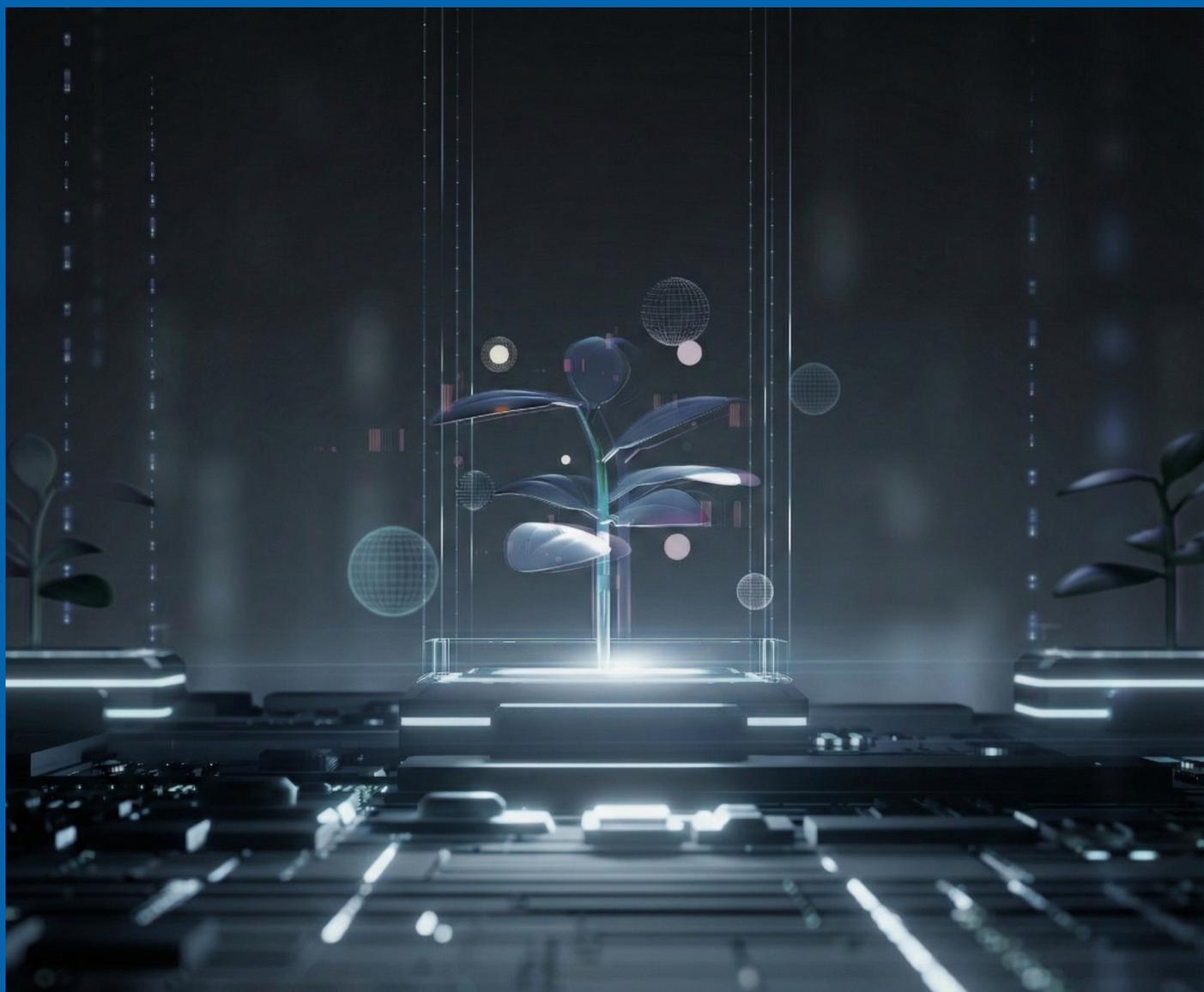


2026 5<sup>th</sup> BK21 FOUR International Conference  
on Interdisciplinary Program in IT-Bio Convergence System

## AI-Based IT-Bio Convergence for Smart Agriculture: Practical Applications in Production, Cultivation, and Life Sciences

AI로 여는 IT-BIO 융합 스마트농업 : 생산·재배·생명과학의 현장 적용

February 23-24, 2026 Lotte Resort Buyeo, Buyo, korea (Offline and Online)



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# CONGRATULATORY ADDRESS



I would like to express my warmest congratulations to the BK21 Four Center for IT-Bio Convergence System Agriculture, Korea's first regional- capital area university consortium, for hosting an international conference entitled "Smart Agriculture through AI-Enabled IT-Bio Convergence: Practical Applications in Production, Cultivation, and Life Sciences"

First, I would like to express my sincere appreciation to Director Jang-Ho Kim, Organizing Committee Chair and the faculty members of Chonnam National University, Suncheon National University, and Kyung Hee University for their dedication and hard work in preparing this conference.

I also wish to convey my deep gratitude to all domestic and international researchers who have participated in person or online, contributing to active scholarly exchange and to the success of this international academic event.

We are living in an era of AI-driven smart agriculture, which is fundamentally reshaping the paradigms of food production and life sciences. Data-driven precision agriculture, biotechnology-based innovation in crop varieties, and the maximization of production efficiency are no longer optional but essential for sustainable agriculture.

I sincerely hope that this international conference will serve as a crucial bridge, organically integrating innovative AI technologies, the knowledge of life sciences, and the fundamental values of agriculture, and enabling their practical application. Furthermore, I am confident that it will significantly contribute to fostering globally competitive, multidisciplinary talented individuals who will lead the future of agriculture.

Chonnam National University will continue to actively support the expansion of future-oriented agricultural research and education, including smart agriculture, through interdisciplinary convergence and international collaboration, and foster diverse and sustainable partnerships across academia and industry.

Thank you.

Sincerely,  
Keun-Bae Lee  
President of Chonnam National University



It is my great pleasure to express my heartfelt congratulations on the commencement of the Fifth International Conference hosted by our research group.

First of all , I would like to express my sincere gratitude to President Keun-Bae Lee of Chonnam National University for his inspirational congratulatory address. I also warmly welcome and express my deep appreciation to all domestic and international researchers and graduate students who are participating in this conference both in person and online.

Our BK21 FOUR Center for IT-Bio Convergence System Agriculture, composed of Chonnam National University, Suncheon National University, and Kyung Hee University, is Korea's first consortium uniting regional and capital-area universities for smart agriculture education and research.

We have set a meaningful milestone, including the establishment and successful operation of a graduate school smart farm convergence major, with eight graduate students earning joint degrees in the first semester of 2025.

Today, we stand at a pivotal moment in history in which artificial intelligence(AI) is evolving beyond a mere technological tool to fundamentally transform the economic, social, and cultural paradigms.

In this context, the international conference, entitled "AI-Based IT-Bio Convergence for Smart Agriculture: Practical Applications in Production, Cultivation, and Life Sciences," will bring together prominent scholars in related fields to share their expertise and insights.

Aligned with the goals of BK21 program to cultivate globally competitive and multidisciplinary talents, this conference provides a timely and meaningful opportunity to share world-class research achievements and strengthen international research networks.

Finally, I would like to express my deepest appreciation to Professor Ok-Ran Lee, General Chair of the Organizing Committee, as well as to all participating faculty members for their dedication in making this conference a success. I sincerely wish all participants for greatness in their academic achievement. I hope this conference will foster enthusiastic discussions and yield valuable outcomes.

Sincerely,  
Jangho Kim  
Dean of BK21 FOUR IT-Bio Convergence System Agriculture  
Professor, Chonnam National University

# PROGRAM SCHEDULE

## AI-Based IT-Bio Convergence for Smart Agriculture: Practical Applications in Production, Cultivation, and Life Sciences

February 23-24, 2026

### Welcome Remark

Time	Feb. 23 (Mon)	Prof. Ok Ran Lee
8:30 - 9:00	Congratulatory Address President of Chonnam National University, Keun-Bae Lee	
	Welcome Address Dean of IT-Bio Convergence System Agriculture, Chonnam National University, Jangho Kim	

### Session 1 : Invited Lecturers

Time	Feb. 23 (Mon)	Chair : Prof. Ok Ran Lee
9:00 - 10:00	“Research Ethics and Dilemmas in the Gen-AI Era” <b>Prof. Taehyeong Lim</b> (Jeonju National University of Education)	
10:00 - 10:30	“When a neuroscientist met a muse” <b>Prof. Juhyun Song</b> (Chonnam National University Medical School)	
10:30 - 11:00	“From Prediction to Experiment: Deep Learning Predictions and Growth-Chamber Validation of Flowering Responses to Climate Warming” <b>Dr. Zeeshan Nasim</b> (Chonnam National University)	



#### ZOOM MEETING (Session 1)

February 23 (Mon), 2026 (08:30-18:00)

Zoom address

Meeting ID : 883 6687 5347

Password : 966249

## Session 2 : Student Short Talks

Time	Feb. 23 (Mon)	Chair : Prof. Hee-Gyeong Yi
11:00 – 11:12	<p>“Gelatin Nanoparticle-Assisted Stem Cell Spheroid Therapeutics for Enhanced Tissue Regeneration”</p> <p><a href="#">Dream Kim</a> (Chonnam National University, Korea)</p>	
11:12 – 11:24	<p>“Integrated Computer Vision and Machine Learning Framework for Multi-Class Anomaly Detection in Group-Housed Growing Pigs”</p> <p><a href="#">Eddiemar Lagua</a> (Suncheon National University, Korea)</p>	
11:24 – 11:36	<p>“ID-CAN: A Derivative Cross-Attention Network Model for Preprocessing- and Form-Independent Classification of Pinellia species Using SWIR Hyperspectral Imaging”</p> <p><a href="#">Yea-Jin Park</a> (Kyung Hee University, Korea)</p>	
11:36 – 11:48	<p>“Defective sperm cells produced by loss of pollen-specific PLA disrupt double fertilization dynamics in Arabidopsis”</p> <p><a href="#">Hae Seong Seo</a> (Chonnam National University, Korea)</p>	
11:48 – 12:00	<p>“Attention Window Adjustment Technique for Longformer Based on Document Characteristics”</p> <p><a href="#">Seung Ju Kim</a> (Suncheon National University, Korea)</p>	
12:00 – 12:12	<p>“Leaf-Scale Prediction of Leaf Water Content in Sweet Basil from Hyperspectral Images via Unsupervised Learning”</p> <p><a href="#">Chi-Won Choi</a> (Kyung Hee University, Korea)</p>	
12:12 – 11:24	<p>“Loss of pollen-expressed peroxidase function impairs pollen tube elongation and reduces fertility in Arabidopsis”</p> <p><a href="#">Yu Na Song</a> (Chonnam National University, Korea)</p>	
12:24 – 12:36	<p>“Development of a Simulation Model for Greenhouse Heating Using an AI-Based Combined Heat Exchanger”</p> <p><a href="#">Sungwan Park</a> (Suncheon National University, Korea)</p>	
12:36 – 12:48	<p>“Metabolomic insights into flavonoid enrichment in the cell wall of Antarctic moss”</p> <p><a href="#">Eun Jin Heo</a> (Kyung Hee University, Korea)</p>	
12:48 – 13:00	<p>“Reinforcement Learning-based Cooperative Manipulation for Dual-arm Agricultural Robot”</p> <p><a href="#">Changjo Kim</a> (Chonnam National University, Korea)</p>	

### Session 3 : Invited Lectures (VOD)

Time	Feb. 23 (Mon) Chair : Prof. Sang Yoon Kim / Prof.Dae Hyun Jung / Dr.Yeon-ok Kim
14:00 – 14:20	<p>“Pollen wall patterning in rice”</p> <p>Dr. Wanqi Liang (Shanghai Jiao Tong University, China)</p>
14:20 – 14:40	<p>“Maize seeds ‘NOT LIKE DAD’: insights into double fertilization and new breeding opportunities”</p> <p>Dr. Thomas Widiez (CNRS, France)</p>
14:40 – 15:00	<p>“Photosynthesis and Photoprotection: Molecular Adaptation Strategies of Plants to Fluctuating Light Conditions”</p> <p>Dr. Eunchul Kim (Nihon University, Japan)</p>
15:00 – 15:20	<p>“Engineering Oilseed Crops for Next-Generation C10-Rich Oils for Bioenergy”</p> <p>Dr. Jinhoon Jang (University of Nebraska, USA)</p>
15:20 – 15:40	<p>“Plant strategies to cope low phosphorus conditions by root functions”</p> <p>Prof. Jun Wasaki (Hiroshima University, Japan)</p>
15:40 – 16:00	<p>“From Biomass to Devices: Sustainable Nanocellulose-Based Materials Design for Advanced Electronics and Environmental Systems”</p> <p>Dr. Youngsang Ko (University of Central Florida, USA)</p>
16:00 – 16:20	<p>“Designing Hydrophobic Lignin Materials Across Dimensions: From Colloidal Particle Coatings to Functional 2D Films”</p> <p>Dr. Kwang Ho Kim (University of British Columbia, Canada)</p>
16:20 – 16:40	<p>“Inter-species differences in domain architecture of cellulose and chitin hydrolases revealed by single-molecule measurement”</p> <p>Dr. Akihiko Nakamura (Shizuoka University, Japan)</p>
16:40 – 17:00	<p>“Quantification of Environmental Chemicals”</p> <p>Dr. Min Jang (Arizona University, USA)</p>
17:00 – 17:20	<p>“Agricultural plastics and climate change: solution or problem?”</p> <p>Dr. Davey Jones (Bangor University, UK)</p>
17:20 – 17:40	<p>“Multimodal Artificial Intelligence and Applications ”</p> <p>Prof. Ha Young Kim (Graduate School of Information, Yonsei University)</p>

# ABSTRACT

## Session 1 \_ Invited Lectures

### Research Ethics and Dilemmas in the Gen-AI Era

Taehyeong Lim Ph.D.

Jeonju National University of Education

This presentation examines the evolving ethical landscape of Generative AI (Gen-AI) in academic research and higher education, tracing institutional responses from the release of ChatGPT through late 2025.

The analysis addresses three dimensions. First, the evolution of academic publishing standards is reviewed. Initial reactions were characterized by strict prohibitions—major journals such as Science and Nature clarified that AI tools cannot be listed as authors due to accountability and originality concerns, mandating disclosure of AI use. By late 2025, however, a paradigm shift emerged as publishers including Elsevier updated guidelines to permit AI use for “accuracy and inclusivity” under human ethical responsibility. This shift raises questions about “AI Co-scientists” actively participating in research design and hypothesis generation, necessitating reconsideration of authorship criteria and human oversight.

Second, the crisis of verification and “self-alibi” practices is addressed. Limitations of AI detection tools have led to documented false accusations of plagiarism. Based on the principle that accepting an AI-assisted paper is preferable to rejecting human-authored work through unreliable detection, the necessity of preserving version histories (e.g., Google Docs logs) to demonstrate human authorship is argued.

Third, educational challenges and “cognitive debt” are examined. University responses to student AI use have varied from complete bans to permitted use with citation. The reliability of detection tools such as Turnitin remains contested, with some institutions disabling them to prevent false accusations. The concept of “cognitive debt” is introduced, warning that over-reliance on AI assistants may attenuate human critical thinking capacities.

The presentation concludes that while AI integration into science is inevitable, human supervision remains paramount. The role of educators emerges as critical in preventing intellectual decline, positioning education as the essential safeguard for preserving human cognitive capacities.

**Keywords:** Generative AI, Academic Integrity, Research Ethics, AI Detection, Cognitive Debt, Higher Education



Interdisciplinary Program in IT-Bio Convergence System

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### Research area

- AI convergence education
- AI human avatar design

### Work experience

- Research professor, institution of educational research, Chonnam National University
- Assistant Professor, Center for Teaching and Learning, Gwangju University

### Education

- 2012 - 2018 Ph.D. Instructional Systems & Learning Technologies, Florida State University
- 2009 - 2011 M.Ed. Department of Education, Chonnam National University
- 2004 - 2009 B.A. Korean Education, Chonnam National University

### Representative publications

- Lim, Taehyeong. (2025). Can LLMs replace human efforts in keyword extraction?: A study focusing on similarity comparison with manual methods. *Journal of Korean Association for Educational Information and Media*, 31(3), 651-671
- Lim, Taehyeong, Eunbyul Yang, Suhyun Ki, Kim, Kukhyeon, Yuseon Jeong, Sunok Lee and Ryu, Jeeheon. (2023). ChatGPT-based Keyword Extraction from Text Data: A Comparative Study of Similarity with Manual Methods. *Journal of Educational Technology*, 39(4), 1337-1368

# ABSTRACT

## Session 1 \_ Invited Lectures

### When a neuroscientist met a muse

Juhyun Song Ph.D.

Department of Anatomy, Chonnam National University Medical School

How does our brain react when we visit an art gallery? Paintings are not merely seen with the eyes; they are appreciated by the brain. The moment we look at a painting and feel that it is “beautiful,” billions of nerve cells within our brains are already dancing. As visual information enters the brain through the retina’s visual cortex, the hippocampus summons memories, the limbic system triggers emotions, and the frontal lobe judges the overall value of the piece. For this reason, a painting is like a symphony performed by various regions of the brain working in concert. We think we “see” the world with our “eyes.” However, in reality, we “interpret” the world with our “brains.” The eyes are merely windows that receive information from light; “vision” is only truly completed within the brain. Seeing color is not simply a process of light entering the retina, but the brain interpreting wavelengths of light. Furthermore, it is the task of connecting emotions and memories to transform that input into a single “meaningful image.” This book dissects the brains of the painters who created great masterpieces, ranging from Rembrandt and Monet to Kahlo, Kandinsky, Picasso, and Hopper. Additionally, it analyzes the pathways through which paintings entering the viewer’s brain evoke deep emotion. While the “painting brain” and the “appreciating brain” may seem vastly different, they actually share a common element called “art.” This book is a record of the wondrous brain that sparks the chemical reaction known as “art” within the minds of both artists and viewers. It is composed of four chapters. The first chapter addresses the correlation between brain science and art. The second chapter deals with how brain-related disorders that plagued painters influenced their work. The third chapter applies the neurotransmitters secreted by the brain to various paintings, and the fourth chapter illuminates the aging brains of painters and their later bodies of work. Through this book, you will come to understand, from a neuroscientific perspective, why the Mona Lisa’s smile, Van Gogh’s starlight, Mondrian’s dots, lines, and planes, and Matisse’s paper cut-outs make our brains dance.



### Interdisciplinary Program in IT-Bio Convergence System

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### Research area

- Neuroanatomy · Neurometabolism · Metabolic syndrome

### Work experience

- 2012 - 2017 Teaching Assistant and Postdoctoral fellowship, Yonsei University
- 2015 - 2017 Research Assistant Professor, Dongguk University and Chonnam University
- 2017 - 2022 Assistant and Associate professor, Medical School, Department of Anatomy
- 2022.4 - Present Full Professor, Chonnam University Medical School, Chonnam University

### Education

- 2009 - 2013, Ph.D. Department of Aging science, Yonsei university, South Korea
- 1999 - 2004, Bachelor of Science (B.S), Department of Biotechnology, Yonsei University, South Korea

### Representative publications

- Circular RNA Tmcc1 improves astrocytic glutamate metabolism and spatial memory via NF- $\kappa$ B and CREB signaling in a bile duct ligation mouse model: transcriptional and cellular analyses, *Journal of neuroinflammation*, May, 2023, Juhyun Song+(Corresponding author)
- Obesity-linked circular RNA circTshz2-2 regulates the neuronal cell cycle and spatial memory in the brain, *Molecular Psychiatry*, Sep, 2021, Juhyun Song+(Corresponding author)
- Pineal gland dysfunction in Alzheimer's disease: relationship with the immune-pineal axis, sleep disturbance, and neurogenesis. *Molecular neurodegeneration*, Jul, 2019, Juhyun Song+(Corresponding author)
- Potential of Glucagon-Like Peptide 1 as a Regulator of Impaired Cholesterol Metabolism in the Brain. *Advances in nutrition*, Nov, 2020, Juhyun Song+(Corresponding author)
- Glucagon like peptide-1 suppresses neuroinflammation and improves neuronal structure, *Pharmacological research*, Dec 24;152, 2019, Juhyun Song+(Corresponding author)
- IGF1 enhances memory function in obese mice and stabilizes the neural structure under insulin resistance via AKT-GSK3 $\beta$ -BDNF signaling, *Biomedicine & Pharmacotherapy*. Jan, 2025, Juhyun Song+ (Corresponding author)
- Adiponectin controls the apoptosis and the expression of tight junction proteins in brain endothelial cells through AdipoR1 under beta amyloid toxicity. *Cell death and Disease* 2017 Oct 12;8(10):e3102., Juhyun Song (1st author)

# ABSTRACT

Session 1 \_ Invited Lectures

## From Prediction to Experiment: Deep Learning Predictions and Growth- Chamber Validation of Flowering Responses to Climate Warming

Zeeshan Nasim Ph.D.

Department of Bioenergy Science and Technology,  
Chonnam National University, Gwangju, 61186, Republic of Korea.

Flowering time is a temperature-sensitive developmental trait and is strongly influenced by climate change. In this study, we examined the potential effect of future temperature variation on flowering time in *Arabidopsis thaliana*. Hourly temperature data spanning the last 50–100 years were aggregated to monthly averages and used to learn historical temperature trends with the Prophet time-series forecasting model. The model was trained using data up to April 2024 and used to predict future monthly average hourly temperatures. Model performance was evaluated using post-training data from May 2024 to August 2025, yielding root mean squared errors of 3.01 to 4.64°C for the selected cities, indicating high accuracy predictions. These predicted temperature conditions were programmed into growth chambers to simulate future climates. Flowering time of *Arabidopsis* natural accessions and flowering-time mutants was assessed under present-day and predicted future temperature conditions.

We observed a pronounced acceleration of flowering in most tested genotypes, primarily associated with elevated expression of the floral promoters FLOWERING LOCUS T (FT) and SUPPRESSOR OF OVEREXPRESSION OF CO 1 (SOC1). In contrast, plants with higher expression levels of the floral repressor FLOWERING LOCUS C (FLC) were relatively resilient to temperature increases. Notably, we identified an *Arabidopsis* natural accession that exhibited early flowering insensitive to both temperature and photoperiod. Further analyses revealed that natural variations in FLC and MADS AFFECTING FLOWERING (MAF) genes, highlighting a previously unknown role for these loci in temperature- and photoperiod-responsive flowering. Together, these findings identify a potential regulatory hub that can buffer plant phenological responses to future climate change and global warming. Moreover, with recent advances in genome editing technologies, these loci could be harnessed to overcome seasonal barriers.

Funding (Arial 12 point):

This work was supported by a Brain Pool Program (BP) grant (RS-2023-00263673) awarded to Z.N by the National Research Foundation of Korea (NRF).



### Interdisciplinary Program in IT-Bio Convergence System

## Zeeshan Nasim Ph.D.

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### Research area

- Temperature-responsive flowering and developmental genetics
- Epigenetic control of haploid induction

### Work experience

- Research Professor, Department of Applied Plant Science, Chonnam National University
- Research Professor, Department of Life Sciences, Korea University
- Postdoc, CDA, King Abdullah University of Science and Technology (KAUST), Saudi Arabia
- Postdoc, Department of Life Sciences, Korea University

### Education

- 2016 - 2021 Ph.D. Department of Life Sciences, Korea University
- 2009 - 2015 Bachelor and Master of Biotech. & Genetic Engineering at the University of Agriculture, Pakistan (Graduated with honor: gold medalist)

### Representative publications

- Nouroz Karim, Zeeshan Nasim\*, Ji Hoon Ahn\*, Hyo-Jun Lee\* (2026) Natural polymorphisms in FLC and FLC-family genes orchestrate the unique temperature- and photoperiod-insensitive insensitive flowering in Arabidopsis natural accessions. *Journal of Experimental Botany*
- Zeeshan Nasim, Nouroz Karim, Hendry Susila, Ji Hoon Ahn (2025) Natural variation in FLOWERING LOCUS C and FLOWERING LOCUS M underlies the weak temperature sensitivity of the Arabidopsis accession Ellershausen. *Current Plant Biology*. 41(2025): 100444
- Zeeshan Nasim\*, Nouroz Karim\*, Hendry Susila, Ji Hoon Ahn (2024) Arabidopsis B-BOX DOMAIN PROTEIN14/15/16 form a feedback loop with ELONGATED HYPOCOTYL 5 and PHYTOCHROME-INTERACTING FACTORS to regulate hypocotyl elongation. *Current Plant Biology*. 40 (2024) 100395
- Zeeshan Nasim, Hendry Susila, Suhyun Jin, Geummin Youn, Ji Hoon Ahn (2022) PAF1C-regulated FLC-clade genes repress flowering in response to chilling. *Frontiers in Plant Science*. 13:817356
- Zeeshan Nasim, Muhammad Fahim, Hocheol Hwang, Hendry Susila, Suhyun Jin, Youn Geummin, Ji Hoon Ahn (2021) Nonsense-mediated mRNA decay modulates Arabidopsis flowering time via the SET DOMAIN GROUP 40-FLOWERING LOCUS C module. *Journal of Experimental Botany*. 72 (20), 7049-7066
- Hendry Susila, Snježana Jurić, Lu Lui, Katarzyna Gawarecka, Kyung Sook Chung, Suhyun Jin, Soo-Jin Kim, Zeeshan Nasim et al. (2021) Florigen sequestration in cellular membranes modulates temperature-responsive flowering. *Science* 373 (6559), 1137-1142

# ABSTRACT

## Session 2 \_ Student Short Talks

### Gelatin Nanoparticle-Assisted Stem Cell Spheroid Therapeutics for Enhanced Tissue Regeneration

Dream Kim<sup>1, 2, 3 +</sup>, Woochan Kim<sup>1, 2, 3</sup>, Harshita Sharma<sup>1, 2, 3</sup>, Shinyull Lee<sup>1, 2, 3</sup>, Chaeyeon Park<sup>1, 2, 3</sup>, Sunho Park<sup>4</sup>, Jangho Kim<sup>1, 2, 3 \*</sup>

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Stem cell spheroids present a promising strategy for tissue repair and therapeutic applications. However, conventional spheroids face limitations such as uncontrolled proliferation, limited nutrient diffusion, and core apoptosis. To overcome these issues, we developed a Gelatin nanoparticle (GNP)-assisted spheroid culture system that promotes compact formation and enhances cellular functions. GNP sized 80–200 nm was fabricated with high biocompatibility and properties that support cell–cell and cell–ECM interactions. Compared to conventional methods, GNP-stem cell spheroids showed enhanced viability, proliferation, and structural complexity. Moreover, their regenerative potential was confirmed in both bone and skin tissue defect models. These findings highlight the efficacy of GNP-enhanced spheroids as a next-generation platform in regenerative medicine.

**Keywords:** Gelatin Nanoparticle, Stem Cell Spheroid, Extracellular Matrix, Tissue Regeneration

## Integrated Computer Vision and Machine Learning Framework for Multi-Class Anomaly Detection in Group-Housed Growing Pigs

Eddiemar B. Lagua<sup>a,b</sup>, Hong-Seok Muna<sup>c</sup>, Md Sharifuzzamana, Md Kamrul Hasana, Ahsan Mehtaba, Jin-Gu Kanga<sup>b</sup>, Young-Hwa Kim<sup>d</sup>, Chul-Ju Yanga<sup>b,\*</sup>

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This study proposed a multi-class anomaly detection framework in group-housed pigs by integrating computer vision and machine learning techniques. There were 9 classification algorithms were trained to classify 5 conditions (Normal (N), Heat Stress + Poor Ventilation (HSPV), Heat Stress (HS), Heat Stress + Infection (HIS), and Heat Stress + Recovery (HSR)) using 10 different feature models (different combinations of nutritive (feeding and drinking) and posture behavior variables). The models achieving  $\geq 90\%$  accuracy were evaluated on unseen data. In the results, distinct patterns in feeding, drinking, and posture behaviors across different stress conditions were observed. Among the evaluated algorithms, Linear Discriminant Analysis (LDA) using all feeding and drinking variables (feature model 5) achieved strong classification performance, with precision, recall, F1-score, and accuracy values of 96.2%, 96.0%, 96.0%, and 96.0%, respectively, and an AUC of 98.7%. Nevertheless, Random Forest and Extreme Gradient Boosting models trained on feature model 3, which was also based solely on feeding and drinking behaviors but excluding relative feeding, drinking, and not-feeding/drinking variables, outperformed LDA by perfectly classifying all data points under N and HS conditions. These findings confirm that feeding and drinking behaviors alone are sufficient for developing robust anomaly detection models with an appropriate classification algorithm. Although incorporating posture-related variables did not consistently enhance classification accuracy, their inclusion substantially improved the interpretability of behavioral responses, offering valuable insights into pigs' adaptive and recovery mechanisms under different stress conditions. In conclusion, this study demonstrates that stressor-specific anomaly detection using behavioral data is feasible through the integration of computer vision and machine learning, providing a practical and scalable approach for precision livestock farming. The proposed framework has the potential to enhance health and welfare monitoring by enabling early and accurate stress detection, thereby improving productivity and management efficiency in swine production and, more broadly, in livestock production systems.

Funding : This research received no external funding.

# ABSTRACT

## Session 2 \_ Student Short Talks

### D-CAN: A Derivative Cross-Attention Network Model for Preprocessing- and Form-Independent Classification of *Pinellia* species Using SWIR Hyperspectral Imaging

Yea-Jin Park a,b, Yu-Jin Jeon a,b, Chi-Won Choi a,b, Dae-Hyun Junga,b\*

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The morphological similarity between the herbal medicine *Pinellia ternata* (Thunb.) Breit and its major adulterant *P. pedatisecta* Schott poses serious risks to consumer safety and public health. Although the two species are highly similar in appearance, they have different toxicity profiles that can cause health hazards when misidentified. Existing RGB imaging-based classification methods are vulnerable to variations in illumination conditions and sample physical forms, while hyperspectral imaging approaches exhibit high dependency on preprocessing method selection. Furthermore, most previous studies have been conducted on single physical forms, limiting their applicability to the diverse processing forms encountered in real-world distribution environments. This study compares the classification performance of RGB imaging and hyperspectral imaging across three physical forms—whole, sliced, and powdered—and proposes a novel deep learning architecture, the Derivative Cross-Attention Network (D-CAN), which integrates learnable derivative filters with a bidirectional cross-attention mechanism. Experimental results demonstrate that while RGB imaging performance degraded sharply to 77-92% for powder forms, SWIR-based D-CAN achieved 100.00% classification accuracy across all physical forms. In six-class integrated classification, D-CAN consistently maintained 100.00% accuracy under all preprocessing conditions including raw spectra, first derivative, second derivative, and SNV, demonstrating preprocessing independence and robustness to diverse processing forms. This represents an improvement of over 8 percentage points compared to the best RGB model performance of 91.98%. This study establishes the feasibility of a form-invariant authentication system capable of integrated classification of herbal medicines across diverse physical forms using a single model based on hyperspectral imaging. D-CAN achieves high classification accuracy without preprocessing optimization, enhancing the practical accessibility of hyperspectral imaging and contributing to public health safety through improved reliability of herbal medicine authentication.

Funding : This research was supported by a grant (23192MFDS106) from Ministry of Food and Drug Safety in 2026.

## Defective sperm cells produced by loss of pollen-specific PLA disrupt double fertilization dynamics in Arabidopsis

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Double fertilization in angiosperms is a distinctive reproductive process in which two immotile sperm cells fuse with the egg cell and the central cell to generate the embryo and endosperm. Because this process is directly linked to seed formation, it is of substantial biological and agricultural importance. Several key genes involved in double fertilization (including DUO1, FBL17, GEX1, GCS1/HAP2, and CDKA;1) have been identified. Loss-of-function mutations in these genes causes sperm defects, gamete fusion failure, or single fertilization (single egg cell fertilization), ultimately leading to endosperm failure and increased seed abortion. Here, we show that genome editing of a pollen-expressed phospholipase results in sperm cell defects, an increased frequency of aborted seeds, and maternal haploid induction. Lipid-marker analysis revealed an altered subcellular localization of an anionic lipid biosensor signal in the mutant pollen. Collectively, these findings point to a previously unrecognized, anionic lipid-associated mechanism of double fertilization and haploid induction linked to defective sperm function. In future work, we will investigate the molecular mechanisms by which the phospholipase-lipid species axis mediates sperm defects and haploid induction, with a focus on auxin and ROS signaling pathways implicated in haploid induction.

This study was supported by grants from the Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Science, ICT, & Future Planning (Grant No.: RS-2023-00217064 and RS-2025-00553838); the New Breeding Technologies Development Program (Project No. RS-2024-00322297), funded by the Rural Development Administration, Republic of Korea.

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# ABSTRACT

Session 2 \_ Student Short Talks

## Attention Window Adjustment Technique for Longformer Based on Document Characteristics

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This paper proposes a data-driven approach for adaptive attention window design in Longformer models based on document length characteristics. Conventional Longformer applies uniform attention window sizes across all layers, which can lead to inefficient computational resource utilization when datasets exhibit diverse document length distributions.

To address this limitation, we introduce a layer-wise attention window configuration strategy guided by document length and information density, and analyze its behavior across datasets categorized into short-, medium-, and long-document groups. The proposed approach reflects the hierarchical representation structure of transformers by allocating smaller attention windows to lower layers for local pattern modeling and larger windows to higher layers for semantic-level interactions.

Through experiments on datasets with varying document length distributions, we examine how attention window allocation strategies interact with computational efficiency and model representation characteristics. This study organizes the design space of dataset-aware attention structures and explores their applicability without introducing additional learnable parameters.

## Leaf-Scale Prediction of Leaf Water Content in Sweet Basil from Hyperspectral Images via Unsupervised Learning

Chi-Won Choi<sup>1,2</sup>, Yu-Jin Jeon<sup>1,2</sup>, Yea-Jin Park<sup>1,2</sup>, Dae-Hyun Jung<sup>1,2\*</sup>

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Increasing drought frequency and growing uncertainty in water availability due to climate change have intensified the need for non-destructive indicators to accurately diagnose crop water status and support optimal irrigation regimes. Leaf water content (LWC) is a key physiological indicator of plant water status, and short-wave infrared (SWIR) hyperspectral imaging has emerged as an effective tool for its non-destructive monitoring due to its sensitivity to water absorption features. However, conventional approaches relying on whole-leaf averaged spectra fail to capture within-leaf spectral and spatial heterogeneity associated with internal tissue structure and localized water variability. In this study, we developed an unsupervised learning based region of interest (ROI) strategy to data-drivenly capture within-leaf spectral substructures and assessed its effectiveness for LWC prediction. SWIR hyperspectral images (900–1700 nm, 140 bands) were acquired from 264 sweet basil (*Ocimum basilicum* L.) leaves subjected to progressive drought stress, with measured LWC values ranging from 60% to 90%. Pixel-level spectra were transformed using principal component analysis (PCA) and residual PCA, followed by unsupervised clustering with K-means and Gaussian mixture models (GMM) to partition each leaf into three spectrally distinct subregions. Mean spectra from each cluster were used as alternative ROI representations for LWC regression. Multiple regression models, including partial least squares regression (PLSR) and support vector regression (SVR), were optimized and combined using a weighted-average ensemble strategy. The optimal configuration (GMM clustering with PCA features, cluster 0) achieved the highest prediction performance ( $R^2 = 0.784$ ), representing an improvement of 0.096 over the whole-leaf mean baseline ( $R^2 = 0.688$ ). These results indicate that ROI regions derived through unsupervised learning contain predictive signals more directly associated with LWC than conventional whole-leaf averaged spectra. The proposed framework provides a robust, non-destructive approach for crop water status monitoring and can be extended to precision irrigation and sustainable agricultural management.

Funding: This research was supported by a grant (23192MFDS106) from Ministry of Food and Drug Safety in 2026.

# ABSTRACT

## Session 2 \_ Student Short Talks

### Loss of pollen-expressed peroxidase function impairs pollen tube elongation and reduces fertility in Arabidopsis

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Class III peroxidases (CIII PRXs) are a conserved family of plant-specific antioxidant enzymes. They are heme-containing proteins that utilize hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) as a substrate and are involved in the regulation of ROS homeostasis during plant physiological and developmental processes. One notable example among class III peroxidases is ZmPOD65/PRX65, with loss-of-function mutants showing haploid induction (HI). Here, we functionally characterized a pollen-expressed Arabidopsis PRX (AtPRX) sharing 50.8% sequence identity with ZmPOD65/PRX65. Expression analysis revealed that high PRX expression in pollen, and loss-of-function mutants exhibited reduced pollen tube elongation and significantly decreased seed set compared with the wild type. HI was not observed in PRX single mutants to date. However, we still cannot exclude the possible involvement of this PRX with a putative pollen expressed HI candidate. These findings indicate a role for pollen-expressed PRXs in reproductive processes and ROS regulation during plant reproduction, remaining the possibility of HI of PRX-based double mutants to be examined in future studies.

This study was supported by grants from the Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Science, ICT, & Future Planning (Grant No.: RS-2023-00217064 and RS-2025-00553838); the New Breeding Technologies Development Program (Project No. RS-2024-00322297), funded by the Rural Development Administration, Republic of Korea; and the Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, and Forestry (IPET) through the Agriculture and Food Convergence Technologies Program for Research Manpower Development, funded by the Ministry of Agriculture, Food, and Rural Affairs (MAFRA) (Project No. RS-2024-00397026 and RS-2025-02263246).

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## Development of a Simulation Model for Greenhouse Heating Using an AI-Based Combined Heat Exchanger

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According to the International Energy Agency (IEA), global carbon dioxide emissions in 2024 reached 37.8 Gt, approximately 18.9 times the level recorded in 1900. In response, the South Korean government requires a 37.7% reduction in carbon emissions in the agriculture, livestock, and fisheries sector compared to 2018 levels, regarding the 2050 Carbon Neutrality Scenario. To overcome the intermittency of single renewable energy sources such as solar energy and maximize heating efficiency, this study developed an AI-based greenhouse heating simulation model for a combined heat source system incorporating a stable auxiliary heat source, specifically a wood pellet boiler. For the methodology, Ansys and TRNSYS were utilized to precisely simulate the physical behavior of the heat exchanger and the greenhouse, while an LSTM model was constructed to predict greenhouse temperatures. Simulation verification results demonstrated high reliability, with the greenhouse model achieving a Nash-Sutcliffe Efficiency (NSE) of 0.777 and the LSTM model showing a Mean Absolute Error (MAE) of 0.39°C. The study confirmed that a stable auxiliary heat source, such as a wood pellet boiler, is essential when utilizing highly volatile solar energy as the primary heat source. Ultimately, the integrated model applying AI-based predictive control was proven to maintain the target temperature more precisely than conventional control methods. This is expected to contribute to the operational optimization of smart farms for carbon neutrality and the reduction of initial investment risks.

**Keywords :** Greenhouse, Combined heat exchanger, Ansys, TRNSYS, LSTM (Long Short-Term Memory)

# ABSTRACT

## Session 2 \_ Student Short Talks

### Metabolomic Insights into Flavonoid Enrichment in the Cell Wall of Antarctic Moss

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Antarctic mosses have successfully adapted as the dominant vegetation across ice-free areas under extremely harsh polar conditions. Unlike vascular plants, mosses lack lignin; instead, they accumulate secondary metabolites such as flavonoids in their cell walls, effectively shielding them from environmental stresses like UV radiation. *Sanionia uncinata*, a predominant Pleurocarpous moss species in the maritime Antarctic, has been extensively used as an experimental model for studying environmental impacts on Antarctic plants. Despite its importance, the chemical mechanisms underlying its survival strategies remain poorly understood. In this study, we investigated *S. uncinata* to uncover its structural and chemical adaptation strategies. Transmission electron microscopy (TEM) analysis of the rhizoid revealed a marked increase in cell wall thickness during the winter season, suggesting that the accumulation of compounds within the cell wall is a key response to environmental stress. To investigate the chemical basis of this structural adaptation, we first analyzed the distribution patterns and relative abundances of cell wall-specific compounds in the extracts of *S. uncinata* using LC-MS/MS. Based on these profiles, we extracted and isolated an uncommon flavonoid derivative, and characterized its chemical structure using NMR analysis. This study provides new insights into the strategic accumulation of specific secondary metabolites within the cell walls of Antarctic mosses and highlights their critical role in survival and adaptation under extreme polar conditions.

**Funding:** This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. RS-2023-00212670).

## Reinforcement Learning-based Cooperative Manipulation for Dual-arm Agricultural Robot

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Traditional single-arm agricultural robots are designed for single tasks, limiting their ability to perform flexible tasks in complex agricultural environments. To solve these limitations, cooperative manipulation based on dual-arm robots is required, capable of effectively responding to agricultural tasks and environmental changes. This study proposes a reinforcement learning-based cooperative manipulation for dual-arm agricultural robots. The proposed method learns a cooperative policy for a dual-arm robot required for complex agricultural tasks by performing supervised learning-based behavior replication (BC) using state-action pairs extracted from human expert demonstration data. The pre-trained policies are further trained based on approximate policy optimization (PPO) and a reward function that reflects similarity with demonstration data, more accurately reproducing human-centered behavior in complex agricultural environments. In particular, the robot achieves more effective task performance by imitating coordinated behaviors such as removing obstacles with one arm while executing target actions with the other. The proposed approach addresses the limitations of existing agricultural robots and contributes to the advancement of smart agriculture.

# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## Pollen Wall Patterning in Rice

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Flowering-plant pollen displays remarkable diversity and species-specific surface ornamentation, a trait widely used in plant taxonomy. Yet how these lineage-specific patterns are generated remains poorly understood. The pollen wall is a specialized multilayered cell wall composed of a cellulose-rich intine and an outer exine that is highly chemically inert. The exine is mainly made of sporopollenin, an exceptionally resistant biopolymer derived from fatty-acid and phenolic precursors. These precursors are synthesized in the tapetum, transported to the microspore surface, and then assembled and polymerized.

Exine development is thought to initiate during the tetrad stage after meiosis. Three processes are considered pivotal for establishing exine architecture: formation and dissolution of the callose wall, deposition of the primexine (a transient matrix outside the microspore plasma membrane), and the synthesis, transport, and ordered assembly of sporopollenin. However, how these steps mechanistically instruct ornamentation—especially species-specific patterns—remains unclear.

Our previous work identified EPAD1, a sporocyte-derived lipid-binding protein in rice, as a key regulator of primexine component deposition. EPAD1 reshapes the spatial sites of sporopollenin deposition and polymerization, thereby altering final exine patterning. EPAD1 belongs to a Poaceae-specific clade of non-specific lipid transfer proteins, implying that different plant lineages may have evolved distinct mechanisms to sculpt exine patterns. More recently, we found that DPW4, a tapetum-secreted enzyme, modifies primexine pectin. Although *dpw4* mutants retain normal sporopollenin biosynthesis and transport, primexine organization is disrupted, leading to altered sporopollenin assembly and distinct pollen ornamentation. We propose that rice exine patterning is coordinately controlled by sporophytic and gametophytic inputs through precise regulation of primexine composition, structure, and deposition.



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### Research area

- Molecular mechanism of plant male reproduction impacts of environmental stress

### Work experience

- 2020 - Dean for Department of Genetics and Development, School of Life Science and technology, SJTU
- 2005 - 2020 Associate Professor and full Professor, School of Life Science and technology, SJTU
- 2000 - 2005 Assistant Professor, Agri-Tech Center of Shanghai Academy of Agricultural Sciences
- 1998 - 2005 Junior Research scientist, Agri-Tech Center of Shanghai Academy of Agricultural Sciences

### Education

- 2001 - 2007 Ph.D. of Genetics at Plant Molecular Genetics, Shanghai Institute of Plant Physiology and Ecology (SIPPE)
- 1995 - 1998 Master of Genetics at Plant Molecular Genetics, Shanghai Institute of Plant Physiology and Ecology (SIPPE)
- 1992 - 1996 Bachelor of Plant physiology at Nanjing University

### Representative publications

- Zhang J, Liu Z, Farrar EJ, Li M, Lu H, Qu Z, Chara O, Mitsuda N, Sakamoto S, Xue F, Shan Q, Yu Y, Li J, Zhu X, Zhu M, Shi J, Ogorek JP, Borges A, Bennett MJ, Liang W\*, Pandey BK\*, Zhang D, Persson S\*. Ethylene modulates cell wall mechanics for root responses to compaction. *Nature*, 2026. 649(8097):685-692
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# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## Maize seeds ‘NOT LIKE DAD’: insights into double fertilization and new breeding opportunities

Andrea Calhau, Laurine Gilles, Nathanaël Jacquier, Marina Millan-Blanquez, Naoya Sugi, Thomas Widiez Ph.D.  
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Sexual reproduction, through the mixing of maternal and paternal genomes, is widely regarded as a cornerstone of the evolutionary success of higher eukaryotes and forms the foundation of plant breeding. In flowering plants, this process relies on double fertilization, in which a pollen grain delivers two sperm cells that fuse with the egg cell and the central cell to form the seed. However, a maize line violates this rule: as a pollen donor, this so-called haploid inducer triggers embryo development in the complete absence of paternal genome contribution, a phenomenon known as in planta haploid induction. This process forms the foundation of doubled haploid (DH) technology, a transformative tool for crop improvement, and has recently gained renewed attention due to its potential to enable genome editing through simple crosses when haploid inducer line is combined with genome-editing machinery.

Our research aims to uncover the genetic basis of haploid induction and to elucidate the underlying molecular and cellular mechanisms. We previously identified the major causal gene responsible for haploid embryo induction in maize, which we named NOT-LIKE-DAD (NLD) (also known as matrilineal or phospholipase-A). Contrary to previous reports, we show that NLD is not a sperm cell protein but is expressed in the adjacent vegetative cell and specifically localizes to the peri-germ cell membrane (PGCM), a membrane that encloses the two sperm cells within the pollen grain. NLD association with the PGCM is mediated by lipid anchoring and electrostatic interactions, revealing an unanticipated mechanism for defining a specific polar domain in the pollen. Our analyses further show that the PGCM possesses a unique lipid composition, suggesting that it contributes to specialized functions. These findings position the PGCM as a previously overlooked regulatory interface controlling sperm cell function and paternal genome stability. We now aim to define the roles of the peri-germ cell membrane and to identify additional PGCM-resident proteins involved in plant reproduction. Collectively, our work establishes the PGCM as a key cellular determinants of pollen function, reshaping our understanding of plant reproduction and enabling new strategies for haploid induction.

Funding: The French National Research Agency projects: ANR-19-CE20-0012; ANR-22-PESV-003; The grant “HD-INNOV” from Région Auvergne-Rhône-Alpes; the ANRT (Association nationale de la recherche et de la technologie) with a the CIFRE fellowship grants: 2015/0777; 2019/0771; 2023/1284.



### Interdisciplinary Program in IT-Bio Convergence System

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### Research area

- Maize haploid induction and plant breeding
- Cellular biology functional genomics/ maize transformation and genome editing platform

### Work experience

- 2020 present Scientific Director, INRAE at ENS de Lyon, France
- 2013 - 2019 Research Scientist INRAE at ENS de Lyon, FRANCE
- 2012 EMBO Postdoctoral Fellow, University of Geneva, Switzerland
- 2010 - 2011 Post-Doc, Rutgers University, USA (collaboration with Freiburg University, GERMANY)
- 2006 - 2009 PhD in Plant Biology, Montpellier SupAgro, FRANCE

### Education

- 2018 Habilitation to Supervise Research (HDR) – highest French academic qualification, authorizing independent supervision of PhD students, ENS de Lyon, FRANCE
- 2006 - 2009 Ph.D. in Plant Biology, Montpellier SupAgro, FRANCE
- 1996 - 1998 Master of plant science Montpellier SupAgro, FRANCE

### Representative publications

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# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## Photosynthesis and Photoprotection: Molecular Adaptation Strategies of Plants to Fluctuating Light Conditions

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Sunlight is the ultimate energy source for plants, but its fluctuation in terms of quantity and quality is a major source of stress. Therefore, optimizing the balance between efficient light-harvesting for photosynthesis and energy dissipation to prevent photooxidative damage is critical to the survival of photosynthetic organisms in fluctuating light environments. Green plants maintain this balance through the sophisticated regulation of their light-harvesting systems, composed primarily of light-

harvesting complex II (LHCII). In this talk, I will introduce a new dimension of the regulation mechanisms by which light-harvesting systems optimize this balance through a multidisciplinary approach integrating biochemistry, biophysics, and network science.

First, I will discuss how the coexistence and distribution of chlorophyll a and b within the LHCII fine-tune the energy transfer network to optimize both efficient light-harvesting and photoprotection, investigated by quantum mechanics-based network analysis.

Expanding this view to the protein level, I will discuss how protein-protein interactions regulate light-harvesting properties through the light-dependent arrangement of the PSII semi-crystalline array and their role in regulating light-harvesting and photoprotection.

I expect these findings broaden our understanding of the diverse molecular adaptation strategies that enable plants to thrive in fluctuating light environments.

### Funding :

This work was supported by the Japan Society for the Promotion of Science (JSPS) KAKENHI, grants 23K14216 and 23H04960, and Takeda Science Foundation.



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### Research area

- Light-harvesting systems · Microspectroscopic study
- Application of spectroscopic techniques to plant study · Computational/mathematical analysis

### Work experience

- 2025 - Current Assistant Professor, Nihon University, Japan
- 2021 - 2025 Assistant Professor, National Institute for Basic Biology, Japan
- 2019 - 2021 Designated Assistant Professor, Nagoya University, Japan
- 2016 - 2019 National Institute for Basic Biology (NIBB) Research fellow, National Institute for Basic Biology, Japan JSPS

### Education

- 2009 - 2015 Ph.D. in Science, Department of Energy Science, Sungkyunkwan University
- 2006 - 2009 Bachelor of Science (Graduating a semester early), Department of Physics, Daejin University

### Representative publications

- M Dann, E Kim\*, K Fujimura-Kamada, V Berisha, M Nomura, A-C Pohland, M Watanabe, M Ostermeier, F Sommer, M Schroda, S-Y Miyagishima, J Minagawa (2025) "CurT/CURT1 proteins are involved in cell and chloroplast division coordination of cyanobacteria and green algae" *Nature Communications*, 16 (8424)
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# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## Engineering Oilseed Crops for Next Generation C10 Rich Oils for Bioenergy

Jinhoon Jang Ph.D. and Edgar Cahoon

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As global demand for renewable and sustainable energy sources continues to grow, decanoic acid (C10) has emerged as an attractive medium-chain fatty acid (MCFA) for next-generation biofuels. However, most conventional oilseed crops naturally accumulate only limited amounts of C10-rich oils, and this limitation remains a major unresolved challenge for biological production systems. This study aims to explore metabolic engineering strategies to promote C10 accumulation in oilseed crops and to outline research directions for overcoming the structural and metabolic constraints associated with current approaches. To this end, we leverage genetic components derived from the genus *Cuphea*, which is known for its natural ability to produce MCFA-enriched seed oils. In particular, we focus on the sequential processes characteristic of *Cuphea* lipid metabolism, including fatty acid synthesis, chain termination and release mediated by thioesterase, and subsequent triacylglycerol assembly and storage driven by acyltransferases. By examining the coordinated regulation across these steps, this work seeks to identify key features that enable efficient C10 accumulation. Through this approach, we aim to establish metabolic engineering design strategies for the future development of oilseed crops capable of producing high-purity C10-rich oils, providing a solid foundation for sustainable bioenergy production.

**Funding:** This research was supported by the DOE Office of Science, Biological and Environmental Research (BER) Program, grant no. DE-SC0023142.



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### Research area

- Metabolic engineering of plant lipid biosynthesis
- Molecular mechanisms of plant haploid induction

### Work experience

- 2025 - Current Postdoc/University of Nebraska-Lincoln
- 2023 - 2025 Postdoc/Chonnam National University

### Education

- 2019 - 2023 Ph.D of Agriculture at Department of Applied Plant Science, Chonnam National University
- 2017 - 2019 Master of Agriculture at Department of Applied Plant Science, Chonnam National University
- 2011 - 2017 Bachelor of Engineering at Department of Biotechnology and Bioengineering, Chonnam National University

### Representative publications

- Jang JH, Bayaraa U, Lee JH, Lee OR. (2025). Overexpression of the patatin-related phospholipase A gene, PgpPLAIII $\beta$ , in ginseng adventitious roots reduces lignin and ginsenoside content while increasing fatty acid content. *Plant Physiology and Biochemistry*. 217:109260
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# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## Plant strategies to cope low phosphorus conditions by root functions

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Phosphorus (P) is a major essential element for plants, and one of the most severe limiting factors for growth. For rock phosphate, which is the most important source of P fertilizers, concerns such as resource depletion, quality degradation, and geopolitical imbalances prevail. On the other hand, an excessive usage is also a risk to the environment. Reducing the amount of P used in agriculture may be an important solution to the global P crisis because the agricultural use of P is the most abundant among human activities.

Plants have developed numerous strategies to cope with P-deficient conditions, such as the efficient use of internal plant P and the mobilization of P in soils, to grow in environments with low P availability. To obtain P from unavailable forms, plants can release a certain amount of carboxylates and phosphatases from their roots into the rhizosphere. Some low P-tolerant plants can form specialized root structures with “root clusters” to increase their root surface area, contributing to P acquisition. In certain groups of dicotyledonous plants, such as Proteaceae and Fabaceae, including white lupin (*Lupinus albus* L.), bottlebrush-like structures with dense and short rootlets are formed on secondary roots, as so-called “cluster roots” or “proteoid roots.” Certain groups of monocotyledonous plants also form unique root structures, such as “dauciform roots” or “capillaroid roots,” which have long and dense root hairs on their lateral roots. These root clusters not only increase the root surface area to stimulate P uptake efficiency but also strengthen P mobilization functions through the exudation capacities of carboxylates and phosphatases.

In this symposium, I will introduce plant P mobilization functions via root functions and the specified mechanisms of low-P tolerance in root-cluster-forming plants. The significance of plants with root clusters in natural environments is discussed from an ecological viewpoint. The capacity of root functions to be applied to agriculture through molecular biology is also discussed.

Funding: This work was supported in part by Grant-in-Aids from JSPS and by a research project from MAFF.



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### Work experience

- Editor of “Soil Science and Plant Nutrition” (2009.10 - 2013.09/ 2019.10 - 2025.09)
- Associate Editor of “Plant and Soil” (2019 - present)
- Division Director, Green Innovation Division, Seto Inland Sea Carbon-neutral Research Center, Hiroshima University, Japan (2023.04 - present)
- Vice Dean for Education, Graduate School of Integrated Sciences for Life, Hiroshima University, Japan (2019.04 - 2020.03)
- Professor, Graduate School of Integrated Sciences for Life, Hiroshima University, Japan (2016.04 - present)
- Associate Professor, Hokkaido and Hiroshima University, Japan (2004.02- 2016.03)

### Education

- 1996 - 1999 Ph.D., Graduate School of Agriculture, Hokkaido University, Japan
- 1994 - 1996 Master of Agriculture, Graduate School of Agriculture, Hokkaido University, Japan
- 1990 - 1994 Bachelor of Agriculture, Faculty of Agriculture, Shizuoka University, Japan

### Representative publications

- Hanashiro, K., Nishida, S., Enomoto, T., Yin, Y.-G., Suzui, N., Miyoshi, Y., Noda, Y., Enomoto, K., Kawachi, N., Unno, Y., Maruyama, H., Maruo, A., Kan, A., Shinano, T., Wasaki, J. (2026) Genome-wide identification of genes associated with enhanced carbon secretion in cluster roots of *Lupinus albus* L. *Plant and Cell Physiology*, 67(1), 30-38. doi: 10.1093/pcp/pcaf127
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# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## From Biomass to Devices: Sustainable Nanocellulose-Based Materials Design for Advanced Electronics and Environmental Systems

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The accelerating accumulation of electronic waste (e-waste) driven by expanding electronics usage and short device life-cycles has exposed critical sustainability challenges in conventional petroleum-based materials. In 2022, global e-waste production reached a record ~62 million tonnes and is projected to exceed ~82 million tonnes by 2030, with advances in artificial intelligence (AI) expected to contribute an additional 1.2–5 million tonnes of e-waste by 2030 under current trends. Biomass-derived polymers, particularly cellulose, offer a promising alternative due to their abundance, biodegradability, mechanical robustness, and versatile surface chemistry. This study introduces material design strategies for integrating various active materials such as conductive polymers, metal nanostructures, and carbon materials into a cellulose matrix to enable tailored functionalities. Through such integration, multifunctional architectures are systematically engineered with controlled porosity, interfacial interactions, and hierarchical structures, enabling tunable electrical, optical, and photothermal properties while maintaining mechanical flexibility and process compatibility. The resulting materials demonstrate broad applicability across advanced electronics, energy storage systems, and environmental applications, including flexible electrodes, sensors, supercapacitors, and solar-driven desalination platforms. This work highlights how nanocellulose-based materials design can serve as a versatile and sustainable foundation for next-generation functional systems, offering a pathway from renewable biomass to practical, high-value devices.

**Keywords:** sustainable materials, cellulose, nanocomposites, flexible electronics, energy & environmental systems



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### Research area

Developing advanced material systems for various electronics, energy-storage device, biomedical & nano-bio applications

### Work experience

- 2019 - 2022 Technical Research Personnel, Research Group for Nanocatalysts (RGN) and Chemical and Process Technology Division, Korea Research Institute of Chemical Technology (KRICT), South Korea
- 2024 - 2025 Composites & Convergence Materials Research Division, Korea Institute of Materials Science (KIMS), South Korea

### Education

- B.S., Department of Plant & Environmental New Resources, Kyung Hee University, South Korea
- Ph.D., Department of Plant & Environmental New Resources, Kyung Hee University, South Korea
- Post - Doctoral Fellow, NanoScience Technology Center, University of Central Florida (UCF), USA

### Representative publications

- Suji Lee, Kangyun Lee, Youngho Jeon, Yuri Seo, Seohyun Park, Youngsang Ko\*, Jungmok You\*, "Nanocellulose-MOF-Derived Carbon Hybrid Aerogels with Hierarchical Micro/Nanostructures for Solar-Driven Water Evaporation", *Advanced Science*, 2026, 13, e16158
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# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## Designing Hydrophobic Lignin Materials Across Dimensions: From Colloidal Particle Coatings to Functional 2D Films

Kwang Ho Kim Ph.D.

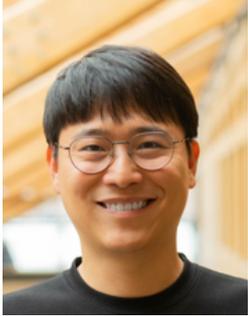
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Lignin, one of the most abundant renewable polymers on Earth, remains largely underutilized in functional materials due to its structural complexity and limited processability. This seminar presents a materials-design framework for transforming technical lignin into hydrophobic surfaces and films across multiple length scales, from colloidal particle coatings to continuous two-dimensional (2D) films.

At the molecular level, lignin is chemically modified through fatty-acid grafting to reduce hydroxyl density and introduce hydrophobic interactions, enabling tunable surface energy while preserving lignin's aromatic backbone. When structured into colloidal particles, the modified lignin can be processed into waterborne coatings that simultaneously impart strong water repellency and mechanical reinforcement to porous substrates, demonstrating compatibility with scalable, solvent-minimized coating technologies.

Extending this design strategy to planar materials, lignin is integrated into biodegradable polymer matrices to form fully renewable 2D films. By combining intrinsic chemical hydrophobicity with controlled surface structuring, including plasma-induced topographical features, these films achieve high water contact angles without relying on fluorinated additives or inorganic fillers. Molecular-scale simulations and experimental characterization collectively reveal how hydrophobic chain length, interfacial interactions, and surface morphology govern macroscopic wetting behavior and mechanical performance.

Together, these case studies illustrate how lignin's chemistry, morphology, and dimensionality can be jointly engineered to create functional, sustainable hydrophobic materials. The work highlights lignin's potential as a platform material for next-generation coatings and films in packaging, surface protection, and bio-based manufacturing.



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### Research area

- Green processing for biomass conversion
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- Biomass chemistry

### Work experience

- Assistant Professor, Department of Wood Science, UBC (2024 – present)
- Senior / Principal Researcher, Clean Energy Research Center, Korea Institute of Science and Technology (2017 – 2024)
- Postdoc, Sandia National Laboratories / Joint BioEnergy Institute (2015 – 2017)

### Education

- 2011 - 2015 Ph.D. Department of Agricultural and Biosystems Engineering, Iowa State University
- 2009 - 2011 MS. Environmental Materials Science, Seoul National University
- 2003 - 2009 BS. Environmental Materials Science, Seoul National University

### Representative publications

- Lignification-mimetic dehydrogenative diphenoquinone synthesis and electrochemical CO<sub>2</sub> capture, Green Chemistry, 2026
- Hydrophobic and mechanically reinforcing coatings from palmitoylated lignin via waterborne spraying, Green Chemistry, 2026
- Decarboxylation of Hydroxybenzoic Acids to Phenol via Deep Eutectic Solvents, Chemsuschem, 2024
- Performance-enhanced eco-friendly triboelectric nanogenerator via wettability manipulation of lignin, Ecomat, 2023
- Catalytic conversion of waste corrugated cardboard into lactic acid using lanthanide triflates, Waste Management, 2022
- One-pot conversion of engineered poplar into biochemicals and biofuels using biocompatible deep eutectic solvents, Green Chemistry, 2022
- Integration of renewable deep eutectic solvents with engineered biomass to achieve a closed-loop biorefinery, PNAS, 2019

# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## Inter-species differences in domain architecture of cellulose and chitin hydrolases revealed by single-molecule measurement

Akihiko Nakamura Ph.D.

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Cellulose, the major component of plant cell walls, and chitin, a key structural polymer in fungal cell walls and arthropod exoskeletons, are hydrolyzed by processive glycoside hydrolases (GHs) that must repeatedly bind to and dissociate from insoluble crystalline surfaces. Here, we present a single-molecule kinetic framework to reveal how polysaccharide-degrading enzymes are “designed” according to the habitats and lifestyles of the organisms that produce them.

The bacterial GH6 cellobiohydrolase CfCel6B from *Cellulomonas fimi* and the fungal GH6 cellobiohydrolase TrCel6A from *Trichoderma reesei* classified to the same GH6 family, yet their domain architectures differ. CfCel6B contains a cellulose-binding domain (CBD) from carbohydrate-binding module family 2 (CBM2) and a fibronectin type III-like linker region, whereas TrCel6A carries a CBM1 and a glycosylated linker. Single-molecule fluorescence imaging showed that the CBD of CfCel6B primarily increases the association rate constant ( $k_{on}$ ), while the glycosylated linker of TrCel6A contributes to surface binding kinetics and the CBM1 mainly enhances binding specificity. These differences suggest that fungal GH6 enzymes exploit linker glycosylation to optimize cellulose degradation.

We further examined the marine GH18 chitinase VpChi1 from *Vibrio parahaemolyticus*, which contains an additional binding domain compared with chitinases from terrestrial bacteria. Full-length VpChi1 shows markedly prolonged residence on crystalline chitin, with a slow dissociation rate constant ( $k_{offslow}$   $0.049\text{ s}^{-1}$ ) that is ~5-fold lower than that of a CBD-truncated variant ( $k_{offslow}$   $0.25\text{ s}^{-1}$ ). Kinetic simulations using the experimentally determined dissociation rates support a CBD-assisted rebinding mechanism that enhances effective chitin degradation under extremely low substrate concentrations, as encountered in the ocean.

Together, these results demonstrate that direct single-molecule measurements of binding and dissociation rate constants provide a quantitative basis for linking enzyme domain architecture to ecological constraints, explaining how microorganisms tailor polysaccharide-degrading enzymes for efficient resource acquisition in distinct environments.

Funding:

This work was supported by the MEXT Leading Initiative for Excellent Young Researchers program (to A.N.), JSPS KAKENHI Grant JP19H03094 (to A.N.), JST FOREST Program Grant JPMJFR210C (to A.N.), and MEXT/JSPS Grants-in-Aid for Scientific Research (15H06898 and 19H03094 to A.N).



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### Research area

- Enzymology
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- Professor, Green Science and Technology at Shizuoka University
- Tenure-Track Associate Professor, Faculty of Agriculture at Shizuoka University
- Assistant Professor, Institute for Molecular Science, National Institutes of Natural Sciences
- Institute for Molecular Science, National Institutes of Natural Sciences
- JSPS Postdoctoral Fellow (PD), Graduate School of Agricultural and Life Sciences, The University of Tokyo

### Education

- 2011 - 2014 Ph.D. in Agriculture Graduate School of Agricultural and Life Sciences, University of Tokyo
- 2009 - 2011 Master of Agriculture at Graduate School of Agricultural and Life Sciences, University of Tokyo
- 2005 - 2009 Bachelor of Agriculture at Faculty of Agriculture, University of Tokyo

### Representative publications

- Development and Production of Moderate-Thermophilic PET Hydrolase for PET Bottle and Fiber Recycling, Takashi Matsuzaki, Toshiyuki Saeki, Fuhito Yamazaki, Natsuka Koyama, Tatsunori Okubo, Daiki Hombe, Yui Ogura, Yoshihito Hashino, Rie Tatsumi-Koga, Nobuyasu Koga, Ryota Iino, Akihiko Nakamura, ACS Sustainable Chemistry & Engineering 2025, 10.1021/acssuschemeng.5c01602
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# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## Quantification of Environmental Chemicals

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School of Interdisciplinary Forensics

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The accurate quantification of environmental chemicals is essential for assessing environmental contamination, human exposure, and associated health and ecological risks. Chromatography–mass spectrometry (CMS) systems, including liquid chromatography–mass spectrometry (LC–MS) and gas chromatography–mass spectrometry (GC–MS), have become the gold standard analytical platforms for the determination of trace-level contaminants in complex environmental matrices. These techniques provide high sensitivity, selectivity, and structural specificity, enabling the reliable analysis of a wide range of chemical classes such as pesticides, pharmaceuticals, industrial chemicals, and emerging contaminants. In this study, a comprehensive chromatographic–mass spectrometric approach was developed and validated for the quantitative determination of target environmental chemicals in representative matrices, including water, soil, and sediment samples. Sample preparation procedures were optimized to minimize matrix interferences and enhance analyte recovery, while chromatographic conditions were tailored to achieve adequate retention and resolution based on analyte physicochemical properties. Quantification was performed using matrix-matched calibration and internal standard correction to account for matrix effects and instrumental variability. Method validation was conducted in accordance with established regulatory and international guidelines, evaluating selectivity, linearity, accuracy, precision, limits of detection and quantification, matrix effects, and analyte stability. The validated method demonstrated excellent linearity ( $R^2 \geq 0.99$ ), acceptable recoveries (70–130%), and reproducible precision ( $\leq 20\%$  RSD) across relevant concentration ranges. Limits of detection at low ng/L or ng/g levels highlight the suitability of the CMS approach for trace environmental analysis. Overall, this work underscores the robustness and versatility of chromatography–mass spectrometry systems for the quantitative analysis of environmental chemicals and supports their continued application in environmental monitoring, regulatory compliance, and exposure assessment studies

Funding: RS-2021-NR057465: 목질계 바이오매스 기반 단량체 고도화 및 신규 바이오플라스틱 제조기술 개발

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- Assistant Professor at Arizona State University
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- 2011 - 2014 Ph.D. in Agriculture Graduate School of Agricultural and Life Sciences, University of Tokyo
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- 2007 - 2012 Bachelor of Science, Michigan State University

**Representative publications**

- Min Jang, Minkyung Lee, Seonghyun Chung, Seul-A Park, Huijeong Park, Hyeonyeol Jeon, Jonggeon Jegal, Sung Bae Park, Dongyeop X Oh, Giyoung Shin, Hyejeong Kim. 2024 Ecotoxicity assessment of additives in commercial biodegradable plastic products: Implications of sustainability and environmental risk. *Science of the Total Environment*. 931172903
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# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## Agricultural Plastics and Climate Change: Solution or Problem?

Davey Jones Ph.D.

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Climate change is intensifying agricultural challenges through increased drought frequency, temperature extremes, and unpredictable rainfall patterns. Plastic film mulches (PFMs) offer substantial climate adaptation benefits: conserving water, regulating soil temperature, and protecting crops against weather extremes. Globally, 12.5 million tonnes of agricultural plastic are used annually, with China's PFM deployment alone saving 35 billion m<sup>3</sup> of water while feeding 85 million additional people through increased yields. As climate pressures intensify, such technologies will become increasingly essential for food security.

However, concerns about microplastic accumulation, soil contamination, and additive leaching have raised critical questions about long-term sustainability. Are we solving one environmental crisis while creating another? This presentation synthesises findings from the UKRI-GCRF AgriPlastics project, which conducted multi-year field experiments across contrasting climate zones to assess real-world impacts on soil health, crop productivity, and environmental quality. Results from realistic field applications challenge common assumptions, showing that many studies overstate environmental risks, with negative effects typically observed only at atypically high concentrations.

The evidence suggests agricultural plastics can be an integral part of climate-smart agriculture if managed properly. The goal should be 'zero plastic leakage, not zero plastic use', focusing on sustainable deployment, material innovation, and proper waste management rather than abandoning a critical adaptation technology when farmers need it most.

Reference: Wang, K., Liu, X., Chadwick, D.R., Yan, C., Reay, M., Ge, T., Ding, F., Wang, J., Qi, R., Xiao, M., Jiang, R., Chen, Y., Ma, J., Lloyd, C., Evershed, R.P., Luo, Y., Zhu, Y., Zhang, F., Jones, D.L. (2025). The agricultural plastic paradox: Feeding more, harming more?. *Environment International* 198, 109416. <https://doi.org/10.1016/j.envint.2025.109416>

Funding: This research was supported by the UKRI Global Challenges Research Fund (GCRF) and the UK Natural Environment Research Council project, "Do agricultural microplastics undermine food security and sustainable development in less economically developed countries?" under [grant number NE/V005871/1].

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- 2018 - 2024 Professor in Soil Science, Murdoch University, Australia
- 2003 - 2008 Senior Lecturer in Applied Ecology, College of Natural Science, Bangor University
- 1996 - 2003 Lecturer in Applied Ecology, School of Agric. & Forestry, Bangor University, UK
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BS Soil Science. Department of Soil Science, Aberdeen University 1986-1990

PhD Rhizosphere Carbon Flow. Dep't of Plant Sciences, University of Oxford 1990-1993

**Representative publications**

- George, P., Lallias, D., Creer, S., Seaton, F., Kenny, J., Lebron, O., Emmett, B., Robinson, D., Jones, D.L., 2019. Divergent national-scale trends of microbial and animal biodiversity revealed across diverse temperate soil ecosystems. *Nature Communications* 10, 1107
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# ABSTRACT

Session 3 \_ Invited Lectures (VOD)

## Multimodal Artificial Intelligence and Applications

Ha Young Kim Ph.D.

Recently, artificial intelligence systems such as ChatGPT have rapidly become integrated into everyday human life, reshaping the way people interact with information and technology. While traditional AI algorithms were primarily developed based on a single modality, such as text or visual data, recent advances have shifted toward algorithms that can process and reason over multiple modalities simultaneously—seeing, listening, reading, and acting—in a more human-like manner. This talk introduces the fundamental concepts of multimodal learning and explains why multimodal artificial intelligence is crucial for building more robust, flexible, and context-aware AI systems. We further discuss key technical challenges in multimodal AI, including cross-modal representation learning, alignment, and fusion, and highlight representative real-world applications across diverse domains, including smart agriculture.

**Interdisciplinary Program in IT-Bio Convergence System**

**Ha Young Kim Ph.D.**

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**Research area**

- Multimodal Deep Learning · Computer Vision · Financial Artificial Intelligence

**Work experience**

- 2024 ~ Present Vice Dean, Graduate School of Information, Yonsei University
- 2019 ~ Present Associate Professor, Graduate School of Information and Adjunct, AI+X, Yonsei University
- 2016 - 2019 Assistant Professor, Ajou University
- 2011 - 2016 Researcher, Samsung Advanced Institute of Technology, Samsung Electronics
- 2010 - 2011 Visiting Lecturer, Indiana University Northwest

**Education**

- 2010, Ph.D. Department of Mathematics, Purdue University
- 2007, M.S. Department of Mathematics with Computational Finance, Purdue University
- 2000, B.S. Department of Mathematics, Kyung Hee University

**Representative publications**

- Jongseong Bae †, Junwoo Ha †, Jinnyeong Heo †, Yeongin Lee †, Ha Young Kim\*, “Towards Temporal Fusion Beyond the Field of View for Camera-based Semantic Scene Completion,” AAAI Conference on Artificial Intelligence (AAAI 2026), 2026
- Sungsoo Kim †, Hyukjae Kwon †, Jisang Yoon, Ha Young Kim\*, “Dynamic Factor-Informed Reinforcement Learning for Enhancing Portfolio Optimization,” Financial Innovation, 2026
- Kisu Lee, Young Jin Kim, Minkyong Kim, Ha Young Kim\*, “Hierarchical Multi-modal Fusion Architecture Search for Stock Market Forecasting”, Applied Soft Computing, 2025
- Jungeun Kim †, Hyeongwoo Jeon †, Jongseong Bae, Ha Young Kim\*, “Leveraging the Power of MLLMs for Gloss-Free Sign Language Translation,” International Conference on Computer Vision, 2025
- Jeongmin Yu †, Susang Kim †, Kisu Lee, Taekyoung Kwon, Won-Yong Shin, Ha Young Kim\*, “Multi-View Slot Attention Using Paraphrased Texts for Face Anti-Spoofing,” International Conference on Computer Vision, 2025
- Jeongeun Park, Changhoon Oh, Ha Young Kim\*, “AI vs. Human-Generated Content and Accounts on Instagram: User Preferences, Evaluations, and Ethical Considerations,” Technology in Society, 2024

**2026 5<sup>th</sup> FOUR**  
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AI로 여는 IT-BIO 융합 스마트농업 : 생산·재배·생명과학의 현장 적용