Future topics]

- The development of systems that automatically disassemble and sort discarded products and systems for high-grade sorting
- Educating the public to help realize a recycling society

Main institutes involved

National Institute of Advanced Industrial Science and Technology (AIST) / Re-Tem Corporation

Development and Commercialization of a Plant -based Useful Material Production System that Promotes Human Health

Aim: the large-scale production of useful material-production using plants, starting with miraculin

We aim to develop and commercialize a system that produces useful materials beneficial in preventing disease and promoting human health using easy-to-grow plants, such as tomatoes. In this way, we hope to contribute to the effective prevention of illness, including lifestyle-related diseases such as diabetes and hypertensive diseases.

Background to the project: Useful Material Production System

Production of useful materials beneficial in preventing disease and promoting human health

Production using a system based on animal cells, microorganisms, and so on:	Production using a system based on easy-to-grow plants, such as tomatoes:
•Expensive culture facilities are essential. •Contamination risks by pathogens and toxins during production are unavoidable.	•Expensive culture facilities are not necessary. •Production costs are low because of the plant. •Contamination risks by pathogens and toxins during production are nonexistent.

A plant-based system allows the safe, low-cost, and stable mass-production of useful materials that contribute to disease prevention and health promotion in humans.

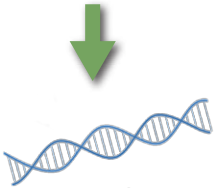
What is miraculin?

Miraculin is a protein that changes sour taste to sweet taste.

- With ingestion of trace amounts (0.1–0.2 mg), its effect lasts one to two hours.
- Unlike sugar and artificial sweeteners, ingestion of large amounts is not necessary.
- Almost zero calories because the ingestion is trace amounts.
- The sense of sweetness is similar to that of sugar.

"Miracle fruit" is the only plant that contains miraculin.

- Tropical shrub native to West Africa
- Difficult to produce stably in large amounts



Miraculin gene

High prices

Miraculin gene was introduced into tomatoes by transgenic engineering.

Overview of activities

[Background]

Miraculin is a protein that turns a sour taste into a sweet taste. It requires using very small amounts and has long-lasting effects. Therefore, as an almost zero-calorie sweetener, it is expected to contribute to preventing lifestyle-related diseases. However, the miracle fruit, the only plant that contains miraculin, is difficult to produce in large amounts in a stable manner, causing the price to rise sharply. This is why the production development of miraculin has made little progress, despite much interest within the food industry.

[Results obtained so far]

- The miraculin tomato has been developed successfully by introducing the miraculin gene of miracle fruits into tomatoes (FY 2006).
- Toward the commercialization of the miraculin tomato, an application has been submitted to be approved as Japan's first recombinant food (FY 2015).

Overview of the project

1. Development of large-scale production, processing, and purification technologies for useful material-producing plants

The following technologies, among others, are being developed that use material-producing plants in an economic and efficient way:

- Low-cost, labor-saving, stable production technologies
- Technologies for effective and efficient use, including the purification of products.

2. Information-centered promotion to extend people's health life expectancy

This includes food education and other awareness-building activities to promote highly functional foods:

- Public relations campaigns and other activities promoting highly functional foods targeting food companies and consumers
- Formation of a consortium including food companies and consumer organizations, and deliberation on a social system for implementing highly functional foods on the consortium.

Successful development of tomatoes that produce miraculin ("miraculin tomato")

Approved as Japan's first genetically modified food

The establishment in Tsukuba of the world's first stable mass-supply model for purified miraculin

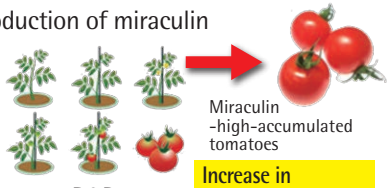
(1) Miraculin purification from miraculin tomatoes

Development for efficient-purification-method of miraculin

Marketability and added value

(2) Efficient production of miraculin

Acceleration of development and commercialization for miraculin-high-accumulated tomatoes



Miraculin -high-accumulated tomatoes

R&D

Increase in distribution amount

[Future topics]

- Establishment of methods for purifying miraculin from miraculin tomatoes with lab-scale.
- Development of high-yield purification method for miraculin and its gradually scaling up to commercial scale within a strategic-zone project
- Firstly, we plan to sell the powder of the miraculin tomato.
- Secondly, we plan to supply purified miraculin. Purified miraculin is colorless and odorless than miraculin-tomato-powder. The characteristics make it more diverse to develop relevant products, thus increasing its marketability.
- Tomatoes that contain higher amounts of miraculin than existing miraculin tomatoes will be developed and selected as a new commercialized line.
- Creating lines with higher miraculin accumulation lead to increasing the amount of miraculin products to be circulated and reducing the cost of miraculin.

Main institutes involved

University of Tsukuba / Inplanta Innovations, Inc.

Special exceptions and support systems in the Tsukuba International Strategic Zone

National Support Systems

(1) Preferential legal measures

- Preferential legal measures are prescribed in advance and are related to relaxing regulations on industrial land use (special measures of the Building Standards Act) and on green land areas in factory sites (special measures of the Factory Location Act and the Act on Formation and Development of Regional Industrial Clusters through Promotion of Establishment of New Business Facilities, etc.).
- Preferential measures to promote projects in the comprehensive special zones are added successively by national and local councils. These councils discuss the matter and then revise the law, government ordinance, ministerial ordinance, or notification based on the regulations.

(2) Financial support measures

The budgets of related ministries and agencies will be utilized preferentially, and will be supplemented flexibly by the reserve fund in order to promote the comprehensive special zones.

(3) Tax support measures (International Strategic Zones)

The following measures are applied selectively:

- Investment tax credit or special depreciation
  For projects in the Tsukuba International Strategic Zone, an investment tax credit or special depreciation can be applied to machines and facilities (JPY 20 million, or more), apparatus and equipment for R&D (JPY 10 million, or more), and/or buildings, annexes, and other structures (JPY 100 million, or more).
  - Ratio of investment tax credit:
    10% of acquisition cost (5% for buildings, etc.)
  - Ratio of special depreciation:
    34% of acquisition cost (17% for buildings, etc.)
    (The deadline for designating a business establishment and acquiring facilities, and so on, is March 31, 2020.)

(4) Financing support

- Interest subsidy system
  An interest subsidy (not exceeding 0.7%, for five years) is available on loans made by a government-designated financial institution for conducting business in a comprehensive special zone.

Local Support System

Ibaraki Prefectural Government

(1) Support for the relocation of research facilities and headquarters functions

- Support for enhancing and promoting the relocation of headquarters function
  R&D functions are provided in growth fields (AI/IoT, robots, next generation cars, etc.) and for the relocation of research facilities, headquarters, and headquarters functions to Ibaraki Prefecture, with subsidies of up to JPY 5 billion.
- Subsidies for promoting the relocation of headquarters functions
  Expenses related to the relocation of multiple departments of headquarters functions, excluding research and training centers (construction cost of company buildings, equipment relocation cost, personnel relocation cost), are covered by subsidies of up to JPY 100 million.

(2) Exemption from prefectural taxes for businesses in Ibaraki Prefecture

Businesses that construct a new facility or add to an existing facility (factory, plant, etc.) in Ibaraki Prefecture and that hire at least five additional employees by March 2021 are exempt from prefectural taxes:

- An exemption from real estate acquisition tax for buildings and land (whole of acquired land) related to the opening of a new office, and so on
- A three-year exemption from enterprise tax on corporations, depending on the percentage of additional employees hired when opening a new office, and so on. (This ends with the openings in 2018 (including land acquisition).)

City of Tsukuba

(1) Tax abatement for entities engaged in one or more strategic zone projects

1) Exemptions from the fixed asset tax and city planning tax for corporate entities that engage in projects in the international strategic zone and receive corresponding national preferential tax measures (tax measures that promote investment in plant and equipment) by March 2020
   - The following equipment and land will be exempt, for a maximum of three years, from the fixed asset tax and city planning tax:
     a) Equipment to which the above "National Support System" applies; such equipment is eligible to receive the benefit of (3) Tax Support System
     b) Land on which the building is constructed, as long as it contains the equipment described in (a).
2) Exemptions from the fixed asset tax and city planning tax, for a maximum of three years, for those who provide land for verification tests by March 2020

(2) Tsukuba City Subsidy for stimulating industries

For enterprises that are opening new facilities or are extending their facilities in the city by March 2021, a subsidy equivalent to the fixed asset tax is granted for the facility in question.

- A one-year (three years for robot/environment-related enterprises) subsidy, equivalent to the fixed asset tax on the land, buildings, and depreciable assets of the, for example, new office; this depends on the number of additional employees hired when opening the new office.

How tax support measures can be used: Flow

Preliminary consultation on investment and project details
(Business ⇔ Prefectural Government ⇔ National Government)
[Several months]

- Businesses that wish to use tax support measures are asked to provide details of their "capital investment" and the "pioneering nature of the project," using prescribed forms.
- Based on the documents provided, the prefectural government holds discussions with the businesses, while holding preliminary consultations with the national government.

*Describe the likelihood of using the support measures in future (capital investment that uses the tax support measures), without omission.

Procedure for the approval of a Comprehensive Special Zone Plan
(Prefectural Government ⇔ National Government)
[One and a half months]

- For projects in which preliminary consultations have been completed, the prefectural government applies the national government changes (e.g., addition of businesses) to the "Comprehensive Special Zone Plan."
- The national government confirms the details and approves the plan after discussions with relevant ministries and agencies.

*The national government accepts applications three times a year (January, May, September).

Procedure for legal person designation
(Business ⇔ Prefectural Government)
[One to two weeks]

- Upon approval of the project plan, the businesses are asked to submit an "Application for Designated Legal Persons."
- The prefectural government designates the business as "legal persons that can use tax support measures" and announces the decision on its official gazette.

*In principle, facilities that have been acquired after the legal person designation are covered.

Reduction of corporate tax

Investment tax credit

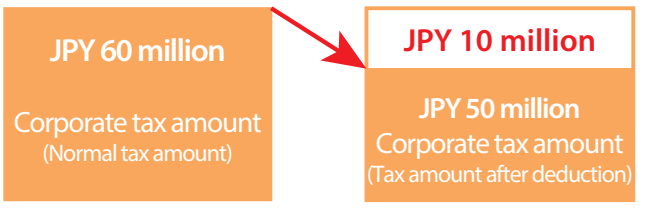
- ◇10% of acquisition cost for machinery and equipment
- ◇5% of acquisition cost for factory buildings

Simulation

Capital investment JPY 150 million
(machinery/equipment JPY 50 million, factory buildings JPY 100 million)

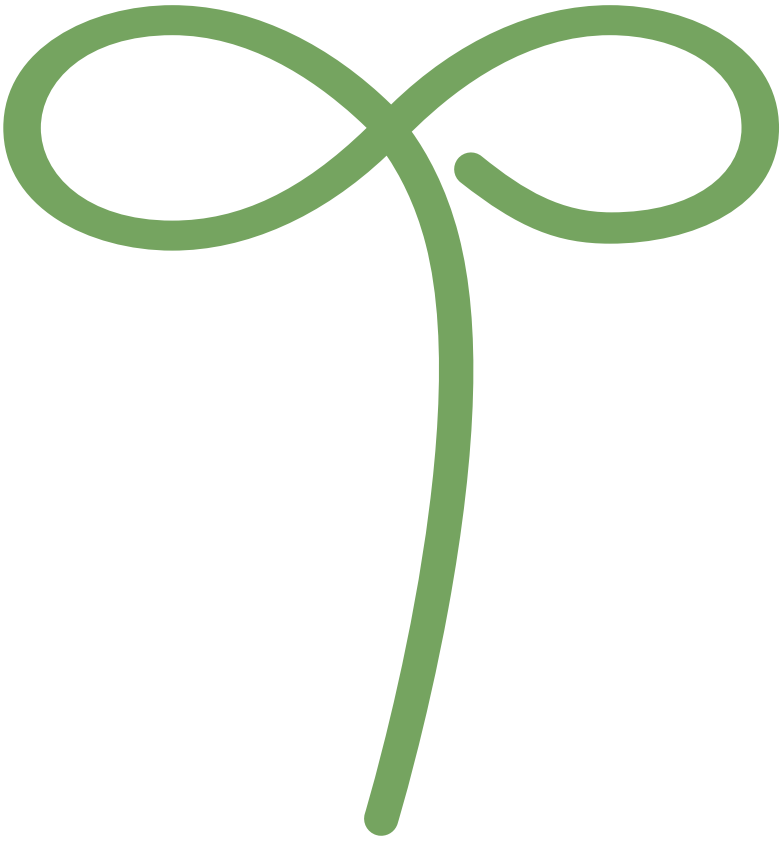
(Machinery/equipment) JPY 50 million × 10% = JPY 5 million (1)
(Factory buildings) JPY 100 million × 5% = JPY 5 million (2)

Tax deduction JPY 10 million ((1) + (2))



Deducted amount
[Up to 20% of pre-deduction tax amount]

*This calculation is only hypothetical; actual amounts may differ.



つくば
国際戦略
総合特区
Tsukuba International Strategic Zone

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