Symposium 1
Bringing the micro-world to everyday life using mobile microscopy

Organizers: Masashi M. Hayakawa and Kuniaki Nagayama (Life is small. Projects, Japan)

Synopsis: A mobile microscope[1] is built on a simple mechanism: a single lens is attached to the digital camera of a smartphone or tablet device. With the mobile microscope, the sample image magnified by the single lens are photographed with the camera, making it easy to observe the detailed structure of microorganisms such as protists. The mechanism of mobile microscope is the same as that of a simple optical microscope which was invented as a hand-made microscope about 300 years ago by Leeuwenhoek. While Leeuwenhoek observed samples through his own eyes, the mobile microscope uses the digital camera of mobile devices instead. And then, the enlarged sample image is displayed on the monitor screen of smartphones or tablets. Therefore, our eyes never get tired, and the same sample image can be shared among a group of people at once, leading a microscopic world sharing. In the past, Leeuwenhoek-type simple optical microscopes has gone extinct, and compound optical microscopes became the mainstream of tool for microscopy. With the advent of mobile devices such as smartphones and tablets, nowadays spread to every corner of this globe, the 21st century Leeuwenhoek-type microscope has been revived as a new tool for inviting people in the micro-world. Interestingly, Leeuwenhoek was also the first person in human history to discover protists using his simple microscope. Just as Leeuwenhoek once observed protists with his microscope, let us play with protists[2] and micro-world as well using mobile microscopy[3]. In order to raise the new culture of microscopes, we, Life is small. Projects, have been managing the science communication using mobile microscopes. In this symposium, we are going to introduce the basic ideas of mobile microscopes, methods of observing micro-world including protists, and our science communication activities in general along with. We would like to share this new tool to access the micro-world with everyone who likes everyday enjoyment with the tool including one who specializes in protistology.
[1] The mobile microscope in Japan was invented by K. Nagayama (co-chair) and T. Ito in 2013, and various variants have since been developed by S. Shirane at the Institute for Science Communication.
[2] Diverse protists movies observed using mobile microscopy are exhibit at MMH (chair) YouTube channel: https://www.youtube.com/channel/UCbRUUtQl1oZ1PcB9LnivpNg [3] Maeda, Nagayama et al., Microscopy Today., 2020 July, 54-59.

S1-1

Watching the micro world with a mobile microscope

Kuniaki Nagayama[1], Junto Shirane[2] ([1]Life is small. Project, Japan; [2]Science Communication Research Institute LLC., Japan)

What is a mobile microscope?

A mobile microscope is a microscope with a minimum configuration consisting of a mobile device and a single lens that is attached externally to the camera of the mobile device. The lens can be attached to either the camera on the screen side of the mobile terminal (in-camera) or the camera on the back side of the screen (out-camera), depending on the purpose. Since the physical magnification of a mobile microscope is given by the ratio of the focal length of the camera lens to that of a single lens, a mobile terminal with a lens having a focal length of 2-4 mm will have a physical magnification of around x 1 if a 3 mmϕ ball lens is used. This guarantees theoretically a resolution of

2 µm, since the pixel size of the mobile terminal photosensor is about 1 µm. The mobile microscope has following features; 1) small, lightweight, portable, easy to operate and maintain, 2) 3D printer manufacturing from a single item at a low price according to the purpose, 3) possible to produce a small quantity of a wide variety of microscopes and able to deliver them directly to users anywhere in the world through internet distribution without going through distributors.

Types of mobile microscopes and their potential applications

Various types of microscopes such as reflective/transmission microscopes, polarized light microscopes, underwater microscopes, and centrifugal microscopes have been realized to date (see Figure). 1) These microscopes look toys only for simple observation but now they have moved into the practical phase, such as improving the efficiency of dissection practice in medical schools2), professional observation in biology3), and use in citizen sciences. In this presentation, we would like to share with you some examples of micro-world observation using hitherto developed mobile microscopes.

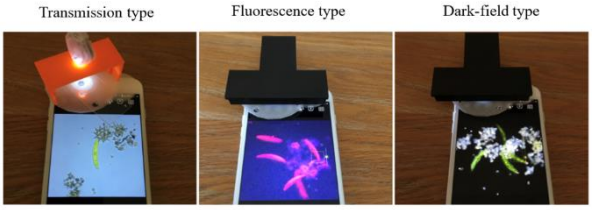

Figure. Examples of various mobile microscopes

References

1, The mobile microscope in Japan was invented by K. Nagayama and T. Ito in 2013, and various variants have since been developed by S. Shirane of Science Communication Research Institute.

2, M. Maeda, N. Usuda, M. Kokubo, S. Shirane, M. Fukasawa and K. Nagayama, “A Leeuwenhoek-Type Mobile Microscope for Histology Education”, Microscopy Today, 2020 July, 54-59.

3, M. Hattori, S. Shirane, T.Matsuda, K. Nagayama and Takeharu Nagai, Smartphone-Based Portable Bioluminescence Imaging System Enabling Observation at Various Scales from Whole Mouse Body to Organelle, Sensors 2020, 20, 7166-1~11.

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S1-2

Using mobile microscope in high school biology "Cell Observation" class in Cambodia

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Microscopes are indispensable for observing living things in schools. In Cambodia, there are at most several and many schools do not have any microscopes in rural areas. We thought that the use of a mobile microscope would be effective under such conditions. In this study, we report the practice of observing cells using a mobile microscope in a biology class at a high school in Cambodia, and discuss the effectiveness of its use and the ideas for development of biology education. An 80-minute class was held on February 7th, 2020, for 36 students of Grade 10 at Preah Sisowath High School in Phnom Penh. 36 students were divided into 9 groups. Mobile microscope enabled students think about a method of observation and discuss with other students, instead of conducting observations and experiments restricted in the textbook and confirming the results. Students were very excited to experience using mobile microscopes. The microscopes are easier to set up and to use. In this research, I could expect the usefulness of the mobile microscope in the class in Cambodia. In the near future, I would like to use it in other unit and conduct classes at other schools. In addition, we aim to realize the supply to each school and conduct teacher training. I will continue to study the development of teaching materials and teaching methods with people involved in education of Cambodia.

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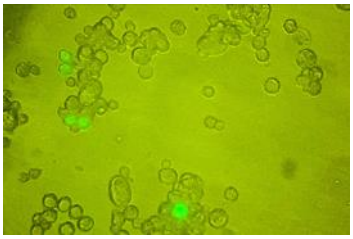
S1-3

Performance improvement in mobile microscopes

Kazumasa Sato (Lasalle middle and high school, Japan)



Since the invention of the mobile microscope, I have been interested in improving its performance. First, I explored the applications of the mobile device, which can increase the capability of the microscope. In general, microscopes used in molecular and cellular biology research(such as CLSM) are controlled by a computer, so I made the mobile device as a display and computer unit. Combination of interbal shooting application and produce animation application enabled advanced microscopic observation such as time-lapse imaging. Second, I modified mobile microscope. For example, I made “mobile fluorescence microscope” just by using UV LED . And I made polarlizing microscope by adding polarlizing filter. These methods can be applied to observe GFP fluorescence. These methods have been basic technology for mobile microscopy. I’m going to introduce these methods and show you beautiful pictures and movies.

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S1-4

The Workshop of Mobile Microscopes for Children

Yoko Takeshita (Science Communicator, Ochanomizu University, Japan)

In the spring of 2020, I held a workshop for children how to use and enjoy “mobile microscopes” in a small village at Kochi prefecture, Japan. A mobile microscope is a small Leeuwenhoek-type microscope that can be made by attaching a single lens to a mobile device such as a tablet device. Due to the COVID-19 pandemic, I had to apply an online meeting system and to remotely ask my colleague scientist who could join to help me. I introduced a picture book “Water Ball Lens” to the participated children and performed several experiments together with them. First, I explained the lens functions to the children by using a drop of water. Then, they moved to the garden from the workshop room to observe plants, animals and microorganisms with the tablet microscopes at several magnifications between x10 and x100. Lastly, a photo contest was held based on the micrographs taken by children and the colleague scientist gave comments to each of the children works through the internet. In this talk, I will present the details of my experience in the unforgettable workshop.

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