PFC
R&D base for advanced next-generation plant factories
R&D Center for the Plant Factory

Plant Factory Center, the global research and training center for the fully controlled plant factory
| Greetings from the Research Center |

Plant factories are cultivation facilities that enable growers and gardeners not only to promote the growth of useful plants, including such as vegetables, by the advanced controlled cultivation environmental factors, such as light, temperature, humidity, the concentration of carbon dioxide concentration, and culture solution and water levels, as well as through the molecular diagnosis of plant diseases and monitoring growth monitoring of plants at a molecular level, and stabilizing the, but also to stabilize year-round, planned production of produce in a planned way. Plant factories are designed for broadly divided into two different types, fully: those that grow plants exclusively in artificial light, and those that grow plants in a mixture of artificial light and artificial light-type plants and artificial light & natural sunlight combined type plants.

As we are facing imminent danger, as a result of because of global environmental problems, it is largely expected that plant factories will be widely used and increasingly demanded and distributed to realize a safe, secure, and stable food supply. They can also solve other issues, and to solve the issues we see in today’s societym by creating new industries which will contribute to boost the national economic growth and local revitalization as the a national strategy.

The Plant Factory R&D Center for the Plant Factory, in the Osaka Prefecture University (OPU) was established in March, 2011 under the MEXT “Advanced Plant Factory Operation Project” of the Ministry of Economy, Trade, and Industry (METI). It was designed as an R&D facility for developing element-related technologies, such as air quality management and conditioning, as well as lighting, and automation. Likewise, Building B (C21) was built under the auspices of the Model House Plant Factory Empirical Demonstration, Exhibition and Training Project” of the Ministry of Agriculture, Forestry and Fisheries (MAFF) as a demonstration, exhibition and research facility for leafy vegetable cultivation techniques. Finally, recently in December, 2014, Building C (C22: the Green Clocks New-Generation Plant Facility) was newly constructed and built as part of METI’s “Center for Innovation Site Promotion Project” to serve as a mass-production plant facility, which demonstrates that the facility can produce as many as 5,000 leafy vegetables a per day. Since the completion of C22, our Center has entered the next a new phase; we, seeking aim to make our the new R&D center a n next-generation and world-renowned basefactory, growing plants exclusively under artificial lights, specialized for a fully artificial light-type plant factory.

Our Center
With the outstanding work of the outstanding OPU faculty and Consortium as well as researchers and engineers belonging to the Consortium, our Center has developed under the adopted four main development strategies: an “R&D Strategy” for aiming theo promote practical collaborative study and the promotion of research collaboration on technology, an “Empirical Demonstration” and “Training and Education Strategy” designed both for teaching to university students "Plant Factory Science" (a sub-major in the College of Engineering and the College of Life, Environment, and Advanced Sciences) and to teach, and working adults further professional skills, as recommended by the MEXT “Development of Cultivation Experts” and by METI and the MADO “Core Personnel Development” programs; the “Strategy for Plant Development” program provides for providing empirical practical demonstrations and evaluations as at a mass-production plant factory in practical current use, while the and “Strategy for Commercializing Plant Facilities” provides structure for structuring for a a business model by designed to encourage industrial-academic-government cooperation.

We are grateful for your continuing support, and hope that you will continue to help us ensure that our in order for our Center makes even greater leading thestrides toward the global commercialization and popularization of plant factories to make greater strides, we would appreciate it if you could support and cooperate with us more than ever.

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Deputy Director
Professor, Graduate School of Life and Environmental Sciences

| Plant Factory Organizational Structure Research Center for the Plant Factory Organizational Structure |
The plant factory employs a broad range of elemental fundamental techniques in various fields; with a several number of industries and university research teams are collaborating to develop the most up-to-date cutting edge, highly advanced technologies. Our R&D Center is committed to this mission pursuing, through its multiple partnerships with diverse members of member industries, its mission as a center of and as a center of research for a new plant factory model using 100% artificial light, completely artificially-lighted plant factory model.

### Direction of R&D

**Establishing a new business model**

Empirical To empirically demonstrate and to expansion of a new business model based on a self-supporting, multi-cooperative management scheme structure, as well as related business opportunities in the areas of technical devices, plant design, and maintenance. Promotion of HTB: human resources development and overseas joint ventures (JV), and exhibitions and expansion activities.

**Integration of elemental fundamental technologies**

Integration strategies and empirical demonstrations

Reduced running costs reduction / enhanced eEfficiency enhancement / hHigh yield cultivation systems / cControl and management network / sScience-based agriculture / rResource recycling / eEnvironmental considerations and compliance

**Realizing Achieving cost reduction**

Reduced costs and efficiency

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### R&D in Plant Cultivation

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<tr>
<th>R&amp;D in Plant Cultivation</th>
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<tr>
<td>Development of functional food production technologies for the cultivation of vegetables and fruits which fruits, which are safe, delicious, and rich in flavor.</td>
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### The Green Clocks Corporation’s Vision for its New Generation Plant Factory Project

**Research**

2007--

Diagnostic techniques for biological clocks

Research into genetic diagnostic techniques

<JST PRESTO, A-STEP Research grant>

**Empirical Demonstration and Evaluation of Facility Development**

2010--

Development of low cost plant factories

C21 Empirical research and demonstration building: 30% cost reduction achieved (250 lettuces/day)

C20 Research building: the development of a genetics diagnosing robot

Operating and managing equipment at the

Empirical Demonstration and Evaluation Facility

2013--

Green Clocks Corporation’s New Generation Plant Factory

C22 Research building: large-scale factory with seedling cultivation lines selected through genetic diagnostic techniques (5000 lettuces/day)

**Empirical Demonstration and Evaluation**

2014--

Empirically evaluating productivity, quality, and cost-efficiency

Evaluating the effects of the clock gene

Evaluating nutritional analysis and safety inspection procedures, marketability, and the cost efficiency of large-scale production

Since 2011, the Green Clocks New Generation (GCN) Plant Factory Empirical Demonstration and Evaluation Innovation Center has used two facilities provided through an academia-industry partnership to advance the low-cost production of vegetables and open new frontiers by creating a model university-based, large-scale production plant factory, the New Generation Plant Factory.

Through the use of advanced technologies, including biological clock analysis, 100% LED lighting, and automated robotic conveyor systems, we have achieved in Japan the world’s first 40% reduction in production costs. Standardizing the design and operations of this factory, together with our new business model—based on empirical research and demonstration systems, will create global demand for Osaka’s plant factory technologies and ideas.

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**What does the name “Green Clocks” mean?**

The name, “Green Clocks” represents this technology, which improves plant cultivation efficiency and quality through a system of biological clocks.
## Outline of Facilities

### C20 (Building A): R&D in fundamental technologies

<table>
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<tr>
<th>a. Cleanroom laboratory A</th>
<th>Plant cultivation in class—10,000 ultra-clean rooms purified using HEPA filters</th>
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<tr>
<td>b. Cleanroom laboratory B</td>
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<tr>
<td>c. Multi-environment laboratory A</td>
<td>Enclosed plant growth chambers with wide-range temperature control (up to 50°C) and high humidity control.</td>
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<tr>
<td>d. Multi-environment laboratory B</td>
<td></td>
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<tr>
<td>e. Cultivation environment simulator room</td>
<td>Control systems simulating the environmental effects of air vent positioning, wind direction and velocity, airflow, temperature, humidity, and CO2 concentrations on plant growth</td>
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<tr>
<td>f. Light source and DC power laboratory</td>
<td>AC/DC powered enclosed growth chamber, with a DC power supply and LED light sources—used for lighting technology research</td>
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<tr>
<td>g. Universal design room</td>
<td>Robotic occupational therapy simulator to create working spaces accessible to disabled or elderly people</td>
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<tr>
<td>h. Measurement and control laboratory</td>
<td>Enclosed R&amp;D chamber for a wide range of sensing technologies used in plant factories</td>
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### C21 (Building B) Empirical Cultivation Research

| i. Functional plant production: Room A | Enclosed system for empirically demonstrating high yield production, hydroponic nutrient control, efficient lighting using various light sources, and optimized air quality. |
| j. Nursery | Enclosed plant production system for lettuce, reducing costs by optimizing cultivation methods and the growing environment |
| k. Precooling Room | Pre-market produce stockyard |
| m. Multi-tiered Plant Production Room A | High lettuce production yield using a picking robot in a 15-tier enclosed Nutrient Film Technique (NFT) system with a vertical setup to conserve floor space |
| n. Multi-tiered Plant Production Room B | Enclosed 15-tier plant cultivation system equipped with a mist sprinkler and picking robot |

Ministry of Economy, Trade and Industry (METI)
- Advanced Plant Factory Operation Project
  - R&D facility for fundamental technologies in air quality, lighting, and automation
  - Two-story reinforced concrete building
  - Total floor area: approx. 1000m²

Ministry of Agriculture, Forestry and Fisheries (MAFF)
- Model House Plant Factory Empirical Demonstration, Exhibition, and Training Project
  - Research and Exhibition facility for the practical demonstration of plant cultivation techniques
  - Two-story reinforced concrete building
  - Total floor area: approx. 1000m²
Outline of Facility

C22 (Building C) Empirical Demonstration and Evaluation of Large-Scale Production

Ministry of Economy, Trade, and Industry (METI) Center of Innovation Site Promotion Project (Grant for the development of empirical demonstration and evaluation facilities for advanced technologies)

The grant provides 2/3rds of the funding needed (costs detailed in the 2013 third revised supplementary budget and the 2014 original budget) to establish a 100% artificially lit large-scale model plant factory, employing advanced technology and established through a joint academia-government-industry collaboration designed to produce 5000 heads of lettuce per day.

- Two-story reinforced concrete building
- Total floor area: Approx. 1300㎡
- Total project cost: Approx. 700 million yen

Through a METI collaborative business support scheme, the GCN Project promotes academia-government-industry partnerships between Osaka Prefecture University and a range of different industries; these operate and manage the facilities and their practical demonstration and evaluation initiatives. Collaborating partners: Itoh Denki Company, Ltd. (Sakai), Nichiden Corporation, Espec Corporation, Densio Corporation, Sanshin Metal Working Company Ltd., Banshu Shinkin Bank, VF Agri Inc., Green Clocks Corporation, and Osaka Shinkin Bank

Objectives

1. Addressing social issues and industrial needs:
   ① Widespread adoption and expansion of plant factories as an industry;
   ② Meeting consumer demand for “delicious, safe, and fresh” produce;
   ③ Contributing to society and the local community by establishing a new empirical academia-government-industry cooperative agricultural model;
   ④ Meeting a global need for produce that can be grown in extreme climates, such as deserts and polar environments.

2. Establishing a center of innovation for new industrial fields:
   ① Promoting empirical research and the application of innovative and viable technologies in plant factory research;
   ② Promoting education and research by consolidating and expanding the plant factory infrastructure, in particular the C20 research lab, C21 empirical research lab, and GCN Plant Factory large-scale C22 empirical research lab.

Main Technologies

1. Green Clocks technology has been used to create the world’s first seedling selecting robot.

2. An industrial robot automatically selects seedlings, based on a diagnosis of their biological rhythms.

3. Japan’s first automatic loading robot and transfer lines
   A battery-operated automatic loading robot has been installed, enabling the fully automated transfer of cultivation racks from the line to a work area.

4. 100% LED lighting from seedling to cultivation
   Energy conservation has been achieved through the use of 100% LED lighting, widely regarded as a next-generation light source.

5. Japan’s first optimized air quality control system
   An air flow and duct system for optimizing the controlled circulation of air through the cultivation lines to dissipate heat from the light sources, reduce temperature differences, and provide a stable growth environment.
Consortium Activities

The Plant Factory Research Center collaborates with Consortium partners to research and develop projects, human resources, and visitor tours and exhibitions to promote and expand operations.

Collaborative Research Projects

Empirical Research on Cultivation
(Dr. Teruo Wada, Graduate School of Life and Environmental Sciences)

An empirical demonstration of the production of leafy vegetables (with lettuce as the main product) from seedling to harvest in an environment with optimized lighting and temperature. Product quality is improved through hydroponic nutrient control and safety and sanitation. This approach also improves marketability through sales and distribution, reduces costs, and conserves energy. By researching cultivation techniques and adding nutritious organic components, scientists have developed a stable production system for vegetables.

Molecular Diagnostic Plant Factory Research
(Dr. Hirokazu Fukuda, Graduate School of Engineering)

Research focuses on identifying and regulating gene expressions in plants to precisely control their metabolism. Techniques in metabolism control, such as monitoring gene expressions, data mining, and control technology, are being developed.

Social welfare-related Plant Factory Research
(Dr. Kuniharu Okuda, Graduate School of Comprehensive Rehabilitation)

This research aims to develop a plant factory working environment that is fully accessible to disabled or elderly people by using ergonomics (human factors) verification, exploring the physiological effects of the working space and environment, and establishing fundamental standards for facility design based on working environment evaluations and on-site inspection models.

Optimized Air Quality Control System Research
(Dr. Atsumasa Yoshida, Graduate School of Engineering)

This project aims to optimize air quality and improve the flow system by monitoring the effects of airflow, CO₂ concentrations, temperature, humidity, and radiation levels on plant physiology, as well by developing simulation techniques to enhance functionality by controlling the cultivation environment.

Direction of Development in Collaborative Research

Organizational Structure

General incorporated association
Joint-stock company
Limited Liability Partnership
Limited Liability Company

Sharing technology and expertise within a project, obtaining capital and funding, and limiting risk.
Human Resources Development and Training

The basic activity of the Consortium is to address the needs of members by providing practical theme-based training sessions at all levels, from basic to advanced, to reflect the experience participants.

The METI and MAFF programs also offer professional training programs that teach working adults cultivation techniques, management, and sales strategies, and enabling them to gain comprehensive knowledge and skills in plant factory operations.

Training sessions, seminars, and exercises
Lectures open to the general public

Widespread expansion and exhibitions

Exhibition booth at a trade show
Exhibition at the Shanghai Expo 2010
The affiliated exhibition, “Fascinating Plants Day,” is open to the public

Visitor Tours

Tours are held at intervals every second Tuesday from 13:30-14:45
Book a place before visiting, though our HP Maximum of 30 people on a tour/everyone is welcome.

Invitation to become a Consortium business partner

For those wishing to become industrial Consortium members, we provide information, a consultation on the required technologies, and membership exchanges. This initiative involves university and Consortium research collaborations, training programs, the monthly publication of a Consortium newsletter, and homepage updates.

For more information:
Please download the Consortium application form from the Plant Factory Office Research Center.
Tel: 072-254-9409(Plant Factory Office Research Center)