Charting a New Course to Health and Wellbeing

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Executive Summary

Health is more than simply the absence of disease, and integrated efforts that harness a broad range of knowledge and capabilities must be invested to address major societal challenges in healthcare and wellbeing. The U.S. spends more than any other nation on healthcare, but has poorer outcomes in life expectancy, maternal/infant outcomes, and obesity and diet-related disease than any comparator country. The discrepancy between health care spending and health outcomes reflects the growing research demonstrating that research in basic biology, medical therapies, and the social and economic contexts in which they function – including time and place, our own behaviors, and the physical environment around us – are needed to improve health outcomes.[1] Berkeley excels in numerous areas and fields necessary to make progress in these areas – including biology, neuroscience, engineering, data sciences, public health, social welfare, public policy, law, economics, and business – and we propose programs to address three major societal issues for which Berkeley has a critical mass of highly integrated expertise and capabilities.

First, the production and consumption of food is central to people's and societies' abilities to survive and grow, and there are major challenges in our global food systems. Agriculture is responsible for 30% of global greenhouse gas emissions, and our food production systems are vulnerable to climate change. In addition, current imbalances in our food production systems contribute to cardiovascular and other diet-related disease, and food insecurity is a major problem within our country and worldwide. We propose a program that spans multiple departments, colleges, schools, and programs to research and, through numerous partnerships, begin to implement technology, education, and policy solutions for these challenges.

In addition to our Transforming Food Systems theme, which impacts health and wellbeing throughout our lifespans, we have focused on two issues that impact society during specific periods of human life. A healthy childhood and adolescence places children on a path to healthy adulthood, and conversely exposure to various stresses during childhood development lead to a range of health problems, both biological and psychological. Our Healthy Development from Infancy through Adolescence theme integrates biology, psychology, education, public health, social welfare, public policy, data sciences, and business to develop evidence based programs that will interface with a broad range of partners – from K-

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[1] For background on health care, health outcomes, and health equity, see:

McGovern L, Miller G, Hughes-Cromwick P. The relative contribution of multiple determinants to health. *Health Affairs*: Health Policy Brief. 21 August 2014.

Dickman SL, Himmelstein DU, Woolhandler S. Inequality and the health-care system in the USA. *The Lancet*. 2017;389(10077):1431-1441.

Kones R, Rumana U. Cultural primer for cardiometabolic health: health disparities, structural factors, community, pathways to improvement, and clinical applications. *Postgraduate Medicine*. 2018;130(2):200-221.

12 education to community-based organizations – to implement changes in medical, educational, and social welfare resources that benefit child development during two particularly critical phases, early childhood and adolescence.

Finally, maintaining healthy cognitive function as we age is a critical goal for individuals, communities, and nations, especially as many regions of the world are faced with aging populations. Unfortunately, age-related neurodegenerative diseases and conditions such as Alzheimer's, Parkinson's, stroke, and dementia are major problems that greatly impact individual quality of life and societal healthcare resources. We propose a theme in Charting a New Course for Neurodegeneration & Aging that will bridge efforts in basic biology, neuroscience, chemistry, cell and genomic therapies, psychology, data sciences, economics, and social welfare to understand the biological and societal factors that promote healthy aging, advance our basic biological knowledge of neurodegenerative disease, translate this knowledge towards the development of new diagnostics and therapies, and develop more fulfilling ways to care for our aging citizens.

Finally, an overarching and supporting domain where Berkeley's excellence can be further strengthened is in the use of data for health. Exponentially growing data and computational innovation offer transformative opportunities for enhancing health and wellbeing. However, these data create profound ethical risks including health disparities and privacy concerns. Burgeoning data come from sources as varied as genome sequencing, electronic health records, wearables sensors, and environmental monitoring. Yet these data are currently often in distinct silos, impeding effective use. We propose supporting and uniting Berkeley's strengths in computer science, statistics, biology, public health, and engineering to develop novel approaches for collecting, analyzing, and interpreting these data to advance public health, medical care, and broader wellbeing. This work will be married to efforts to ensure the effective and ethical use of these data, drawing on expertise in economics and business, anthropology, sociology, psychology, law, public policy, social welfare, and rhetoric. These communities will enable responsible collection, stewardship, analysis, and application of data to prevent dignitary harm, with a goal of surmounting existing disparities and supporting wellness equity at all stages of the data use cycle. Berkeley has outstanding strengths addressing all aspects of these opportunities; synergizing expertise transcending boundaries across the campus in Data for Health offers unparalleled potential.

By integrating our world-class education and research programs, and leveraging our partnerships with other institutions in the Bay Area, California, and worldwide, our campus is poised to address these major societal challenges and advance human health and wellbeing.

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Theme 1: A Sustainable and Equitable Food System for People and the Planet

Societal Challenge
Food production and consumption are vital for human existence, yet the predominant global food systems are implicated in some of the most challenging problems of our time. Agriculture is a major contributor to **climate change,** emitting 30% of global greenhouse gases, *second only to the fossil fuel industry,* and using 70% of all available water. How we grow food, including overuse and improper use of pesticides and fertilizers, **harms human health** and leads to **environmental degradation and pollution**. Our current food system perpetuates **food insecurity and hunger**: while 30% of food produced globally is lost or wasted, millions of households in the U.S. are food insecure, and nearly a billion people in the world are chronically undernourished. Climate change and increases in the global population will further constrain food resources by 2050. The current food system, with corporate consolidation in many market segments and perverse economic incentives, is implicated in massive increases in **diet-related diseases, including heart disease, cancer, obesity and diabetes**.

All of these challenges do, and will, disrupt billions of lives. They also disproportionately affect the most vulnerable among us. It has never been more urgent to create sustainable and equitable food systems for people and the planet.

Berkeley's breadth of expertise – from genetic engineering to regenerative agriculture to food policy and labor movements – allows us to leverage basic, applied, and translational research to create a more sustainable our food system. Basic research to identify techniques that increase the drought-tolerance and yield of crops; research on policies that are most effective in incentivizing adoption of climate-healthy agriculture; and translational research to identify the means of distributing and encouraging a healthy and sustainable diet among consumers. Further, our strengths allow us to create interdisciplinary, cross-campus learning environments for undergraduate and graduate students.

How we will address this topic
To achieve greater than incremental change, we will bring key stakeholders together to pursue four major approaches to transforming the food system. **First**, we will combine innovations in basic and applied research across the food system to *study their interactive, system-level effects. Basic scientific research, which aims to uncover fundamental principles about the natural world, draws top scholars to UC Berkeley and fuels the California economy.* **Second**, *we will translate research findings into policies* that support a sustainable and equitable food system. **Third**, we will train the next generation of leaders in food systems, creating a multi-disciplinary network of practitioners and researchers who will continue to work for equity and sustainability in the food system. **Lastly**, we will support our incredibly innovative undergraduate and graduate students in transforming the food system through social movements and through values-based business approaches that put the health of people and the planet first.

Within these major approaches to transforming the food system, there are a number of specific strategies we will pursue:
- Expand the Innovative Genomics Institute's research on **high-yield, drought-tolerant and disease/pest-resistant crops** while improving efficiency of food distribution **to ensure equitable access to food.**
- Applied research to inform **policies across the food system that incentivize sustainable agricultural practices** such as certified organic, integrated pest management, diversified farming, and soil health for carbon sequestration.
- Partner with organizations driving the growth of value-based food supply chains (e.g., organizations that support public institutions in using their buying power to promote sustainably

and ethically produced foods) to determine their effects on: **demand for sustainably-sourced foods; health of local economies; changes in fair labor practices; accessibility of healthy foods** in marginalized communities; and **nutritional value of foods served by public institutions** (e.g. hospitals, schools, and prisons).

- In partnership with national (e.g., Partnership for a Healthier America) and international (e.g., the UN's FAO/UNEP) organizations, facilitate development and rigorously evaluate the effect of incentive and disincentive structures to increase procurement of sustainably-sourced foods by **major corporations in the food industry**.
- Convene stakeholders and facilitate the creation of **networks to increase demand for sustainably-sourced foods.**
- Establish or partner with one major sustainable and equitable food research and innovation center in those geographies whose food systems will need to rapidly transform to feed growing populations and to respond to climate change -- Latin America, sub-Saharan Africa, Southeast Asia.
- **Expand experiential learning opportunities** for students, including on UC farms, with novel extension and community engagement around urban and peri-urban food systems. Work with K-12 pipeline institutions to ensure that all students are prepared and have access to advanced training in food systems at the university level.

Why Berkeley?
UC Berkeley is poised to undertake innovative and transdisciplinary, systems-level work that will bring the most recent social and scientific advances to bear on the food system. Unlike private universities working in this space, Berkeley brings a more diverse student body, including many students from agricultural communities. California, a biodiversity hotspot from an ecological perspective, is the major agricultural producer for the nation and the world, contributing most of what people are "supposed" to be eating (fruits, vegetables, nuts). This gives us ready access to producers and suppliers. Berkeley is also a land grant university with close stakeholder connections through Cooperative Extension.

Berkeley, historically the largest driver of state law in Sacramento, has **deep expertise in translating research into policy**. We are a learning lab for governments that want to implement sustainable solutions to environmental, health, and other challenges. Our proximity to Silicon Valley gives us ample access to partners at the cutting edge of technology and our urban location allows us to explore possibilities of urban food production as a cleaner, more self-sufficient solution for the world's rapidly growing urban populations.

Berkeley has a **breadth and depth of expertise** across the food system that is unparalleled by other universities. Berkeley faculty are world-renowned for their research, from the development of CRISPR technologies to sequestering carbon in soil to creating policy that promotes economic, racial, gender, and other forms of social equity.

Importantly, the Berkeley Food Institute (BFI), a partnership of 7 Colleges and Schools across campus working to tackle challenges in the food system, provides **proof-of-concept for collaborative engagement across the food system**. BFI has supported cross-department collaborative research in soil health, diversified farming, food policy, food insecurity, and health equity.

Rethinking our educational mission at Berkeley, BFI created a Food Systems Minor and a Graduate Certificate in Food Systems in the last 5 years. BFI also prioritizes partnerships with community stakeholders across the food system, including UC farms, governmental bodies and non-governmental

organizations, multiple school districts and departments of health, and small and mid-size farmers.

Student support
In the first two years of its existence, the core course for the graduate Food Systems certificate has brought together students from Geography, Anthropology, Policy, Business, Natural Resources, Public Health, Engineering, and Journalism, among others. We will take advantage of the existing infrastructure of the graduate certificate and the undergraduate minor in Food Systems to expand the current offerings to include hands-on learning experiences in agricultural, business, and policy settings related to the food system.

Impact in 5-10 Years
Pursuing our four major approaches to transforming the food system, we can have major impacts in 5 to 10 years. With respect to how we grow foods, organic foods currently make up less than 4% of foods sold, and only a small fraction of farmers use sustainable techniques. We believe that our concerted efforts in research, policy and social movements can double the amount of sustainably produced food (including methods that sequester carbon in soil) and organic food in California in 5-10 years, which will mitigate the impact of food systems on climate change.

From a policy perspective, building on Berkeley's inclusive leadership, we believe we can change the Farm Bill (the major legislation related to the food system) to include sustainable agriculture, which is currently almost entirely left out of the Farm Bill. The Farm Bill is also a critical policy lever to ensure access to healthier foods for low-income youth and families, and we believe we can ensure stronger policies in this arena.

In partnership with existing national organizations, we can double the amount of whole and unprocessed foods served by major U.S. institutions (schools, hospitals, and prisons), which both expands the market for more sustainable foods and improves the health of our nation's youth.

Improving the food system globally is critical to ensure food security, reduce diet-related disease, and to protect our planet. By supporting or enhancing the development of sustainable and equitable food research and innovation centers in Latin America, sub-Saharan Africa, Southeast Asia, we can have global impact. Over the next 5-10 years, we expect to form strong working relationships and establish international standards for sustainable and equitable food systems.

Resources
We will continue to convene a critical mass of approximately 25 faculty across campus to move this signature initiative forward. Approximately 10 additional faculty FTE will be sought with expertise in sustainable and efficient agricultural practice, food equity, the political economy of the food system, the food supply chain, and agent-based modeling. This is an important opportunity to bring in **Professors of Practice, with real-world experience in the food system**. We would seek support for research seed funding for new projects, and potentially for shared research facilities. We would also seek funds for PhD and postdoctoral training in domains across the food system. Because outreach to the broader community and the national discourse is essential, additional funds could support meetings, discussion panels, Community Advisory Boards, etc.

Campus Entities Involved
- Center for Entrepreneurship & Technology
- Center for Law, Energy & the Environment (CLEE)
- Center for Responsible Business
- Berkeley Food Institute
- Innovative Genomics Institute (IGI)
- Berkeley Water Center
- California Institute for Energy and Environment
- Climate Readiness Institute
- Center for Environmental Design Research
- Center for Environmental Research and Children's Health (CERCH)
- Nutrition Sciences and Toxicology and Dietetics credentialing program
- CGIAR Research Centers

[Note: this theme has potential strong overlap with the Environmental Change, Sustainability and Justice Working Group]

Theme 2: Healthy Development from Infancy through Adolescence

Societal Challenge
There is strong scientific evidence that a wide range of adult health conditions, from obesity and auto-immune disease to psychopathologies, have antecedents in earlier phases of the life course. In addition to the prenatal period, early childhood and adolescence appear to be particularly crucial periods, involving both special vulnerabilities and offering unique opportunities to shape adult health and well-being. Exposure to early developmental stressors (from environmental toxins to adverse experiences) sets a life trajectory that can be difficult to alter; growing evidence also suggests that certain stressors during adolescence can be especially consequential. Yet early and/or well-timed interventions, such as economic transfers, high-quality preschool, or enriched parenting, have been shown to set trajectories for health and well-being later in life.

We know more today about healthy development than ever before. Berkeley scientists are making strides that inform the treatment of pediatric cancers, the prevention of infectious diseases in childhood, and uncovering how immune activation may be implicated in the development of autism, and roles the microbiome plays in shaping child health trajectories. Yet there are still significant challenges in both understanding the nuanced interplay of factors that shape healthy development and implementing effective policies and programs to promote the health and well-being of children and adolescents and their transition to healthy adulthood. One scientific challenge is that development is intrinsically interactive and multi-causal – genetic, biological, cognitive, familial, social, and environmental factors are deeply intertwined. A second scientific challenge is that children in different developmental periods are, by their very nature, different from one another - an infant, a preschooler and an adolescent are profoundly different creatures, with different strengths and vulnerabilities. Although there is strong evidence that childhood and adolescence are intrinsically "plastic" periods, this plasticity plays out in different periods and domains in different ways - the visual or immune system may be particularly vulnerable in infancy, for example, while social and sexual development are particularly strongly shaped in adolescence. We see great promise in leveraging diverse research findings across disciplines to hone the timing and targeting of prevention and interventions in childhood to disrupt disease and potently shape immediate and future health.

Too often, children's destiny is shaped by the neighborhood in which they were born, their parent's economic vulnerability, their race or ethnicity, or their sexual or gender identity. These features of U.S. family and community life result in marked inequalities of opportunity, experience, and outcomes. Thus, the policy challenge is that environmental contexts and systems that support healthy development are not contained in health, educational or social welfare institutions in isolation. Cultivating health and wellbeing across development requires meaningful interactions between health, education, welfare and justice systems, and the families embedded in and across these systems. However, few existing early childhood programs or wellness approaches for adolescents potently integrate multiple systems and sectors.

Beyond integration across these systems charged to serve children and youth, many barriers to child and adolescent health and well-being are entrenched within locations, public and private sector organizations, institutions, complex political environments, and reflect unequal distribution of economic resources. For example, asthma and other chronic diseases disproportionately affect lower-income communities, which in turn undermine children's school attendance and success. Crucially, children and adolescents are the most vulnerable to and least buffered from direct experiences of poverty, inequality, and violence. Social inequalities impact not only early brain development, but also social success, educational and occupational attainment, and health and well-being across the lifespan.

There are multiple urgent crises for healthy development in the U.S. and beyond that require our best

integration of cross-disciplinary scientific thinking with the expertise of cross-sector policymakers and practitioners -- as well as families and youth themselves. For example, the recent skyrocketing rise in childhood obesity, with its profound risk to later health, takes place in the context of complex interactions between individuals, families and environments, such as unequal access to healthy foods and safe recreation spaces. Similarly, the increasing emphasis on universal preschool and early childhood programs, such as the proposed State of California preschool effort, raise important questions about just what developmentally appropriate programs should be like. Another key question worldwide is the impact, for good and ill, of digital technology on the development of children and adolescents, with strong intersections with private sector technology companies, legal privacy issues, and educational stakeholders.

How we will address this topic
Building on Berkeley's historical intellectual strengths, we propose a robust, innovative, transdisciplinary, and community-engaged approach to tackle these challenges.

There is an exciting opportunity at UC Berkeley to promote local and global impact through integrative developmental science – with trans-disciplinary and community integrated teams – focusing in particular on key developmental windows of: a) early childhood and learning and b) adolescence. This impact will be achieved by bridging from basic science to the development, testing and implementation of well-timed interventions and policy innovations in critical familial and social environments to improve development trajectories and reduce inequalities.

We will develop and rigorously assess novel interventions and policies building on the rapid progress that has been made in understanding brain plasticity and environmental impacts in later childhood and adolescence through the following initiatives:

- Create research clusters for faculty, students and trainees to learn in trans-disciplinary teams. Research hubs of allied scholars will scaffold mentoring of graduate and undergraduate students to leverage cutting edge developmental, health, and social science to develop innovations relevant to school, health, and social service settings.
- Expand new faculty networks and initiatives focused on adolescent health and wellbeing (e.g. the Center for the Developing Adolescent and Innovations for Youth (I4Y).
- Implement Berkeley Engaged to build a sustained infrastructure for Research-Practice Partnerships to create "two-way streets" to capitalize on and formally "network" existing relationships between Berkeley faculty and key partners locally, in California, and beyond.
- Develop interdisciplinary undergraduate minors focused on areas such as early child development and context, addressing students' enthusiasm to learn for real-world impact. Interdisciplinary minors that connect the social sciences and professional schools would offer opportunities for students to learn basic science with implications for education, public health, public policy, journalism, and social welfare.
- Develop the Early Childhood Education (ECE) programs at Berkeley as vibrant laboratories for positive interventions and research.

Why Berkeley?
- Berkeley has played an historic role-- through institutions such as the Institute of Human Development, the Harold E. Jones Child Study Center, and the federally-funded Center of Excellence in Maternal, Child, and Adolescent Health-- in developing knowledge and interventions that span the life course, and is emerging as a national and international leader in

both early childhood and adolescent development. This represents a unique strength beyond other peer universities such as Harvard that lead primarily on child development.

● Medical schools dominate the health research landscape, but the broad multidisciplinary perspective of our top arts and sciences campus with strong professional schools allows us to address the 80% of health determinants that are "social" and "behavioral" rather than medical, especially as one of the only universities with a School of Public Health (SPH) embedded within the general campus. We are particularly well-poised for this integration given that our SPH founded and leads in the social epidemiology field.

● Berkeley enjoys top-ranked departments across disciplines and professional schools expert in health and development across the life-span. We have world-class scholars in immunology, genetics, infectious disease, biology, neuroscience, social epidemiology, and psychology who are at the forefront of scientific breakthroughs in understanding the role of place, race, family, neighborhood, and environmental impacts on development. Researchers in professional schools (Education, Public Health, Social Welfare, Public Policy, and Haas) are leaders in advancing novel interventions to promote healthy development and interrupt systems and structures that contribute to unequal developmental supports.

● Berkeley is host to current initiatives that build on the science of adolescence (e.g., Innovations for Youth (I4Y)); big data (e.g., California Child Welfare Indicators Project); partnerships with local communities, school districts, and service systems (e.g., Bay Area Social Services Consortium, CalPrep, Research-Practice Partnerships with local school districts, YPLAN); campus-based early childhood education programs; the summer minor in The Developing Child; and the Early Development and Learning Science program in the Institute of Human Development.

● Our location and relationships provide ripe opportunities for Berkeley to lead on urgent issues of technology and the development of children and adolescents, and partner with private sector Silicon Valley stakeholders as well as non-profit sector legal and advocacy groups (e.g. ACLU, Electronic Frontier Foundation, Commonsense Media) concerned with the impact of technologies on rights and development. Berkeley faculty are international experts on these issues yet Berkeley has no organized scientific or translational policy- and community-partnered effort in this domain.

Impact in 5-10 Years

● Berkeley is immediately poised to play significant roles in shaping the course of child and adolescent policy developments unfolding locally in California and globally. For example,
  ○ We expect transformative changes in education policy in California, particularly public transitional kindergarten and other public preschool offerings. This provides a unique opportunity for Berkeley to be directly involved in shaping these policies in a way that reflects the best science and scholarship.
  ○ California recently initiated a groundbreaking Local Control Funding Formula for K-12 education intended to promote equitable opportunities for the most marginalized students (e.g. English language learners, foster youth) *and* mandates family and student participation in budgeting. Yet implementation varies widely with no systematic approach. Deep collaborative work with K-12 education partners statewide would help to

fulfill the promise of systematic stakeholder participation and achieve more equitable educational outcomes and success for all of California's young people.

- In 5 years, Berkeley will be recognized as the international leader for research and mentored training for developmentally-informed, community-and policy-relevant research that promotes children's health and wellbeing. We will have established productive and sustained research partnerships with industry, government, and nonprofit sectors around the world. We will be able to point to specific examples of how research-informed efforts by Berkeley scholars and trainees are making a difference to address specific real-world problems concerning healthy development for all.
- In 10 years, these partnerships will be fully integrated into the faculty-student-alumni experience of Berkeley – an experience that continues beyond the degree as graduates continue to participate in the programs as partners in their new workplaces.

Resources Needed
Berkeley currently possesses numerous assets that provide proof of concept of our great capacity for transdisciplinary and impactful work on healthy development. However, these efforts occur independently, without sustained sources of funding or infrastructure, do not fully leverage opportunities to bridge research programs across campus, and do not capitalize on the significant networks with community partners that are naturally occurring on campus. We are at a critical inflection point where these initiatives can be coalesced and synergized with the right supports.

- Cluster FTE positions at the intersection of life course development and the structures and systems that promote well-being including education, health, social services, and law.
- FTE positions explicitly designed to bridge disciplines (e.g. education and public health, social welfare and neuroscience)
- FTE positions focused on dysregulation of immune activation and brain development and interactions between the microbiome and immune function in early developmental periods.
- Build on the new Berkeley Way West "Healthy Futures" theme across Psychology, Public Health (SPH), and Education (GSE) through expanded funding for graduate student research assistantships; postdoctoral fellows, and faculty to catalyze cross-unit professional school and Arts and Sciences cross-training and research collaboration.
- Initiate a large-scale fellowship training program for doctoral students and undergraduates to support transdisciplinary science related to child and adolescent well-being and development. Building on the new Youth Equity Scholars (YES) model supported by the VCRO, utilize the fellowship to scaffold mentoring for undergraduates as a signature Berkeley "discovery" experience.
- Expand funding for infrastructure, FTE's, staff, and greatly expanded community- and policy-engaged funding opportunities building on the Chancellor's Community Partnership model. Transdisciplinary efforts require sustained support for collaboration among faculty - including funding for faculty and students to work together over time and to engage meaningfully with external stakeholders. These opportunities will serve as proof of concept for UC-Berkeley as providing leadership in working collaboratively with key stakeholders (policy-makers, practitioners, philanthropy, and youth and families) across sectors to promote healthy development for all.

- Funding to support training/retraining for community-based practitioners and policy makers engaged in local and state-wide efforts to promote child and adolescent health and well-being
- Transform the current ECE programs into a sustainable locus of research and training
    - Funding to expand and implement currently formulated and successful pilot Early Childhood programs/ projects.
    - Create a FTE position that focuses on, early childhood development and education

Theme 3: Charting a New Course for Neurodegeneration & Aging

Societal Challenge
Maintaining healthy cognitive function as we age is a critical goal for individuals, communities, and nations faced with aging populations. Age-related neurodegenerative disorders, including Alzheimer's Disease (AD) and Parkinson's Disease, are a major societal health burden, currently affecting 7 million people in the US. By 2050, as many as 20% of Americans will be over age 65, and the number of patients with AD is expected to reach 14 million. AD is estimated to cost the US over $277 billion in 2018, including the cost of family-based caregiving, and over $1 trillion globally. Yet there is currently no effective cure for AD, no definitive diagnostic test, poor understanding of the biological causes and early-life risk factors, and few assistive technologies for cognitive impairment. The same is true for most other aging-associated disorders, including cardiovascular disease, arthritis, and diabetes. Moreover, American society generally lacks a model of healthy, value-added aging, and most communities are poorly set up to manage long-term age-associated decline. These societal issues increase the burden for the elderly, patients, and families.

A key scientific challenge is the unsolved riddle of age-associated disease processes. As a key example, neurodegenerative diseases are thought to be caused by abnormally folded proteins that accumulate as toxic aggregates, which somehow cause brain cells and synapses to progressively deteriorate, causing memory impairment, loss of ability to think clearly or walk independently, and ultimately, death. But why this happens, and how to stop it, remain unknown. For Alzheimer's, 20 years of medical research has focused on one hypothesis: that amyloid protein is the causative toxic agent. But despite multiple clinical trials and millions of dollars spent, no effective therapy has emerged. A new approach is needed that involves more innovative research on disease mechanisms. Diagnostic methods are also needed to detect Alzheimer's before substantial and irreversible neuron loss has occurred. By the time cognitive decline has begun, it may already be too late.

There are also public health and societal challenges. We must understand how early interplay between social factors and genes guide brain and cognitive development, and how these factors tie into later risk for neurodegenerative disease. We must understand how ongoing risk factors like diabetes and hypertension increase disease risk. We need better ways to support people experiencing cognitive impairment. This includes assistive technologies (ranging from "user friendly" mobile assistive applications to possible brain-machine interfaces to assist memory), music or dance therapy, and emotional and social support. We must understand how age-related disorders impact our communities, and how we could reimagine communities to better support patients and families. We must explore how the positive features of aging, such as the capacity for nurturing younger people and increased happiness and wisdom, can be encouraged and leveraged to ameliorate the negative consequences of aging.

The goal of this initiative is to radically improve health during aging, with a focus on innovative approaches to neurodegenerative disorders and age-related cognitive decline. We must bring together Berkeley's great strengths in biology, chemistry, genomics and neuroscience, which can study disease mechanism and identify new targets for treatment, with our deep expertise in public health, psychology, engineering, and social science. Together we can:
- Identify the basic biological causes of age-associated disease
- Seek promising new avenues for therapy
- Pioneer new methods for early diagnosis
- Better understand the biological and social factors, including early- and mid-life factors, that promote healthy cognitive aging, or that predispose to age-related cognitive disorders.

- Raise public health awareness of risk factors for neurodegeneration in order to improve brain health across the lifespan. For Alzheimer's, reducing the risk factors of hypertension, diabetes, obesity, and smoking could delay onset of AD by 2-5 years, which would reduce overall AD prevalence by 30%.
- Develop assistive technologies for cognitive decline, better diagnosis and patient safety.
- Expand community options for non-medical approaches including music, art, and social support for cognitive impairment.
- Understand and improve social and community influences, such as the built environment, on age-related cognitive decline.

How we will address this topic

We will establish a multi-pronged, multidisciplinary, cross-campus initiative on Neurodegeneration & Aging that leverages Berkeley's great strengths across biology, psychology, neuroscience, chemistry, vision science, public health, engineering, economics, social welfare, data science, and beyond. The goal is to pioneer radical new approaches to understand both healthy aging and neurodegenerative disease.

To accomplish this goal, we will build 6-8 self-organized networks of faculty around shared research themes. One network could focus on protein folding, aggregation, and cell health, including applying recent Berkeley discoveries to harness cells' natural protein breakdown pathways to reduce the levels of disease-related proteins. A second network could focus on neural circuit and synapse function in aging and neurodegenerative disease, including brain imaging biomarkers and genetic risk factors for early diagnosis. Another could study the role of immunology and inflammation in the disease process. A fourth could focus on neurodegenerative diseases of the retina, which are leading causes of blindness and allow neuroprotection and neuroregeneration strategies to be tested effectively. A fifth would study early life and social influences on healthy cognitive aging, including childhood, community, and social disparities. A sixth would build a public health program to improve brain health throughout the lifespan. A seventh would develop assistive technologies for cognitive impairment. An eighth network could study sociological aspects of aging, including community and economic impacts, ethics, and how communities may be improved to better handle aging and cognitive decline.

Importantly, the biological research networks will have access to rapid development of both gene editing tools and genetic diagnostics by the Innovative Genomics Institute (IGI). This enables us to create a rapid research-to-translation pipeline in which promising biological discoveries can be used to generate genetic tools designed to correct molecular problems in neurodegeneration. In parallel, the UCB Drug Discovery Center within with Center for Emerging and Neglected Disease (CEND) execute screens to identify molecules to modulate newly-identified targets, providing validated starting points for development of novel therapies. These tools will be used in basic research and in preclinical studies to test for safety, greatly speeding the identification of promising therapeutic approaches.

These are suggested networks based on existing faculty research at Berkeley. Berkeley has remarkable strength in in these areas, with many labs and research teams already performing innovative research related to neurodegeneration. The actual networks that form will be based on the most exciting shared research questions, and will evolve as research progresses. Large-scale coordination across networks will be achieved by broad, cross-network discussions, meetings, and public events, and by integrated education and training for undergraduates, graduate students, and postdoctoral scientists.

Through this approach, we will:
- Perform innovative research into the fundamental biology of age-associated diseases, including the causes of organismal aging, age-related cognitive, sensory, and motor impairment.

- Seek potential therapeutic interventions, including by creating a research-to-translation pipeline based on CRISPR-based gene editing, gene therapy and gene delivery tools, and stem cell therapies.
- Invent new methods for early diagnosis of disease prior to symptom onset, including CRISPR-based genetic diagnostics as well as imaging technologies.
- Build a multi-disciplinary understanding of healthy cognitive aging from biological, psychological, and sociological perspectives.
- Identify early-life factors that predict healthy cognitive aging, neurodegenerative disease, and cognitive decline. Implement public health innovations to raise awareness of these risk factors and reduce incidence of neurodegenerative disorders.
- Develop assistive technologies to help patients compensate for memory and cognitive challenges, to improve diagnosis, and to increase patient safety.
- Study and implement non-medical approaches (music, dance, social, and emotional support) to offset age-related cognitive decline.
- Understand societal and economic impacts of age-related cognitive decline, and plan healthy communities that better incorporate aging adults as contributing members.

This initiative will extend existing campus efforts to integrate research across disciplines, including HWNI and the Berkeley Brain Initiative. It will expand partnerships to include centers such as the Osher Lifelong Learning Institute, the Center on the Economics and Demography of Aging, CITRIS, and the Innovative Genomics Institute (IGI). It will also link with efforts to build an intercampus 'NeuroHub' with UCSF, LBNL, and LLNL to leverage clinical data and perspectives. The research networks will integrate Data Science at all levels.

Alongside this research program, we will implement an integrated, cross-disciplinary educational and training program on Biology, Psychology, and Sociology of Aging for undergraduates, graduate students, and postdoctoral scientists. We envision undergraduate and graduate classes that include broad biological, psychological, public health and societal perspectives of these issues, mentored research experiences for undergraduates, and seminar series for all trainees that provide broad exposure to current research and social perspectives.

Why Berkeley?
Overcoming the challenge of neurodegeneration and aging involves much more than drug development or new diagnostics. Berkeley brings together broad, unique and world-class talent in innovative basic biology (cell biology, protein biochemistry, neuroscience, genetics, molecular tool development, retinal biology), in brain imaging, in psychology, public health, engineering, computer science, demography and economics, the arts, and social welfare. No other US university offers this breadth of disciplines, operating at Berkeley's level of excellence. We believe strongly that the new ideas and approaches that will transform our understanding of the brain, the process of aging, and how to slow the pace of degeneration, will come from advances in basic science, engineering, and data analysis - areas in which Berkeley excels. We are not hampered with not having a medical school—in fact our lack of a medical focus frees us to innovate and think differently, and harness new ideas from unlikely places that would be drowned out in a medical setting.

- We can seek new biological causes using innovative technologies and approaches.
- We can invent new assistive technologies that benefit patients and caregivers.
- We can develop molecular, genetic, and stem cell tools to treat and prevent disease.

- We can combine biological discovery with the IGI's diagnostic and gene editing tools to rapidly identify promising new therapeutic approaches for translation in humans.
- We can leverage data science expertise to enhance research of complex problems, and target new areas for research.
- We can leverage Berkeley's status as a top national recipient of federal BRAIN Initiative awards, UCB/UCSF NeuroHub, and off-campus partnerships with LBNL, LLNL, and UCSF in neurotechnology, computation and protein biology.
- We can launch public health campaigns to identify disease risks and reduce them.
- We can determine how early-life and social factors affect successful cognitive aging.
- We can help communities to improve support for patients with cognitive impairment.
- We can define new, holistic views of healthy aging.

Coupling biological investigation with equally strong efforts in these other areas builds on our great strengths at Berkeley, and is only possible here.

Impact in 5-10 Years
We imagine several concrete goals:
- To delay the onset of cognitive decline in neurodegenerative disease by 2-3 years, which would for example reduce the prevalence of AD by 30%. This will be achieved primarily through public health interventions.
- To discover new causes for neurodegenerative disorders that suggest new avenues for therapy, and new methods of early diagnosis. To test these using the vast biochemistry, small molecule screening / drug discovery, gene therapy, and gene editing expertise and resources at Berkeley. This will be achieved by basic biology, chemistry, neuroscience, drug discovery/translational science, engineering, and brain imaging research.
- To identify childhood health, social and educational practices that promote brain health and cognition throughout the lifespan.
- To establish an educational and training program on Biology, Psychology, and Sociology of Aging for undergraduates, graduate students, and postdoctoral scientists, that draws new talent into this area of critical societal need, and promotes new discovery.

Resources Needed
The research networks will be seeded by ~20 current Berkeley faculty. We would then seek to build them to even greater national prominence by adding up to 10 new FTEs (1-2 new faculty members per network), emphasizing the most novel and promising approaches. We would seek support for research seed funding for new projects, and potentially for shared research facilities to enhance translational science capabilities. We would also seek funds for PhD and postdoctoral training in aging, neurodegeneration, and cognitive impairment. Because outreach to the broader community and the national discourse is essential, additional funds could support meetings, discussion panels, outreach to public health professionals, etc. Support for an administrative director is also needed who would coordinate the many activities of the Initiative.

Campus Entities Involved
Departments
MCB, Helen Wills Neuroscience Institute, Psychology, Public Health, School of Optometry, IB, Chemistry, Bioengineering, School of Social Welfare, Economics, Chemical and Biomolecular Engineering, Computer Science and Electrical Engineering

Centers
Innovative Genomics Institute (IGI), Paul F. Glenn Center for Aging Research (UCB-UCSF), Center on the Economics and Demography of Aging, Center for Emerging or Neglected Diseases, CITRIS, Osher Center for Lifelong Learning UCB Drug Discovery Center (within CEND)
Selection of Relevant Berkeley Faculty
Bill Jagust** (Public Health), Bob Knight (Psychology), Ehud Isacoff (MCB), Randy Sheckman** (MCB), Susan Marqusee (MCB and QB3), Michael Rape (MCB), Andy Dillin** (MCB), Kaoru Saijo** (MCB), Daniela Kaufer** (IB), Peter Sudmant** (IB), Jack Gallant (Psychology), David Feinberg (HWNI), Danica Chen** (Nutritional Sciences & Toxicology), Robert Levenson (Psychology), Rich Ivry** (Psychology), Andrew Scharlach** (Social Welfare), Michael Shapira** (IB), Sylvia Bunge (Psychology), Linda Wilbrecht (Psychology), Chris Chang (Chemistry), David Schaffer** (CBE, BioE, MCB, HWNI), Will Dow** (Public Health), David Linderman** (CITRIS), Julia Schalesky (CEND), Sanjay Kumar (Bioengineering), Bin Yu (Statistics), Fyodor Urnov (MCB/IGI), Karsten Gronert** (Optometry), John Flannery** (Optometry), John Flanagan** (Optometry), Teresa Puthussery** (Optometry), Julia Schalesky (CEND)

*** substantial ongoing work on aging or neurodegeneration*

APPENDIX: Theme 4: Data for Health

*The following theme on **Data for Health** received strong support from the working group but was not originally developed beyond its first draft for various reasons. We welcome campus comment on the ideas.*

Societal Challenge
- Healthcare consumes a vast fraction of National and State resources in the US, both public and private, yet life expectancy dropped in the past year, and health outcomes are no better than in countries with substantially lower investment. Different approaches are needed to identify novel, and potentially lower cost interventions to treat and cure disease, and improve overall health and wellbeing. Insightful and effective use of **big data offers a compelling opportunity to develop such approaches**, which can synergize with and be incorporated into both existing and future public health and healthcare systems.
- Spurred by the exponential growth in computing power over the last 20 years, significant new sources of health-related data are now coming online, and growing at astonishing speed, including:
  - **Genetic sequence data** for individuals (today, one can sequence the full set of genes in a person for $200);
  - **Microbiome** genetic data and other large scale biological **omics technologies**;
  - **Electronic health records**, allowing ready analysis of an individual's personal history as well as broad analyses of vast virtual patient cohorts impossible to assemble into any specific study;
  - **Wearable sensors (mHealth)**, which provide ever more data about individuals, such as their location, activity & movement, environmental exposures, and increasingly other measurements (such as cardiac events);
  - **Social media and other electronic interactions**, which provide a vast trove of information about health and health-related behaviors.
- **Interpreting** these data and gaining health insights for health and wellness is challenging, requiring **synthesis of biology, computer science, public health, and medicine** – and critically drawing upon many other disciplines noted below.
  - New analytical approaches, computational methods, and validation systems must be created and deployed. We need to transform the knowledge derived from these data into

actionable interventions that benefit health and wellbeing. This goes beyond the medical reactionary model, and aims to inform approaches to **ongoing, and pervasive preventive care and public health**.

- How do we use these data make foundational **biological discoveries** and **advance understanding of human health** from the collected data?
    - **Environmental factors** make important contributions to health and have been historically challenging to capture, so we need to integrate the physical and social environment, both of which can be **now sampled with new tools.** These can be cross-referenced with **administrative data** including information about income, public program participation or education
- How do we **engineer systems** to collect and aggregate appropriate data in culturally sensitive, human-centered, and ethical ways to provide results to individuals and to clinical practitioners.
    - **These data are generally collected in silos,** limiting the ability to understand individual and population health, which we know arise from the relationships between different factors.
    - With data generation inexorably expanding, collection and interpretation much be designed to, to ensure that analysis does not inadvertently exacerbate inequities among populations.
    - We need to **overcome existing disparities**. For example, most genetic data come from individuals of European descent, meaning we cannot provide comparably effective interpretations for individuals with different backgrounds.
    - We need to **mitigate future inequity and disparities**, by enabling all people to have health-relevant data recorded and interpreted, to enable best health and wellness activities and interventions. How do we also support communities with this information? In addition to traditional disparities, there is particular **risk** but **potential for elderly** or and other vulnerable individuals could could be subject to misunderstanding, manipulation, or discrimination.
- Data for health raise a plethora of **ethical and equity considerations**, especially regarding privacy and autonomy.
    - How do we preserve individuals' **privacy** and autonomy, while also sharing data to enable both personal benefit and society-wide research? What is possible? What is desirable? What do people even want done with their data, and what do they not want to know? How to we provide responsible **stewardship** and develop appropriate levels of trust?
    - In the foreseeable future, parents will likely have the opportunity for their newborn baby (or even fetus) to be sequenced. How will this information be used?
    - **Personal health-related data** will be pervasive and its collection inexorable; what are the **risks** and how can these be managed? How do they alter our understandings of ourselves and humanity? What about people who don't want to know?
    - How do we develop **effective interventions** that support individuals in making the recommended activities that support their health and wellbeing?
    - How do we ensure that new diagnostics and tools, and opportunities for treatment based on diagnostic data, are **equally available** to all populations, including low-income and marginalized groups, homebound individuals, seniors, etc.?
    - How do **we educate the population** to make better use of the data they already have access to, and to understand new opportunities? And how do we transfer this into making informed health decisions?
- What are the **best economic and business models** for that will bring greatest **benefit to society**? (**econOMICS**) For example, should donors give data free to researchers? Should customers give data free (or even pay, per 23andMe) in exchange for information, as with the Facebook/Google model? Or could clients be provided royalties for their contributions (e.g., via blockchain

tracking)? World's largest companies pursuing this space. How do we **prevent** the natural tendency to winner-take-all **monopoly**, as exists already with electronic health records, that incur huge costs and stifle innovation?
- How will our health data impact our personal connections to doctors and caregivers, or surpass our own bodily intuition, and what are the implications of these changes?
- What type of policies will be relevant to a data centered health care system?

How we will address this topic
This initiative proposes to establish a new interdisciplinary focal point or 'hub' for the Berkeley campus, to drive the collection, curation and analysis of health-relevant data, to support robust new research to identify new pathways to improved health and wellbeing for individuals and populations. This effort will leverage data and expertise across biology, data science, public health and medicine, enriching research with intellectual contributions and data from a broad spectrum of departments and units across the social sciences, arts and humanities and the environment.

Through this effort, we will be able to:
- Research new ways to draw actionable interpretations for individuals from integrating disparate data, requiring new computational and biological methods and extensive further studies.
- Discover new biological mechanisms and thus potential therapeutic interventions from disparate data sources.
- Identify current and prospective sources of disparity and inequity and develop processes and policies to mitigate them. Generate new data from and for underrepresented groups.
- Develop an understanding of the ethical issues arising from the creation and use of data for health.

Key features will include:
- Fostering a community of data/health-oriented researchers, creating a gathering space for researchers, students and staff interested in (big) data and health to meet and exchange across disciplines and units
- Driving new research to mine existing data through seed grants and support for development of interdisciplinary research proposals to gather and analyze health-related data, and incorporate computational approaches into current research.
- Curating datasets: Developing capacity for structuring and curating current campus data into integrated datasets (e.g. microbiome, genomic, epidemiological and economic data) as well as helping researchers to identify and gain access to private and publicly-available datasets (UC joint medical record data, medicare/health financing data, department of health, etc).
- Driving development of tools and algorithms to collect and analyze data.
- Supporting training and education to help faculty and students integrate computational approaches into their research.
- Developing a code of ethics for the collection and stewardship of health-related data to reduce introduction of bias and avoid dignitary harm; advocate for the adoption of similar policies by broader society.
- Supporting translation of findings into policy and practice.

Why Berkeley?
- Understanding the multifaceted nature of disease (and health) using rich data requires an interdisciplinary approach and the ability to learn from and implement solutions across a multitude of settings. It is critical that this endeavor move well beyond disease-specific or even clinical setting or clinical trial-based solutions.
- Berkeley is home to a broad array of leading researchers working on understanding fundamental questions in data science, biological discovery, and their synthesis. Many of these researchers are

also pioneers in addressing the equally-essential areas of addressing public health and disparity, ethical dilemmas and legal ramifications of privacy and data sharing, as well as policy development, economic and business models to see data for health deployed most effectively. **No other institution combines the diversity of strengths necessary to best address these challenges. Berkeley is at the very top in the critical disciplines and has a history of fostering interdisciplinary approaches.**

- Berkeley is also uniquely well positioned to develop the approaches, statistical methods and data protection and ethical frameworks needed to assess efficacy using population data.
- Berkeley is also the ideal place to understand the whole person in the context of health. Personalized or precision medicine, an exciting area, has primarily focused on understanding specific biomedical markers as they relate to health conditions and treatments. While this is a necessary endeavor, truly personalized medicine requires both an understanding of biomedical/genetic pathways, as well as individual behaviors and social and economic factors that influence disease and treatment. Put simply, personalizing a treatment may require an understanding of an individual's genes -- but it also requires understanding whether that person is in a position to actually take their medication once it is identified.

Campus Entities Involved

Integration of biology, computer/data science, ethics, policy, public health, law, statistics, economics, digital humanities, business and law. This draws upon Department of Integrative Biology, Department of Molecular and Cell Biology, Center for Computational Biology, Department of Plant and Microbial Biology, Department of Nutritional Sciences and Toxicology, Department of Psychology, School of Public Health (including the Division of Biostatistics), School of Social Welfare, iSchool / Division of Data Science, Department of Statistics, Department of Bioengineering, Department of Economics, Department of Demography, Department of Electrical Engineering and Computer Science, Haas School of Business, Berkeley Law, Center for Science Technology Medicine & Society, Berkeley Institute for Data Science (BIDS), D-Lab, Guizhou-Berkeley Big Data Innovation Center, Berkeley Institute for Transparency in Social Science (BITSS), Anthropology, Sociology, Rhetoric, California Policy Lab, and beyond.

Impact in 5-10 Years

- In 5-10 years we will have new systems for improving wellbeing using data that individuals currently generate, or will naturally produce in the near future. These systems will build on scientific discovery of disease, applications to individuals, public health perspectives, all informed by appropriate economic and social development.
- California will have the linked administrative data infrastructure to understand detailed impacts of biomedical and social determinants of health and the impact of the health care system on wellbeing, economic and policy outcomes. The State will lead the US in evidence-based health care policy, and realize better health outcomes and lower cost.
- Deployment of data for health is inexorable, but will it be for good? Thoughtful attention to the ethical and societal issues will help ensure it provides a benefit for humankind, diminishing disparities, providing robust trustworthy stewardship of biological data, and helping prevent discrimination. We will develop a recognized "Berkeley standard" for ethical stewardship of health-related data.

Resources Needed

Transdisciplinary efforts require sustained support of collaboration among faculty and researchers. Areas of contribution necessary include:

- Faculty research support/seed grants to stimulate and sustain new, interdisciplinary research
- Fellowships to support trainees who transcend disciplines
- Novel interdisciplinary educational opportunities

- A new or expanded Center, with executive leadership to unite disparate faculty and their groups towards these shared goals, and operational support to facilitate engagement
- Scientific career staff whose primary goal is pursuing these synergies

Additionally, specific campus-level investments will be needed to support these efforts:
- Secure data computing resources
- Collection and creation the biological resources and data needed for these analyses

Vehicles for outreach, dissemination, and deployment of our findings