Submission
2016 National Research Infrastructure Roadmap
Capability Issues Paper

Name	Dr John Hooper
Title/role	Head of Biodiversity & Geosciences Program
Organisation	Queensland Museum

Questions

Question 1: Are there other capability areas that should be considered?

No, the listed capabilities are logical focus areas. The Queensland Museum relies heavily on and therefore fully supports other NCRIS facilities for some of our scientific research activities, including but not restricted to the Atlas of Living Australia, the Australian Synchrotron, the Australian Microscopy and Microanalysis Research Facility, AuScope, Bioplatforms Australia, and the Integrated Marine Observing System, as well as other national infrastructure such as the National Sea Simulator at AIMS and the Marine National Facility RV "Investigator" at CSIRO.

Question 2: Are these governance characteristics appropriate and are there other factors that should be considered for optimal governance for national research infrastructure.

Yes. The governance characteristics should also include broader research infrastructure investment across the Australian research environment that undertakes public good as well as business/ private research outside the non-university sector, recognising in particular the unique role of the museums and herbaria in the various state, territory and commonwealth jurisdictions that hold the nationally distributed natural history collections of Australia. That is, the data associated with collections are recognised as nationally significant (as evidenced by the continued innovation, service delivery and community uptake of the ALA outputs), but the collections themselves lack significant or coordinated infrastructure support as Australia's distributed collection of natural history. The Council of Australian Museum Directors (CAMD), Council of Heads of Australian Faunal Collections (CHAFC), Council of Heads of Australian Herbaria (CHAH), Council of Heads of Australian Botanic Gardens (CHABG), the various Departments of Environment and the CSIRO National Research Collections do not necessarily have a coordinated, and certainly not proportional resources compared to collection holdings, to hold up an infrastructure plan as the *defacto* Australian National Museums of Natural History.

Question 3: Should national research infrastructure investment assist with access to international facilities?

Yes. 50% of research conducted in Australia (based on publications) involves international collaboration, which while above the global average, is below the metric for most science and innovation-leading economies. Australia should

strategically invest in research infrastructure in which it is globally – or near to globally – leading and strategically seek access to international infrastructure to supplement this effort for private and public research. The European SYNTHESYS Programme, facilitating mobility of researchers and scientific collections, is one such model.

These issues include the few and uncoordinated resources available to enable Australian researchers' access to international facilities and infrastructure (including the *ex situ* collections of Australasian fauna and flora held by museums and herbaria worldwide, particularly the British, French and Dutch ex-colonial flagship institutions that hold the majority of our type material); technical, technology and student exchanges (such as the Marie Curie Outgoing Fellowships); and greater mobility for researchers to attend international meetings or serve on international committees.

To some extent the Australian scientific community is highly disadvantaged and the potential benefits of international collaborations are not realised due to our physical isolation. The Australian Academy of Science's International Exchanges programs are effective and productive, but are inadequate to foster continued or longer-term international collaborations that require more than one or few physical staff exchanges. The Australian Government is the most appropriate and effective facilitator to improve coordination and better mobility to international infrastructure through government-to-government agreements, rather than (or in addition to) local and institutional agreements.

Question 4: What are the conditions or scenarios where access to international facilities should be prioritised over developing national facilities?

There are a number of logical instances:

1) Where the investment or circumstances required to develop the infrastructure domestically are beyond the resources of the Australian Government (e.g., CERN)
2) Where the Australian Government has decided to invest in a particular capability that is a strategic priority, but where increased international access represents a more cost effective and targeted investment than large-scale domestic investment.
3) Where a focus area in a capability has been assessed as a national priority but falls outside the funding envelope for domestic investment, funding for international access in some sectors enables the Australian Government to maximise investment across the research sector.

Question 5: Should research workforce skills be considered a research infrastructure issue?

Yes. The highly specialised skills required to be a technical specialist operating on research infrastructure are recognised globally as is the shortage of such skills in many fields and the difficulty of retaining researchers in such positions at the cost of academic recognition. The provision of skilled technicians associated with

infrastructure is a key component to the international recognition of a piece of infrastructure and of central concern to the on-going funding of a piece of infrastructure.

Question 6: How can national research infrastructure assist in training and skills development?

No comment

Question 7: What responsibility should research institutions have in supporting the development of infrastructure ready researchers and technical specialists?

Provided the Australian Government provides clear advice on the funding horizon for research infrastructure, institutions hosting infrastructure can and do have a responsibility to initially co-invest and then fully support the development and maintenance of technical specialist and provide training services for researchers in using infrastructure. The Australian Government does have to have realistic expectations that publicly-funded research infrastructure, once the funding horizon has been met, needs to be supported by cost recovery.

Question 8: What principles should be applied for access to national research infrastructure, and are there situations when these should not apply?

Access should be on a cost reduced basis for the duration of Australian Government funding to all users and thereafter revert to cost-recovery.

Question 9: What should the criteria and funding arrangements for defunding or decommissioning look like?

The Australian Government should establish a clearer funding horizon model similar to other substantial long term investments such as CRCs and CoEs that provide funders and recipients a clearer understanding of the investment window, which enables recipients to develop strategies for management.

Question 10: What financing models should the Government consider to support investment in national research infrastructure?

No Comment

Question 11: When should capabilities be expected to address standard and accreditation requirements?

All facilities should be expected to meet national and international accreditation requirements as a requirement of funding.

Question 12: Are there international or global models that represent best practice for national research infrastructure that could be considered?

European Commission, United Kingdom and Germany provide excellent models.

Question 13: In considering whole of life investment including decommissioning or defunding for national research infrastructure are there examples domestic or international that should be examined?

European Commission, United Kingdom and Germany provide excellent models.

Question 14: Are there alternative financing options, including international models that the Government could consider to support investment in national research infrastructure?

European Commission, United Kingdom and Germany provide excellent models.

Health and Medical Sciences

Question 15: Are the identified emerging directions and research infrastructure capabilities for Health and Medical Sciences right? Are there any missing or additional needed?

No comment.

Question 16: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Under emerging capability needs, the requirement for Biobanking and population genomics (5.2.4) and underlying tissue banking extends well beyond the realm of human health and medical science. The Australian Government should consider a holistic approach that meets the needs of tissue banking for research across environmental and natural resource management, agriculture, forestry and biosecurity as well as human health and medical research. The success of genomics and tissue banking is strongly dependent on rigorous, in-perpetuity collections management. This requires that tissue banks are held by entities set up for the specific purpose of long term preservation and which have systems in place to link tissues to identified voucher specimens and individuals. The necessary institutional longevity and processes are in place in the network of natural history museums, herbaria and seedbanks represented by the CHAFC, CHAH, CAMD and Australian Seed Bank Partnership managed by the CHABG. The Queensland Museum continues to build frozen tissue collections and DNA extracts of around 35,000 specimens, linked to voucher specimens in the State Collection, and used for various 'omics' research projects. It would be logical to extend tissue collections into the medical arena based on a similar premise.

The value of these collections cannot be under-stated. They are the irreplaceable, nationally distributed research infrastructure that manages this type of material to national and international standards, and these collections are "pivotal enablers" for other biodiversity sciences. Publicly available repositories of DNA sequences such as Genbank ultimately depend on the ability to verify voucher specimens upon which the genomic data rest. This is essential for high quality, repeatable science. The same goes for tissue samples and their associated physical vouchers that carry the phenotypic traits. Where there are no vouchers underpinning sequence/tissue data,

those data are untestable and hence of lesser or dubious scientific value. Where those vouchers do exist they predominantly reside in the national publically accessible collections (museums, herbaria). On this basis, 5.2.4 should be considered holistically as Underpinning Research Infrastructure and combined with an approach for improving natural history collections as well.

Question 17: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Health and Medical Sciences capability area?

The Australian Government should transfer 5.2.4 to Underpinning Research Infrastructure, making it a holistic approach to national DNA and tissue banking that meets the needs of tissue for research across environmental and natural resource management, agriculture, forestry and biosecurity as well as human health and medical research. This would be logically linked to existing digital infrastructure such as the Atlas of Living Australia and Bioplatforms Australia and proposed digital infrastructure for human health and medical science. There are already strong national distributed networks in the form of the Collection Councils in place that have a long history of collaborating nationally and these could be capitalised on and expanded to deliver a cross-sectoral national approach.

Environment and Natural Resource Management

Question 18: Are the identified emerging directions and research infrastructure capabilities for Environment and Natural Resource Management right? Are there any missing or additional needed?

The Environmental and Natural Resource Management section is an excellent overview of the digital requirements of the capability. It does not, however, consider the major research infrastructure investment represented by the natural resource collections. These are held by the nation's natural history museums, universities, seedbanks (managed by Botanic Gardens), herbaria and CSIRO. They are represented by peak bodies, chiefly CHAFC, CHAH, CAMD and Australian Seed Bank Partnership managed by the CHABG.

The fundamental shifts in imaging and characterisation technology and genomics have revolutionised the value of collections over the past ten years. Whereas even seven years ago, digitally accessible specimens may have been mooted as a key endpoint for utilising collections, the importance of the specimens themselves now equals or surpasses that value.

The distributed research infrastructure of the natural resource collections includes over 73.8 million specimens and represents a research infrastructure investment of slightly over $2 billion in specimens alone. The Queensland Museum's (databased) State Collection of 1.2 million objects and specimens of natural history is valued at more than $479 million (2015 figures), and another approximately 14 million unregistered Non-State Collection items are gradually being assessed for their significance and incorporated into the State Collection. The collections grow by

between 10,000 and 30,000 specimens each year. These collections provide the basic research tools for disciplines from taxonomy to fisheries stock, biodiscovery and forestry research, and from mineralogical investigation for future mining operations to stratigraphic understanding of Australia's mineral resources. These collections are accessible nationally and internationally with national visitation by researchers estimated at 9,100 Australian researchers per annum and approximately 4,130 international researchers spending a total of 11.2 person years each year using this research resource. These collections underpin biosecurity, genomics, fisheries, mining, forestry, agriculture, environmental management. They represent the primary source of genetic material in endeavours from pharmaceutical discovery to adaptive management of human-induced perturbation such as climate change. Globally, this is the largest research investment infrastructure investment of this type in the southern hemisphere. It provides broad scale infrastructure support to a diverse array of scientific disciplines and helps underpin the economic and social welfare of the nation. Importantly, most of the collections referenced here have a core role of ensuring the availability of specimens for research in perpetuity. They have the necessary infrastructure to reference tissue samples, type specimens, geological specimens and core samples. These collections meet international standards and industry requirements for specimen holdings for tissue samples, bio-banking and the mining industry.

Existing research infrastructure such as the Atlas of Living Australia provides invaluable digital access to the small proportion of the 73 million specimens that have been digitised. Aside from that investment, however, the collections themselves represent a major infrastructure investment. Targeted investment in that infrastructure could improve the distributed network as well as access for researchers and the delivery of services to researchers and industry. This would include better provision of tissue, seed and bio-banking, coordinated access to key biosecurity resources, notably herbaria and entomology collections, and better access to geological specimens.

The Australian Government should recognise this essential research infrastructure investment as part of the road-mapping process, recognise the necessity for a holistic national approach to the infrastructure for natural resource management through specimen and tissue management at a national scale and recognise the necessity for further investment in this capability in future. This should be added to Environmental and Natural Resource Management, but along with section 5.2.4 above, the response should be included under Underpinning Research Infrastructure, making it a holistic approach to meeting the needs of research across environmental and natural resource management, agriculture, forestry and biosecurity as well as human health and medical research.

Question 19: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Natural Resource Collections increasingly form the basis of research done with emerging technologies and that generates end-user products. Examples are: next generation sequencing; environmental DNA (eDNA) for rapid biodiversity assessment; advanced imaging of geological specimens for the mining industry; DNA finger-printing to track illegal harvesting of tropical timbers or CITES species; rapid identification for biosecurity using imagining or DNA; using advanced imagining and chemical trace analysis to develop sustainable fisheries or analysing climate change responses. This mirrors trends in medical and health science research. Such new research trends require better, direct access to biological and geological collections. Australia is already a global leader in this area. The Queensland Museum is recognised internationally for its rate and scope of new species discoveries, ranging from around 100-250 new tropical species of animals described each year, a large proportion of which are nowadays accompanied by genetic sequence data that unequivocally delimit species boundaries. The QM is also renowned for contributing much of the animal tissues that were extracted for their pure compounds and now form the Compounds Australia library developed by the Eskitis Institute at Griffith University, with chemical compounds tested against high-throughput commercial biological screens in the search for bioactive and more effective therapeutic drugs. The palaeontology collection at the QM is used for stratigraphic dating of subfossil and fossil sites associated with the Pleistocene megafaunal extinctions and climate change, ancient DNA, CT biomechanics and 3D fossil reconstructions. Improving collection access to specimens across the sector to a high standard is just as important as digital referencing of collections via the Atlas of Living Australia. Digitising also needs to be extended to largely un-databased crucial collections such as geological collections widely used by the mining industry, for example, and which comprise the largest component of the QM collections.

Question 20: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Environment and Natural Resource Management capability area?

See statement above

Underpinning Research Infrastructure

Question 30: Are the identified emerging directions and research infrastructure capabilities for Underpinning Research Infrastructure right? Are there any missing or additional needed?

Collections should be seen as underpinning infrastructure in their own right, supporting a broad range of sciences from medical and health research to resources research and environmental sciences. They are value-added by digital access through the ALA (for example) but require recognition and development in their own right.

Question 31: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Yes. There are major global collections, particularly in Europe and Asia, where increased access would be of massive benefit to Australian researchers. Examples include cross-Tasman collaboration with Museums and Herbaria in New Zealand; collaboration with the Natural History Museum and Kew Gardens (as major holders of Australian material) and emerging collections in Asia which increasingly hold geological and biological material of importance in applied research on biosecurity and mineralogy (for example).

Question 32: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Underpinning Research Infrastructure capability area?

Other comments

If you believe that there are issues not addressed in this Issues Paper or the associated questions, please provide your comments under this heading noting the overall 20 page limit of submissions.

No comment.