S-face

SFC makes the future through researches

Creation of a perfect guide for the amazing journey from Egg to Embryo

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The study in the creation of life

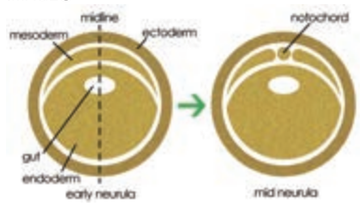
There is infinite variety in animal forms. However, all life begins through the workings of a similar system, whereby a spherical egg is fertilized, and the fertilized egg goes through the repetitive process of somatic cell division. "Firstly, how is life created?" With this question as the leading proposition, Associate Professor Hiroki Kuroda places his focus on the notochord, which is the first organization formed in the early stages of creation for vertebrates, including human beings. Associate Professor Kuroda elucidates the substances that are indispensable to the birth of life, and carries out research on the functions of these substances. He also explores a variety of themes, from the characteristics of these substances to their potential for application in the field of medical science.

Discovery of the key molecule AXPC, which is indispensable for the formation of spines

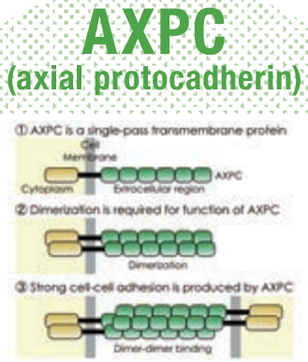
Animals cannot be vertebrates without the presence of a spine; the origin of a spine is the notochord. When we observe a fertilized egg, we would find that invagination first occurs on the inside of the surface layer. This is followed by the emergence of something resembling a single strand of wire in the area that would become the back in the future. This is the notochord, and the egg becomes elongated while it grows and extends forward and backward. After that, the notochord disappears, and its space is taken up by the spinal cord and vertebrae, which combine to form the spine.

The handful of cells that are present near the centermost line of the mesoderm gather to become the notochord, while the cells that will become the notochord in the future (presumptive notochord cells) congregate in the central region even if they become mixed with other cell groups (IMAGEⒶ). The molecular mechanism of this sorting activity on presumptive notochord cells was integrally explained by my finding of novel cell adhesion molecule called as "axial protocadherin (AXPC)." Compared to other cell groups, presumptive notochord cell groups have exceedingly strong cellular adhesiveness by AXPC. Except for AXPC, there have been no reports to date on other molecules that express specifically only in vertebrates. Hence, it may even be acceptable to declare that vertebrates were able to emerge through the birth of AXPC. As AXPC is also involved when vertebrates require extremely strong cell aggregation competence, the first AXPC function could perhaps be described as aggregating presumptive notochord cells to a central region.

IMAGEⒶ

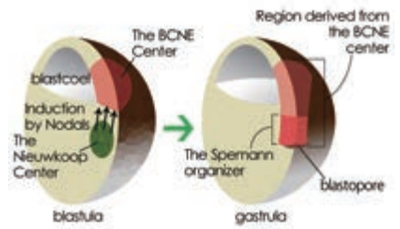


AXPC (axial protocadherin)



AXPC is specifically expressed in vertebrate and found by Kuroda. It is also known as "protocadherin-1". Evolution to vertebrate might be required for appearance of AXPC.

BCNE center



Precursor region of the Spemann organizer in gastrula is existed in blastula and called as the BCNE center. If the BCNE center has an effect by nodal protein secreted from the Nieuwkoop center, it gives rise to the Spemann organizer in gastrula. The BCNE center and this molecular mechanism were found Kuroda.

Providing a clear and irrefutable guide toward elucidating the induction system for tissues

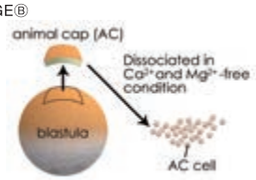
Professor Spemann from Germany discovered the 'Spemann organizer,' which has very strong induction competence in the dorsal lip region of the blastospore in amphibian embryos. In 1935, he received the Nobel Prize in Physiology or Medicine for this discovery. Triggered by this discovery, developmental biologists have accepted that the Spemann organizer plays a central role in the induction of all organizations. However, later research proved the fact that nerves are also induced even under conditions where the Spemann organizer does not exist. If that is the case, what is it that fulfills the role of induction for the nerves? I proved that even before the gastrula stage when the Spemann organizer emerges, the presence of the chordin and noggin in the protein that are expressed during the blastula stage is related to nerve induction, and named the unique region where chordin and noggin are expressed as the Blastula Chordin- and Noggin-Expressing center (BCNE center). Two centers appear during the blastocyst stage; one of these is the BCNE center, and the other is called the Nieuwkoop center. When a substance known as nodal, which is secreted from the Nieuwkoop center, works on the BCNE center, the inducted BCNE center becomes a Spemann organizer. This research has been recognized worldwide as a guide toward the stages of neurogenesis.

Will the time soon arrive when we are able to create life artificially?

I am currently conducting experiments to verify the role that the BCNE center plays in the formation of the Spemann organizer. If this research moves forward successfully, it may be possible to effectively create the Spemann organizer in a test-tube.

Animal cap (AC) cells (existing only in amphibians) (IMAGEⒷ), which belong to the undifferentiated cell group of the animal pole side of the blastula stage (the part of multicellular animal egg cells that give rise to polar bodies), have similar properties as iPS cells (pluripotent stem cells), which has almost same abilities as ES cell (embryonic stem cells). By harnessing the artificially induced BCNE center and Nieuwkoop center to create pseudo-embryo-like structures only from AC cells, it has been found that notochords, muscles, and nerves have been formed from AC cells, which originally only bring about the formation of the epidermis region. Furthermore, it was also proven that they react to stimulation and engage in greater motion (The image of AC cells moving is available on YouTube: http://youtu.be/HJ4DM0TIGb0). Advancement on this research is expected to produce swimming tadpoles through the induction of the overall structure of embryos only in the epidermis region. In addition, if iPS cells are used instead of AC cells to successfully create BCNE center and Nieuwkoop center, it could then serve as a foundation for creating the structure of the entire body of vertebrates. This could bring us dramatically closer to a future in which life could be created artificially.

IMAGEⒷ



Profile

Hiroki Kuroda

Associate Professor, Faculty of Environment and Information Studies, Keio University. Graduated from the School of Science, Nagoya University, and completed the doctoral program at the Graduate School of Arts and Sciences, University of Tokyo with Ph.D. After that, he became a research fellow at the University of California, Los Angeles (UCLA) and Associate Professor at the Faculty of Education, Shizuoka University. He took up his present post in April 2013.

Please visit S-face website for details!

There are more articles and video of Hiroki Kuroda

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