ASSOCIATION OF PUBLIC & LAND-GRANT UNIVERSITIES

APLU Comments and Input on Senate Reauthorization of COMPETES Act
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The Association of Public and Land-grant Universities (APLU) is a research, policy, and advocacy organization with a membership of 238 public research universities, land-grant institutions, state university systems, and affiliated organizations. Founded in 1887, APLU is North America's oldest higher education association with member institutions in all 50 states, the District of Columbia, four U.S. territories, Canada, and Mexico. Annually, its 196 U.S. member campuses enroll 3.9 million undergraduates and 1.2 million graduate students, award 1 million degrees, employ 1 million faculty and staff, and conduct $40.2 billion in university-based research.

APLU appreciates the opportunity to submit input at the request of Senator Cory Gardner (R-CO) and Senator Gary Peters (D-MI) of the Senate Commerce, Science, and Transportation Committee, as they lead the Senate efforts to craft a bipartisan reauthorization of the America COMPETES Act. APLU's member institutions have a significant stake in this legislation and are keenly interested in supporting a bipartisan bill that sets a bold vision for science. As our comments below detail further, we urge Congress to craft a multi-year authorization bill that will put our nation on track to safeguard against a potentially damaging U.S. *innovation deficit.* This threatening innovation deficit is the widening gap between actual and needed investments in research and higher education to keep the United States the global innovation leader.

(1) Maximizing basic research

First and foremost, a COMPETES reauthorization must include robust funding for the science agencies authorized in the bill. As other countries ramp up their investments in scientific research, the United States must not complacently fall behind, allowing nations such as China and South Korea to outpace our science efforts. Currently, the U.S. leads the world in federal science investments, but if we remain on the same trajectory as we have been recently, and if China remains on its same science investment trajectory, China will overcome the U.S. in only a few years.

Investing in basic research at the front end of the innovation process is critical to ensuring we have a strong research pipeline. Basic research begets new knowledge, which in turn yields new potential applications, which generates new products, industries and jobs. We need to robustly support the basic research beginnings of this process. The federal government is the nation's largest and most important funder of basic research and is able to take on long-range, strategic projects outside of the scope of private industry. Private funding in research and development (R&D) tends to rise and fall depending on the economy and largely focuses on short-term results, ie the development side of R&D. Research and development has not exceeded five percent of the

federal budget since 1990, and was at an all-time low of 3.8 percent in 2013. Comparatively, in the 1960s, research and development was closer to 12 percent of the federal budget and led to discoveries and innovation we benefit from today. The American Academy of Arts & Sciences report, *Restoring the Foundation: The Role of Research in Preserving the American Dream* recommends a "sustainable real growth rate of *at least* four percent" for federal investment in basic research (American Academy of Arts & Sciences, 2014).

Furthermore, it is important for Congress to invest in all disciplines of basic scientific research. Increasingly, science advances at the boundaries of traditional disciplines – with knowledge from one field melding into knowledge of another to enable transdisciplinary approaches to address grand challenges of research. To ensure our national competitiveness, we need to maintain a strong foundation of basic research across all scientific disciplines, from the physical, mathematical, life sciences and geosciences, to the social, economic and behavioral sciences, to engineering.

It is fundamental that a COMPETES bill include a multi-year authorization that paves a predictable funding path without unwarranted delays, uncertainty, or stops and starts in programs. Research investigators require the ability to maintain their research teams and make long-term plans in order to undertake multi-year projects, and educate graduate students, who are the next generation science workforce. Too often we hear from our campuses that young researchers observing (and sometimes being themselves) the casualties of funding uncertainties in the laboratory are discouraged from entering the sciences and decide to pursue other opportunities instead. It is critical we provide the necessary support to attract and keep high quality professionals in the various scientific disciplines. While much of the funding uncertainty occurs in the budget and appropriations process, a visionary and productive COMPETES bill will outline a blueprint to help guide a constructive annual funding process.

Of similar importance to steady and sustained funding for science, is ensuring the current system of awarding grants remains in-tact and removed from political interference. The federal science agencies, guided by their scientific advisory committees and boards, should continue to set priorities for funding within and among the full range of scientific disciplines. A COMPETES reauthorization bill must ensure we uphold our current peer review system and protect the scientists who voluntarily and confidentially participate in this system. This legislation must ensure we do not inadvertently diminish the interest of leading scientists to undertake this service. Our current system of funding research—based on excellence, competitive scientific merit, and scientific review—is world-renowned as the gold standard for culling top research proposals. Congress most certainly has an important role in ensuring federal funds are not mismanaged or ill-spent. Such oversight must balance rigor and deterrence. It is important not to undermine the acclaimed project review process that has served science and our country so well. Along these lines, APLU supports the National Science Foundation's new policies and increased attention to transparency and accountability and believes that further legislating on this matter is unnecessary and also may be counter-productive and have a chilling effect on funding of meritorious high-risk research.

COMPETES reauthorization provides an excellent opportunity to include provisions aimed at easing the regulatory burden on investigators and institutions. Current research practices include an onerous accumulation of federal and state regulatory and reporting requirements. These mandates drive up the cost of compliance for researchers and research institutions (National Research Council of the National Academies, 2012). COMPETES legislation should direct agencies to reduce or eliminate unnecessary or duplicative federal regulations and reporting requirements which increase research costs and pull researchers away from their science.

APLU supports the recommendations of the 2014 National Science Board (NSB) report *Reducing Investigators' Administrative Workload for Federally Funded Research*. Among many recommendations, this report proposes the implementation of a mechanism to ensure uniform audit practices are based clearly and directly on regulatory requirements. The report urges that audits focus on larger expenditures to significantly reduce investigators' workload while still maintaining proper oversight. The report cites a continued lack of consistency in requirements within and between federal agencies and recommends the creation of a permanent high-level, inter-agency, inter-sector committee to coordinate these requirements (National Science Board, 2014). A COMPETES reauthorization is an appropriate vehicle to address the recommendations in the NSB report and work with stakeholders to identify additional opportunities to streamline and harmonize regulations. The legislation can also help standardize the implementation of new requirements affecting investigators and institutions.

In addition, we strongly suggest this legislation promote unimpeded and convenient public access to the results of federally funded research, including articles and valuable datasets. Such public access accelerates the advancement of research and brings direct benefits to members of the public. The SHared Access Research Ecosystem (SHARE) is a higher education initiative intended to maximize research impact via a widely accessible, discoverable and reusable comprehensive inventory of research products. SHARE is also creating an openly available data set about research activities across their life cycle. APLU strongly supports public access policies and is on record in support of S. 779, the Fair Access to Science and Technology Research Act of 2015, as it passed the Senate Homeland Security and Government Affairs Committee in July 2015.

(2) Improving science, technology, engineering, and math (STEM) education research and practices for students

APLU strongly supports the belief that our country must recruit and train more STEM education teachers to prepare our next generation of STEM workers. To address this challenge, in 2008, APLU launched the Science and Mathematics Teaching Imperative (SMTI) based on the highest priority recommendation by the National Academies in *Rising Above the Gathering Storm* (National Research Council of the National Academies, 2007): to prepare 10,000 new science and mathematics teachers each year. The President's Council of Advisors on Science and Technology has also called on the federal government to recruit, prepare, and support at least 100,000 new STEM middle and high school teachers. This corresponds with their goal of producing one million additional STEM graduates over the next decade (President's Council of Advisors on Science and Technology, 2010).

APLU supports PCAST's recommendation to launch a national experiment in postsecondary mathematics education to address the math preparation gap (President's Council of Advisors on Science and Technology, 2012). Already accounting for about 20% of the nation's production, our Mathematics Teacher Education Partnership aims to produce 40% more well-prepared secondary mathematics teachers in five years, engaging more than 90 universities and 100 school systems across 31 states.

APLU believes the federal government should support programs that train STEM education teachers and STEM faculty to implement evidence-based teaching approaches to enhance learning (Singer, 2012; Freeman, 2014). There are known programs, such as those run by the National Academies and the American Physical Society, that have demonstrated success in positively impacting student achievement and engagement, and we should expand significantly the use of these models (President's Council of Advisors on Science and Technology, 2012).

APLU supports increasing support for discipline-based education research (DBER), which is the essential tool for transforming STEM education (Kober, 2015; Singer, 2012). Discipline-based education researchers are currently leading reform in several national efforts, including the APLU/STEM Education Center Network.

NSF should continue to be the leader in supporting improvement of STEM education. It has the infrastructure, including a peer review process and works well with other federal agencies. The Education and Human Resources directorate is balancing foundational research and development while aggressively promoting how to implement and scale solutions.

APLU urges the Committee to craft a COMPETES reauthorization bill that would expand undergraduate research opportunities. This is an important and effective approach to stimulate undergraduate students' interest in their education. Further, we must encourage the continued growth in industry-university collaboration in undergraduate course and research design. In addition, we would like to see a bill that emphasizes opportunities for women and other under-represented minorities in the STEM fields. Notably, non-traditional STEM students may need special attention or recognition of alternative pathways to a STEM degree. There should be multiple entry points and pathways to a STEM degree. For example, the Department of Education summer STEM learning program for high school students, authorized in the 2007 America COMPETES Act, is one way to engage students (President's Council of Advisors on Science and Technology, 2012).

Incorporating the education and training of the next generation of researchers with the performance and execution of research is critical, as is recognition that the future workforce will need to draw on the greater gender and ethnic diversity of our population. This legislation should support innovative and effective education programs that can equip all citizens with the scientific and technical knowledge required to meet national and global challenges, as well as to train future generations of scientists and engineers.

APLU agrees with the NRC report recommendation that Congress should provide greater support for graduate education through a balanced approach of fellowships, traineeships, and research assistantships provided by the science agencies (National Research Council of the National Academies, 2012).

(3) Translating federal research results into innovative commercial applications for the benefit of the economy and society.

So that new ideas and technologies developed with federal research funding can be translated into the marketplace and for public good, the federal government must work with universities, national laboratories and non-profit research organizations to develop and support new and innovative translational research, technology transfer, and commercialization programs. While there is significant interest in increasing such activities at universities, one of the major challenges is that funds often do not exist to support such activities. Innovative, relatively new federal programs such as the Innovation Corps (I-CORPS) and the i6 Challenge are positive developments in this area. We would encourage further exploration of how federal agency programs like these can help in accelerating innovation and technology transfer.

In particular, "proof of concept" funding programs have the potential to vastly accelerate innovation and commercialization. Public policy and public expectations have increasingly emphasized the need to move university basic research discoveries into the commercial marketplace. Bridging this gap, often referred to as the "valley of death," is a critical need. To tackle this problem, federal research agencies have focused on developing new translational research programs. While such programs can play a supporting role in transferring research into the marketplace, effective tech transfer and commercialization require more than translational research. A central barrier to effective transfer and commercialization is that researchers and universities do not have resources available to support the proof of concept work, market analysis, and mentoring needed to translate these ideas from the university laboratory into commercial products.

APLU encourages Congress to support the creation of a new multi-agency program focused on funding earlier stage proof of concept research across research agencies and scientific disciplines. One might think of such a program as a Small Business Innovation Research (SBIR) "phase-zero" program. A program like this would help more projects cross the valley of death, and also aid in enhancing the infrastructure (e.g., expertise, personnel) and facilitating the cultural change necessary for universities to better support this kind of transfer. The National Institutes of Health (NIH) has recently developed the Research Evaluation and Commercialization Hub program to address this need. We are hopeful that this program model can be expanded and adopted by other federal research agencies.

New fundamental research needs are often driven and informed by later stages of research and development (the same bi-directional feedback is also true in medical research, as advances in clinical and population health research often contribute to discoveries in fundamental biomedical

research). Government mechanisms to encourage, incent and support university-industry collaborations have proven successful. Programs such as the National Network for Manufacturing Innovation (NNMI) and the Semiconductor Technology Advanced Research network (STARnet) are important models that should be expanded and replicated in other industrial sectors.

Congress should support efforts to enhance and increase collaborative innovation between universities and industry. In *Research Universities and the Future of America*, the NRC recommends that the federal government "(s)trengthen the business role in the research partnership, facilitating the transfer of knowledge, ideas, and technology to society, and accelerate 'time-to-innovation' in order to achieve our national goals," and further notes that "(t)he federal government should continue to fund and expand research support mechanisms that promote collaboration and innovation" (National Research Council of the National Academies, 2012). (As part of this recommendation, the NRC notes that the federal government should implement new tax policies, including making the R&D tax credit permanent, that "incentivize business to develop partnerships with universities.") Additionally, the American Academy underscores the need for federal efforts to strengthen university-industry collaboration, noting that Congress should "consider legislation to remove lingering barriers to university-industry research cooperation" (American Academy of Arts & Sciences, 2014).

As described in the 2014 Brookings report, *The Rise of Innovation Districts*, regional innovation ecosystems are "synergistic relationship[s] between people, firms, and place (the physical geography of the district) that facilitates idea generation and commercialization" (Brookings Institution, 2014). The report further points out that while economic and physical assets are important, networking assets are at least as critical, and that an important step in creating innovation districts is to build a collaborative leadership network. Congress should consider policy models focused on fostering the leadership networks without which the other critical elements cannot and will not fall into place.

Universities and other higher education institutions frequently play a convening role for such networks. They bring core assets and innovation economy infrastructure (from labs to classrooms), and help to build connections between and among other innovation network nodes. One example of this dynamic comes in the form of what the National Governors Association has called "institutes for collaboration"—facilities that house assets from multiple universities and industry partners in the same physical space and have a catalytic effect on not only technology development but also stimulation of innovation networks. Examples of such institutes for collaboration include the Commonwealth Center for Advanced Manufacturing (CCAM) in Virginia, Clemson University International Center for Automotive Research (CU-ICAR) in South Carolina, California Institute for Quantitative Biosciences (QB3) in California, and Oregon Nanosciences and Microtechnologies Institute (ONAMI) in Oregon. The NNMI model is essentially an "institutes for collaboration" strategy, and this approach can and should be extended across industry sectors and beyond manufacturing.

Policy models that support institutes for collaboration could be central to innovation district strategies. Programs that require collaboration between universities and industry, and involvement

of economic developers, could also help. Policy strategies to promote innovation districts and measure their success should include the extent to which a network has been established and whether the network has undertaken new efforts. If policies focus only on the intended outputs and outcomes of such networks and do not also value the networks and interactions themselves as important inputs needed to reach intended outcomes, it will be difficult to achieve success in policy implementation.

The i6 Challenge from the Economic Development Administration (EDA) is a good example of how the Federal Government can foster regional innovation ecosystems. The program is modeled after successful university strategies—specifically the Massachusetts Institute of Technology Deshpande Center for Technological Innovation and the von Liebig Center at the University of California, San Diego School of Engineering—that focus on proof of concept work as central to success in regional innovation and entrepreneurship. Programs supported by i6 increase and deepen partnerships between institutions of higher education, industry partners, and economic developers, helping to establish the innovation networks that form the backbone of regional innovation ecosystems.

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