Kia ora,

I am primarily interested in and will address here **Question 17: How do we support sustainable, efficient and enabling investment in research infrastructure?** I also have brief comments on Questions 1 and 9 at the end. I've included a brief science 'mihi' at the end to give context to where my perspectives come from.

Access to world-class research infrastructure is essential for the quality and competitive of New Zealand science and how this is managed and supported is critical for the results the infrastructure delivers for New Zealand.

I write this contribution as an individual who leads an infrastructure at AgResearch (metabolomics) and has led university infrastructure and been a part of wider national infrastructures in Sweden, as well as being a user of other laboratory infrastructures. My thoughts are based on my own experience and observations as well as discussion with others.

There needs to be a clear infrastructure culture towards collaboration and supporting science for New Zealand

Culture plays an important role in any organisation and infrastructure at the macro (NZ science infrastructure) and micro (an individual lab providing or hosting scientific equipment as part of an infrastructure). This culture should focus on enabling collaboration across different parts of NZ science infrastructure and wider science collaboration, for the benefit of strong science outcomes for New Zealand.

Infrastructure should be science outcome focused, rather than focused on running samples or projects

Science infrastructure is not the same as fee-per-sample analyses and cannot use the same KPIs. Science infrastructure needs an integrated team approach to get value from research projects to make sure that not just samples are measured, but appropriate sample types and numbers are used, and follow up data analysis and interpretation support are available. A request to use a part of the infrastructure should trigger a wider team to support that request from idea through to science output.

I have observed many times people requesting analyses, getting data at great expense, and then returning and expecting to have the data interpreted and paper written. And when this is not possible, being very disappointed. At AgResearch Metabolomics, due to this phenomenon, we will not provide people with just data without a clear plan on data analysis.

Infrastructures run by active scientists, not as core facilities

Related to the focus on science outcomes, infrastructures do not work optimally if set up as 'core facilities', especially for analyses where there is a lot of specialist knowledge involved and people engaging with the infrastructure may not be experts themselves. Neither do they work well when they are run within the lab of a particular science team as there is a risk that they are operated as de facto fiefdoms to serve the interest of the host scientist(s) rather than providing a service that supports science as a whole.

A better balance is to have scientists who are experts in the area of the infrastructure who are affiliated with the infrastructure and part funded by the infrastructure, but maintain an active research profile. We have a hybrid system similar to this within AgResearch Metabolomics, though I note that the pain point is that there is an issue in being able to translate results across extremely diverse fields. We may do work on soil one day, milk another, and human faecal material the next. Providing biological interpretation of the data is complex for one person and becomes a bottleneck. This is where being able to use pooled expertise to help bring the best team together to solve a science question will be far more effective than a limited number of people generating data but struggling to keep up with the follow up questions ('nice, but what do we do with it?'). I have both observed and experienced this in my work with academic and national infrastructures in Sweden, and if not addressed can lead to poor satisfaction on all sides. In general it is much faster to acquire and process data than it is to analyse and interpret it, and infrastructures need to be set up to reflect this.

Counter geographic spread by frequent meetings of infrastructure teams and networks and building in user travel into the cost of running a national infrastructure

One of the major pain points of developing national science infrastructure that should serve all, is that it will be spread across our two main islands. There are real issues with this in that people tend to think that if a piece of equipment is not close to them, then it is not available. We have encountered this at AgResearch, and work hard to counter this. One strategy that has worked is to make sure that students and other users are and feel welcome to come and run samples for a few days or weeks. It is a mindset change, but people who have done this appreciate the ability to do so as it gives them hands on experience and interpersonal connection with those working with the infrastructure.

In some cases there may be related instrumentation spread across the country (metabolomics is one such example where there are various CRI labs using the title 'metabolomics' in Auckland, Hamilton, Palmerston North and Lincoln). Centralisation has its advantages, but also means upheaval for those currently working with distributed infrastructure. There is a need for common infrastructures to have common systems and ways of working and this should be achieved by regular and close working contact with those working at different sites. This is something less challenging after Covid-19, though having regular face to face contact across sites is still essential.

Whether an infrastructure or 'capability' should be centralised or not will depend on what already exists, but every effort should be made to ensure that distance is not a limitation for someone wanting to use the infrastructure.

Networks for integrated science projects

Using the example of metabolomics, often we will be just part of the overall scientific puzzle – in this case usually trying to understand biological systems. There should be an overall infrastructure network focused on systems biology, with experts/leaders in e.g. bioinformatics, eResearch, statistics, genomics, proteomics and metabolomics. Then within each of these sub infrastructures there are networks and teams who are focused on one area, but with the goal that there is clear sharing of information so that if someone approaches metabolomics for analysis, their project can be assessed for other needs to tailor the right team to give the greatest chance for a good scientific outcome. Again, the system should be set up to enable science outcomes rather than pushing samples and projects through.

Teaching and extension work

An important part of one of the national infrastructures I was involved in in Sweden was roadtrips to different universities to showcase what could be done within the infrastructure and to encourage engagement. These really didn't seem to work that well in terms of bringing new scientists onboard and it was usually the same scientists using the infrastructure (and who were often already involved in the infrastructure organisation). My observation was that this was often due to a lack of time and/or interest from individual researchers at universities, and it was possibly seen as a one-way communication exercise. 'Come and use the national infrastructure. We don't know much about what you do and what you want to do, but come and use us anyway!'

For national infrastructure to be effective, there needs to be widespread knowledge that it exists and that it is open for use by the science (and wider) community. There are likely several ways of doing this, and I can give two examples here: teaching and studentships.

National infrastructures must play an active role in university teaching. This will bring in personal engagement with lecturers who can then be advocates for using infrastructure, and students who will become aware (especially if they have lectures from several different parts of the national science infrastructure) of what is possible.

Funding needs to be available to allow students to work at the infrastructures. As part of PhD programmes and e.g. summer studentships. This should include funding for travel and accommodation. There should be no financial problem for a student in Auckland to spend a couple of weeks in Invermay helping to prepare their samples for genetics analysis. And this will be a lot more cost effective than duplication of instrumentation and staff across several sites in New Zealand.

How should a national research infrastructure be financially sustainable?

We need to acknowledge that we already have substantial investments in science infrastructure spread across CRIs (as well as Universities, though they are not the main focus at this point), and having nationally coordinated science infrastructure will not necessarily cost more than now, and could, given efficiencies in systems, have even more science impact for present funding. Possibly based on my own CRI experience, there are no unified systems for deciding when equipment should be replaced, and the process for getting approval for replacement instrumentation is time consuming and inefficient. There are many different systems for sample tracking and storage (if they exist at all) and there is major scope for time efficiencies by standardising tools and systems across a national infrastructure. This is not without its issues, but an overall goal of seamless tracking of samples and data from creating sample lists through to backup and storage on eResearch infrastructure is possible. As is tracking of when instrumentation is due to be replaced and how well utilised it is.

How much science analyses should be subsidised vs paying the true cost is possibly beyond what I have aimed to answer, beyond that trying to provide a cheap service is often a disservice if it cannot also provide the support needed to achieve science outcomes. At AgResearch we are considered to be quite expensive, but relative to the private sector (overseas) we are still competitive.

Whatever the financial system, there does need to be scope to grow in terms of instrumentation and staff, though also for assessment of what sort of science infrastructure is needed (including whether it has become obsolete or has a very low NZ user base).

Innovation within the infrastructure

There must be a clear mandate within the infrastructure for innovation and improvement. Science is moving all the time and there is a risk that if infrastructure gets focused on delivery only, that both instrumentation and people will no longer be able to deliver world standard results. There should also be scope in some areas of the infrastructure for there to be a clear mandate that New Zealand should be world leading, and funding to match that mandate. This will also make the infrastructure more attractive for staff and improve sustainability of staff through lower turnover.

Infrastructure commitments to Māori

While inclusivity is implicit in the role of a national infrastructure, there should be scope for specialist 'Māori measurement' infrastructure to put tikanga Māori concepts for measurement into practice both using traditional tools and through use of the very latest instrumentation available in New Zealand. An example could be building on ways of assessing environment. This from my own thinking is still quite immature, but based on korero with Māori steeped in mātauranga, there could be good scope to include this as part of a national science infrastructure.

Summary:

We have an opportunity to create a strong NZ science infrastructure that supports great science outcomes. This science infrastructure should become a hotbed of collaboration and innovation support, acting as an engine that enables science. To do this, an infrastructure will need to have a culture of collaboration and support, as well as realistic funding levels. Teaching and supporting students will provide long-term sustainability and with time increase the level of expectation around what science is possible in New Zealand.

Notes in relation to other questions:

1. *What principles could be used to determine the scope and focus of research priorities?*

An observation from the Covid-19 epidemic science response was the disconnect between the Ministry of Health and MBIE. It seems somewhat incongruous that there is apparently little connection between health research and other research. Especially when there is a large amount of overlap in infrastructure and skills.

As principles for scope are discussed and developed, there needs to be strong consideration on how health research can be integrated with other research, especially in 'border' areas such as nutrition.

9. How do we design collaborative, adaptive and agile research institutions that will serve our current and future needs?

The Netherlands is often held up as an example of excellent collaboration between industry, government research and universities. My personal experience working with Dutch people is that they all seem to know each other as there is a seeming roundabout between industry, TNO and the universities, no doubt helped by the relatively small geographic distances involved. However this was not achieved organically. Government stated that funding would only be given if there was clear and real collaboration between industry and academia and there was much wailing and rendering of garments. NZ industry does need a kick to up its R&D game relative to e.g. Europe, if we are to meet government goals of greater export revenue with lower emissions. Having people who have deep experience on both 'sides' will be a major help as research systems that are agile enough to keep up with ever changing industry needs.

This to some extent also addresses question 13.

Science mihi – my background science culture which colours my view on how New Zealand science infrastructure could operate.

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- Main research areas: food and nutrition, metabolomics, analytical chemistry as a tool to advance research, systems biology
- BSc(Hons) Lincoln University (Food and Nutritional Biochemistry)
- PhD Swedish University of Agricultural Sciences (Food Chemistry)
- Post docs at Uppsala University, Sweden and Nestlé Research Centre, Switzerland
- Senior scientist at Nestlé Research Centre, Switzerland
- Assistant Professor and Associate Professor at Chalmers University of Technology, Sweden
- Senior scientist and metabolomics platform lead at AgResearch
- I have worked in industry (Nestlé Research Centre), academia (Chalmers University of Technology, Sweden) and government (AgResearch)
- I have led lab infrastructure in Sweden, including incorporation with national infrastructures in metabolomics and proteomics, and lead lab infrastructure in New Zealand (AgResearch Metabolomics)
- I have worked hands on with analytical chemistry for 23 years.
- I have published over 90 peer reviewed papers and reviews, H-index: 35