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PERSPECTIVE

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The value of learned societies in the biological sciences: benefits, threats, and futures

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Abstract

Learned societies play a vital role in fostering interactions that are important in scholarly discourse and the advancement of biological sciences. However, they now face threats from declining funding and membership, shifting disciplinary boundaries, changing approaches towards digital communication, and academic marketization. We outline the historical development of these societies and propose ways to sustain them. Key considerations include improving meetings, adapting publishing models, ensuring financial stability, expanding membership, strengthening outreach, and managing increasingly broad remits. Our main aim is to examine how regional learned societies can maintain their roles to support scientific progress and enrich broader society.

Keywords Learned societies, Biological sciences, Scholarly societies

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The social foundations of scientific progress

Humans are social, evolving to thrive in relatively small groups, mostly through face-to-face interactions [1, 2]. Not surprisingly, scholarly advancements also rely on social interactions and groupings [3, 4].

Here we examine learned societies (Table 1), social groupings that have profoundly shaped the world, scholarly and wider (5–13). Although they may vary in focus, from academic to public engagement, and in membership, from 10 to 1000 s (Table 1), learned societies have a common, and admirable, purpose: to encourage and foster the gathering, sharing, and application of knowledge and understanding.

Our synthesis explores the current and future role of those learned societies particularly associated with the biological sciences. Specifically, we focus on academically oriented *regional* societies (Table 1), which we argue are essential and under numerous threats, including lack of funding, reduced membership, the changing nature of disciplines, and the marketization of academia (see the "Threats" section, below). However, where appropriate

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Table 1 Definitions of current learned societies, based on size, directions, and support

Learned societies (also call learned associations, scholarly/academic/intellectual societies, scientific associations/societies, literary/philosophical associations/societies) have a common purpose: to encourage and foster the gathering, sharing, and application of knowledge and understanding. However, they vary widely in size, interests, and support. Here we offer four categories of learned societies, with an emphasis on those in the biological sciences. Of course, these categories are just points along a continuum, but they offer structure, allowing us to evaluate where issues exist and where efforts may be needed to be placed to sustain them
***Global*:** these are pan-global or at least make efforts to be so. There are few, and, in fact, they are not learned societies per se. Instead, they tend to be umbrella institutions, providing support and guidance rather than focusing on a discipline; examples are the *International Science Council* and *UNESCO.* Income streams are generated by memberships (often states rather than individuals) and international support from governments and organizations. We include them here to recognize their existence and importance in facilitating the maintenance of other levels of learned societies but then exclude them from further discussions
***International*:** these are multinational to continental. There are hundreds of these that often arose from continental unity, such as the *European Society for Evolutionary Biology*, or from national societies expanding to become international, such as the *Association for the Sciences of Limnology and Oceanography* (formally the *American Society for Limnology and Oceanography*). Their interests tend to be aligned with academic and higher education pursuits. They have memberships ranging in the hundreds to thousands, hire administrative and support staff, and tend to be financially sound, with income streams generated by memberships, publications, meetings, and occasionally commercial sources
***Regional*:** these may be national, in defined areas of large nations, or mergers of two or more smaller national societies. There are hundreds of these, which may or may not recognize national identity and may be associated with an international parent society, such as *The Norwegian Bioscience Society*, the *Association of Southeastern Biologists* (USA), and the *Australia and New Zealand Society for Cell and Developmental Biology*. Like the international societies, they tend to be aligned with academic and higher education interests. They have memberships ranging in the tens to hundreds, are typically supported by volunteer staff, and rely on memberships and possibly grants for financial support. Rarely do they produce scholarly journals
***Municipal*:** These are associated with towns, cities, and other municipal regions. There are hundreds—possibly thousands—of these. They generally focus on local issues, such as biodiversity of parks, while recognizing international and global concerns, such as climate change. They tend to be less aligned with academic and higher education interests and are not normally of a scholarly nature, often focusing on public engagement and education; examples are the *Edinburgh Natural History Society* and the *Georgia Microscopical Society*. They have memberships in the tens and are mostly supported by volunteer staff, and possibly receive local grants for financial support. They may publish newsletters but not scholarly journals

our examination extends to include smaller *municipal* and larger *international* societies. To understand the benefits of these, Fig. 1 provides an overview of the wide range of roles that societies may play and outlines their relative contributions at three of our defined levels of learned societies (Table 1).

To provide context, we begin with a brief historical overview, "The evolution of learned societies". This builds a foundation for our evaluations of current learned societies, which is based on a review of the literature, including cross-cultural perspectives and cross-field considerations, such as sociology, STEM, and management.

Furthermore, we distinguish between learned and professional societies. Our focus is on the former, which are concerned with scholarship (e.g., the *Royal Society,* the *Académie des sciences,* the *Royal Society of Canada*) rather than the latter, which are more practitioner-oriented, offering additional services such as legal and financial advice, accreditation, and workforce support (e.g., the *Royal Society of Biology,* the *American Association of University Professors,* the *Company of Biologists*)—although there is, of course, overlap between the two types (Fig. 1, [5]).

Finally, we view universities as distinct from learned societies per se. Rather, as the name implies, universities are now universal in their scope. Having originated to educate Medieval priests, European universities began to be more secular in the late Renaissance, and by the mid-1800s most universities across the world were developing into their current state, coupling research with education across many disciplines [6, 7]. Critical to our concerns for the survival of regional learned societies, through our historical overview, we show that although universities and learned societies developed independently, they have become synergistically co-dependent. We then examine why this union is now under threat. Finally, we defend the need for learned societies as independent entities and explore how they may be fostered, with an emphasis on regional ones.

The evolution of learned societies

This brief synthesis provides context for the roles and fate of our current societies. More detailed accounts can be found in [8–13].

Academies

During the *Enlightenment* ca. 1600–1700s academies (e.g., the UK's *Royal Society of London*, 1660; the Netherland's *Koninklijke Hollandsche Maatschappij der Wetenschappen* 1752; the Italian's *Accademia Nazionale delle Scienze*, 1782) formed to obtain and disseminate knowledge across a range of topics. In contrast, at that time, European universities were centers for teaching. The academies were independent bodies—often with exclusive membership—relying on state support as well as membership subscriptions. Academies also published their findings and awarded funding. Then, as universities embraced research and publishing and as funding became available through other sources, such as the state and industry, the role of academies declined. However, the academies, of European origin have had a legacy,

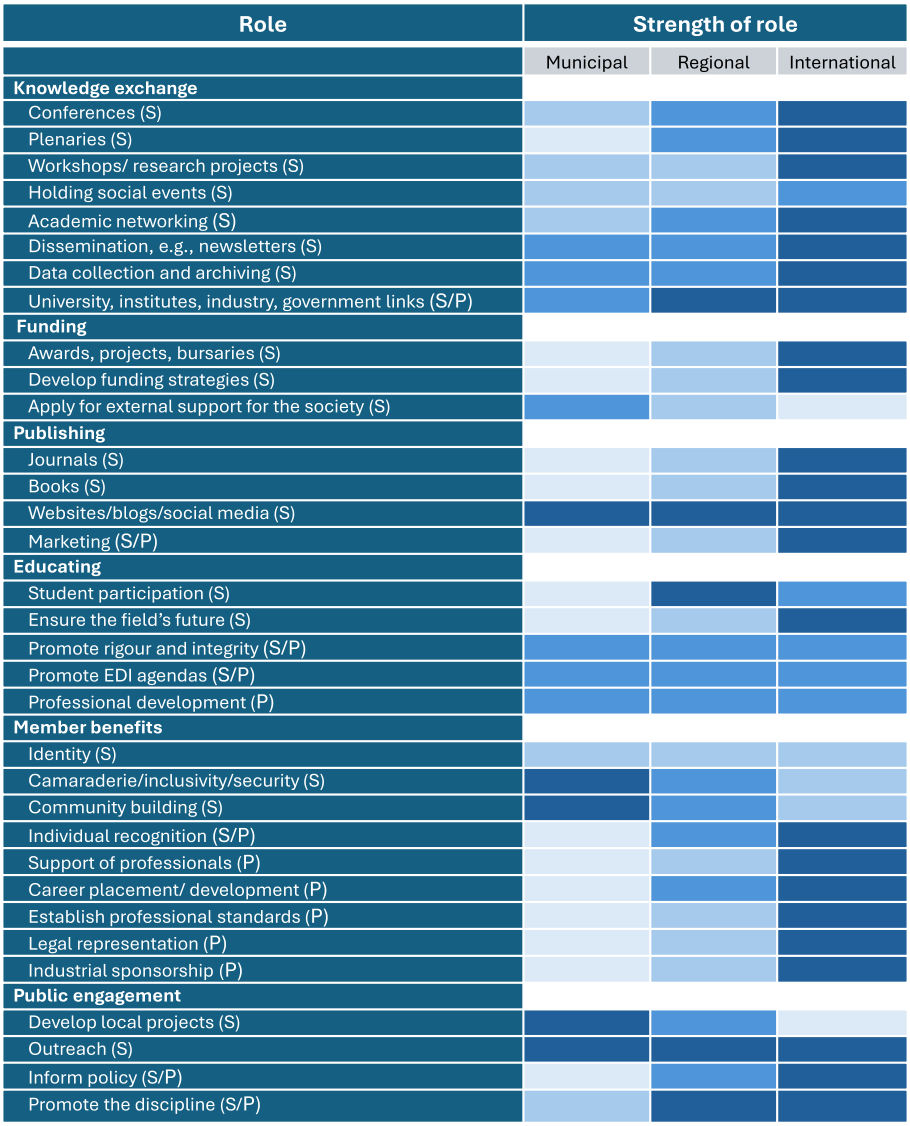

Fig. 1 The roles of three levels of learned societies (Table 1), with an emphasis on those in biological sciences. Tints of blue represent the relative strength of what a society might achieve in terms of impact of a specific role: lighter tints reflect weaker impacts. Although the list of "Roles" arises from a summary of our wide review (i.e., of websites, popular articles, much of the literature cited in this paper, discussions with other academics, and personal experiences of the authors), the tint-scale, associated with "Strength of roles," is qualitative and is based on our observations and interpretations of the wider literature. The societal roles have also been loosely categorized as: scholarly (S); professional (P); and a combination of both (S/P). Note that our ranking schemes are, for illustrative simplicity, divided into discrete categories, recognizing that shades between them are the reality

stimulating the formation of others across the globe, such as the Japanese's *Nihon Gakushiin,* 1879; the *Academia Brasileira de Ciencias, 1916*; and the *Chinese Academy of Science*, 1949.

Literary and philosophical societies

During the Industrial Enlightenment (coinciding with the Industrial Revolution) ca. 1700–1800s, especially in the North of the UK, literary and philosophical societies formed as local and more conversational versions of the larger academies (e.g., the *Manchester Literary and Philosophical Society,* 1781; the *Literary and Philosophical Society of South Carolina*, 1813; the *Berlin Mittwochsgesellschaft, 1863–1944).* Like academies, they were concerned with broad areas of intellectual inquiry but with a more local focus on arts and science, technology, and commerce. They, therefore, might reasonably be viewed as clubs, sometimes exclusive, for intellectual discourse.

But, like the academies, they remained separate from universities, each occupying a distinct niche.

Associations and societies

In tandem with European colonial expansion, an increase in global travel—by the wealthy—during the eighteenth century led to the creation of large collections of natural specimens, both private and public. During the 1800 s and early 1900 s, access to these collections, coupled with an increase in publicly accessible natural history and geological literature, led to greater, general—including those of lower economic means—interest in the natural world; this was especially evident for the Commonwealth Victorians [14]. Such interest became more formalized in the new associations and societies, which were "an integral part of middle-class urban life, a component tool in the fashioning of a sophisticated cultural identity" [15].

These associations and societies shifted from the wider purview of the academies and the literary and philosophical societies to focus on discipline-based areas of intellectual inquiry, such as organisms (*The Zoological Society of London*, 1826; the *Société Botanique de France*, 1854) and technologies (*The Quekett Microscopical Club*, 1865). They were very much part of the urban culture, providing social cohesion and tended to not be scholarly in nature—although their amateur efforts were often exceptional, and they formed strong ties with both museums and universities, with students and staff of the latter contributing to discussions and field work [16]. In fact, parallels can be seen between the newly formed discipline-centered departments of Victorian-age universities (e.g., Zoology, Botany, Geology) and the focus of many societies and associations. From this, we might say that universities and scholarly societies, across the globe, were becoming symbiotically commensal [10].

Learned societies

From the 1900 onwards, evolving from the scholarly societies outlined above, the current learned societies per se arose. These non-profit, inclusive bodies tend to focus on a particular discipline and to be concerned with research and knowledge dissemination. They now range in size and stature (Table 1), from regional (e.g., *Società Italiana di Protistologia*, 1965; Germany's *Deutschsprachige Mykologische Gesellschaft*, 1961; The *Phycological Society of India*, 1962) to international (e.g., the *International Council for the Exploration of the Sea-ICES, 1902*; *Académie Internationale d'Histoire des Sciences*, 1927; the *Microbiology Society*, 1945). However, in the broadest sense learned societies also include municipal-based groups (Table 1) that tend to be more public oriented and, critically, provide understanding of and local engagement with scientific approaches towards environmental issues (e.g., the *Hong Kong Natural History Society*, 1949; Australia's *Bairnsdale & District Field Naturalists Club Inc*, 1960; the UK's *Paisley Natural History Society*, 1968).

In the mid to Late 1900s, learned societies increased in number and stature. This was undoubtedly due to sea changes in the "long-1960s" (mid 50 s–mid 70 s) that saw scholarly pursuits—and specifically the sciences—become a dynamic component of society, rather than the privilege of experts in their ivory towers [17]. Likewise, "groovy science" in the 1970 s increased both global collaborations and an awareness of environmental issues [18], the latter being stimulated by recently popularized concerns, such as the landmark environmental book *Silent Spring* [19].

Amateurs, activists, and academics became more aligned. This 20th Century Renaissance of ideologies was further fostered by the "golden age of prosperity", starting in the 50 s and ending in the early 70 s [20] that allowed more academic freedom—financial- and time-based—to explore new ideas. In turn, this sea change strengthened and shifted the relationship between regional/international learned societies (Table 1) and universities toward mutualistic symbiosis.

Learned societies today

Mutualistic symbiosis

Although the primary motivations of the new discipline-focused learned societies remain knowledge transfer, networking, education, public engagement, and informing policy [21], their remit has widened to include many scholarly and professional roles (Fig. 1). In these ways, learned societies have worked in conjunction with and complemented the missions of universities [6, 9]. Critically, many of the regional and international learned societies have come to depend on universities. That is, almost axiomatically, learned societies, at least those associated with scholarly endeavors, are often founded, led, and populated by university academics and students—filling positions that are volunteer or minimally remunerated—with a smaller proportion of members coming from elsewhere, such as industry, research institutes, museums, and the public [8, 9, 22, 23].

Universities, in kind, rely on regional/international learned societies, which offer numerous benefits: (1) research and travel awards; (2) unbiased advice and peer review services; (3) equality, diversity, and inclusion (EDI) support; (4) training in specialized areas; (5) a neutral forum for connecting government, industry, and higher education; (6) a mechanism for national and international networking and policy making; (7) promotion of multilingualism; (8) subsidy of scholarly publications; (9) hosting academic meetings; and (10) awarding scholarly accolades [22, 24–26]. Universities, recognizing these

benefits, tend (tended) to encourage their staff to engage with learned societies, provide (provided) funds to attend meetings, and expect (expected) to see evidence of membership in learned societies as professional milestones in performance and promotion reviews—why the past tense? See the following discussion of changing attitudes.

Threats

For decades the mutualistic symbiosis between regional/international learned societies and universities remained profitable for both parties, but the survival of the former is now threatened. In an, albeit, slightly dated survey of senior members of biological societies, Musante and Potter [21] identified six major challenges facing these societies: (1) funding issues, such as difficulties obtaining money to support members' participation; (2) maintaining and recruiting members, especially in times of economic instability and job insecurity [27]; (3) journal publication issues, such as the costs and complications arising from changing publication approaches and policies; (4) issues with the public understanding and appreciating a society's interests and aims; (5) the changing nature of the discipline, which includes both the narrowing of fields and the increase in interdisciplinarity, leading to a loss of a society's identity; and (6) challenges associated with defining and maintaining a society's wider identity.

We add four further threats. First, several of the roles of learned societies (Fig. 1) are being replaced by digital services. For instance, there is now less need to rely upon society-based journals (or their meetings) that are dedicated to a single discipline—electronic searches provide cross-journal information [27]. Likewise, communication via social media has led to a perceived lack of need for face-to-face society gatherings, especially as younger members fail to gain—and benefit from—"soft skills" associated with interacting and communicating, which ironically is at least in part due to reduced face-to-face communication [2, 28, 29].

Second, commercial journals run by large multinational businesses now compete with learned society journals by offering pricing and high-throughput advantages. Additionally, so-called "predatory" journals, which mimic legitimate outlets while bypassing rigorous peer review, undermine the quality and integrity of published scholarly works and threaten learned society journals, which are often a source of income for societies [30].

Third, we highlight one important aspect of the "changing nature of the discipline" (point 5, above). Remarkable developments in molecular tools and biotechnology have led to a revision of the remits of societies, and their meetings, to encompass the breadth, strength, and utility of these advances—parallels are seen in university restructurings, where the classic organism-based departments have been replaced by "integrative" ones. For learned societies, this revision is a double-edged sword, as such growth in numbers and breadth in subject matter can cut into the more intimate and focused approach of many "more traditional" learned societies [27].

Fourth, an increase in neoliberal marketization of universities over the last few decades [31, 32] has changed the academic landscape. This marked focus has led to increased staff workloads, pressures imposed by performance metrics, changes in academic values, reduced collegiality, and reduced academic freedom [33–35]. Consequently, academics now have less time to pursue agendas not directly related to the perceived market-driven benefit to their universities [36]—this includes volunteering to administer and actively participate in learned societies.

In the context of the above threats, we next address the fate of learned societies, with an emphasis on what Meyer-Gutbrod [26] refers to as "chapters and affiliates" but which we call regional (Table 1) to include societies not associated with a parent body.

Introspection and the need to adapt

Recognizing the wide roles of learned societies (Fig. 1), we now summarize their benefits (Fig. 2), reflecting on the relative merits at municipal, regional, and international levels (Table 1). Then we explore if there is a need for learned societies—possibly not surprisingly we conclude that there is—and finally, based on issues raised in the "Threats" section (above), we discuss ways in which learned societies might adapt to survive in the face of current change.

Do we need regional learned societies?

Here, we only consider regional and international societies, as both are more scholarly in nature than global or municipal ones (Table 1). Both have evolved over the last four centuries to fill a unique niche, with a diversity of roles and benefits (Figs. 1 and 2). As we have stated, these societies have a common purpose: to encourage and foster the gathering, sharing, and application of knowledge and understanding. In doing so they complement and expand upon the roles of other bodies, not just universities but also governments, industries, and museums. But there is good evidence that learned societies, especially those associated with sciences, can be much more; they promote rational discourse, benefiting society at large, from organizing public outreach events to influencing global policies. Table 2 provides quotes from three studies that we feel best exemplify these benefits—we could not have said it better and encourage reading them.

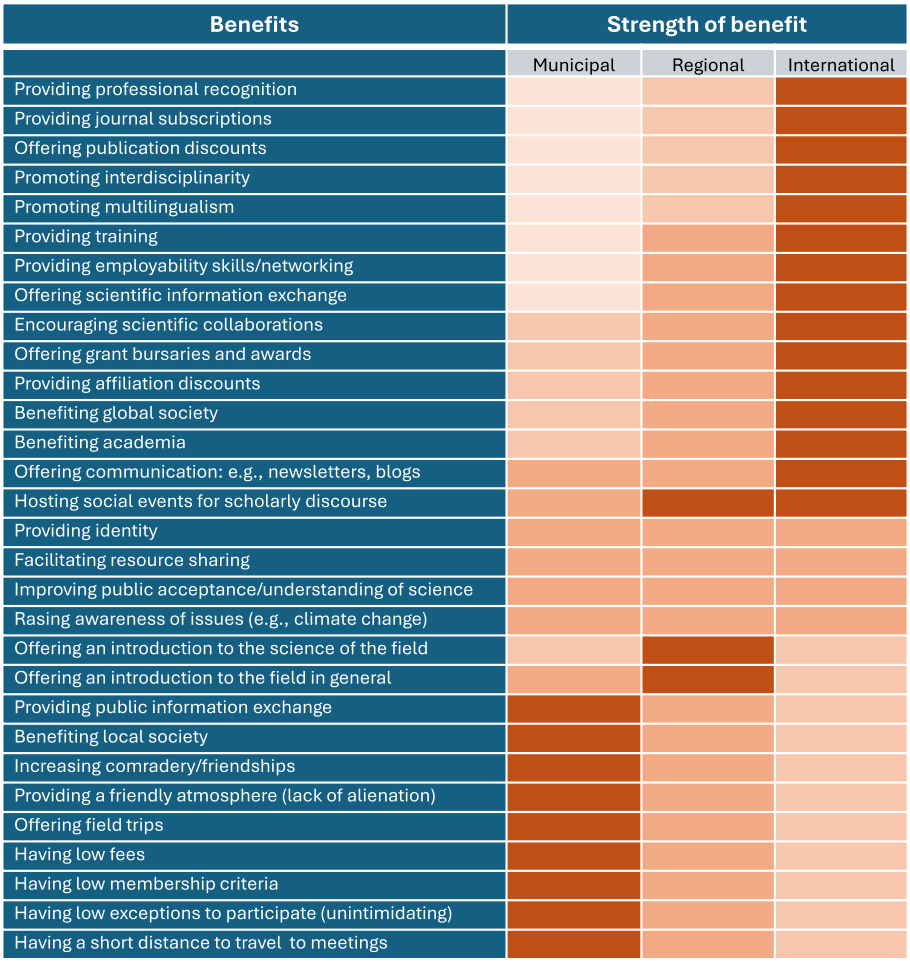

Fig. 2 The benefits of maintaining learned societies, at three levels of learned societies (Table 1). These benefits are a summary of our wide review (of websites, popular articles, much of the literature cited in this paper, discussions with other academics, and personal experiences of the authors); their categorization is qualitative and is mostly based on our observations and interpretations of the wider literature. The relative strength of a benefit is presented as tints of terracotta, with lighter tints reflecting weaker benefits. The discrete levels of the tint-scale are for illustrative simplicity, recognizing that gradations between them are the reality

Table 2 Learned societies benefit society at large

Here are three exemplary quotes from papers that detail the benefits of learned societies, illustrating, in broad terms, that the roles of learned societies extend beyond the gathering, sharing, and application of knowledge and understanding—they also improve local and global civilization
"By fostering international collaborations, scientific societies not only advance scientific knowledge but also bridge different nations and cultures, leading to the improvement and development of societies" [37]
"The IHS < International Headache Society > will intensify efforts to accomplish its mission, to bring science where it is most needed, to reduce disparities, to foster inclusion and ultimately to peacefully, but strongly oppose the consequences of violence, obscurantism, and propaganda" [38]
"We scientists cannot continue to allow society to descend into the nightmarish scenario of being unable to distinguish science from pseudoscience or facts from opinions pedalled by vested interests. A culture of critical thinking needs to be fostered, and scientific societies are part of the answer for achieving this… Scientific societies that calmly and firmly express the collective opinions of experts can more persuasively inform the public and policymakers on specific matters" [27]

To the above ends, virtually all learned societies have four main activities: they *publish*, *educate*, provide *support*, and encourage *group identity* (Fig. 3). The value of the first three is difficult to dispute as the outcomes are quantifiable (e.g., [21, 24, 28]); these activities are also mostly associated with regional and international societies with greater resources (Figs. 1 and 2). In contrast, *identity* and its more recent corollary *inclusivity* are less

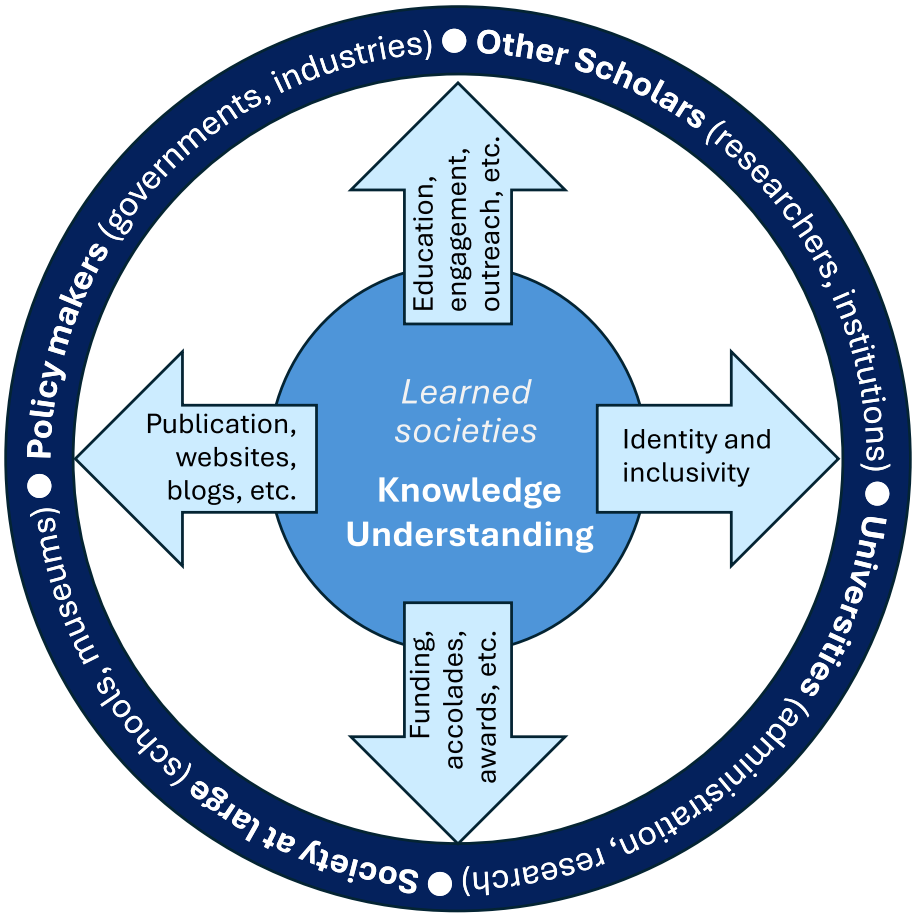

Fig. 3 A visual synthesis of the contributions (arrows) of regional/international learned societies (light blue circle) to end users and collaborators (dark blue ring); to varying degrees all contributions from the societies may aid all end users (i.e., the end users are not associated with specific arrows)

tangible but equally—if not more—important to the future of discipline-based societies (e.g., [25]). Both identity and inclusivity are represented across all three levels of societies but may be of greater benefit in smaller, more intimate, regional ones (Fig. 2).

We now continue to focus on regional societies, which have other essential roles. Firstly, they help to ensure the success of international societies by providing local awareness of and encouraging membership in the parent bodies [26]. In this sense, they parallel "farm" or "feeder" teams in sports that foster the discipline and provide new international players.

Secondly, regional societies replace a tradition that arose in Victorian Britain (although its roots date back to the ancient Greek *symposion*, [39]): the *conversazione* was at the time a social meeting, often focusing on the natural sciences, of urban, middle-class sophisticates (including women) to present, discuss, and exhibit scientific wonders. These conversaziones fostered group identity and provided public education and engagement [15], similar to meetings held by modern regional learned societies. For instance, Delicado et al. [8] have argued that regional (national) learned societies play an important role in wider, national engagement.

> *Whereas the internationalisation of science has moved the communication, collaboration and competition between researchers into the transnational sphere, the links that associations forge between science and other social spheres are still deeply rooted in national settings... [8]*

Thirdly, regional societies fill a gap left by the loss of a more informal set of venues that foster cross-disciplinary group identity: academic tea (or coffee) and common rooms—whether as a cost-cutting measure or to subvert rebellious academic discourse [40, 41], the closure of these university-based rooms has led to academic staff losing a safe space to nurture group identity and inclusivity. The meetings of regional learned societies offer a replacement.

Finally, while meetings held by international societies prioritize large-scale research dissemination and international networking, regional society meetings provide an excellent venue to build and sustain scholarly communities in often less intimidating environments, encouraging collaboration, mentorship, and inclusive participation [42, 43]. In fact, society members tend to "perform better, suffer fewer mental health issues, and remain in active research for longer than non-members" [27].

In summary, there is not only a need to maintain and improve learned societies, but there is currently a pressing need for regional ones to exist. We next explore how to ensure the latter's survival.

Meetings, meetings, meetings… how can we sustain and manage local learned societies as funds become scarce?

Annual meetings are often the greatest expense for learned societies and their members [44]. This is particularly so for regional societies, for which other overheads are relatively low. We, therefore, focus on this main expenditure (but see below, "Publish or perish: how can we ensure the success of learned society publications?").

We are now decades past the academically affluent "golden age of prosperity" [20]. But paradoxically there seems to have been an increase in the cost of meetings, as they have become more opulent [45]. For good reasons less expensive online meetings are now common (see below). However, online meetings are poor at replacing the, often serendipitous, benefits of face-to-face gatherings, including speaker-audience interactions but also informal discussions during coffee, social activities, and conference dinners and outings [46]—there are continued efforts to include online coffee breaks in virtual meetings [47], but the benefits of face-to-face social interactions are arguably irreplaceable [2].

Understanding the need for face-to-face interactions has been formalized by Collins [48], who divides knowledge transfer into *explicit* forms that can be successfully expressed and represents the mainstay of scientific knowledge transfer (e.g., publications, oral presentations, posters) and *tacit* forms that are less tangible. Collins [48] divides tacit knowledge into (1) *relational* that may be explicitly articulated but has not been, such as failing to mention a key, but elusive, step in the methods section of a publication; (2) *collective* that is associated with practices, norms, and values, such as appreciating differences in the way in which questions are asked in scientific meetings, or recognizing the appropriate social setting for informal discussion, such as over meals, beer, or coffee; and (3) *somatic* that is innate behavior, which resists explication; for instance, the ability to be fast and efficient, needed for successful bench-work. Live, face-to-face meetings provide a venue for the transfer of explicit knowledge and all three forms of tacit knowledge.

Recent work shows that even for larger meetings live, face-to-face ones have advantages. While assessing the value of such meetings during the COVID pandemic when they were rare, Collins et al. [49] contrasted two models of scientific communication: the *enculturational* model, which argues that social interactions stimulate progress; and the *algorithmical* model, which argues that meetings simply facilitate information exchange. They conclude that:

> *…conferences and similar gatherings are costly, elitist, and environmentally damaging, but under the enculturational model abandoning them could be disastrous for science, which depends on the development of cross-national trust and mutual agreements through face-to-face interaction and, in turn, disastrous for science's role in democracy [49].*

This sentiment is echoed by others,

> *Conferences are the invisible college made incarnate, the tangible manifestation of the spirit of the academic community. They are an indicator of something bigger: our broader ability to cohere and maintain what we do as a profession. But in that case, as goes the conference, so goes our profession. If scholars collectively cannot figure out how to get conferencing right, what hope is there for our community more broadly? [46]*
>
> *Two hundred years ago, German Romantic philosophers saw this facet <meetings> of learned societies as their most valuable characteristic. Friedrich Jacobi thought that regular social contact among the members of a society made intellectual connections possible that simply could not be achieved through more geographically distant forms of communication. 'Sciences that seemed foreign to one another realize their close and increasing relation; narrowness of perspective disappears,' Jacobi wrote in 1807 (Jacobi 1807, 17). From their beginnings, scientific societies have been, in one way or another, about managing both face-to-face relationships and global, 'virtual' networks of contacts. There is every reason to think that they will remain important even in a world where new virtual forms of communication are proliferating [10].*

Still, in-person meetings are rightly criticized: (1) they can be costly, especially for students and people from less affluent areas; (2) they are often held in attractive but hard-to-access, and hence expensive, venues; (3) their location and venues may discriminate against minorities,

those who have difficulties obtaining visas, disabled people, and those with other travel constraints (e.g., child care); and finally, (4) the carbon footprint, in terms of travel and venue, rightly dissuades many potential attendees [44, 45, 49]. Although we argue for face-to-face meetings, there is a place and need for online meetings, and social interactions should be embedded into them (for tested examples see [47]).

To summarize, live meetings certainly have their pros and cons, and the reader is directed to Etzion et al. [46] for a more general and thorough review of this. And, of course, careful planning of live meetings to reduce the issues associated with them is needed ([44, 45, 47]). However, live meetings are, and should remain, an essential component of the functioning of learned societies, especially for regional ones, as they provide both social and environmental benefits (Figs. 1 and 2).

Publish or perish: how can we ensure the success of learned society publications?

Our focus is on regional societies associated with the biological sciences. These are less likely than international societies to publish their own journals, with some exceptions such as societies in non-English speaking countries that, rightly, publish in their own languages [50]. As a result, we have not provided a detailed discussion on society publications, especially as this has been dealt with elsewhere (e.g., [30, 51–53]).

However, many international learned societies base their business models and support for other activities—including funding regional affiliates—on journal subscription income from members and libraries [54]. Therefore, we briefly raise several concerns about the future of society journals. First, changing business models of publishers and universities is an issue: market consolidation (e.g., mergers of publishing houses); payment for open access (e.g., transformative agreement fees vs individual paper fees); university cost-cutting; and the international political climate all present challenges to journal-based incomes [54, 55]. Second, society journals are often discipline-oriented. Where disciplines are perceived as niche or local, the associated journals may score low on rankings, metric-based or perceived (e.g., impact factors, the UK REF ratings; the Chinese Journal Lists, [54, 56–58]), simply because of the more focused readership. This in turn deters submissions, as academics are often forced to game the system to retain their jobs, gain promotion, and obtain funding by those who overemphasize journal rankings [46, 59, 60]. Finally, learned societies, notably larger ones, are faced with dangers that "predatory and vanity journals" impose on science [30], not the least of which is a loss of an income stream.

How might the above problems be solved? Academics have the power to address this. Foremost, if there is a recognized need to retain society journals, society members must provide support by publishing in them, reviewing for them, and encouraging their university libraries to subscribe to them. A corollary to this is that academics should defend the need for and benefits of independent society journals, including by arguing against the indiscriminate application of rankings to assess author performance and stature [30]. Likewise, societies should work with publishing houses that recognize that the mission of a society journal tends to prioritize reach, access, and promotion of the discipline [61]. A more aggressive stance might be, in some cases, for academics to boycott journals that do not adhere to their standards [62]. Finally, a slightly surprising finding is that societies, including smaller ones, might benefit from exploring recent developments in self-publishing, if they have the means and will to do so [55].

Show me the money: how can we run and maintain regional (non-publishing) learned societies in the current academic climate?

This question is linked to the dwindling availability of finances but also arises due to pressures on academics by the marketization of academia and the associated reduction in their time to volunteer to run societies.

For regional societies, we will discount the possibility of increasing revenue to hire full-time staff, as this seems mostly impractical, although some creative thinking may lead to feasible solutions (Table 3). It is also unlikely that in the foreseeable future universities will become less market-driven or change their policies and approaches that tend to—directly or indirectly—discourage staff engagement with regional societies [34]. Of course, academics can and should encourage university higher management to include learned society participation in their workload models and metrics for advancement (as is being done in some institutions, Anon.), but in the meantime there is a need for immediate solutions; Table 3 offers some options.

Join now: how can we attract and retain new members?

The intellectual and financial health of a learned society benefits from a large membership—both researchers and those following other paths. However, attracting and retaining new members (undergraduates, postgraduates, technicians, postdoctoral fellows, new academic staff, retired academics, teachers) is a challenge [21]. This has been addressed by Humphries et al. [28], who make several recommendations. Here we summarize their guidance: (1) encourage new members to join societal committees, boards, and working groups; (2) develop and

Table 3 Potential income streams, rationalization, and reorganization to support staff at regional learned societies

Here we offer some suggestions to streamline costs for regional learned societies, divided into three categories: feasible, possible, and challenging. Suggestions are both our own and from others [23, 54, 63]
Feasible
• Restructure for efficiency. For instance, this review recognizes several threats (funding, membership, outreach). Societies might organize to have individual committee members address each of these topics, possibly led by students/postdocs
• Obtain volunteers from other sectors. e.g., retired academics, industry, museums
• Increase junior membership (see "Join now: how can we attract and retain new members?"). Empower these members by involving them in the running of the society
• Fund raising events at conferences. For instance, auctions and book sales are sometimes held, but these are unlikely to generate sufficient income to hire staff
• Better advertising. For instance, publicity through institutions, indicating benefits
• Increased engagement. Through meetings, blogs, on-line discussion groups
Possible
• Increase funding agency, government, industrial, or foundation support. This is not dependable
• Increased membership fees and conference rates. Especially as young members are to be encouraged to join and attend, this may be a deterrent and counterproductive
• Parent body support. This is not always available, but if it is should be pursued
Challenging
• Increase publication income. Although practical for prestigious regional societies, the administrative efforts and the low potential market make this unrealistic
• Provide professional income streams. For instance, providing accreditation, editorial services, expert advice. These are possible but require their own staffing and administration in a competitive market and may not be logistically sensible
• Non-scholarly income streams. Selling other services (e.g., car insurance), but this may be unwelcomed

foster online channels of communication including social media, such as blogs—note that we are now a decade older than this recommendation, and it is likely that even "older researchers" already engage this way; (3) establish mentorships for early career members; (4) run professional development programs for early career members; and (5) offer awards targeted specifically at those in financial need. We add to these: make efforts to improve inclusivity, especially by ensuring a welcoming environment for non-experts.

The above recommendations offer means to retain new members, but they fail to attract them in the first place. An obvious mechanism is for existing members to encourage engagement. For instance, supervisors and employers often urge their students and staff to attend meetings. Likewise, many students (undergraduate and postgraduate) obtain jobs in industry, and this too is a possible target. There is, therefore, a need to develop mechanisms that encourage this to happen; recruitment is further addressed below in the section "We are important: how can we increase public and student understanding of our local society's interests?".

Finally, regional societies have an important role to play in international recruitment. Having a more grass-roots foundation, they can aid in engaging new members with the field and the parent society, as the local societies tend to be more introductory, less intimidating, and less costly than their international parent societies (Figs. 1 and 2). The parent society, recognizing this, might then support the satellite societies through discourse on best practice, marketing and communication, awards, and finances [26]—in turn the parent will grow in numbers, stature, finances, and inclusivity.

We are important: how can we increase public and student understanding of and appreciation for regional societies' interests?

Providing public understanding of their discipline(s) has been a fundamental role of learned societies for four centuries, although admittedly it was originally directed towards the elite public [9, 64]. Now there is a recognized need for learned societies—large to small—to engage with all levels of society [27, 65–67].

It is tempting for STEM academics to feel they know how to develop outreach and public engagement activities; after all, most academics are educators, participants in open days, parents of children, and members of the public who have experienced attempts at outreach in one form or another. However, there are good arguments that such anecdotal and personal experiences constitute poor preparation and that academics should take a more methodological approach [68]. The recent literature is rife with examples and evaluations of outreach and engagement activities to learn from; see the following for good overviews: [65–71]. Main messages from these reviews are (1) appreciate and follow the holy trinity of communication: always consider your *audience*, *purpose*, and *means of communication*; (2) treat the exercise as a scholarly activity: conduct a full literature search, write a proposal with aims, collect data on outcomes, evaluate the outcomes, and iteratively improve the approach based on the evaluation; (3) consult and collaborate with experts on the subject, such as engagement scholars; (4) engage with and respect the audience, recognizing what they want/need and what can be learned from them; and (5) do not lecture to the audience; rather, provide interactive learning.

There are, of course, long-term benefits of many aspects of outreach and engagement across all levels of society, and these align with the wider aims of learned societies (Figs. 1, 2, and 3) and with the more recent efforts of universities and funding agencies to be accountable [72]. But our focus is on regional societies, which tend

to rely less on external funding and, therefore, need not justify their existence through engagement and outreach. Still, there is an immediate *purpose* for local societies to engage in outreach: to battle their declining membership ([28], "How can we attract and retain new members?"). A corollary to this is that, until they have the luxury of a healthy membership, regional societies should probably focus on an *audience* composed of people who will potentially join the society, such as undergraduates, postgraduates, academics, other professionals, and retired professionals [28]—this is a very different strategy to that of universities, museums, funding agencies, and international learned societies, which rightly aim outreach and engagement activities across all facets of society.

How regional learned societies might increase membership through outreach and engagement is beyond the scope of this paper, but we offer some general suggestions: (1) academic members could use their universities to encourage engagement in the subject and membership by including material in their syllabus, inviting guest speakers, hosting events, and promoting the society; (2) the society could host events targeted at potential members, such as field days, citizen science projects, workshops, courses, teacher training, and public lectures; (3) the society could partner with local museums, art galleries, schools, and universities, providing mentorship to potential members; and (4) the society could increase exposure using social media, websites, videos, podcasts, and newsletters. To reiterate, the main point is that societies must reach out to potential members wherever possible.

Too big for our boots: how can our discipline-based societies embrace both the narrowing and widening—the growing breadth and depth—of disciplines?

Many disciplines are fragmenting into more highly specialized niches [73]. This is exemplified in microbiology, where research often focuses on individual taxa or clades (e.g., prokaryotes vs. eukaryotes), leading to phylogenetic boundaries [74] and to barriers for the exchange of information between scientists working with different taxa but sharing approaches and objectives. But, of course, microbiology intersects with numerous disciplines—to address such societal and scientific challenges requires a transdisciplinary approach [73].

Microbiology is just one example; there is a wider need for discipline-based learned societies to embrace both depth within sub-disciplines and breadth across disciplines. The challenge is for the societies, especially regional ones, to remain inclusive and incorporate a wide range of cross-disciplinary approaches, while engaging members with specialized interests. Recognizing this dichotomy, Casadevall and Fang [75] offer some suggestions: (1) encourage those who move between fields; (2) welcome outsiders; (3) promote cross-disciplinary interactions; (4) avoid tribalism; (5) articulate a field's dogmas, ensuring understanding of the field's nature; and (6) define a field's important questions.

Along these lines, we suggest, notably at meetings, to (1) encourage plain language that anyone within the organization (or outside it) can appreciate, for instance, avoid the use of acronyms; (2) develop transdisciplinary interactions through activities and sessions with diverse presentations around a central theme; (3) invite members from other fields; and (4) encourage "new" technologies, such as online chats, in live meetings.

However, when the above attempts at inclusivity fail, possibly due to the breadth of the field, it may be sensible to create new societies that can then partner under a larger international umbrella (e.g., *ACLS,* the *American Council of Learned Societies* or *ALLEA,* the *European Federation of Academies of Sciences and Humanities*). Then, sister societies may hold joint meetings to economize and foster transdisciplinarity.

Sustaining the future of learned societies

Current learned societies in the biological sciences (Table 1) have a range of roles (Figs. 1, 2, and 3). Evolving from elitist entities in the 1600 s, learned societies are now mutualistically symbiotic with university-based research and higher education. However, due to a wide and growing range of reasons they are now under threat; this is especially so for regional learned societies (defined in Table 1). We argue strongly for the need for learned societies to exist and flourish, as they encourage and foster the gathering, sharing, and application of knowledge and understanding, while also having wider societal benefits. Recognizing this, we have offered specific guidance and an introduction to the wider literature on (1) maintaining and sustaining regional and international learned societies; (2) obtaining funding; (3) the need for face-to-face meetings; (4) coping with changes in publishing; (5) coping with marketization of higher education; (6) encouraging membership; (7) self-promotion; and (8) adapting to changes in academic disciplines. In short, our aim has been to indicate the mechanisms by which learned societies—with an emphasis on regional ones—may continue to play an important role in scientific and wider society. It is now our individual and collective responsibility to sustain and nurture the important roles of these regional societies.

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Authors' contributions
DJSM conceived the direction of this *Perspective* article. With the help of all the other authors (JD, JRD, VE, RF, EN, ADT), DJSM produced a first draft. Then, through a series of iterations, guided by DJSM, all authors provided constructive criticism, changes, and inputs of a significant nature. DJSM then produced a final draft for submission. After review, revisions were addressed by all authors. In short, this was a joint effort, albeit guided by DJSM.

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