

Developing a portable video-rate atomic force microscope for biological specimens

A summary of my JSPS short-term Fellowship with Prof. Tatsuo Ushiki at Niigata University's School of Medical & Dental Science

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Research Proposal

The basis of my Ph.D and subsequent postdoctoral position was the design and development of an atomic force microscope (AFM) capable of imaging at video rates (100 to 1,000 times faster than conventional AFM) and its application to biological samples. The high resolution images available from an AFM allow biologists to observe structures as small as 1 nm on living specimens as a series of “snap shots” (a typical image takes several minutes to collect). The video-rate version I have developed goes one step further: enabling the direct observation of the dynamic behaviour of biological samples with a time resolution of less than 1 millisecond, making it the fastest AFM in the world. Although this new type of AFM has been highly successful, it does not overcome one practical consideration: these delicate biological samples require skilled preparation. Unfortunately this means that collaborative research tends to move very slowly when researchers (such as myself and my Japanese Host) are working in different labs. My JSPS Short-Term Fellowship proposal (the development of a portable video-rate AFM) gave me an excellent opportunity to bring my AFM and the specialised samples of Prof. Ushiki together in the same lab and to advance the collaborative research we had been working on during my Ph.D.

Professor Ushiki, Niigata University

Prof. Ushiki has been a long-time collaborator with the Bristol AFM group (and myself in particular) studying the structure of fully-hydrated human chromosomes in aqueous environments. While he is principally a medical biologist he is also active in the development of new instrumentation and has an excellent understanding of the difficulties inherent in combining cutting-edge instrumentation with fragile biological samples on the nanometer scale.



Scientific Highlights

During my three month stay I undertook the challenging task of developing a high-speed scan stage that was small enough to add to Prof. Ushiki's existing AFM, thereby turning it into a video-rate microscope. Once operational I was then privileged to work closely with Prof. Ushiki and his group in investigating important questions in chromosome and cell research. Thanks to the proximity of the microscope and the biological labs we had fast experiment-to-result turn around times and we were able to make fantastic progress in the preparation and imaging of specimens during my project.

One highlight of my trip was an entirely unexpected overlap in our research. During my stay I discovered that Prof. Ushiki had a relatively rare type of AFM that is capable of imaging samples under vacuum conditions. I was very pleased to be able to integrate my video-rate scan stage with this microscope because there are still significant questions related to the exact imaging mechanism behind video-rate AFM. By performing several typical experiments under vacuum rather than liquid conditions I collected some crucial results that have helped me to develop a clearer picture of how the video-rate AFM operates – a completely unplanned benefit of my trip!

Finally, I had an amazing opportunity to discuss my research with Japan's top researchers in atomic force microscopy when I was invited to present my work at the ATI Committee for BioSPM in Tokyo. The members of this committee include some of the leading figures in the field of AFM and it was invaluable to have the chance to speak with them and discuss my work in person.

Cultural Highlights

Prof. Ushiki's love and enthusiasm for Japanese art and culture enriched my entire trip but was especially useful during my visits to historic sites in famous places such as Kyoto and Nikko. His guidance and suggestions meant I got the most out of my time and helped me to see more than what the guide books alone describe.

I also had the great pleasure of playing Go with work friends on a traditional goban board and in return introducing them to some of the recent popular western games (such as Carcassonne and Settlers of Catan). However, the aspect of my experience that I consider the most valuable is that my day-to-day interactions with my colleagues, discussing news stories, music, politics, or perhaps cooking for them gave me a real feeling for life in Japan and how much I'd enjoy living there.



Advice For Others

The region around Niigata is famous in Japan for the quality of its seafood, its rice and by extension, its sake! But no matter where you might go in Japan I'd unreservedly recommend sampling as many types of Japanese cuisine as possible, the variety is spectacular and it is amongst the most balanced and healthy in the world.

As a rule the Japanese researchers you meet will probably speak at least some English, but it is still worthwhile (and fun) to try and learn some basic Japanese phrases, greetings etc., any attempt you make will be appreciated and it is not so difficult as you might expect.

The public transport network is as fast and efficient as people say and definitely one of the best ways to explore the country and to visit other labs. I'd definitely recommend making the most of the opportunity to give talks and to engage with the foremost Japanese scientists in your field – it is easily combined with sightseeing!



Enjoying a ski trip with Prof. Ushiki (right) and colleagues.