

## 【Grant-in-Aid for Transformative Research Areas (A)】

### Section III



#### Title of Project : Material properties determine body shapes and their constructions

INOUE Yasuhiro  
(Kyoto University, Graduate School of Engineering, Professor)

Number of Research Area : 20A306 Researcher Number : 80442929

#### 【Purpose of the Research Project】

When building a house, it is important to choose the appropriate building materials. This is because the physical properties of the building materials determine how they are manufactured and assembled, which in turn determines the final shape of the house. This factor can be linked to the morphogenesis of living organisms. Since cells alone are not rigid enough to build and maintain the physical body, support materials (calcium, collagen, chitin, etc.) are used. For building “bodies,” cells must choose construction methods depending on materials.

In this area, we aim to reveal the principle of morphogenesis by demonstrating a new paradigm for processing non-cellular materials. By viewing the essence of morphogenesis as “body = workpiece, cell = worker,” we believe that mathematical modeling and large-scale simulation will become easier whereby the relationship between “macroscopic shape” and “cellular behavior” will become clearer at a stroke. In addition, since this paradigm is engineering itself, we can expect the application of industrial design technologies to living organisms, as well as the industrial application of discoveries obtained from living organisms.

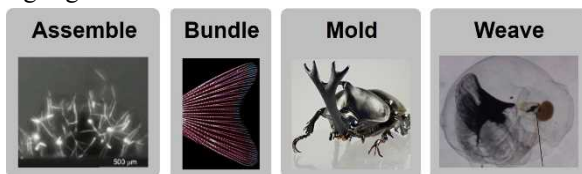


Fig. 1 Processing of support materials.

#### 【Content of the Research Project】

In this area, three research groups will be promoted with the support of Administrative group. Research group A01 consists of biological researchers who have experimental systems suitable for elucidating new principles. Although the phenomena are diverse, the principle of morphogenesis will be approached from the viewpoint of the processing non-cellular materials. In research group A02, the formation of the body is modeled and simulated in terms of the processing of materials, and the principles of morphogenesis are studied theoretically. In research group B01, we will promote the above projects by developing measurement and manipulation techniques for materials and cells, and conversely, we will apply the principles of biological morphogenesis to theoretical engineering and technological development. We aim to develop new engineering applications that have been inspired from the principles and processes by which the shapes of living organisms are constructed.

#### 【Expected Research Achievements and Scientific Significance】

By understanding the morphogenesis based on a new paradigm of “processing of non-cellular materials,” we expect to revolutionize our understanding of developmental biology in general, beyond the subject matter covered in this research area. The contribution of cells will be viewed as more than just a part of the body, cellular behaviors will be viewed as “workers” processing and assembling the support materials that determines the shape of the body.

This research focus has a high affinity with engineering since morphogenesis is defined as the processing of materials. In this regard, we will explore engineering applications of the discovered biological principles. For example, the principle of manufacturing and storing 3D structures as compact planes, as seen in the formation of a house of Larvacea, is expected to lead to new design and manufacturing technologies for architecture and machinery. The cellular behaviors as workers in sponges can also be expected to lead to the development of new decentralized control theories for systems such as drones that operate in many occupational capacities.

Furthermore, since research in this area will be conducted through collaboration among a wide range of disciplines, we expect that it will lead to the development of young researchers who can discover and solve problems from a variety of perspectives by having an overview of all contributing factors, from basic science to its complex applications.

#### 【Key Words】

Support material:  
A pyramid shape stacked with soft dumplings will collapse under their own weight. With skewers, you can make a tower like this. In this case, the skewer, a support material, makes the shape.

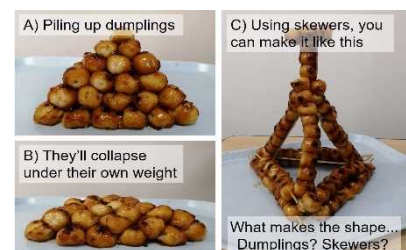


Fig. 2 Making the shape.

【Term of Project】 FY2020-2024

【Budget Allocation】 1,147,300 Thousand Yen

【Homepage Address and Other Contact Information】

<https://www.architect-bio.info>