VISION FOR A SCIENCE NATION. Responding to Science, Technology, Engineering and Mathematics: Australia's Future (June 2015)

Consultation Questions – CAMD responses

Topic 1 Australian competitiveness

Not answered

Topic 2 Education and Training

Do these proposals adequately respond to the Chief Scientist's recommendations?

The Council of Australasian Museum Directors (CAMD) congratulates the authors of the Government consultation paper for their recognition of the role played by science museums and science centres, as part of the wider informal learning sector, in providing 'a direct avenue for Australians to engage with and be enthused by STEM'. This recognition complements and expands on the acknowledgement in the Chief Scientist's paper of the contribution made by informal education providers in:

- laying the foundations for lifelong STEM literacy in the community;
- developing a skilled and dynamic workforce;
- inspiring young people to pursue studies in core STEM subjects and to develop STEM-related careers and
- supporting and engaging the community in citizen sciences activities.

CAMD

CAMD represents the leaders of the major national, state and regional museums who work to enhance and promote museums and the collecting sector in the Australasian region. CAMD member institutions include Questacon – the National Science and Technology Centre; Scitech, Perth and the State and Territory natural science museums. Many of the museums with natural science collections run separate science centre sites (eg Museum Victoria, Queensland Museum and South Australian Museum) and/or have substantial, core education programs in STEM areas for all ages. Others focus directly on the applied sciences and technology (eg the Museum of Applied Arts and Sciences).

As the Government's report notes, science museums and centres are a major force for community engagement and education in the sciences. Museums combine vast research collections, in-house scientific research (particularly in the areas of biodiversity and biosecurity) and a framework for a variety of citizen science endeavours. Both science museums and science centres balance in-house expertise in science education with approaches to STEM learning which are well known for their ability to engage and inspire.

Museum/Science Centre Reach

Science museums and centres also have a unique reach into the community. In 2013-14 there were **10.8 million** visits to CAMD science museums and centres or to their travelling exhibitions and events (*CAMD Annual Survey Report*, 2013-14). This number includes over **1.8 million school children** who attended school programs on site or participated in organised museum/science centre programs delivered in their own classrooms. Even if return visits are taken into account, it is clear that these centres hold a strong attraction for the visiting public and provide a critical opportunity for community education and engagement in the sciences. Another 18.2 million people also visited the websites of these institutions and utilised the online resources for teachers and the wider community developed to support STEM programs.

CAMD's Museums and science centres have also played a significant role in developing the citizen science movement, opening up opportunities for people to assist scientists to collect specimens or field data and to digitise significant scientific records.

Contribution to STEM engagement

Science museums and centres are critical to the STEM informal education sector as they provide year-round access to:

- STEM exhibitions, education and events for all ages from pre-school to seniors (eg Science Week at the Powerhouse Museum; Queensland Museum STEM partnership); the Australian Museum's (AM) Month of Science including the AM Science Festival, AM Eureka Prizes and the AM Research Institute annual lecture and medal presentation);
- opportunities for different age groups especially different generations within families to participate in STEM activities together (eg MAAS 'Physical Computing for Families' program);
- vibrant, hands-on and inspirational STEM activities – many of which are designed to align with school curriculums (eg Questacon; Scitetech Perth programs; MAAS Workshops) ;
- well-designed formal education programs, developed by research scientists and trained experts, which are curiosity-driven and prioritise the problem-based learning of STEM for pre-schoolers, school students and tertiary students (eg MAAS Mar Lab project)
- informal STEM learning opportunities for Indigenous communities and students from disadvantaged and marginalised backgrounds (eg Scitech award-winning Indigenous science program);
- travelling programs and video-conferencing to reach those in regional and remote areas (eg Shell Questacon Science Circus);
- professional education/training and curriculum resources for STEM teachers (eg MAAS Mars Lab teachers resources; the Australian Museum runs professional development days for science and other teachers, and will shortly be an accredited service provider)
- apps for the scientifically curious (eg the award-winning museums' Fauna Field Guides whose expansion was funded by *Inspiring Australia*);

- digital innovations to engage a broader cross-section of the community;
- major promotional programs to highlight Australian science and technology and its achievements eg the Australian Museum's Eureka Awards, offering 16 prizes in four categories of science;
- awards and symposia to advance women and other groups underrepresented or disadvantaged in science professions (eg Women and Science Symposium, Australian National Maritime Museums);
- opportunities for cross-fertilisation between the creative arts, culture and sciences;
- citizen science programs which engage and inspire a rapidly growing proportion of the community to donate their time to work on science programs; and
- career pathways for science graduates in science communication and education.

In combination, science museums and centres address the critical need, as identified by both reports for the 'lifetime engagement for all Australians with STEM, beginning in childhood and constantly renewed as knowledge and technologies expand' (Chief Scientist, 21).

Do you consider there are any areas that require more urgent action? Have we missed anything?

The Big Picture

Currently the Government's response must be read in conjunction with the report from the Chief Scientist to gain an understanding of why STEM education is being prioritised over, for example, the critical thinking skills, social knowledge and understanding provided by the Humanities, Arts and Social Sciences sector or indeed over other disciplines. The final policy produced by the Government should clarify the importance of STEM and the reasons for it being prioritised in this way.

Coordination

CAMD supports the recommendations made by the reports for improving science literacy and engagement in Australia. The response acknowledges that this improvement needs 'a national response from the key partners in educating and training'. To ensure that this happens across the many levels of government, departments, universities and institutions will require careful oversight and enhanced levels of coordination.

The question of national coordination cannot be emphasised too much. Museums and science centres operate in a unique space between universities and schools, science and industry, innovation and technology. However, because science museums are more likely to be under the jurisdiction of Arts or Cultural Heritage Ministries in their respective States and Territories they have found in the past that their expertise and contribution to science research and engagement has often been overlooked when national policy is debated.

CAMD members have benefitted greatly from the support the *Inspiring Australia* program has provided for a range of activities including the International Year of Biodiversity, the development of the Field Guides for Australian Fauna and the many events promoted during Science Week. In return, CAMD

member museums host and in some cases directly resource *Inspiring Australia* Regional Hub staff. *Inspiring Australia* has also provided a national overview of science engagement activities. Given the continuing importance of STEM engagement, as highlighted by the Chief Scientist and the Government, CAMD would like to see *Inspiring Australia* further resourced to allow it to employ staff and to ensure that the various players in the formal and informal learning sectors, in science, industry and education are part of a coordinated national effort.

Access

CAMD acknowledges the Government's intent to ensure access to STEM learning and engagement opportunities for those in regional and remote parts of the country. As the paper notes, this can include the development of STEM-focused exhibitions that tour regional Australia like those provided by Questacon. Questacon's most well-known program, the Shell Questacon Science Circus (approaching its 30th anniversary in 2015) visited more than 330 venues last financial year, covering 20,000 kilometres around Australia.

Similarly, the Australian Museum's 'Museum in a Box' program reached 95,000 students and others in 2014-15. Now celebrating its 50th year of outreach, the program is going from strength to strength and also works in combination with video conferencing. The Australian Museum's touring exhibitions reached more than 622,127 visitors – 63,126 in NSW; 431,984 interstate in five other states/territories, and 127,017 in New Zealand.

Scitech, Perth reached 173,000 through its outreach and travelling programs including its international award-winning Aboriginal Education Program (AEP). Since its inception in 2007, the Scitech AEP program has addressed challenges of access and equity by visiting every remote community in South Australia every two years with a comprehensive suite of engaging science activities and resources for children, parents, and teachers that recognise the communities' unique Aboriginal culture and language.

Similar outreach activities are provided by the science museums. To take one example, Queensland Museum Loans, active since 1987, provides self-contained loan kits to schools and other institutions which effectively combine the Queensland Museum's expertise with object-based learning and the Australian Curriculum. In 2013/14, 787,098 people from schools, libraries and community groups throughout Queensland accessed learning resources from Queensland Museum Loans. Almost 30 per cent of these borrowers were from regional Queensland, accessing resources from one of 26 distribution centres. Kits cover a diversity of topics from Indigenous Science and Trade to Starlab.

CAMD museums also occupy a well-earned position as innovative online educators. The Australian Museum in Sydney, for example, reached 5,581 students via video-conferencing last year; an estimated 2,000 more interacted with content from participating external providers. At the National Museum of Australia 'museum robots' allowed hundreds of students from remote areas to virtually tour the museum and interact with a museum educator/guide. The well-established touring regimes of science museums and centres and the different forms of emerging technology adopted to reach remote communities should be noted and built on in any development of STEM touring and access initiatives.

The Government also proposes to encourage public funded research agencies to support citizen science initiatives to augment relevant data collections and promote community awareness. It should be noted that many museums, (which are in themselves public-funded research agencies), are already supporting a variety of citizen science initiatives. In 2014 the Queensland Museum hosted the conference establishing the Australian Citizen Science Association which has just held its inaugural national conference. At the same time, the Australian Museum has drawn the existing citizen science projects it manages, which include Bushblitz, Bioblitz, Birds in Backyards and Streamwatch , into a new Australian Museum Centre for Citizen Science. The Museum has also created the hugely successful 'Digivol'- Digital Volunteer – program where volunteers delve into the Australian Museum collection transcribing the data, so it is discoverable online for anyone to access anywhere in the world. Its volunteers reached 100,000 transcriptions last year. This project has inspired other similar projects across Australia and was recently adopted by the Smithsonian.

Finally, it should be noted that museums are particularly well placed to encourage a more creative interchange between arts and culture and the sciences. One way to build on this opportunity to extend the reach of science could be a strategic funding stream between the new *National Program for Excellence in the Arts* and *Inspiring Australia* to encourage applications which seek to unite activity in arts organisations with STEM projects. This would nurture and encourage the creativity inherent in both these vital fields and send a powerful message about their linked importance.

All of the initiatives above should be considered and built on to advance the STEM engagement program.

Which of these proposals will have the greatest impact on Australia's STEM performance?

Informal learning – its importance

Many of the proposals outlined will clearly have a significant impact on Australia's STEM performance but the importance of informal learning to life-long STEM literacy and engagement cannot be underestimated. There is a growing body of evidence demonstrating that most science is learned outside school and it is becoming clearer that much of the science and technology learnt at school will be increasingly out of date as we grow older. Science museums and centres occupy a unique and trusted role within the community in providing a science literacy basis and in explicating advances in science as they happen as well as providing a forum for debate about their impact.

Research into learning in museums (eg see Kelly, Piscitelli and Barrett in Understanding Museums) has long demonstrated that people look to cultural institutions as places of stimulating ideas and active learning which can be accessed by the whole family. The family orientation is important as studies of adult learning suggest that a readiness to engage in lifelong learning is strongly linked to the family and early family experiences. From supporting schoolchildren's education, to motivating adults to discover more about science and life today, museums facilitate discovery, the sharing of knowledge and inspire thought. Their programs and exhibitions are designed to put people into a receptive frame of mind, foster questioning and critical thinking and stimulate curiosity and creativity.

Early research on science centres visits noted that they can engender long-lasting memories, suggesting a strong personal impact on visitors. Falk, Dierking and Rennie (2004) showed that a visit to a science centre produced different short-term and long-term outcomes. The short-term outcomes were knowledge and skills, motivation and interests. The long-term outcomes were perspective and awareness, and social learning. The major learning outcome over time was a positive shift in visitors' perspective and awareness. The vast majority (73%) of visitors could articulate an outcome after several months of elapsed time. Most of them reported that they gained new perspective and awareness on science. These findings have been reinforced by more recent studies including the International Science Centre Impact Study 2014, which covered centres in 13 countries including Australia, and the Inspiring Australia, How do Australians engage with science? (2014) report.

The collective evidence strongly indicates that science centres (and by extension museums which share similar pedagogical approaches):

- strengthen science learning in both youth and adults;
- strengthen motivation to learn science;
- affect attitudes towards science and technology positively;
- increase understanding of STEM subjects as socially meaningful and culturally relevant;
- increase confidence in science;
- position staff as co-investigators and learners alongside young people; and
- influence career choices by young people.

These results enable the participating science centres, and by extension others within the science centre community, to state with much greater confidence that science centres and museums represent a vital mechanism for creating and maintaining a scientifically and technologically informed, engaged and literate public.

Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

The proposals around 'better community engagement with STEM' are one of two ways that CAMD's members can contribute to and inspire Australia's STEM program. The second way relates to their involvement in science research which is addressed in response to Question 3 following.

Topic 3 Research

Do these proposals adequately respond to the Chief Scientist's recommendation?

CAMD supports the need for longer term planning and funding for science and research in Australia. We note that the review of the National Collaborative Research Infrastructure program is currently underway and would encourage the Government's consideration of longer funding cycles as part of this review as well as recognising that the collections of museums constitute important research infrastructure.

CAMD also supports the need for the development of strategic research priorities. Having considered the Science and Research Priorities recently recommended by the Commonwealth Science Council, we would suggest the inclusion of a priority which adequately encompasses the contribution provided by Australia's humanities, arts and social science researchers. Their fields, which link universities, government departments, collecting institutions and the creative industries, address complex questions which are increasingly pressing such as the use of resources, population growth, social cohesion and security. The humanities, arts and social sciences can provide critical input not only to immediately recognisable social and cultural issues but across the sciences to encourage new thinking about the conceptualisation of problems and the implementation of workable solutions. Museums, which are multi-disciplinary institutions by nature, have learnt from experience that such approaches provide unique opportunities to identify and implement innovative problem solving approaches to a wide range of key challenges.

Do you consider there are any areas that require more urgent action? Have we missed anything?

As outlined above, CAMD's member science museums and centres have a significant role in promoting and enhancing community engagement in science. They are nevertheless concerned that the reports from the Chief Scientist and the Government both fail to acknowledge and therefore harness the full contribution made to science by the museum sector. This additional contribution is on two fronts:

- museums generate ground-breaking research in a wide range of fields in their own right, in collaboration with the private sector and through research partnerships with university researchers; and
- this research in natural science, cultural heritage, humanities and social sciences fields is informed by vast and deep museum collections which traverse all subject areas and media.

Research Collections

Collections are an essential part of Australia's future as they provide the raw material through which researchers can discover the extent and character of biological and cultural diversity and how it may be sustained in the future. CAMD museums hold over 60 million natural science and geoscience specimens and cultural, heritage and technological objects which form part of the distributed national collection and which are continually expanded through acquisitions and field work. These collections provide a rich resource for evidence-based research of national and international significance in broad fields of knowledge. They provide the raw material through which researchers can discover the extent and

character of biological diversity and how this may be explored and managed in the future. Other museums deal with the applied arts and sciences with collection development, exhibitions, programs and research in technologies, health and medicine, physical sciences, engineering, architecture and the built environment. Technological developments are providing methodologies which create opportunities for different interrogation of these historic collections, providing new and often more detailed data which can contribute to and influence government policy. It is worth noting that many of Australia's principal research scientists are employed within the museum sector.

As one example, the Australian Centre for Wildlife Genomics (ACWG) at the Australian Museum draws on the knowledge of Museum wildlife experts and molecular biologists to answer questions about forensics, conservation and biodiversity. The Centre holds an extensive frozen tissue collection which preserves genetic material from thousands of species, a key resource for forensic work in identifying smuggled wildlife, quarantine incursions and wildlife involved in aviation strikes.

The Museum of Applied Arts and Sciences (Powerhouse Museum) is working with ANSTO doing neutron activation analysis on Samurai swords and unused rivets from the Sydney Harbour Bridge for cultural heritage and industrial applications respectively, the Australian Wool Innovation (AWI) sponsored analysis of 1,200 wool samples from the Museum's historic collection and historical records from several institutions including MAAS are being used to corroborate paleo and rainfall records in a major Australian climate study.

A significant amount of research has also taken place within museums; education research, mobile applications, data visualisations, human computer interaction studies to name a few. The 'Pathways to Space' project and its successor the 'Mars Lab' project were both research projects that looked at the effectiveness of project based learning for high school science for example.

Utilising collections, museum scientists generate significant in-house research projects and collaborations with other research agencies and academies, across the sciences and humanities, between disciplines and in nationally and globally significant areas such as biosecurity, biodiversity, biodiscovery, climate change, education, digital visualisation and resource management. In 2013-14, CAMD museums:

- participated in 416 grant and non-grant funded research projects;
- expended close to $18.5m in research grants;
- delivered 620 research presentations; and
- produced 772 scholarly publications.

In addition, natural science and science and technology museums and centres:

- continue to add to collections by initiating and collaborating in exploration, discovery and associated field work;
- undertake research topics which are unique or insufficiently represented at other research institutions (eg systematics, taxonomy, phylogenetics and biogeography);

- produce a range of other studies and projects in fields like genomics, ecology, evolutionary biology, disease modelling, palaeobiology, mineralogy, ecological resource management, bioprospecting and biosecurity amongst others;
- play a similarly significant role in undertaking research in areas such as education technique, mobile applications, data visualisations, and human/computer interaction studies;
- employ research staff holding adjunct appointments at universities, supervise postgraduate biology and taxonomy students and mentor undergraduate science students;
- play a significant research role in detecting, identifying and managing terrestrial and marine environmental pests which, if unchecked, can have massive environmental and economic impacts;
- participate in numerous international collaborations which enhance Australia's reputation as well as contributing to the global cultural and science knowledge base; and
- engage members of the community in biodiversity issues by developing public exhibitions and public programs with interpretative skills unique to the museum sector.

The expertise of museum researchers, particularly in the field of species identification and adaptation, is not replicated at universities or other research institutions, which uniquely positions museums to address areas of significance to society such as environmental health, biodiversity loss, climate change, biodiscovery and biosecurity. With only 20% of the world's biodiversity discovered and described to date it is critical that accurate determination of species is available to inform decision-making in biodiversity conservation, resource management and biosecurity fields.

For examples of the work of museum scientists see the South Australian Museum's Unlocked: Stories from Our Scientists, the Australian Museum Research Institute, Museum Victoria's Collections and Research and the research projects at Queensland Museum and Western Australian Museum.

There are a number of reasons for the current sidelining of museum science in science policy including the:

- decline of funding for biodiversity research;
- unequal allocation of funds between museums and universities collaborating on ARC grants and lack of a national funding scheme, like the National Science Foundation in the US which provides funding directly to major state museums;
- State/Territory nature of science and technology museums;
- location of science museums in arts portfolios whereas policy in biodiversity tends to lie within science, environment, conservation and land management ministries and technology in industry and innovation. The lack of a national science museum also undoubtedly inhibits consultation between the Australian government and the states, particularly on research and collection issues;
- a lack of understanding that biodiscovery plays a fundamental role in underpinning a whole range of other applied research. The major source of funding for biodiscovery in recent years has been

the Australian Biological Resources Study, which issues grants worth around $2 million in total per year throughout Australia.

To address these barriers, the science museums have acted individually to gain industry and university partners and collaboratively to develop important science projects. CAMD museums commenced the process of bringing together biodiversity collections which resulted in the highly successful online Atlas of Living Australia (ALA). To date the museums have contributed over 3.5 million records to the ALA which has recently passed the 6 billion mark in research downloads internationally. ALA has clearly been a highly successful program not only as a tool for organising Australia's biodiversity information and as a supporting basis for prioritising public collection research and management but as a mechanism for organising data for environmental analysis.

Which of these proposals will have the greatest impact on Australia's STEM performance?

The development and implementation of strategic research priorities accompanied by long term funding and investment. CAMD also believes that there is a need for a body which has an overarching brief to coordinate policy implementation in relation to both science engagement and research in all of the areas outlined in the consultation paper.

Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

Museum researchers, utilising both existing research collections and adding specimens through ongoing field work, can make a significant contribution to the development and implementation of the proposed science and research priorities including:

- Food (biosecurity in relation to pests and invasive species);
- Soil and water (particularly in relation to terrestrial and marine biodiversity);
- Resources (via study of geology collections); and
- Environmental change (biological collections, bioinformatics and biostatistics are key capabilities. Geological and paleontological collections also have the capacity to assist in research seeking to understand past climate patterns and the current use of earth resources).

Topic 4 International Engagement

Do these proposals adequately respond to the Chief Scientist's recommendation?

Yes

Do you consider there are any areas that require more urgent action? Have we missed anything?

CAMD would note that museums, as much as business and higher education, have long made an important contribution as international STEM ambassadors through a range of mechanisms.

Which of these proposals will have the greatest impact on Australia's STEM performance?

CAMD supports the need for an international strategy for science, research and education.

Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

As the majority of science museums and centres in Australia are State/Territory-based institutions it would be easy to overlook their role in the development of international relationships. It should be noted, however, that international engagement and the building of strong relationships with international scientists, research organisations, collecting institutions, education consortiums and Governments has always been integral to the work of the major museums. For many years they have engaged in hosting visiting dignitaries and sharing exhibitions internationally, showcasing Australia and its culture in creative and innovative ways. The close ties developed with ambassadors, consuls and embassies, here and overseas, helps build a scaffold of trust and understanding, at many levels, with other countries and regions which endure for many years. Special relationships have been built up with other countries as has been the case, for example, with the Australian National Maritime Museum and the USA; Questacon with Japan; and the Western Australian Museum with the Dutch Government, while many others have developed Pacific relationships around research and conservation skill exchanges. They have also actively participated in many international programs such as the Global Biodiversity Information Facility (GBIF), the Barcoding of Life (COBOL) project and SciColl which aims to ensure the accessibility and management of scientific collections held in museums and other research facilities around the world.

In 2013-14 alone, CAMD museums signed formal agreements with over 25 countries to develop and tour exhibitions, exchange loans, undertake scientific research collaborations, and exchange interns, staff and skills. They have also participated in the Department of Foreign Affairs and Trade Focus Country Program and in countless expos and biennales. Individual research scientists in the museum sector also have strong, specialist international networks. The relationships thus forged often endure when formal Government relations have become more challenging.

Museum directors, scientists, curators and educators have the knowledge, contacts and professional skills to foster the cross-cultural understanding necessary for the development of long-term, productive relationships between Australia and its international partners. CAMD encourages the Government to take full advantage of these skills and established networks in developing its science engagement strategy.