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# Building momentum through networks: Bioimaging across the Americas

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**Abstract**

In September 2023, the two largest bioimaging networks in the Americas, Latin America Bioimaging (LABI) and BioImaging North America (BINA), came together during a 1-week meeting in Mexico. This meeting provided opportunities for participants to interact closely with decision-makers from imaging core facilities across the Americas. The meeting was held in a hybrid format and attended in-person by imaging scientists from across the Americas, including Canada, the United States, Mexico, Colombia, Peru, Argentina, Chile, Brazil and Uruguay. The aims of the meeting were to discuss progress achieved over the past year, to foster networking and collaborative efforts among members of both communities, to bring together key members of the international imaging community to promote the exchange of experience and expertise, to engage with industry partners, and to establish future directions within each individual network, as well as common goals. This meeting report summarises the discussions exchanged, the achievements shared, and the goals set during the LABIxBINA2023: Bioimaging across the Americas meeting.

**KEYWORDS**

bioimaging networks, BioImaging North America, community-building, imaging scientists, Latin America Bioimaging

## 1 | LATIN AMERICA BIOIMAGING (LABI)

LABI is formed upon three main pillars: *building capacities*, which involves supporting training and career development programs; *building community*, which includes organising annual meetings and satellite events as well as developing and maintaining a website and social media communication channels; and *promoting global integration* to the international bioimaging community. LABI was created in 2020 with seven partners (Argentina, Brazil, Chile, Colombia, Mexico, Peru and Uruguay). Its kick-off meeting happened in 2022 during their first in-person meeting in Montevideo, Uruguay. Over the last year, the number of members has increased by 117%, from 137 to almost 300 in 2023. Members represent 23 countries, of which 13 are Latin American or Caribbean (Figure 1). Latin Americans worldwide are encouraged to join, as LABI aims to serve as a network to reverse the brain drain faced in the region and forge bridges between Latin Americans at 'home' and abroad.

As part of its structure, LABI has several working groups, including *Training and Education, Communication, Cooperation with partners, Outreach and Integration, and Corporate and Industry partners*. With the support of several funders, including the Chan Zuckerberg Initiative (CZI) and Invest in Open Infrastructure, LABI supports multiple travel awards for Latin Americans to strengthen capacity-building in the region, foster collaborations, and take full advantage of the regional expertise and infrastructure.

## 2 | BIOIMAGING NORTH AMERICA (BINA)

BINA is formed upon four main pillars, *Interaction, Education, Advocacy* and *Standardisation*, with its core values being community, inclusion and excellence, the latter of which includes ensuring reproducible and quantitative methodology for microscopy. BINA was officially created in 2018 as a volunteer-based organisation. Since December 2020, and thanks to CZI, BINA has received funding that has been key for its efforts in community-building, dissemination, and training and education programs. Since its 2022 meeting, the number of BINA members has increased by 48%, from 791 to 1,167 members at the time of the LABIxBINA meeting. In addition to Canada, Mexico and the United States, members represent over 36 other countries including 5 from Latin America (Argentina, Brazil, Chile, Colombia and Uruguay) (Figure 2). BINA had six well-established working groups at the time of the meeting: *Communications, Corporate Partners, Diversity, Equity & Inclusion, Image Informatics, Quality Control and Data*


**FIGURE 1** Infographic map of the evolution of the LABI community. The LABI community now comprises 297 members from 23 countries, 13 of which are in Latin America. Relative to 2022, membership saw a twofold increase, both in total numbers and in the number of Latin American countries where members reside. Map was created using Datawrapper.de.

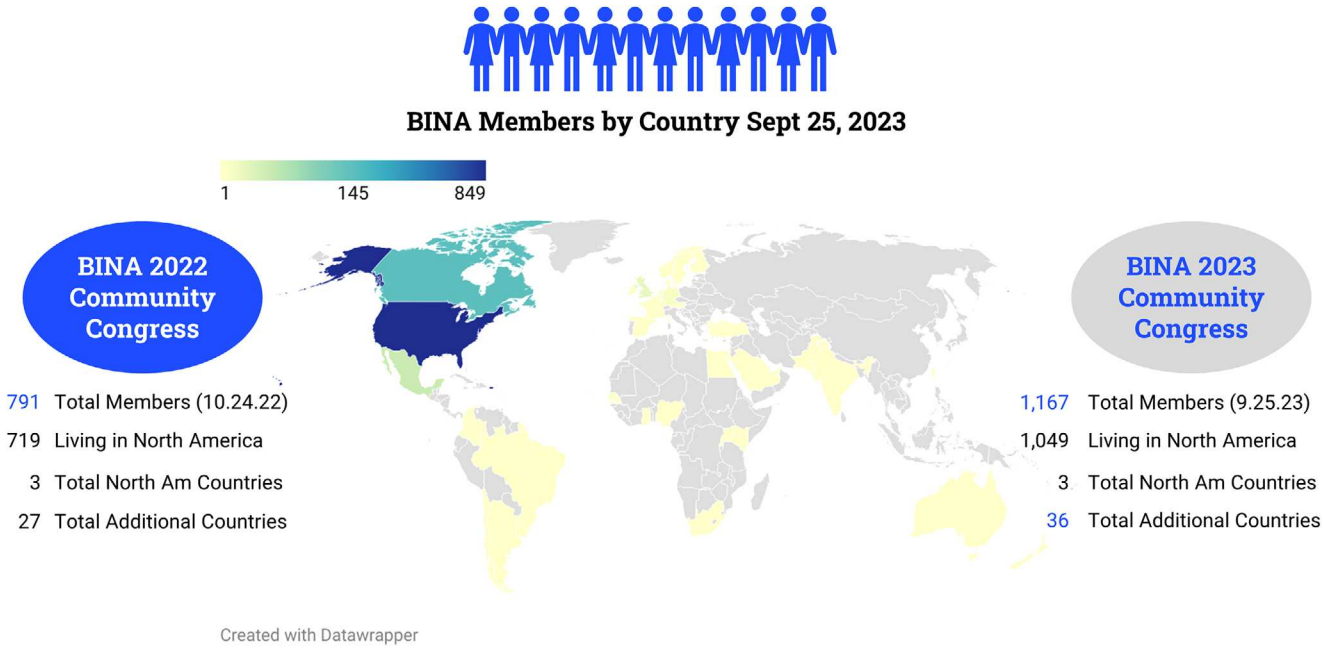


**FIGURE 2** Infographic map of the evolution of the BINA community. The BINA community now comprises 1,167 members from 36 countries, 3 of which are in North America. Relative to 2022, membership saw a 48% increase in total numbers and 33% increase in the number of countries where members reside. Map was created using Datawrapper.de.

*Management, and Training and Education*. Each working group presented detailed updates of their achievements over the past year, as well as future directions. Two emerging Working Groups, Builders and Early Career, were discussed and a co-chair from each was in attendance at the meeting; at this time these are now formal BINA Working Groups.

## 2.1 | The importance of joint network meetings

The LABIxBINA meeting brought together two of the largest bioimaging networks in the Americas, with over 150 participants from 16 nations in the Americas and abroad. This created the opportunity for all participants to

interact with new communities, and combined the expertise and mentorship of experienced scientists with the creativity, energy and enthusiasm of early career scientists. An important result was an inspiring atmosphere and outlook of both bioimaging communities. The idea of organising a joint meeting such as this offers multiple benefits:

- Participants from diverse backgrounds can contribute their unique perspectives to shape the future of imaging worldwide. They can share lessons learned, challenges encountered, and the outcomes of national and international bioimaging initiatives. This collaborative effort fosters progress in an efficient manner, optimising time and resources based on risk-assessments.
- Joint meetings establish a foundation for enhanced communication and successful collaborations. They facilitate the exchange of information on technological advances, network structures, professional development, and opportunities for funding and cooperation across different regions. This aims to prevent redundant efforts, focusing energy on new developments and accelerating scientific progress. Over the coming years, we plan to document emerging collaborations and interactions between LABI and BINA members.
- Joint meetings provide a platform for diverse stakeholders to come together. Examples of this during the LABIxBINA meeting included the opportunity to communicate shared successes and challenges to the local Academy of Science representatives in Morelos, Mexico and CZI, a funder that has had a vital impact regionally and globally.
- Joint meetings enable engagement with corporate partners from different regions who manufacture instruments, image analysis tools, and reagents. This interaction helps industry partners gain a deeper understanding of the bioimaging communities' successes and challenges.

The LABIxBINA meeting also brought together CZI grantees (both, networks and individuals) from BINA and LABI, facilitating discussions with CZI leadership about the progress of various initiatives and ongoing challenges and opportunities. The meeting highlighted CZI's significant impact in both regions, illustrating to other funders the critical role of community-building and networks in advancing high-quality science. The event featured participation from imaging networks across the globe, such as Euro-Bioimaging, BioimagingUK, German Bioimaging, and the Africa BioImaging Consortium, and Corporate partners such as AVR Optics, Carl ZEISS, Bruker, Thermo Fisher Scientific, TissueGnostics, JEOL, Thorlabs, 3i and Omicron. We refer interested readers to the complete meeting program as published by BINA and LABI and to the detailed report of each session as published in our initial white paper.

## 3 | LABI

### 3.1 | Key recommendations and findings

The LABI meeting focused on two key topics, which are further elaborated with specific recommendations in the following sections.

- Expanding core facilities and regional hubs in Latin America: This topic involved discussions about the role and objectives of regional hubs within the region to enhance and coordinate both intra- and inter-regional bioimaging opportunities.
- Diversifying Career Pathways in Latin America: The session explored human resource challenges faced by imaging scientists working in core facilities in the region. It focused on showcasing and defining career pathways, improving recruitment processes, assessing training issues, and the need for specialised development programs. These programs aim to attract and retain talented individuals and promote a diverse workforce in bioimaging core facilities.

#### 3.1.1 | Expanding core facilities and regional hubs across Latin America

*Pathways to bioimaging core facility creation in Latin America*

A vital aspect of developing core facilities has been the transfer of infrastructure scattered across individual laboratories through consolidation in centralised facilities, ensuring equitable access to state-of-the-art technologies and expertise by all research groups within institutions. During the LABI meeting, various core facility leaders highlighted key evolutionary steps and achievements of the facilities they lead, as well as noting the challenges that exist for the creation and maintenance of facilities in different Latin American countries (Figure 3). Speakers included Chris Wood (Director of Laboratorio Nacional de Microscopía Avanzada (LNMA) in Mexico), Gloria Soldevilla (Director of Laboratorio Nacional de Citometría de Flujo (LabNalCit) in Mexico), Gustavo Chiabrando (Director of Centro de Micro y Nanoscopía de Córdoba (CEMINCO) in Argentina), Andres Rossi (Director of the Imaging, Microscopy and Cytometry Facility at Fundación Instituto Leloir (FIL) in Argentina) and

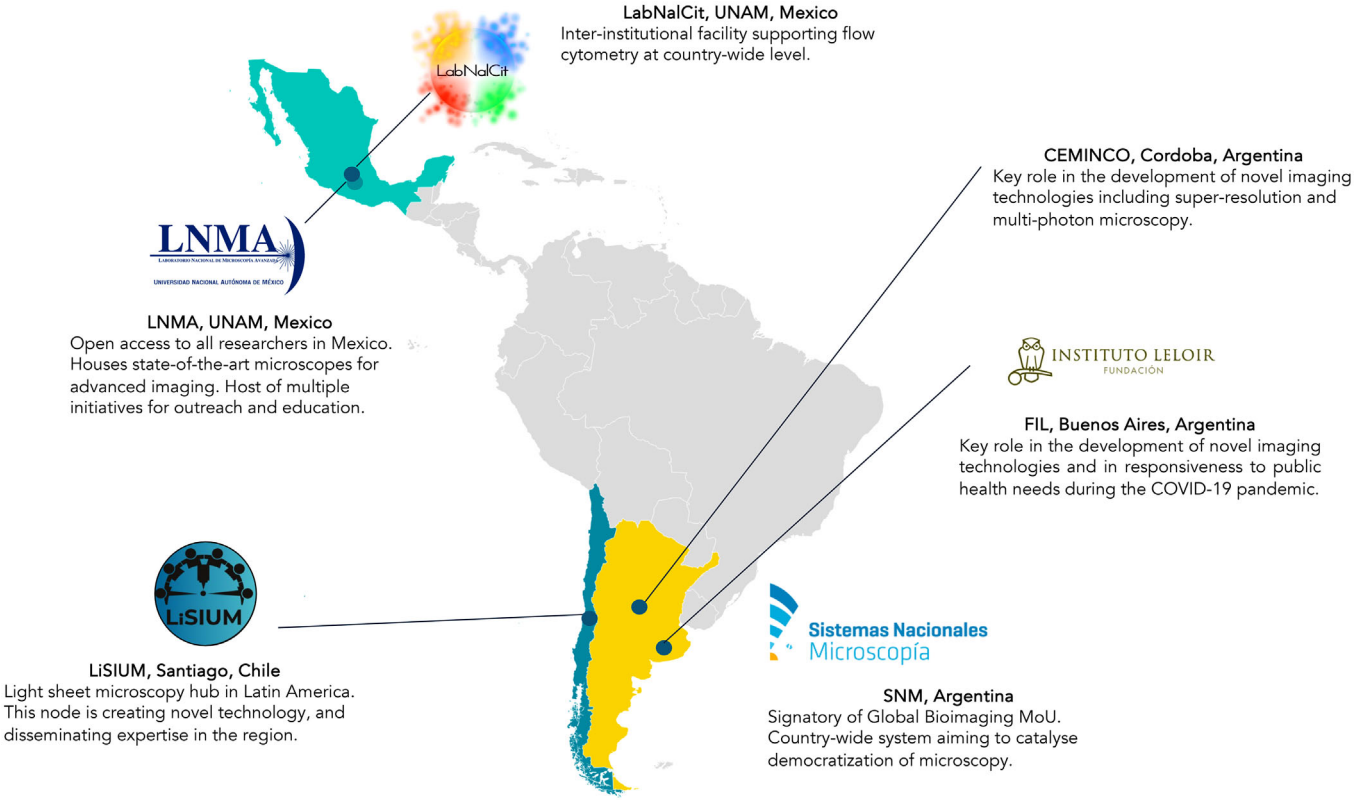


**FIGURE 3** Infographic map of examples discussed during the LABIxBINA meeting on core facility creation in Latin America. Directors of LabNalCit (Mexico), LNMA (Mexico), CEMINCO (Argentina), Fundación Instituto Leloir (Argentina) and LiSIUM (Chile) spoke about the creation of these facilities, challenges, and future directions. Map created with Datawrapper.de.

Alenka Lovy (Director of The Light Sheet Bioimaging Hub at Universidad Mayor (LiSIUM) in Chile). Key recommendations and shared experiences covered by the speakers focused around eight overall topics:

- *Creation of Core Facilities*. Key factors for setting up Core Facilities include strategic and thorough planning, securing institutional support, engaging local and national communities, identifying researchers' needs, recruiting and securing motivated personnel, fostering curiosity, and obtaining sufficient funding to accelerate research and technology development.
- *Sustainability of Core Facilities*. Essential practices for long-term sustainability include standardising autonomous user training, implementing regular quality control, calibration and maintenance programs, expanding image analysis services, maintaining robust and efficient communication with vendors, liaising with institutions, and actively disseminating information with the scientific community.
- *Introduction of Novel Technology and Open Science*. Core Facilities are instrumental in introducing advanced technologies at a regional and national level, and promoting open-science practices, particularly in resource-limited settings. Examples of technological implementations discussed at the meeting included the use of super-resolution techniques and hybrid and multimodal imaging platforms in Mexico, the application of super-resolution and two-photon microscopy techniques in Argentina, and the deployment of lightsheet microscopy in Chile.
- *Serve as Reference Centres*. Core Facilities support research beyond the institutional level and can provide specialised services regionally, nationally and internationally. The significant role that core facilities in Latin America played during the COVID-19 pandemic was highlighted, along with the provision of specific services relevant to clinical, agricultural, veterinary and public health sectors, among others.
- *Capacity-Building*. Core Facilities are crucial for capacity-building, offering workshops, courses, and certifications to regional and national communities.
- *Outreach Initiatives*. Efforts to bring science to the broader public include extensive training and outreach programs, such as those conducted by Mexico Bioimaging.
- *Challenges Faced*. Core Facilities in Latin America encounter several challenges, including high maintenance costs, exceptionalism in resource access among academic staff, lack of recognition of the relevance

and value of facilities and their staff members; difficulties with multifunder bureaucracies; and inconsistent government support.
- *Success Stories*. A significant success highlighted was the Argentine National System for Microscopy (Sistema Nacional de Microscopía (SNM)), the National Systems (Sistemas Nacionales) and the National Booking System (Sistema de Gestión de Turnos). These initiatives have catalysed democratic access to microscopy and other technologies in the country, as well as minimising equipment redundancy, ensuring the timely replacement and upgrade of equipment, and its equitable geographic distribution.

Altogether, all presenters addressing the creation and evolution of core facilities in Chile, Mexico and Argentina reached similar conclusions regarding the value of core facilities.

*Bioimaging Hub models from around the world, and the creation of Bioimaging Hubs across Latin America*

Like core facilities, Bioimaging Hubs are committed to balancing resource distribution and broadening access across scientific, commercial, and public sectors. These hubs empower researchers globally to undertake studies that might otherwise not be feasible for a single research laboratory or institution, due to constraints in accessing advanced technology and specialised expertise. While regional Hubs already exist in Latin America, a main challenge discussed during the LABIxBINA meeting was the need to coordinate, connect and align their objectives more effectively. This alignment is essential to maximise the benefits from existing opportunities with bioimaging centres worldwide.

Bioimaging Hubs are already operational across various global regions, and the LABIxBINA meeting featured several international speakers who shared their experiences and strategies for successful operation and collaboration. The speakers included Antje Kepler, representing Euro-Bioimaging, a European Research Infrastructure Consortium (ERIC); Teng-Leong Chew, representing the Advanced Imaging Center (AIC) at the HHMI Janelia Research Campus; Caron Jacobs, representing the African BioImaging Consortium (ABIC); and the Africa Microscopy Initiative (AMI), and Vladimir Ghukasyan, representing the Chan Zuckerberg Initiative (CZI). Key points discussed included:

- *Commitment to equitable science and access*. This includes facilitating programs that support the visit of national and foreign scientists to conduct research projects at the Bioimaging Hubs. This ensures that researchers globally can access the necessary expertise and technology.
- *Innovative Access Programs*. An example highlighted was the initiative by the AIC which provides access to pre-commercial imaging technologies at no cost. This allows researchers to have access to cutting-edge tools before they are commercially available to accelerate science discovery.
- *Funders and support structures*. Recognising that the development of new cutting-edge techniques faces challenges including the long delay to commercialisation and prohibitive costs, and that not all technologies are suitable for commercialisation. CZI has developed strategies to ensure both access to technologies and specialised capacity-building, which includes needs assessments, awareness, and training programs.
- *Role of Networks and Collaborations*. The significant role played by networks like Euro-Bioimaging, BINA, LABI, ABIC, AMI and national and international institutions was recognised. These entities have been crucial in facilitating access to microscopy and fostering international collaborations, enhancing the impact and reach of Bioimaging across the scientific community.

Highlighting the work done in Latin America, speakers included Kildare Miranda, Head of the National Center for Structural Biology and Bioimaging (CENABIO) in Rio de Janeiro, Brazil; Rodrigo Portugal, Head of Brazilian Nanotechnology National Laboratory (LNNano/CNPEM) in São Paulo, Brazil; Leonel Malacrida, Head of the Advanced Bioimaging Unit (UBA), a joint initiative between Institut Pasteur and Universidad de la República in Montevideo, Uruguay; and Karina Alleva, co-Coordinator of Centro de Biología Estructural del Mercosur (CEBEM). The Mercosur is a union of countries in South America, which, similar to the European Union, enables travel, study, and work with total freedom for nationals of the various nations that integrate this union. The speakers at the meeting highlighted key recommendations and shared their experiences around nine critical topics related to the development and sustainability of Bioimaging Hubs in Latin America:

- *Challenges to Equitable Resource Distribution*. A significant issue across Latin America is the uneven distribution of microscopy instruments both, within countries and across the region. The role of Bioimaging Hubs in overcoming this uneven distribution by ensuring equitable access to resources was emphasised.
- *Introduction of Novel Technologies*. The importance of Bioimaging Hubs in introducing novel, high-end

technologies at regional and national levels was highlighted. An example discussed was the establishment of a Cryo-EM network in Brazil that connects facilities across the country.

- *Strategic Planning and Sustainability*. Effective strategic planning is essential for establishing Bioimaging Hubs. Key elements of this planning include developing a clear roadmap for infrastructure, implementing funding programs for capacity-building, engaging the community, and devising multidisciplinary solutions to research challenges. For long-term sustainability, these hubs require consistent funding, successful integration of facilities within a hub, and a critical mass of expert personnel to support advanced technologies.
- *Challenges to Sustainability*. Challenges such as funding constraints, the absence of a regional economic zone beyond Mercosur, and a lack of coordinated strategic planning in research infrastructure pose significant limitations to these efforts.
- *Achievements and Successes of Bioimaging Initiatives*. Initiatives hosted or initiated by members of the Bioimaging Hubs in Latin America include the organisation of workshops and educational programs, implementation of train-the-trainer programs, and the establishment of key organisations such as LABI and the Hub for Integrative Bioimaging.
- *Challenges and Strategic Directions for Bioimaging Initiatives in Latin America*. Bioimaging initiatives are currently navigating challenges such as adapting to changing policies, engaging stakeholders, and securing sustainable funding, with an emphasis on the need for a regional agency to ensure equitable access and shared objectives. Upcoming initiatives include a bi-regional consortium to democratise access to entry and middle-level research infrastructures, supported by the 4th European Union - Latin America and the Caribbean (EU-LAC) Joint Call in Science Technology and Innovation (STI) 2022 for research infrastructure. Future directions, include the need to start working more closely with organisations such as FOCEM (Fondo para la Convergencia Estructural del Mercosur) to offer some primary regional funds that can support coordinated research infrastructure in Latin American countries; and establishing or supporting existing non-governmental funding agencies to move forward the synergy between private and public funding to improve research infrastructure in the region as a critical tool to develop science and innovation.
- A plenary talk, given by Dorit Hanein, discussed major achievements and state-of-the-art techniques for cryogenic correlative light and transmission electron microscopies (cryo-CLEM), cryogenic transmission electron microscopy (cryo-EM) and in situ cryogenic cellular tomography – disciplines of microscopy currently gaining momentum in Latin America.

Altogether, the presenters reached similar conclusions regarding the value of Bioimaging Hubs to ensure global access to microscopy, increased efforts needed in the creation and expansions of hubs in the region, considerations to have for future directions, and the importance of creating synergy with governmental and non-governmental organisations to develop science and innovation (Figure 4).

### 3.1.2 | Diversifying career pathways in Latin America

*Professional graduate programs to form imaging scientists*

The second major topic discussed during the LABI meeting was capacity-building and human resources in the region. Of specific relevance were programs to train imaging experts, and career opportunities and expectations as an imaging scientist. Speakers of this session included four speakers from four different Latin American countries, introducing the following graduate programs:

- Hernán Grecco, Director of the Department of Physics at Universidad de Buenos Aires, Argentina: Carrera de Especialización en Microscopía
- Silvana Allodi, Lecturer at Universidade Federal do Rio de Janeiro (UFRJ), Brazil: graduate program in Technologies of Bioimaging and Biostructure hosted at UFRJ
- Luis F. Jiménez-García, Lecturer at Universidad Nacional Autónoma de México (UNAM), México: Specialty in Electron Microscopy for Biological Sciences Program
- Laura Daza, PhD student and Lecturer at the Center for Research and Formation in AI (CinfonIA) in Bogotá, Colombia: Master's Program in AI, entirely taught virtually through the Coursera platform and fully taught in Spanish (thus eliminating the language barrier that often hinders inclusion in the region).

The speakers agreed that while the main components in a core facility are equipment and infrastructure, funding agencies rarely realise the relevance of investing in people. In addition, there is an urgent need for funders and the scientific community itself, to realise that training is a continuous process because knowledge and technology

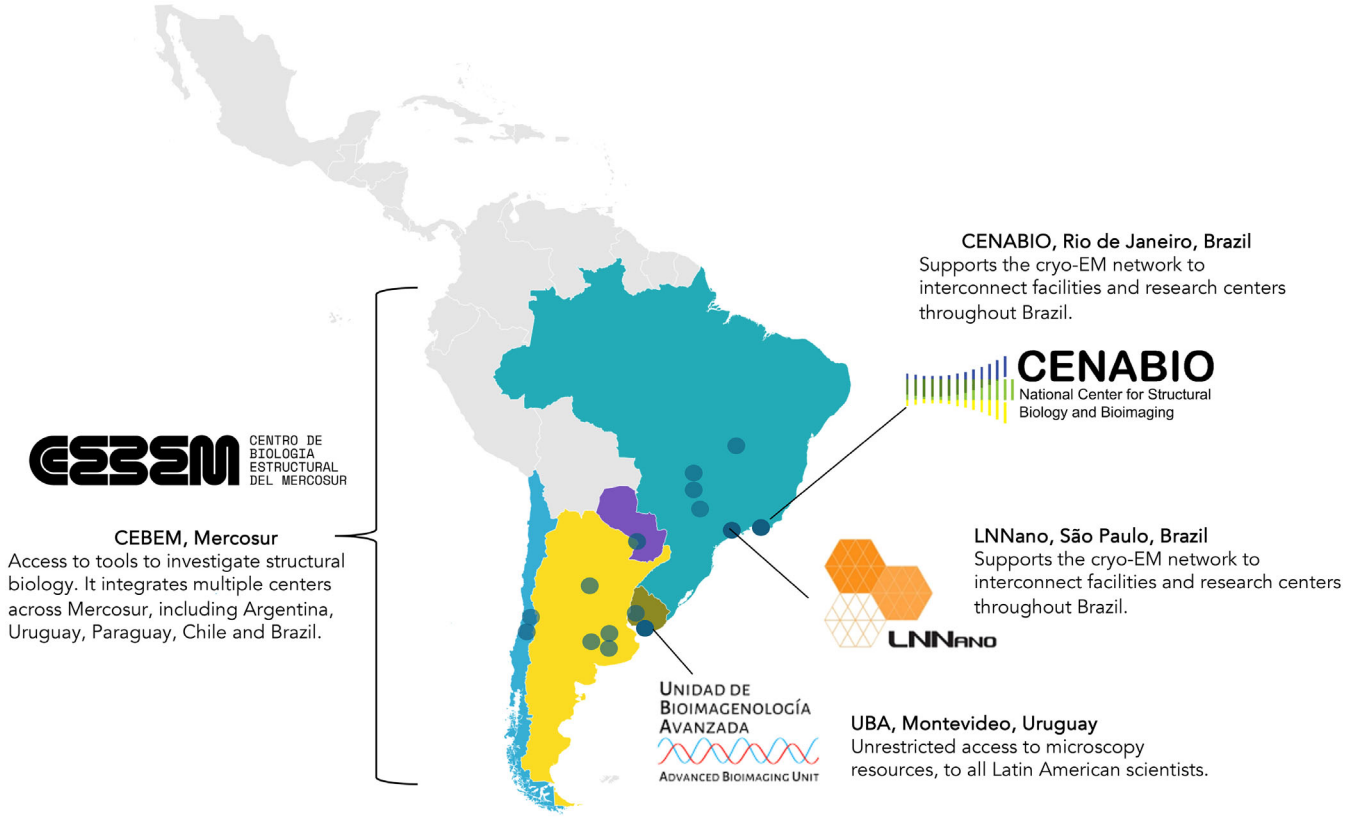


**FIGURE 4** Infographic map of examples discussed during the LABIxBINA meeting on bioimaging hub creation in Latin America. Directors and/or main leaders of CENABIO (Brazil), LNNano/CNPEM (Brazil), UBA (Uruguay) and CEBEM (Mercosur) spoke about the creation of these hubs, challenges, and future directions. Map was created using Datawrapper.de.

are in constant evolution. In this context, the Microscopy-specific training programs highlighted by each speaker aim to train new generations of imaging professionals capable of addressing the ever-evolving needs of the scientific community (Figure 5).

### *Mobility between academic and commercial sectors in Latin America*

Vital to diversifying career paths in bioimaging is awareness of the possibilities that exist beyond academia. The transition between academic and commercial sectors in bioimaging was highlighted by four professionals who have navigated significant career shifts. Speakers included Natalia de Val, Senior Sales Development Scientist at Thermo Fisher Scientific; Bruno Vale, Head of ZEISS Brazil; Vanessa de Sa from the Business Development Division and R&D Support of TissueGnostics Brazil; and Vilma Jimenez Sabinina, Director CMC Analytical Strategy at Bayer. Their key messages are as follows:

- *Role of Core Facilities*. Core Facilities are strategically positioned to facilitate the transition between academic and industry. They serve as pivotal platforms for fostering collaborations with industry partners.
- *Transition Considerations*. Key considerations for those contemplating transitions between academia and industry include taking calculated risks, gaining familiarity with corporate roles early in one's academic career, identifying optimal timing for transitions, as well as effective networking.
- *Improving Communication*. There is a need for enhanced communication between academia and industry to facilitate faster matching of the talent pool with available positions.
- *Development of Imaging Methods*. The advancement of imaging-based methods that are key to the biotechnology sector acts as a significant bridge between academic research and industrial application, underlining the collaborative potential and mutual benefits of cross-sector mobility.

### *The relevance of training and education for long-term sustainability of Microscopy as a career*

The messages from Latin American speakers were echoed by international guest speakers including Claire Brown, Peter O'Toole, Philip Hockberger and Beth Cimini. The speakers recognised top challenges faced by scientists at imaging facilities: poor recognition of the value of the work


**FIGURE 5** Infographic map of examples discussed during the LABIxBINA meeting on professional postgraduate programs focused on Bioimaging in Latin America. Representatives of UNAM (Mexico), UFRJ (Brazil), UBA (Argentina), and CinfonIA (Colombia), spoke about important postgraduate courses held in their institutes, focusing on training bioimaging scientists. Map was created using Datawrapper.de.

of imaging scientists; a divide between academic and core facility staff; the complexity of recruitment and retention; lack of sustainable funding mechanisms; and the need for better dissemination of success stories from around the globe (i.e. role models). Together they explored the importance of formal training programs; official career paths and recognition; management and leadership programs targeted to core facilities; and the development of interdisciplinary areas such as image analysis. Important elements discussed in this context included:

- The recent international recommendation to survey the needs and expectations of the community regarding Career Development for Imaging Core Facility Staff.
- The Technician Commitment in the United Kingdom which focuses on aspects vital to core facility scientists: visibility, recognition, career development, and sustainability.
- The Leadership and Management in Core Facilities Kellogg Course at Northwestern University, a hands-on program that explores topics including business management and leadership in an academic setting.
- The development and evolution of the CellProfiler, open-source image analysis software. Its creation aimed at breaking barriers preventing biologists from fully engaging in computer science-based disciplines.
- Further efforts are required to convince the scientific community of the importance of image analysis (and image analysts) and to convince funding agencies about the need for training resources and sustainability of this discipline and of training resources.

*Conclusion of LABI meeting.* The LABI meeting concluded with key insights from Andres Olivera, the LABI Network Manager, who emphasised the need to accelerate the development and access to innovative technologies in Latin America; develop a unified approach for funding; and promote the regional hub concept to enhance its development and expansion. He highlighted the importance of standardising and coordinating training pathways. The LABI meeting concluded with the signing of a Memorandum

of Understanding for the creation of Mexico Bioimaging, a network that will focus on fostering collaborations and outreach programs throughout the country. Finally, the next LABI meeting was announced to take place in Rio de Janeiro, Brazi l in August 2024.

## 4 | BINA

The BINA meeting began with an inspiring homage, led by Claire Brown, to Michael W. Davidson and his career. A highly versatile and multitalented scientist, he is an inspiration to much of the work that BINA does. He was a researcher, photographer, mentor, entrepreneur, storyteller, and a highly productive scientific author and microscopist with over 600 journal and magazine covers. With his artistic and graphical design skills, he generated a collection of cocktail ties and scarves, and he imaged computer chips and developed websites for multiple microscopy companies including ZEISS, Olympus and Nikon. As a mentor, he trained over 500 young scientists across multiple areas, including website development, and graphic design. As a scientist, he developed a plethora of fluorescently-tagged proteins, and donated the largest collection of its kind to Addgene, as a major contribution to science. As part of his work with corporate partners, he collected camera quantum efficiency curves, characterised filter cubes, and consulted on microscopy hardware and software.

### 4.1 | Key recommendations and findings

In this spirit, the BINA sessions highlighted the values of the versatility of microscopy as a career. They focused on three main topics:

- Training and education approaches in North America (related to technologies, imaging informatics, and core facility leadership and management training).
- Managing and sharing data.
- BINA Impact stories around training and education engagement, quality control and technology development.

Below we summarise the main discussions on each topic.

### 4.2 | Training and education

#### 4.2.1 | Microscopy technology

The technology training and education session began with Philip Kesner from McGill University in Canada who introduced the Montreal Light Microscopy Course (MLMC) Fundamentals – Train-the-Trainer. Next, Alison North representing the United States, discussed various existing Microscopy-specific courses, including Marine Biology Laboratories (MBL)-led Optical Microscopy and Imaging in the Biomedical Sciences (OMIBS), Analytical and Quantitative Light Microscopy, and the Deep Learning for Microscopy and Image Analysis courses in Woods Hole; the MDIBL Quantitative Fluorescence Microscopy course in Maine; the Advanced Imaging Methods Workshop at the Cancer Research Laboratory at UC Berkeley; and the Cold Spring Harbor Laboratory course on Quantitative Imaging: from Acquisition to Analysis. Then, Diego Delgado highlighted the efforts, successes, and progress of the Mexican Bioimaging Workshops. Different stimulating questions were raised during this session, for instance: why are these courses valuable? How are the participants selected when there are large numbers of applicants? What is the impact of existing courses in the larger scientific community in North America and elsewhere? How can BINA act as an amplifier of expertise in the region? And what defines a successful course? These questions were addressed in the following highlights from the session:

- *Technology Training.* The organisation of courses is a way for researchers to work towards a common goal in serving the scientific community, establishing networks with other partners and collaborators, and training the next generation of microscopy experts.
- *Recipe for Success.* Successful courses are characterised by versatile and complementary skills among the course directors and managers; an efficient, friendly and hard-working team of facilitators; an inspiring team of academic and commercial faculty with a clear love for teaching; and enthusiastic and focused participants that can make the most of the course and can amplify its benefits in their own institutions and beyond.
- *Shared key lessons.* From the organisation of training courses include knowing the target audience; organising the course into modular sections that can be customised; tuning to the length of time; and reaching a balance between theory and practice.
- *Train-the-Trainer Programs*. These are aimed at imaging scientists who intend to run their own courses are vital to ensure capacity-building, to build community and collaborations between trainers in different countries, and to facilitate dissemination of teaching materials.
- *Going forward*. It will be important to foster continuous connection and collaboration among participants; increasing communication and dissemination by

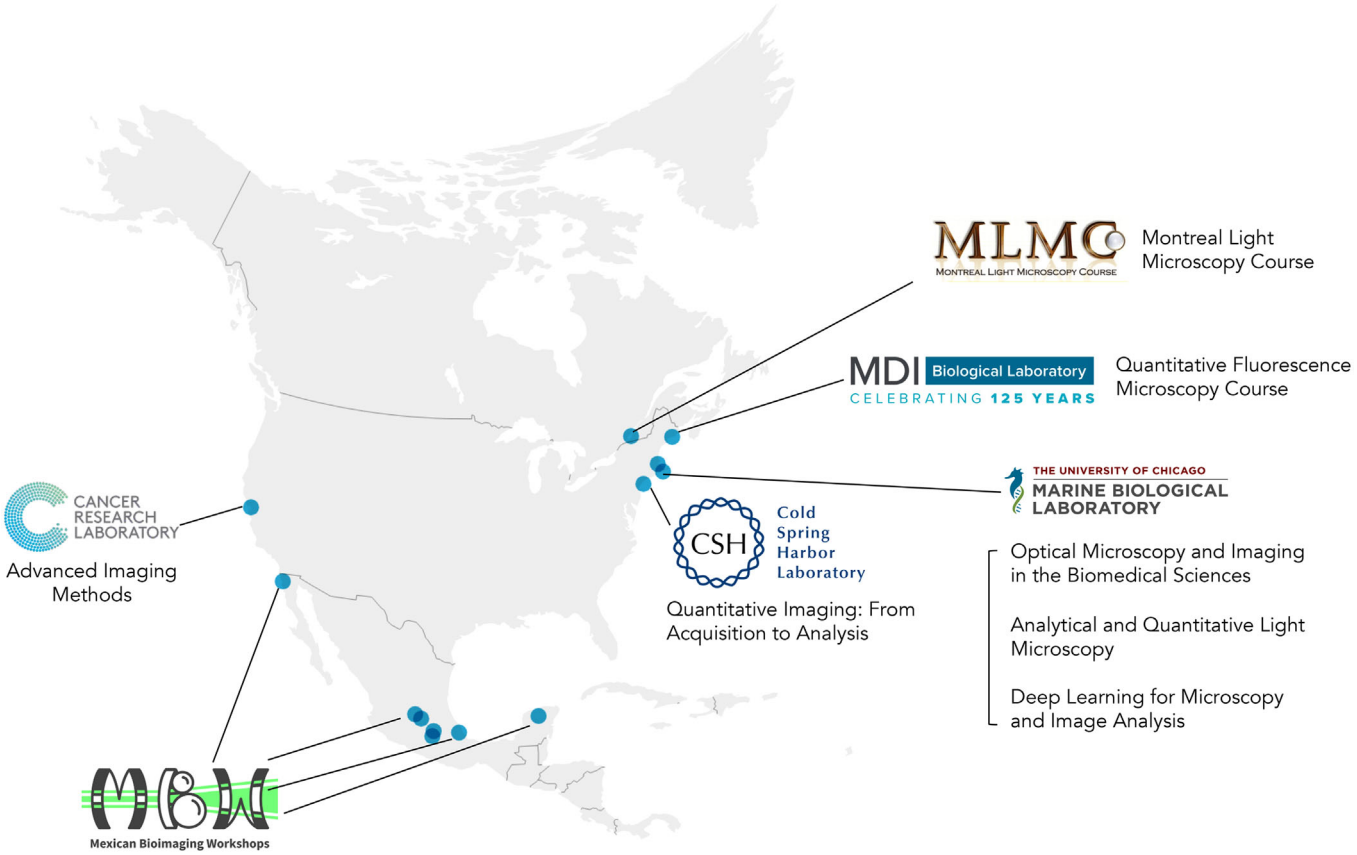


**FIGURE 6** Infographic map showing the location of training opportunities discussed during the LABIxBINA meeting. Courses mentioned were held in Montreal (Canada); across the United States in Woods Hole (Massachusetts), Cold Spring Harbor (New York), Bar Harbor (Maine), and Berkeley (California) and at various locations in Mexico including Mexico City, Guerrero, Ensenada, Morelos, Yucatan, and Queretaro, organised by the Mexico Bioimaging Workshops. Map was created using Datawrapper.de.

writing articles regarding the course; planning virtual meetings for those participants who cannot obtain visas; ensuring ongoing access to resources; and designing the courses with instructors from different facilities.

- *Role of Networks*. The value of BINA's role in disseminating information about various courses in the region, and funding attendance to participate in these courses through the Professional Development Program, was highlighted.
- *Outreach.* Training events and workshops can implement outreach activities at public and private schools, science museums, and public parks to foster engagement with the general public.

Various approaches to technology training were shared, providing the audience with an opportunity to evaluate those and alternative or additional approaches to consider in serving their community's training needs. Figure 6 summarises the courses discussed in this session.

### 4.2.2 | Image informatics

Beth Cimini, leader of the CellProfiler open-source image analysis software project, began the image informatics session by discussing the historically qualitative nature of microscopy. She highlighted that 60%–80% of high-content imaging-based studies focus on only 1–2 cellular features, despite the fact that images contain extensive and valuable information. This information, in the form of quantifiable features, can provide deeper insights into biological processes. She also pointed out that while programming plays a major role in the era of big data, many scientists engaged in data acquisition are not always comfortable with, or at the forefront of, computational programming. Thus, training on image informatics is critical to bridge the significant gap between the various disciplines involved in Microscopy.

This session also spotlighted initiatives from Canada, the United States and Mexico, some of which have been developed or expanded with support from CZI. These projects include 'Advancing Bioimaging Core Services with

Artificial Intelligence' led by Paul Hernandez in Mexico, 'Bioimage analysis efforts in the United States and beyond' led by Beth Cimini in the United States, and 'Canadian resources and the AIMM User Group' led by Judith Lacoste in Canada. Key messages and conclusions of this sessions were:

- *Challenges in Data Analysis Education*. Specific challenges identified in data analysis education programs include the significant time commitment required to learn new skillsets for image analysis, the need for trained personnel to develop training programs; staff expertise to assist in image analysis and securing necessary funding.
- *Successful Initiatives and Community-Building*. Notable achievements have been made in creating bioimaging data analysis clusters, and fostering community through networks such as BINA, Network of European BioImage Analysts (NEUBIAS), Global BioImage Analysts' Society (GloBIAS), LABI, and Royal Microscopical Society (RMS). These communities actively work to overcome barriers by developing educational webinars, repositories of training materials, and in-person events, like BINA's Pop-Up Exchange of Experience (EoE). Highlighted initiatives include Halfway to I2K, I2K, AI4Life, NEUBIAS, and forums such as image.sc, all of which are open to the broader scientific community.
- *Resource Development and Integration of AI Technologies*. The image analysis community has developed important resources, such as guidelines for bioimage analysis, to enhance the reporting of imaging and image analysis in scientific publications. Concurrently, the emergence of novel AI technologies underscores the importance of initiatives such as 'Advancing Bioimaging Core Services with Artificial Intelligence', which are essential to encourage biologists to explore AI tools and engage with image analysts to develop tailored solutions.
- *The Importance of Standards in Bioimaging*. Discussions included the importance of Quality Assessment and Reproducibility for Instruments & Images in Light Microscopy (QUAREP-LiMi), and the adoption of FAIR (Findable, Accessible, Interoperable, and Reusable) standards to ensure reproducibility in image data.
- *Support for Digital Research Infrastructure*. National support for digital research infrastructure is crucial for future advances. As an example, the mission of the Digital Research Alliance of Canada (DRAC) is to provide support for advanced research computing, data management, and software development. In Canada there is significant support for FAIR science and databases, such as Open Microscopy Environment (OMERO) while similar to elsewhere the support for human resources to support these resources is lacking.
- *The Role of Virtual Environments*. Virtual environments play a pivotal role by bringing individuals with varying levels of expertise. They foster communication, facilitate feedback in accessible ways, and promote sharing of information.

### 4.2.3 | Core facility management

The core facility management session emphasised the critical role of management and business training for imaging scientists. The session featured insightful talks: Phil Hockberger, discussed 'Business Training Opportunities for Core Directors and Staff'; Adan Guerrero from LNMA in Mexico discussed the GBI-LNMA 2023 Facility Management Course; and Kate Luby-Phelps spoke about the Virtual Core Management training opportunities organised by BINA's Training and Education Working Group (Figure 7). The MicroscopyDB was also mentioned as a great way for sharing training and education resources being generated by communities to be shared more broadly between imaging network organisations partnering with this effort, including BINA and LABI. Key takeaways included:

- *Core Director as an Entrepreneur*. Phil Hockberger opened the session with the question 'Why does a Core Director need training?' Core Directors operate similar to entrepreneurs, managing a 'small business' within a non-profit framework. Their primary responsibilities include leveraging their own and their staff's expertise to advance user research providing cost-efficient services, engaging in collaborations, managing fee-for-service models, and facilitating the applications of advanced technologies.
- *The Importance of Business Training*. Business training is essential for Core Directors to advance research and research priorities, maximise results, determine the scale of investment, demonstrate institutional impact, and ensure the sustainability of the facility.
- *Leadership Training Opportunities*. Various training opportunities were discussed, including BINA and ABRF online workshops and webinars, the German Bioimaging (GerBI-GMB) facility leadership and management course facilitated by hfp-consulting, Global Bioimaging online courses, and the Kellogg Leadership and Management in Core Facilities program organised at Northwestern University in Chicago.

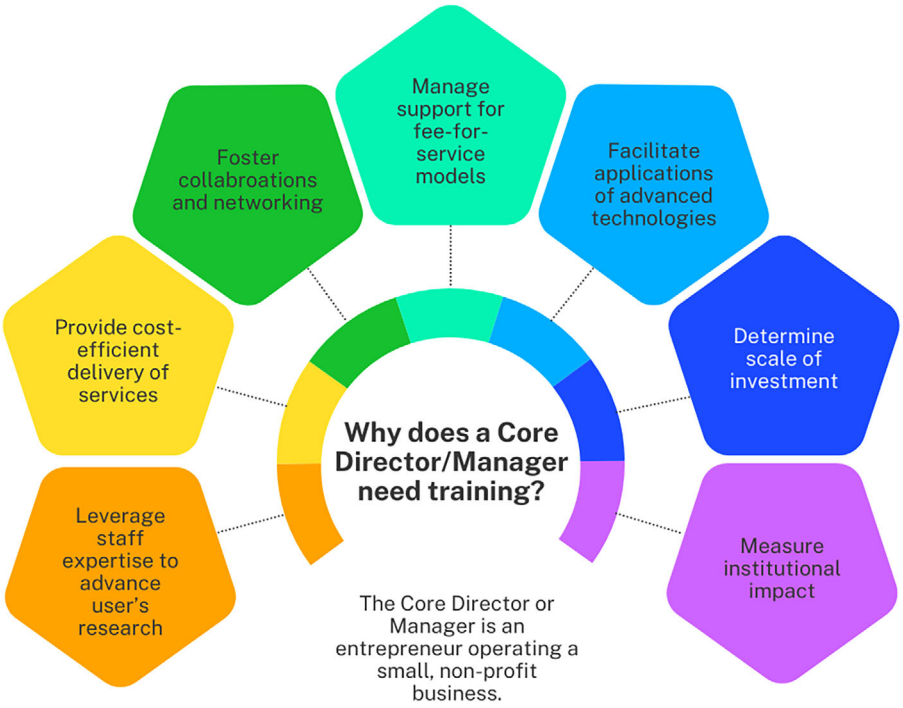


**FIGURE 7** Summary of discussion on the importance of training for a Core Director or Manager. The discussion was centred around the versatile role of Core Directors, and the need for training in different areas including business management, leadership, marketing and finances. Image created with Canva.

- *Elements of Successful Leadership*. Effective leadership in core facilities requires effective delegation and communication, collaboration, avoiding micromanagement, fostering trust, prioritising long-term sustainability over immediate perfection, and securing liquid funding well in advance to avoid delays due to administrative processes – among other skills.
- *Virtual Courses to Overcome Barriers*. Virtual courses aim to increase affordability, time efficiency, and eliminate travel costs. In 2023, BINA facilitated ad hoc virtual sessions led by Soft Skills Inc, which increased training accessibility in terms of both cost, and time commitment. A survey was generated to understand why many imaging scientists were unable to attend leadership and management-related courses. The main reasons included high costs, lack of time, topics of interest not being covered, and underestimation of the value of leadership training. Topics that were identified as important were both generic soft skills (i.e. leadership, communication, and supervision), and core-specific skills (such as proposal writing, workflow generation, defining service costs, preparing budgets, core management and training users). The survey results have been crucial to shape the direction of future virtual courses offered by BINA.

## 4.3 | Managing and sharing data

The 'Managing and sharing data' session focused on the importance of open, reproducible and FAIR science, through the appropriate management and sharing of imaging data and facilitating adoption of best practices through automation, where possible. The session was elegantly introduced by Judith Lacoste using the analogy of a car to help make the complexity of image data management more accessible. Presentations in this session were led by Josh Moore, focused on the car's systems and what's under the hood, Caterina Strambio-de-Castilla, focused on the car's dashboard or interface with the systems, and Caroline Miller, focused on the driver's role in the different aspects of image data and metadata. Key discussion points were:

- *'BioImage Town'*. It was noted that one of the reasons that research data management (RDM) is complex is due to the large quantity and variety of data being generated. OME-Files, Bio-Formats and OMERO aim to provide solutions and standardisation to data management problems.
- *Next-generation formats*. These are multiresolution data which do not require conversion between formats,

thus reducing wasted storage when submitting and downloading images. Moreover, next-generation formats come closer to enabling upload and sharing of data through websites, wiki-sites and forums, overcoming the need for databases. Moving forward, it will be vital to improve communication and increase engagement to better handle core facilities' and researchers' needs (Figure 8).

- *Metadata is essential for data organisation, quality control and FAIR sharing.* Metadata is data describing the data, namely, for microscopy, this represents all the information that is needed for interpretation and evaluation of the images obtained. Metadata makes it possible to evaluate the quality of the information acquired, and to know all the specifications that make the images both reliable, and reproducible. Metadata also makes it possible to track information and communicate between researchers and core facility managers.
- *International efforts towards metadata management*. Such efforts will be vital in the near future and include consolidating all the information including materials and methods, instrument characteristics, calibration, quality control metrics and image analysis processes.
- *Image data correlation*. Correlation of imaging data with orthogonal experiments from other disciplines is essential, as it increases confidence in the project results and can lead to new conclusions. For this, it is key to know what kind of data is needed (either qualitative, quantitative or both), what type of image analysis needs to be done, and what experimental design is best for addressing the research hypothesis.
- *Communicating the importance of metadata.* Altogether, the speakers agreed that the relevance of metadata in imaging must be further emphasised, and its importance communicated to researchers across disciplines.

## 4.4 | Impact of BINA and individual members across communities

This session highlighted the impact BINA and its members are having in the community, through the CZI-funded initiatives. Speakers included Michael Almeida, Gastón Contreras Jiménez, Aurélie Cleret-Buhot and Frederic Bonnet. The impact stories carried on the themes of education and training, technology development and applications, and quality control which weaved throughout the BINA program. Summarised in Figure 9 are the key points emerging from these presentations and their broader impact.

### 4.4.1 | Education and training outcomes

Education and training of bioimaging scientists is not just about the training of critical technical and instrumentation skills, but for many involved in core facility roles it is about developing their teaching skills, business and people management skills, organisational and finance skills. These stories demonstrated how impactful the training can be, beyond the original recipient. The effects can ripple out to broader impacts in the scientific community and general public through workshops, outreach events and the generation of audiovisual material, such as books and videos. Key messages from this session were:

- It is important to know who can provide help when needed – highlighting the needs for collaboration and capacity-building through the networks.
- Doing virtual demonstrations, when carrying out virtual or hybrid training sessions is not a routine task, since in order for this to be truly inclusive, it requires a complex setup to capture a complete visualisation of the practical activities.
- Two examples of achievements included (1) a book, an outcome of this Imaging Workshop published in an Open Access repository of UNAM, and (2) the work of meeting participant Armando Burgos Solorio from the Bio-Artropods Bioimagen México group. The latter is an example of the use of local insects to understand the connections between communities and their environment. Their astonishing insect images decorated the meeting spaces, and their moving video shed light on the disappearing culture and language of the Naha people of Mexico.
- It is important to engage in outreach to communicate with the next generation of microscopists, in order to sustain this rich research field.

### 4.4.2 | Quality control

Essential to the publication of microscopy-derived data is reliability and accuracy during image acquisition. Part of the quality control for this is the use of standards and patterns to calibrate microscope function in both 2D and 3D, and core facilities play pivotal roles in this process.

- Frederic Bonnet discussed how quality is ensured at the Mount Desert Island (MDI) Biological Laboratory light microscopy facility. The documentation for quality control (QC) includes a complete report for each microscope, a simplified version on GoogleDocs for the users, and good records of maintenance.

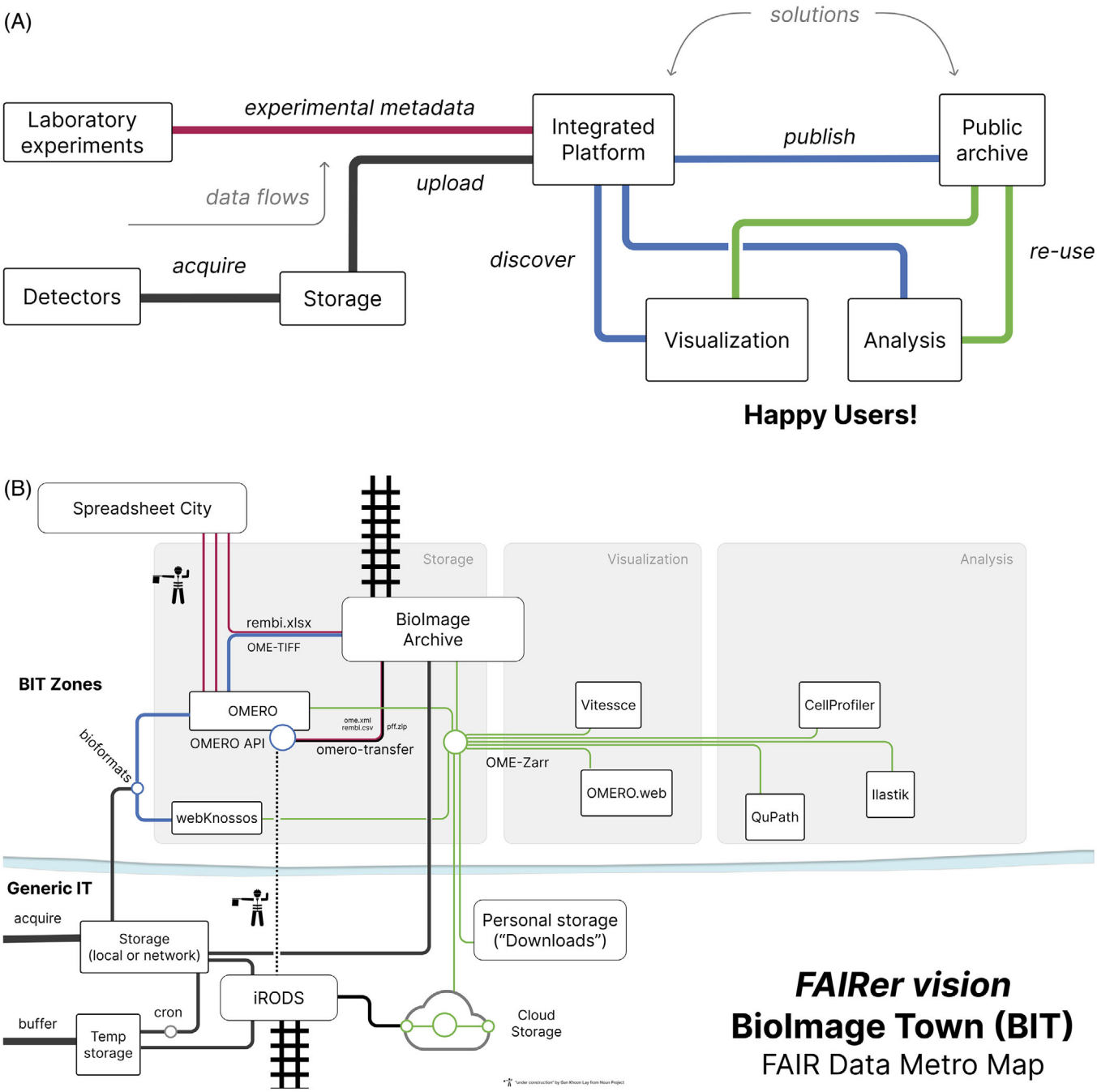


**FIGURE 8** The Bioimage Town metro map. Figures were created collaboratively by the presenters of the Data Management and Analysis session of ELMI2023. (A) They represent an idealised metro through which data ('the passengers') travel between various solutions ('the stops') within bioimaging ('BioImage Town'), connecting to IT solutions, metadata, and other areas. Red lines represent experimental metadata; black lines represent acquired images; visualisation, sharing and analysis through public domains is shown in blue lines, and further analysis and re-use is shown in green lines. (B) This panel shows specific tools related to each of the aforementioned steps of the FAIR Data Metro Map, emphasising the value of OMERO, the BioImage Archive, the need for cloud storage, and the value of software such as CellProfiler, QuPath and Ilastik.

- It is important to implement a maintenance schedule with routine checks to ensure proper function of the equipment, and to meticulously document the result of such checks in logs.
- The guideline for users prior to publication includes overseeing that the checklist of essential imaging guidelines for publication is complete, providing customised templates and files with microscope-specific information, and post essential information where microscopes are housed.
- Aurélie Cleret-Buhot shared about the BINA Metrology Suitcase Program, which is modelled on

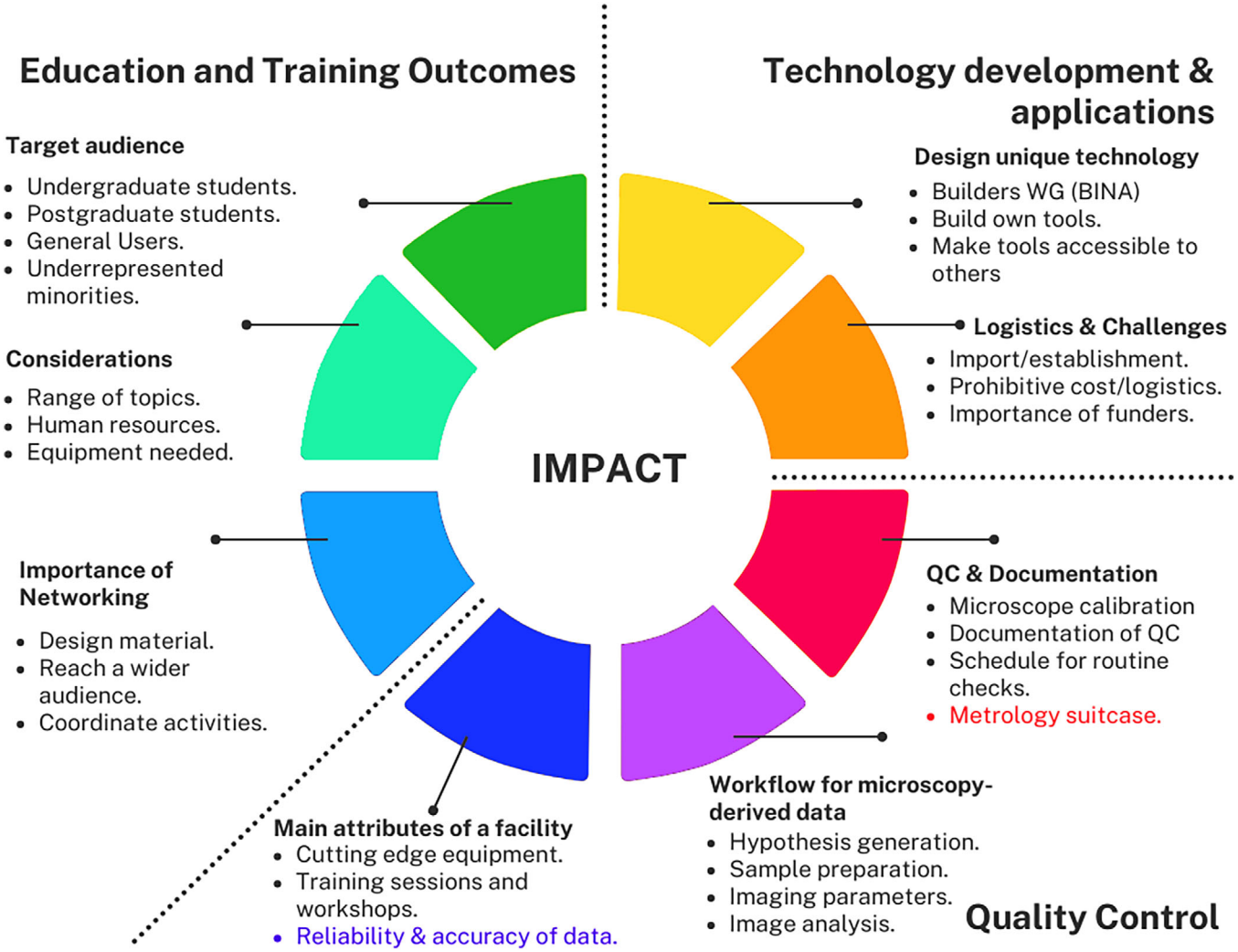


**FIGURE 9** Summary of the BINA Impact session. These stories highlighted the impact being made through training and education outcomes (both within the institution and national and international engagement); through quality control of instruments; and through the development and dissemination of novel technology. Image created with Canva.

a CNRS (Centre National de la Recherche Scientifique) initiative for multidimensional optical fluorescence microscopy (Réseau Technologique Microscopie de Fluorescence Multidimensionnelle (RTmfm)). The suitcase includes tools for light source intensity/stability measurements and point spread function/resolution analysis. The suitcase is currently under beta-testing, to ensure that the tools and protocols in the case are straightforward and user-friendly once the 'traveling portion' of the program is deployed. The intention is to provide facilities with the protocols and tools they need to QC their microscopes and to make data collection as uniform as possible between different facilities.

- It will also be possible to upload the data collected with the metrology suitcase protocols to a centralised repository organised by QUAREP-LiMi to track instrument quality over time, help better understand common quality issues, and help determine optimal instrument QC frequency.
- Important impacts of the metrology suitcase initiative for the facilities include the ability to follow up on the instruments in an organised fashion; monitoring in order to prevent major problems; providing a tool for quality control and reproducibility; and being a link to the community, including providing help when required.

### 4.4.3 | Technology development and applications

The final session of the BINA meeting focused on technology development and applications, particularly on the philosophy of removing barriers to transitioning new technology into the hands of the users. Core Facilities, because

of the wide range of biological challenges among their user base, represent an ideal sector of the bioimaging community to showcase and use these new technologies but adoption can be challenging. Talks were led by Abhishek Kumar (MBL, USA), Reto Fiolka (UT Southwestern Medical Center, USA), Anita Mahadevan-Jansen (Vanderbilt University, USA), Shalin Mehta (CZI Biohub San Francisco, USA), and Alenka Lovy (Universidad Mayor, Chile), with Kevin Eliceiri (UW-Madison and Morgridge Institute for Research, USA) as moderator. Key points reached during this session were:

- Technology development depends on joint efforts of the people involved in developing tools and those performing biological research, to make sure technological barriers are well-identified, that the right tools are designed in response to this need, and making sure that the tools are working as expected.
- Several next-generation instruments were highlighted by the various speakers, each of which have multiple active collaborations worldwide and various labs replicating the designs elsewhere.
- The importance of deploying computational microscopy was discussed. Tools used in combination with computational models, include quantitative label-free with phase and polarisation (QLIPP), multimodal instant polarisation microscope (miPolScope), uniaxial permittivity tensor imaging (uPTI) and MANTIS. Each of which have specific advantages including sensitivity, speed, resolution and sample preservation.
- In view of the importance of training imaging scientists in building their own tools, the formation of a 'BINA Builders Working Group' was introduced. The aim of this group is to organise events relevant to microscope design; to set up a webpage and other online tools that facilitate designing tools and sharing them with the scientific community; reaching a consensus for sharing microscope parts and designs; and providing a forum for continued discussions.
- Introducing novel technology to resource-limited settings has many considerations, even when we speak about open-science initiatives. An example discussed was the introduction of the Flamingo lightsheet microscope to Latin America. Logistics included ensuring funding and institutional support, for which CZI funding has been key. Funding, however, is only one of many hurdles. These hurdles represent important barriers to the implementation of novel technology, even as open science. Institutional bureaucracies are a major barrier to sharing technology due to the cost involved, which sometimes has to be paid up-front and out-of-pocket, to the logistical requirements, the complexities of importing instruments from other regions, and a significant amount of paperwork making it prohibitive for a research scientist to organise a workshop. There was a call for better understanding, support and initiatives to tackle these barriers.

## 4.5 | Conclusion of BINA meeting

The BINA meeting ended with a closing summary that emphasised the different approaches being used across North America for training and education of technologies, image informatics, core facility management and data management – that there is no 'one size fits all'. That we can and should be sharing resources among our communities (as exemplified by MicroscopyDB). The bioimaging community as a whole is facing similar challenges around image analysis and data management so it is important for us to share experiences and invite everyone to contribute to the discussions and finding solutions. Technology developers need partners to bring their technologies to fruition, and users are essential for providing the feedback needed to strengthen and develop the technologies – software and hardware alike – to ensure they are relevant and useful to the biologists. As community networks, we are raising awareness of shared challenges and supporting each other. With passion and commitment, we can work together to address these challenges by sharing resources and expertise to improve efficiency, reduce duplication and accelerate scientific progress. Finally the next BINA meeting was announced to take place in Madison WI, USA in September 2024.

## 4.6 | Final concluding remarks

Overall, this article summarises why joint meetings are vital for promoting dialogue and initiatives to build a truly global and open microscopy community. LABI and BINA are community organisations that are part of a larger global ecosystem of imaging infrastructures and communities. Global BioImaging comprises many national or international open infrastructures (Euro-BioImaging, Microscopy Australia, National Imaging Facility, Advanced BioImaging Support, Singapore Microscopy Infrastructure Network, Mexican National Laboratory for Advanced Microscopy, National Microscopy System) that have largely existed for the last decade, to broaden access to microscopy technologies and expertise and a growing group of community organisations or networks that exchange expertise (India BioImaging Consortium, South Africa BioImaging, African BioImaging Consortium, Canada BioImaging) and includes LABI and BINA. Thanks to the vision, desire

to build capacity on the global scale and financial support of the Chan Zuckerberg Imaging Initiative, this global ecosystem is growing and joining forces to address shared challenges and nurture new and emerging networks in new communities. Meetings like this one are critical for strengthening ties between communities of bioimaging scientists, learning from each other's experiences and expertise, and reducing redundancy of, and facilitating alignment of efforts. There is so much work to be done in this space that it is essential to work together to share and support one another and rapidly advance biomedical science.

This meeting has strengthened bonds between the North and Latin American bioimaging communities and has already resulted in exchanges and opportunities that would not have occurred had these communities not come together in Mexico in September 2023. For example, there has been greater engagement and participation of LABI members in BINA working groups (Builders, Early Career, Quality Control and Data Management) and initiatives (Professional Development and Exchange of Experience). This was an outcome BINA had expected but had not anticipated would happen so quickly. BINA members have also become more involved and engaged in training events and courses in LABI. For example, new funding from the Global Affairs Canada faculty mobility for partnership building program is supporting a microscopy fundamentals course in Latin America being offered in Spanish in Uruguay and a train-the trainer microscopy course targeted to Latin American imaging scientists in Argentina. These events also involve key mentorship activities that were initiated at the LABIxBINA meeting. Members belonging to both networks are also playing a significant role in addressing common challenges to both regions such as raising awareness of career opportunities in bioimaging and facilitating connection. Coordination has been initiated to compensate for LABI's limitations to provide funding outside of Latin America through BINA's Professional Development and Experience of Exchange program. Spanish translation efforts are extending beyond the initial Microcourses efforts to include the metrology suitcase videos and work is ongoing to include Portuguese translations, which should also benefit some partners in the African BioImaging community.

Finally, this meeting brought together many young scientists from Latin and North America, some of whom highlighted the value of establishing a network of Young Microscopists which could inspire a next generation of scientists, nurture their motivation to connect with global cultures, and promote creative and ambitious solutions to address challenges faced by young scientists around the world. A step in this direction has included an Early Career/Young Microscopists meeting with significant participation as a direct outcome of the LABIxBINA meeting. Future plans are for these interactions and joint activities to grow and expand beyond the individuals and groups currently involved. We intend to give long-term sustainability to this initiative by taking advantage of BINA's annual meeting rotation between Canada, the United States and Mexico, to hold regular joint meetings with LABI in Mexican territory every 4 years. There are plans to follow up with meeting participants in the future to understand other additional impacts of the meeting over the long term. Resources from the full meeting are shared in the supplementary resource section.

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