The 2009 Kyoto Prize Workshop in Basic Sciences

Symposium

"Evolution, Speciation and Long-Term Field Study"

Laureate: Dr. Peter Raymond Grant
[Professor Emeritus, Princeton University]

Laureate: Dr. Barbara Rosemary Grant
[Professor Emeritus, Princeton University]

13:00 - 17:10, November 12, 2009 (Thu.)
Kyoto International Conference Center

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Program

Coordinator and Moderator
Yoh Iwasa
(Chairman, Kyoto Prize Selection Committee; Professor, Faculty of Sciences, Kyushu University)

13:00 **Opening Address**
Yoh Iwasa

Introduction of Laureates
Nanako Shigesada (Member, Kyoto Prize Committee; Professor, Faculty of Culture and Information Science, Doshisha University)

Laureate Lecture
Peter Raymond Grant (the Laureate in Basic Sciences)
Barbara Rosemary Grant (the Laureate in Basic Sciences)
"Evolution of Darwin's Finches"

Lecture
Hiroshi Nakamura (Professor, Faculty of Education, Shinshu University)
"Cuckoo—Rapid Evolution of Egg-Mimicry—"

Intermission

Lecture
Tetsukazu Yahara (Member, Kyoto Prize Selection Committee; Professor, Faculty of Sciences, Kyushu University)
"Floral Adaptation to Insect Pollinators: An Experimental Study in Daylilies"

Lecture
Makoto Kato (Professor, Graduate School of Global Environmental Studies, Kyoto University)
"Obligate Pollination Mutualism Discovered in Phyllanthaceae: Rapid Synergistic Diversification of the Partners"

Lecture
Norihiro Okada (Member, Kyoto Prize Committee; Professor, Graduate School of Bioscience and Biotechnology, Tokyo Institute of Technology)
"Search for the Mechanisms of Rapid Speciation of Victorian Cichlids"

17:10 **Closing**

Abstract of the Laureate Lecture

Dr. Peter Raymond Grant
Professor Emeritus, Princeton University
Dr. Barbara Rosemary Grant
Professor Emeritus, Princeton University

Evolution of Darwin’s Finches

This year is the 150th anniversary of the publication of the “Origin of Species” in which Charles Darwin established the scientific basis for understanding how evolution occurs by natural selection. Darwin was less clear about the actual process of species formation. Nevertheless he envisioned a three-step process: colonization, involving the expansion of a population into a new environment; divergence, when populations become adapted to novel environmental conditions through natural selection; and finally, the formation of a barrier to interbreeding between divergent lineages. Since Darwin’s time insights from the fields of genetics, behavior and ecology have continued to illuminate how and why species evolve. In this lecture we will discuss the progress that has been made in our understanding of speciation with special reference to the young radiation of Darwin’s finches on the remote Galápagos Islands.

Fourteen species evolved from a common ancestor in the last two to three million years. They occupy different ecological niches in different combinations on different islands, the vegetation on several of the islands is close to the natural state, and as far as we know none of the finch species has become extinct as a result of human activities. These features make them particularly suitable for study. Two important questions are (1) how do species derived from an ancestral species coexist on the same island without severe competition for food, and (2) how are species able to coexist without interbreeding and fusing into a single population. With regard to the first question, a strong divergence in beak size and associated diet is required for sustained coexistence. The role of natural selection in causing the divergence has been demonstrated on the small island of Daphne Major over a period of 37 years. Moreover competition for food between similar species contributes to the divergence caused by natural selection. With regard to the second question, closely-related species imprint on their parents when they are nestlings, learn the song and morphological characteristics of their parents, and later, when they are breed, they use those characteristics when choosing a mate. Nevertheless rare hybridization takes place. We will discuss how these results help us to understand not only the radiation of Darwin’s finches but the early stages of evolutionary diversification of organisms elsewhere.

Abstracts

Hiroshi Nakamura
Professor, Faculty of Education, Shinshu University

Cuckoo—Rapid Evolution of Egg-Mimicry—

Darwin assumed that evolution by natural selection would proceed so slowly that we would not be able to observe the changes ourselves. However, there are now several examples of variants having such a strong selective advantage in nature that evolutionary change takes place even within a few years. One of them is brood parasitism in birds. Hosts of the Common cuckoo Cuculus canorus gain no reproductive rewards from a successfully parasitized nest. In theory then, natural selection should favour host defences. This, in turn, will select for more sophisticated trickery by the cuckoo. The result should be an evolutionary 'arms race', leading to intricate adaptations and counter-adaptations by either side. This cycle of evolutionary change is known as co-evolution. During the last 35 years, field workers have produced a wealth of new observations on the extent of brood parasitism in birds. Our field study of the cuckoo and its hosts in Nagano, central Japan, suggested that host behavior and cuckoo egg markings are changeable in a short-term through the tug-of-war between them.

Tetsukazu Yahara
Member, Kyoto Prize Selection Committee; Professor, Faculty of Sciences, Kyushu University

Floral Adaptation to Insect Pollinators: An Experimental Study in Daylilies

Since the pioneering work by Charles Darwin, the diversity of showy flowers has been considered to be a consequence of adaptive evolution to various pollinating animals. However, it was not until the 1990s that experimental studies on adaptive evolution of flowers to pollinating animals were initiated. By using such experimental approaches, we study the floral adaptation of daylilies (Hemerocallis) and their genetic background.

H. fulva is pollinated by swallowtail butterflies, having flowers with red petals and no recognizable odor. The flowers of H. fulva open in the morning and close in the evening on the same day. H. citrina is pollinated by hawkmoths, having flowers with yellow petals and sweet odor. The flowers of H. citrina open in the evening and close in the morning of the next day. We crossed these two species and obtained F2 hybrids that were then used to study the genetic backgrounds of the interspecific differences of flower color, odor and flowering time. We also studied the preferences of swallowtail butterflies and hawkmoths to flower color and odor, also using F2s.

We found that at least six major genes are differentiated between the two species. The first step of evolution from daytime-flowering species to H. citrina was most likely the change in carotenoids. We also found evidence suggesting that hybridization played an important role in the evolution of nocturnal-flowering hawkmoth-pollinated species.

Abstracts

Makoto Kato
Professor, Graduate School of Global Environmental Studies, Kyoto University

Obligate Pollination Mutualism Discovered in Phyllanthaceae: Rapid Synergistic Diversification of the Partners

Plant–pollinator mutualism has contributed to a spectacular radiation of flowering plants on earth. Recently, an obligate pollination mutualism was discovered between a plant genus Glochidion (Phyllanthaceae) and a moth genus Epicephala (Gracillariidae). The moth larva is a host-specific seed parasite, and the female moth actively pollinates the female flower by using her hairy proboscis to ensure nourishment for her offspring. Extensive surveys have shown that various clades of Phyllanthaceae adopt the mutualism, and that the mutualism is pervasive throughout tropical regions of the world. Molecular phylogenetic studies suggest that the active pollination behavior has originated once in the Miocene, and that after multiple host changes by the moths, the mutualism has accelerated synergistic diversification of the partners. The obligate pollination mutualism in Phyllanthaceae is a novel model system that can provide clues to various questions on the evolution from parasitism to mutualism and the coevolution and cospeciation between the partners.

Norihiro Okada
Member, Kyoto Prize Committee; Professor, Graduate School of Bioscience and Biotechnology, Tokyo Institute of Technology

Search for the Mechanisms of Rapid Speciation of Victorian Cichlids

The characteristic of Lake Victoria is its young establishment about 10 thousand years ago. Therefore, about 500 cichlids species in this Lake have been diversified only since that time. Accordingly, their genome sequences are considered to be almost the same except mutations that have been responsible for speciation. These mutations are fixed in the population, so if we could characterize them, genes including these mutations are speciation genes. Using this strategy, we discovered that LWS (long wavelength-sensitive opsin gene) is one of these speciation genes. We first organized a research group to Lake Victoria, collected many samples of cichlids and finally elucidated a mode of speciation, named sensory drive, in which LWS gene is adapted to a certain light environment coupled with changes of male nuptial coloration.