

**Report on the short-term overseas study program
for KU Engineering students
Graduate School of Engineering, Kyoto University**

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I spent two months studying at the Georgia Institute of Technology (GT) in Atlanta. I stayed in Takayama Laboratory in the Department of Biomedical Engineering and participated in their research. I will present my stay in several parts.

[Atlanta and Georgia Institute of Technology]

Atlanta is the capital of Georgia. Half of the population is blacks, but you can also see many whites, Asians and others. There are many restaurants of various countries so that you can enjoy different kinds of ethnic foods too. Atlanta is known as a city that traffic jam often occurs, and what I was surprised is that the highway had eight lanes in each direction but there were traffic jams every morning and evening.

GT locates in the west side of midtown and there are many greens and beautiful buildings. Most of the faculty are engineering majors, but 40% of the students are women. GT has many organizations which help our research and daily life, such as Invention studio where we can use many shared facilities such as 3D printer or Metal CNC machine for free. There are also a big building and field to do various kinds of exercise and I usually spent my weekends there.

During my stay, I was often approached by strangers. At first, I was timid because I could not understand what they were saying, but in the latter half of my stay, I gradually became able to ask for help and make small talk with strangers on my own. Conversations with the people I met in the elevators of my apartment became a small pleasure.



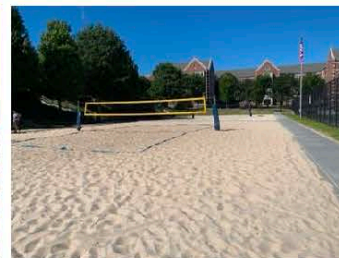
(a)



(b)



(c)



(d)

(a)GT campus. You can find 8 lane highway in the lower left corner of the photo. (b)Tech tower, the building symbolized GT. My favorite place in campus. (c) The building where the laboratory where I stayed was located. (d)Beach volleyball courts. I didn't expect to be outside when me friend invited me to join volleyball.

[Research]

The main topic of my master course research is “Organ-on-a-Chip”. It is a small microfluidic device which is

made by 3D Microfabrication technology, and what I'm trying is to integrate sensors such as temperature sensors or electrical sensors to evaluate cell condition inside the device. This technology contributes to medical and drug discovery application, so that it is highly practical research.

In my bachelor research, I was working on the electrical measurement (called **TEER**) held inside the device for evaluating cell barrier function which prevents drugs or other substances from entering the body. To do this measurement accurately, we need to design electrode pattern properly, but the design method was not established. Therefore, I proposed new design method which enables us to measure TEER accurately and showed its usefulness through the cell culture experiments.

In Takayama lab, they also use TEER measurement to show the advance of their cutting-edge cell culture method (Reference: <https://doi.org/10.1002/adhm.202100879>). However, their measurement had large standard deviation which cannot be explained only by cell condition, and I considered that it was due to the electrode design. Therefore, I planned to decrease the deviation by applying my knowledge. In addition, I focused on their co-culture system. In the system, they culture two types of cells so that there are two cell layers. However, normal TEER measurement can only evaluate them as a mono layer. In other words, it cannot evaluate two layers separately. Therefore, I considered that if we could measure each layer's TEER, we could get more detail on what's going on the culture system.

I had worked on these two topics and finally did 30 minutes presentation at the lab meeting. However, unfortunately I can't show any data or detail because my work has been unpublished. I describe the outline of my research here.

Just after the arrival to GT, I had finished all orientations needed to do research and started the research work. First, I observed how they measure TEER on their culture system and found out that (1) electrode position can be moved only in the direction of height and (2) electrode position differs between each sample. Based on these situations, I set two objectives to reduce the standard deviation; (1) Calculating appropriate electrode position by using FEM, (2) Making a jig to fix electrode at a same position at each sample. Finally, I completed these objectives, and the standard deviation was successfully reduced by about half.



(e)presentation at the lab meeting

Furthermore, I worked on the topic to measure two layer's TEER separately. I considered using Electrochemical Impedance Spectroscopy (EIS), a method to get object's parameter by measuring its impedance and analyze it by equivalent circuit, is a good way to measure them separately. However, Takayama lab didn't have the setup to do EIS, so I built the EIS setup and measure impedance in their cell culture system. I completely separated each cell layer's TEER, and the results enabled us to know what was happening on each cell layer. The development in these studies is expected to make significant contribution to future research at Takayama lab and others.

Through research, I learned and felt a lot of things. I describe some of them below.

First, I thought staying at Takayama lab was the best choice for me. As a mechanical person, I have been involved in research to contribute to the field of medical engineering, but I have never visited the destination of the technology we have developed, i.e., the field of medicine and biology. Having witnessed various experiments

in a laboratory belonging to bioengineering, I became keenly aware of the complexity and difficulty of experiments in biology, and it made me think that in the devices we develop, we need not only the integration of the latest technology but also (1) a high-throughput experimental system that can handle many samples and (2) versatility that allows people without engineering knowledge to easily use the device.

Second, I felt comfortable during my research because everyone in the lab was very positive. If we do our research, there will always be times when we make mistakes. I and Takayama lab member also made some mistakes during our research. However, they didn't look back on the past mistakes so much and never got depressed, but always considered what should we do next. We didn't blame anyone for failing but encouraged them and discussed about future work. I believe this experience will help me and my lab mate to maintain motivation for research when we make a mistake, or our research don't go well.

[Other activity]

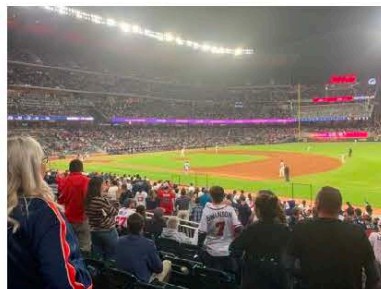
I enjoyed daily life as well as the research. First, the time spent with the lab members was wonderful. Most of them were from Southeast Asia, but there were also students from the US, India and Europe. Not only was there a diversity of nationalities, but there were also vegetarians and LGBT, and by talking and eating with them a lot, I was able to understand their different ways of thinking.

Second, I love sports, so I enjoyed many sports such as GT volleyball, football, basketball and MLB. I found that the race of people who came to watch each sport was different. For example, at the football stadium, most of the spectators were white. On the other hand, in GT volleyball and basketball, there were many black and Asian people too.

Finally, I went some sightseeing. There are many famous places, and I went most of them. Of all of them, Georgia aquarium which is the biggest aquarium in the US was the most amazing place in Atlanta. If you like marine and river life, you must go there.



(f)



(g)



(h)

(f) Halloween party with lab members at Prof. Takayama's house. It is common to invite their family in the US.

(g) MLB game which was so excited. Atlanta Braves had won this game and few days after they won the championship of National league. (h) Whale shark in Georgia aquarium.

[Acknowledgement]

I would like to thank Graduate school of Engineering, Kyoto University for supporting my stay. I am grateful to Takayama lab's member for their kindness and hospitality.

