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The Advanced Imaging Center in Ashburn, Virginia, provides technical training for core-facility managers.

CORE CURRICULUM: LEARNING TO MANAGE A SHARED MICROSCOPY FACILITY

High-tech tools are increasingly being consolidated in specialized centres. Running these technological wonderlands takes a unique blend of skills. **By Sandeep Ravindran**

It's the long wait for equipment that H. Krishnamurthy remembers from his master's studies at Bangalore University in India. "I used to stand in line to get my turn to use a rusted hammer to nail [down] a frog for dissection," he says.

Today, Krishnamurthy directs a facility so that other researchers in Bengaluru and throughout India need never experience that lack of access. The Central Imaging and Flow Cytometry Lab at the National Center for Biological Sciences in Bengaluru "has helped scientists to take their research to next level", he says. "Before I started this facility, there was no paper published in *Cell* from India." Since then, users have published more than half a dozen papers in *Cell*, as well as others

in journals such as the *Proceedings of the National Academy of Sciences*.

Over the past 20 years, as instrument costs have risen and funding levels fallen, institutions have increasingly consolidated microscopes, mass spectrometers, flow cytometers and other high-tech equipment in specialized core facilities, where dedicated staff can cost-effectively provide a breadth of expertise and access to equipment beyond what any single laboratory could manage. Numbers are hard to come by, but Peter O'Toole, director of the Bioscience Technology Facility at the University of York, UK, has seen meetings for UK core-facility managers grow from a dozen participants in 2006 to around 200 today. And in Germany, the number of imaging core facilities doubled

between 2011 and 2015, from 30 to 60.

The people tasked with running these facilities have a rare collection of skills: in-depth knowledge of the hardware they oversee, managerial and financial acumen to run what is effectively a business, and scientific know-how to guide researchers through a range of experimental systems and designs. The management aspects alone would usually fill three jobs – financial manager, project manager and people manager – says Graham Wright, acting director of the Research Support Centre at the Agency for Science, Technology and Research in Singapore. Krishnamurthy was once asked to list his responsibilities, and says he was shocked at how many he had. "This is not a 9-to-5 job, it's a 24-hour job," he says.

Until a few years ago, however, there was no clear career track, and few specialized training opportunities. “All the people in my generation figured it out as we went along,” says Jennifer Waters, director of the Nikon Imaging Center at Harvard Medical School in Boston, Massachusetts.

But things are changing. Waters has launched a programme at Harvard that provides technical training for core-facility managers (J. C. Waters *Trends Cell Biol.* **30**, 669–672; 2020), and other institutions have created similar programmes, including the Advanced Imaging Center (AIC) at the Howard Hughes Medical Institute’s Janelia Research Campus in Ashburn, Virginia, and the European Molecular Biology Laboratory (EMBL) in Heidelberg, Germany. And fresh funding opportunities for managers and staff are making the career track easier to navigate.

“Probably the most important thing I’m going to do in my career is to help train this next generation,” says Waters.

Combining breadth and depth

At some core facilities, users drop off samples and receive data in return. At others, including Krishnamurthy’s, staff train users, but are not involved in the actual experiments. Many microscopy facilities lie between these extremes, with staff advising users on what imaging techniques are best suited to their projects and working with them as they operate the equipment.

Whatever the operational model, technical expertise is paramount. “The most important prerequisite to work in a core facility is that you really have to be very good at the techniques that you are operating, be it microscopy, flow cytometry or mass spectrometry,” says

Teng-Leong Chew, who directs the AIC. That means having not just technical proficiency in that equipment, but also a deep understanding of its theoretical underpinnings, as well as the engineering skills to be able to install, maintain and repair it.

Also required are the skills and experience to weigh in on a diverse array of projects and experimental models. “One minute you’re working on yeast and bacteria and the next minute on brain slices, and that means not only do we see a whole variety of scientific specimens, but also a huge range of microscopy technology,” says Alison North, senior director of the Rockefeller University Bio-Imaging Resource Center in New York City.

Chew, for instance, helps researchers to work out what imaging approach to use, how to design experiments, how to handle the equipment and how to analyse and interpret the resulting images – a process that can take anywhere from hours to days of one-on-one time. “You have to provide very good training, not just in how to use the instrument, but [in] how to make sure that your experiment is accurate, ethical, quantitative and reproducible,” he says.

Staying up to date with technology is crucial, be it through the literature, conferences or word-of-mouth. “That’s part of the job, to scout for new technology and make sure you’re using it earlier,” says Stefanie Reichelt, who runs the light-microscopy core facility at the Cancer Research UK Cambridge Institute at the University of Cambridge. Popular meetings for microscopy core-facility staff include the European Light Microscopy Initiative; Focus on Microscopy; the UK Royal Microscopical Society’s Microscience Microscopy Congress; and the Seeing is Believing conference.

Yet despite their crucial role in the conduct of research, core facilities are often as much businesses as laboratories, and staff rarely receive authorship unless they also provide significant scientific input. Acknowledgements are more common, although not guaranteed. “Sometimes you do hard work, and you will not see that reward directly coming in terms of an acknowledgement,” says Jan Peychl, head of the Light Microscopy Facility (LMF) at the Max Planck Institute of Molecular Cell Biology and Genetics in Dresden, Germany. To help address this, the Royal Microscopical Society and the US Association of Biomolecular Resource Facilities (ABRF) have developed authorship guidelines that core facilities can provide to their users.

Service providers

As microscopy core facilities become increasingly prevalent, they offer an intriguing career option for PhD and postdoctoral researchers. “I think it is a great career,” says North. But it’s not a position for someone who’s just applying “because they’re worried that they won’t get a job” as a principal investigator, she says.

North looks for applicants who have experience with different types of specimen and in training others in microscopy, and who have been responsible for troubleshooting. The exact scientific training can vary, but a “lack of ego” is a must, she says. “If it’s all about getting credit for the work you’ve done, then this is not the right job for you.”

Indeed, core-facility staff have very different jobs from conventional scientists, and organizations might need to implement performance metrics for core-facility managers to match, says Wright. These metrics “are likely not focused on the number of publications or grants awarded, but more on the users trained, level of user satisfaction, cost recovery, acknowledgements in publications et cetera”, he says.

Facility-director salaries can vary widely, from around £35,000 (US\$47,000) per year for postdoc-like positions to £90,000 for senior managers, says O’Toole. “These can be very different roles with a very similar job title,” he says. Those on the lower end of the scale are likely to have many fewer responsibilities and staff, will not write grant applications and might not fully control their budgets. But they can progress by expanding their core facility or moving to a more senior position at a larger facility.

Before he was a core-facility director, Peychl was a medical doctor, a stage actor and an assistant professor. The common denominator, he says, is people skills: “I deal with hundreds of people, and I need to understand their motivations, and their needs and emotions as well,” he says.

As a junior assistant professor at the Charles University Faculty of Medicine in



Harvard Advanced Microscopy Fellows Rylie Walsh and Federico Gasparoli.

Hradec Králové in the Czech Republic, Pechl says, he was always the one taking care of his department's common microscopes. "The person who first goes and fixes it probably is highly qualified to become core-facility manager," he says. "It's important that you have this inner drive to support people with cool technologies."

In 2001, Pechl's interest in microscopy inspired a career change, and he applied for an imaging-specialist position at the LMF. "Of course, they were surprised that a medical doctor would apply for a technician job, but they immediately offered me a postdoctoral fellowship to support the work of the core imaging facility," he says.

The business end

Pechl's experience is unusual in that training opportunities for core-facility management are relatively rare. But they are increasing in number.

The German Society for Microscopy and Image Analysis, known as German BioImaging, has offered a course on core-facility management and leadership in Germany since 2013, and Global BioImaging, an international network of imaging infrastructures and communities coordinated from EMBL Heidelberg, offers similar courses around the world. The ABRF and Core Technologies for Life Sciences, a Paris-based non-profit association of core-facility scientists and staff, have workshops that teach business skills such as accounting and budgeting. Staff can sometimes take business-school classes offered by the universities where their facilities are based. And some managers, including Wright, even complete a master's of business administration, which he says has been "incredibly useful".

German BioImaging and Global BioImaging also organize job-shadowing programmes, which allow staff to pick up skills from their peers. "I see real value in visiting other core facilities to understand how they operate and bring home the relevant bits to help improve our own operations," says Wright.

Grant-writing skills are essential. "The success of a core facility, to some extent, is reflected by the number of shared instrumentation grants that it secures," says Chew. In the United States, the National Science Foundation and Department of Defense both fund core facilities, and the National Institutes of Health's S10 shared instrumentation grant is "almost tailor-made for core-facility directors", Chew says. Facilities in other parts of the world, including most European countries, are also funded mainly by government grants.

Most of these grants cover only instrumentation, but some, including the German Research Foundation's core facilities funding programme and the imaging scientists programme from the philanthropic organization

the Chan Zuckerberg Initiative in Redwood City, California cover staff, too.

Facility staff positions are often not permanent, which can lead to regular loss of institutional knowledge. "Usually you need minimum of a year to get a person up to speed," says Pechl. Such turnover presents challenges, he says, but it also encourages flexibility.

For instance, facility managers had to react quickly when faced with the COVID-19 pandemic, both to keep their staff and users safe and to minimize disruptions.

"In the end, it's all about hands-on experience."

Pechl, working with Elisa Ferrando-May at the University of Konstanz Bioimaging Center in Germany and others, published COVID-19 guidelines for core facilities, such as avoiding face-to-face training and providing remote support to microscope users (S. Dietzel *et al. Cytometry A* 97, 882–886; 2020). Roland Nitschke, head of the Life Imaging Center at the University of Freiburg, Germany, set things up at his facility so that he could remotely control microscopes to show users what to do. The set-up required ultra-high-resolution cameras, and scientists started using the same cameras to check in on long-running experiments from home. "Maybe it's the only good thing to come out of the coronavirus," says Nitschke.

A core crash course

To bring new recruits up to speed, some managers turn to external courses and workshops. Waters teaches yearly microscopy courses at Cold Spring Harbor Laboratory in New York, and North does the same at the Woods Hole Marine Biological Laboratory in Massachusetts. And Krishnamurthy provides a training programme on confocal microscopy and flow cytometry in Bengaluru. But, "in the end", says Pechl, "it's all about hands-on experience".

Most researchers use just one or two types of microscopy during their PhD or postdoc. "We have everything from single molecules to organoids and embryos coming into the core, and we have 15 different imaging modalities," says Waters. "The idea of anybody walking out of a postdoc and into a core facility, and being able to immediately know what they're doing, is ridiculous," she says.

That's what motivated Waters to start Harvard's Advanced Microscopy Fellowship in 2013. Waters originally funded two fellows by reallocating salary for a staff member, but has since been supported by microscope manufacturer Nikon and three departments at Harvard Medical School. The programme costs about US\$80,000 a year for each fellow, and participants are guaranteed two years of funding.

Fellows spend half of their time on core service work, such as training users and maintaining microscopes, and another half on an independent project, such as writing code to assess the quality of microscopy images.

Fellows also learn management and budgeting skills, and work on grants with Waters. And they learn the fine art of dealing with clients. "I want them to have the confidence to sit in a room with a group of faculty and say, 'I know that technology looks interesting, but you don't have the need for it,'" says Waters. "If I have to write an uncomfortable e-mail to a faculty member, I will write it and then forward it to my postdoc so they can see how I worded it," she says. "They get to see how those situations are handled, and they leave with a little bit of a toolkit of how to manage that."

Waters has two current fellows and four alumni who have gone on to work at or run other core facilities. "I want them all to walk out of here being technical experts who deserve respect and are given autonomy," she explains. Staff might also go into industry, especially to microscopy companies.

Other institutes have created similar programmes. For instance, Janelia's Advanced Microscopy Fellows spend half of their time getting hands-on experience at the AIC and the other half on self-directed training, whether that's learning how to code or how to run an international microscopy workshop. "That 50% protected time allows them to hone their skill to become a successful core director in the future," says Chew.

In Europe, EMBL's ARISE fellowship programme is launching training for 62 fellows over the next five years, supported by some €12.7 million (US\$15 million) from the European Commission and EMBL. Calls for applications went out in November, and fellows will be hosted at one of six EMBL sites across Europe.

"We want to build through the programme the future heads or senior staff of research infrastructure facilities," says Tanja Ninkovic, ARISE programme manager at EMBL Heidelberg. As well as learning the ins and outs of core-facility management, fellows will pursue an independent research project and study technology transfer, entrepreneurship and science policy. "These are the skills that are needed by research infrastructure scientists regardless of the technology that the facility is offering," says Ninkovic.

Pechl, who attended a German BioImaging course for facility managers, sees the increase in core-facility management courses as a sign that these positions are increasingly valued. And he encourages others to consider the role. "For those who like to support others, who are technologically inclined and who have people skills, this could be a rewarding career."

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