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INVITED REVIEW

More than just ‘added value’: The perils of not establishing shared core facilities in resource-constrained communities

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Abstract

The accelerating pace of technological advancements necessitates specialised expertise and cutting-edge instruments to maintain competitive research in life sciences. Core facilities – collaborative laboratories equipped with state-of-the-art tools and staffed by expert personnel – are vital resources that support diverse scientific endeavours. However, their adoption in lower-income communities has been comparatively stagnant due to both financial and cultural challenges. This paper explores the perils of not supporting core facilities on national research enterprises, underscoring the need for balanced investments in discovery science and crucial infrastructure support. We explore the implications from the perspectives of funders, university leaders and lab heads. We advocate for a paradigm shift to recognise these facilities as essential components of national research efforts. Core facilities are positioned not as optional but as strategic investments that can catalyse breakthroughs, particularly in environments with limited resources.

KEYWORDS
core facilities, infrastructure support, microscopy, technology access

1 | INTRODUCTION

There has been sustained and fast-paced development in nearly every enabling technology used in life science in the past few decades, from quantitative genomics, metabolomics, microscopy, and mass spectroscopy to data analysis and reagent development. These advances have transformed biological science into an increasingly multidisciplinary field. Most biomedical and life science projects can no longer be successfully completed without involving multiple highly specialised advanced techniques and instruments. More importantly, as biological data continue to grow in complexity, the expertise required to perform quantitative data analysis, particularly utilising artificial intelligence, and mathematical modelling have likewise grown significantly more sophisticated. It is now beyond the resources and bandwidth of most individual labs to handle and master all these technologies.

To address this challenge, many institutions have established shared research infrastructures; chief among them are specialised, shared laboratories called core facilities. Core facilities are often organised into technique-specific units, making them ideally suited to nimbly respond to inevitable and rapid technological advancements. Often equipped with expensive, state-of-the-art instruments too resource-intensive for a single lab, and staffed with application scientists with unique expertise, core facilities offer specialised research support on a fee-for-service basis that are integral to modern, high-impact research. Albeit a relatively new concept, core facilities have nonetheless garnered significant attention due to the immense return on investment they create. As a result, there is no shortage of literature touting the added value of core facilities,[1–5] especially in the field of microscopy due to the cost-prohibitive nature of the instrumentation and the level of expertise required to support such a core facility effectively.[6–9] For this reason, we will use shared microscopy infrastructure as an example in this paper to explore the importance of core facilities. However, it is important to note that the contribution of core facilities to modern science is not specific to any single technology.

The increasing awareness and acceptance of core facilities have led to the formation of a plethora of organisations that represent them, such as the Association for Biomolecular Research Facilities (ABRF),[10] Global BioImaging[11] and BioImaging North America.[12] The importance of shared access to research instruments is further exemplified by the creation of national- and continental-level networks of core facilities such as EuroBioimaging[13] and Advanced Bioimaging Support (ABiS) in Japan.[14] Despite the well documented advantages, many lower-income communities continue to conduct scientific research without the support of core facilities, unfortunately to their detriment. The most common argument against the establishment of core facilities is cost and lack of expertise. Yet, it is not uncommon to see expensive instruments awarded to individual labs in these communities, only to be severely under- or mis-utilised. This self-conflicting situation negates the argument of cost as the key determining factor against creating core facilities, and points to a more deceptive root cause that needs to be examined. Funding models that exclusively support single labs incontrovertibly widen the inequity and schism within a scientific community, which is especially devastating to the already underserved countries.

We will address these issues with the funding organisations, academic leaders and group leaders in resource-constrained countries as our target audience. Instead of repeating the well-articulated added values and societal impact of core facilities,[1–5] we dissect the importance of core facilities through a unique angle – by their absence. We aim to explore the following questions: Will a resource-constrained scientific community miss out only on the oft-mentioned 'added value' of core facilities? Or, will their research endeavours be imperilled by other hidden barriers?

1.1 | Opportunity cost for funders: reduced return on research investment

While private foundations and governmental funders may differ in their funding foci, from tackling diseases of national importance to channelling funds to drive long-neglected scientific fields, every funding organisation has mandated priorities. Despite these differences, it is an irrefutable fact that funders at every level across the globe grapple with resource constraints. The demand for scientific investment is always greater than what is available. As a result, when faced with the full spectrum of funding requests, most funders must find creative ways to maximise the return on their investment while adhering to their general funding directions. Unfortunately, this is where the dichotomy of funding discovery science and capacity-building efforts are often perceived as mutually exclusive priorities. This is especially the case in lower-income countries, where the urgency to siphon limited resources into curbing high priority diseases usually overshadows investments in other components of the scientific enterprise.

While the notion of steering research investment singularly towards targeted areas of discovery-based research is logical in principle, it often falters in practice for several reasons. Individual labs rarely can maximally leverage every technology necessary to drive their research due to the rapid development of modern research tools and methods. Approaches that consolidate all the largess into single labs over others create an inequitable environment that minimises interdisciplinary discussion and partnership. More importantly, it locks up precious resources that could have created sustainable research infrastructure and attracted expertise. Such siloes often produce research inefficiencies, with both considerable unused instrument capacity and duplication of research capacity across individual labs. Further, individual labs are then forced to shoulder the full cost of maintenance contracts, or to forego such coverage altogether. Ultimately, such underutilisation often discourages future research investment, as it is often seen as a poor use of funding.

The key is to not treat support of discovery-driven science and research infrastructure enhancement as diametrically opposed goals. In fact, they are not even a zero-sum game. An approach where research funding for individual labs is balanced by investment in research infrastructure – such as shared facilities and application scientists – can potentially multiply the investment

Journal of Microscopy RMS

TABLE 1 Disadvantages faced by funders, academic institutions and individual research labs in the absence of open-access core facilities, and the recommended steps to address the challenges.

	Pitfalls in the absence of core facilities	Recommendations
Funding organisations	• Duplicative investment • Under-utilisation of redundant instruments • Lack of sustainability • Support of research siloes that may not fully achieve the funded scientific goals	• Balance funding between discovery science and research infrastructure • Encourage institutions to create open-access facilities • Allow requests for core facility user fees
Institutional leadership	• Unable to foster collaborative, open science ecosystems • Struggle to support globally competitive research • Loss of "institutional memory" in the form of expertise	• Articulate the need and strategy to establish shared core facilities • Create and sustain career paths for application scientists in core facilities • Pool research resources by forming alliances with other institutions
Individual research labs	• Unable to maintain services for advanced instruments • Expensive to hire sufficient experts to perform modern scientific research • Siloed labs handicapped by the lack of synergistic crosstalk	• Advocate for the need to share instruments and research resources • Lobby for funders to support shared instrumention

impact far beyond the original sum. As has been advocated repeatedly in the literature,[1–3,15,16] supporting infrastructure facilitates more efficient research and also reduces duplicative investment. It is also significantly more cost-effective to fund core facility user fees than to purchase multiple similar instruments for individual labs. In addition, the steady revenue stream from user fees helps defray maintenance contract costs and provides a route to acquire future instrument upgrades – all hallmarks of a sustainable funding model (Table 1).

The challenge in this model is that funders generally do not have sufficient information about the local research capacity and institutional infrastructure needs to strike the ideal balance between funding individual labs and creating the necessary infrastructure that supports the very research they are funding. In fact, there is an ongoing debate as to whether building research infrastructure should be the responsibility of funders at all, or should this responsibility reside with individual institutions. This offers a segue for us to explore the perilous impact on institutional research missions in the absence of shared research resources such as core facilities.

1.2 | Stifled infrastructure development of academic institutions

The missions of most academic research institutions, regardless of geography, are strikingly similar and centred around (i) education, (ii) sustaining academic research activities and (iii) faculty recruitment for future expansion. Institutions with post-graduate programs support research activities at various levels of complexity as part of their educational and research missions. Those with research funding from various stakeholders also shoulder additional responsibility to achieve the goals described in grant applications. Unfortunately, such commonality in goals quickly stratifies into remarkable disparities in operation, driven by the uneven sizes of institutional coffers across the globe. Precisely because of such inequity, it is easy to dismiss the way in which research infrastructures are built in affluent communities as simply unattainable for those in the lower- and middle-income echelons. One commonly overlooked fact, however, is how the enormous research enterprises in top-tier institutions proportionately drain their resources. While the struggles may appear distinct at first glance, there are indeed common subtexts in resource management – most notably the perpetual need to minimise resource duplication while maximising the impact of institutional resources. It is therefore beneficial to study how universities with outsized research enterprises meet the commensurately large demand relative to the available resources. More importantly, we will explore how some of these strategies can be translated to empower more resource-constrained institutions.

The lack of shared research infrastructure, commonly staffed with highly skilled specialists who are the local technical focus,[17] exposes an institution to long-term risks that may not be immediately apparent. If these experts with highly specialised skill sets are hired into individual labs due to the absence of core facilities, it immediately creates several challenges for the institution – regardless of funding level: (i) the expertise will quickly be siloed and may not be available to the rest of the institution; (ii) the institution will need to duplicate such expertise if other labs also require it – dipping into funds that it may not have to hire another researcher with the same calibre who may not exist in the region; (iii) the departure of the expert, due to the loss of funding or change of research direction by the original hiring lab, causes an immediate, and potentially total, loss of the related expertise to the entire community. The latter situation underscores the added value of core facilities as important sources of 'institutional memory'.[17] Through the recruitment of technical experts that are strategically important to an institution into shared facilities – and their retention in these positions through judiciously considered career trajectory development[17] – academic leaders can better allot their limited resources for maximal, long-lasting impact. However, such a strategy can only work if there is enough institutional funding to create sufficient research infrastructure in the first place.

In severely resource-constrained settings, the crippling cost of sustaining research, the threat of losing research faculty members, and the challenge in recruiting new talent all conspire to fuel the vicious cycle of stifled research progress and difficulty in securing future funding. In fact, it would be sanctimonious to expect institutions confronting these limitations to 'maximise' the impact of their research investments when the available funding can only sustain a basic level of research. The unvarnished truth – and hence the indelible perils – is that disadvantaged institutions will be further marginalised at an accelerated pace in this age of rapid technology development and increase in research cost if nothing is done to combat the status quo (Table 1).

It is precisely under such systemic challenges that resource-constrained institutions must consider strategies that will squeeze the most value out of already parsimonious research support. One tested and effective way to overcome such a handicap is to pool resources from multiple institutions to form research partnerships, especially when it comes to cost-intensive tools such as microscopy. This is not a novel concept, as many alliances at the intracity (Chicago Biomedical Consortium[18]), regional (Core for Life,[19] WAMBIAN[20]), national (ABiS,[14] Microscopy Australia,[21] SingaScope,[22] Latin America BioImaging (LABI)[23] (see case 2, Text Box 1)), continental (EuroBioimaging,[13] Africa Microscopy Initiative[24,25]), and even intercontinental levels (the alliance[25,26] of the African Microscopy Initiative Imaging Centre,[24,25] Advanced Bioimaging Unit at the Institut Pasteur de Montevideo in Uruguay[27] (see Text Box 1), and the Advanced Imaging Center at HHMI Janelia Research Campus, USA[28,29]) can attest. This rapidly growing trend is a strong indicator of the effectiveness of combining resources to achieve what single institutions (or even single countries) cannot. This strategy has proven to be enormously successful through the recent awards of the 'Open Infrastructure Fund'[30,31] to LABI and AfricaOSH.[32] The Open Infrastructure Fund – jointly funded by the Simons Foundation, the University of Buffalo Library, and Invest in Open Infrastructure[33] – supports capacity-building, community governance, and critical shared infrastructure for under-represented communities. These awards are a clear testament to the importance of open-access infrastructure, and the benefits of community organisations as the representative voices of regional research needs.

While still relatively uncommon among countries in the Global South, regional research alliances may be the most effective way to buttress scientific infrastructure. This realignment of common goals is a drastic but necessary shift from the zero-sum mindset that has, for far too long, harmed research enterprises across the globe, most notably in resource-challenged communities. Furthermore, it constitutes the foundation upon which to deliberate the philosophical question of whether developing research infrastructure is the responsibility of individual institutions or that of funding agencies.

Without a large network of wealthy donors and alumni, academic institutions do not have the means to create and promote research infrastructure. The source of support for research infrastructure is therefore decidedly in the hands of funding organisations. To a smaller extent, some commercial partners may also recognise the value of jointly supporting infrastructure as a strategic partnership.[34] In addition to numerous such imaging centres in affluent communities, some have also begun to see the value in establishing such industry-academic partnership in developing countries, as exemplified by the Institut Teknologi Bandung Olympus Bio-Imaging Center in Indonesia[35] (see Text Box 1). However, funders are in no position to dictate how infrastructure should be created, and their missions are rarely focused on capacity-building. It is then the responsibility of individual academic institutions to strategize how best to build local/regional shared research infrastructure and articulate these needs and strategies to funders. In fact, a regional consortium of shared resources may be an easier plan to pitch to funding agencies, rather than individual institutions fighting for a limited funding pool with no strategic, or even coherent vision. It is also the responsibility of institutions to elaborate on the benefits of shared access to research infrastructure to their faculty members to create the necessary buy-in,[16,36] and to carefully listen to their scientific community how best to create and sustain effective research infrastructure (Table 1).

1.3 | Barrier to technology accessibility for individual labs

The establishment of shared resources first and foremost requires 'buy-in' and agreement from all parties, ranging from individual researchers to institutional leadership.

TEXT BOX 1: Successful models for resource-constrained communities building their own facilities

The four case studies below show how successes can be attained despite resource constraints in various parts of the world, through the strategies outlined here.

Case 1: The Uruguayan Government, Universidad de la República and Institut Pasteur de Paris have collaboratively established a foundation dedicated to advancing scientific research in human health, mirroring the objectives of the French headquarters. Institut Pasteur provided seed funding, catalysing the foundation's inception, while the Uruguayan government ensures sustained growth.[42] This collaboration led to the recognition of shared resources' significance, prompting the funding of the Advanced BioImaging Unit (ABU).[27] ABU is actively developing innovative instrumentation and providing services and training to researchers within Uruguay and to the greater Latin American community.

Case 2: The Latin America BioImaging (LABI) network,[23] a collaborative initiative across Latin American countries, offers a successful model in addressing individual limitations through collective action. By pooling resources and expertise, LABI effectively enhances training, education and access to imaging technologies throughout Latin America and the Caribbean. This collaborative approach, particularly notable in Uruguay, Chile, Brazil and Mexico, sets an example of how resource-constrained communities can successfully overcome challenges, optimise shared resources and achieve impactful outcomes in the realm of scientific advancements and technological access.

Case 3: In a remarkable case, the regional government of Yobe State in one of the least developed parts of Nigeria has demonstrated a commitment to scientific progress through the establishment of the Biomedical Science Research and Training Centre (BioRTC).[43] BioRTC stands as an exemplary initiative providing advanced infrastructure for biomedical research and fostering the training of African scientists. This success story illustrates how a regional government, cognizant of local challenges, aspires to build a robust research community, showcasing a transformative model for addressing scientific and developmental needs in underdeveloped regions.

Case 4: The collaboration between Olympus and Institut Teknologi Bandung (ITB) in Indonesia,[35] resulting in the establishment of the ITB-Olympus Bio-Imaging Center, stands out as a successful case. It reflects a harmonious partnership between academic national institutes and industry. This cooperative venture not only signifies a commitment to advancing bioimaging technologies but also demonstrates how strategic alliances can contribute to the flourishing of scientific innovation within educational institutions like ITB.

Yet, regions with limited resources often face substantial resistance towards sharing infrastructure. Resource scarcity understandably engenders a protectionist mindset and fuels the natural tendency to isolate expensive research equipment from general use. Group leaders or departments who receive these investments may fear that sharing equipment will lead to scheduling conflicts, instrument downtime, unexpected repair costs, and potential malfunctions during critical times. This unfortunately perpetuates a culture that restricts shared use of expensive equipment, hindering the creation of common infrastructure that can contribute to broader institutional research efforts. In short, this promotes siloed research resources that go against the spirit of open science.

What is worrisome is how such siloes can derail the very research they are funded to perform. Individual labs, saddled with the prohibitive cost of service contracts for high-end equipment, tend not to have sufficient financial cushion to sustain long-term maintenance. Likewise, the lack of a robust revenue stream, such as user fees, also precludes subsequent instrument upgrades to keep pace with technology development. Buried under these apparent disadvantages, however, are additional – and more pernicious – disadvantages for individual labs in the absence of shared core facilities. First, individual labs are often limited in their capacity to hire an entire staff with all the necessary expertise. This limitation is certainly true in affluent universities and will inevitably be exacerbated in resource-challenged settings. Second, with its increasingly multidisciplinary nature, modern science can no longer be effectively performed in isolation. The concentration of resources in single labs creates intellectual islands rather than synergistic ecosystems necessary for the exchange of ideas, further choking research progress.

The benefits of sharing such precious resources may appear, at first glance, counter-intuitive to a group leader, but the added value is immense. First, by working with the academic leadership, an expert may be hired by the institution to support the operation of an advanced technology without incurring any financial burden on the individual lab. Second, the revenue stream generated through user fees ensures that the instrument can be reasonably maintained and potentially upgraded in the future. Third, a wider user base minimises instrument idle time, thus strengthening the justification for future funding requests. These advantages alone outweigh the requirement to pay user fees on one's 'own' instrument (Table 1).

There are many encouraging signs indicating an increasing awareness within various scientific communities of the added value associated with research infrastructure, especially microscopy core facilities. This is in part driven by rapidly proliferating organisations representing research scientists and microscopy specialists, such as Latin America BioImaging,[23] the African BioImaging Consortium,[37] Middle East/North Africa Bioimaging[38] and India BioImaging.[39] These networks, together with their members, not only send a collective message about the importance of core facilities, but they have each devised strategies of how open-access research infrastructure can be enacted within their communities, and their bottom-up voices are beginning to resonate with their academic leadership.

2 | SUMMARY

All the pitfalls listed thus far could affect funders' missions, institutional ambitions and individual research goals. It should repudiate the notion that only institutions replete with financial largess are in the position to consider building shared research infrastructure. In fact, institutions with limited resources can ill-afford to not consider creating core facilities. It is important to note that the argument has never been about jettisoning investment in individual lab-driven, discovery-based science in favour of supporting capacity-building research infrastructure. In fact, the two fronts work synergistically to propel scientific progress. The central question is whether some of the investment can draw more immediate impactful return if it is channelled into establishing shared core facilities. Both the oft-advocated added value of core facilities championed by many international organisations[1] and the drawbacks mentioned here of not having such shared resources send an unequivocal answer – modern science thrives in a collaborative ecosystem with shared resources.

3 | DISCUSSION

The importance and benefits of shared research infrastructure, especially core facilities, have been so universally and frequently extolled that it warrants a different perspective to gauge their overall impact. We explore the threats to entire national research enterprises in the absence of such infrastructures, particularly when considering research capacity-building efforts in resource-limited settings. It is important to emphasise that the underlying reason for our approach is not to be alarmist, but to counter the common argument that core facilities are a luxury that is beyond the means of lower-income communities.

Although the reasons that core facilities are essential for modern scientific discoveries are numerous and compelling, the unfamiliarity with – and worse yet, the disinclination towards – the idea of creating shared research infrastructure are the result of deeply entrenched cultural and systemic barriers. These obstacles cannot be overcome by simply listing the benefits of such scientific resources. As we have previously alluded,[25,29] to be protective of expensive investments is an instinctive human reaction. Unfortunately, it also leads to the reluctance of many institutions to offer costly instruments on a shared basis, out of fear that such investments will be damaged by less experienced users. This hesitancy is of course further exacerbated by the scarcity of local technical support necessary for timely maintenance and repair. In this paper, we have discussed not only the added value of sharing these expensive research tools, but more importantly the net negatives of not sharing them. It is, indisputably, even more compelling for resource-challenged communities to create core facilities than their more affluent counterparts. In fact, the lack of core facilities is a severe handicap that scientific communities in lower-income countries can ill-afford.

Another, less apparent, barrier to establishing shared research infrastructure in resource-constrained countries is coincidentally an age-old conundrum: should the creation of resources such as core facilities be the responsibility of academic institutions or that of funding organisations? There is unfortunately no standard answer. Indeed, within the more affluent echelons of the world – even across various national funders within a single country – a myriad of solutions to the problem exists. In most cases, the initial motivation for establishing a core facility originates from within an academic institution responding to requests for certain technologies from faculty and staff. However, this is where the approaches bifurcate. A privileged institution can easily invest in such technologies using its own largess, or rapidly raise funds from its donors and alumni. This fundraising approach is especially prevalent among top-tier institutions in the United States. On the other hand, less affluent universities or those with more rigid funding mechanisms may need to rely on external federal funding. Regardless of the funding source, however, these overtly disparate strategies share one important subtext: the institution itself must both be responsive to the needs of its research community, as well as willing and capable of articulating these needs to the appropriate funding sources. While the funding may come from external sources, the motivation and the sense of responsibility to provide shared research facilities must stem from within the institution.

Importantly, larger research infrastructures must involve significant planning – often between academic institutions and governmental organisations, or in direct response to targeted government funding in certain biomedical research areas deemed to be of high national interest. Here we introduce two models for comparison. The National Institutes of Health (NIH), the primary biomedical research funder in the United States, drives research via discipline-specific institutes and centres.[40] The resulting NIH-funded research infrastructures can be remarkably variegated, reflecting wide-ranging federal investment strategies. The scopes of some NIH-funded research resources are predicated on the topics for which they are funded. For instance, the majority of core facilities created by the National Institute of Neurological Disorders and Strokes (NINDS, part of the NIH) centre core grants cannot be used to facilitate research beyond neuroscience. Conversely, similar infrastructure created under the aegis of the National Institute for General Medical Sciences (NIGMS, part of the NIH) can cater to a wider range of utilisation. The European Research Infrastructure Consortium,[41] commonly known as ERIC, is a continental-level funding entity established to facilitate the creation and operation of shared research infrastructures with joint European interests. Similar federally driven approaches can be found from East Asia to the Middle East and from North America to Australia. As varied as these initiatives across the globe are, they send a resounding and unmistakable message – research infrastructure is the backbone of national research interests and must ultimately be the responsibility of the government. In this regard, government funding agencies must be prepared to both deploy top-down initiatives important to national interests and embrace bottom-up communication from academic institutions about how to steer national science, as evident in Nigeria and Uruguay (see Text Box 1). There is significant incentive for funding agencies to establish and continue to support shared research infrastructure for one simple reason: core facilities, as has been repeatedly pointed out here and elsewhere, remain the single most cost-effective and sustainable measure to fuel science, consistently generating the highest return on research investment.

Out of the many arguments that could be made advocating for core facilities, nothing speaks louder than the fact that every nation with highly developed scientific research programs builds shared research infrastructure. The concept of a core facility is not novel but has been in existence for decades as a way to allow scientists to compete more effectively. Core facilities continue to gain rapidly increasing acceptance precisely because they are effective. More importantly, they give scientists in resource-constrained settings the possibility to gain access to technologies too costly to own and operate otherwise. Those who do science in isolation, shunning any suggestion of resource-sharing, will continue to witness the rapidly widening gulf between them and the rest of the scientific world. For decision makers still considering the merits of shared resources and whether the community can afford them, a more salient counterpoint is whether their scientific community can afford the perils of not establishing them.

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