

Field: Life science and medicine; Keywords: sweat gland, visualization of the Three-dimensional Structure, heat stroke, hyperhidrosis, antiperspirant

## Successful Visualization of the Three-dimensional Structure of the Sweat Gland, which Regulates Body Temperature

-Hope for the Explanation and Treatment of Heatstroke and Hyperhidrosis and the Development of Next-generation Antiperspirants-

### [Research Results at a Glance]

- ◆ Successful visualization of the complicated 3D structure of the sweat gland and detailed explanation of the contraction of the gland during sweating.
- ◆ Comprehending the mechanism of sweat gland contraction requires the understanding of the structure of complex sweat glands; however, the existing method (two-dimensional structural analysis) cannot provide sufficient information to understand the mechanism of contraction.
- ◆ This information might lead to the clarification of the mechanism of sweat gland contraction during sweating, which will be immensely useful for the elucidation and treatment of heatstroke and hyperhidrosis, as well as the development of next-generation antiperspirants.

### ❖ Outline

Our Osaka University research group, including Guest Professor Fumihiro Okada, Laboratory of Advanced Cosmetic Sciences, Graduate School of Pharmaceutical Sciences, Osaka University, Professor Kiyotoshi Sekiguchi of the Research Department of the Protein Research Institute, and Professor Ichiro Katayama of the Dermatology Department of Integrated Medicine at the Graduate School of Medicine, succeeded, for the first time, at visualizing the 3D structure of a

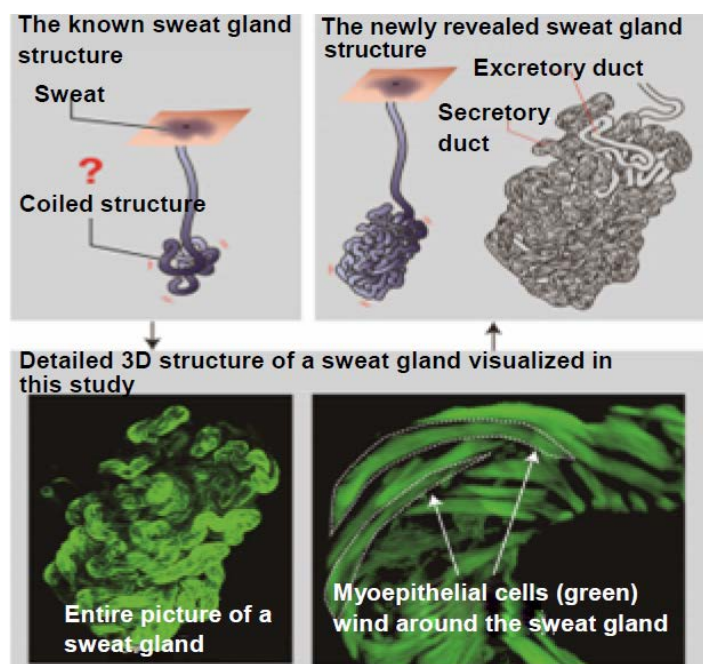


Figure 1: Detailed 3D structure of a sweat gland revealed in this study

human sweat gland, which is expected to allow the understanding of the contraction of the sweat glands during sweating (Figure 1).

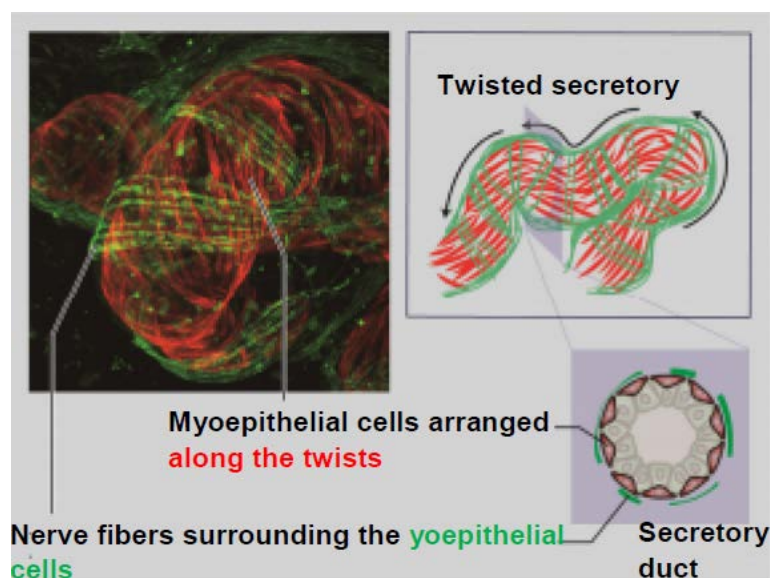
Clarifying the mechanism by which the sweat gland contracts during perspiration requires the understanding of its structure in detail. However, **because the sweat glands have a complicated three-dimensional structure, elucidating their structure by using conventional two-dimensional structural analysis was not possible.**

#### ❖ Background of the research

Because of global warming and the emergence of a super-aged society, increases in the numbers of patients with hyperhidrosis and heatstroke have become a social problem. Improving the impaired sweating function noted in these disorders requires the understanding of the structure of the sweat gland and the manner in which it contracts during perspiration. The sweat gland is a single tubular exocrine gland composed of a secretory duct and an excretory duct, and the sweat released at the secretory duct is discharged to the skin surface through the excretory duct. The secretory duct at the end of the sweat gland and a portion of the excretory duct are intricately folded into a coil shape, similar to a tangled ball of string. The outermost layer of the secretory duct of this sweat gland, present in this coil region, is surrounded by the myoepithelium, which is said to contract during sweating. However, **because the sweat gland has such a complicated structure, its intricacies could not be clarified using conventional analysis.**

#### ❖ Research Content

Our research group has **succeeded in visualizing the 3D structure of a human sweat gland by using whole-mount immunostaining.** In order to understand the complex coiled structure of the sweat gland, we first selected markers that can be used to identify each part of the human sweat gland. By using these markers to visualize the three-dimensional structure of the sweat gland, we found that the tubes of the secretory gland within the coiled structure had adopted a twisted 3D orientation, almost like a wrung-out towel. The myoepithelial cells covering this secretory duct



**Figure 2: The 3D Arrangement of Myoepithelial Cells and Nerve Fibers in the Secretory Part of a Human Sweat Gland**

were arranged in the direction in which they had been wrung. In addition, by visualizing the nerves necessary to conduct the stimulus that cause perspiration, we found that they surrounded only the myoepithelial cells of the secretory duct (Figure 2). This characteristic 3D structure is completely different from that of other secretory glands (such as the

mammary gland and salivary gland); therefore, we concluded that the sweat gland secretes sweat via a unique secretion mechanism.

❖ Social impact of these research results (significance of these research results)

We have revealed the detailed 3D structure of a human sweat gland, which is important in contraction during sweating. Understanding the contraction of the sweat gland is indispensable for the treatment of impaired perspiration patterns. If our findings lead to further explanation of the basic mechanism of sweat gland contraction during sweating, further understanding and even [treatment of disorders resulting from impaired sweating function \(heatstroke and hyperhidrosis\) might become possible](#). Further, in the realm of antiperspirants, which have, to date, functioned only as “lids” for the openings of sweat glands, direct action of the sweat glands might realize antiperspirants with novel capability to directly control the amount of perspiration.

❖ Remarks

These findings will be published in the American science journal PLOS ONE (Online) on June 22, 2017 at 4 AM Japan time.

Title: “Three-dimensional Cell Shapes and Arrangements in Human Sweat Glands as Revealed by Whole-mount Immunostaining”

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This study was performed with funding from the Japan Society for the Promotion of Science Grant-in-Aid for Scientific Research 16K19721 (The Three-dimensional Structural Analysis of the Contractile Coil Element of the Human Sweat Gland, Responsible for Thermoregulation, and Adjacent Blood Vessels and Nerves )

❖ Glossaries

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Jointly set up in June 2015 by Graduate School of Pharmaceutical Sciences, Osaka University, and Mandom Corporation. This laboratory accepts financial support from private enterprises and aims to produce excellent research results on common themes in joint research conducted on equal footing. This laboratory is an independent research organization set up within Osaka University and conducts flexible and speedy research activities through discussions between Osaka University and Mandom.

### \*2 Coiled Structure of a sweat gland

A sweat gland is a single tubular exocrine gland, and the end part of a sweat gland is folded intricately in coiled structure like thread waste entanglement. The outmost layer of the secretory duct in this coiled area is surrounded by myoepithelial cells and contracts in sweating.

### \*3 Whole-mount immunostaining

A method that involves the staining of an entire tissue or organ for the investigation of the spatial distribution of cells therein.

## ❖ Inquiries

### <About the research contents>

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### <About this news release>

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### [Comment by the Researchers]

During evolution, and in order to avoid lethal increases in body temperature, human beings came to possess sweat glands throughout their body and chose to accomplish thermoregulation via sweating. This function is absent in other animals. The sweating function of our evolutionarily immature sweat gland tends to change according to our living environment and can become a social problem (such as heatstroke due to global warming or a decrease in the quality of life due to conditions such as hyperhidrosis). However, the current model of perspiratory function, necessary for the understanding and treatment of the underlying causes of impaired perspiration, is quite sparsely detailed compared with that of other organs. Studies on this shortcoming of our understanding of the sweating function characteristic of human skin tissue can, by forming a strong basis on which further studies can be performed, lead to applicable findings in the future. Thus, we have been developing techniques to isolate individual sweat gland cells, identifying sweat gland stem cells, and analyzing the 3D structure of sweat glands (this press release). In order to overcome disorders of impaired perspiratory function, we pledge to continue our research efforts.