Understanding the real life of microorganisms and the dynamics of cellular components

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[My basic science approach]

Basic biological research, which explores the secrets of life, is slightly different from engineering research where humans try to design and create something new that does not exist in the world.

In other words, our research interests are living organisms that have survived over billions of years through evolution and have complex functions, shapes, and relationships with each other.

Animals, including humans, eat other living organisms and break down their biological components into glucose and amino acids, which are then used as raw materials for the building blocks of the body while at the same time obtaining energy. On the other hand, plants use photo energy to synthesize all biomolecules from the lowest energy level compound, CO_2. This is photosynthesis. Therefore, plants are at the top of the food chain, and other organisms on the earth live on them by consuming their carbon and energy resources. However, this does not mean using it all at once; instead, our metabolic system can efficiently extract maximum energy step by step. Even plants, which appear to be able to survive alone, need symbiotic microorganisms or soil microorganisms to pass their lives on to the next generation. As described in detail in the "About my research" section below, microorganisms that live in symbiosis with plants were thought to be found underground, like rhizobium bacteria. In reality, however, there are microorganisms on the leaves that have important interactions with plants, and they have been symbiotic and helped plants grow from ancient times without our knowledge.

We need to be honest and humble when investigating these wonders of life.

Successes and failures are because of the assumptions and objectives that the researcher wants the results to be. In fact, the results of any experiment are "facts," and there are no successes or failures. In this sense, if the purpose or vision is too distinct, it may blur our instinct when we come across an unexpected experimental result or discovery.

I think that the intuition needed for discovery is similar to what top jazz musicians feel when playing an ad-lib. May I say a "the ambiance" of the stage?

At the first-class ad-lib performance, often the musician utters a cry, feeling something that exists only in that place and time. To reach such a feeling, I think that not only perfected playing techniques but also other personal experiences that are seemingly unrelated have great influences. So to speak, I believe that the process of converting everything, including successes, failures, and hard work, into personal experiences and cultivating sensitivity through them is what prepares us for discovery in science.

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[My research]

Although invisible to the naked eye, microorganisms perform various and significant functions that we are unaware of. Yeast supports our food culture by helping to produce fermented foods such as alcohol and bread. Gut bacteria support our health. And the coordinated material cycle by various microorganisms protects the global environment. Basic research to explore their way of life and mechanism has led to many scientific discoveries and has continued to provide solutions to various problems.

About 50 years ago, a yeast (C1 yeast) that grows by eating a compound called methanol, which has only one carbon, was found in our laboratory. Based on basic research on how methanol is metabolized to obtain energy and assemble all cellular components from a single carbon, C1 yeast is now indispensable for producing many valuable proteins, various pharmaceuticals including vaccines, and other industrial enzymes.

Production of human proteins using *E. coli* cells sometimes fail because of misfolding of the expressed proteins. On the other hand, since yeast is an eukaryote just like humans, they share similar system of protein synthesis. When the process is set up appropriately, it can produce proteins with the correct structure.

In the process of studying the "insides" of yeast, we have made several discoveries. When C1 yeast eats methanol, the number of tiny organelles called "peroxisomes" increases and becomes surprisingly large. When the methanol is gone, the peroxisomes are degraded by autophagy. We have been studying how peroxisomes are formed, how they are enlarged, and conversely, how they are degraded. Notably, microautophagy, in which vacuoles directly surround and degrade intracellular organelles, has been found to be driven by a set of genes that are different from those so far found in autophagy.

C1 yeast proliferates in nature by feeding on methanol that exists on plant leaves. Methanol concentration on leaves significantly fluctuates from day to night. C1 yeast regulates the rate of methanol intake by balancing the synthesis and degradation of peroxisomes and methanol-metabolizing enzymes in response to these fluctuations. By investigating why they live go through such a troublesome procedure in nature, we learn for the first time about the real life of microorganisms. Such insights give us many hints for both basic and applied researches, such as for protein production and for overcoming environmental problems.

C1 bacteria that can eat methane and methanol are also known. C1 bacteria that live on leaves also give benefits to the plants, such as promoting the plant growth. Many studies have been conducted on microorganisms that live in the underground parts of plants, typically, rhizobacteria,

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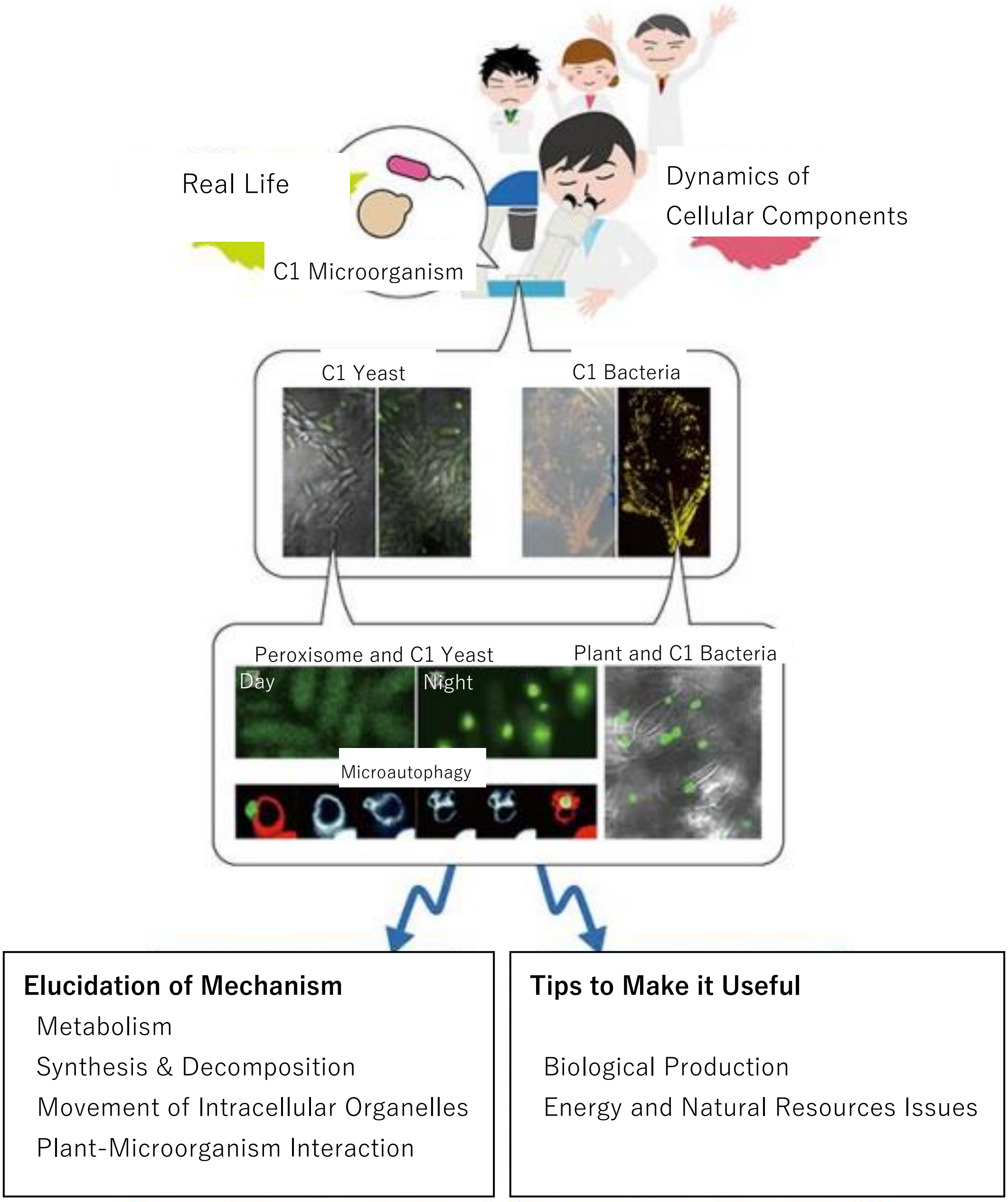
But nothing is known about plant-microorganism interaction of the above-ground parts of plants, which are greatly affected by diurnal variations in sunlight and temperature. Although we are not sure yet where such research will lead us, I enjoy science every day, expecting new experimental results that will provoke us to new ideas and break-through technologies in increasing crop yields or in reducing greenhouse gases.

The central theme of our laboratory is to learn from the real life of microorganisms, to essentially understand their functions, to gain hints from them, and to make use of them. This is not an easy task by any means, but we would like to continue our dialogue with microorganisms.



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