Joint NSF/NIH Initiative on Quantitative Approaches to Biomedical Big Data (QuBBD)

PROGRAM SOLICITATION
NSF 16-573

National Science Foundation

Directorate for Mathematical & Physical Sciences
Division of Mathematical Sciences

National Institutes of Health

John E. Fogarty International Center

National Institute of General Medical Sciences

National Institute of Allergy and Infectious Diseases

National Institute of Neurological Disorders and Stroke

National Eye Institute

National Institute on Aging

National Institute on Alcohol Abuse and Alcoholism

National Institute of Biomedical Imaging and Bioengineering

National Institute on Drug Abuse

National Institute on Deafness and Other Communication Disorders

National Institute of Dental and Craniofacial Research

National Institute of Mental Health

National Cancer Institute

National Human Genome Research Institute

Eunice Kennedy Shriver National Institute of Child Health and Human Development

National Library of Medicine

National Institute of Environmental Health Sciences

National Institute of Diabetes and Digestive and Kidney Diseases

National Center for Complementary and Integrative Health

National Institute of Nursing Research

National Institute of Arthritis and Musculoskeletal and Skin Disease

Office of Behavioral and Social Sciences Research

National Center for Advancing Translational Sciences

Full Proposal Deadline(s) (due by 5 p.m. submitter's local time):

September 28, 2016

September 12, 2017

Second Tuesday in September, Annually Thereafter

IMPORTANT INFORMATION AND REVISION NOTES

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 16-1), which is effective for proposals submitted, or due, on or after January 25, 2016.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Joint NSF/NIH Initiative on Quantitative Approaches to Biomedical Big Data (QuBBD)

Synopsis of Program:

Recent advances in medical and healthcare technologies are creating a paradigm shift in how medical practitioners and biomedical researchers approach the diagnosis, prevention, and treatment of diseases. New imaging technologies, advances in genetic testing, and innovations in wearable and/or ambient sensors are allowing researchers to predict health outcomes and develop personalized treatments or interventions.

Coupled with the rapid growth in computing and infrastructure, researchers now have the ability to collect, store, and analyze vast amounts of health- and disease-related data from biological, biomedical, behavioral, social, environmental, and clinical studies. The explosion in the availability of biomedical big data from disparate sources, and the complex data structures including images, networks, and graphs, pose significant challenges in terms of visualization, modeling, and analysis.

While there have been some encouraging developments related to foundational mathematical, statistical, and computational approaches for big data challenges over the past decade, there have been relatively few opportunities for collaboration on challenges related to biomedical data science. The National Science Foundation (NSF) and the National Institutes of Health (NIH) recognize that fundamental questions in basic, clinical, and translational research could benefit greatly from multidisciplinary approaches that involve experts in quantitative disciplines such as mathematics, statistics, and computer science.

The Quantitative Approaches to Biomedical Big Data Program is designed to support research that addresses important application areas at the intersection of the biomedical and data sciences by encouraging inter- and multi-disciplinary collaborations that focus on innovative and transformative approaches to address these challenges.

Cognizant Program Officer(s):

Please note that the following information is current at the time of publishing. See program website for any updates to the points of contact.

- Nandini Kannan, Program Director, MPS/DMS, NSF, telephone: (703) 292-8104, email: nakannan@nsf.gov
- Lora Billings, NSF, telephone: (703) 292-8039, email: lbilling@nsf.gov
- Vinay Pai, Program Director, NIH/NIBIB, NIH, telephone: (301) 451-4781, email: BD2K_QuBBD@mail.nih.gov

Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):

- 47.049 --- Mathematical and Physical Sciences
- 93.172 --- National Human Genome Research Institute
- 93.173 --- National Institute on Deafness and Other Communication Disorders
- 93.213 --- National Center for Complementary and Integrative Health
- 93.242 --- National Institute of Mental Health
- 93.273 --- National Institute on Alcohol Abuse and Alcoholism
- 93.279 --- National Institute on Drug Abuse
- 93.286 --- National Institute of Biomedical Imaging and Bioengineering
- 93.350 --- National Center for Advancing Translational Sciences
- 93.361 --- National Institute of Nursing Research
- 93.396 --- National Cancer Institute
- 93.846 --- National Institute of Arthritis and Musculoskeletal and Skin Disease
- 93.847 --- National Institute of Diabetes and Digestive and Kidney Diseases
- 93.853 --- National Institute of Neurological Disorders and Stroke
- 93.856 --- Microbiology and Infectious Diseases Research
- 93.859 --- National Institute of General Medical Sciences
- 93.865 --- Eunice Kennedy Shriver National Institute of Child Health and Human Development
- 93.866 --- National Institute on Aging
- 93.867 --- National Eye Institute
- 93.879 --- National Library of Medicine
- 93.989 --- John E. Fogarty International Center

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant or Cooperative Agreement

Estimated Number of Awards: 10 to 20

10 to 20 Awards from this competition may be made, subject to availability of funds and receipt of proposals of adequate quality, by either NSF or NIH at the option of the agencies, not the grantee.

Anticipated Funding Amount: $5,000,000

$5,000,000 per year for new applications ($2,000,000 from NSF, $3,000,000 from NIH), subject to availability of funds and receipt of proposals of adequate quality. Award sizes are expected to range from $200,000 to $300,000 (total costs) per year with durations of up to 3 years.

Eligibility Information

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the Grant Proposal Guide, Chapter I, Section E.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI:

There are no restrictions or limits.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Not required
- **Preliminary Proposal Submission:** Not required
- **Full Proposals:**
  - Full Proposals submitted via FastLane: NSF Proposal and Award Policies and Procedures Guide, Part I: Grant Proposal Guide (GPG) Guidelines apply. The complete text of the GPG is available electronically on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg.
  - Full Proposals submitted via Grants.gov: NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov Guidelines apply (Note: The NSF Grants.gov Application Guide is available on the Grants.gov website and on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide)

B. Budgetary Information

- **Cost Sharing Requirements:**

  Inclusion of voluntary committed cost sharing is prohibited.

- **Indirect Cost (F&A) Limitations:**

  Not Applicable

- **Other Budgetary Limitations:**

  Not Applicable

C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

  September 28, 2016

  September 12, 2017

  Second Tuesday in September, Annually Thereafter

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review considerations apply. Please see the full text of this solicitation for further information.

Award Administration Information

Award Conditions:

Additional award conditions apply. Please see the full text of this solicitation for further information.

Reporting Requirements:

Additional reporting requirements apply. Please see the full text of this solicitation for further information.

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I. INTRODUCTION

Innovations in medical technology, coupled with rapid advances in computing infrastructure, are creating new challenges and opportunities for collaborative research at the interface of the quantitative and biomedical sciences. Through this initiative, the National Science Foundation and the National Institutes of Health plan to support the development of sophisticated mathematical, statistical, and computational approaches and methods to address important application areas in biomedical science.

Biomedical big data encompasses health- and disease-related data from biological, biomedical, behavioral, social, environmental, and clinical studies. It includes genomics data from next-generation sequencing, data from different imaging modalities, real-time and static data from wearable electronics, mobile devices, and environmental sensors, and clinical data from hospitals, insurance, and electronic medical records.

Novel methodology for visualization, modeling, and analysis of biomedical big data is essential to addressing the challenges posed by complex data structures such as images, text, networks, and graphs, unstructured data formats, complex dependence structures, non-stationarity, missing information, and sparsity.

This program is designed to support novel mathematical, statistical, or computational approaches to biomedical big data challenges. Collaborative efforts that bring together quantitative scientists and biomedical researchers are a requirement for this program and must be convincingly demonstrated in the proposal. The program is designed to foster and support new inter- and multi-disciplinary teams of investigators. A "new team" is defined as a team where none of the biomedical scientists have previously collaborated with any of the quantitative scientists. Evidence of prior collaboration includes but is not limited to having joint publications or being listed as key personnel on the same grant. Research teams with pre-existing collaborations should instead submit directly to other NSF and/or NIH funding opportunities. Proposals from teams of junior investigators are encouraged.

Successful projects will involve the development of novel mathematical, statistical, or computational models and methodology to solve important biomedical big data problems. Research that involves the application of standard mathematical, statistical, or computational tools to solve important biomedical big data problems is not appropriate for this competition and should be submitted directly to NIH. Similarly, proposals that focus on research in mathematics or statistics that is not tied to a specific biomedical big data problem should be submitted to the appropriate DMS program at NSF.

II. PROGRAM DESCRIPTION

The Division of Mathematical Sciences in the Directorate of Mathematical and Physical Sciences at the National Science Foundation and the National Institutes of Health Big Data to Knowledge (BD2K) Initiative plan to support research that addresses critical application areas at the intersection of the biomedical and data sciences. Appropriate application areas are those supported by the NIH Big Data to Knowledge initiative (see https://datascience.nih.gov/bd2k), including, but not limited to biomedical, behavioral, clinical, and translational sciences.

Proposals that are not appropriate for funding by NIH BD2K or NSF DMS will be returned without review. Investigators are strongly encouraged to discuss proposal aims with the NIH or NSF program officers listed as points of contact on the program webpage.

Examples of application areas that are appropriate under this competition include the following:

- Development of methods for mobile health (mHealth) data, where mHealth includes new data not traditionally used in the biomedical sciences (e.g. data from mobile devices, social networks, wearable electronics, sensors)
- Development of methods for precision (or personalized) medicine. The goal of precision medicine is to develop a targeted

treatment (or prevention) regimen that takes into account unique characteristics of an individual such as genetic makeup, environmental factors, and lifestyle.

This list is not intended to be exhaustive or exclusive. Applicants are encouraged to visit the website (https://datascience.nih.gov/bd2k) for a list of current topics supported by the NIH BD2K Initiative. However, proposals should clearly address how this new collaboration will address a biomedical challenge and describe the use of large-scale publicly-available biomedical datasets to illustrate the proposed models and methodology. Applicants are expected to list the datasets that will be used for this purpose.

III. AWARD INFORMATION

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

It is estimated that approximately $5 million ($2 million from NSF, $3 million from NIH) will be available for each year of this competition to fund new applications. Award sizes are expected to range from $200,000 to $300,000 per year (total costs) with durations of up to 3 years. Estimated program budget, number of awards, and average award size/duration are subject to the availability of funds and receipt of proposals of adequate quality.

Upon conclusion of the review process, meritorious proposals may be recommended for funding by either NIH or NSF, at the option of the agencies, not the proposer. Subsequent grant administration procedures will be in accordance with the individual policies of the awarding agency.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the Grant Proposal Guide, Chapter I, Section E.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI:

There are no restrictions or limits.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via Grants.gov or via the NSF FastLane system.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the NSF Grant Proposal Guide (GPG). The complete text of the GPG is available electronically on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg. Paper copies of the GPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.

- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov. The complete text of the NSF Grants.gov Application Guide is available on the Grants.gov website and on the NSF website at: (http://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

In determining which method to utilize in the electronic preparation and submission of the proposal, please note the following:

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via the NSF FastLane system. Chapter II, Section D.5 of the Grant Proposal Guide provides additional information on collaborative proposals.

See Chapter II.C.2 of the GPG for guidance on the required sections of a full research proposal submitted to NSF. Please note that the proposal preparation instructions provided in this program solicitation may deviate from the GPG instructions.

The following instructions supplement and/or deviate from guidelines in the GPG and NSF Grants.gov Application Guide.

Proposal Title

Proposal titles must indicate the QuBBD program, followed by a colon, then the title of the project. Titles of collaborative proposals should be prepared as above, but should also include "Collaborative Research" followed by a colon before the title of the project. For example, the title of each proposal for a collaborative set of proposals for a project would be **QuBBD: Collaborative Research: Title**.

Project Description

The project description is limited to 15 pages, with no more than **12 pages** addressing the NSF criterion of *Intellectual Merit*. Note that this NSF criterion corresponds with the NIH criteria of Significance, Investigators, Innovation, Approach, and Environment.

Supplementary Documents

Multiple PD/PI Leadership Plan: The multiple PD/PI approach should be described in no more than **3 pages**. This description should discuss the role of each investigator, as well as the governance and organizational structure of the leadership team and the research project, including communication plans, process for making decisions on scientific direction, and procedures for resolving conflicts. The roles and administrative, technical, and scientific responsibilities for the project or program should be delineated for the PD/PIs and other collaborators. For the purpose of the solicitation, PIs must self-identify as either quantitative or biomedical scientists and make the case that they have expertise in the selected field. The plan must also demonstrate that this is a new collaboration between the biomedical PIs and the quantitative PIs. If budget allocation is planned, the distribution of resources to specific components of the project or the individual PD/PIs must be delineated in the Leadership Plan. In the event of an award, the requested allocation may be reflected in a footnote on the Notice of Grant Award (NOGA). This information should be submitted separately as a **Supplementary Document**.

Protection of Human Subjects/Use and Care of Vertebrate Animals: Both NSF and NIH have rules regarding the use of human subjects and/or vertebrate animals in research. Proposals that involve human subjects or use vertebrate animals **MUST INCLUDE** the information required by both agencies. See the NSF Grant Proposal Guide (Proposal Preparation, Special Guidelines) AND the NIH PHS Form 398 for additional information. Information on the use of human subjects and/or vertebrate animals is considered in the review of the proposals and should be submitted separately as a **Supplementary Document**.

Letters of Collaboration: The Project Description should document the need for and nature of collaborations, such as intellectual contributions to the project, permission to access a site, an instrument, or a facility, offer of data, samples and materials for research, logistical support to the research and education program, or mentoring of U.S. students at a foreign site. Such collaborative arrangements of significance to the project may be documented through letters of collaboration. (See GPG Chapter II.C.2.d(iv)). Letters of collaboration should be limited to stating the intent to collaborate and should not contain endorsements or evaluation of the proposed project. The recommended format for letters of collaboration is as follows: "If the proposal submitted by Dr. [insert the full name of the Principal Investigator] entitled [insert the proposal title] is selected for funding by NSF, it is my intent to collaborate and/or commit resources as detailed in the Project Description or the Facilities, Equipment or Other Resources section of the proposal." Departure from this format may result in the proposal being returned without review. Requests for letters should be made by the PI well in advance of the proposal submission deadline, because they must be included as **Supplementary Documents** at the time of submission. Please note that letters of recommendation for the PI are not permitted.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

  September 28, 2016

  September 12, 2017

  Second Tuesday in September, Annually Thereafter

D. FastLane / Grants.gov Requirements

For Proposals Submitted Via FastLane:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: https://www.fastlane.nsf.gov/a1/newstan.htm. For FastLane user support, call the FastLane Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov. The FastLane Help Desk answers general technical questions related to the use of the FastLane system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: http://www.grants.gov/web/grants/applicants.html. In addition, the NSF Grants.gov Application Guide (see link in Section V.A) provides instructions regarding the technical preparation of proposals via Grants.gov. For Grants.gov

user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

Proposers that submitted via FastLane are strongly encouraged to use FastLane to verify the status of their submission to NSF. For proposers that submitted via Grants.gov, until an application has been received and validated by NSF, the Authorized Organizational Representative may check the status of an application on Grants.gov. After proposers have received an e-mail notification from NSF, Research.gov should be used to check the status of an application.

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

Proposals received by NSF are assigned to the appropriate NSF program for acknowledgement and, if they meet NSF requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF either as *ad hoc* reviewers, panelists, or both, who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with oversight of the review process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts of interest with the proposal. In addition, Program Officers may obtain comments from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards. A flowchart that depicts the entire NSF proposal and award process (and associated timeline) is included in the GPG as Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: http://www.nsf.gov/bfa/dias/policy/merit_review/.

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Investing in Science, Engineering, and Education for the Nation's Future: NSF Strategic Plan for 2014-2018*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

One of the strategic objectives in support of NSF's mission is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions must recruit, train, and prepare a diverse STEM workforce to advance the frontiers of science and participate in the U.S. technology-based economy. NSF's contribution to the national innovation ecosystem is to provide cutting-edge research under the guidance of the Nation's most creative scientists and engineers. NSF also supports development of a strong science, technology, engineering, and mathematics (STEM) workforce by investing in building the knowledge that informs improvements in STEM teaching and learning.

NSF's mission calls for the broadening of opportunities and expanding participation of groups, institutions, and geographic regions that are underrepresented in STEM disciplines, which is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

A. Merit Review Principles and Criteria

The National Science Foundation strives to invest in a robust and diverse portfolio of projects that creates new knowledge and enables breakthroughs in understanding across all areas of science and engineering research and education. To identify which projects to support, NSF relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF makes every effort to conduct a fair, competitive, transparent merit review process for the selection of projects.

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether or not to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.
- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These "Broader Impacts" may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.
- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (GPG Chapter II.C.2.d.i. contains additional information for use by proposers in development of the Project Description section of the proposal.) Reviewers are strongly encouraged to review the criteria, including GPG Chapter II.C.2.d.i., prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit:** The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- **Broader Impacts:** The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to
    a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
    b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

Proposers are reminded that reviewers will also be asked to review the Data Management Plan and the Postdoctoral Researcher Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

For this solicitation, clinical, biological, and technological applications are specifically included among the societally relevant outcomes that could be related to a project's broader impacts, in addition to the potential outcomes listed above.

The following additional review criterion reflects this solicitation's central goal of enabling high-quality collaborative research:

Quality and Value of Collaboration. Is the expertise of the proposers complementary and well-suited to the problems being addressed? Does the collaboration productively bring together new combinations of investigators, approaches, or resources? Are the specific roles of each collaborating investigator clear? Does the collective team have expertise in both the quantitative and biomedical fields? To what extent is the novelty of the collaboration between the biomedical PI(s) and the quantitative PI(s) presented and justified?

Both NSF and NIH merit review criteria will be used in evaluating proposals. The NSF merit review criteria are described in the preceding. Information about the NIH merit review criteria follows:

NIH Merit Review Criteria

The mission of the NIH is to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life and reduce illness and disability. In their evaluations of **Intellectual Merit**, reviewers will be asked to consider the following criteria that are used by NIH:

Overall Impact. Reviewers will provide an overall impact score to reflect their assessment of the likelihood for the project to exert a sustained, powerful influence on the research field(s) involved, in consideration of the following review criteria, and additional review criteria (as applicable for the project proposed).

Significance. Does the project address an important problem or a critical barrier to progress in the field? Is there a strong scientific premise for the project? If the aims of the project are achieved, how will scientific knowledge, technical capability, and/or clinical practice be improved? How will successful completion of the aims change the concepts, methods, technologies, treatments, services, or preventative interventions that drive this field?

Investigator(s). Are the PD/PIs, collaborators, and other researchers well suited to the project? If Early Stage Investigators or New Investigators, or in the early stages of independent careers, do they have appropriate experience and training? If established, have they demonstrated an ongoing record of accomplishments that have advanced their field(s)? If the project is collaborative or multi-PD/PI, do the investigators have complementary and integrated expertise; are their leadership approach, governance and organizational structure appropriate for the project?

Innovation. Does the application challenge and seek to shift current research or clinical practice paradigms by utilizing novel theoretical concepts, approaches or methodologies, instrumentation, or interventions? Are the concepts, approaches or methodologies, instrumentation, or interventions novel to one field of research or novel in a broad sense? Is a refinement, improvement, or new application of theoretical concepts, approaches or methodologies, instrumentation, or interventions proposed?

Approach. Are the overall strategy, methodology, and analyses well-reasoned and appropriate to accomplish the specific aims of the project? Have the investigators presented strategies to ensure a robust and unbiased approach, as appropriate for the work proposed? Are potential problems, alternative strategies, and benchmarks for success presented? If the project is in the early stages of development, will the strategy establish feasibility and will particularly risky aspects be managed? Have the investigators presented adequate plans to address relevant biological variables, such as sex, for studies in vertebrate animals or human subjects?

If the project involves human subjects and/or NIH-defined clinical research, are the plans to address 1) the protection of human subjects from research risks, and 2) inclusion (or exclusion) of individuals on the basis of sex/gender, race, and ethnicity, as well as the inclusion or exclusion of children, justified in terms of the scientific goals and research strategy proposed?

Environment. Will the scientific environment in which the work will be done contribute to the probability of success? Are the institutional support, equipment and other physical resources available to the investigators adequate for the project proposed? Will the project benefit from unique features of the scientific environment, subject populations, or collaborative arrangements?

Where applicable, the following items will also be considered:

- ***Protections for Human Subjects.*** For research that involves human subjects but does not involve one of the six categories of research that are exempt under 45 CFR Part 46, the committee will evaluate the justification for involvement of human subjects and the proposed protections from research risk relating to their participation according to the following five review criteria: 1) risk to subjects, 2) adequacy of protection against risks, 3) potential benefits to the subjects and others, 4) importance of the knowledge to be gained, and 5) data and safety monitoring for clinical trials. For research that involves human subjects and meets the criteria for one or more of the six categories of research that are exempt under 45 CFR Part 46, the committee will evaluate: 1) the justification for the exemption, 2) human subjects involvement and characteristics, and 3) sources of materials. For additional information on review of the Human Subjects section, please refer to the Guidelines for the Review of Human Subjects.
- ***Inclusion of Women, Minorities, and Children.*** When the proposed project involves human subjects and/or NIH-defined clinical research, the committee will evaluate the proposed plans for the inclusion (or exclusion) of individuals on the basis of sex/gender, race, and ethnicity, as well as the inclusion (or exclusion) of children to determine if it is justified in terms of the scientific goals and research strategy proposed. For additional information on review of the Inclusion section, please refer to the Guidelines for the Review of Inclusion in Clinical Research.
- ***Vertebrate Animals.*** The committee will evaluate the involvement of live vertebrate animals as part of the scientific assessment according to the following criteria: (1) description of proposed procedures involving animals, including species, strains, ages, sex, and total number to be used; (2) justifications for the use of animals versus alternative models and for the appropriateness of the species proposed; (3) interventions to minimize discomfort, distress, pain and injury; and (4) justification for euthanasia method if NOT consistent with the AVMA Guidelines for the Euthanasia of Animals. Reviewers will assess the use of chimpanzees as they would any other application proposing the use of vertebrate animals. For additional information on review of the Vertebrate Animals section, please refer to the Worksheet for Review of the Vertebrate Animal Section
- **Biohazards:** Reviewers will assess whether materials or procedures proposed are potentially hazardous to research personnel and/or the environment, and if needed, determine whether adequate protection is proposed.

As applicable for the project proposed, reviewers will address each of the following review considerations, but will not give NIH scores for these items and should not consider them in providing an overall NIH impact score.

- **Budget and Period Support:** Reviewers will consider whether the budget and the requested period of support are fully justified and reasonable in relation to the proposed research. For more details, please see Budget Information.
- **Additional Comments to the Applicant:** Reviewers may provide guidance to the applicant or recommend against resubmission without fundamental revision.

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by Ad hoc Review and/or Panel Review.

NSF will coordinate and manage the review of proposals in consultation with NIH. Copies of proposals and unattributed reviews will be shared with NIH, as appropriate.

Reviewers will be asked to evaluate proposals using two National Science Board approved merit review criteria and, if applicable, additional program specific criteria. A summary rating and accompanying narrative will generally be completed and submitted by each reviewer and/or panel. The Program Officer assigned to manage the proposal's review will consider the advice of reviewers and will formulate a recommendation.

NSF Process: After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new awardees may require additional review and processing time. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director acts upon the Program Officer's recommendation.

After programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

Once an award or declination decision has been made, Principal Investigators are provided feedback about their proposals. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers or any reviewer-identifying information, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline funding.

NIH Process: For those proposals that are identified for funding consideration by participating NIH Institutes or Centers, NIH will ask the proposer(s) to resubmit the proposal in an NIH-approved format directly to the Center for Scientific Review (http://www.csr.nih.gov/) of the NIH. PIs invited to resubmit to NIH will receive further information on resubmission procedures from NIH. An applicant will not be allowed to increase the proposed budget or change the scientific content of the application in the

resubmission to the NIH. Subsequent award processing and grant administration procedures will be in accordance with NIH policies and procedures.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Notification of the award is made to *the submitting organization* by a Grants Officer in the Division of Grants and Agreements. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. Verbatim copies of reviews, not including the identity of the reviewer, will be provided automatically to the Principal Investigator. (See Section VI.B. for additional information on the review process.)

B. Award Conditions

An NSF award consists of: (1) the award notice, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award notice; (4) the applicable award conditions, such as Grant General Conditions (GC-1)*; or Research Terms and Conditions* and (5) any announcement or other NSF issuance that may be incorporated by reference in the award notice. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

*These documents may be accessed electronically on NSF's Website at http://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

More comprehensive information on NSF Award Conditions and other important information on the administration of NSF awards is contained in the NSF *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

Special Award Conditions:

For all awards, one or more designated QuBBD project representatives (PI/co-PI/senior researcher or NSF-approved replacement) must attend annual QuBBD PI meetings.

Attribution of support in publications must acknowledge the joint program, as well as the funding organization and award number, by including the phrase, "as part of the NSF/NIH/ Quantitative Approaches to Biomedical Big Data Program."

Grants made by NSF will be subject to NSF's award conditions. Grants made by NIH will be subject to NIH's award conditions (see http://grants.nih.gov/grants/policy/awardconditions.htm). Contact the cognizant NIH organization Program Officer for additional information.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer no later than 90 days prior to the end of the current budget period. (Some programs or awards require submission of more frequent project reports). No later than 120 days following expiration of a grant, the PI also is required to submit a final project report, and a project outcomes report for the general public.

Failure to provide the required annual or final project reports, or the project outcomes report, will delay NSF review and processing of any future funding increments as well as any pending proposals for all identified PIs and co-PIs on a given award. PIs should examine the formats of the required reports in advance to assure availability of required data.

PIs are required to use NSF's electronic project-reporting system, available through Research.gov, for preparation and submission of annual and final project reports. Such reports provide information on accomplishments, project participants (individual and organizational), publications, and other specific products and impacts of the project. Submission of the report via Research.gov constitutes certification by the PI that the contents of the report are accurate and complete. The project outcomes report also must be prepared and submitted using Research.gov. This report serves as a brief summary, prepared specifically for the public, of the nature and outcomes of the project. This report will be posted on the NSF website exactly as it is submitted by the PI.

More comprehensive information on NSF Reporting Requirements and other important information on the administration of NSF awards is contained in the NSF *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

Grants made by NSF will be subject to NSF's reporting requirements. Grants made by NIH will be subject to NIH's reporting requirements. Contact the cognizant NIH organization Program Officer for additional information

VIII. AGENCY CONTACTS

Please note that the program contact information is current at the time of publishing. See program website for any updates to the

points of contact.

General inquiries regarding this program should be made to:

- Nandini Kannan, Program Director, MPS/DMS, NSF, telephone: (703) 292-8104, email: nakannan@nsf.gov
- Lora Billings, NSF, telephone: (703) 292-8039, email: lbilling@nsf.gov
- Vinay Pai, Program Director, NIH/NIBIB, NIH, telephone: (301) 451-4781, email: BD2K_QuBBD@mail.nih.gov

For questions related to the use of FastLane, contact:

- FastLane Help Desk, telephone: 1-800-673-6188; e-mail: fastlane@nsf.gov.

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: support@grants.gov.

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF Grants Conferences. Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on NSF's website.

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this mechanism. Further information on Grants.gov may be obtained at http://www.grants.gov.

This solicitation advances the objectives of the National Strategic Computing Initiative (NSCI), an effort aimed at sustaining and enhancing the U.S. scientific, technological, and economic leadership position in High-Performance Computing (HPC) research, development, and deployment.

National Institutes of Health (NIH):

Big Data to Knowledge (BD2K) initiative: https://datascience.nih.gov/bd2k

ABOUT THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

Facilitation Awards for Scientists and Engineers with Disabilities provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See Grant Proposal Guide Chapter II, Section D.2 for instructions regarding preparation of these types of proposals.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-5090 and (800) 281-8749, FIRS at (800) 877-8339.

The National Science Foundation Information Center may be reached at (703) 292-5111.

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and to access abstracts of awards, visit the NSF Website at http://www.nsf.gov

- **Location:** 4201 Wilson Blvd. Arlington, VA 22230
- **For General Information** (NSF Information Center)**:** (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090

- **To Order Publications or Forms:**

  Send an e-mail to: nsfpubs@nsf.gov

  or telephone: (703) 292-7827

- **To Locate NSF Employees:** (703) 292-5111

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004), and NSF-51, "Reviewer/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004). Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 3145-0058. Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding the burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden, to:

Suzanne H. Plimpton
Reports Clearance Officer
Office of the General Counsel
National Science Foundation
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