Evolution of the animal temperature sensor: The functional adaptation to environmental change

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The animals on the earth have adapted themselves to the environmental temperature changes such as hot in deserts, or cold in the glacial epochs. However, the molecular mechanism for adaptation to thermal environments in the evolutionary process involving temperature sensors was not well understood.

Professor Makoto Tominaga and Assistant Professor Shigeru Saito at The National Institute for Physiological Sciences (Okazaki Institute for Integrative Bioscience, Japan) demonstrate that the molecule called TRP channels, serve as temperature sensors in animals, sense different temperature ranges between mammals and western clawed frog (amphibians) even the same type of the TRP channels have been investigated. This observation indicates that the temperature sensors can dynamically change their temperature sensitivities to adapt to thermal environments in the evolutionary process. The report is published in American science magazine, PLoS Genetics (online edition).

The research was performed in collaboration with Professor Ryuzo Shingai at Iwate University.

In this study, western clawed frog (Xenopus tropicalis) inhabiting the tropics was used. Their optimal ambient temperature is approximately 26 degrees Celsius and temperatures below 20-18 degree Celsius causes detrimental effects. The research team identified the TRPV3 gene,

which is know as a warm temperature sensor in mammals, from western clawed frog, and examined its function. They found that the temperature sensitivity of western clawed frog TRPV3 is different from that of mammal TRPV3. TRPV3 channel of mammals was activates by warmth (33-39 degree Celsius or more), but that of western clawed frog was activated by cold temperature (16 degree Celsius or less). Therefore, western clawed frog feels the detrimental low temperature with this temperature sensor. In addition to the difference in temperature sensitivity, the amino-acid sequences of TRPV3 channel in the putative cytosolic termini are highly diversified between western clawed frog and mammals. This structural difference may be involved in the shift in temperature sensitivities of TRPV3 channels. On the other hand, TRPV3 channel of mammal is known to be activated by several chemical compounds, while TRPV3 channel of western clawed frog was not activated by such chemical compounds except for one kind, thus, the chemical sensitivities of TRPV3 channels are also different between western clawed frog and mammals.

"We investigated the evolutionary process of TRPV channel genes, which serve as the temperature sensors in vertebrates, and found that the gene repertoires have been diversified among different vertebrate species. The evolutionary changes of the temperature sensors related to the adaptation to thermal environments or the shift in physiological characteristics were poorly understood. We here clarified one of the molecular mechanism for the functional change "Modal-shift" in temperature sensors. Results of our study indicate that TRPV3 channels have acquired opposite temperature sensitivities during the course of terrestrial vertebrate evolution. This, in turn, indicates that the temperature sensitivity of the thermosensitive TRP channels is not always stable but can change dynamically, even reverses in some cases, during the course of evolution to adapt to thermal environments", said Tominaga

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