Goal1 Realization of a society in which human beings can be free from limitations of body, brain, space, and time by 2050.

Structuring Spatiotemporal Environmental Information in the Body Using In-body Cybernetic Avatars

Here begins our new MIRAI

MOONSHOT RESEARCH & DEVELOPMENT PROGRAM

R&D Item

4. Basic research and technology of in-body CA

Progress until FY2024

1. Outline of the project

The purpose of this R&D Item is to identify trends in competing and emerging technologies related to in-body cybernetic avatars (in-body CA). Based on trends in in-body CA, current concepts and plans will be updated as appropriate. When unanticipated issues emerge in in-body CA for the digestive system, we will investigate and identify elemental technologies to solve them, improve concepts as appropriate, and conduct feasibility experiments. For in-body CA for the circulatory and cranial nervous systems other than the digestive system, we identify social issues, requirement specifications, technical constraints, and elemental technology issues, design concepts to solve these issues, and identify gaps and insufficient technologies, competitive technologies, and new technology trends compared to in-body CA technology for the digestive system. To devise new concepts for different social issues, feasibility experiments of elemental and integrated technologies will be conducted as needed. For example, the risk of becoming abnormal increases with the aging of the population. In-body CA technology can contribute to their prevention, diagnosis, and health maintenance. We will identify the elemental technologies necessary for these gaps and missing technologies in in-body CA technology, and conduct appropriate concept design and feasibility experiments.

To date, we have conducted research activities by scrutinizing the latest journals and participating in academic conferences to understand the trends of competing and new technologies. The results of our research to date have increased the importance of interfaces that convert digital information from interactions based on physical and chemical reactions that occur in the digestive system. In building this basic technology, we focused on IgA antibodies, which play an essential role in maintaining human health, as they play a key role in mucosal defense, protecting the mucosa from invasion by foreign enemies. As shown in Figure 1, IgA antibody distinguishes between good and bad bacteria and controls the growth of bad bacteria. Intestinal IgA antibodies in the elderly are said to be less sensitive to enterobacteriaceae, which are pathogenic and inflammatory bacteria. For this reason, we focused on IgA antibodies and started research in FY2024 to visualize the distribution of enterobacteriaceae-attracting bacteria.
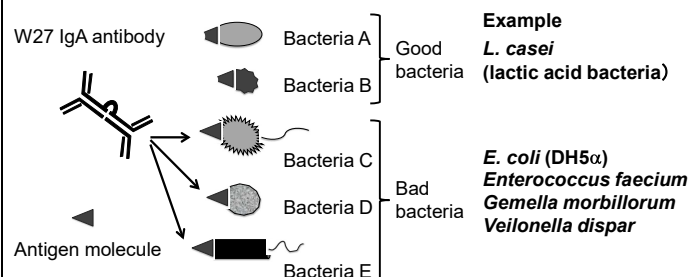

Figure 1: The role of IgA antibody

2. Outcome so far

We have been conducting a thorough review of domestic and international academic conferences and the latest journal articles. Although we have not found any research cases that are similar to the concept of in-body CA or that have the impact to significantly changing the plan of this project, there has been progress in the development of advanced functionality in capsule-type devices related to in-body CA.

In a journal survey, there is an increasing number of examples of research on magnetically driven robots using flexible magnetic composites. We also participated in the 2024 IEEE International Conference on Robotics and Automation (ICRA 2024), Yokohama, Japan, where we surveyed related research and presented research on elemental technologies for future in-body CA. One of the technologies lacking in-body CAs is a moving mechanism with external control. Since driving technology for small CAs will be important in the future, we prepared to propose a new concept.

In addition, as part of the research and development of basic technology for visualizing the distribution of intestinal inflammation-attracting bacteria, we conducted basic research on fluorescent labeling of IgA antibody clone candidates that selectively recognize and bind to intestinal inflammation-attracting bacteria, to visualize the distribution of IgA antibodies in the intestinal tract. Chronic inflammation induced by certain intestinal bacteria has been found to be one of the causes of colorectal cancer.

3. Future plans

We will continue to conduct technical surveys on current, competing, and new technologies related to in-body CA to determine if any technologies are missing and possible solutions. If necessary, we will update the concept/plan for in-body CA and consider its applicability to in-body CA for targets other than the digestive system.

We will also accelerate research to visualize the distribution of enteritis-attracting bacteria. Combined with in-body CA technology, this is expected to lead to the detection of early-stage colorectal cancer lesions.

JST Japan Science and Technology Agency