

Self-organizing researcher networks in the plant sciences

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Societal Impact Statement

The next generation of plant scientists must have expertise in a broad range of fields and experimental approaches to overcome the grand challenges of the 21st century. Plant science will play a role in addressing these challenges, for example, our plant scientists must contribute to diverse areas, from plant breeding to ensure robust and resilient crops; to large-scale climate modeling in response to climate change events. Small international networks led by early career scientists can help facilitate the progression of such individuals to leadership roles in the plant sciences and thus can help nurture our next generation of scientific pioneers.

KEYWORDS

botanical gardens, international networks, networking, plant sciences careers, science without borders

The global plant sciences community is extremely well supported by national and international academic societies. Medium to large in scale, these provide a platform for activities such as large conferences, focused workshops, society-run journals, and outreach. Moreover, large societies of this nature command the required gravitas to advise funders and government on strategy and policy. This is combined with hundreds of botanical gardens and herbaria worldwide, which are often closely associated with plant sciences departments at universities or museums, offering a unique platform for science, education, and outreach, including public engagement with research.

Here, we consider recent experiences of the formation of a relatively small and unstructured plant sciences network, which has been allowed to self-organize through the aspirations of early career scientists (graduate students and post-doctoral researchers). Specifically, we consider an unofficial plant sciences partnership that has arisen between the UK (University of Bristol), Japan (Kyoto University), and Germany (Heidelberg University) (Figure 1). This has comprised small conferences and collaborative research work over the past 3 years, rather than a virtual or social

network-based partnership. The partnership has been shaped largely by early career scientists, with academic sponsorship, who have identified the existence of academic overlap with colleagues in other institutions and are using this to conduct mutually-beneficial research.

While it helps to have existing institutional structures in place—such as the historical partnership agreements between Kyoto University and both the University of Bristol and Heidelberg University—networks of this type will undergo a degree of self-selection, with only those of benefit persisting. Unlike large societies with considerable inertia, they also provide scope for immediate and rapid expansion where suitable opportunities exist.

At the center of this network has been a series of multi-institutional workshops, which have been designed, planned, and run by and for early career scientists. The most recent of these was a 3-day meeting at the University of Bristol incorporating oral presentations from 12 Kyoto University early career scientists, 13 from the University of Bristol, 2 from Heidelberg University, and 1 from the University of Zurich, along with a wide-ranging poster session (Figure 2). The workshop also included a career-guidance

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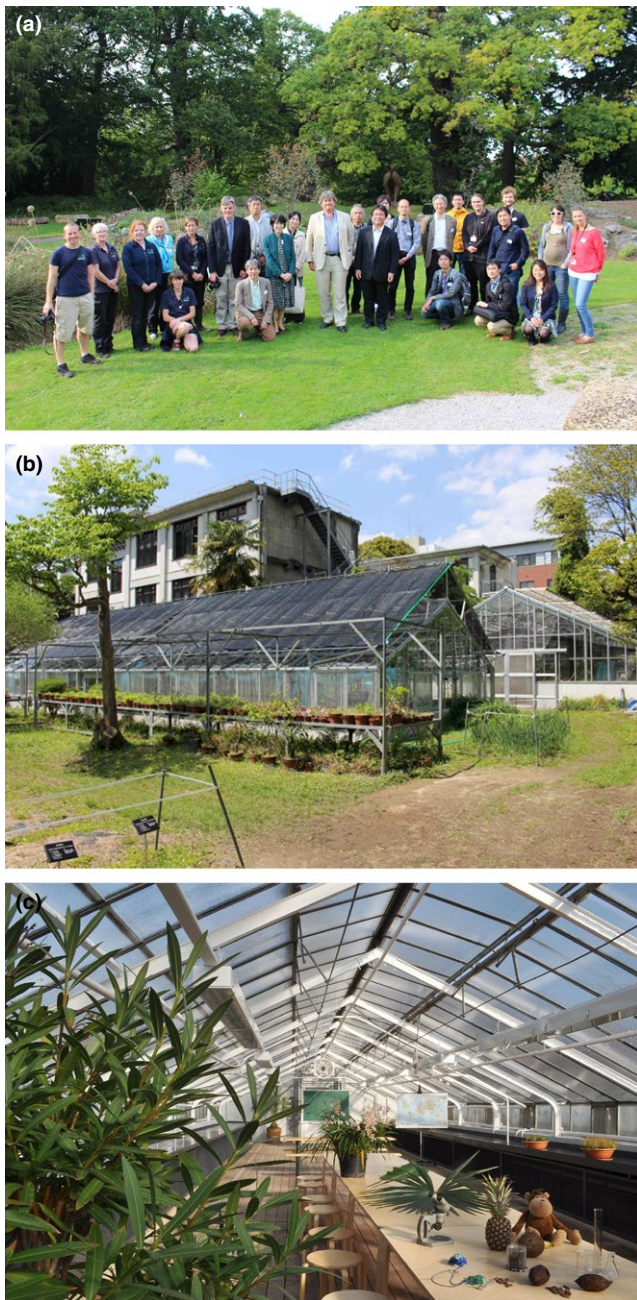


FIGURE 1 (a) Workshop delegates from the University of Bristol and Kyoto University enjoy a tour of the University of Bristol Botanic Garden. (b) Glasshouses at Kyoto University Botanical Gardens. (c) Inside a glasshouse at the Botanical Garden of the University of Heidelberg. Photographs: Antony Dodd, Minoru Tamura and Marcus Koch

talk by a senior academic from Kyoto University and a keynote speaker from the University of Durham, UK. To build a lasting network, the workshop had an informal and sociable botanic garden tour, evening networking/social events, and small group-work facilitated discussion sessions. Several challenges were tackled and surmounted by the organizing committee of PhD students and postdoctoral researchers in order to choreograph this workshop. This included the acquisition of funds to support the workshop—in

this instance, internal University of Bristol and Kyoto University funds, combined with funding from the New Phytologist Trust (<https://www.newphytologist.org/>) for a keynote speaker—which involved the preparation by early career scientists of several funding proposals, with academic mentorship. It was also necessary to assemble a coherent scientific program incorporating considerable disciplinary breadth, ranging from signal transduction to phenology and pollinator ecology to plant taxonomy, which forced an organizing committee of specialists to think about plant sciences in its widest context.

Benefits arising from a network of this nature may persist for long periods of time (Figure 3). Often, scientific networks form from alumni of the same research organization, and the networks arising through conferences can be within individual disciplines. In contrast, this small network developed by early career scientists spans the diversity of plant sciences within a number of institutions and provides a career-developing network with considerable disciplinary breadth. Additionally, coordinating and running a network that incorporates young scientists from diverse disciplinary backgrounds is an excellent way to develop the abilities of graduate students to articulate



FIGURE 2 (a) Representatives of the University of Bristol, Kyoto University, and Heidelberg University during the 2015 multi-institutional Bristol University workshop. (b) Early career scientists gather for a photograph during the Bristol University workshop in 2017. Photographs: Antony Dodd, Ashutosh Sharma and Bhagesh Sachania

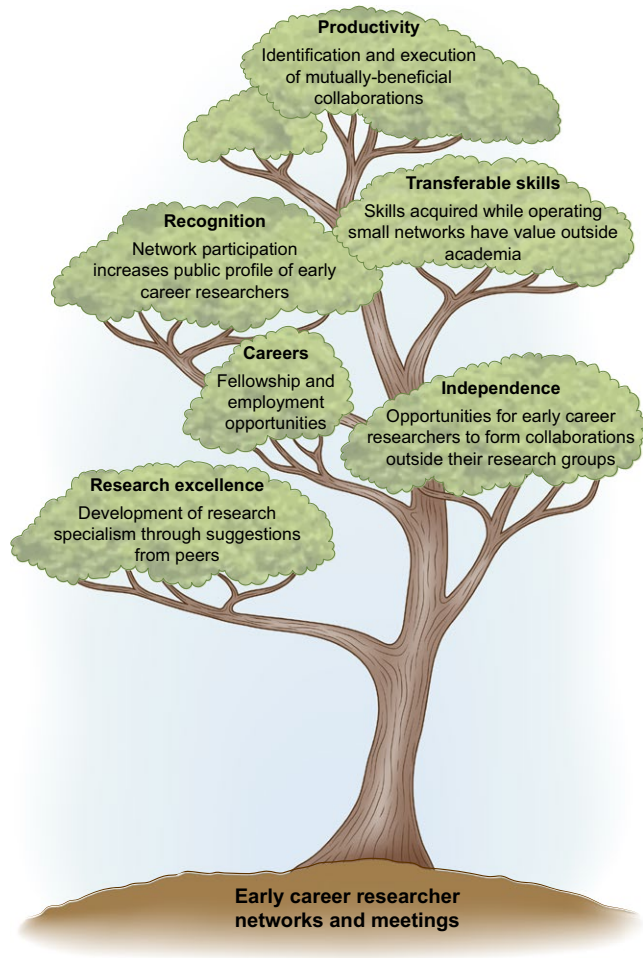


FIGURE 3 Self-organizing researcher networks confer multiple benefits to scientific progress and career development.

and think deeply about their research interests. This is especially important in an age of digital communication, where real, intensive face-to-face discussion about science happens less frequently. A valuable aspect of a network of this nature is that it is less constrained by the broader scientific and educational background of the participants, providing inspiration for novel collaborative research. One example of collaborative research arising from our network has been a funded and ongoing study of cell signaling in natural environments. Another resultant collaboration has involved the transfer between institutions of a method for single-cell imaging, driven by individual experimental visits and one-to-one training between PhD students from Bristol and Kyoto. Moreover, memoranda of understanding have been signed between the botanic gardens of Kyoto University, the University of Bristol and Heidelberg University to provide a framework for the open sharing of resources and information to enhance plant species conservation, biodiversity awareness, and public engagement with plant sciences more generally. In this context, of particular practical importance is the exchange of best practice in working within the Nagoya protocol when sharing a spectrum of genetic resources, from whole plant material to DNA/RNA. This relationship between the three botanic gardens has provided a

framework to study the evolutionary history of relict and endemic UK flora, using the Bristol region of the UK as an experimental model.

We believe it to be particularly timely and beneficial for early career scientists to develop and reinforce international research connections, since scientific research is a pursuit that should operate without borders between nations, disciplines, technologies, and scientific and educational structures. This also reflects our experience of taught graduate programs in institutions within this partnership, because such programs are specialist and provide less scope for breadth and networking. On the one hand, specialization and focus is crucial for graduate students to pass exams and complete original research projects. On the other hand, it is essential that graduate students have the opportunity to develop networks early in their career, so that they can operate with independence from their immediate PhD projects.

Modern plant sciences include a broad range of fields and experimental approaches, and we argue that an overview of many aspects of the discipline is needed to become a pioneer in the field. This is offset against the need for young scientists to specialize to produce the papers needed to develop their career. The type of modest network that we formed can help to balance these demands by combining complementary or attractive interdisciplinary aspects of plant sciences, and eliciting a degree of academic serendipity, rather than being defined by existing strategic or structural frameworks such as the UK doctoral training partnerships. Examples of networks that provide such benefits include small partnerships of the type we describe here, and also larger self-organizing networks such as the N8 Research Partnership (eight research-intensive universities in Northern England, <https://www.n8research.org.uk/>), PhD student conferences supported by the Scandinavian Plant Physiology Society (<http://spps.se/>), and The New Phytologist's "Next Generation Scientists" conference (<https://www.newphytologist.org/nextgenevents>), which is specifically for PhD students and early career post-docs.

A further output from networks of this nature is that the resultant interactions between Principal Investigators provide a basis for large, multicentered project grants. The potential for large international projects of this nature is somewhat limited, yet the European Research Area Network for Coordinating Action in Plant Sciences (ERA-CAPS) (<http://www.eracaps.org/>) and Human Frontier Science Program (<http://www.hfsp.org/>) funding schemes provide a useful resource in this context. It would be extremely welcome for more national funding agencies to contribute to ERA-CAPS, allowing incorporation of additional countries that are major players in plant sciences within this important international funding mechanism.

Networks of this nature are important to support in the long term, because while the administrative burden is limited, research outputs take time to emerge, and funders and institutions can have impatient, short-term perspectives on research activities. Moreover, university management may favor networks that link to substantial financial advantage rather than operate for optimal scientific benefit. While small networks might not contribute

directly to the research outputs of every member of the network, they do enhance graduate students' appreciation of the infinite possibilities that exist within plant sciences. In this way, such networks can create hidden benefits such as career opportunities for students, which may not be immediately quantifiable in terms of publication outputs or grants.

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