The **Plant Factory Center**, a global research and training center for efficient plant production
Greetings from R&D Center for the Plant Factory

In plant factories, stable production of leafy vegetables, fruit vegetables, and other useful plants can be achieved by controlling environmental factors, such as light, temperature, humidity, carbon dioxide concentration, nutrients, and air current, and by monitoring and analyzing plant growth. The cultivation facilities can be divided into three types: plant factories with artificial light, plant factories with sunlight, and plant factories both with artificial light and sunlight.

Amid environment issues plaguing us on a global scale, which matters the survival of mankind, practical application and widespread use of plant factories could offer a silver lining of stable and secure food supply for humanity facing limited resources. Plant factories can provide a solution to various problems in our modern society and contribute to the creation of a new industry that is much anticipated as indicated in Japan’s strategies for economic growth and regional revitalization.

In March 2011, R&D Center for the Plant Factory at Osaka Prefecture University (PFC) completed the construction of Building A (Bldg.C20) as a facility for research and development of elemental technology concerning lighting and ventilation environments, under the "advanced plant factory development project" led by the Ministry of Economy, Trade and Industry. We also constructed Building B (Bldg.C21) as a facility to demonstrate, exhibit, and research leafy vegetable cultivation technology, as part of the "model-house demonstration, exhibition and research project" sponsored by the Ministry of Agriculture, Forestry and Fisheries. Success results of the researches conducted in Buildings A and B led to the construction of another building, Building C (Bldg.C22; the next-generation plant factory) in September 2014, which was designed to function as a model system of mass-producing lettuce plants with a daily production rate of 5,000 heads (currently 8,000 heads per day at a maximum), and funded by the Ministry of Economy, Trade and Industry under the name of "innovation base promotion project". PFC is one of the most advanced international R&D centers that specialize in the research of plant factory using artificial light. PFC aims at promoting research and development and fostering human resources with regard to plant factory technology, as well as implementing plant factories in society.

To advance research and development, educators and researchers at Osaka Prefecture University, who have their laboratories within PFC, are working on research projects jointly with scientists and engineers of a business consortium managed by PFC.

To develop human resources, PFC provides a wide range of training courses both for undergraduates and working professionals. As a minor subject, ‘Plant Factory Science’ is offered to undergraduate students majoring in Engineering or Life and Environmental Sciences at Osaka Prefecture University. For working professionals, PFC offers various training programs and holds meetings to have them share joint research results.

To implement plant factories in society, PFC provides study tours and training programs to raise awareness of plant factories, and promotes industry-government-academia partnerships to develop and demonstrate new business models.

We sincerely ask for your continued support and cooperation so that PFC may attain significant research outcomes and make major advances as a world-leading R&D center.

October 2017

Organizational Structure

PFC management meeting

Director

Deputy Directors (engineering, life sciences)

PFC Virtual Laboratories
- Laboratory of the Prediction and Control of Plant Growth
- Laboratory of High Technology for Plant Production
- Laboratory of Plant Disease and Insect Pest Management in Plant Factories
- Laboratory of the Operations Management for Plant Production

Collaboration

Consortium management council

Joint Research Projects
1) plant production with resource recycling
2) the functional plant production
3) the plant factory based on molecular diagnostics
4) the welfare-oriented plant factory
5) the optimization for air conditioning in the plant factory

Corporate members
- Operating company of Building C22
- Research Institute for Environment, Agriculture and Fisheries, Osaka Prefecture

Individual members
- Researchers
- Growers

PFC Management office

Organization for research promotion
Laboratory of the Prediction and Control of Plant Growth

PI: Hirokazu Fukuda

<Research Objective>
The aim of this laboratory is to develop mathematical models on plant growth and metabolic processes at a plant factory to implement a precise simulation of dynamic processes of the growth and useful components of a plant using a computer.

Laboratory of High Technology for Plant Production

PI: Teruo Wada

<Research Objective>
This laboratory aims at establishing an advanced method for plant production by integrating plant physiology-based cultivation technology with bioenvironmental engineering technology.

Laboratory of Plant Disease and Insect Pest Management in Plant Factories

PI: Norio Hirai

<Research Objective>
This laboratory aims to identify types and characteristics of hazardous insects, bacteria, and microorganisms at a plant factory to develop a sanitation control method for improving safety and productivity.

Laboratory of the Operations Management for Plant Production

PI: Katumi Ohyama

<Research Objective>
The objective of this laboratory is to develop and demonstrate a production management method for minimizing the use of resources (such as manpower, energy, and water) and maximizing and/or optimizing crop productivity at a plant factory.
**Summary of Facilities (1)**

**Bldg.A (Building C20) R&D for elemental technology**

Supported by the Ministry of Economy, Trade and Industry  
Structure: reinforced concrete  
Story: 2  
Total floor area: approximately 1,000 m²  
Research and development of element technology for plant factories is conducted in Bldg. C20.

<table>
<thead>
<tr>
<th>Room Description</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cleanroom laboratory A</td>
<td>Research can be conducted using a growth chamber capable of creating a clean environment with the level of class 100,000 through HEPA filters.</td>
</tr>
<tr>
<td>b. Cleanroom laboratory B</td>
<td></td>
</tr>
<tr>
<td>c. Multi-dimensional environment laboratory A</td>
<td>Research can be conducted using a growth chamber capable of establishing a wide range of air temperature (up to 50°C) and humidity conditions.</td>
</tr>
<tr>
<td>d. Multi-dimensional environment laboratory B</td>
<td></td>
</tr>
<tr>
<td>e. Cultivation environment simulation room</td>
<td>Research can be conducted using a growth chamber capable of creating a uniform environment in terms of air temperature, humidity, and CO₂ concentration.</td>
</tr>
<tr>
<td>f. Laboratory for light source and DC power supply</td>
<td>Research can be conducted using a growth chamber equipped with LED lamps and an air conditioner both driven by DC power.</td>
</tr>
<tr>
<td>g. Universal design room</td>
<td>Occupational therapy research can be conducted to create a working space accessible to handicapped or elderly people.</td>
</tr>
<tr>
<td>h. Measurement and control laboratory</td>
<td>Research can be conducted on a wide range of sensing technologies applicable to plant factories.</td>
</tr>
</tbody>
</table>
Summary of Facilities (2)

Bldg.B(Building C21)R&D for plant cultivation

Supported by the Ministry of Agriculture, Forestry, and Fisheries
Structure: reinforced concrete
Story: 2
Total floor area: approximately 1,000 m²
Research and development of plant cultivation is performed to promote the implementation of plant factories in society. Training programs are also offered in Bldg. C21.

<table>
<thead>
<tr>
<th></th>
<th>Lecture room</th>
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<tbody>
<tr>
<td></td>
<td>Training rooms A&amp;B</td>
</tr>
<tr>
<td></td>
<td>Lab3</td>
</tr>
<tr>
<td></td>
<td>2F</td>
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<td></td>
<td>Lab4</td>
</tr>
<tr>
<td></td>
<td>1F</td>
</tr>
<tr>
<td>i. Functional plant production room A</td>
<td>Leafy vegetables can be produced experimentally in these rooms to demonstrate a high yield production with efficient light sources and air conditioners.</td>
</tr>
<tr>
<td>i. Functional plant production room B</td>
<td></td>
</tr>
<tr>
<td>j. Nursery room</td>
<td>In this room, lettuce seedlings can be produced at a low cost by optimizing cultivation methods and environment.</td>
</tr>
<tr>
<td>k. Precooling room</td>
<td>Products can be precooled and stored here before shipped.</td>
</tr>
<tr>
<td>m. Multilayer plant production room A</td>
<td>Small-scale plant production (with a daily production rate of 250 heads) can be conducted in this room equipped with fifteen-layer shelves employing nutrient film technique (NFT) and an automatic picking robot.</td>
</tr>
<tr>
<td>n. Multilayer plant production room B</td>
<td>Similarly to the room A, plant production can be conducted in this room equipped with fifteen-layer shelves, a mist irrigation system and an automatic picking robot.</td>
</tr>
<tr>
<td>Summary of Facilities (3)</td>
<td></td>
</tr>
</tbody>
</table>

**Bldg.C(Building C22) R&D for plant mass production**

Supported by the Ministry of Economy, Trading and Industry  
Structure: steel frame  
Story: 2  
Total floor area: approximately 1,300 m²  
Based on our research and development results, lettuce plants are continuously produced in Bldg. C22 at a daily production rate of 6,000 heads.

**The Green Clocks New Generation Plant Factory**

© Production Process (at Bldg.C)

- **Seeding and germinating (process)**
- **Raising seedling (process)**
- **Cultivation (process)**
- **Harvesting (process)**

Lettuce seeds are sown in urethane foam beds, which are placed in a germination chamber. After germination, the plants are transferred to culture shelves equipped with LED lamps. One day prior to transplanting, selections are made by a diagnostic robot.

Seedlings embedded into nursery panels (153 cells/panel) are cultivated hydroponically in the nursery room, where environmental conditions are optimized to realize best plant growth through a control system for LED lighting, air conditioning, CO₂ concentration, etc.

Seedlings, each weighing five to eight grams, are manually transplanted into 32-cell panels, and cultured for 18 days. Similarly to the nursery room, environmental conditions are controlled to realize optimum plant growth.

Plants, whose head has grown up to 80 to 100 grams, are harvested by hand. After having poor-quality or excess leaves removed, harvested plants are packed and shipped to customers.
Four major points featuring the plant factory at Osaka Prefecture University

1. Seedling selection robot (Green Clocks Technology)

One day before being transplanted into nursery panels, seedlings are exposed to blue LED light so that their fluorescent chlorophyll pigments can be photographed with a CCD camera every four hours up to six times. Based on the obtained data on chlorophyll fluorescence, circadian rhythm cycle and amplitude, as well as morphological characteristics including size and shape, only high-quality seedlings are selected.

2. Automatic transport system

Battery-powered automatic transporting devices are employed to move cultivation panels in the plant factory, which requires few operators on the cultivation site. Thanks to the full automation system, reduction of labor cost can be expected.

3. LED lamps

In the plant factory, 12,432 LED lamps (1,200 lamps in the nursery room and 11,232 lamps in the culture room) are employed as cultivation light sources. Compared with a conventional lighting system of fluorescent lamps, the energy consumption of the LED lighting system is lower by 30%. Also, this hybrid LED lighting system consisting of red, blue, white, and far-red lights enables faster growth.

4. Air distribution system

In the culture room as tall as 9 m, a number of air ducts with vents are installed between culture shelves to provide uniform air distribution in terms of flow, temperature, and CO2 concentration. To obtain the air uniformity, the aperture of each ventilator in the air ducts is determined based on computational fluid dynamics, or CFD analysis.
CAMPUS

ACCES

①南海高野線「白鷺駅」下車、南西へ約1km（徒歩約15分）
②南海高野線「中百舌鳥駅」下車、南東へ約1.5km（徒歩約20分）
③地下鉄御堂筋線「なかもす駅（5号口）」下車、南東へ約1.5km（徒歩約20分）

C20棟：植物工場研究センターA棟
C20 Facility:  R&D Center for the Plant Factory, Building A

C21棟：植物工場研究センターB棟
C21 Facility:  R&D Center for the Plant Factory, Building B

C22棟：植物工場研究センターC棟
C22 Facility:  R&D Center for the Plant Factory, Building C

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Organization for Research Promotion

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