

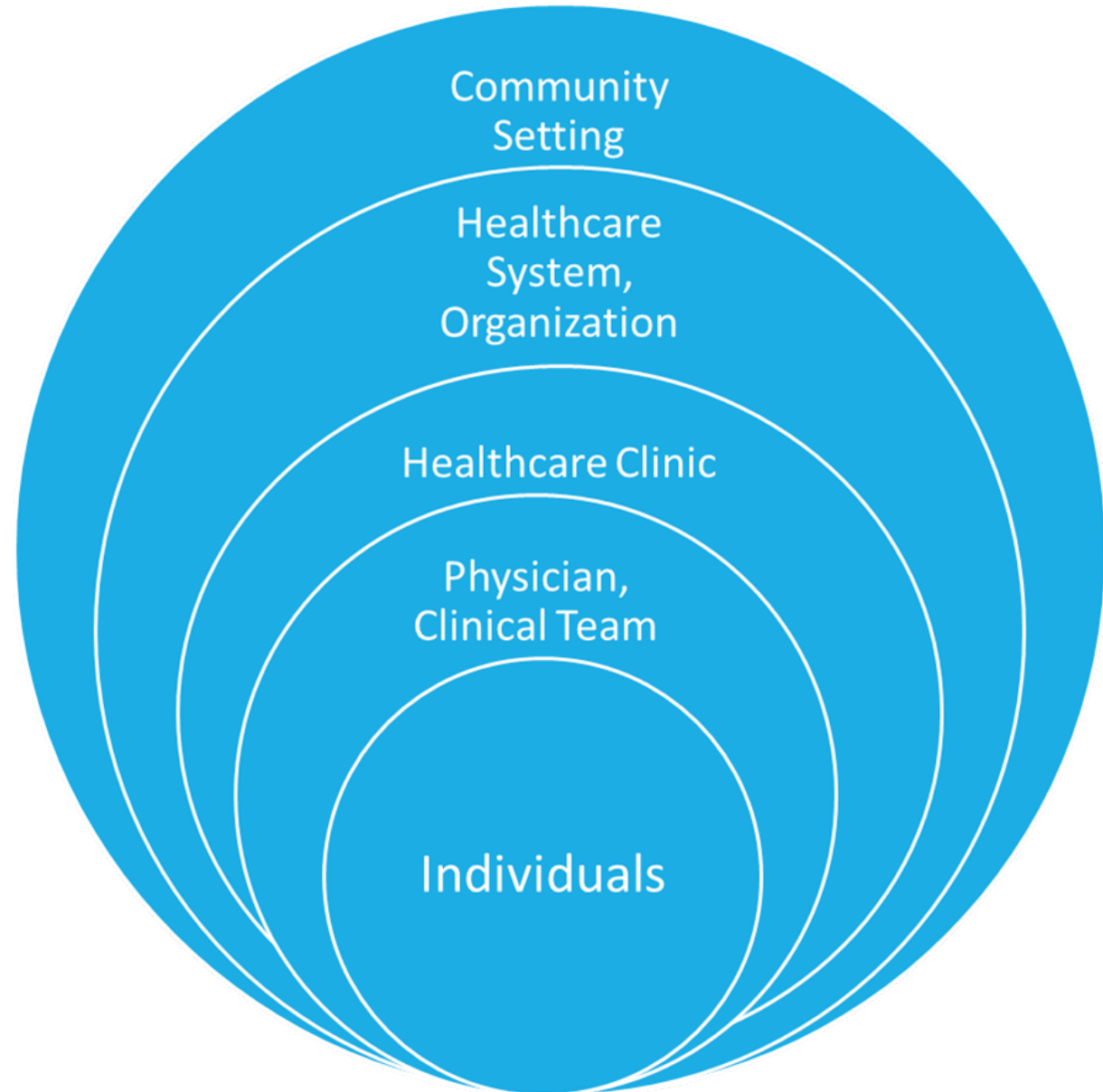
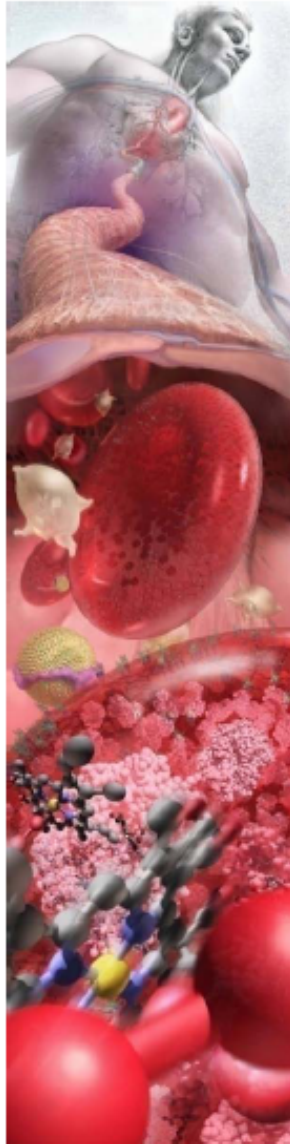
National Cancer Institute

Multiscale Modeling & Machine Learning Programs / Funding / Projects

Dave Miller & Emily Greenspan

IMAG ML-MSM Pre-meeting Webinar, October 10th, 2019

Multiscale Modeling & ML from a Cancer Research Perspective



Extramural Divisions



Office of the Director

- Center for Biomedical Informatics and Information Technology (CBIIT)
- Center for Cancer Genomics (CCG)
- Center for Cancer Training (CCT)
- Center to Reduce Cancer Health Disparities (CRCHD)
- Center for Strategic Scientific Initiatives (CSSI)
- SBIR Development Center (SBIR/STTR)

**DIVISION OF
CANCER
BIOLOGY**

**DIVISION OF
CANCER
CONTROL AND
POPULATION
SCIENCES**

**DIVISION OF
CANCER
PREVENTION**

**DIVISION OF
CANCER
TREATMENT
AND DIAGNOSIS**

Research Project Grant (Parent R01)

PA-19-056 Clinical Trial Not Allowed
PAR-18-560 Clinical Trial Required

Standing NIH Study Sections

- Biomedical Computing and Health Informatics Study Section – BCHI
- Genomics, Computational Biology and Technology Study Section – GCAT
- Modeling and Analysis of Biological Systems Study Section – MABS
- Biodata Management and Analysis Study Section – BDMA

- Tackle challenging, multivariate problems in cancer using systems biology approaches
 - Explicit integration of experimental biology and predictive computational methods
 - Experimentally test/validate, refine, and apply computational models
 - Disseminate data, tools, and computational models/algorithms
 - Establish training and outreach programs

Currently: 13 Research Centers (multi-project), 17 Research Projects + 1 Coordinating Center

New U01 Funding Opportunity Announcement: PAR-19-287

“Research Projects in Cancer Systems Biology (U01 Clinical Trial Optional)”

Contact: Shannon Hughes
shannon.hughes@nih.gov
@NCISysBio
www.csbconsortium.org

Summary of CSBC Research Centers

Lung

Prostate

Breast

Colon

Head and Neck

Melanoma

Glioblastoma

ALL

CML

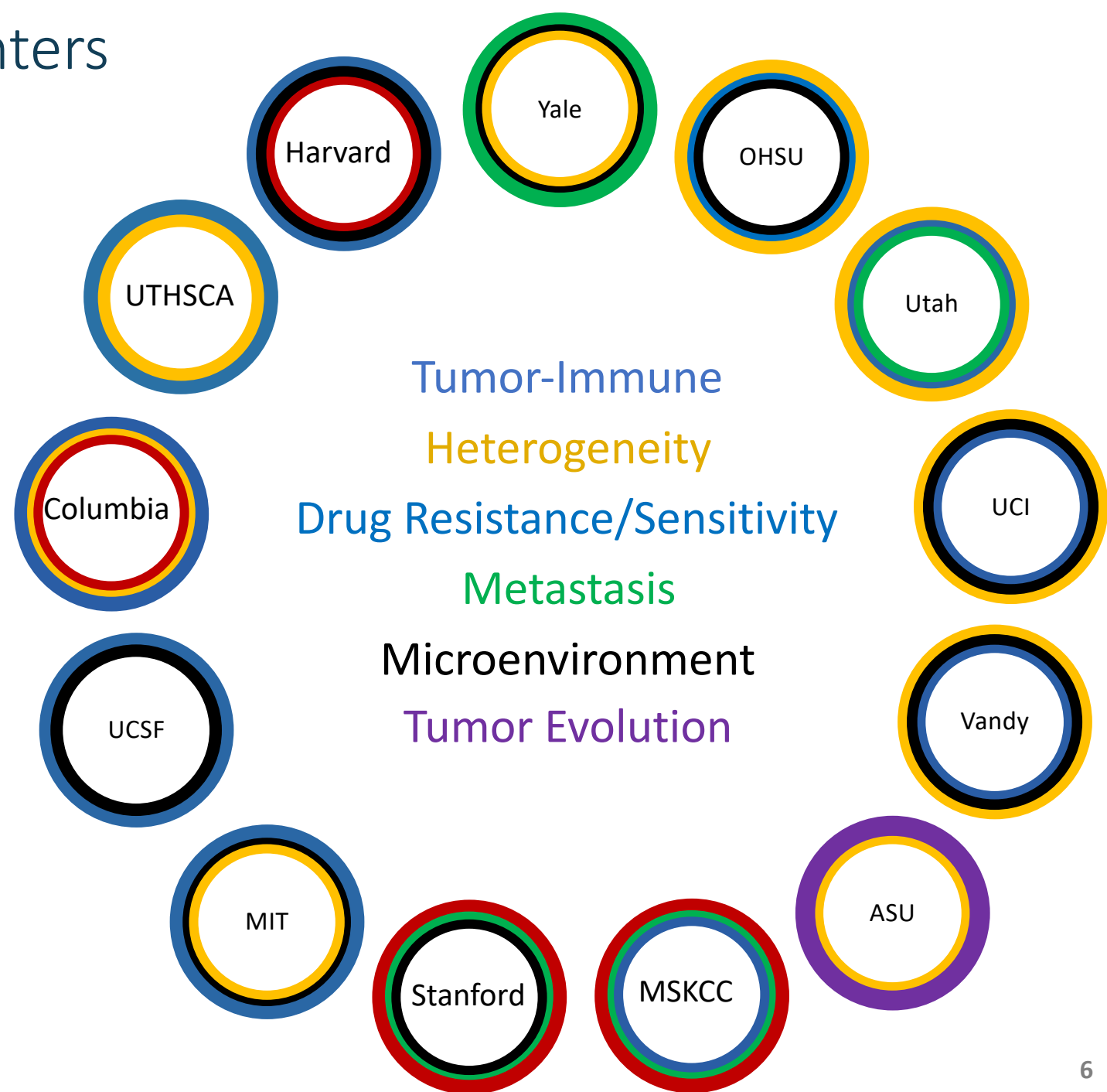
Pancreas

Network Inference / Statistical Modeling

Machine Learning / Deep Learning

Evolution / Ecology

Mechanistic Modeling (ODEs, etc)



Physical Sciences in Oncology Network (PS-ON)

Overarching Goals and Scientific Research Areas



To foster transdisciplinary research and environments that integrate perspectives and approaches from the *physical sciences* with *cancer research* to address fundamental questions in cancer biology.

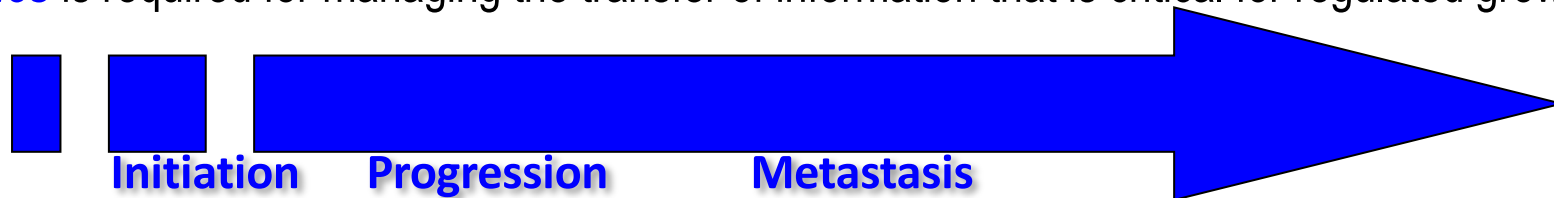
PS-ON Scientific Themes

➤ *The Physical Dynamics of Cancer*

Physical properties such as mechanical cues, transport phenomena, bioelectric signals, and thermal fluctuations can modulate the behavior of cancer cells and the tumor microenvironment.

➤ *Spatio-Temporal Organization in Cancer*

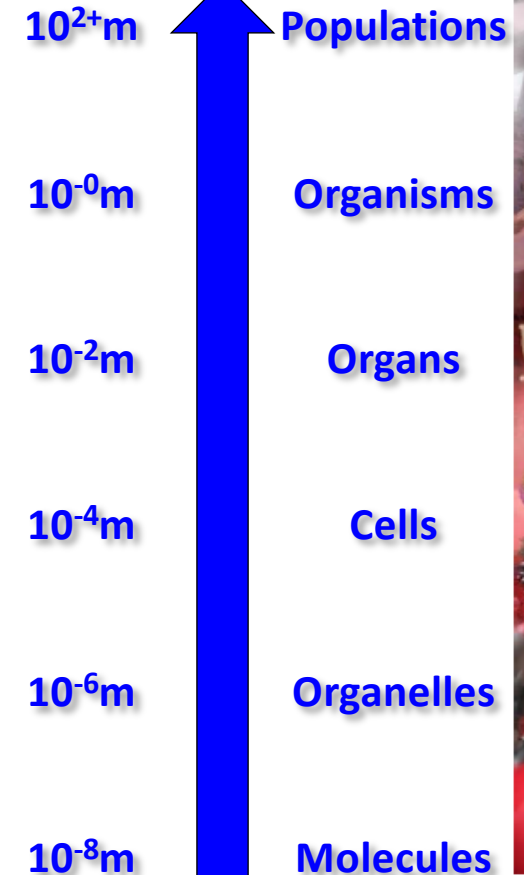
Appropriate spatial and temporal *organization of structures across many biological and physical length-scales (e.g., subcellular, cell, tissue, organ, whole organism) and time-scales* is required for managing the transfer of information that is critical for regulated growth.



Multi-scale computational models

Novel technologies

Across Length Scales



Michor et al. *Nat Rev Cancer*, 2011
Zahir. *Trends in Cancer*, 2018
Fischbach, White, Gatenby. *Cancer Res*, 2019

PAR-19-101: Physical Sciences-Oncology Network (PS-ON): Physical Sciences-Oncology Projects (PS-OP) (U01 Clinical Trial Optional)

Contact:
Nastaran Zahir
nas.zahir@nih.gov

U54 Centers (PS-OC; hyperlink to Center website)

[Columbia](#) (Rabadan)
[Cornell](#) (Fischbach)
[Dana Farber](#) (Michor)
[Hopkins](#) (Wirtz)
[Methodist](#) (Ferrari)
[Minnesota](#) (Odde)
[MIT](#) (White)
[Moffitt](#) (Gatenby)
[Northwestern](#) (O'Halloran)
[Upenn](#) (Discher)

Cancer TEC Projects (affiliated)

BU (Tien)
B&W Hospital (Sengupta)
Cleveland Clinic (Huang)
Harvard (Mooney)
MIT (Kamm)
Pitt (Sant)
Wisconsin (Kreeger)
UCSF (Aghi)
UI-Chicago (Burdette)

U24 Coordinating Center

Sage Bionetworks (Guinney)

U01 Projects (PS-OP)

Berkeley (Groves)
Georgia Tech (Zhu)
Harvard (Fredberg)
ISB (Heath)
MGH (Toner)
Michigan (Luker)
MIT (Kamm)
Utah (Alter)
Vanderbilt (McCawley)
Wake Forest (Vidi)

Image Analysis Workshop and Hackathon

(Sponsored by the Image Analysis Working Group of the NCI Cancer Systems Biology Consortium and NCI Physical Science-Oncology Network)

Computational Challenges Shared by Diverse Imaging Platforms
(e.g., CODEX, CyCIF, mIHC, imaging mass cytometry, time-lapse microscopy)

1. Accurate cell segmentation
2. Quantification of per-channel intensities per cell
3. Accurate cell-type calling
4. Integration of imaging with other data modalities
5. Cost-effective, low-latency access to large datasets

Prioritize topics during workshop; address them during hackathon:

2-day workshop hosted by Sage Bionetworks, Seattle, WA, Jan 9-10, 2020

2-day hackathon hosted by Vanderbilt CSBC U54, Nashville, TN, March 4-6, 2020

Application available at <https://www.synapse.org/CSBCPSONImageAnalysisWorkshop2020> & due Oct 11

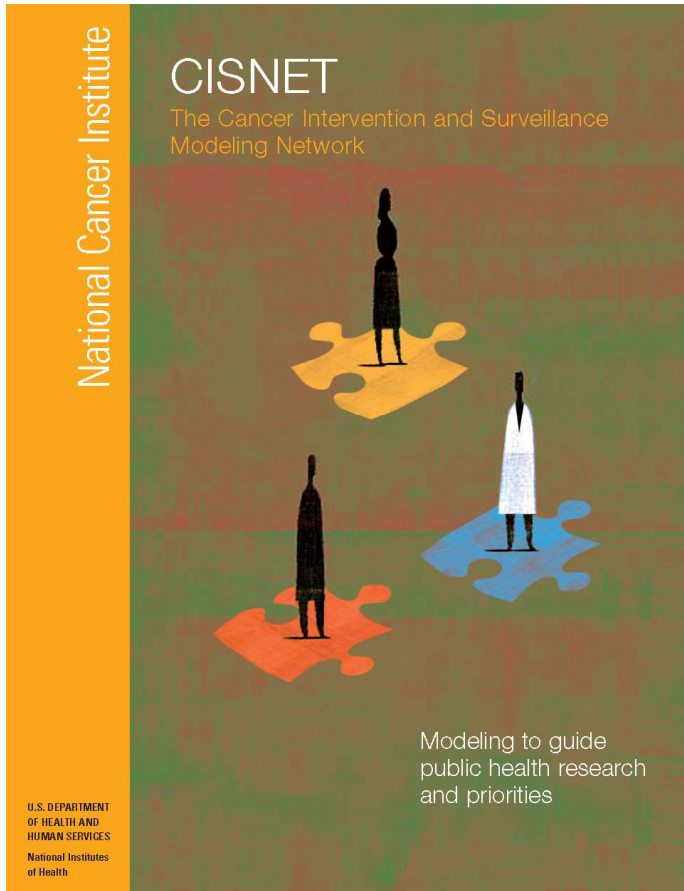
Darren Tyson (darren.tyson@vanderbilt.edu) or Brian White (brian.white@sagebase.org)

Cancer Intervention and Surveillance Modeling Network (CISNET)

- CISNET is the NCI Sponsored Collaborative Consortium (U01) of simulation modelers in Breast, Prostate, Colorectal, Lung, Esophagus, and Cervical cancers formed in 2000
- Purpose of CISNET: Extend evidence provided by trial, epidemiologic, and surveillance data using simulation modeling to guide public health research and priorities
- Utilizes a comparative modeling approach with 3-6 independent modeling groups per cancer site
- One multiple PI grant per cancer site with a coordinating center

New funding announcement - RFA-CA-19-054

Eric J. (Rocky) Feuer
CISNET Overall Project Scientist
Surveillance Research Program, DCCPS
email: rf41u@nih.gov



<https://cisnet.cancer.gov/>

Quantitative Imaging Network (QIN)

Mission

QIN is organized to improve the role of quantitative imaging for clinical decision making in oncology by the development and validation of data acquisition, analysis methods, and tools to tailor treatment to individual patients and to predict or monitor the response to drug or radiation therapy.

A long term program goal is to translate quantitative imaging methods and algorithms as clinical decision support tools into clinical utility, creating the condition where all imaging scanners perform as measuring instruments.

Funding Opportunities

- **PAR-18-919:** Quantitative Imaging Tools and Methods for Cancer Response Assessment (R01 Clinical Trial Optional)
- **PAR-18-248:** Quantitative Imaging Tools and Methods for Cancer Therapy Response Assessment (UG3/UH3 Clinical Trial Optional)

Scientific Contacts

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Darrell Tata

E-Mail: darrell.tata@nih.gov

Academic-Industrial Partnerships

- AIP stimulates efforts to translate scientific discoveries and engineering developments into methods and tools addressing unmet needs in cancer
- Requires formation of an academic-industrial partnership

Funding Opportunities

- **PAR-18-530:** Academic-Industrial Partnerships for Translation of Technologies for Diagnosis and Treatment (R01 - Clinical Trial Optional)
- **PAR-18-009:** Academic-Industrial Partnerships to Translate and Validate *in vivo* Cancer Imaging Systems (R01 Clinical Trial Optional)

See funding opportunities for NCI Scientific Contacts

CANCER MOONSHOTSM

[Blue Ribbon Panel](#) 
[Research Initiatives](#) 

Cancer MoonshotSM – Funding Opportunities

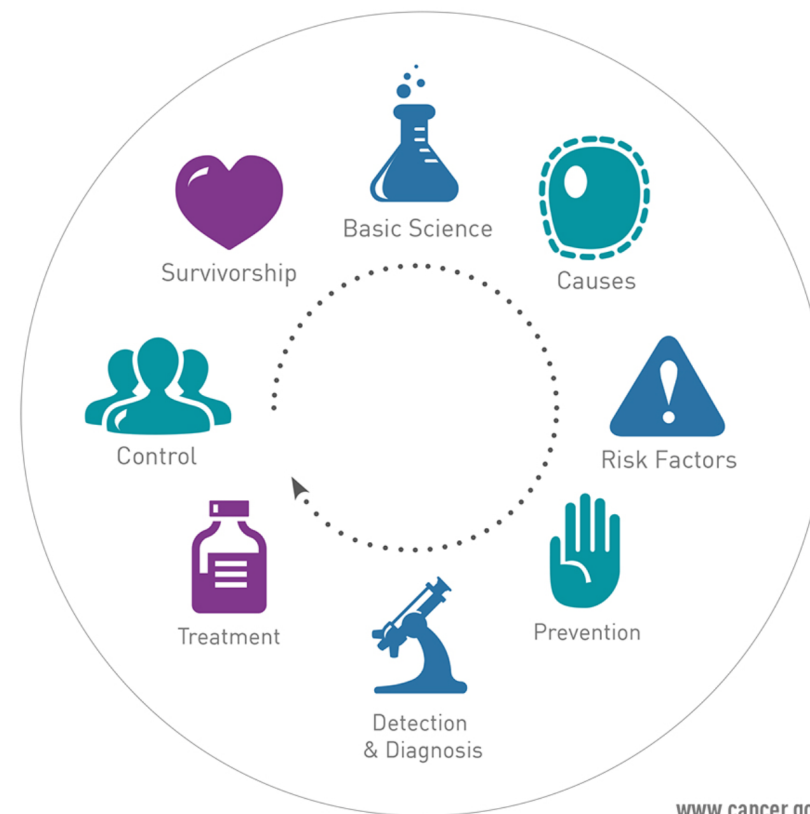
The funding opportunity announcements (FOAs) listed below highlight research initiatives that align with the efforts of the Cancer Moonshot. They may be supported with existing funds or with the 21st Century Cures funding.

BRP Recommendation	Title	Announcement Number	Receipt Date
New Enabling Technologies	Novel Technology Tools to Facilitate Research Using Next Generation Patient-derived Cancer Models (U01 Clinical Trial Not Allowed)	RFA-CA-19-055	08/30/2019
New Enabling Cancer Technologies	Spatial Sequencing Technologies with Single Cell Resolution for Cancer Research	PHS 2020-1/Topic 403	10/23/2019
New Enabling Cancer Technologies	Subcellular Microscopy and -Omics in Cancer Cell Biology	PHS 2020-1/Topic 404	10/23/2019
New Enabling Cancer Technologies	Intra-Tumor Sensing Technologies for Tumor Pharmacotyping	PHS 2020-1/Topic 405	10/23/2019
Prevention and Early Detection	Software for Patient Navigation Through the Cancer Care Continuum	PHS 2020-1/Topic 406	10/23/2019
National Cancer Data Ecosystem	Cloud-Based Software for the Cancer Research Data Commons	PHS 2020-1/Topic 407	10/23/2019
Generation of Human Tumor Atlases	Tools and Technologies for Visualizing Multi-Scale Data	PHS 2020-1/Topic 408	10/23/2019
Network for Patient Engagement	Cancer Clinical Trials Recruitment and Retention Tools for Participant Engagement	PHS 2020-1/Topic 410	10/23/2019

Informatics Technology for Cancer Research (ITCR)

ITCR is a trans-NCI program to support investigator-initiated informatics technology development driven by critical needs in cancer research.

- Support informatics technology development driven by cancer research
- Develop open-source, interoperable software tools and resources
- Promote broad dissemination of user-friendly resources

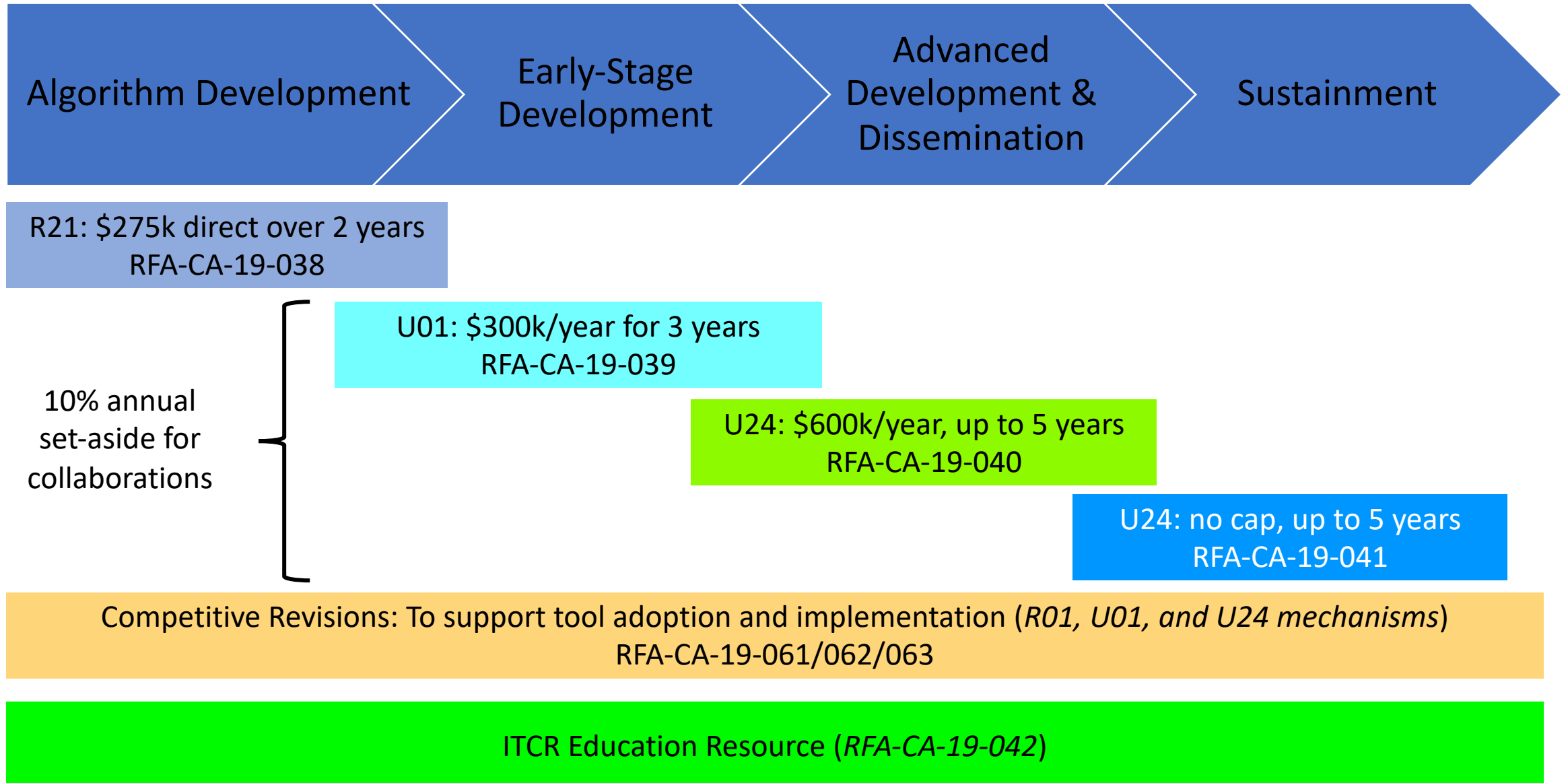


Juli Klemm

klemmj@mail.nih.gov

<https://itcr.cancer.gov>

ITCR Program Structure



ITCR Projects



HOME / INFORMATICS TOOLS

The ITCR Program funds tools that support the analysis of -omics, imaging, and clinical data, as well as network biology and data standards. All of the tools are free for use by academic and non-profit researchers. Access to tools, code repositories and introductory videos is available through the links below.

Category Filter

All Imaging (23) -omics (43) Clinical (14) Data Standards (10) Network Biology (3)

Select Category Search Tool Name Search Tool Description Grid | Table

3D Slicer
3D Slicer is the free open source software for medical image visualization and analysis.
Category: Imaging

Bioconductor
Bioconductor provides tools for the analysis and comprehension of high-throughput genomic data. R/Bioconductor will be enhanced to meet the increasing complexity of multiassay cancer genomics experiments.
Category: -omics

Cancer-Related Analysis of Variants Toolkit (CRAVAT)
CRAVAT is an easy to use web-based tool for analysis of cancer variants (missense, nonsense, in-frame indel, frameshift indel, splice site). CRAVAT provides scores and a variety of annotations that assist in identification of important variants. Results are provided in an interactive, highly graphical webpage and include annotated 3D structure visualization. CRAVAT is also available for local or cloud-based installation as a Docker container. Finally, our new OpenCustom Ranked Analysis of Variants Toolkit is a configurable python package with community developed analysis modules.
Category: -omics

Allele-Specific Alternative mRNA processing (ASARP)
A software pipeline for prediction of allele-specific alternative RNA processing events using single RNA-seq data. The current version focuses on prediction of alternative splicing and alternative polyadenylation modulated by genetic variants.
Category: -omics

Cancer Imaging Phenomics Toolkit (CaPTk)
CaPTk is a software toolkit to facilitate translation of quantitative image analysis methods that help us obtain rich imaging phenotypic signatures of oncologic images and relate them to precision diagnostics and prediction of clinical outcomes, as well as to underlying molecular characteristics of cancer. The stand-alone graphical user interface of CaPTk brings analysis methods from the realm of medical imaging research to the clinic, and will be extended to use web-based services for computationally-demanding pipelines. CaPTk replicates basic interactive functionalities of radiological workstations and is distributed under a BSD-style license.
Category: Imaging

Clinical Interpretation of Variants in

Apache Clinical Text and Knowledge Extration System (cTAKES) and Cancer Deep Phenotype (DeepPhe)
The tool extracts deep phenotypic information from the clinical narrative at the document-, episode-, and patient-level. The final output is FHIR compliant patient-level phenotypic summary which can be consumed by research warehouses or the DeepPhe native visualization tool.
Category: Clinical

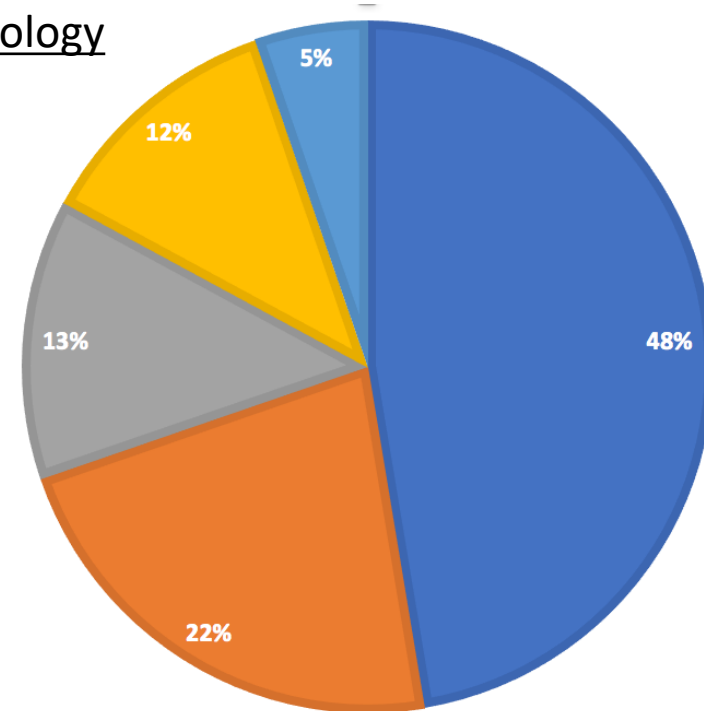
Cancer Slide Digital Archive (CDSA)
The CDSA is a web-based platform to support the sharing, management and analysis of digital pathology data. The Emory Instance currently hosts over 23,000 images from The Cancer Genome Atlas, and the software is being developed within the ITCR grant to be deployable as a digital pathology platform for other labs and Cancer Institutes.
Category: Imaging

Cistrome
Curated and processed human/mouse ChIP/DNAse-seq datasets in GEO, allowing users to search, browse, download ChIP-seq data signals, peaks, QC, motifs, target genes and similar datasets.
Category: Imaging

Biomarkers & Network Biology

Clinical Data & Data Standards NLP Ontologies

Additional types
Protein structure
Data transfer
Radiation therapy



-Omics
Genomics
Transcriptomics
Epigenomics
Proteomics
Genomic viz

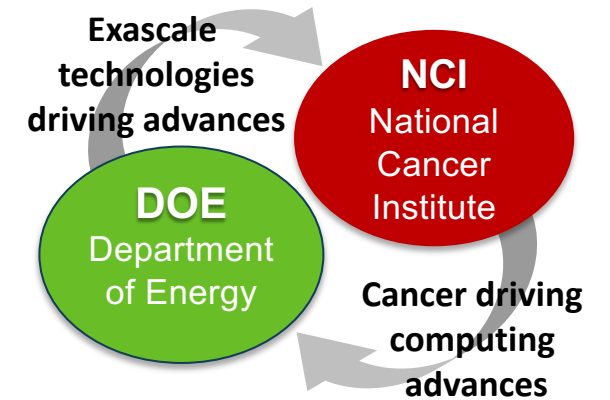
Imaging
Medical imaging
Pathology imaging

<https://itcr.cancer.gov>

NCI-DOE Collaboration: Joint Design of Advanced Computing Solutions for Cancer (JDACS4C)

*DOE-NCI partnership to advance
exascale development through
cancer research*

JDACS4C established June 27, 2016 with signed 5-
year MOU between NCI and DOE



Initiatives Supported NSCI and PMI

NIH > NATIONAL CANCER INSTITUTE

Argonne
NATIONAL LABORATORY

OAK
RIDGE
National Laboratory

Lawrence Livermore
National Laboratory

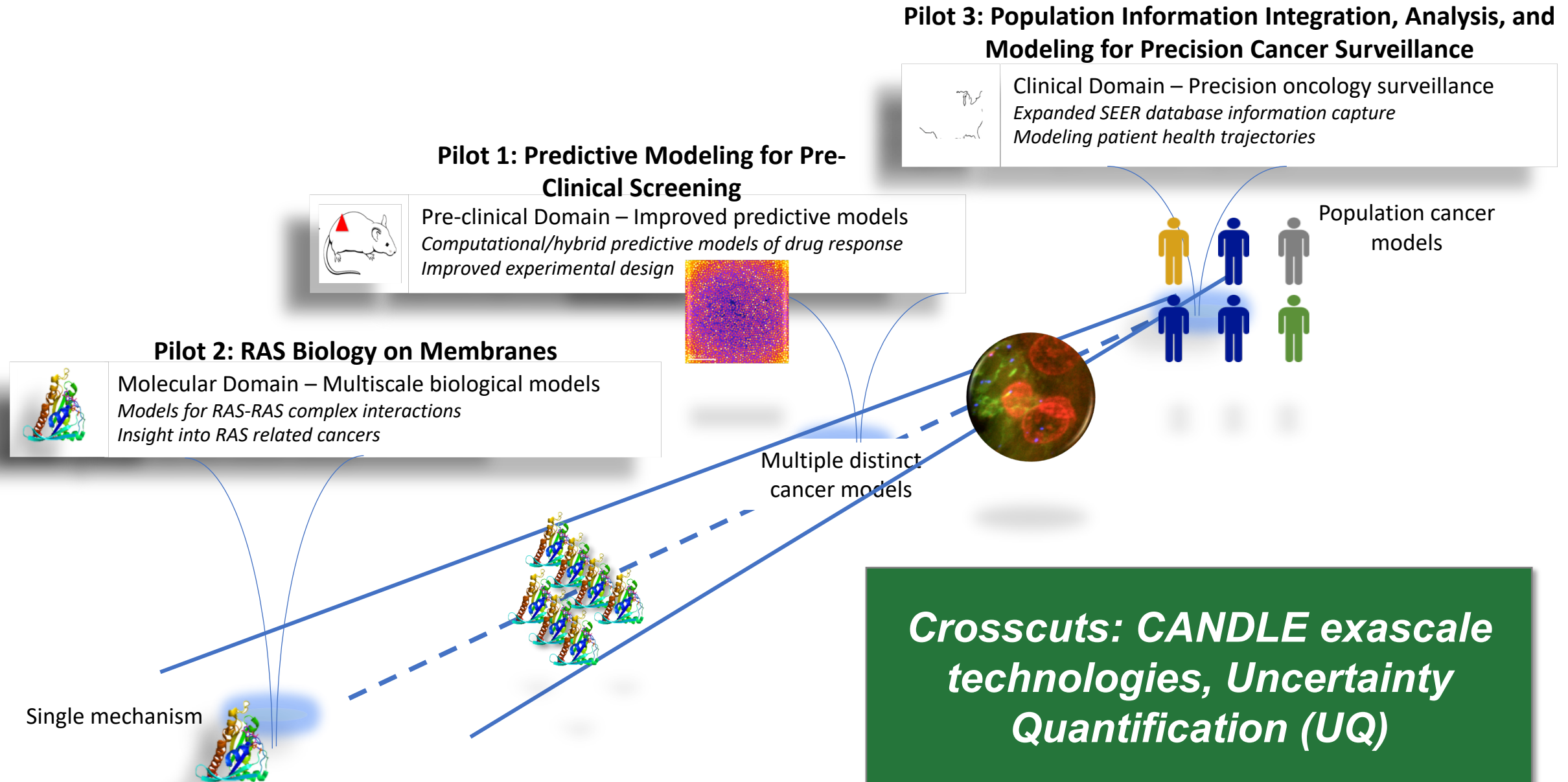
Los Alamos
NATIONAL LABORATORY
EST. 1943

Frederick National Laboratory
for Cancer Research

sponsored by the National Cancer Institute



JDACS4C: Pioneering New ML Predictive Oncology Capabilities



CANDLE: A Distributed Learning Environment for Cancer

- Supported by the DOE Exascale Computing Project (ECP)
 - Project Lead: Rick Stevens, Argonne National Laboratory
- Extends several existing and emerging deep learning frameworks to support **open source, scalable deep learning applications** in cancer, enabling deep learning to take advantage of both the scale and technologies being developed for exascale computing

ECP-CANDLE GitHub Organization:

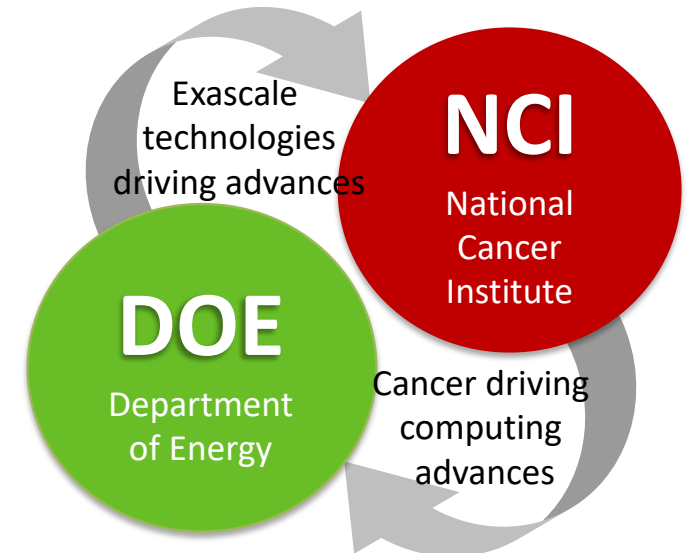
- <https://github.com/ECP-CANDLE>

ECP-CANDLE FTP Site (hosts all public databases for the benchmarks):

- <http://ftp.mcs.anl.gov/pub/candle/public/>

CANDLE on Biowulf:

- <https://hpc.nih.gov/apps/candle/index.html>

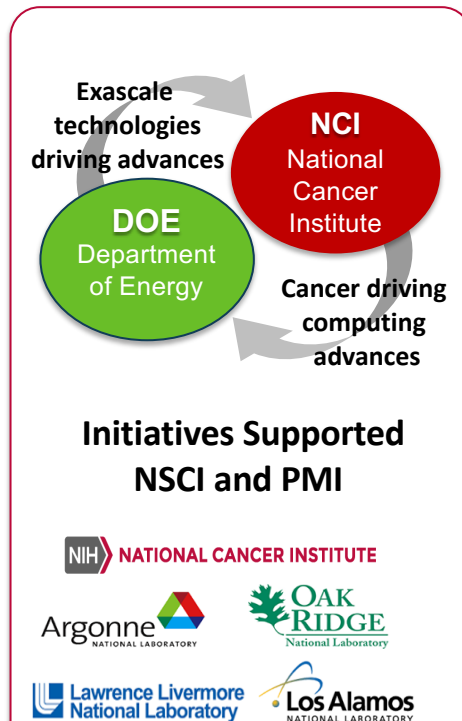


Envisioning Computational Innovations for Cancer Challenges (ECICC) Community

Joint Design of Advanced Computing Solutions for Cancer (JDACS4C)

2016-present

NCI-DOE partnership to advance exascale HPC through cancer research

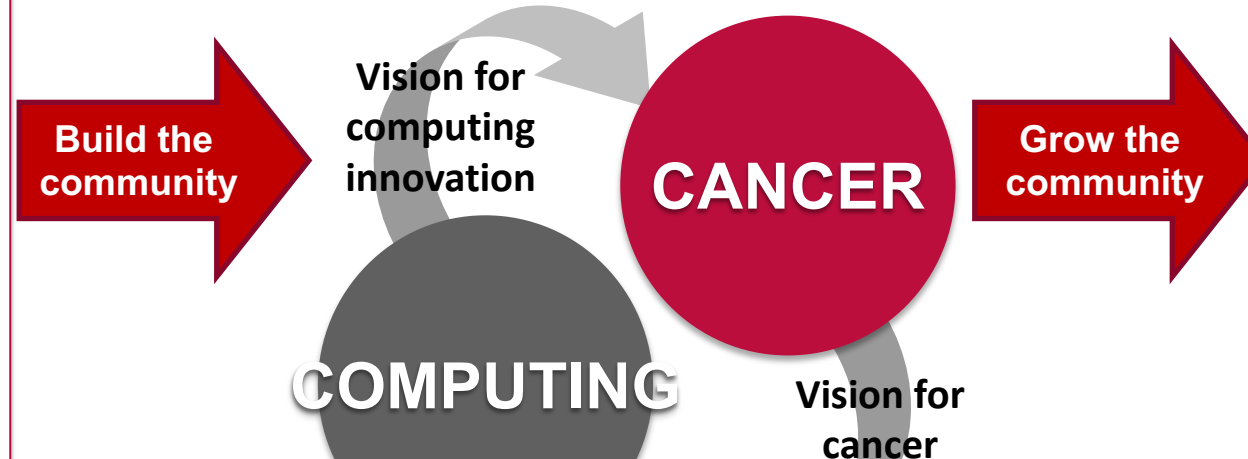


ECICC Scoping Meeting

March 6-7, 2019, LLNL

*Community brainstorming identified **four major Cancer Challenge Areas***

- *Generating synthetic data*
- *ML for iterative hypothesis generation*
- *Digital twin technology*
- *Adaptive cancer treatments*



Cancer Challenges & Advanced Computing MicroLabs

Virtual interactive events, ongoing

Broadly engage the cancer and HPC communities

1st MicroLab: June 11, 2019:
Discussed ideas and challenges relating 4 Cancer Challenge Areas

2nd MicroLab: Sept 25, 2019:
Develop use cases and persona through the lens of the 4 Cancer Challenge Areas

Join the community! Contact: ECICCcommunity@nih.gov

Thank you!

Questions?

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