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A comprehensive strategy to strengthen bioimaging in Africa through the Africa Microscopy Initiative

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The Africa Microscopy Initiative (AMI) aims to promote the use of microscopy in biomedical research through facilitated access to instruments and expertise, and via training and networking opportunities. By coupling technology dissemination with expertise and training, AMI is designed to serve as a crucible for the sustainable development of imaging expertise across Africa.

Africa is an epicentre for biomedical and environmental research, with substantial global impact. The frontlines against infectious and non-communicable diseases[1], food insecurity, humanitarian crises, and climatic shocks often converge in Africa. Despite the implications and urgency of these challenges, however, African scientific interests are underrepresented globally. Moreover, African science is impeded by constraints in funding, accessibility to technology, infrastructure, and technical expertise. Compounding these challenges, a deeply entrenched colonial hierarchy from centuries of exploitation has eroded the ability of African scientists to gain equal global footing.

Collaborations between African scientists and the Global North are often ones of dependence, if not subordination[2–4]: local scientists are relegated to the role of collecting samples, often under dangerous conditions, while analyses are carried out abroad by colleagues who receive most of the credit. Inclusion of scientists from the Global South in the name of diversity — only to have the project accede to international research interests at the expense of a tangible regional impact — is essentially 'scientific tokenism', a particularly prevalent problem in Africa[2,5]. Although research is rightfully globally competitive, scientific practices and infrastructure should not be exclusive and exploitative. Capacity-strengthening initiatives must therefore be mindful of the benefits to underserved regions[6].

Recently, Africa has witnessed an increase in training opportunities and international research investment, as exemplified by programs such as DELTAS Africa (scienceforafrica.foundation/deltas-africa). These encouraging trends are discussed in a previous commentary on our microscopy training program, 'Imaging Africa'[7]. Unfortunately, historical encumbrances continue to fuel a vicious cycle, compromising the effectiveness of many initiatives. These include problems in availability of research tools, exposure to advanced techniques and technologies, intracontinental collaboration, and global elevation of African scientific interests.

Challenges

Although capacity-strengthening efforts in Africa are rife with multilayered challenges, they also present an untapped space for innovation. The challenges are summarized in Fig. 1a. In the worst-case scenario (Fig. 1a, situation 1), scientists combating biomedical battles in remote areas often lack both access to and knowledge of modern microscopy. Consequently, they may turn to more familiar assays, unaware that microscopy might better address their needs[7]. In situation 2 (Fig. 1a), limited accessibility commonly douses any enthusiasm for advanced microscopy, driving local scientists to abandon it as a research tool. Such barriers accentuate the high attrition rate that must be mitigated.

Workshops are a popular and effective approach to bolster fundamental knowledge of microscopy (Fig. 1a, situation 3), yet they can be a double-edged sword if not handled judiciously[7]. An overly basic curriculum glosses over the full power of modern quantitative microscopy. Conversely, exposure to the most advanced technologies can frustrate students, owing to lack of access at their home institutions. This can lead to 'brain drain' from Africa as participants seek access to high-end instruments elsewhere.

Notably, centres of research excellence equipped with high-end instruments are found in many affluent areas in Africa. Their exclusive accessibility, however, only underscores the considerable regional discrepancies (Fig. 1a, situation 4). Globally, this further barricades African scientists from advanced open-access microscopy resources, as many projects cannot be developed to a level that would require such resources (Fig. 1a, situation 5). An example of this inequitable access was encountered at the Advanced Imaging Center (AIC) at the Howard Hughes Medical Institute Janelia Research Campus[8] (Fig. 1b).

Yet, these inextricably entangled challenges also frame their own solutions. To counter them, a virtuous cycle must be established that simultaneously embraces (1) a continent-wide, equitably accessible microscopy centre, (2) a platform whereby inchoate but promising research projects receive the resources necessary to develop sufficiently to take advantage of internationally accessible resources, (3) the perpetuation and expansion of workshops such as 'Imaging Africa', (4) the enthusiasm of the global microscopy community for training in Africa, (5) the importance of online training with strong African representation, and (6) a recipient-driven redistribution of functional pre-owned instruments. These approaches synergistically constitute the two pillars of the Africa Microscopy Initiative (AMI) — microscopy access and training — guiding all programs and activities described below (Fig. 2a).

Microscopy access

AMI Imaging Centre. Enabling equitable access to modern microscopy is the foundation of AMI. Its centrepiece is the AMI Imaging Centre, accessible via peer-reviewed proposals solely from scientists in

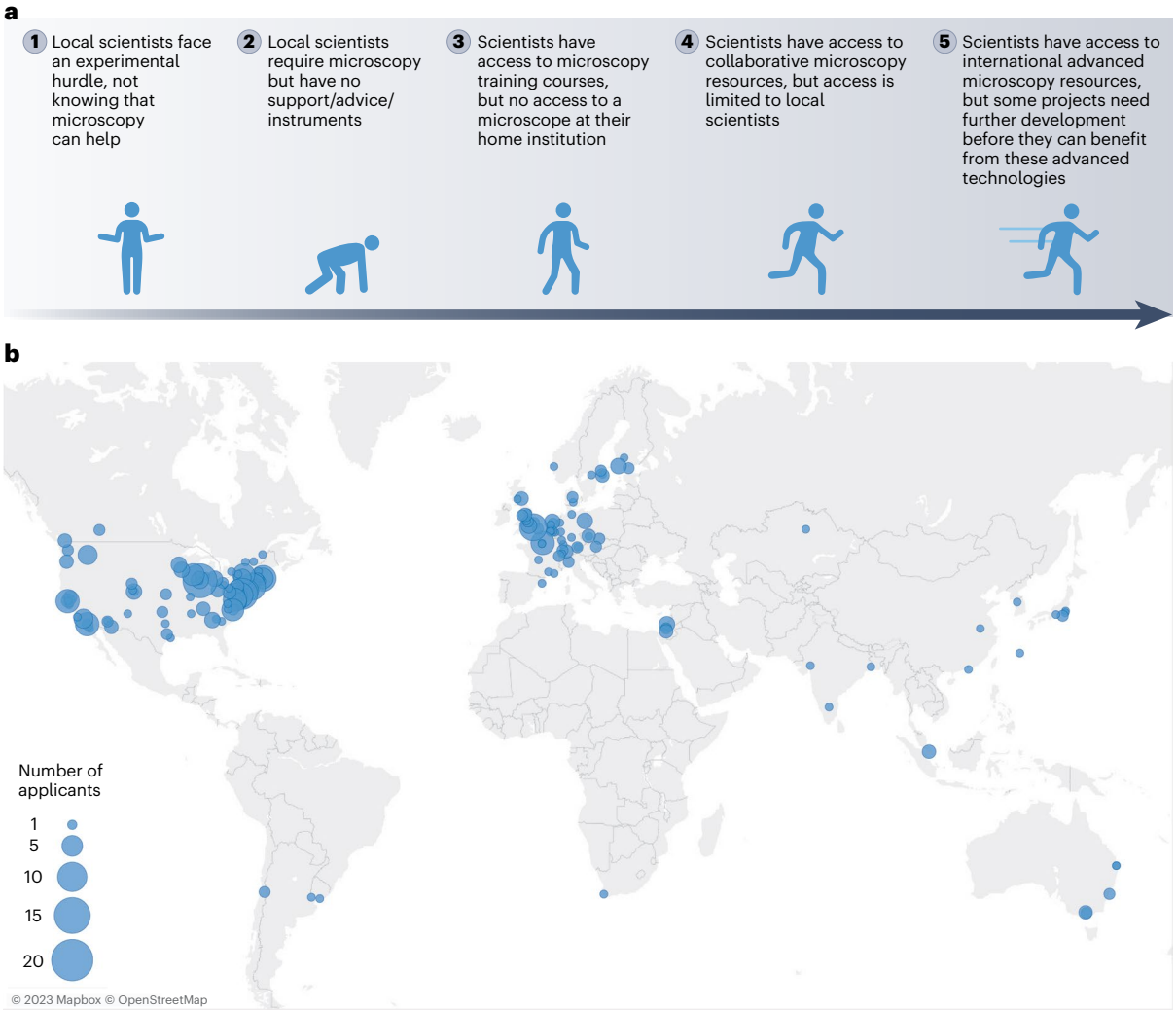


Fig. 1 | Challenges associated with the dissemination of microscopy. **a**, Stages in the road to microscopy awareness and utilization. African scientists face access barriers to microscopy instruments and expertise at multiple levels. Each challenge calls for its own set of solutions, which in turn help steer the AMI programs. **b**, Equally accessible research resources do not always lead to equitable access, as shown by the origins of proposals submitted to the AIC at the Howard Hughes Medical Institute Janelia Research Campus from 2014 to 2022, prior to the launch of the AMI. Up to this point (after ten rounds of proposal calls), the AIC received a single proposal from Africa.

non-profit African institutions. Located in 250 m^2 of purpose-built space in the Institute of Infectious Disease and Molecular Medicine at the University of Cape Town, its operation is modelled after the AIC[8], but with enhanced support. All experimental, travel and lodging costs are fully covered for approved proposals for four to six weeks. The AMI Imaging Centre is equipped with a fleet of newly purchased instruments as well as standard laboratory equipment (Fig. 2b). The instrument portfolio will be re-evaluated regularly to respond to changing needs. Crucially, this necessitates experienced imaging scientists and a program coordinator, who will provide support for hosted projects and offer technical consultations to guide prospective applicants toward formulating effective proposals.

Project incubator. The AMI Imaging Centre also doubles as a vital project incubator. Its entire ecosystem serves to catalyse project development, allowing the generation of compelling preliminary data. This, in turn, paves the way to more advanced microscopy technologies at other global open-access resources. To further realize this potential, an alliance among three sister imaging centres (the AMI Imaging Centre, the Advanced Bioimaging Unit at the Institut Pasteur de Montevideo in Uruguay, and the AIC) has been forged in order to expedite projects and allow the exchange of expertise.

A single imaging centre is insufficient to address the needs of an entire continent. Consequently, there is recognition that additional AMI Imaging Centres will be required to ensure wider geographical coverage and greater responsiveness to regional needs. Even then, the strategic placement of microscopy capacity cannot be restricted to a handful of centralized locations, underscoring the need for a distributed approach. Otherwise, the AMI Imaging Centre risks becoming a technology island that fails its mandate. Addressing this challenge

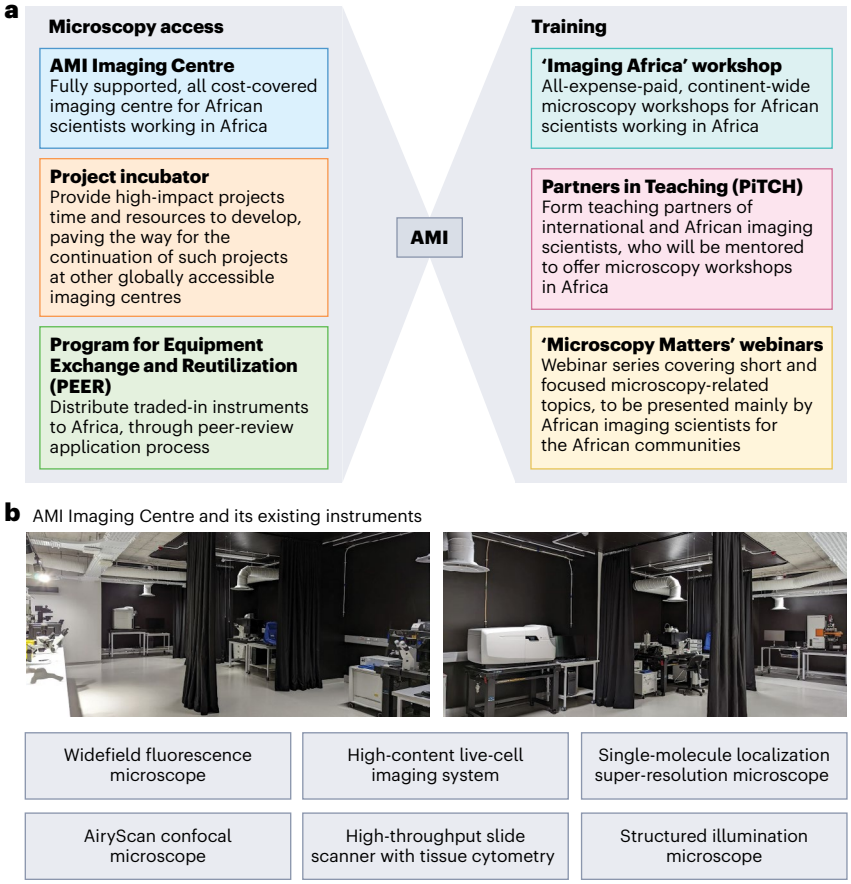


Fig. 2 | AMI at a glance. a, The multipronged approach of AMI. Microscopy access and training constitute the two pillars of AMI and consist of six multipronged approaches to bolster microscopy capacity in Africa. **b**, Selected views of the AMI Imaging Centre and its existing instrument portfolio. The AMI Imaging Centre is housed at the University of Cape Town, and was inaugurated in October 2022.

requires coordinated distribution and local technical support of research-grade microscopes in Africa. These constitute the remaining components of AMI (Fig. 3).

Program for Equipment Exchange and Reutilization (PEER). Manufacturers regularly promote their latest microscope models using trade-in discounts on existing equipment. Although fully operational, these traded-in instruments regrettably remain idle in warehouses until storage costs dictate their disposal. The novel PEER aims to unlock these pre-owned microscope repositories. PEER also invites the participation of socially conscious companies, which is an essential component that streamlines the logistics of instrument inventory, shipping, installation and service. Without their support, the effectiveness of PEER will be curbed. The benefits of PEER, however, extend beyond instrument distribution. Implemented creatively, it becomes an effective tool to promote resource sharing through core facilities, a model not yet common in Africa.

PEER is also designed to bolster local microscopy expertise. Following each announcement of instrument availability, interested institutions will submit applications in which they must to clearly justify how the requested instrument will be utilized (Fig. 3). Crucially, the applicant institution will be expected to commit to (1) cover the cost of instrument maintenance, (2) designate a technical point-person who will be fully trained by the microscope company and the AMI Imaging Centre, and (3) manage the PEER instrument as a shared resource. This ensures that the instrument will be awarded to institutions with local expertise that are committed to keeping the instrument accessible. Institutions that further pledge to offer regional open access will be viewed favourably. Close interaction with community organizations such as the African BioImaging Consortium (ABIC; www.africanbioimaging.org) will help to identify user needs, publicize lists of available instruments, and disseminate application calls.

Although instrument dissemination is indispensable, it is insufficient to deliver the full promise of AMI. Ultimately, technical expertise makes technology work; therefore, training constitutes other central tenet of AMI.

Training

To improve microscopy access and utilization, capacity building must be accompanied by the development of technical expertise and a general awareness of what microscopy can deliver.

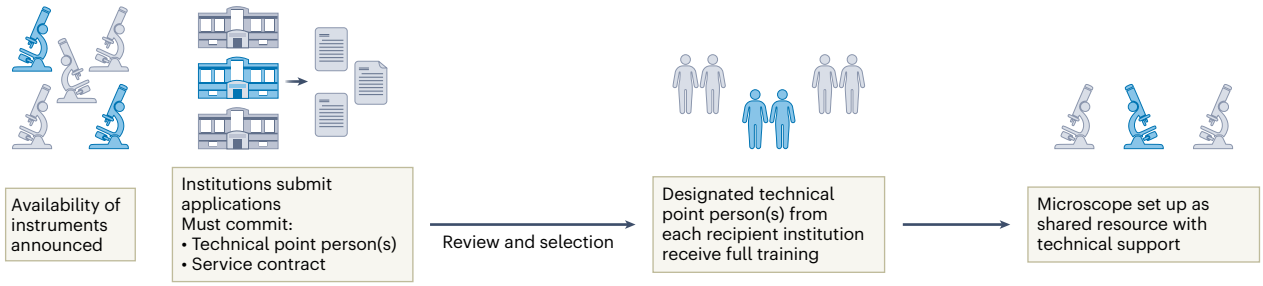


Fig. 3 | The PEER application process. PEER aims not only to disseminate the large cadre of traded-in commercial microscopes to African recipients, but also to (1) use a bottom-up approach to draw institutions in need to submit applications, (2) demonstrate institutional commitment to cover the maintenance cost, (3) designate full-time employees to be trained as local technical support staff, and (4) turn the donated equipment into a shared research resource.

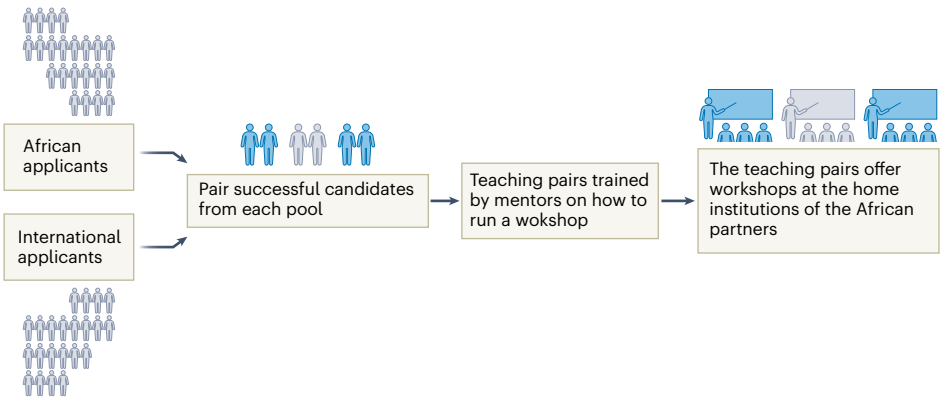


Fig. 4 | The PiTCH fellowship application process. The PiTCH program pairs early-career international imaging scientists with their African counterparts. The selected pairs will be coached by mentors experienced in conducting international microscopy workshops. The pairs will then offer microscopy workshops at the home institutions of the African teaching partner.

Imaging Africa. The 'Imaging Africa' workshop[7] was the initial impetus for AMI and has been incorporated as the cornerstone training program. The first two workshops were held in Cape Town in 2020 and 2022. To spotlight francophone communities, the next workshop will rotate through West Africa. These all-expenses-paid workshops are designed as high-level introductory courses focused on optical microscopy and image analysis[7]. However, smaller, regional satellite workshops planned around specific scientific themes can be equally valuable. For example, a microscopy course for malaria studies will focus on how imaging and analysis techniques can transform this field. Themed workshops will enable in-depth discussions and participants will be encouraged to bring samples from ongoing projects. The goal is for attendees to return with knowledge of in sample preparation, and biologically informative data. Such outcomes will illustrate the power of quantitative microscopy more effectively than many other approaches.

Partners in Teaching (PiTCH). Mentorship and peer support often elude early-career African scientists[9], especially in less explored career paths, such as imaging scientists. Compounding funding constraints, the paucity of mentorship and peer support drives young scientists to seek opportunities abroad — often not to return. This robs Africa of talent otherwise eager to contribute to their local communities. A strategic solution is the integration of mentorship, peer support, training opportunities and fellowships into a single program: PiTCH.

The vast global microscopy community includes many early-career scientists who are interested in organizing their own microscopy workshops. This enormous resource can be tapped to bolster AMI training aspirations by pairing them with an African counterpart through a mentored and funded partnership to offer microscopy workshops in Africa. Each teaching pair will be coached remotely by mentors with extensive international workshop experience. Following training, the pair will offer a workshop at the host institution of the African partner. Therefore, the PiTCH program (Fig. 4) functions as an international fellowship, supporting the local workshop and travel of the international partner.

This creative 'train-the-trainers' approach will therefore simultaneously (1) mobilize the global pool of imaging talent, (2) assemble teaching pairs that would not otherwise exist, (3) foster long-term partnerships, (4) make international mentorship available, and (5) fund locally focused workshops. Importantly, the PiTCH strategy will rapidly grow the number of regional workshops in a distributed manner, supplementing the centralized model of Imaging Africa. However, to reach the widest possible audience, a set of curated webinar series is also essential.

'Microscopy Matters' webinars. Webinars are easier and less resource intensive than hands-on workshops. They reach a larger audience, facilitate on-demand participation, and allow repeated viewing of complex topics. To complement the Imaging Africa and PiTCH workshops, AMI will develop webinars, entitled 'Microscopy Matters', on a range of topics, to be delivered predominantly by African imaging scientists.

There exists much excellent microscopy-focused content — for example, at iBiology (www.ibiology.org) and μCourses (www.youtube.com/microcourses), as well as other training resources curated by BioImaging North America (www.bioimagingnorthamerica.org/training-education-resources) and Global BioImaging (globalbioimaging.org/international-training-courses/repository). Instead of replicating this material, 'Microscopy Matters' will do the following: (1) feature African scientists as instructors, thus upending the conventional role of students to which they are often relegated; (2) establish the alumni of various African imaging workshops as role models to share their expertise; (3) place the webinar ownership in the hands of the African scientific community; and (4) formulate didactic materials contextualized for African scientific interests.

Stakeholders and partners

The success of AMI hinges on local and global partnerships, as well as vital support from funders, academia and industry.

International funders. The receptiveness of the Chan–Zuckerberg Initiative and the Bill & Melinda Gates Foundation has been pivotal. Their keen insights crystallized the many details of AMI and aligned it with other initiatives on the continent.

African partners. Both the University of Cape Town and its Institute of Infectious Disease and Molecular Medicine were instrumental in driving AMI to fruition, providing administrative and infrastructural support to the flagship imaging centre. Fortuitously, the development of AMI coincided with the formation of the ABIC community. As a key AMI partner, the membership of ABIC will propel the PiTCH program and Microscopy Matters, and its reach will help coordinate our workshops.

Global partners. The global support for AMI is substantial. As the inspirational model for AMI, the AIC has shared substantial operational guidance, even before its launch. It continues to offer writing workshops and clinics for AMI Imaging Centre proposal calls. Likewise, EuroBioImaging (https://www.eurobioimaging.eu) has contributed its resources with alacrity, providing a welcoming ecosystem for job shadowing and technical training to PEER trainees. In addition to technical knowledge, they will share core facility management skills. France BioImaging (https://france-bioimaging.org) will partake in workshops and assist in communication with francophone African countries. Notably, in conjunction with the Horizon Europe Programme, it has launched the Africa–France Joint Initiative for Biological Imaging (Box 1). These add-on programs are a testament to the capacity of AMI to inspire global participation — a key indicator of sustainability and potential for expansion.

Industry partners. The success of AMI, and especially of PEER, relies on support from industry partners. Zeiss Microscopy Solutions has offered their inventory of traded-in instruments as well as technical and logistical support to PEER. Exceeding what a for-profit company would usually offer, Zeiss has created scholarships and travel awards to support African students attending microscopy conferences or workshops in the USA. AMI educational programs will also benefit from donations of numerous teaching microscopes by Zeiss, and from job shadowing opportunities at the Harvard Center for Biological Imaging. TissueGnostics (Austria) and Tokai-HIT (Japan) have also provided StrataQuest cytometry software, and pledged funds for PiTCH fellowships, respectively.

Discussion

AMI alone is not the ultimate end-goal; it is an opportunity not only to enhance microscopy infrastructure, but also to galvanize the adoption of open-access resources in Africa. The long-held penchant of 'protecting' costly high-end equipment from external users has created a sclerotic scheme that is incompatible with the rapid technological advancements and cost increments in imaging tools. Considering the paucity of financial resources and on-the-ground technical support, this situation is understandable. Yet such siloed resources are counterproductive in overcoming the invidious distribution of scientific capital and inefficient use of scarce resources in Africa. It is antithetical to the fast-growing global trend of creating open-access infrastructure against dwindling research investment[10].

It is a prevalent misstep that research investments tend to facilitate one-off purchases or donations of expensive instruments without commensurate development of local expertise. Rather than building capacity, such an investment causes an unintended predicament for the recipient institution, now saddled with advanced equipment that is under-utilized. Admittedly, this oversight is encountered worldwide. Unfortunately, its deleterious effects are amplified in resource-constrained settings in which institutions do not have the luxury of hiring their way out of this quandary. Ultimately, lack of usage translates into difficulty in defraying maintenance costs; worse yet, under-utilization dissuades future investments and, in some cases, further reinforces prejudices against African science.

The perils of treating Africa as a 'dumping ground' for pre-owned instruments through well-intentioned donations that lack coordinated training and support are real[11,12]. This is why PEER emphasizes the enhancement of local technical support as an integral component. Indeed, a strong emphasis on technical expertise underpins all AMI programs. The lack of appreciation for application scientists can derail technology implementation. However, recruitment — and, more importantly, retention — of skilled application scientists demands considerably more forethought than simply assigning existing staff as instrument caretakers. Without careful consideration of career trajectory, such hastily created, short-term positions will serve more to stultify enthusiasm than to fuel one's vision in effectively deploying technology to the community. Although there is increasing awareness of the essentiality of application scientists in the global scientific enterprise, it will take some time before this notion is fully embraced in resource-constrained settings.

In years 1–3, AMI will establish the logistical details of its programs. Further, the AMI Imaging Centre anticipates offering two to three proposal calls and hosting the accompanying visitor projects (Box 1). The PiTCH program will be launched in 2024. We have also consolidated an instrument repository sufficient for several rounds of PEER applications. The next 'Imaging Africa' workshop is also planned to take place in West Africa. Operationally, AMI deliverables can be grouped as follows: (1) the number and effectiveness of our educational outreach programs; (2) successful operation of the imaging centre; (3) the number and extent of collaborations fostered through the initiative; and (4) scientific output facilitated by

BOX 1

Early successes of AMI

Although the long-term impacts of the initiative are yet to be fully realized and measured, the positive effects of AMI have already surfaced in numerous areas.

AMI Imaging Centre proposal call: round 1

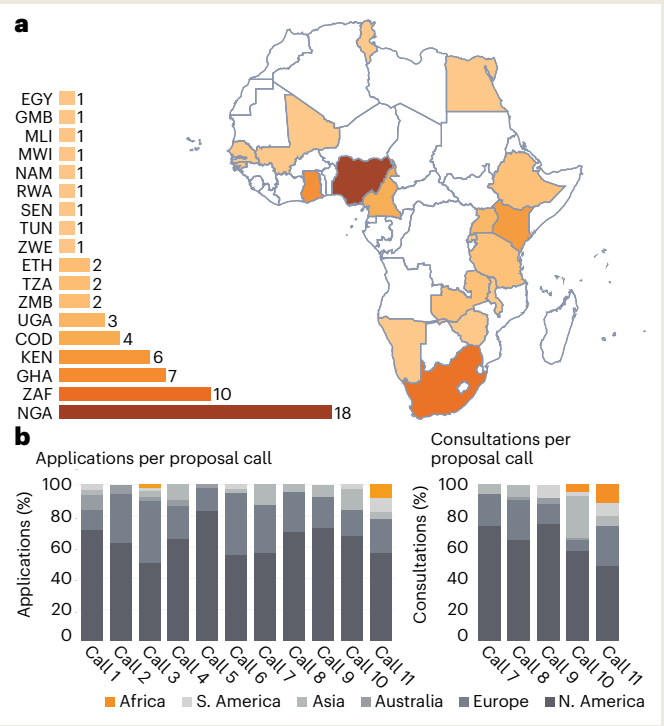
The AMI Imaging Centre has received 63 proposals from 18 countries (Box Fig. 1a). Encouragingly, several were intracontinental collaborations. In addition, the vast majority aim to use fluorescence microscopy and live-cell imaging at various degrees of sophistication. This is a welcome departure from the immunohistochemistry-based imaging commonly believed to be the extent of microscopy in Africa. These are some of the major, early successes, and one of the key indicators that the AMI approach is generating the desired outcome.

Access to other imaging centres

Box Fig. 1b shows the applications and consultation requests to the Janelia AIC by continent. The AIC received a single proposal (and a single consultation request, from the same group) from the first to the ninth open proposal calls (2014–2019). Following the COVID-19 pandemic and the first 'Imaging Africa' workshop, we received four consultation requests in call 10. In call 11 — 3 months after the AMI launch — the number of technical consultations rose to 8 (11.6% of the total requests). There were also four submitted proposals (8.7% of the total submission), a 400% increase in proposal submission over the previous 8 years combined. In addition to South Africa, the origins of the proposals have also expanded to Rwanda and Nigeria.

Amplification of partnership and access

In direct response to the creation of AMI, France Bioimaging has launched the Africa–France Joint Initiative for Biological Imaging. Its mission is to foster bilateral research funding programs between Europe and Africa under the Horizon Europe Programme. This joint initiative will fund: (1) external access to microscopes available through the France Bioimaging network, feasible within 2–3 weeks that include travel, housing, and equipment usage; and (2) twinning exchange programs between an imaging facility or laboratory in Africa and one of its counterparts within the France Bioimaging network, to focus on core facility activities, practices, and training approaches. This represents an important 'amplification effect' whereby other international organizations continue to bolster the impact of AMI.



Box Fig. 1 | Early successes of AMI. a, Countries of origin for the 63 proposals received in the first round of proposal calls by the AMI Imaging Centre. **b**, The immediate and positive effects of AMI in improving proposals and technical consultation requests received by the AIC (Howard Hughes Medical Institute Janelia Research Campus).

AMI. Ultimately, the success of AMI can be measured by how well it can disentangle the vicious cycle that has encumbered the African scientific community for far too long. AMI also seeks to raise awareness among funding organizations that open-access resources — instrumentation and expertise alike — must be the cornerstone of all capacity-strengthening investments. The willingness of the recipients of such investments to share research capacity must be incentivized, and preferably mandated. Many communities are treading this strategic path, as exemplified by other regional organizations with similar goals, such as EuroBioimaging, BioImaging North America (https://www.bioimagingnorthamerica.org), Advanced Bioimaging Support in Japan (ABiS; https://www.nibb.ac.jp/abis), ABIC, Latin America BioImaging (https://labi.lat), and, at the intercontinental level, Global BioImaging (https://globalbioimaging.org). These organizations and programs, while representative of the plurality of local interests, collectively convey a resounding message: open science must transcend geography.

AMI is but one of the many necessary steps through which the African scientific community will position itself on an equal global footing. It provides a powerful reminder to the global scientific community to consider African colleagues not as beneficiaries but as key partners. It is equally important that the African community does not receive the misguided impression that, with the launch of AMI, the end-goal has been achieved. Rather, AMI represents an important opportunity to equip local scientists with the tools and expertise that will catalyse important advances, in turn providing leverage to secure future funding. African scientific interests must be equitably represented in other global open-access infrastructure, ensuring that the most-advanced

technologies can be used by African scientists to conduct globally impactful research.

Ultimately, the success of the initiative must be the shared responsibility and destiny of Africa. Yet open-access infrastructure is successful not because it operates in regional isolation, but because it draws strengths from the global network that promotes the exchange of experience and expertise. Amidst the ebullient wave of capacity-strengthening initiatives on the continent, the African scientific community should likewise recognize that this is a pivotal moment: there is an opportunity not only to perpetuate the momentum, but to demonstrate the immense benefit of open-access infrastructure networks to other geographical regions.

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Competing interests

The authors declare no competing interests.