DAESUNG HAEGANG
MICROBES FORUM

Program

12:00 - 13:00 **Registration & Reception**

13:00 - 13:05 **Opening**

13:05 - 13:20 **Congratulatory Speeches**
Sung-Chul Shin President, KAIST
Jin-Won Lee Director, The C1 Gas Refinery R&D Center
Se-Jung Oh Member, The National Assembly of the Republic of Korea

13:20 - 13:40 **Scene Setting Speech**
Younghoon David Kim Chairman and CEO, Daesung Group
Chair, World Energy Council

13:40 - 15:20 **Presentations**
Philippe Soucaille, INSA, UIniversity of Toulouse, France
Michael Koepke LanzaTech, USA
Eun-Yeol Lee Kyung Hee University, Korea
Chen Yang CAS, China
Gyoo-Yeol Jung POSTECH, Korea

15:20- 15:35 Coffee Break

15:35 - 16:35 **Panel Discussion**
"From Waste to Energy", is it really coming to us?
Moderator: Byung-Kwan Cho KAIST, Korea
Panelists: Gyoo-Yeol Jung, Michael Koepke, Eun-Yeol Lee, Chen Yang, Philippe Soucaille

16:35 - 17:20 **Young Scientists Presentations**
Dong-Hyuk Kim UNIST, Korea
Sang-Woo Seo Seoul National University, Korea
Suk-Hwan Yoon KAIST, Korea

17:20 - 17:30 **Wrap up**

DAESUNG HAEGANG
MICROBES FORUM

Young Scientists Presentations

Young Scientists Presentations

Technology on artificial bacteria to produce bioenergy

Dong-Hyuk Kim
UNIST, Korea

Fossil fuels are a finite resource, which necessitated developing renewable energy sources. Bioenergy became one of powerful renewable energy sources with recent advances in synthetic biology encompassing systems biology and metabolic engineering. This enable us to engineer and/or create tailor made microorganisms to produce alternative biofuels for the future bio-era. The efficient transformation of biomass to bioenergy requires maximum performance of cellular metabolism to be designed and engineered. Toward this end, investigation of bacterial metabolism with artificial bacteria with systems biology became one of powerful tools. Here, how systems biology advances metabolic engineering for bioenergy production will be covered. In addition, how machine learning technology can help with understanding metabolic regulation in bacteria will be also discussed.

Department of Chemical Engineering,
School of Energy and Chemical Engineering, UNIST, Korea

From waste to energy by synthetic microbes

Sang-Woo Seo
Seoul National University, Korea

The growing interest in the bio-based industry as an alternative production route has given rise to numerous efforts to redesign existing biological systems or synthesize new ones. Imagined to build a system, we require various molecular parts/tools and also need insights based on the understandings how to assemble the subset or entire biological systems to actually exhibit specific functions. The former can be achieved by "Synthetic Biology" approach (bottom-up) and the later can be achieved by "Systems Biology" approach (top-down). The coordination between these two approaches is mandatory to effectively achieve the goals in this field. In typical industrial bioprocesses, freshwater is used as a major component of medium for culturing microorganisms. In order to avoid contamination, sterilization of freshwater is required by using intensive thermal energy under high pressure. Thus, osmolality of seawater as a selection pressure could be one of the most attractive options to reduce the process cost. From these aspects, if marine microbes can perform similar or better than conventional microbes, we can utilize seawater rather than freshwater as culturing medium. Therefore, the process can be free from contamination issue, resulting in reduction of the operational costs. In addition, there are ongoing global issues for waste treatment such as microplastics, crab shells, and non-edible seaweeds; thus, eco-friendly process is required to solve these problems. Our vision is to revolutionize current paradigms of the industrial bioprocess becoming more cost-efficient, highly-productive, and environmentally-sustainable. In this talk, I will describe how this can be achieved by synthetic microbes.

School of Chemical and Biological Engineering, Seoul National University, Korea

Engineering environmental microbiomes for control of greenhouse gas emissions

Suk-Hwan Yoon
KAIST, Korea

A large fraction of global greenhouse emissions originates from use of nitrogen (N) fertilizers in the agricultural sector. Energy consumed in production of N fertilizer accounts for an estimate of 1-2% of global energy consumption, which translates to CO2eq emissions of 0.5-1 Pg/year. Surprisingly large portion of applied N fertilizers is lost via microbially catalyzed nitrogen transformation reactions, namely nitrification and denitrification, necessitating excessive use of fertilizers. These microbial reactions also release nitrous oxide (N2O), a potent greenhouse gas with ~320 times higher global warming potential than CO2. Although turnover of N fertilizers amounts to approximately 50-60% of the global N2O sources, this N2O source is not controllable with conventional physicochemical approaches. The only solution to these N dilemmas can be found in microbial ecology. The soil nitrogen cycling can be manipulated for more efficient use of fertilizers. Blocking of nitrification may be one of the solutions; dissimilatory nitrate reduction to ammonium (DNRA) competing with denitrification may be able to be stimulated to outcompete denitrification, recycling nitrate back to ammonium for enhanced nitrogen retention in soil and increased fertilizer efficiency; and high-affinity N2O reducing population can be established in the soil microbial community for enhanced consumption of N2O produced in situ, limiting its release to the atmosphere. At the Environmental Microbiology Laboratory, we are striving to better understand the microbial nitrogen cycling and develop such microbiome engineering techniques with the conviction that developing sustainable management of soil nitrogen with minimal impact to climate change is key to a sustainable future of the human race.

Department of Civil and Environmental Engineering, KAIST, Korea

DAESUNG HAEGANG
MICROBES FORUM

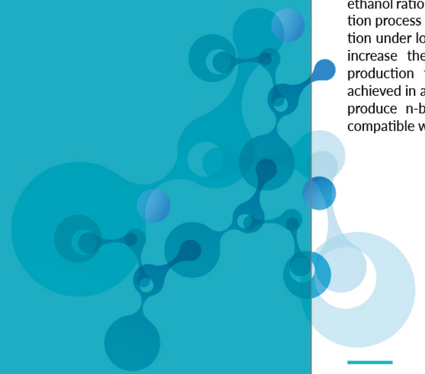
From Waste to Energy

DAESUNG GROUP

Hosted by Daesung Haegang Science and Culture Foundation
Co-organized by KAIST | Intelligent Synthetic Biology Center | C1 Gas Refinery R&D Center
Sponsored by Daesung Group | Korean Society for Microbiology and Biotechnology

DAESUNG HAEGANG
MICROBES FORUM

From Waste to Energy



Presentations

Reviving the Weizmann process for commercial n-butanol production

Philippe Soucaille
INSA, University of Toulouse, France

The industrial production, by Clostridium acetobutylicum, of n-butanol for use as both a chemical and an alternative transportation fuel, is not currently economical due to low yield, titer and productivity. We used an advanced metabolic engineering approach to engineer C. acetobutylicum to produce n-butanol from glucose at a high yield: the deletion of genes encoding unwanted pathways was combined to the debottlenecking of the n-butanol pathway for maximizing both the yield of alcohol production and the n-butanol to ethanol ratio. We also designed a new continuous fermentation process using i) in situ extraction of alcohols by distillation under low pressure and ii) high cell density cultures to increase the titer, yield and productivity of n-butanol production to levels that have never been previously achieved in any organism. This process provides a means to produce n-butanol at performance levels that are now compatible with a commercial process.

Professor at the INSA, University of Toulouse, France
Professor of Synthetic Biology at the University of Nottingham, UK
Chief Technology Officer of Metabolic Explorer

An integrated, multi-scale gas fermentation platform for commercial-scale production of fuels and chemicals from low cost feedstocks

Michael Koepke
LanzaTech, USA

LanzaTech has developed a fully integrated gas fermentation platform for commercial-scale production of fuels and chemicals from sustainable low cost feedstocks. Using this platform, production of over 50 different molecules has been demonstrated directly from a diverse range of feedstock options including waste gases from industrial sources (e.g., steel mills and processing plants) or syngas generated from any biomass resource (e.g., agricultural waste, municipal solid waste, or organic industrial waste). The process has been successfully scaled up from the laboratory bench through in-lab and in-field pilot and demonstration units to first 48k MTA commercial units. At the heart of the process is an acetogenic microbe Clostridium autoethanogenum capable of autotrophic growth on a range of low cost C1 substrates such as carbon monoxide (CO) and/or CO2. LanzaTech has developed a highly efficient platform strain and an advanced strain engineering platform to expand the product portfolio beyond native products ethanol and 2,3-butanediol. Not even than 10 years ago, acetogenic bacteria have been considered genetically inaccessible and were poorly characterized. LanzaTech has since developed gene editing methods, extensive libraries of genetic parts and high-throughput methods. This effort is complemented by computer-aided design algorithms and metabolic and process models that are highly integrated and validated against hundreds of continuous fermentation runs and strain lines. Proprietary, scalable reactor designs and optimized process chemistry, ensure efficient, continuous, single-pass gas conversion with a high selectivity to the product of interest.

Director, Team Leader, Synthetic Biology, LanzaTech, USA

Microbiological conversion of methane green house gas to biofuels and chemicals

Eun-Yeol Lee
Kyung Hee University, Korea

Methane gas has ambilaterality. It is waste gas, 25 times more potent than carbon dioxide as green house gas that needs to be mitigated. On the contrary, it is considered as next-generation carbon feedstock for biomanufacturing of biofuels and value-added chemicals due to its huge abundance, low price and high degree of reduction. Methane waste gas can be microbiologically converted to biofuels and chemicals using methanotrophs as a biocatalyst. Methanotrophs are proteobacteria that utilize methane as a sole carbon and energy source. In the first step of methane assimilation, methane is oxidized to methanol by methane monooxygenase such as soluble methane monooxygenase (sMMO) and particulate methane monooxygenase (pMMO). The expression of sMMO can be regulated by the concentration of copper ion. pMMO is imbedded in intercytoplasmic membrane. The methanol is converted to formaldehyde by methanol dehydrogenase, and the formaldehyde is assimilated into biomass through ribulose monophosphate pathway (RuMP cycle) or serine pathway (serine cycle). In general, type I methanotrophs utilize RuMP cycle, and type II methanotrophs have serine cycle. Wild-type methanntrophic whole cells have been used as the biocatalyst for the production of methanol from methane. However, wild-type methanotrophs cannot be employed as the biocatalyst for the production of non-natural products such as various biofuels and platform chemicals. In order to convert methane to such target products, methanotroph strains need to be metabolically engineered. In this presentation, recent progresses on microbiological conversion of methane waste gas to biofuels and chemicals will be presented and discussed.

Professor of Chemical Engineering, Kyung Hee University, Korea

Toward a photoautotrophic cell factory for terpenoid production

Chen Yang
CAS, China

Terpenoids are used in diverse markets as pharmaceuticals, nutraceuticals, cosmetics, and disinfectants. The simplest terpene, isoprene, is a key building block of synthetic rubber and currently produced entirely from petrochemical sources. To produce isoprene directly from CO2, we engineered the isoprene biosynthetic pathway in the cyanobacterium Synechococcus elongatus, with guidance provided by dynamic flux analysis and metabolite profiling. The methylerythritol phosphate (MEP) pathway was selected for cyanobacterial isoprene synthesis based on comparison of carbon efficiency and precursor driving force between MEP pathway and mevalonate (MVA) pathway. The engineered strain directed about 40% of photosynthetically fixed carbon toward the isoprene biosynthetic pathway, resulting in the production of 1.26 g L-1 of isoprene from CO2, which is a significant increase for terpenoid production by photoautotrophic microorganisms. The strains developed in this study can be used to construct a photoautotrophic cell factory for the production of diverse terpenoids from CO2. In the second part of my talk, I will introduce our recent work on identification of the synergy between the MEP pathway and the MVA pathway for isoprene production in Escherichia coli.

Professor of Plant Physiology and Ecology
Shanghai Institutes for Biological Sciences, CAS, China

Synthetic biology approaches for biotransformation of C1 compounds to high value-added products

Gyoo-Yeol Jung
POSTECH, Korea

Natural gas is a mixture of low molecular weight hydrocarbon gases that can be generated from either fossil or anthropogenic resources. Although natural gas is used as a transportation fuel, constraints in storage, relatively low energy content (MJ/L), and delivery have limited widespread adoption. In recent years, advanced utilization of natural gas has been explored for the production of various value-added chemicals such as platform chemicals and fine chemicals by microorganisms. However, naturally occurring microorganisms which are capable of converting C1 gas to the value-added products can not be easily engineered due to lack of molecular biological tools. In addition, transplant of C1 gas assimilation pathways into the industrial microorganisms including Escherichia coli and Saccharomyces cerevisiae has not been successful thus far. In this presentation, recent efforts to develop synthetic biology tools to convert C1 gas to the value-added products efficiently will be examined.

Professor of Chemical Engineering/I-Bio Program, POSTECH, Korea