Japan Academy Prize to:

Kanji Ohyama

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for "Gene Content, Organization and Molecular Evolution of Plant Organellar Genomes and Sex Chromosomes —Insights from the Case of the Liverwort *Marchantia polymorpha*—"

Outline of the work:

Dr. Kanji Ohyama has contributed exceptionally to the development of plant molecular biology and genome research. He has established a series of highly innovative research projects on the genomes of organelles in plants (chloroplasts and mitochondria) and on the sex chromosome in the liverwort *Marchantia polymorpha*.

Plant cells harbor two kinds of organelle with specific genetic material (DNA), chloroplasts, which provide photosynthesis, and mitochondria, which supply respiration in all cells. Dr. Ohyama has succeeded to completely decode the DNA sequences of these genomes in both organelles. He has clarified their gene contents and thrown light on their biological functions. In addition, Dr. Ohyama has accomplished to elucidate through the DNA sequence the entire gene content and organization of a Y-male sex chromosome in a dioecious plant, the liverwort *M. polymorpha*. His work has laid the basis for molecular research on sex determination and evolution of sex chromosomes in plants.

1. Gene organization deduced from the complete sequence of the liverwort *M. polymorpha* chloroplast DNA

Since the demonstration of the presence of chloroplast DNA by Ishida and Sanger in 1963, Dr. Ohyama succeeded to determine the complete sequence of liverwort *M. polymorpha* chloroplast DNA in 1986. He made two major discoveries: The first was the elucidation of a trans-splicing gene in the coding region for the ribosomal protein S12. The second was the recognition of light regulation in the expression of overlapping genes in a photosystem II gene cluster. His accomplishment in the structure analysis in chloroplast DNA was a milestone of worldwide organelle genome research.

2. Gene organization deduced from the complete sequence of the liverwort *M. polymorpha* mitochondrial DNA

Plant mitochondrial genome analysis was hampered by the complex multipartite genome structure. In 1992, Dr. Ohyama determined the first complete nucleotide sequence of a plant mitochondrial DNA. Firstly, he demonstrated that transfer RNAs encoded by the nuclear genome were imported into mitochondria and are essential for mitochondrial protein synthesis. Secondly, he found that a number of liverwort mitochondrial introns show high similarity to those of fungal mitochondria, indicating that these introns in plant and fungal mitochondria have common ancestors. Thirdly, Dr. Ohyama discovered that

several clusters of introns intra-propagated in the mitochondrial genome of the liverwort *M. polymorpha* after its evolutionary separation from the higher plants.

3. Gene organization of the liverwort Y chromosome and distinct sex chromosome evolution in a haploid system

The liverwort *M. polymorpha* is a dioecious haploid plant, the male plant is defined by a single unique Y sex chromosome, the female is characterized by an X chromosome. Dr. Ohyama has determined the gene content of the Y chromosome and has pioneered the first sequence analysis of a Y sex chromosome. He identified a total of 64 genes on the 10 million nucleotide long Y chromosome. Several of these genes are detected only in the male genome and are expressed in reproductive organs. Another 40 genes on the Y chromosome are expressed in male sexual organs as well as in other cells of the plant. These intriguing findings indicate that the Y and X chromosomes evolved from the same ancestral autosome and predict that in a haploid organism essential genes on sex chromosomes are more likely to persist than in a diploid organism. Furthermore Dr. Ohyama's exemplary research shows that it is possible to elucidate the molecular mechanisms of sex determination and the development and evolution of sexual organs in plants.