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

## Plastid Reprogramming Dynamics



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## Purpose and Background of the Research

### ●Outline of the Research

The plastids, plant-specific organelles, differentiate into several types including photosynthesis-performing chloroplasts and starch-accumulating amyloplasts during cell differentiation and in response to various stresses. These specific types of plastids are differentiated from the primordial type of plastids named proplastids, which usually develop in seed cells or stem cells in meristems (Figure 1). The acquisition of the highly-plastic plastids would be a key event for plants to flourish and diversify across the world. However, the evolutionary history and molecular mechanisms of the plastid plasticity remain largely unknown. In this study, we aim to understand the central mechanisms that enable plastids to carry out extensive differentiation and to reveal how plants regulate the mechanisms during development and in response to changing environment.

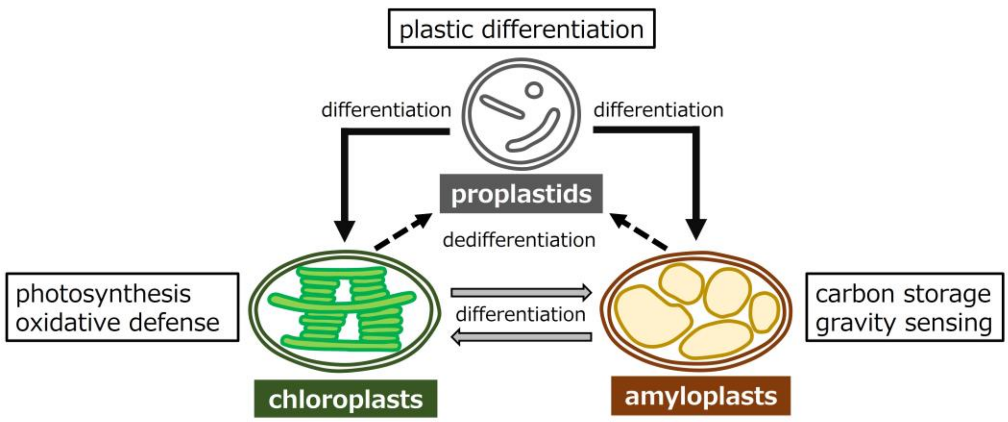


**Figure 1. Differentiation among chloroplasts, amyloplasts, and proplastids.**

### ●Background

Plastids, the organelles unique to plants, are believed to originate from a cyanobacterium engulfed by a primitive plant cell via endosymbiosis. In seed plants, plastids differentiate into various types during tissue development and in response to several stresses.

Each type of plastids plays specific roles according to host cell types but how plastids have acquired such functions remains uncertain.

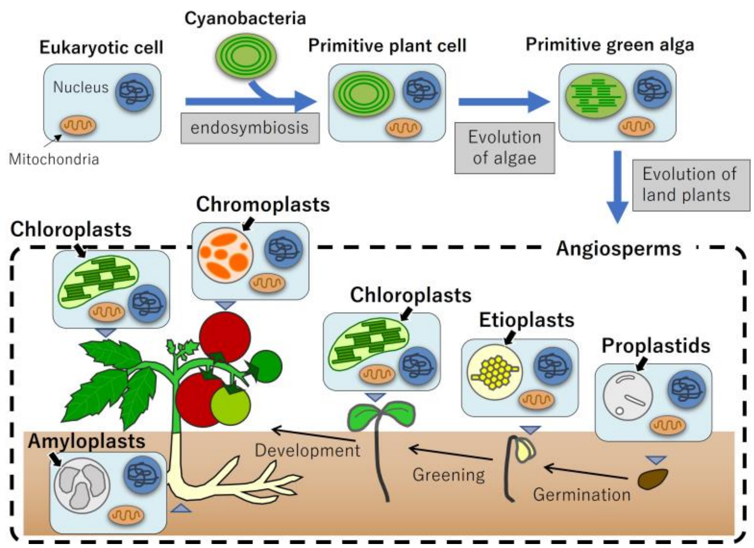


**Figure 2. Plant evolution includes endosymbiosis and plastid diversification**

## ●Aim of the study

The aim of this study is to reveal (i) how plastids differentiate into various types according to their host cell types, (ii) how chloroplasts self-organize the construction of photosynthetic machinery and how they collaborate with the nucleus to regulate photosynthetic functions, (iii) how plastids function in plant cells during artificial organogenesis from the undifferentiated cell mass  such as callus, (iv) how plastids respond to the attacks by plant pathogens and how pathogens target and avoid nutritious and harmful plastids, respectively, and taken together, to understand the molecular mechanisms that regulate plastid differentiation and functionalities according to cell functions.

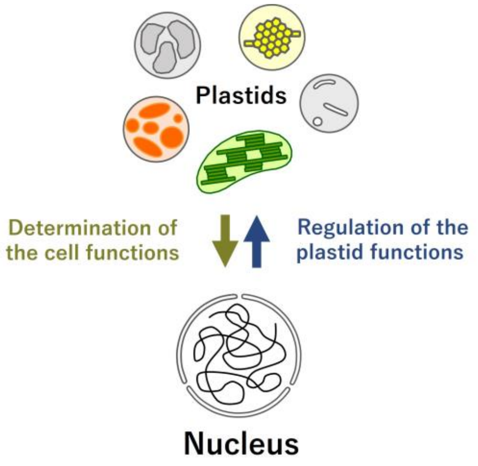


**Figure 3. Bidirectional regulation between plastids and the nucleus**

# Expected Research Achievements

## ●Molecular mechanisms that coordinate reprogramming of the host cell and plastids

We hypothesize that there must be signal transduction pathways between nuclear genome and plastid genome to synchronize the differentiation states during plant tissue development and we test the hypothesis.

**Figure 4. Callus tissues at wound sites of leaves**

## ●Regulatory mechanisms of chloroplast development

Chloroplasts carry out primary photosynthetic reactions in the thylakoid membrane containing photosynthetic protein-cofactor complexes. We attempt to reveal how the thylakoid membrane is formed and how the formation event affects differentiation state of the host cells during chloroplast biogenesis and photosynthetic establishment.

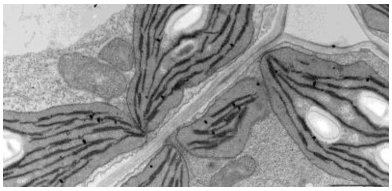

**Figure 5. Ultrastructure of the thylakoid membrane in chloroplasts**

## ●Visualization and control of the reprogramming process of plastids and host cells during artificial organogenesis

To monitor the coordinated differentiation process of plastids and host cells and to find out the crucial steps of those events, we try to identify the factors that determine the differentiation state of plastids and to trace them during differentiation processes in the organogenesis of tissue culture.

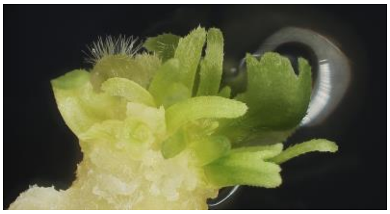

**Figure 6. Leaves regenerated from callus in tissue culture**

## ●Molecular dissection of the conflict between plastids and pathogens

Plant pathogens target starch-containing plastids to take carbohydrates away from the plastids, whereas they keep away from chloroplasts to avoid oxidative damage or enslave them to exploit them for photosynthates. We explore how plant cells with plastids attack pathogens and defend against them.

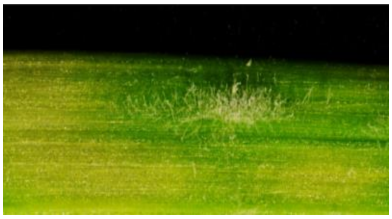

**Figure 7. Green tissues maintained by pathogens**

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