

Elements for systems of life-support in closed bio-ecosystem

Kaori Tomita-Yokotani^{1*}

¹University of Tsukuba

Living creatures on the earth have been evolved since its origin a long time ago. They equip several important functions affecting each other. Knowledge on those functions and interaction of the ecology is essential for secure design of a closed-ecosystem with limited number of living species under the harsh environments, such as space and deep sea or desert. Here, the important elements related to the closed bio-ecosystem will be discussed by the researchers having each specialized field .

Keywords: systems for life, life-support, closed bio-ecosystem

Closed environmental system view from photosynthetic organisms

Hiroshi Katoh^{1*}

¹Mie University

Photosynthetic organisms are said to have changed the environment of the primeval earth. Especially, cyanobacteria, algae and plants have water splitting system and absorption system of light energy effectively and make organic matters, such as sugar. Some of cyanobacteria have nitrogen-fixing activity that changes the nitrogen in the air into amino acid and make polysaccharide from sugar to protect outside of cells. The ability of cyanobacteria may use as food or soil. This presentation may discuss closed environmental system viewed from isolated useful cyanobacteria that can survive in the severe environment and test of removing radioactive cesium using a terrestrial cyanobacterium *Nostoc commune*.

This work was supported by A-STEP (Adaptable & Seamless Technology Transfer Program through Target-driven R&D): Program for Revitalization Promotion, Japan Science and Technology Agency (JST).

Keywords: closed environment, cyanobacteria, photosynthesis

Evaluation of allelopathy by volatile natural chemicals in closed ecosystem

Yoshiharu Fujii^{1*}, Tomita-Yokotani Kaori²

¹Tokyo University of Agriculture and Technology, ²University of Tsukuba

We have developed a bioassay for allelopathy in closed ecosystems. We named this method as a kind of Life cycle assesent (LCA). This method is also valuable to evaluate the allelopathic activity in the closed ecosystems in space and also contribute for the future agricultural interaction in grass house or agriculture on earth. LCA Method was established using agar medium, and Arabidopsis or Rapid Plants (*Brassica* sp.). DNA microarray analysis using plant material with LCA method could analyze the gene expression to specific allelochemicals. *Fagopyrum esculentum* is one of the several crop species possessing strong allelopathic properties. In our previous study we had identified eight allelochemicals in buckwheat and analyzed by microarray analysis two important compounds such as rutin and gallic acid. The gene expressions of 20 days old *A. thaliana* plants were analyzed using Affymetrix GeneChips ATH1. The results showed 168 and 55 genes with higher expression after 6 hours of exposure to gallic acid and rutin, respectively. However, only 14 genes were found common for both compounds. The study revealed some genes which are important in regulating plant responses to stress. Induced genes fell into different functional categories mainly, metabolism; cell rescue, defense and virulence; cellular communication/signal transduction mechanism and transcription. This study may lead to a better understanding of the allelochemicals mode of action which in the future could be used in biological control of weeds..

Keywords: allelopathy, volatile chemicals

Evaluation of products as food in closed bio-ecosystem

Yasuko Kimura^{1*}, Kaori Tomita-Yokotani², Fumie Niitsu², Seigo Sato², Hiroshi Katoh³

¹Jumonji University, ²University of Tsukuba, ³Mie University

We have been studying life-support in closed bio-ecosystem to provide food and oxygen for the habitation area. A cyanobacteria, *Nostoc* sp. HK-01, has high several environmental tolerance. We have already confirmed that *Nostoc* sp.HK-01 had an ability to grow for over several years on the Martian regolith simulant in a laboratory experiment. *Nostoc* sp HK-01 would have high contribution to control the atmosphere in closed bio-ecosystem. In outer environment, all of materials have to circulate for all of creature living in artificial eco-systems. This material has several functions as the utilization in the agriculture under the closed bio-ecosystem condition. Here, we are proposing using them as a food. We are trying to determine the best conditions and evolution for food using *Nostoc* sp.HK-01 and studying the proposal of utilization of cyanobacteria, *Nostoc* sp HK-01, for the variation of meal under the sever environment.

Keywords: Cyanobacteria, *Nostoc* sp. HK-01, food

Environmental measurement and reproduction of farmland in the DASH MURA which became a closing system by 3.11.

Katsuya Hasegawa^{1*}

¹Japan Aerospace Exploration Agency

3.11 caused the nuclear power plant accident. The radioactive material diffused broadly generated strong radiation, and the control area was made by the government. The mountain farm village managed by people's became a closing system, and the ecosystem changed. we perform environmental measurement is performed from immediately after an accident, and the approach to reproduction of future farmland.

Keywords: nuclear power plant disaster, control area, farm village, environmental measurement

”Cell to body dynamic theory” in closed environment

Yoriko Atomi^{1*}, SHIMIZU, Miho¹, FUJITA, Eri¹, ATOMI, Tomoaki², HIROSE, Noboru², HASEGAWA, Katsuya³

¹Cell to body dynamics Lab., Univ of Tokyo, ²Dept Physical Therapy, Teikyo University of Sci & Tech, ³JAXA

Human beings will be able to live in space for a long period. But we must consider our body theory even in closed environment. Human beings are evolved to be bipedal standing and walking utilizing gravity at ordinary state and these body traits made human beings as human with culture (see a book ”Thumbs, toes and tears: and other traits that make us human”, by Chip Walter, 2007). Compare to other four-legs animals, musculoskeletal systems especially anti-gravitational skeletal muscles are dominantly developed in our system in order to make us possible to move around on the ground by a bipedal walking. Decreased physical activities of anti-gravitational skeletal muscles induce increased lifestyle related diseases and mental disorder. Human beings are required to move appropriately in order to keep our body and mind healthy and normal. We will try to explain the anti-gravitational muscle adaptable mechanism with an aspect of ”Cell to body dynamic theory”.

Keywords: health, gravity, bipedal-standing, Cell to body dynamic theory, anti-gravitational muscle

Developing the Simulator of Material Circulation Control System, SICLE

OHGI, Takuya¹, Eriko Moriyama^{1*}, MOROSHIMA, Reiji¹, IINO, Shota¹, YAMASHITA, Teruhiro¹, HAMADA, Daisuke¹, HIROSAKI, Tomofumi¹, KOHEI, Ryo¹, MIYAJIMA, Hiroyuki², ISHIKAWA, Yoshio³, NAKANE, Masakatsu³

¹Space Systems Development Corporation, ²Tokyo Jogakkan College, ³Nihon University

More than 50 years have passed since the first human space flight had realized. Since then, a variety of Environmental Control and Life Support Systems (ECLSS) have been developed to sustain human life in space. Material circulation is the primary objective to create ECLSS and it can be achieved by utilizing plants and chemical/physical devices recycling waste materials. In the International Space Station, now, oxygen and water are recycled and the recycling system makes us possible to stay in space for a long period of time. In the future, research and development of more advanced ECLSS will be needed for construction of lunar base and manned space exploration to Mars.

As ECLSS becomes larger and more complicated, it is more important to control material circulation of the entire system. In order to support such researches, we are developing an ECLSS simulator called Simulator for Closed Life and Ecology (SICLE), aiming to take the current research streams into account, as well as to make a useful tool satisfying a wide range of research themes including optimum control of material circulation. We concern that the simulator is desired to have following two features.

- User-friendly interface with intuitive operation
- High versatility to apply new control models and functionalities

Users can visually design and follow their own systems with simple block diagrams, which contribute to easier usability. In addition, by implementing XML file template, the simulator allows users to create new types of equipment. Moreover, it is able to cover various devices' behaviors.

For future improvement, we will make it possible to incorporate new theories of control optimization method, and examine the performance of this simulator comparing real data of existing ECLSS environment.

Keywords: ECLSS,, CELSS, Material Circulation Control, Life Support System, Simulator

A method using a biosensor for measurement of bacterial growth in a closed-ecosystem

Tomoko Abe^{1*}, Hitomi Trii², Koichi Handa², Masao Yamana¹

¹School of Science and Engineering, Tokyo Denki University, ²Graduate School of Science and Engineering, Tokyo Denki University

In recent years, piezoelectric quartz systems have been used in analytical chemistry because their oscillating frequencies are sensitive and have wide range. A quartz crystal microbalance (QCM), which is a nanogram mass sensing device, has been applied to determine gases, ions, and some biomolecule. These studies are based on the fact that the resonant frequency change of the quartz crystal corresponds to mass change on the crystal surface.

We have developed a method for simple and precise cell count using QCM. In this study, we measured bacterial growth by the QCM combined an flow cell in real time. This method will also be variable to analyze the behavior of cells in the closed-ecosystem.

Keywords: Biosensor, Microbalance, Microorganism

The function of high temperature tolerance in cyanobacteria, *Nostoc* sp. HK-01

Shunnta Kimura^{1*}, Kaori Tomita-Yokotani¹, BABA, Keiichi², IGARASHI, Yuichi¹, ARAI, Mayumi³, SATO, Seigo¹, Hiroshi Katoh⁴

¹University of Tsukuba, ²Kyoto University, ³National Museum of Emerging Science and Innovation, ⁴Mie University

The function of dried colony of a cyanobacteria, *Nostoc* sp.HK-01, with high temperature tolerance was investigated.

Cyanobacteria, phototropic bacteria, have several high contribution on the closed bio-eco-engineering. The cells in the colony was viable under the environment of 100 °C during 10 hours. It was suggested that the function of high temperature tolerance was related to sugar polymer containing many components.

Keywords: cyanobacteria, high temperature tolerance, *Nostoc* sp.

Utilization of functional woody plant line, Japanese cherry tree, in closed bio-ecosystem on the biological activity.

FUMIE NIITSU^{1*}, Yasuko Kimura², Yukari Chida¹, Yoshiharu Fujii³, SATOU, Seigo¹, Kaori Tomita-Yokotani¹

¹University of Tsukuba, ²Jumonji University, ³Tokyo University of Agriculture and Technology

Trees have high contribution under the severe closed bio-ecosystems. Trees produce excess oxygen, woody materials for the living cabin, and provide a biomass by cultivating crops and other species of organisms. Our dwelling would be built using these materials in the closed-bio-ecosystems. It is possible that we use them as some herbal medicine or foods from the products of tree. In the study for life-support related to closed-ecosystem, it is one of important matter that the detail data in the given environment is examined. Here, we show the results of one of our studies using Japanese cherry tree as material tree. We will discuss the changes of the function in the materials from the tree.