Informatics Technology for Cancer Research (ITCR) Expert Panel Report

J. Robert Beck
Fox Chase Cancer Center

Joe W. Gray
Oregon Health & Science University

Paul Kinahan
University of Washington

Subha Madhavan
Georgetown University Medical Center

Dong-Guk Shin
University of Connecticut

Shaying Zhao
University of Georgia

June 2018

IDA SCIENCE AND TECHNOLOGY POLICY INSTITUTE

The Informatics Technology for Cancer Research (ITCR) Program is a trans-NCI grant program supporting investigator-initiated informatics technology development driven by critical needs in cancer research. The program was initiated in 2012 and was first renewed in 2015. The program is currently supported through four funding opportunities. In support of a second renewal request, NCI requires an independent evaluation of the program. It is anticipated that the renewal request will be submitted in September 2018 to NCI Scientific Program Leadership, and the program evaluation will provide important input for preparing and submitting this request.

NCI chose to convene an expert panel to provide evaluative insights. The panel was charged to assist NCI in addressing five questions regarding the ITCR program:

1. What impact is the program having on advancing the field of cancer informatics and providing necessary informatics tools to cancer researchers?
2. Should NCI continue to support a dedicated program for informatics technology development?
3. Are the unique characteristics of the program that drove its initiation still relevant?
4. Are the current funding mechanisms (R21, U01, two U24s) appropriate to achieve the program goals?
5. Are there additional activities that should be undertaken by the program to support its goals?

NCI asked the IDA Science and Technology Policy Institute (STPI) to facilitate the expert panel process; STPI identified potential panelists, issued invitations, and supported the panel in its deliberations. The panel consisted of six members with a mix of backgrounds in cancer biology, oncology, and informatics. NCI provided publicly available information to the panel as background, but panelists did not have the opportunity to review confidential materials such as applications and review documents. The panel was convened around the ITCR principal investigator (PI) meeting, which was held on May 23 and 24, 2018, where panelists heard presentations from the PIs, interacted with program staff and investigators during unstructured sessions, and collected information relevant to their charge. Panelists provided initial reflections on the program in response to the charge individually, and discussed the program as a group in a teleconference on June 11.

Contents

Introduction and Panel Charge

The Informatics Technology for Cancer Research (ITCR) Program is a trans-NCI grant program supporting investigator-initiated informatics technology development driven by critical needs in cancer research. The program was initiated in 2012 and was first renewed in 2015. The program is currently supported through four funding opportunities:

- PAR-15-334 (R21): Development of Innovative Informatics Methods and Algorithms for Cancer Research and Management
- PAR-15-332 (U01): Early-Stage Development of Informatics Technologies for Cancer Research and Management
- PAR-15-331 (U24): Advanced Development of Informatics Technologies for Cancer Research and Management
- PAR-15-333 (U24): Sustained Support for Informatics Resources for Cancer Research and Management

In support of a second renewal request, NCI requires an independent evaluation of the program. It is anticipated that the renewal request will be submitted in September 2018 to NCI Scientific Program Leadership, and the program evaluation will provide important input for preparing and submitting this request. If approved to renew the program funding opportunity announcements as requests for applications (RFAs), the renewal request will also require approval of the NCI Board of Scientific Advisors (BSA). Although the program is not currently funded through RFAs, the fact that it has been running for several years suggests that an evaluation is appropriate in support of an RFA request to the BSA.

NCI chose to convene an expert panel to provide evaluative insights. The panel was charged to assist NCI in addressing five questions regarding the ITCR program:

1. What impact is the program having on advancing the field of cancer informatics and providing necessary informatics tools to cancer researchers?
2. Should NCI continue to support a dedicated program for informatics technology development?
3. Are the unique characteristics of the program that drove its initiation still relevant?
4. Are the current funding mechanisms (R21, U01, two U24s) appropriate to achieve the program goals?
5. Are there additional activities that should be undertaken by the program to support its goals?

NCI asked the IDA Science and Technology Policy Institute (STPI) to facilitate the expert panel process; STPI identified potential panelists, issued invitations, and supported the panel in its

deliberations. The panel consisted of six members with a mix of backgrounds in cancer biology, oncology, and informatics (full biographies of panelists are provided in an appendix).

NCI provided publicly available information to the panel as background, but panelists did not have the opportunity to review confidential materials such as applications and review documents. The panel was convened around the ITCR principal investigator (PI) meeting, which was held on May 23 and 24, 2018, where panelists heard presentations from the PIs, interacted with program staff and investigators during unstructured sessions, and collected information relevant to their charge. Panelists provided initial reflections on the program in response to the charge individually, and discussed the program as a group in a teleconference on June 11.

Summary of Panel Conclusions

The panel came to the five summary conclusions listed below. The subsections that follow present the panel's response to the charge, in the order NCI asked the questions.

- ***Continuing rationale for ITCR:*** The panel reached consensus that informatics technology development remains a pressing need in cancer research and therefore for NCI. The amounts and types of data generated in cancer research will continue to increase over time, so that the current need for support for informatics development will become even more pressing in the future.
- ***Increasing funding level***: The panel concluded unanimously that the ITCR program should be continued, and that NCI should work to enhance further the impact and efficacy of the projects arising from the ITCR program. Enhancements to expand the program's impact and influence, however, likely will require additional funding.
- ***Increasing outreach to investigators:*** The panel observed that additional outreach to cancer researchers may be required for ITCR-developed tools to be fully integrated into the cancer research community. A related observation is that outreach appears to be concentrated in cancer informatics technology communities specifically, rather than the broader cancer research communities. A final observation is that there may be an opportunity in connecting the tools that ITCR has supported.
- ***Fostering collaboration and uptake of tools:*** The panel noted that a new funding mechanism may be needed to foster collaboration between ITCR tool developers and "grassroots" small- and medium-sized laboratory cancer researchers to speed the uptake of ITCR-supported tools throughout the cancer research community.
- ***Sustaining tools for long-term excellence:*** The panel observed that successful tools will require sustainment to remain world class, which may need to involve NCI resources, especially if the intent is for tools to remain open-source and free for all researchers to exploit.

Panel Response to Charge

Question 1: What impact is the program having on advancing the field of cancer informatics and providing necessary informatics tools to cancer researchers?

The panel began by considering the program's impact to date, identifying both strengths and weaknesses. The panel identified that ITCR has funded multiple strong projects. Some tools (e.g., cBioPortal, Trinity, CIViC) are already very broadly disseminated. The number of mature, web-oriented community tools is growing and already impressive. Several developers have generated downloadable tools that can be used to manage and interpret local protected health information.

While the panel identified overall strengths associated with the program to date, opportunities for future enhancement remain. The panel found that the breadth, depth, and impact of the many projects are somewhat chaotic. It is not always clear how the productivity of the ITCR program translates into long-term sustainability for supported tools—in some cases the "next step" for tool development subsequent to the completion of given ITCR projects was not apparent. Another issue identified concerned outreach to investigators. If ITCR is fully integrated into the cancer research community, its tools should be common knowledge for leading cancer research investigators and the NCI intramural community, but this did not currently appear to be the case across projects. It seems that a large fraction of biologically oriented NCI investigators may not know about or take advantage of current or future ITCR tools. This is a missed opportunity. A related observation is that outreach appears to be concentrated in cancer informatics technology communities specifically, rather than the broader cancer research communities. For example, many toolsets and resources from ITCR will meet the desperate needs of the pre-clinical models (e.g., animal models) based cancer research community, but outreach to those investigators appears to be limited. A third opportunity lies in the area of data, where the panel observes that the computational field is still limited by the lack of well-curated, standardized data sets and well-defined computational needs. A final opportunity lies in connecting and integrating the tools that ITCR has supported. While the program's efforts mimic a marketplace (e.g., Amazon) of point solutions, connecting/high impact themes for toolsets are not immediately apparent to the scientific community of end users.

Question 2: Should NCI continue to support a dedicated program for informatics technology development?

The panel concluded unanimously that the ITCR program should be continued. The panel further concluded unanimously that NCI should work to enhance further the impact and efficacy of the projects arising from the ITCR program. Specific recommendations include:

- The ITCR funding level should be increased
- Funding areas should be more diversified within specific high-priority focus areas
- A dedicated permanent review panel (study section) should be considered, to promote continuity of reviews

- More active outreach to the broader cancer community and better integration with the users is necessary to facilitate tool development and uptake
- Consideration should be given to sustainability of useful ITCR projects
- Consider ways other than usage and bibliometrics to track the impact of the program
- The program should seek connectivity with other NCI programs that are driven by strong scientific and clinical use cases to guide further development of tools
- The NCI should consider developing formal education outreach functions (courses, workshops, etc.) to introduce ITCR tools to the larger biological user community.

Further explication of many of these recommendations occur in response to the questions that follow.

Question 3: Are the unique characteristics of the program that drove its initiation still relevant?

The original rationale for initiating the ITCR program is that NIH-wide software development mechanisms have not historically served NCI well, suggesting value in NCI-specific approaches. The ITCR program was initiated to fill this void. The panel reached consensus that informatics technology development remains a pressing need in cancer research and therefore for NCI. The research community has collected considerable data that are not fully leveraged, reused, and integrated. New informatics technologies that facilitate leveraging these data are therefore of great importance for NCI. Moreover, researchers are desperate for bioinformatics and computational support. New informatics technologies that allow investigators from many cancer research-relevant disciplines to conduct sophisticated analyses themselves without necessarily requiring specialized bioinformatics support will make the research enterprise more productive and facilitate discovery.

The panel therefore reached consensus that not only do there remain NCI-specific needs around informatics technology development, but also that the current program is too small (funding-wise) given the breadth and importance of the continuing need. The panel further concluded that this informatics need will continue to grow, perhaps at an increasing rate, so the program is answering a specific need in the cancer research community.

The panel, nevertheless, noted a potential shift in the continuing rationale for the ITCR effort. NCI funds networks that have a specific mission relative to developing informatics tools. For example, the Quantitative Imaging Network (QIN) has a specific mission relative to developing and validating informatics tools to enhance imaging methods in clinical trials and is expected to develop tools that will be used by members of the National Clinical Trials Network (NCTN). The panel noted that there currently is no single driving cancer research need that ITCR research supports. Given the breadth of ITCR, the panel agreed, it would be difficult to identify a single driving project, but NCI could pick particular areas upon which ITCR might focus and researchers and informatics developers might rally around (e.g., single cell transcriptomics, natural language processing for EMRs, single cell imaging, image feature assessment, deep learning, making cancer

genomic testing data more available through EHRs). An emphasis on driving projects would facilitate the development and uptake of useful tools. The panel identified the Human Tumor Atlas Network, which is an initiative of the Cancer Moonshot, as an example of an ideal use case that could drive -omics, imaging, and integrative tool development and will have the advantage of access to a well-curated data set. The panel noted that building a community of investigators around particular focus areas would also help to drive researchers toward common standards.

Question 4: Are the current funding mechanisms (R21, U01, two U24s) appropriate to achieve the program goals?

The panel found that the current funding mechanisms are generally appropriate to achieve the program's current goals, with the R21 awards focused on new approaches, the U01s on early-stage software development, and the U24 awards focused on late-stage development and long-term sustainment. The panel suggested two incremental changes to existing mechanisms that might enhance efforts to meet current goals. One suggestion relates to the consideration that many funding opportunity announcements (FOAs) have short application deadlines, while the effective coordination and design of larger projects may require considerable time for planning. The NCI might therefore consider initiating large scale projects with several smaller scale 1–2 year planning grants followed by full scale funding for the most compelling methods and tools. A second suggestion is that the current FOA language is geared toward informatics PIs, and so PIs and projects tend to focus on tool development, although some projects have co-PIs who are the scientific leads or are designed with integral scientific driving projects. To foster the involvement of cancer researchers in ITCR projects, NCI might consider revising FOAs to include language to encourage co-leadership between a science/clinical and an informatics PI (as co-PIs).

At the same time, the panel identified important objectives that might require new mechanisms. One objective is the long-term maintenance of ITCR-supported tools and fostering their use by investigators throughout the cancer research enterprise. Successful tools will require sustainment to remain world class, but if NCI continues to support successful tools through U24s, given limited resources it may become difficult to balance between new/emerging areas and continuing existing awards. NCI may want to encourage awardees to consider long-term sustainment beyond NCI funding explicitly (e.g., technology transfer/licensing). Alternatively, NCI might create National Computational Research Resource Centers that would support computational tool development for NCI investigators throughout the country. This would support computational innovation as well as the use of existing tools. NCI might build upon models such as the National Institute of General Medical Sciences' Biomedical Technology Research Resources and the National Institute of Biomedical Imaging and Bioengineering's Biomedical Technology Resource Centers to facilitate long-term dissemination and sustainment activities.

Question 5: Are there additional activities that should be undertaken by the program to support its goals?

The panel recommended one possible future extension of the program to foster collaboration between developers and cancer researchers at both large and small institutions, in order to speed the uptake of ITCR-supported tools throughout the cancer research community. A new funding mechanism may be needed to foster collaboration between ITCR tool developers and "grassroots" cancer researchers with small and medium-sized laboratories to speed the uptake of ITCR-supported tools throughout the cancer research community. The panel considered the set-aside project/supplement-based approach to be insufficient in size to foster these new collaborations, and suggested that NCI consider an R03 or R21 mechanism oriented toward application of informatics tools and systems, with a cancer domain expert and an informatician/computer scientist leading the award as multiple PIs but where some funding also flows to tool developers for enhancements or refinements to tools as required. Another suggestion was for NCI to explore the feasibility of an administrative supplement to NCI-designated Cancer Centers' P30 awards to induce investigators at these institutions to exploit the tools and systems in the U24 portfolio.

In addition, the panel identified two sets of additional activities that might be undertaken by the program to support its goals. One set of considerations revolved around ITCR network activities. While the panel considers current activities meritorious, they suggested that NCI consider additional activities that have been pioneered by other NCI-funded networks. One possibility would be for ITCR to support challenge projects. In this approach, awards operating in similar domain areas compete to address a common challenge for the purpose of identifying the most effective or efficient approaches; an alternative value would be to identify where ITCR-supported open-source tools provide functionality comparable or superior to existing commercial software and tools. A variant on this challenge-based approach would be the development of well-curated data sets associated with specific NCI initiatives coupled with identification of the computational needs associated with analyzing these datasets. Opening datasets to analysis (whether using ITCR-supported tools or other tools) could foster new research discoveries that might also showcase the potential of ITCR-supported informatics tools. A different recommendation is for NCI to support pooling efforts where ITCR program staff encourage awardees operating in similar areas to work together, perhaps supported by small "interaction" awards or through set-aside projects. One example the panel identified surrounded standards development for ontologies, whereby ITCR awardees could work collectively to address what ontologies might be needed in the future and what activities will be required to develop standards for community use.

The second set concerned review processes. Without a standing review group, special emphasis panels have a limited institutional memory, so that reviews of similar projects received at different times may widely vary. Having standing computational review panels would increase overall review quality. At the same time, the panel agreed that the NCI program staff does an excellent job orienting reviewers; panelists noted that the "sustainability" U24s are closely

scrutinized. Another consideration identified by the panel regarding review is that many ITCR-supported projects look similar—although competition is of course valuable even at the risk of the potential for duplication of effort. The panelists noted that diversity of projects is also important. Some promising cancer research areas (e.g., metabolomics, microbiome, spontaneous cancer models) do not have corresponding ITCR awards, while much of the focus of the ITCR portfolio is on tool development for traditional imaging and genomics. The panel recommends that important and underfunded areas should be identified and diversity should be considered as a scoring factor.

Appendix: Panelist Biographies

J. Robert Beck

J. Robert Beck is Deputy Director and the H. O. West and J. R. Wike Professor at Fox Chase Cancer Center. He received his AB from Dartmouth in 1974 and his MD from Johns Hopkins 1978, where he began developing his interests in health services research and health informatics. He trained in pathology and laboratory medicine at the Dartmouth-Hitchcock Medical Center, followed by a fellowship in Clinical Decision Making at the New England Medical Center. During his fellowship Dr. Beck worked with Stephen Pauker and Jerome Kassirer, and developed Markov and life expectancy models for medical decision making that have strongly influenced the field.

Bob returned to Dartmouth Medical School in 1982 as Assistant Professor of Pathology. Over the next eight years he served as medical director of the blood bank, staff hematopathologist, acting director of clinical pathology, and founding director of a program in medical information science. He was promoted to Associate Professor of Pathology and Community & Family Medicine during this period. In 1989 Dr. Beck was recruited to Oregon Health Sciences University as Professor of Pathology, Medicine, and Preventive Medicine & Public Health, where he built and directed the Biomedical Information Communication Center. He also served as OHSU's Chief Information Officer.

In 1992 Bob moved to Baylor College of Medicine as Vice President for Information Technology and Professor of Pathology and of Community & Family Medicine. During that period he led Baylor's NLM-funded Integrated Academic Information Management Systems initiative, developed collaborative training programs with Rice University and the University of Houston, and served on the board of the Houston Academy of Medicine – Texas Medical Center Library. He assisted the University of Texas Health Science Center at Houston in converting its School of Allied Health to one of Health Information Sciences. In 1999 Dr. Beck was asked to take an interim role as Executive Director of the HAM-TMC Library, while retaining a vice presidency for Information Research and Planning at Baylor.

Dr. Beck was recruited to Fox Chase Cancer Center in 2001 as Vice President and Chief Information Officer. He has served in several roles at Fox Chase, becoming Deputy Director of the Division of Population Sciences in 2006, Senior Vice President and Chief Academic Officer in 2007, Chief Medical Officer in 2009, and Deputy Director of the Center in 2013. In his current role Bob supervises the Office of Academic Programs, the Office of Corporate Partnerships, the Office of Health Communications and Health Disparities, the Institutional Review Board, Clinical Research Operations, Informatics, and Information Technology. He is a key advisor to the President and CEO on matters related to value creation, patient safety, investment in quality, risk

management, regulatory and accreditation matters, clinical outcomes, employee and faculty engagement, medical staff and faculty governance, and public reporting. Bob serves as the Dean of the Faculty—Fox Chase has its own Appointments and Promotions structure that reports to his office. He also has a Provost function in that all academic support activities are in his purview.

Dr. Beck has published over 200 papers, has held grants throughout his career, and has served in many editorial capacities. Bob has served on non-profit, private and public corporate boards. He is a member of several academic societies, including the American College of Medical Informatics, the Society for Medical Decision Making (for which he served as President), and the College of American Pathologists.

Joe W. Gray

Dr. Joe W. Gray, a physicist and an engineer by training, holds positions as Professor and Gordon Moore Endowed Chair, Biomedical Engineering; Director, Center for Spatial Systems Biomedicine (OCSSB); and Associate Director for Biophysical Oncology, Knight Cancer Institute at the Oregon Health & Science University. He is also Emeritus Professor, University of California, San Francisco. He was a Staff Scientist in the Biomedical Sciences Division of the Lawrence Livermore National Laboratory (1972–1991), Professor of Laboratory Medicine at the University of California, San Francisco (1991–2011), and Associate Laboratory Director for Biosciences and Life Sciences Division Director at the Lawrence Berkeley National Laboratory (2003–2011). He joined Oregon Health & Science University in 2011. He is Principal Investigator of a National Cancer Institute Cancer Systems Biology Consortium (CSBC) U54 Center that is aimed at developing a systems level understanding of how intrinsic and extrinsic factors work together to enable triple-negative breast cancer to escape therapeutic control; PI of a National Institutes of Health U54 Center in the Library of Integrated Network-based Cellular Signatures (LINCS) program; Co-director of a philanthropically funded study "Serial Measurement of Molecular and Architectural Responses to Therapy" (SMMART) program to develop more durable and tolerable therapies for cancers of the breast, prostate, pancreas and leukemia; and PI of a Susan G. Komen project to identify the mechanisms by which ERBB2+ breast cancer cells escape inhibition by ERRB2-targeted therapies.

Dr. Gray's work is described in over 500 publications and in 80 US patents. He is a Fellow of the American Association for the Advancement of Science and the American Institute for Medical and Biological Engineering; an elected a member of the National Academy of Medicine; a Fellow of the American Association of Cancer Research Academy; and United States Councilor to the Radiation Effects Research Foundation (RERF), Hiroshima, Japan.

Paul Kinahan

Paul Kinahan received BASc and MASc degrees in Engineering Physics from the University of British Columbia, and his PhD in Bioengineering from the University of Pennsylvania in 1994. From there he became an Assistant Professor of Radiology at the University of Pittsburgh where

he developed two industry-standard PET image reconstruction algorithms and was a member of the team that developed the first PET/CT scanner and CT-based attenuation correction. In 2001 he moved to the University of Washington, where he is now the Vice Chair for Research and Professor of Radiology and Bioengineering. He is an Adjunct Professor of Physics and Radiation Oncology, Head of the Imaging Research Laboratory, and Director of PET/CT Physics at the UW Medical Center. He has served in several leadership roles for the IEEE, SNM, RSNA, and AAPM. He has served as the chair of the SNM Computer and Instrumentation Council, the American Board of Science in Nuclear Medicine, and the Executive Committee of the Quantitative Imaging Network. He is currently a member of the Science Council of the AAPM, co-chair of the RSNA Quantitative Imaging Biomarkers Alliance (QIBA) Nuclear Medicine Modality group, and co-Director of the ACRIN PET/CT core laboratory. In 2012 he co-founded PET/X LLC, a startup company with the goal of accelerating the development of quantitative imaging systems that guide the best selection of breast cancer therapy. He is a Fellow of the IEEE and the AAPM.

Subha Madhavan

Dr. Subha Madhavan is Director of the Innovation Center for Biomedical Informatics (ICBI) at the Georgetown University Medical Center and Associate Professor of Oncology. She is a world-class leader in data science, clinical informatics and health IT who is responsible for several biomedical informatics efforts including the software development of Georgetown Database of Cancer (G-DOC) a resource for both researchers and clinicians to realize the goals of personalized medicine and co-directs Lombardi Cancer Center's Biostatistics and Bioinformatics shared resource.

In her role as the CTSA biomedical informatics director, she has enabled access to over 2.5 million patient records from 10 MedStar Health hospitals to translational researchers. She was the PI on the Breast and Colon Cancer Family Registries data center that coordinates public health and epidemiology data across 12 sites in the US, Australia, and Canada. More recently, she has partnered with the FDA on the Center for Excellence in Regulatory Science program to develop evidence bases for pharmacogenomics and vaccine safety. She collaborated with the Inova translational medicine institute to help manage 1000's of patient genomes on the Amazon cloud to facilitate large-scale statistical analysis and genotype-phenotype association testing. She has contributed to novel information sciences findings in research articles published in journals such as Nature, Bioinformatics, Molecular and Cell Biology (MCB), AJPM, Frontiers in Oncology, Bioinformatics, Cancer Informatics, and Molecular Cancer Research (MCR).

Prior to joining Georgetown, Dr. Madhavan served as the Associate Director of Product and Program Management in the Life sciences informatics area at NCI's Center for Biomedical Informatics and Information technology. At NCI she led a group of scientists, physicians and software engineers in building REMBRANDT (REpository for MolecularBRAin Neoplasia DaTa) —a data platform that hosts and interconnects clinical data points with various genomics datasets from large brain tumor clinical trials. This effort won the Service to America Award. While at NCI

she also established the data coordination center for The Cancer Genome Atlas (TCGA), managing genomic data of approximately 100 TB over a period of 3 years.

Dr. Madhavan has a Master's degree in Information Technology from University of Maryland and a Ph.D. in Molecular Biology and Biological Sciences from the Uniformed Services University for the Health Sciences through a highly ranked Indo-US Collaborative program.

Dong-Guk Shin

Dong-Guk Shin is a Professor of Computer Science & Engineering at the University of Connecticut. Dr. Shin is also Director of the Bioinformatics and Bio-Computing Institute (BIBCI) of UConn which he established in 2003 through the funding from the NIH BISTI P20 program. One of BIBCI's missions has been establishing a bioinformatics R&D network interlinking the biomedical research of UCHC (Farmington) with the computational expertise of UConn (Storrs). Dr. Shin's research has been focusing on analyzing next generation sequencing data, building visual user interfaces for scientific user communities, and mining of massive amount of data to turn them into knowledge base systems. In addition, he has been addressing a broad range of research and development issues involving databases of various data types (images, text, sound, etc.) and building associated user interfaces. Specifically, his research topics include: (1) Development of user-friendly workflow environment capable of incorporating various human factors into intelligent business logics; (2) Applying data mining technology to turn massive amount of data into a knowledge-bases system to aid agile business decision making; (3) Development of various types of scientific and engineering databases that are capable of supporting seamless data analysis and process interoperation.

Shaying Zhao

Dr. Zhao is a Professor of Biochemistry, Molecular Biology, and bioinformatics at the University of Georgia. She was trained in biochemistry in the laboratories of Dr. Stephen Ragsdale and Dr. Aziz Sancar, a Nobel laureate. She have worked at The Institute for Genomic Research (TIGR) from 1998–2005, where she led the best bacterial artificial chromosome (BAC)-end sequencing operation in the world and made notable contributions to the sequencing and analyzing of the human, mouse, rat, and cow genomes. Since becoming a faculty member at UGA in 2005, Dr. Zhao has been funded by the National Cancer Institute, the American Cancer Society, the Georgia Cancer Coalition, and the AKC Canine Health Foundation to develop a novel dog-human comparative genomics and oncology strategy for cancer driver identification. Work from her lab has shown a strong dog-human molecular homology for histologically matched cancer types/subtypes for mammary cancer, colorectal cancer, and head and neck squamous cell carcinoma. Her group has also successfully validated this novel dog-human comparison strategy for cancer driver-passenger discrimination for amplified or deleted genes in colorectal cancer.