Collective action is needed to build a more just science system

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The current science system is unjust – from the systems that determine its membership to its outputs and outcomes. We advocate for contextually responsive, collective action to build a more just science system that demonstrates a relational duty of care to all its participants. To achieve this, we urge the science community to harness the powerful processes of complexity with deliberate intent.

Science has been described as promoting exclusion and oppression by rewardingthosewhopracticeentrenchednorms, including individualism, hypercompetition and productivism, and penalizing those who challenge them¹. Today, these norms permeate the design of scientific institutions and funding – reified in overt hierarchies and short-term funding cycles that disincentivize participatory and collaborative approaches.

The science system picks winners

Harré et al.² describe the science system as one that 'picks winners' through a zero-sum finite game in which it is perceived that for one individual to gain, another must lose. The opportunity to 'win this game' is not equally shared; scientific successes tend to accumulate with individuals and organizations who are structurally and socially advantaged³. People who experience relatively few intersecting forms of marginalization remain uniquely privileged and visible in science, including in promotions, grant success, pay and publication rates⁴. Meanwhile, demographically underrepresented researchers remain undervalued and underrewarded⁵. These intersecting patterns of privilege and marginalization are wielded or experienced (knowingly or unknowingly) by all who participate.

Enabling broader societal participation in the science system does not only matter from an egalitarian perspective; collaborative knowledge creation is urgently needed to address the complex global challenges that humanity faces⁶. Here, we assert that collective action is also necessary to transform our science system and that complexity theory could help to achieve this.

'Solutions' can have unintended consequences

Scientific institutions are increasingly engaged in structural reform, including policies and practices intended to improve diversity, equity and inclusivity. Depending on how they are defined and enacted, these

initiatives have the potential to hold unethical behaviours such as discrimination and bullying to account, and to support diverse and everyday forms of care, resistance and reworking. Yet accountability and context are often neglected during their conception and implementation and, as a result, many diversity, equity and inclusivity initiatives disguise or deepen inequities⁷.

When implemented as standalone solutions, even the most well-intended initiatives can drive perverse outcomes. In 2005, the Athena Scientific Women's Academic Network (SWAN) Charter was established to increase the representation, progression and success of women in science, technology, engineering, mathematics and medicine. Organizations who signed up were expected to adopt ten key principles, develop an action plan and apply for awards that conferred accredited status. From 2011, Athena SWAN accreditation allowed organizations to apply for ring-fenced government funding. Early iterations of the charter were criticized for a binary focus on gender and lack of attention to intersectionality, whereas today's expanded Athena SWAN scheme addresses issues of equity more broadly. Despite its promise, the charter is still too often implemented in ways that are perceived as 'box-ticking' and that lead to women - particularly those from other underrepresented and marginalized groups - taking on the bureaucratic and administrative heavy lifting, sometimes at the expense of their careers and wellbeing⁸.

In Aotearoa-New Zealand, the 'Vision Mātauranga' policy framework was developed by the former Ministry of Research, Science and Technology to recognize and support the 'unlocking of the innovative potential of Māori [Indigenous peoples of Aotearoa-New Zealand] for the benefit of all New Zealand'. To help to achieve this, the framework provides strategic direction for funding decisions on research of relevance to Maori across four broad themes (economic growth, environmental sustainability, health and social well-being, and Indigenous knowledge). Although Vision Mātauranga has made critical steps towards its original purpose, its primary author Te Ahukaramū Charles Royal notes it has 'not had the amount of activity, inspiration or spirit ... initially envisioned', owing to patchy implementation across the national research system and a lack of strong incentives. The mismatch between the aspirations of Vision Matauranga and the realities of the wider system result in scientific and cultural 'double shifts', most often borne by Māori researchers9.

Embracing complexity

When birds flock together for flight, they move from an individual state to an ordered group, easing their collective journey (Fig. 1a). The flock represents an emergent state that arises from the behaviours of individuals acting in interconnected ways. This emergence is one of several critical features that distinguish complex from simple systems.



'Policies' denotes government, institutional and organizational rules, regulations and priorities that guide the entity's own and others' actions

'Practices' are the espoused activities of institutions, coalitions, networks and other entities that are targeted to improving social and enviormental progress. Also, within the entity, this refers to the procedures, guidelines or informed shared habits that comprise its work

'Resources' refers to how money, people, knowledge, information and other assets (such as infrastructure) are allocated and distributed

'Relationships and networks' describes the quality of connections and communication that occur among actors in the system, especially among those with differing histories and viewpoints

'Power dynamics' is the distribution of decision-making power, authority and both formal and informal influence among individuals and organizations

'Mental modes' are habits of thought — deeply held beliefs and assumptions and taken-for-granted ways of operating that influence how we think, what we do and how we talk

Fig. 1 | **Complex systems and six conditions of change. a**, The ordering of birds into a flock is an example of a complex system. Triangles represent actors (for example, individuals, communities or institutions). The actors on the left are homogenous, disconnected and unable to effectively respond to interventions. The actors on the right are connected to one another; their ability to receive and respond to feedback enables rapid transitions to an ordered and collective state, such as birds flying in a shared direction of travel. In the flock example, regular switches between leading and trailing positions also share and reduce the overall energetic cost of flight. Image courtesy of Jo Bailey. b, An adaptation of the six conditions of systems change, translated into Māori by M. Kirby (Ngāti Whakaue) for Healthy Families Rotorua. This heuristic identifies six conditions required for sustained and equitable change in complex systems. Adapted from 'The Water of Systems Change' FSG, by John Kania, Mark Kramer, and Peter Senge, 2018.

Complex systems may also exhibit sensitivity to initial conditions (that is, path dependence), nestedness, nonlinearity, feedback loops and critical transitions, such as the moment birds assemble into a flock.

Like a flock of birds, the science system is relational and dynamic with emergent potential: an assemblage of people, places, knowledge and other heterogeneous entities, whose combined interactions are understood in relation to each other; and with an effect that is more than the sum of each part¹⁰. This was a feature of Aotearoa–New Zea-land's response to COVID-19. In the absence of formal advisory bodies, networks of researchers leveraged trusted relationships with policy-makers and Māori communities to support a rapid and coordinated response. The response was widely considered a success by social, health and economic measures¹¹.

These emergent qualities, and other features such as pathdependence, emphasize the importance of recognizing and engaging with complexity in deliberate and care-full ways. Complexity theory offers one way to understand barriers (and clues) to systems change, including why intervening only at specific points (as with Athena SWAN and Vision Mātauranga) can generate unforeseen consequences.

In Aotearoa–New Zealand, our health system has also been unsuccessfully grappling with how to address long-standing and increasing inequities. Although these emergent outcomes have been known for decades, and despite targeted policy and resources, our underlying health systems – and thus trajectories of community health and well-being – remain largely unchanged¹².

The whole-of-community systems approach (Fig. 1b) taken by Healthy Families NZ has been described as a game changer in its most recent evaluation report. The initiative makes a strategic move away from fragmented, small-scale and time-limited programmes by supporting existing local action on health, while influencing local and national funding and policies to be more responsive to communities and their diverse contexts (Box 1). Sharing success and failures across the community teams has been key to the initiative's success, along with fostering a responsive, timely and trusting contractual relationship with the central agency funder.

Towards systems change

To realize a science system that demonstrates a relational duty of care to all its participants – including those on the margins, in precarious positions and in support roles – systematic, collaborative and whole-of-community action is needed. We advocate for action that is responsive to diverse geopolitical, cultural and temporal contexts, made global by a shared ethical orientation and mobilization towards a science system that enables individual, collective and scholarly flourishing¹³.

We see promise in five interconnected pathways, with each intersecting with most or all six conditions of systems change (Fig. 1b):

How we act. We encourage scientific communities and organizations to identify their shared values and uphold contextually responsive ethical and professional principles. For instance, our approach to research at Te Pūnaha Matatini (a Centre of Research Excellence in Aotearoa-New Zealand) is guided by four principles, which are expressed through a Māori lens. *Pono*, or a commitment to truth and genuineness, provides the foundation principle to guide both the purpose and practice of our research, and thereby frames the following: *tika* is to undertake research in ways that are just or right for a given context; and *tapu* is to do so in ways that recognize the intrinsic value, and rights, of every person and thing. *Manaakitanga* is to do so in ways that enhance reciprocal relationships of care.

nature human behaviour

How we lead. We encourage a shift towards models of mentorship, learning and respectful collaboration that demonstrate reciprocity and engender trust. Research communities such as Te Pūnaha Matatini offer pathways to pursue relational models in which everyone has something to gain and to give; here, mentoring and advisory roles are built into projects to foster growth into research leadership, with early-career members supported to lead research clusters and applications for seed funding.

How we resource. We support funding models that provide long-term support and equitable access to funding opportunities (for example, as signalled by Canada's Tri-Agency EDI Action Plan). For example, high-trust, flexible contracting and meaningful investment into relationship building, codesign and growing capability will better enable sustained participatory and transdisciplinary work.

How we evaluate others. Many institutions and funding schemes – even those designed to address complex intergenerational challenges – still rely on narrow market-based metrics such as publication productivity and journal impact factor to evaluate 'excellence'. We support the San Francisco Declaration on Research Assessment (DORA), which promotes practical, robust and community-driven approaches to research evaluation¹⁴. DORA's recommendations have informed NSERC Canada's recent guidelines and the widespread introduction of narrative-style CVs, including in Aotearoa–New Zealand. Initiatives such as these can be used to recognize and affirm diverse expertise, societal impact and care work (such as equity work, mentorship, teaching and peer support) in promotions, hiring and funding decisions.

How we evaluate ourselves. We encourage reflexivity when performing relational duties of care. We urge scientific communities, organizations and funding bodies to recognize diverse histories; to investigate how funding and authority are distributed; to attend to qualitative and quantitative data¹⁵ about why people enter, leave and remain in the science system; and to evaluate and adapt policies accordingly. In general, ongoing reflection on how we are situated in relation to others in the science community – including the purpose and consequences of our work – will help to navigate real-world complexity in ways that are consistent with our principles, and which support the messy work of 'getting along' in just ways.

Our challenge

Kia mau tau ki tēnā Kia mau ki te kawau mārō Whanake ake! Whanake ake! Stick to that, the straight-flying cormorant! -Maniapoto

The leading *kawau* (cormorant) extends its neck forward as it flies, knowing that when it tires another will move forward into its place. Maniapoto, ancestor of the people of Ngāti Maniapoto, translated this phenomenon into an effective military strategy based on coordinated, collective action: *te kawau mārō*.

To be responsive to the critical challenges of our time, the global science community needs to travel forward in a shared and purposeful direction – one that moves us closer to a better, more just society. We challenge the science community to harness the processes of complexity with intent and urgency to build a science system that is prepared to address the complex global challenges in which we all have a stake.

BOX 1

A multi-community system-change health and well-being initiative

First implemented in late 2014 and now established in 11 communities across Aotearoa–New Zealand, Healthy Families NZ aims to improve people's health where they live, learn, work and play. To achieve this, the initiative uses whole-of-community approaches that make sustainable and long-term changes to the systems that influence the well-being of individuals, families and communities. Teams are located in various organizations, including local councils, Māori health providers, Pacific social change organizations and sports trusts.

The teams have engendered systems thinking and action through participatory and codesign techniques within their communities, drawing strongly from approaches grounded in Māori worldviews and using the 'Six Conditions for System Change' as a valued tool (Fig. 1b). Their approaches broadly focus on shifting mindsets, strengthening relationships, identifying power and valuing local practices. For example, the teams are:

- Amplifying local voices in decision-making
- Making use of evidence within diverse local contexts
- Making tangible built and natural environmental change
- Using reflective evaluation tools to improve their own practices
- Making collaborations for health and well-being intentional
- Leveraging resources for collective health goals
- Advocating for better local and national health policy, and
- Building collective community agency

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Published online: 8 June 2023

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Acknowledgements

We are grateful to Te Pūnaha Matatini executive team and the co-founders of the Kindness in Science Collective, including K. Hannah and D. Hikuroa, for their support and foresight. We warmly acknowledge our colleagues engaged in Kindness in Science, past, present and future. We thank T. Baisden for early conversations about complexity and the research system. We thank J. Bailey for her original illustration from which Fig. 1a is adapted. We thank Healthy Families Rotorua and J. Kaka-Scott for their assistance with Fig. 1b, and M. Kirby for providing te reo Māori translations of the six conditions. We are also grateful to M. Tadaki for kind and insightful feedback on an early version of the manuscript.

Competing interests

The authors declare no competing interests.