Neural circuit mechanisms for adaptive modulation of the chemosensoory behaviors in the nematode *C. elegans*

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*Caenorhabditis elegans* is a unique experimental system for neuroscience because the structure of the whole neural circuit composed of 302 neurons is already known. In addition, its strong genetics makes discovery, analysis and manipulation of functional molecules possible. We focus on chemotaxis of this organism because input-output relationship of the neural circuit can be precisely studied in these behaviors and therefore the principle of the information processing to generate both stereotyped and plastic behaviors can be studied at molecular and cellular levels.

In this lecture, I will describe integrative studies at multiple levels, focusing on chemotaxis to NaCl. In salt chemotaxis, worms show associative learning: they associate salt concentration during cultivation with presence or absence of food. Thus fed animals migrate to the salt concentration at which they were fed and starved animals avoid the salt concentration. Our focus is how this plastic behavior is generated by the neural network and molecules acting there.

1) The behavioral level
By quantifying the chemotaxis behaviors on agar surface, two mechanisms for the migration toward or away from the chemical have been found. The directionality of these mechanisms are reversed depending on past experience.

2) The neuronal circuit level
By ablation of each neuron, neurons important for generating the chemotaxis behavior have been determined. In addition, by calcium imaging of the activity of each neuron, the basis of behavioral changes caused by learning is inferred. Finally, photoactivation of individual neurons verified the model.

3) The molecular level
Through identification of mutants that show abnormal behaviors, molecules important for chemotaxis and learning have been found. By looking at the mutant phenotypes and cell-specific expression or inhibition of the genes, site of action of each molecule is determined. In addition, the dynamism of the molecules are visualized by using fluorescent probes, leading to unexpected findings.

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