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Continuing the Mission of Professor Keiichi Tanaka
Pursuing — and Communicating — Beauty
in the Form of Truth
(Part Two)

A conversation with Sumire Inaga of Tottori University and Daisuke Koga of Asahikawa Medical University to commemorate the accomplishments of Professor Keiichi Tanaka, an international authority on SEM who passed away in October 2019.

In this second part of our conversation, titled “Continuing the Mission of Professor Keiichi Tanaka,” we asked our panelists to describe their efforts to advance Professor Tanaka’s lifelong mission to expand the possibilities of electron microscopy—and to discuss future prospects for their own research.

(Panelists)

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**Creating an Environment for Children
to Become Familiar with Electron
Microscopy**

— A core mission of Professor Tanaka’s work—and one that has now been passed on to the two of you as the next generation of his research family—is to broaden the realm of what is possible to achieve with SEM. Professor Inaga, I understand that one of your initiatives in this direction is a partnership with your local city government involving the slogan Yonago: the electron-microscope town.* Could you describe this project?

INAGA: This is something that arose out of the blue just as I was retiring from the university in 2018. It all started when Professor Tanaka’s advanced age started to make it difficult for him to continue his research, and he decided to donate his cherished S-2460 Natural SEM system—which he had installed at his home and used with great pleasure for many years—to Yonago City. It seems that initially there was some progress toward making this happen, but then things ground to a halt due to various obstacles and a change of mayors, and eventually Professor Tanaka asked me what would be best to do. At that point I asked one of my former

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classmates to step in and help out, and we wound up contacting the city's Superintendent of Education to rejuvenate the project.

As it turned out, Professor Tanaka was not the only giant of microscopy to hail from Yonago City: the late Professor Eizi Sugata, a TEM pioneer who was Dean of the Osaka University School of Engineering, was from Yonago as well. Thus Yonago can count the preeminent researchers in both SEM and TEM among its native sons—an honor that links the city inextricably to the art and science of microscopy, but one which remains almost entirely unknown! So we used this opportunity to help spread the word: we created an exhibition showcasing the microscope that Professor Tanaka donated and other instruments, both to celebrate and tell the world about the achievements of Yonago's two illustrious microscopists and to establish a meaningful environment for microscopy education—we even proposed holding a fund-raising drive to allow us to purchase a new microscope system. And thus, with the enthusiastic support of Yonago's mayor, we launched our project to install a tabletop low-vacuum SEM system—both for exhibition purposes and for actual research—in a corner of the Yonago City Children's Center.

As for my part in all this, I had been planning to wait until I retired and had more free time before getting involved, but the Dean of the Faculty of Medicine said “No, the alumni and the Medical Association are willing to help out, so you should really take care of it before you retire.” So I started working on it in December 2017. As it turned out, we received fewer donations than we had expected, and we didn't achieve our funding goal of 5 million yen until after the opening ceremony on March 26, 2018—a rather precarious situation! Happily, though, Professor Tanaka—who had been hospitalized for more than 2 months at that point—was able to attend the ceremony in a wheelchair, and we were thrilled to be able to celebrate the occasion with him.

Our actual Miniscope[®] system is installed in one corner of the main entrance hall of the Children's Center; we call it the Corner for Exploration of Microscopic Worlds and the installation is designed to make it easy for anybody—both adults and children—to observe microscopic phenomena. The system can only be used when a supervisor is present—we have a total of three supervisors, including myself—and we do get many requests from people asking us to show them a specimen. During summer vacation we allow users to sign up



The Corner for Exploration of Microscopic Worlds at the Yonago City Children's Center.



Professor Tanaka Keiichi in good spirits at the opening ceremony.



Children have the opportunity to control the electron-microscope system with their own hands.



Doctor Inaga guiding students through an observation. Volunteers who have taken a training course offered by members of the project committee may serve as guides in rotation to help children make observations.

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for one-hour slots during which the instrument is theirs to use for their independent research; there are a total of about 40 such slots, and they always get fully booked almost immediately. The total number of electron-microscopy images captured to date is already around 9,000.

KOGA: I've visited this facility too—I was invited to speak as part of a special lecture series commemorating its dedication, and I remember being astonished by the unusual laboratory environment. It was the first time I had ever seen an electron microscope installed next to a ping-pong table! But the notion of a facility offering both children and adults the opportunity to play around with electron microscopy is truly revolutionary, and I doubt there's anything else like it in the world.

INAGA: Even though the system is installed in an environment with a lot of dust and a lot of vibrational noise—and with children running around everywhere—to date we've had no operational problems with the instrument itself; all that dust seems to have no impact on the interior of the microscope! It's a real testament to the solid construction and robustness that Hitachi High-Tech designed into the Miniscope[®] system.

* Promotional website for Yonago: the electron-microscope town:
<https://denkenyonago.com/>
(in Japanese)

Outreach Activities via Mass-media Channels

— I understand a few children have already won awards for research they did with this microscope.

INAGA: That's right! Kaname Ishikura was in his second year of middle school when we opened the facility, and he wound up spending so much time there that now he can operate the microscope by himself. He's also a gifted writer who has entered many writing competitions, and just the other day we learned that his essay "Inheriting the challenge of the microscopic world," which he submitted to the contest for Sankei Shimbun's 2020 Culture Award for high-school students, had won an Excellence Award—the second-highest prize in the national competition. His essay described his experience, starting in middle school, of using electron microscopes to observe specimens; he also

discussed his interactions with Professor Tanaka and with me, and expressed a firm commitment to following in Professor Tanaka's footsteps as an explorer of the microscopic world. If our decision to install an electron microscope at the Children's Center played any role in stoking Kaname's interest in science, that would be a truly wonderful reward.

Meanwhile, Chiaki Muku, a primary-school student, captured an image of secretory gland structures on the surface of a mini tomato that won an "Honorable Mention" in the Japanese Society of Microscopy's 2019 photo contest. The image very clearly depicted protrusions closely resembling four-leaf clovers, and was recognized by an Honorable Mention even though the contest usually selects only one winning image. The news that a second-grader had pulled off such an impressive accomplishment was a hot topic of conversation throughout the region.

In capturing microscopy images, children are often able to succeed where we researchers fail due to our preconceived notions and biased thinking; when this happens, we find it tremendously stimulating. Professor Tanaka always said that he wanted children to appreciate the beauty of the microscopic world—and to experience it for themselves; as we move toward turning this dream into reality, I like to think he's up there somewhere looking on with pride and joy.

KOGA: To me it seems clear that this project could only have been successful with Professor Inaga at the helm. My own efforts to expand awareness of electron microscopy—which seem almost embarrassingly feeble by comparison—have focused on mass-media strategies; for example, with help from the folks at Hitachi High-Tech I recently appeared on an NHK science program. I should say that, in general, presenting to an audience is one of my least favorite things to do, and I'm not even sure that performing on TV or in other media is the right strategy, so in the past when I was asked to provide photographs or appear in public I always declined. However, eventually someone encouraged me to make more of an effort—"as part of an outreach effort to promote awareness of electron microscopy among the general public," they said—and I began to reevaluate my reticence.

One current societal trend that I find concerning is "detachment from electron microscopy." I think an effective way to counteract this trend is to reach out to children—through the media, of course—to

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get them interested and engaged in the microscopic world. Of course this isn't something I can do on my own—we need help from the good folks at Hitachi High-Tech and many other people—but I've become committed to outreach initiatives to convince even just one more person of the enormous appeal of our field.

Inaga: In contrast to our work promoting Yonago: the electron-microscope town—whose impact is obviously limited to a single geographical region, Professor Koga's work has the potential to reach people all throughout Japan—and around the world. I think both types of outreach are important. People find Professor Koga's microscopy images to be convincing precisely because they are so spectacular—it's impossible to look at them without being moved by their beauty. Going forward, I'll keep doing everything I can to sound the message far and wide: Beauty is truth, truth beauty.

Koga: Thank you very much for those kind words.

Appreciating Electron Microscopy Images—as Works of Art

— Do I understand correctly that there is even a gentleman who presents electron microscopy images as works of art?

Inaga: That's correct. The work we do to promote Yonago: the electron-microscope town has sometimes involved working with artists, and in March 2019, to celebrate the one-year anniversary of our founding, we presented exhibits at the Children's Center and at the Yonago City Museum of Art displaying a collection of over 100 electron-microscopy images captured by children. One of the visitors to our exhibition was the artist and musician Tomoya Matsuura, whose work involves SEM images presented as works of art—and who, we heard, had submitted an entry to the Japanese Society of Microscopy's photo contest. By coincidence, this happened to be the year in which an image of HeLa cell chromosomes submitted by me and my collaborators at Hitachi High-Tech won first prize in the contest, so it was through that connection we wound up working with Mr. Matsuura.

Later that year, at a conference on chromosomes in September 2019, Mr. Matsuura and I presented an artistic creation consisting of a movie made from

our HeLa cell micrographs and set to music; this communicated research results, not through papers, but through sound and images, and was a big hit with the audience. Right now we're collaborating with Mr. Matsuura to create video content in which electron-microscopy images are paired with music; we plan to show the completed product in the planetarium at Yonago Children's Center.

Mr. Matsuura's work exudes an artistic beauty that captivates many viewers—including, for example, the organizers of the BIWAKO BIENNALE 2020 art festival, who used a SEM image captured by Mr. Matsuura as the background of the festival's official poster. Looking at his creations, one has the sense of being present at the creation of a promising new domain of applications for electron microscopes—as tools for artistic expression.

Koga: I agree that there's a sense in which SEM images can be interpreted as artworks. Black-and-white images give a feel for the structural beauty of nature, while adding color takes you to totally different worlds. These days we add color to enhance the visual clarity of images for the sake of academic accuracy, but with more time I'd love to explore more artistic coloration schemes.

“But Still It Seems Like There Might Be Something Missing...”

— I'd like to close by asking you both to describe your goals for the future.

Inaga: For me, as I said before, the main goal is to organize all the research I've done thus far. As a matter of fact, I used some of my retirement pay to purchase a Miniscope® for myself, and even after my position as a project researcher comes to an end I plan to continue doing research just like Professor Tanaka did. However, working with chromosomes really requires a FIB-SEM system, so for the time being my immediate goal is to organize all the data I've gathered thus far. I'd also like to work on establishing low-vacuum SEM techniques for renal biopsy analysis that would be easy to implement at clinics, to help make this approach more common.

I'm also hoping to continue moving forward with our work promoting Yonago: the electron-microscope town. Recently we've been excited about the idea of running an electron-microscopy image contest, open to pros and amateurs alike, to celebrate our three-year anniversary.

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KOGA: There are a number of things I'd like to do going forward, but the one most closely related to our discussion today is to establish osmium maceration as a method that anybody can use. When things go well, osmium maceration really does allow you to capture beautiful images. However, although many people understand this, a lot of times they say it's just too hard and give up—and some even grumble that Koga's the only one who can get it to work. But the reality is that, even after working on it for more than 10 years, I've only recently started to feel like I'm getting the hang of it.

The basic idea of osmium maceration (as we discussed in Part One) is to use a thin osmium liquid to remove soluble proteins while selectively retaining cell membranes. After a lot of my own trial-and-error experiments, I've come to understand that the temperature settings for the maceration procedure are crucial. Professor Tanaka recommended keeping the temperature fixed at 20°C, but I've found that slightly higher temperatures allow the maceration time to be reduced with almost no failures, and I was able to present this in a research paper. Going forward, I'd like to revisit the fixing fluid conditions to simplify things and make the method into something that anybody can recreate with good stability.

If my work on this helps make osmium maceration a more common technique, I'll feel like I have repaid some of my debt to Professor Tanaka. I dream of visiting the Professor's grave to let him know that osmium maceration has become a

technique that anybody can use.

Inaga: Professor Koga, a while back you and I went together to visit Professor Tanaka in the hospital, and I remember that he talked to us for an unusually long time and was full of praise and encouragement for our work. And yet, toward the end, he said "But still it seems like there might be something missing..." Do you remember that?

Koga: Yes, I remember that well.

Inaga: Whenever I would report some new research achievement, I remember Professor Tanaka would always congratulate me—but then would always repeat that same sentence at the end. I think he was trying to say "Never be satisfied with any single success, and always keep striving toward your goal." I'm pretty sure that this is what he said to himself, and that it's what motivated him to work so hard for so long.

So, whenever I'm feeling happy about something that has gone well, I try to remember the Professor's advice—and, Professor Koga, I suspect you'll always continue to hear Professor Tanaka saying the same thing to you. Never be satisfied with the status quo, and always keep searching for the next round of answers. This disposition as a scientist is part of Professor Tanaka's legacy, and I think we have a duty to pass it on to future generations whenever and wherever we can.

(Interview and text: Akiko Seki)

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