Exploring the Wonders of Morphogenesis of Living Organism

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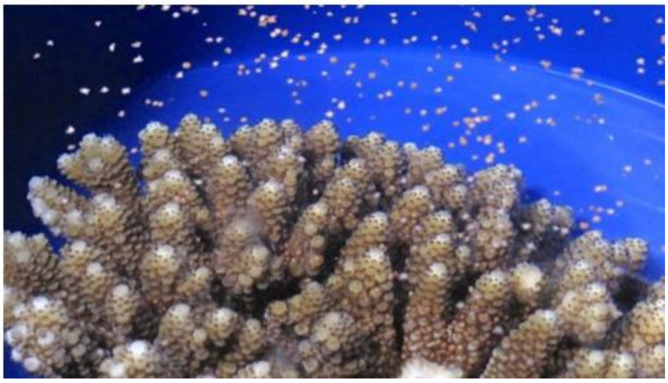
[About my research]

I believe that the driving force of basic science is curiosity. The earth we live on is full of a wide variety of living organisms. Each creature has its unique form, and its mysterious ecology and behavior arouse our curiosity. Among the books in the "Ohsumi Collection," which Dr. Ohsumi donated to the Okazaki City Library for children, "Fabre's Book of Insects" is included. This book was one of my favorite books when I was a child. And I cannot help but marvel at Fabre's curiosity in patiently observing the ecology of a wide variety of insects. This kind of curiosity, I believe, also allows researchers to drive research.

But I think other things are also essential to advance science, not just curiosity. That is passion. To solve the pure question of "Why?" as a science question and not just leave it as a simple question, it is necessary to tackle the subject head-on, which may take years to solve and maintain the passion for working on it with colleagues. Scientists may need hard work, talent, and luck. But I believe that the development of science is best achieved when scientists themselves are motivated by curiosity, do not feel pained by the many issues they face, and enjoy their work. I believe that the high-valued results obtained by working on essential questions rooted in curiosity without looking away will one day belong to society and not individual scientists.

On the other hand, it is also true that research does not proceed in the expected direction. The word "serendipity" is often used. It is quite possible that our initial idea for a research project will not work out, and in the process, we may come across a significant discovery by chance. I still feel that scientists must also have the sensitivity and insight to recognize the importance of accidental discoveries without overlooking them. Basic science requires scientists with such sensitivity and an environment that allows them to stop and take side trips.

Fabre is said to have begun writing his Insect Book at the age of 55. When I was in my mid-fifties, I too became interested in a biological phenomenon quite different from the subject of my own research in developmental biology. That is the "mystery of simultaneous coral spawning." In Okinawa, corals lay their eggs simultaneously on the night of high tide in May or June every year. To be precise, the eggs, called bundles, release particles encasing sperm, which burst on the surface of the seawater to initiate fertilization. Many of you may have probably seen this mysterious phenomenon on television. Also, the timing of spawning is slightly different for different coral species.



Coral spawning (Photo by Hiroki Takahashi, Division of Morphogenesis, National Institute for Basic Biology)

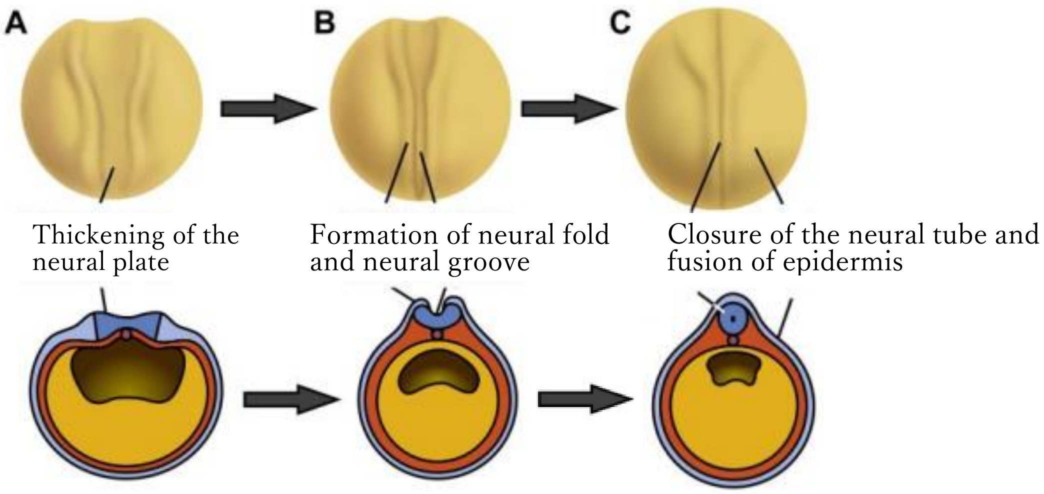
Why is May or June the specific month? Why do they give birth around the day of high tide (full moon)? It is expected to be determined by a complex combination of many factors, including rising water temperatures, the influence of moonlight, circadian rhythms, and tides. Corals spawn only once a year. And if this phenomenon is caused by a complex combination of so many environmental factors, it is easy to imagine that research to elucidate the mechanism would be very difficult. However, I myself am very romantic about this research and am actually conducting research from the perspective of "coral photo-response." And recently, I have gradually obtained some exciting findings, and I am spending my time excitedly looking forward to the next experiment during the spawning season. My time as a researcher is limited, but I am pretty sure that the next generation of researchers will solve the mystery.

[About my research]

The fertilized egg is a single cell, which gradually takes on the shape of a living organism through repeated cell division (proliferation) and the acquisition of cellular characteristics with various functions (differentiation). This process is extremely rapid, and in the case of human beings, most of the formation is completed in the mother's body within one month after fertilization. The research field of "developmental biology" studies how cells grow from a single round cell, acquire diverse characteristics, and how a group of cells (tissue) develops a three-dimensional shape.

We have been studying how the dorsal-ventral axis of animals body is determined. For example, in vertebrates, including humans and mammals, the central nervous system, such as the brain and spinal cord, is located on the dorsal side of the body and internal organs on the ventral side. On the other hand, Insects have their nervous system on the ventral side and appear to have their dorsoventral side reversed from that of vertebrates. Determining the dorsoventral position of an animal is inseparable from the question of which side of the body the nervous system is located.　We have demonstrated that the dorsoventral axis is determined by a secreted protein called BMPs. When BMP function is interrupted, the nervous system is formed on the original ventral side.

We are currently studying how the neural tube, the origin of the brain and spinal cord forming on the dorsal side, is formed.



Neural tube formation occurs in steps A to B to C

Neural tubes are made initially of a flat sheet of cells. This two-dimensional (2D) cell sheet (neural plate) is then folded to form a three-dimensional (3D) tube, which is necessary to build the brain and spinal cord. Many studies have revealed that the cells at the "folds" of the cell sheet change their shape from cubic to rectangular and then wedge-shaped.　It is essential for every cell to change its shape and move around significantly to create the shape of our body, not only the neural tube.

Changes (evolution) in these shaping mechanisms result in various morphological changes (evolution).　In the case of human neural tube formation, this is known to manifest itself as congenital diseases such as “the neural tube defects” and “the spina bifida.” On the other hand, the evolution of these morphological mechanisms is the driving force behind the acquisition of diversity in living organisms.　For example, it is believed that the great variety in the shapes of insects' legs, wings, horns, and other organs is due to the gradual changes in this morphogenetic mechanism over a long evolutionary history.　The study of how organisms form is closely related to basic medicine and evolutionary studies.