Advancing Innovation and Convergence in Cancer Research

Jerry S.H. Lee, Ph.D.

Health Sciences Director

Deputy Director, Center for Strategic Scientific Initiatives (CSSI)
Office of the Director, National Cancer Institute (NCI)
National Institutes of Health (NIH)

LEUKEMIA & LYMPHOMA SOCIETY® fighting blood cancers
someday is today®

Northern California Blood Cancer Conference, Hyatt Regency- San Francisco

Feb 4, 2017

CLINICAL PROTEOMIC TUMOR ANALYSIS CONSORTIUM
NCI Alliance for Nanotechnology in Cancer
IMAT INNOVATIVE MOLECULAR ANALYSIS TECHNOLOGIES
Provocative Questions Initiative

- **WHY** am i here?
- **WHO** i am **&** **WHAT** is cssi?
- **WHY data quality & sharing are IMPORTANT**
- **2016** at a glance
- **2017** moving the needle

04/09/2013

Systems Biology and the Impact on Understanding Cancer

Systems Fiveology

Fredricka Hunter
Sanford Jeames
Kim Alexandre Powell
Lauren Wilkerson

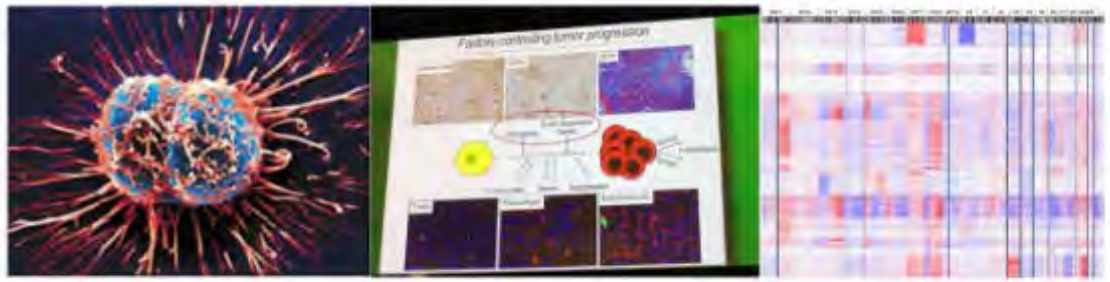
Patient Mentor: Peg Ford

Scientific Mentor: Dr. Jerry Lee

AACR American Association for Cancer Research

04/21/2015

CANCER COMPLEXITY



Work Group 4: Mary Kay Dauria, Leila Evangelista, Jeri Francoeur, Michael Jones, Yoshiyuki Majima, Jeannine Walston

Mentor: Cynthia Ryan, Ph.D.

Scientific Mentor: Jerry Lee, Ph.D.

AACR American Association for Cancer Research

Work Group 4: Mary Kay Dauria, Leila Evangelista, Jeri Francoeur, Michael Jones, Yoshiyuki Majima, Jeannine Walston

Mentor Cynthia Ryan

Scientific Mentor: Jerry Lee

04/20/2016

Mission

- Make a **decade's** worth of progress in **cancer prevention, diagnosis, treatment, and care** – ultimately to end cancer as we know it.

1 million healthy genomes

2001 **2010** **2015**

2016

1,685,210

new cases of cancer in the U.S.

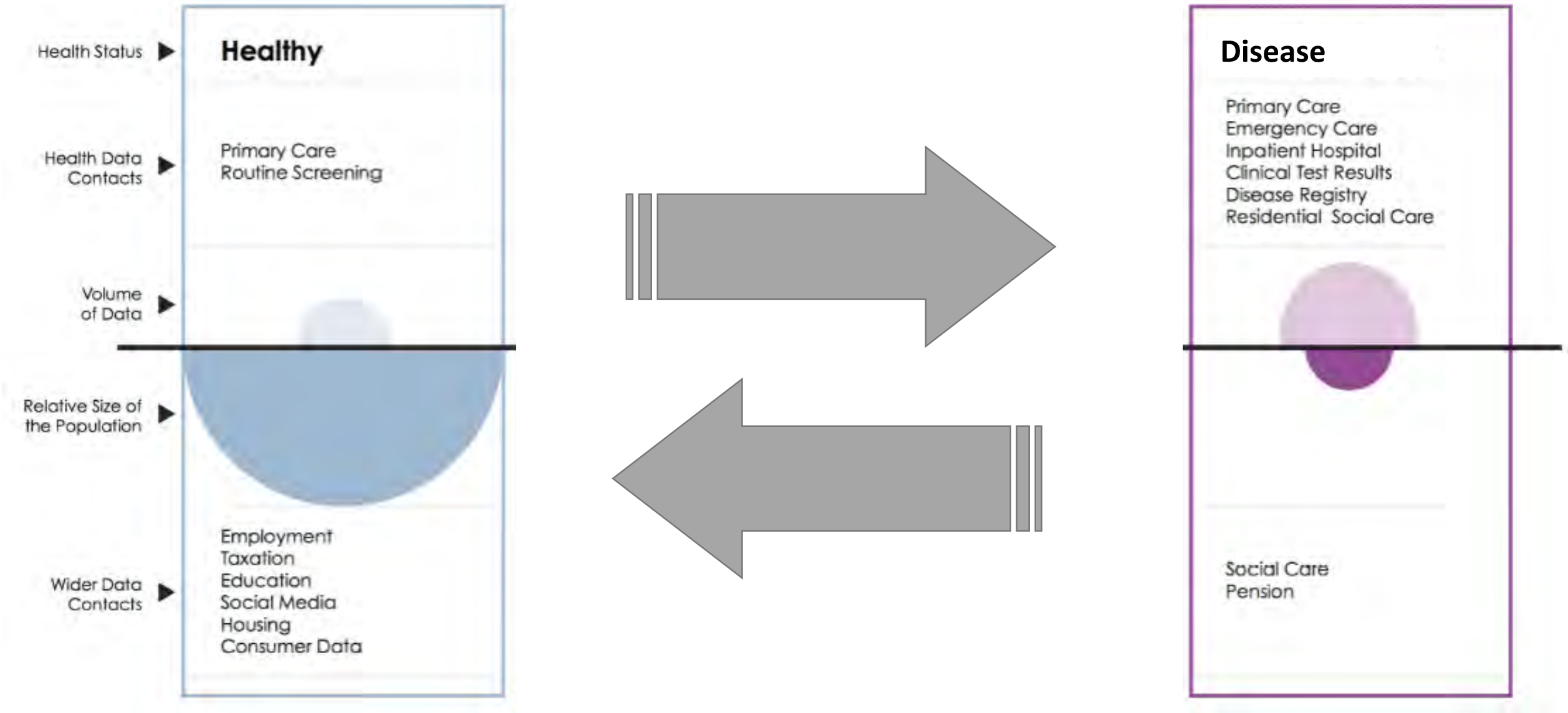
595,690

projected deaths due to cancer in the U.S.

2016

15,533,220

cancer survivors in the U.S.



Denny and Steventon. *BMJ*, 2015

Big Hopes for Big Data: Digital Information Focus Underpins Cancer Moonshot Goals

Andrew D. Smith | January 13, 2017

Daniel F. Hayes, MD

The passage of the 21st Century Cures Act[1] sparked unusually robust holiday celebrations throughout the cancer research community, which harbors high hopes for both the newly funded initiatives and future budget increases.

The act will provide the National Cancer Institute (NCI) an extra $1.8 billion to fund the Cancer Moonshot, an effort to make 10 years of research gains in just 5 years by directing new money to 10 potentially transformative research areas (**Chart, Table**). It also gives the FDA the ability to consider real-world clinical data in determining drug indications.

"…asked what tied the various aspects of the Moonshot together, he [Daniel Hayes] answered with a single word: ***data***. Most of the specific research recommendations envision the **aggregation of huge amounts of data** and the **extraction of important discoveries** from those collection points…"

http://www.onclive.com/publications/oncology-live/2017/vol-18-no-02/big-hopes-for-big-data-digital-information-focus-underpins-cancer-moonshot-goals

01/26/2017

CNN Health » Diet + Fitness | Living Well | Parenting + Family U.S. Edition +

'Automated dermatologist' detects skin cancer with expert accuracy

By Susan Scutti, CNN

Updated 6:37 PM ET, Thu January 26, 2017

nature

LETTER

doi:10.1038/nature21056

Dermatologist-level classification of skin cancer with deep neural networks

Andre Esteva[1]*, Brett Kuprel[1]*, Roberto A. Novoa[2,3], Justin Ko[2], Susan M. Swetter[2,4], Helen M. Blau[5] & Sebastian Thrun[6]

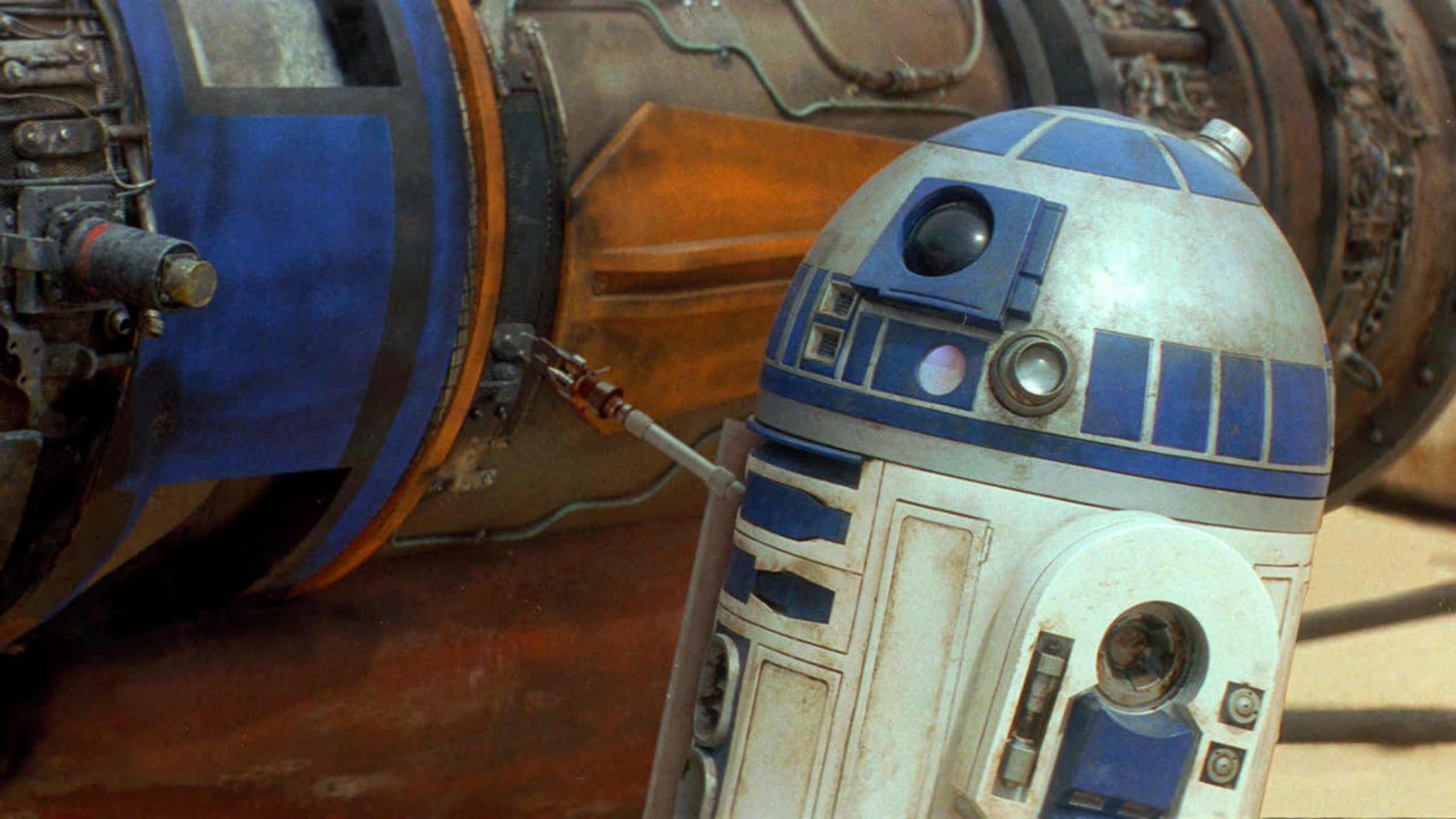
Skin cancer, the most common human malignancy[1–3], is primarily diagnosed visually, beginning with an initial clinical screening and followed potentially by dermoscopic analysis, a biopsy and histopathological examination. Automated classification of skin lesions using images is a challenging task owing to the fine-grained variability in the appearance of skin lesions. Deep convolutional neural networks (CNNs)[4,5] show potential for general and highly variable tasks across many fine-grained object categories[6–11]. Here we demonstrate classification of skin lesions using a single CNN, trained end-to-end from images directly, using only pixels and disease labels as inputs. We train a CNN using a dataset of 129,450 clinical images—two orders of magnitude larger than previous datasets[12]—consisting of 2,032 different diseases. We test its performance against 21 board-certified dermatologists on biopsy-proven clinical images with two critical binary classification

images (for example, smartphone images) exhibit variability in factors such as zoom, angle and lighting, making classification substantially more challenging[23,24]. We overcome this challenge by using a data-driven approach—1.41 million pre-training and training images make classification robust to photographic variability. Many previous techniques require extensive preprocessing, lesion segmentation and extraction of domain-specific visual features before classification. By contrast, our system requires no hand-crafted features; it is trained end-to-end directly from image labels and raw pixels, with a single network for both photographic and dermoscopic images. The existing body of work uses small datasets of typically less than a thousand images of skin lesions[16,18,19], which, as a result, do not generalize well to new images. We demonstrate generalizable classification with a new dermatologist-labelled dataset of 129,450 clinical images, including 3,374 dermoscopy images.

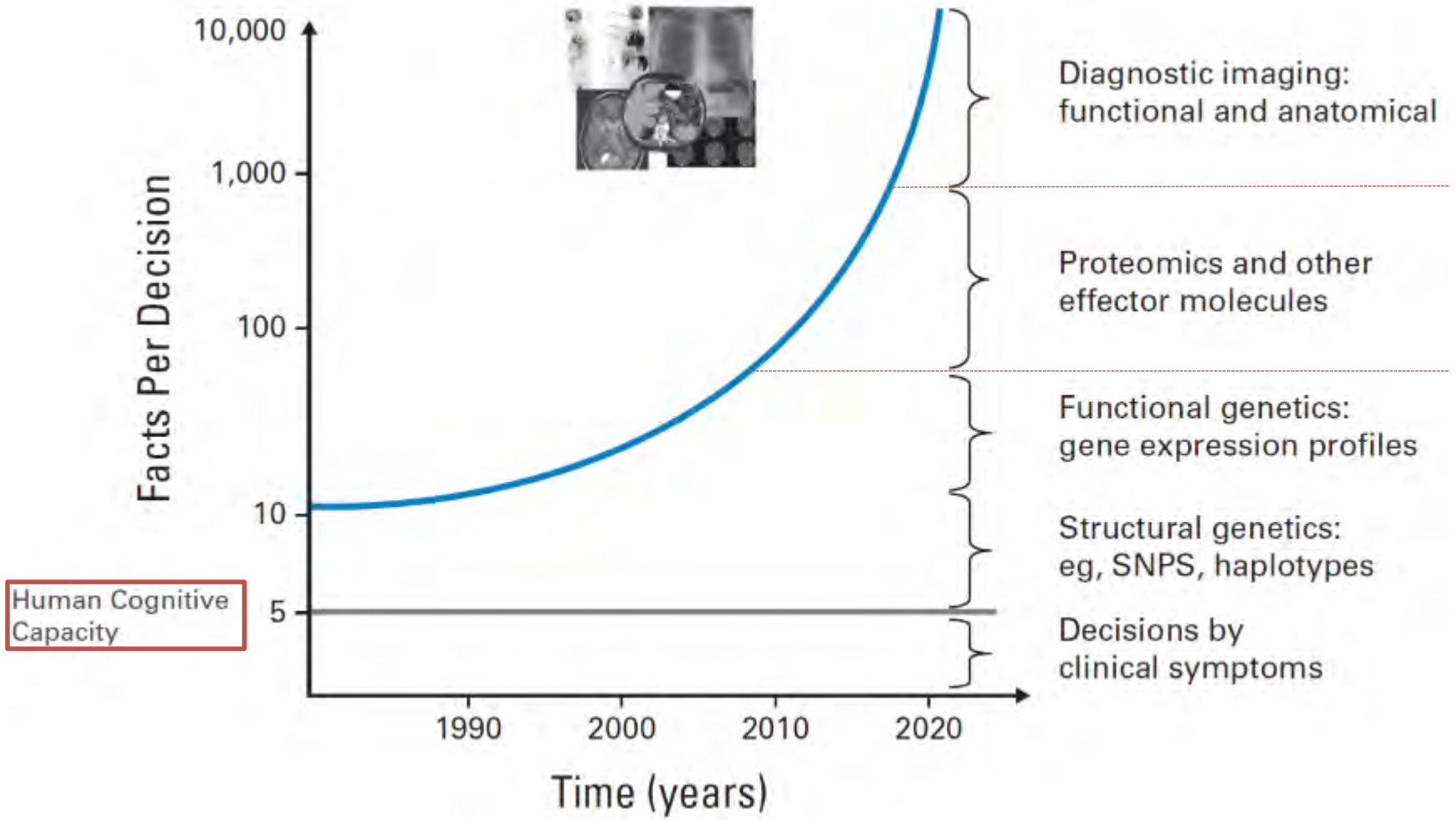
Esteva et. al. *Nature,* 2017

"…an **advantage** of **machine learning** is that it can be used even in cases where it is **infeasible** or **difficult** to write down **explicit rules** to **solve** a problem…"

https://www.whitehouse.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf



VOLUME 28 · NUMBER 27 · SEPTEMBER 20 2010
JOURNAL OF CLINICAL ONCOLOGY

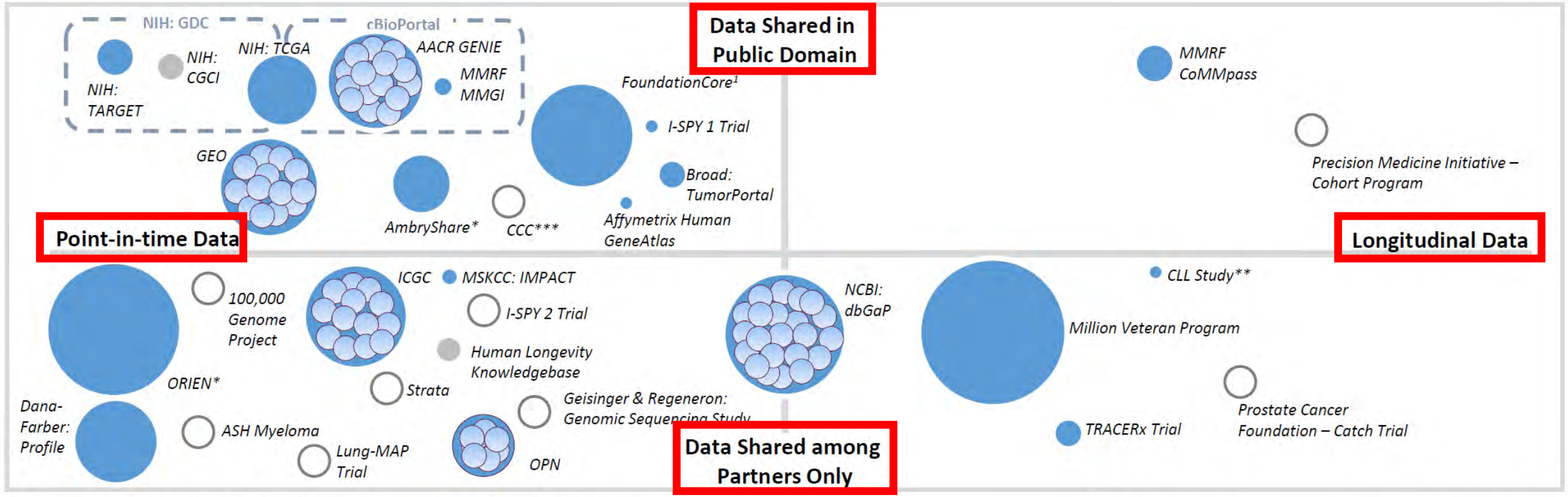


Modified from Abernethy et. al. *JCO* 2010

"…to apply machine learning, a practitioner starts with **a historical data set**, which the practitioner divides into a ***training set*** and a ***test set***…"

https://www.whitehouse.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf

10/14/2016



Bubble size = estimated size of available dataset
Note: Representative selection of landscape, not all inclusive

Available datasets, size known
Available datasets, size unknown
Dataset in development
Available datasets that comprise multiple smaller datasets
Portals that are currently active/utilized in the public domain

Opportunity exists to generate publicly available longitudinal data to drive understanding of genetic mutations and find Precision Medicine cures

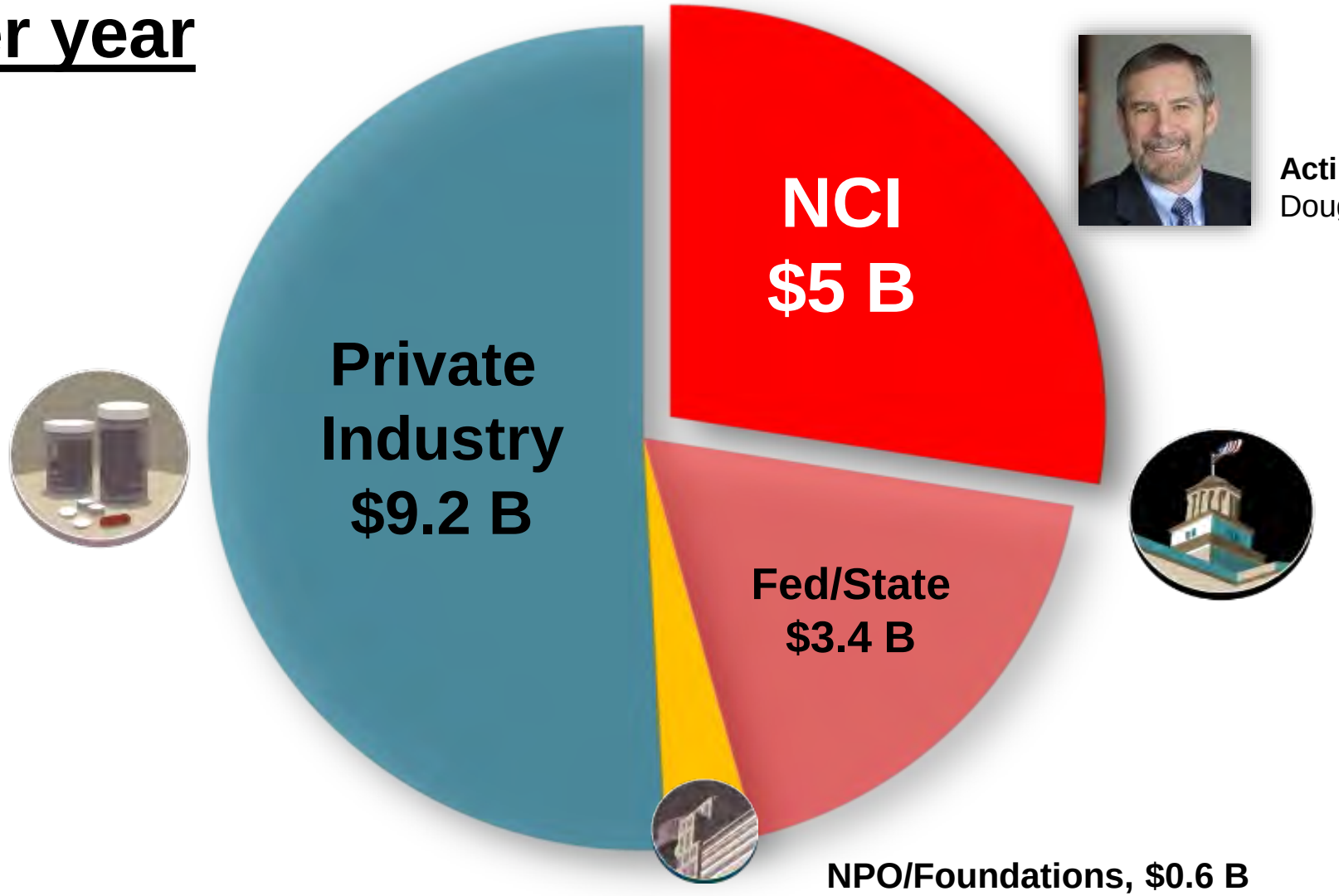
*Datasets have potential to include longitudinal data in the future
**Public/private information not available
***Serves as a portal also, has potential to include longitudinal data in the future

1. FoundationCore's pediatric cancer data has been made public

HARVARD BUSINESS SCHOOL
Kraft Precision Medicine Accelerator

U.S. National Cancer Program: Stakeholders

~$18 B per year



Acting Director
Douglas R. Lowy, MD

NCAB Working Group Report, 2010

NCI Center for Strategic Scientific Initiatives (CSSI): Concept Shop

Director
Douglas R. Lowy, MD

CENTER *for* STRATEGIC SCIENTIFIC INITIATIVES

Deputy Director
Jerry S.H. Lee, PhD

Mission

"…to create and uniquely implement exploratory programs focused on the development and integration of advanced technologies, **trans-disciplinary approaches, infrastructures, and standards**, to accelerate the **creation and broad deployment** of **data, knowledge, and tools** to empower the **entire cancer research continuum** in better understanding and leveraging knowledge of the cancer biology space **for patient benefit**…"

IMAT — **2003, 2007, 2011, 2013, 2014**

Clinical Proteomic Technologies for Cancer — **2005, 2010, 2015**

Physical Sciences in Oncology — **2008, 2013***

Provocative Questions Initiative — **2011, 2014**

NCI Alliance for Nanotechnology in Cancer — **2004, 2008, 2014**

The Cancer Genome Atlas — **2005, 2008**

Cancer Target Discovery & Development (CTD²) — **2010**

Dates indicate approval(s) by NCI Board of Scientific Advisors; *Program moved to NCI Division of Cancer Biology

2006-2015: Building a historical data set

A Decade of Illuminating the Underlying Causes of **Primary Untreated Tumors**

(12,000+ patient tumors and increasing)

Early Years

THE LANCET

2002

MECHANISMS OF DISEASE

Mechanisms of disease

Use of proteomic patterns in serum to identify ovarian cancer

Emanuel F Petricoin III, Ali M Ardekani, Ben A Hitt, Peter J Levine, Vincent A Fusaro, Seth M Steinberg, Gordon B Mills, Charles Simone, David A Fishman, Elise C Kohn, Lance A Liotta

Summary

Background New technologies for the detection of early-stage ovarian cancer are urgently needed. Pathological changes within an organ might be reflected in proteomic patterns in serum. We developed a bioinformatics tool and used it to identify proteomic patterns in serum that distinguish ovarian cancer from non-ovarian disease within the ovary.

Methods Proteomic spectra were generated by mass spectrometry (surface-enhanced laser desorption and ionisation). A preliminary training set of spectra derived from analysis of serum from 50 unaffected women and 50 patients with ovarian cancer were used by an iterative searching algorithm that identified a proteomic pattern that completely discriminated cancer from non-cancer. The discovery pattern was then used to classify an independent set of 116 masked serum samples: 50 from women with ovarian cancer, 66 from unaffected women or those with non-malignant disorders.

Findings The algorithm identified a proteomic pattern in the training set, completely segregated cancer from non-cancer. The discriminatory pattern correctly identified all 50 ovarian cancer cases in the masked set, including all 18 stage I cases. Of the 66 cases of non-malignant disease, 63 were recognised as not cancer. This result yielded a sensitivity of 100% (95% CI 92–100), specificity of 95% (87–98), and positive predictive value of 94% (86–97).

Introduction

Application of new technologies for detection of ovarian cancer could have an important effect on public health,[1] but to achieve this goal, specific and sensitive molecular markers are essential.[2–5] This need is especially urgent in women who have a high risk of ovarian cancer due to family or personal history of cancer, and for women with a genetic predisposition to cancer due to abnormalities in predisposition genes such as *BRCA1* and *BRCA2*. "There are no effective screening options for this population.

Ovarian cancer presents at a late clinical stage in more than 80% of patients,[1] and is associated with a 5-year survival of 25% in this population. By contrast, the 5-year survival for patients with stage I ovarian cancer exceeds 90%, and most patients are cured of their disease by surgery alone.[1] Therefore, increasing the number of women diagnosed with stage I disease should have a direct effect on the mortality and economics of this cancer without the need to change surgical or chemotherapeutic approaches.

Cancer antigen 125 (CA125) is the most widely used biomarker for ovarian cancer.[6] Although concentrations of CA125 are abnormal in about 90% of patients with advanced-stage disease, they are increased in only 50–60% of patients with stage I ovarian cancer.[7] CA125 has a positive predictive value of less than 10% as a single marker, but the addition of ultrasound screening to CA125 measurement has improved the positive predictive value to about 20%.[8]

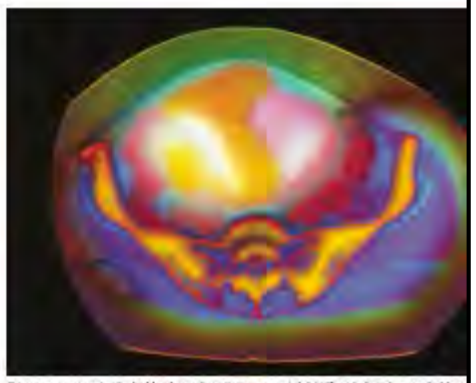
Lancet 2002; 359: 572-577

2004

news feature

Running before we can walk?

Two years ago, a new proteomic test was heralded as the future of cancer diagnostics. But since then, doubts about its effectiveness have begun to grow. Erika Check reports.



Seldom does a single piece of research prompt the US Congress to pass legislation urging continued funding to drive a new diagnostic test towards the clinic. But that's what happened in 2002, when *The Lancet* published a paper[1] claiming a breakthrough in the diagnosis of ovarian cancer.

The paper described the use of mass spectrometry to analyse the pattern of proteins present in samples of blood serum. On the basis of these patterns, the test detected all the patients with ovarian cancers in a set of 50 samples, and falsely identified just three healthy patients as suffering from the disease from a total of 66 control samples.

Most unnervingly, the technique seemed to work well on patients with early-stage cancer — offering the prospect of earlier diagnosis, which improves the chances of successful treatment. The best current blood test, which relies on the detection of a single protein called CA125, misses at least half of patients in the earliest stages of the disease.

Early warning

Critics warn that the spectre illustrates the dangers of moving rapidly to the clinic with innovative technologies such as those of proteomics. They say that scientific and regulatory

"Whether or not OvaCheck works, we will learn from this experience what kinds of evidence we might apply in the future to find useful results more efficiently."

Nature 2004; 429: 496-497

2004

The New York Times

February 3, 2004

New Cancer Test Stirs Hope and Concern

By ANDREW POLLACK

Jill Doimer's mother died in 2002 from ovarian cancer, detected too late to be effectively treated.

So Ms. Doimer is eagerly awaiting the introduction of a new test that holds the promise of detecting early-stage ovarian cancer far more accurately than any test available now, using only blood from a finger prick.

Not only does she plan to be tested, but an advocacy group she helped found, Ovarian Awareness of Kentucky, also intends to spread the word to women and doctors.

"If it's going to happen to me or anyone I know, I want it to be caught at an early stage," said Ms. Doimer, who lives in Louisville.

The new test, expected to be available in the next few months, could have a big effect on public health if it works as advertised. That is because when ovarian cancer is caught early, when it is treatable by surgery, more than 90 percent of women live five years or longer. But right now, about three-quarters of cases are detected after the cancer has advanced, and then only 35 percent of women survive five years.

The test is also the first to use a new technology that some believers say could revolutionize diagnostics. It looks not for a single telltale protein -- like the prostate-specific antigen, or P.S.A., used to diagnose prostate cancer -- but rather for a complex fingerprint formed by all the proteins in the blood. Similar tests are being developed for prostate, pancreatic, breast and other cancers. The technique may work for other diseases as well.

“What is Water?”: Measurements → Insights

Color (clear, yellow, brown)

Taste (none, metallic, awful)

Phase (liquid, gas, solid)

Phase change (boil, melt, freeze)

Qualitative Descriptions

Measurements Taken

Saturated steam				Superheated steam		
Pressure (kg/cm²)	Temp (°C)	Vapour enthalpy (kcal/kg)	Specific volume (m³/kg)	Density (kg/m³)	Specific volume (m³/kg) at 250°C	Specific volume (m³/kg) at 300°C
1	99,1	638,8	1,725	0,580	2,454	2,691
2	119,6	646,2	0,902	1,109	1,223	1,342
3	132,9	650,6	0,617	1,621	0,812	0,893
4	142,9	653,7	0,471	2,123	0,607	0,668
5	151,1	656,0	0,382	2,618	0,484	0,533
6	158,1	657,0	0,321	3,115	0,402	0,443
7	164,2	659,5	0,278	3,597	0,343	0,379
8	169,6	660,8	0,245	4,082	0,299	0,331
9	174,5	661,9	0,219	4,566	0,265	0,293
10	179,1	662,9	0,198	5,051	0,238	0,263
12	187,1	664,5	0,166	6,024	0,196	0,218
14	194,1	665,7	0,143	6,993	0,167	0,186
16	200,4	666,7	0,126	7,937	0,145	0,162
18	206,1	667,4	0,112	8,929	0,128	0,143
20	211,4	668,0	0,101	9,901	0,114	0,128
22	216,2	668,4	0,092	10,870	0,103	0,116
24	220,7	668,7	0,085	11,765	0,093	0,106
26	225,0	669,0	0,078	12,821	0,085	0,097
28	229,0	669,1	0,073	13,699	0,078	0,089
30	232,7	669,2	0,068	14,706	0,072	0,083

LOTS of Quantitative “Data”

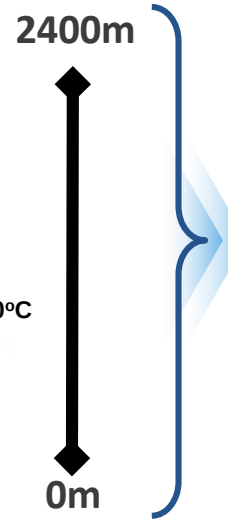
But also LOTS of disagreements…

Boiling point = 92°C

Boiling point = 100°C

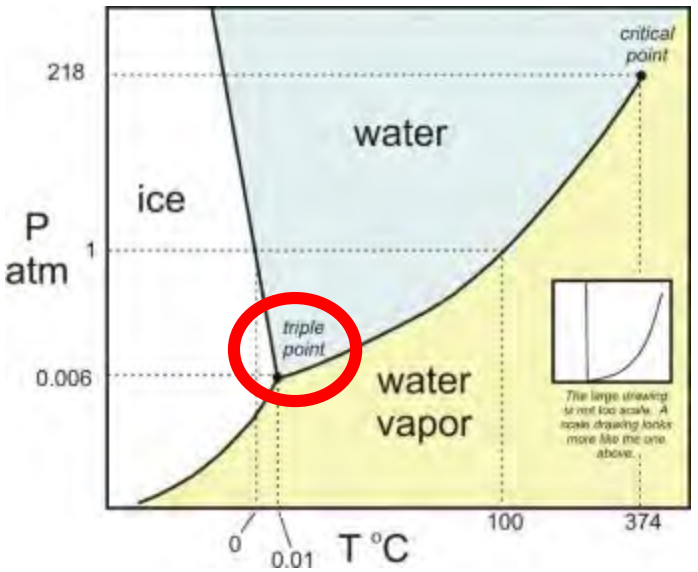
“What is Water?”: Standards and Sharing of Data → New Insights and Understanding

- Define *samples and protocols*
- *Share collected data*



New Parameter

“Pressure”



New Understanding

- **Phase boundaries**
  - V/L equilibrium
- **Triple Point**

(Phase Diagram)

	Saturated steam				Superheated steam		
Pressure (kg/cm²)	Temp (°C)	Vapour enthalpy (kcal/kg)	Specific volume (m³/kg)	Density (kg/m³)	Specific volume (m³/kg) at 250°C	at 300°C
1	99,1	638,8	1,725	0,580	2,454	2,691
2	119,6	646,2	0,902	1,109	1,223	1,342
3	132,9	650,6	0,617	1,621	0,812	0,893
4	142,9	653,7	0,471	2,123	0,607	0,668
5	151,1	656,0	0,382	2,618	0,484	0,533
6	158,1	657,0	0,321	3,115	0,402	0,443
7	164,2	659,5	0,278	3,597	0,343	0,379
8	169,6	660,8	0,245	4,082	0,299	0,331
9	174,5	661,9	0,219	4,566	0,265	0,293
10	179,1	662,9	0,198	5,051	0,238	0,263
12	187,1	664,5	0,166	6,024	0,196	0,218
14	194,1	665,7	0,143	6,993	0,167	0,186
16	200,4	666,7	0,126	7,937	0,145	0,162
18	206,1	667,4	0,112	8,929	0,128	0,143
20	211,4	668,0	0,101	9,901	0,114	0,128
22	216,2	668,4	0,092	10,870	0,103	0,116
24	220,7	668,7	0,085	11,765	0,093	0,106
26	225,0	669,0	0,078	12,821	0,085	0,097
28	229,0	669,1	0,073	13,699	0,078	0,089
30	232,7	669,2	0,068	14,706	0,072	0,083

LOTS of Quantitative and Reproducible Data

(Steam Table)

Many “Thermometers” (Genomics and Proteomics)

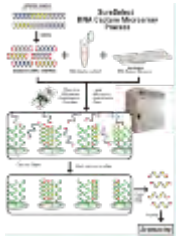


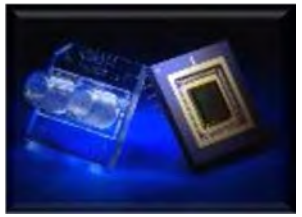






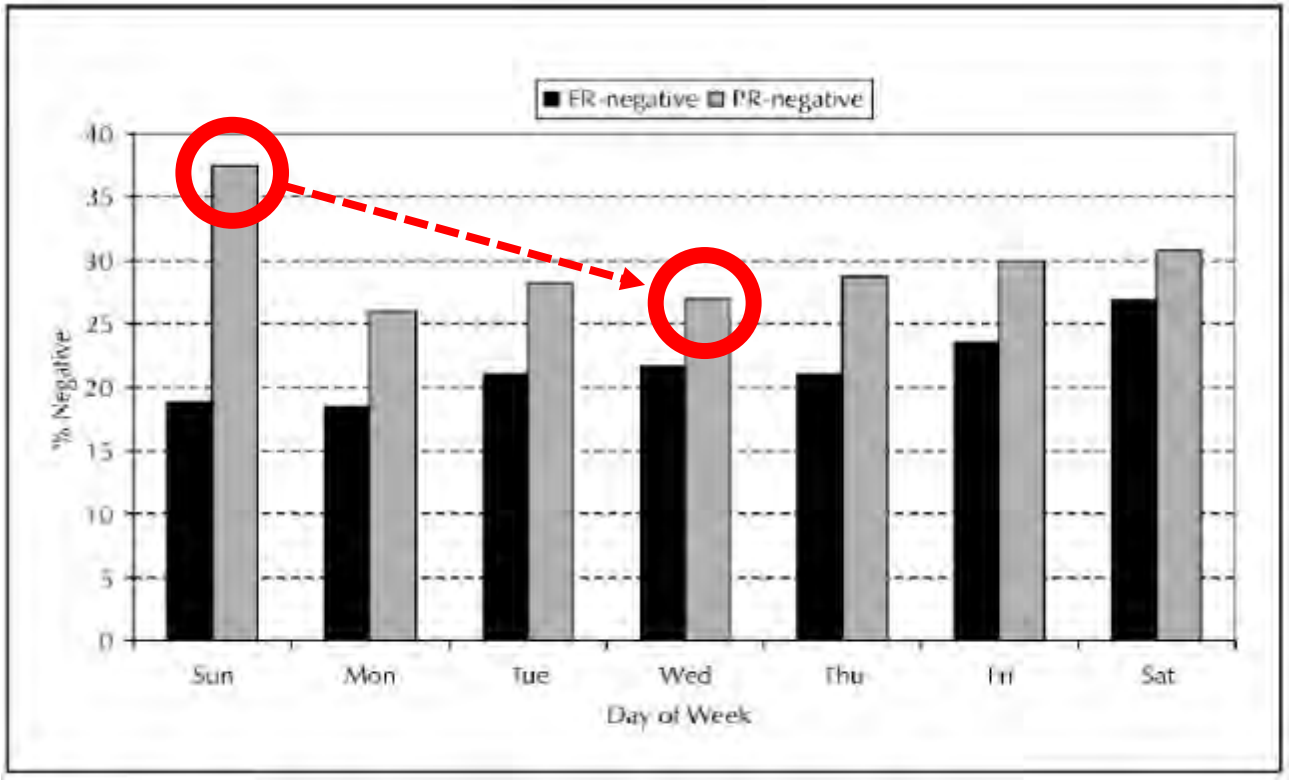







Samples AND Handling Matter!



"…We found that specimens **obtained late in the week** are **more likely to be ER/PR negative** than specimens **obtained on other weekdays**…"

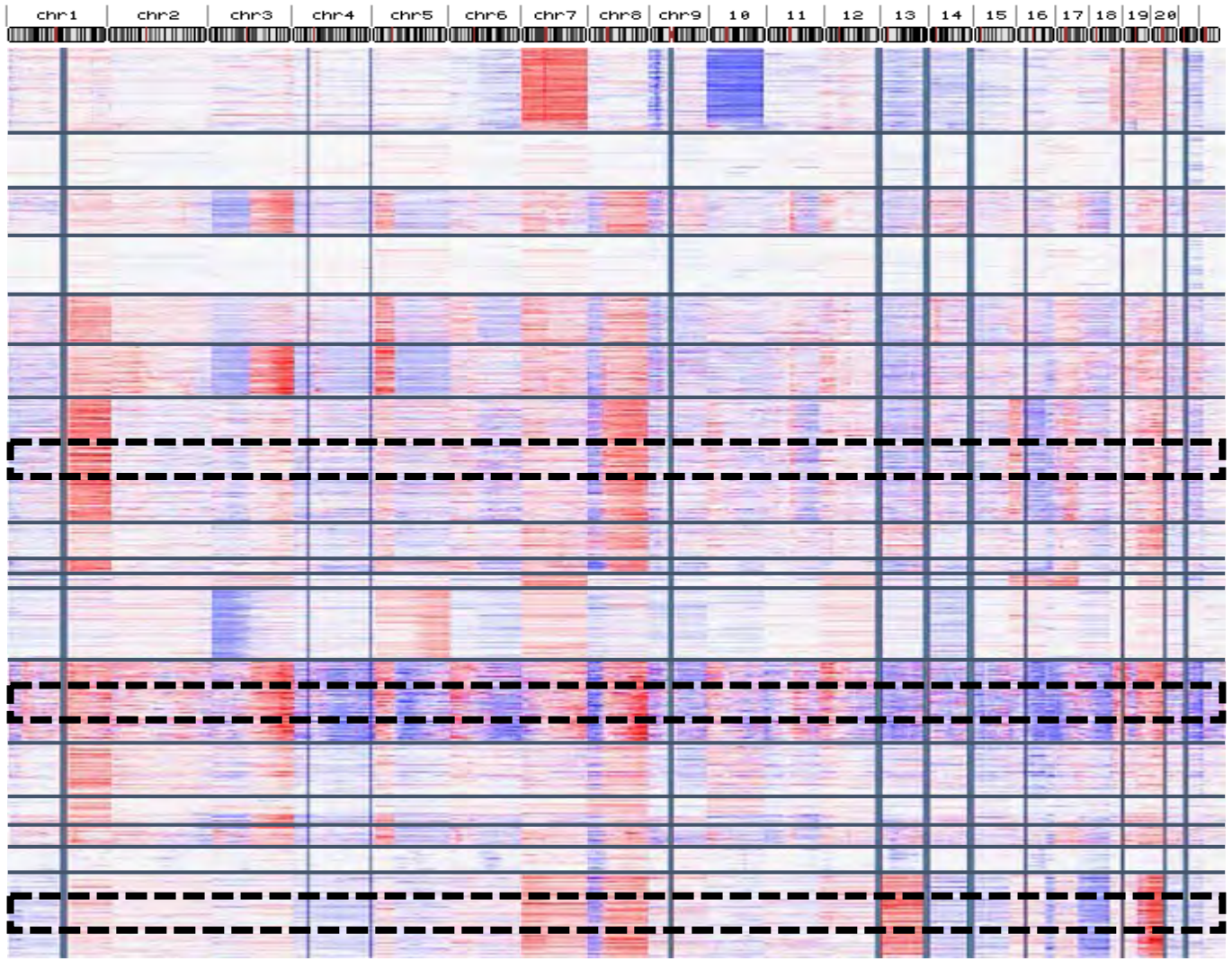
Table 1. Frequency of Specimen Removal by Day of the Week

Day	Cases	ER-Negative	PR-Negative
Sunday	16	3	6
Monday	1252	230	325
Tuesday	1176	248	332
Wednesday	784	170	212
Thursday	904	191	259
Friday	919	216	276
Saturday	26	7	8
System	**5077**	**1065**	**1418**

Abbreviations: ER, estrogen receptor; PR, progesterone receptor.

Nkoy et. al., Arch Pathol Lab Med, April 2010

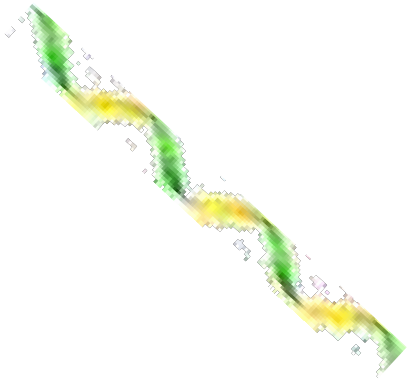
The Cancer Genome Atlas



Glioblastoma:	563
Brain lower grade glioma:	180
Head & neck:	306
Thyroid carc:	401
Lung adeno:	356
Lung squamous:	343
Breast carc:	866
Stomach adeno:	237
Liver hep. carc:	97
Kidney pap. cell carc:	103
Kidney clear cell carc:	493
Ovarian serous:	559
Uterine corpus end. carc:	492
Cervical carc:	102
Bladder carc:	135
Prostate adeno:	171
Colon/rectum adeno:	575
Total:	**5,979**

Source: UCSC Cancer Genomic Heatmaps (CopyNumber GISTIC2) [https://genome-cancer.ucsc.edu/] Compiled by Jerry S.H. Lee, PhD, March 2013

Central Dogma of Biology

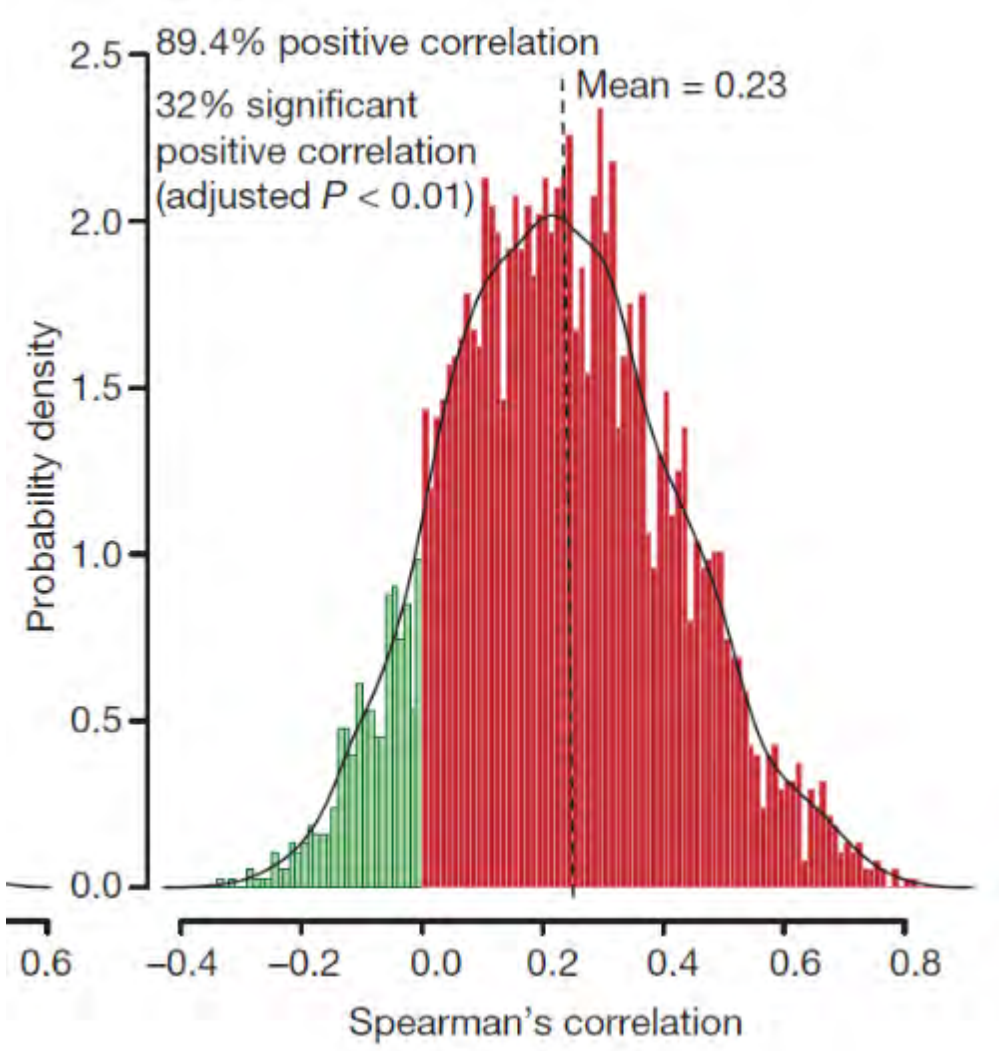


DNA → **RNA** → **Protein**

The Cancer Genome Atlas

CLINICAL PROTEOMIC TUMOR ANALYSIS CONSORTIUM

Re-writing Central Dogma “Rule”



On average across 375 tumor samples, ***ONLY*** **33%** of DNA/RNA predicted cancer protein abundance

CLINICAL PROTEOMIC TUMOR ANALYSIS CONSORTIUM

Zhang, B. et. al. Proteogenomic characterization of human colon and rectal cancer. *Nature*. 2014 Jul 20

"…there is great potential for **new insights** to come from the **combined analysis** **of cancer proteomic and genomic data**, as proteomic data can **now reproducibly** **provide information** about protein levels and activities that are ***difficult or impossible to infer from genomic data alone***…"

Douglas R. Lowy, MD
Acting Director of the National Cancer Institute, National Institutes of Health

5/25/2016


2016

Mission

- Make a **decade's** worth of progress in **cancer prevention, diagnosis, treatment, and care** – ultimately to end cancer **as we know it.**

STRATEGIC GOALS

IMPLEMENTATION PATH

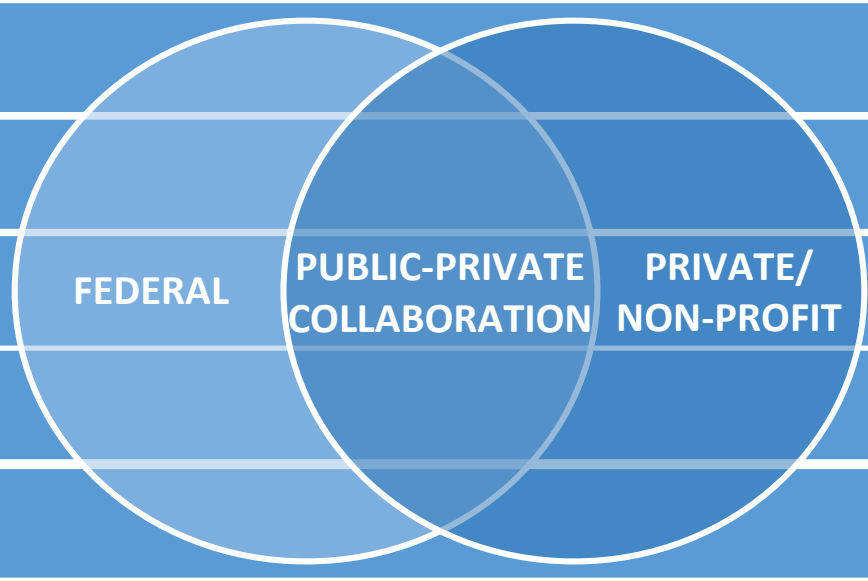
Catalyze New Scientific Breakthroughs

Unleash the Power of Data

Accelerate Bringing New Therapies to Patients

Strengthen Prevention and Diagnosis

Improve Patient Access and Care

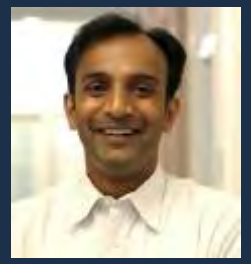


2/1/2016

10/17/2016

Cancer Moonshot Data & Technology Team

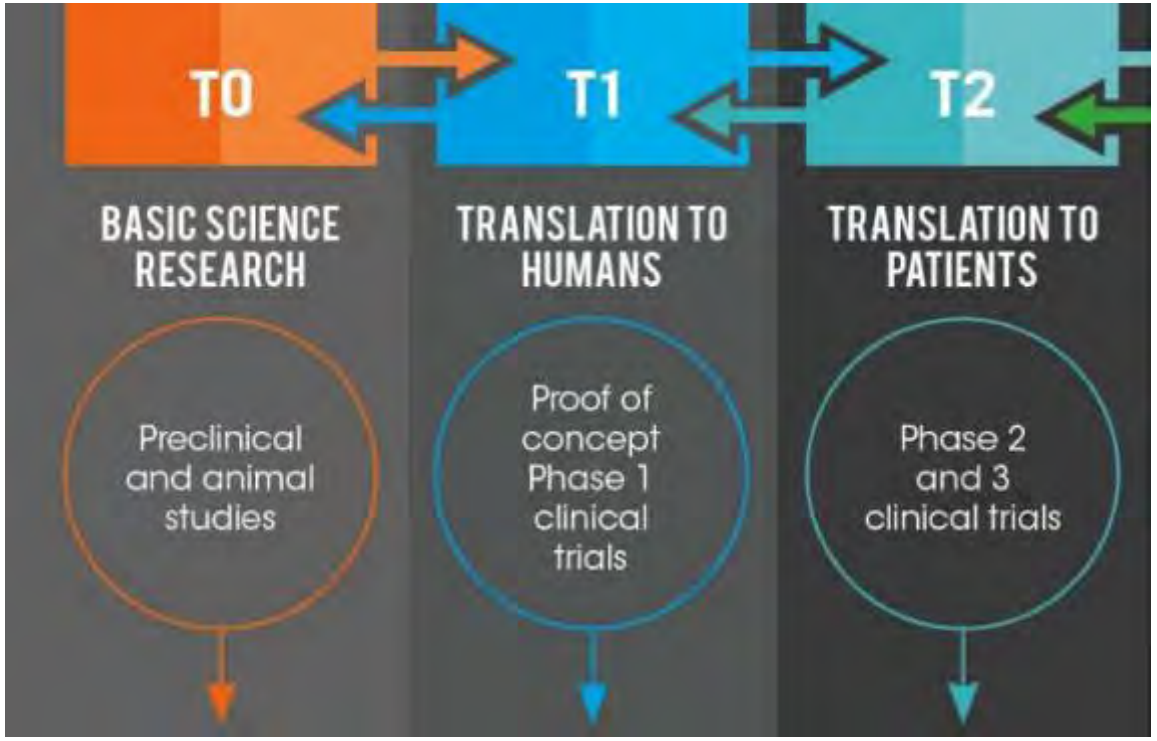
<u>Co-Chairs:</u> Dimitri Kusnezov (DOE), DJ Patil (OSTP), and Jerry Lee (OVP)



<u>Members:</u>

- John Scott **(DoD)**
- Craig Shriver **(DoD)**
- Cheryll Thomas **(CDC)**
- Frances Babcock **(CDC)**
- Teeb Al-Samarrai **(DOE)**
- Sean Khozin **(FDA)**
- Alexandra Pelletier **(PIF)**
- Maya Mechenbier **(OMB)**
- Henry Rodriguez **(NCI)**
- Karen Cone **(NSF)**
- Michael Kelley **(VA)**
- Louis Fiore **(VA)**
- Warren Kibbe **(NCI)**
- Betsy Hsu **(NCI)**
- Niall Brennan **(CMS)**
- Thomas Beach **(USPTO)**
- Claudia Williams **(OSTP)**
- Vikrum Aiyer **(USPTO)**
- Tom Kalil **(OSTP)**
- Kathy Hudson **(NIH)**
- Dina Paltoo **(NIH)**
- Al Bonnema **(DoD)**
- Michael Balint **(PIF)**
- Kara DeFrias **(OVP)**
- Greg Pappas **(FDA)**
- Erin Szulman **(OSTP)**
- Paula Jacobs **(NCI)**

Translational from basic science to human studies



Defining mechanisms, targets, and lead molecules

Controlled studies leading to effective care

New methods of diagnosis, treatment, and prevention

TCGA

MPACT

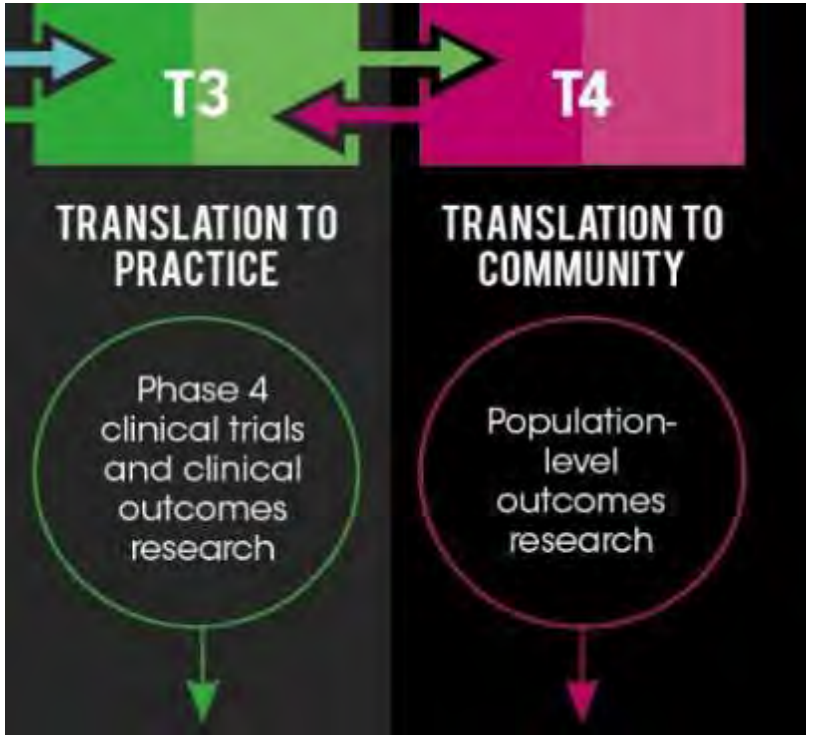
LungMAP

ALCHEMIST

MATCH

2004 → **2016**

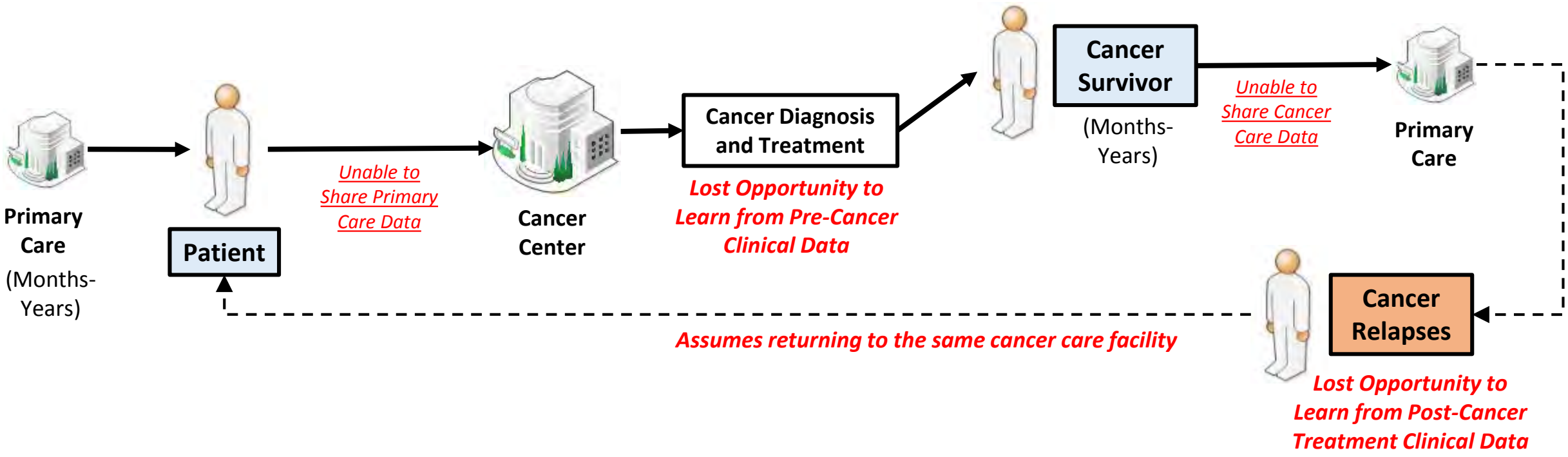
Translational of new data into the clinic and health decision making



Delivery of recommended and timely care to the right patient

True Benefit to society

Without a National Learning Healthcare System for Cancer



Vision:

Enable the creation of a ***Learning Healthcare System for Cancer,*** where as a nation we learn from the ***contributed knowledge*** and experience of ***every cancer patient***. As part of the Cancer Moonshot, we want to ***unleash the power of data*** to enhance, improve, and inform the journey of every cancer patient from the ***point of diagnosis through survivorship***.

VOLUME 28 · NUMBER 27 · SEPTEMBER 20 2010

JOURNAL OF CLINICAL ONCOLOGY

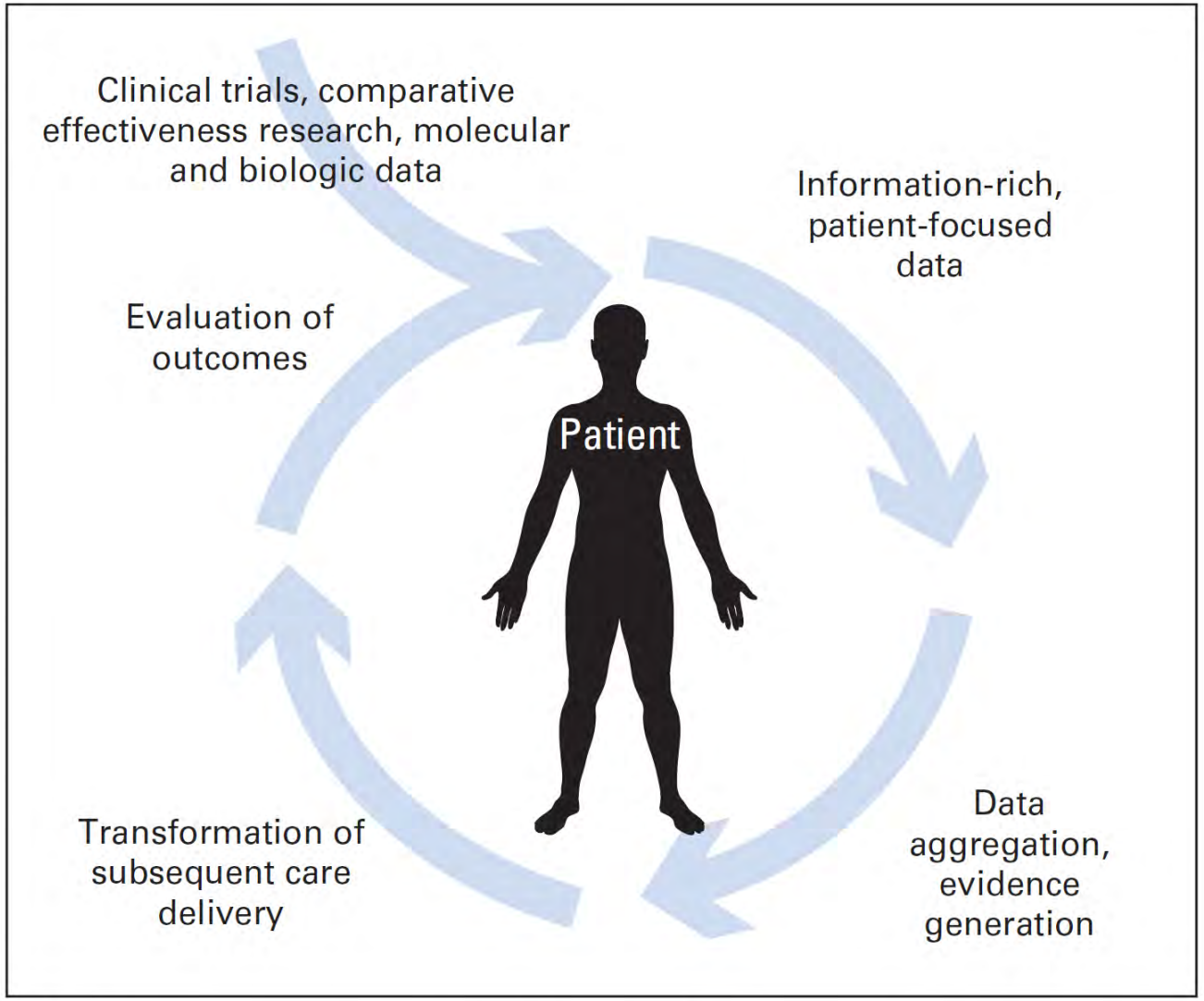


Fig 1. Cycle of evidence in rapid-learning health care. In a patient-centered system of rapid-learning health care, patient-level data are aggregated to achieve population-based change, and results are applied to care of individual patients to achieve meaningful patient-level practice change.

Modified from Abernethy et. al. *JCO* 2010

Priorities Areas: Cancer Moonshot Data & Technology

- **Priority Area A:** Enabling a seamless data environment — **[If you build it…]**
- **Priority Area B:** Unlocking science through open computational and storage platforms — **[Make it easy AND relevant to use…]**
- **Priority Area C:** Workforce development using open and connected data — **[They will come…]**

NCI Blue Ribbon Panel Report Recommendations

http://www.cancer.gov/brp

A. Establish a network for direct patient involvement

B. Create a clinical trials network devoted exclusively to immunotherapy

C. Develop ways to overcome cancer's resistance to therapy

D. Build a national cancer data ecosystem

E. Intensify research on the major drivers of childhood cancers

F. Minimize cancer treatment's debilitating side effects

G. Expand use of proven cancer prevention and early detection strategies

H. Mine past patient data to predict future patient outcomes

I. Develop a 3-D cancer atlas

J. Develop new cancer technologies

NCI Genomic Data Commons

launched at ASCO on June 6, 2016

https://gdc-portal.nci.nih.gov

2.6 PB of legacy data and **1.5** PB of **harmonized** data.

Making Data FAIR

Findable

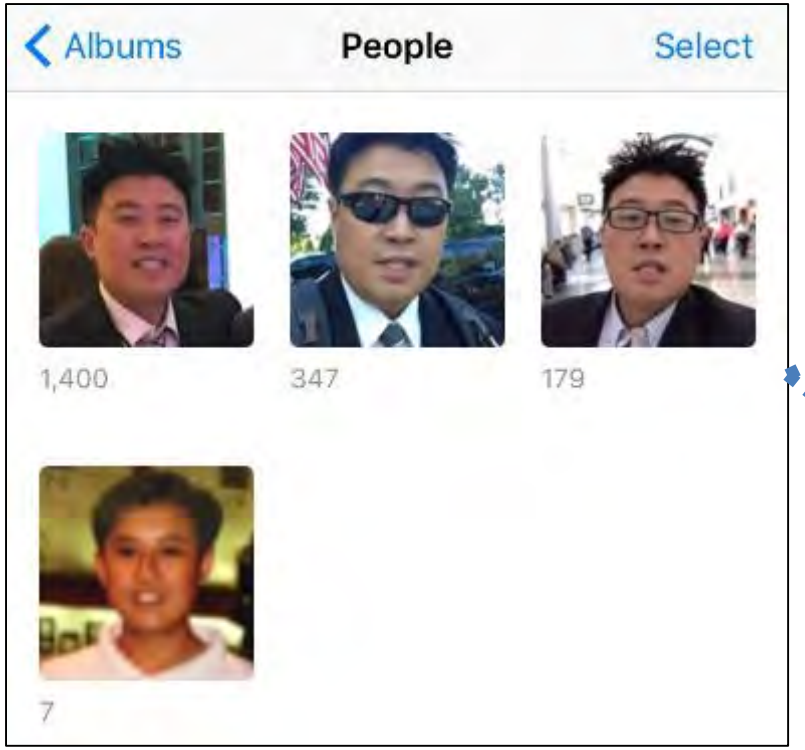
Accessible

Interoperable

Reusable

https://www.force11.org/group/fairgroup/fairprinciples

FORCE11
The Future of Research Communications and e-Scholarship

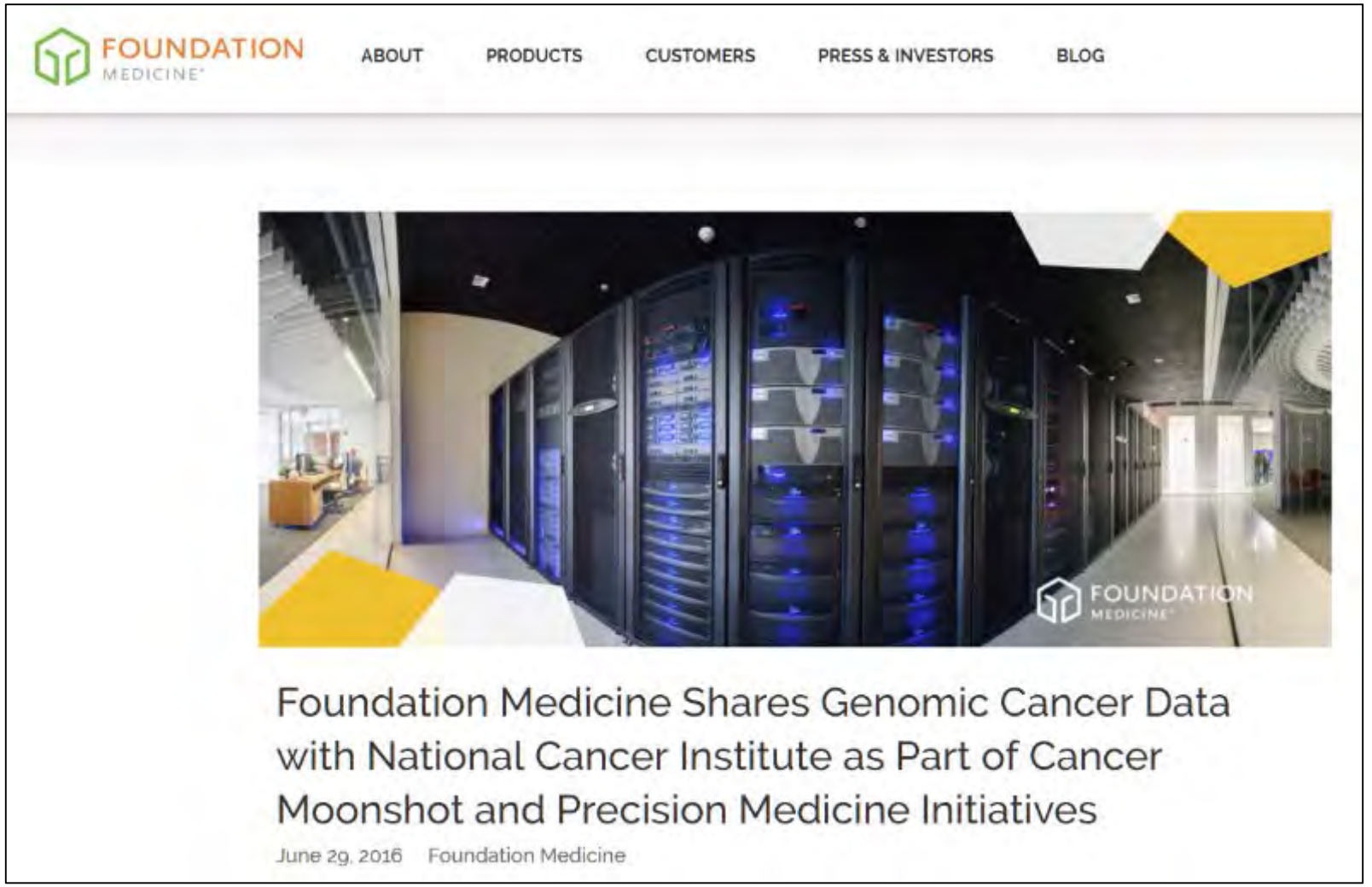


My Local “Data”
&
Reuse

“Data” Uploads

“Data” Uploads
Reuse A

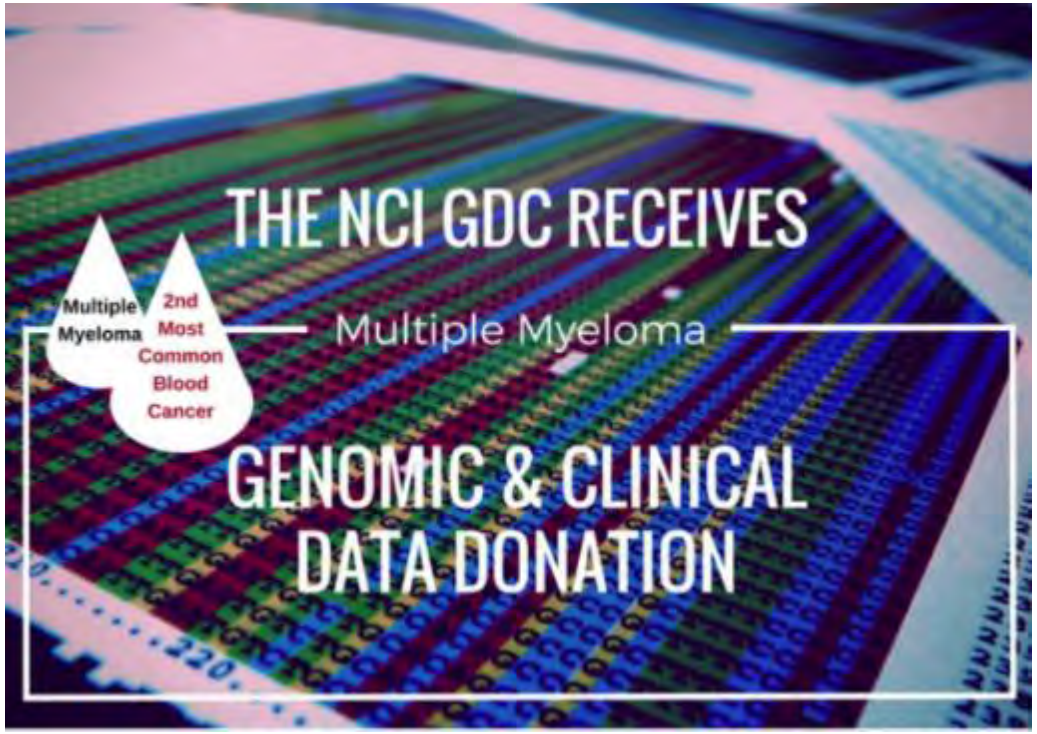
“Data” Uploads
Reuse B



At the June 29th Cancer Moonshot Summit, *Foundation Medicine* announced the release of 18,000 genomic profiles to the NCI GDC

Multiple Myeloma Research Foundation to Contribute to NCI's Genomic Data Commons

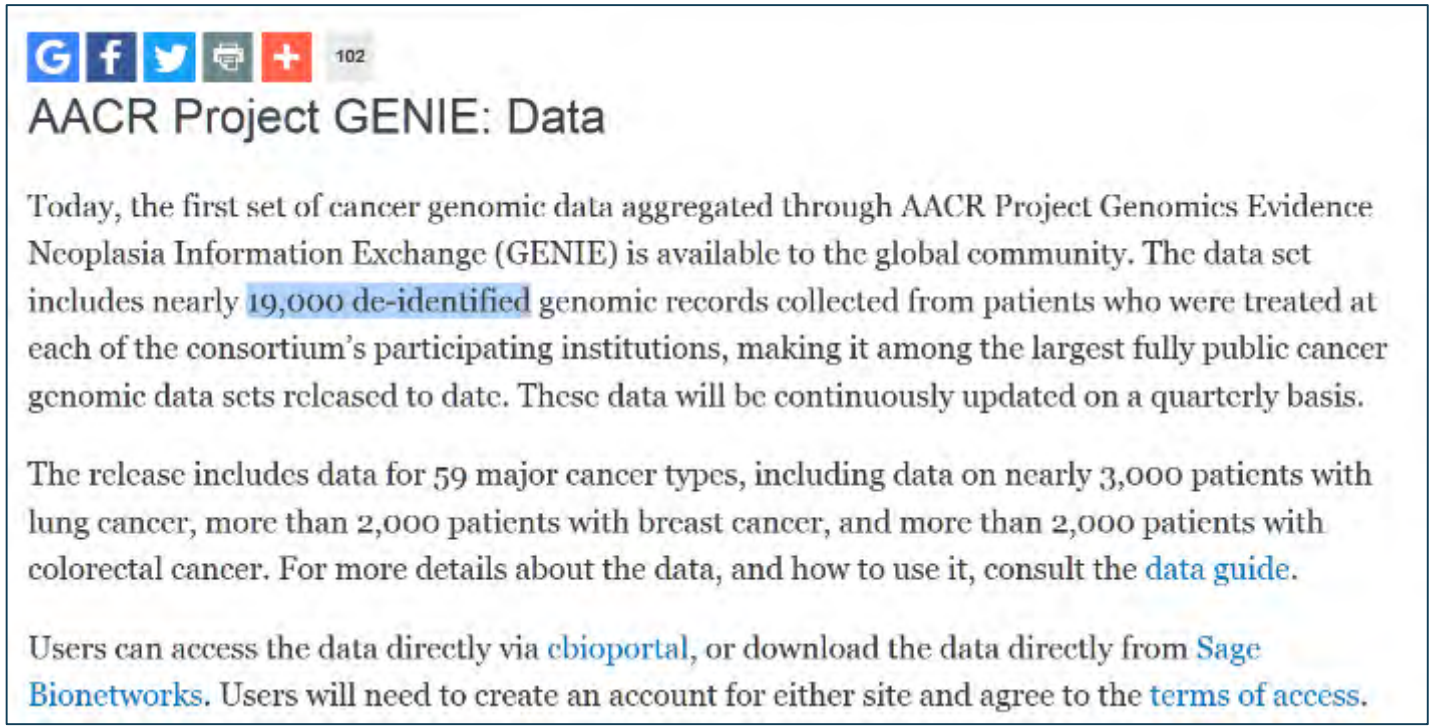
Sep 29, 2016 | a GenomeWeb staff reporter



- MMRF is the **first non-profit organization** to upload information to the GDC
- Among its contributions will be data from relating **C**linical **O**utcomes in **MM** to **P**ersonal **Ass**essment of Genetic Profile (CoMMpass) study which began in 2011 and has thus far enrolled over **1,150** patients
- Over the next eight years, patients in CoMMpass will get a **repeat biopsy** and a new genomic analysis at **each six-month checkup** and/or at disease progression
- Tumor samples are being collected and analyzed when possible at the time of any relapse. **New data will be deposited every six months at a minimum**

AACR American Association for Cancer Research

01/05/2017



102

AACR Project GENIE: Data

Today, the first set of cancer genomic data aggregated through AACR Project Genomics Evidence Neoplasia Information Exchange (GENIE) is available to the global community. The data set includes nearly 19,000 de-identified genomic records collected from patients who were treated at each of the consortium's participating institutions, making it among the largest fully public cancer genomic data sets released to date. These data will be continuously updated on a quarterly basis.

The release includes data for 59 major cancer types, including data on nearly 3,000 patients with lung cancer, more than 2,000 patients with breast cancer, and more than 2,000 patients with colorectal cancer. For more details about the data, and how to use it, consult the data guide.

Users can access the data directly via cbioportal, or download the data directly from Sage Bionetworks. Users will need to create an account for either site and agree to the terms of access.

"…while many of the important lessons learned from this first year of the project…Sawyers said that the data also speaks for itself in terms of the project's success **in tackling difficult harmonization challenges…**

…All the subjects in the GENIE collection had to have **level 1A clinical data**, Sawyers explained, and the group had to make sure that they could harmonize this information across sites. For example, "**you can imagine a name of a rare condition might be very different in Amsterdam versus Toronto or Nashville," Sawyers said**…"

https://www.genomeweb.com/informatics/aacr-project-genie-releases-first-public-cancer-genomic-data-shares-lessons-learned

GDC Content

Current

- TCGA — 11,353 cases
- TARGET — 3,178 cases

Coming soon

- Foundation Medicine — 18,000 cases
- Cancer studies in dbGAP — ~4,000 cases

Planned (1-3 years)

- NCI-MATCH — ~3,000 cases
- Clinical Trial Sequencing Program — ~3,000 cases
- Cancer Driver Discovery Program — ~5,000 cases
- Human Cancer Model Initiative — ~1,000 cases
- **APOLLO – VA-DoD — ~8,000 cases**

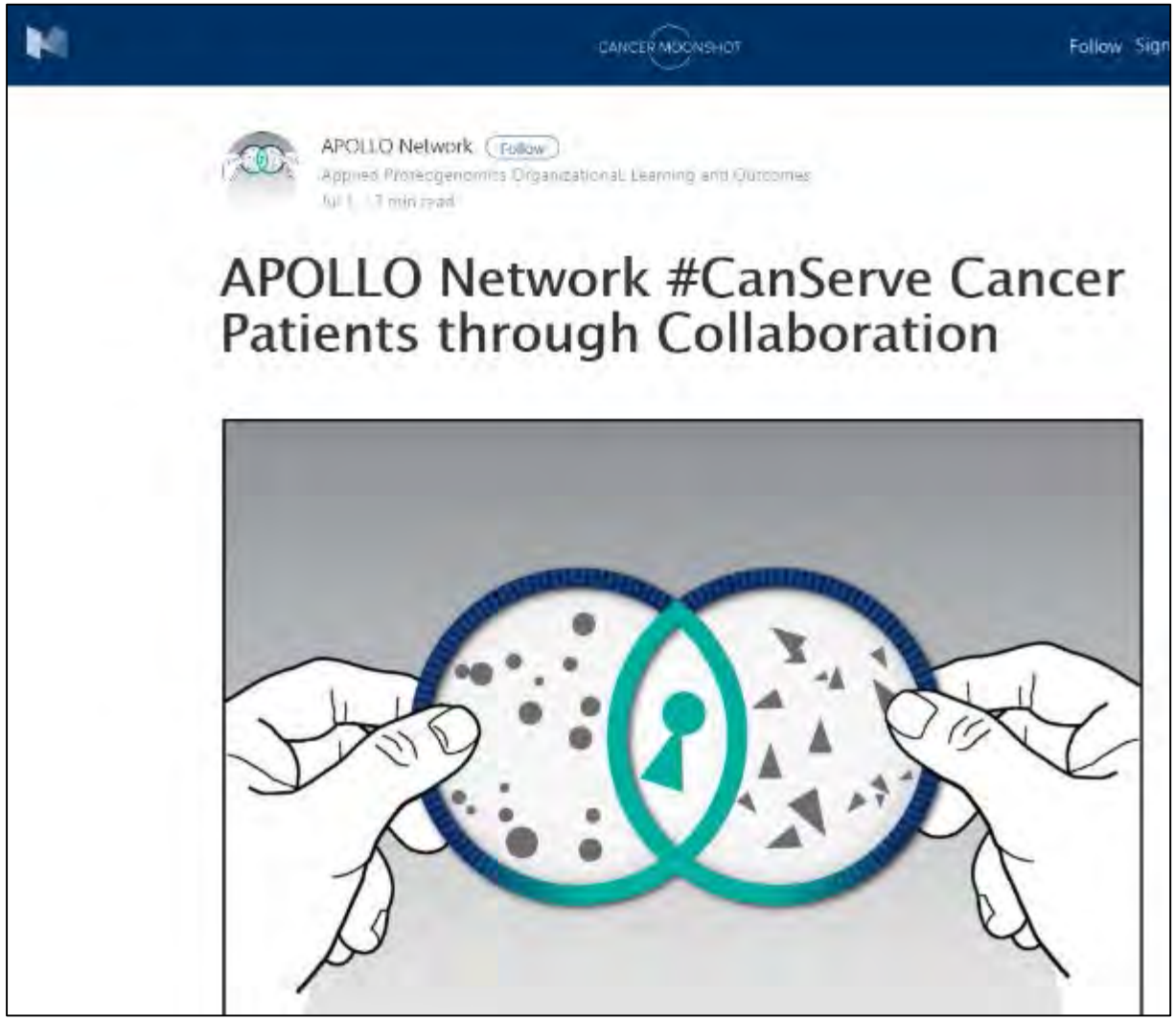
~56,000 cases

Col. Craig Shriver, MD

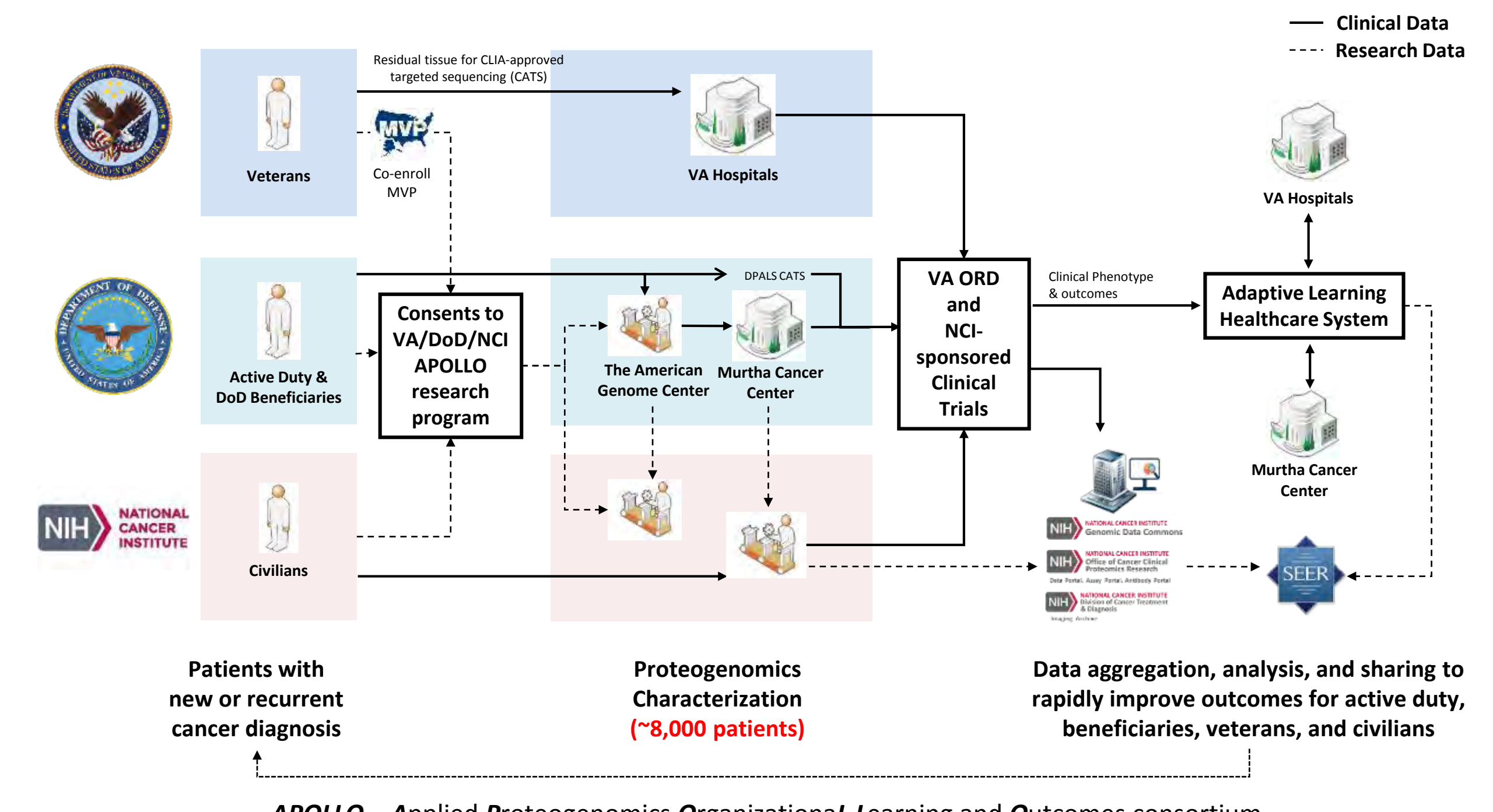
Jennifer Lee, MD

NIH NATIONAL CANCER INSTITUTE

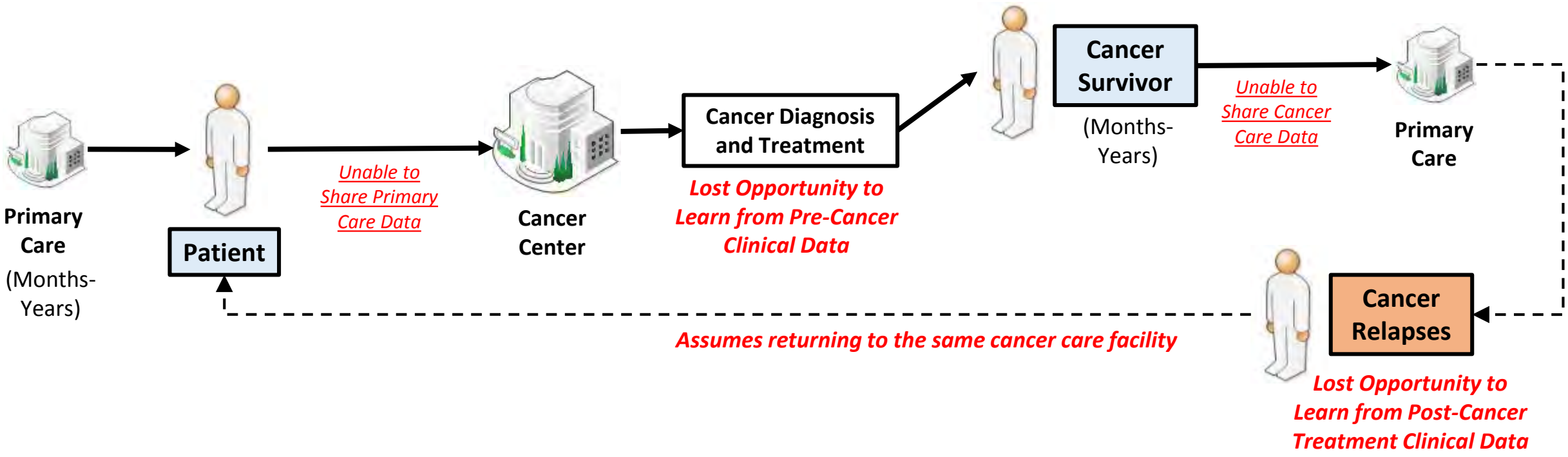
Henry Rodriguez, PhD, MBA



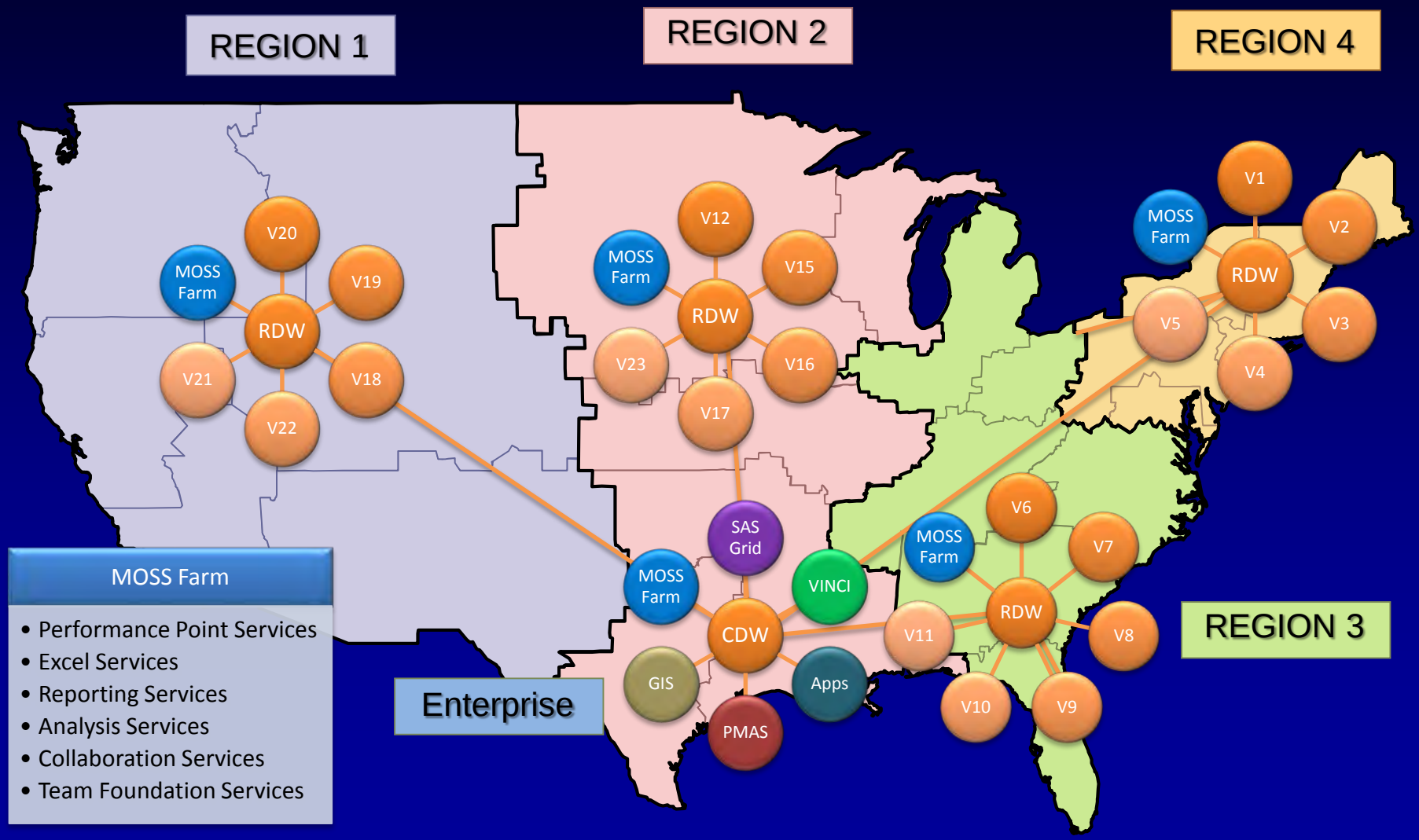
https://medium.com/cancer-moonshot/


Clinical Data
Research Data
Residual tissue for CLIA-approved targeted sequencing (CATS)
Veterans
Co-enroll MVP
VA Hospitals
Active Duty & DoD Beneficiaries
Consents to VA/DoD/NCI APOLLO research program
DPALS CATS
The American Genome Center
Murtha Cancer Center
VA ORD and NCI-sponsored Clinical Trials
Clinical Phenotype & outcomes
Adaptive Learning Healthcare System
VA Hospitals
Murtha Cancer Center
Civilians
NATIONAL CANCER INSTITUTE
Genomic Data Commons
Office of Cancer Clinical Proteomics Research
Division of Cancer Treatment & Diagnosis
SEER
Patients with new or recurrent cancer diagnosis
Proteogenomics Characterization (~8,000 patients)
Data aggregation, analysis, and sharing to rapidly improve outcomes for active duty, beneficiaries, veterans, and civilians
APOLLO – Applied Proteogenomics OrganizationaL Learning and Outcomes consortium

Without a National Learning Healthcare System for Cancer



VA Medical Centers Regional / Corporate Data Warehousing and Analytical Environment

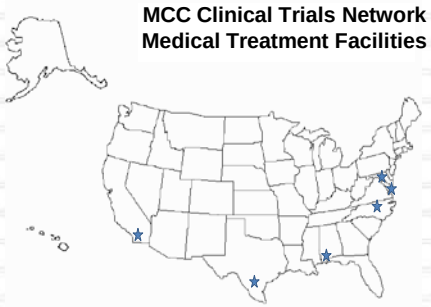


Courtesy of Ross Fletcher (DC VAMC)

Walter Reed National Military Medical Center

John P. Murtha Cancer Center

MCC Military Clinical Trials Network



Murtha Cancer Center

- **Clinical Trials** — Increased Access
- **Referral Center** — High cost/low volume
- **Genetics Counseling** — Telehealth technologies
- **Training &Education** — Distributed learning/fellowships
- **Patient Outreach** — Education and information
- **Standardized Clinical Practice Guidelines** — Evidenced-based clinical practice & research
- **MCC Membership**

MHS

- **Naval Medical Center Portsmouth, VA**
- **Naval Medical Center San Diego, CA**
- **Womack Army Medical Center Ft Bragg, NC**
- **Keesler Air Force Medical Center Biloxi, MS**
- **Lackland Air Force Medical Center San Antonio, TX**

Patient and Providers

time

Ongoing clinical care

Usual care continues

time

time

Research activities

Ongoing collection of data [genomics, proteomics, medical imaging]

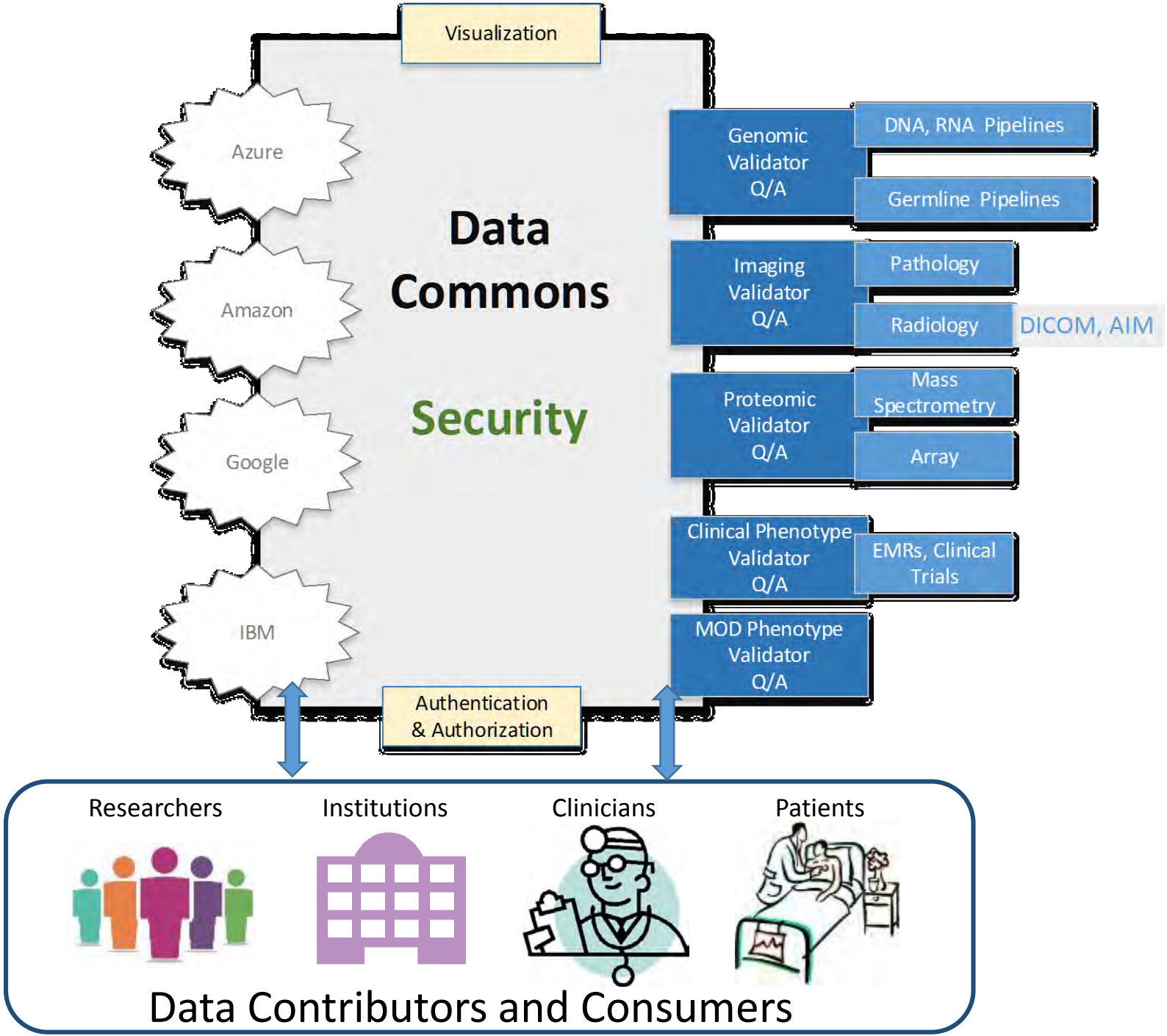
Initiate system for specific learning or research activities

Courtesy of Lou Fiore

Applied Proteogenomics OrganizationaL Learning and Outcomes

APOLLO Leadership Meeting
August 29, 2016

NCI Thesaurus
caDSR
NLM UMLS
RxNorm
LOINC
SNOMED



Courtesy of Warren Kibbe, PhD

7/17/2016

https://www.whitehouse.gov/the-press-office/2016/07/16/fact-sheet-victoria-comprehensive-cancer-center-vice-president-biden

"…**proteogenomics**, which is -- as I used a metaphor -- it's like the **genes** are the **full roster** of a **basketball team**….but the winning strategy comes from finding out who their starting lineup is. The **proteins** are the **starters** you're going to play against -- the five you are going to **have to defend against**

I'm pleased to say, Mr. Prime Minister, that we've signed three memorandums of understanding between our two nations …we're going to be able to **share patient histories**, ***proteogenomics*** and **clinical phenotypes data** -- data on various proteins and genetic characteristics of almost ***60,000 patients*** in Australia and the United States with full privacy protections…

And I predict that you're going to see this repeated around the world."

- *Vice President Biden, Australia*

9/19/2016

Joe Biden announces major new steps in his fight for better cancer research

1.6k SHARES Share on Facebook Share on Twitter +

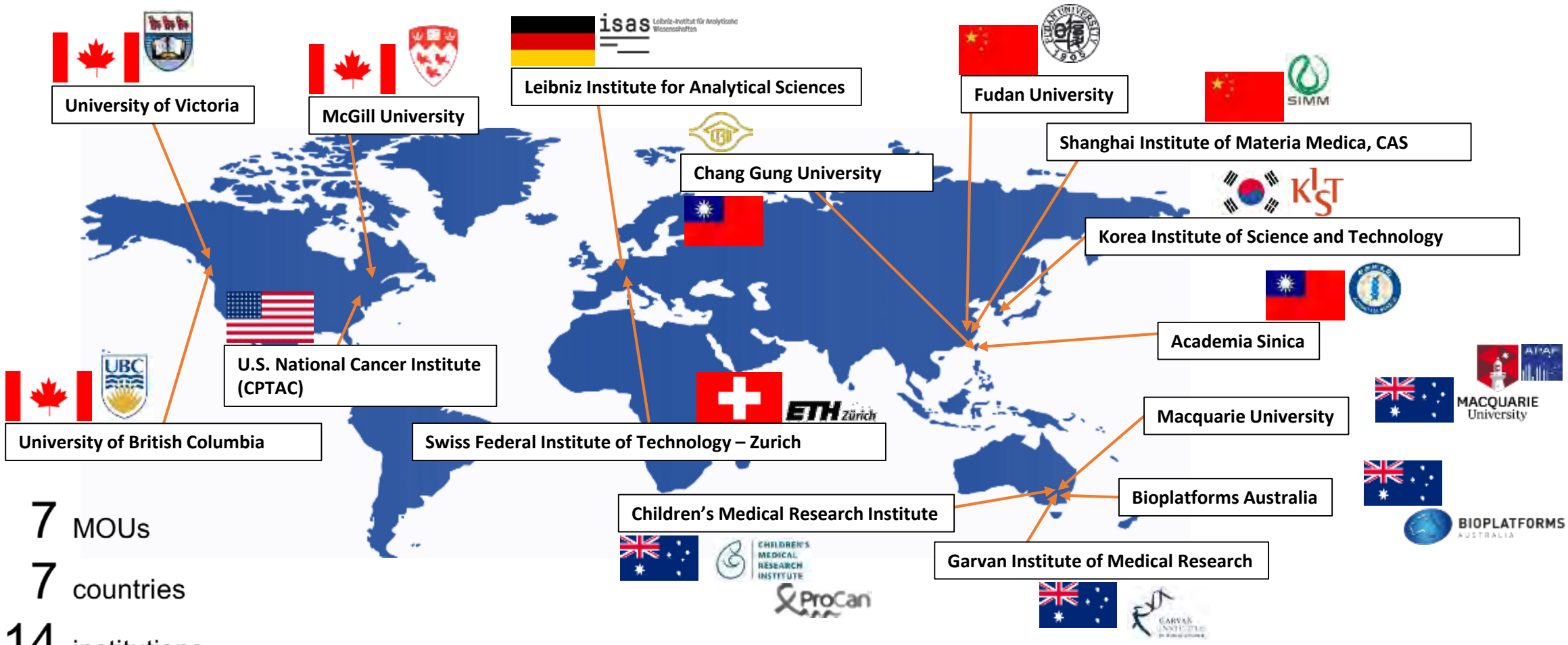
Vice President Joe Biden speaks at the 2016 Social Good Summit on Monday, Sept. 19, 2016

The first step is the announcement of 10 new commitments with nine nations to support better international cancer research and care. The U.S. will work with institutions in Canada, China, Germany, Switzerland, Taiwan, Japan and South Korea in the field of proteogenomics, and with Serbia, Sweden and Japan to open a discussion about better prevention, screenings, treatment and research collaborations. The U.S. Department of Energy will also work with Norway to share 1.7 million cervical screening results over the course of 25 years to seek out patterns in diagnoses and treatments.

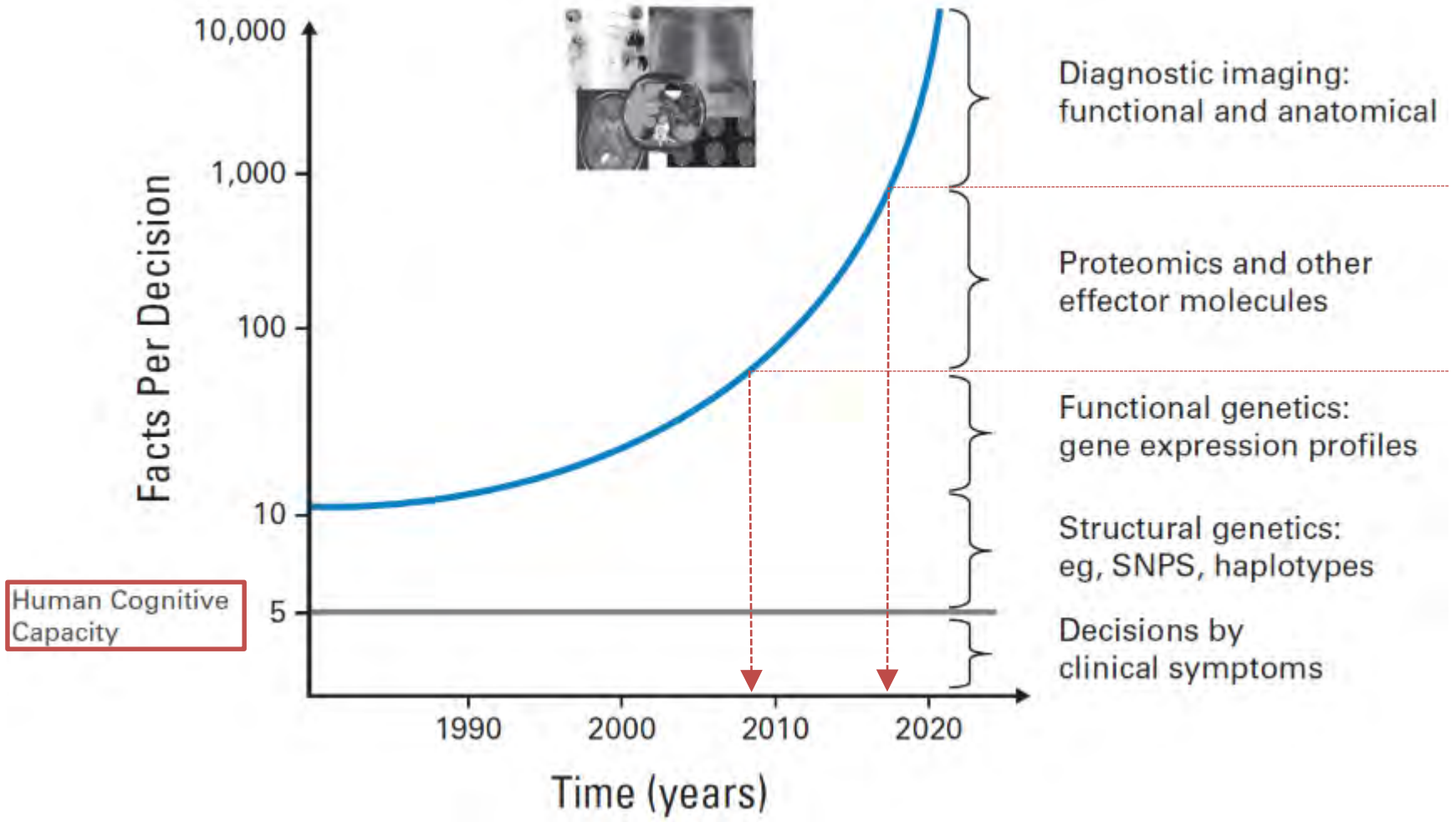
Biden also announced the creation of regional hubs — collaborative centers that can help decrease disparities in cancer research around the world. These hubs will be funded by the National Cancer Institute, working wit
Japan, South Korea, New Zealand, th
focus on areas of the world where spe

http://mashable.com/2016/09/19/joe-biden-cancer-moonshot-social-good-summit/#RdZcawT8ZGqu

International Proteogenomic Moonshot Programs



VOLUME 28 · NUMBER 27 · SEPTEMBER 20 2010
JOURNAL OF CLINICAL ONCOLOGY



Modified from Abernethy et. al. *JCO* 2010

What About Blood?

Forbes

Eight Milestones Of 2016 In The War On Cancer

Arlene Weintraub, CONTRIBUTOR
I cover the science and business behind drug development and health FULL BIO
Opinions expressed by Forbes Contributors are their own.

DEC 28, 2016 @ 08:35 AM

Only 22 novel drugs were approved by the U.S. Food & Drug Administration in 2016—way down from the 45 approved in 2015—and just six of the new entries are for treating or diagnosing cancer. Still, 2016 was far from a washout for oncology research. Here were some of the high points of the year in the war on cancer:

Between the Cancer Moonshot and the 21st Century Cures Act, the White House made a big commitment to cancer research in 2016. (Credit: MANDEL NGAN/AFP/Getty Images)

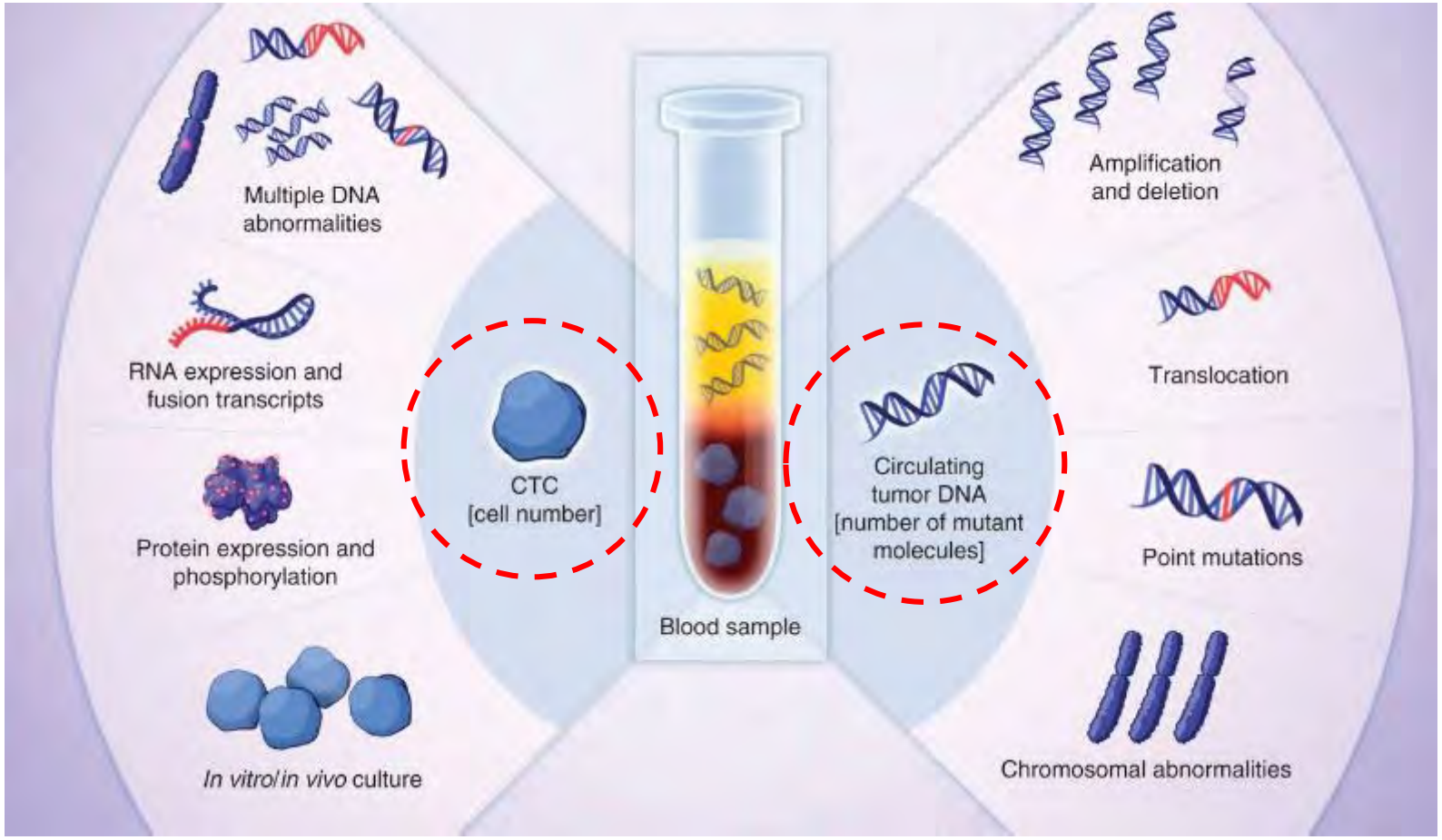
January 12: V.P. Biden is tapped to lead the new Cancer Moonshot. During the State of the Union address, President Barack Obama launched the Cancer Moonshot and appointed Vice President Joe Biden to lead the initiative. The goal is not just to speed new therapies to market, but also to improve access to treatment and come up with methods for detecting the disease early, when it's easier to treat and cure. Biden spent much of the year tapping academics, drug company executives, patients and physicians for advice, as well as establishing five strategic goals for the Moonshot.

In October, the veep announced a new project called the Blood Profiling Atlas, which will try to accelerate the development of "liquid biopsies," tests designed to detect early-stage cancer by tracking tiny bits of tumor DNA cast off into the bloodstream. Much to the surprise of some executives, he assembled an impressive list of organizations that might normally balk at the idea of working together to help build the atlas, including Novartis , Pfizer PFE +0.50% , Thermo Fisher and Foundation Medicine.

April 13: Napster billionaire Sean Parker launches a cancer institute. The glitzy star-studded gala that ushered in Sean Parker's new cancer research institute may have drawn some ire, but the money the Napster founder and former Facebook president is devoting to the effort is nothing to sneeze at. The Parker Institute for Cancer Immunotherapy is backed

http://www.forbes.com/sites/arleneweintraub/2016/12/28/eight-milestones-of-2016-in-the-war-on-cancer/

Finding the Right “Needle” at the Right “Time” of Disease



10/17/16

Biden announces USC participation in new Cancer Moonshot project

The project aims to accelerate the development of reliable blood tests for biologically based precision treatment and disease monitoring

Personal Genome Diagnostics Selected to Participate in U.S. Cancer Moonshot Effort to Jump Start Liquid Biopsy Database

-- PGDx Joins Consortium of Public, Private and Academic Innovators Developing Pilot for a Blood Profiling Atlas to Help Ensure the Validity, Utility and Accessibility of Liquid Biopsies for Cancer Research, Diagnosis and Treatment --

Seven Bridges Joins Cancer Moonshot Initiative with Cloud Platform to Speed Blood Profiling Research

Blood Profiling Atlas Project Aims to Advance the Development of Simple, Blood-Based Test for Early Cancer Diagnosis

Forbes

White House To Announce Big Push For Cancer Blood Tests

U-M researchers will support new 'liquid biopsy' Cancer Moonshot initiative

Government, academia, pharma partnership will create open dataset to stimulate translational research

Guardant Health makes commitment to share expertise and data to advance Blood Profiling Atlas, part of White House Cancer Moonshot

Lilly Partnering on Cancer Research

Posted: Oct 17, 2016 5:00 PM EDT
Updated: Oct 18, 2016 8:53 AM EDT

College Of American Pathologists To Participate In The Cancer "Moonshot" Effort

Industry News: Thermo Fisher Scientific Joins the Cancer Moonshot Initiative to Help Advance Precision Medicine

10/18/16: Blood Profiling Atlas Face 2 Face

12/20/16

https://medium.com/cancer-moonshot/blood-profiling-atlas-in-cancer

Blood Profiling Atlas Members

- Open Commons Consortium (OCC) in collaboration with the University of Chicago commits to organizing and operating an open Blood Profiling Atlas Commons. The Commons will be based upon the same open source software stack used by the NCI Genomic Data Commons so that the genomic, image and clinical data in the Commons can be shared with the appropriate security, privacy and compliance controls. To facilitate the rapid development of this critical resource, the OCC / University of Chicago team will contribute up to six months of engineering, bioinformatics and project management resources to the project and up to $500,000 of compute and storage resources for building the commons and for the use of the commons by the research community.

- Seven Bridges will contribute its experience in accelerating pharmaceutical research and development and in building national-scale research systems by developing the Blood Profiling Atlas Analysis Cloud, specifically tailored to the needs of the liquid biopsy community. This environment – based on the company's work partnering with the NCI, Genomics England, the VA and others – will integrate with the Blood Profiling Atlas Commons, allowing molecular, clinical and imaging data to be easily, securely, and cost effectively analyzed by researchers across disciplines. In addition, Seven Bridges will share its expertise in cancer genomics and immunoinformatics analysis. To do so, the company will release algorithms for analyzing liquid biopsy data at scale, committing six months of engineering, bioinformatics and project management resources, and up to $500,000 compute and storage resources to facilitate use of the analysis tools and data donated by the Blood Profiling Atlas community.

- In support of the Blood Profiling Atlas, AstraZeneca will provide standard operating procedures for ctDNA isolation and library construction for targeted and whole genome/exome sequencing of ctDNA. The AstraZeneca bioinformatics pipeline for variant calling in ctDNA is available for all interested parties. Furthermore, AstraZeneca will generate ctDNA for comparative studies of other bioinformatics pipelines with the goal to develop best practices in identifying variants in ctDNA after high depth sequencing that will standardize analyses of data acquisition for the Atlas. AstraZeneca will additionally provide data on method comparisons and can assist in data generation for samples provided to this project.

- Celgene will contribute advanced analytic capabilities to the effort and sponsor a crowdsourced Challenge for patient benefit in the blood profiling domain. Celgene has

Blood Profiling Atlas in Cancer

Members

- Open Commons Consortium
- University of Chicago
- Seven Bridges
- AstraZeneca
- Celgene
- CytoLumina
- Eli Lilly and Company
- Epic Sciences
- Foundation Medicine
- Genentech
- Genomic Health, Inc
- Guardant Health
- Memorial Sloan Kettering Cancer Center
- Novartis
- Personal Genome Diagnostics
- Pfizer
- Thermo Fisher Scientific
- University of Michigan
- University of Southern California

https://www.bloodpac-data.org/

2017

“Working together, we got the job done” - Medical Innovation Game-Changer Now Law

Dec 13, 2016 Press Release

Signing Ceremony Marks Culmination of Three-Year Journey on the #Path2Cures

Delivering #CuresNow: Speaker Ryan Signs Bipartisan Game-Changing Medical Innovation Bill

Dec 8, 2016 Press Release

Bill Officially Heads to The White House to be Signed into Law

https://energycommerce.house.gov/cures

The NEW ENGLAND JOURNAL of MEDICINE

01/12/2017

Funding for NIH Innovative Research Initiatives under the Cures Act.*

Fiscal Year	BRAIN	PMI	Cancer Moonshot	Regenerative Medicine
		millions of $		
2017	10	40	300	2
2018	86	100	300	10
2019	115	186	400	10
2020	140	149	195	8
2021	100	109	195	
2022	152	150	194	
2023	450	419	216	
2024	172	235		
2025	91	36		
2026	195	31		
10-Yr total	1,511	1,455	1,800	30

* BRAIN denotes Brain Research through Advancing Innovative Neurotechnologies, and PMI Precision Medicine Initiative.

Hudson et. al. *NEJM* 2017

"***To support*** cancer research, such as the development of cancer vaccines, the development of more sensitive diagnostic tests for cancer, immunotherapy and the development of combination therapies, and research that has ***the potential to transform*** the scientific field, that has ***inherently higher risk***, and that seeks to ***address major challenges*** related to cancer…"

H.R.34—21st Century Cures Act

https://www.congress.gov/114/bills/hr34/BILLS-114hr34enr.pdf

NCI Blue Ribbon Panel Report Recommendations

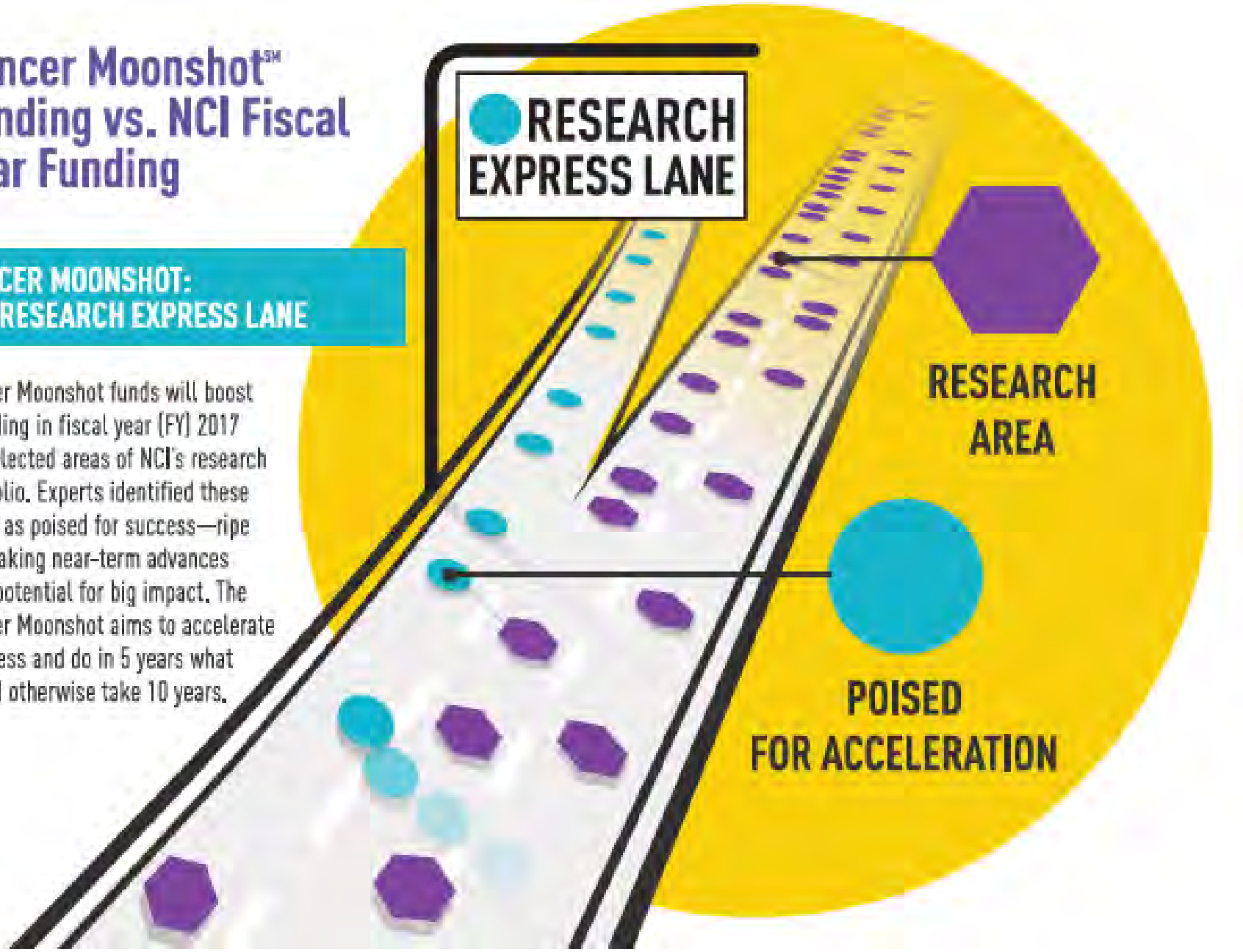
http://www.cancer.gov/brp

A. Establish a network for direct patient involvement
B. Create a clinical trials network devoted exclusively to immunotherapy
C. Develop ways to overcome cancer's resistance to therapy
D. Build a national cancer data ecosystem
E. Intensify research on the major drivers of childhood cancers
F. Minimize cancer treatment's debilitating side effects
G. Expand use of proven cancer prevention and early detection strategies
H. Mine past patient data to predict future patient outcomes
I. Develop a 3-D cancer atlas
J. Develop new cancer technologies

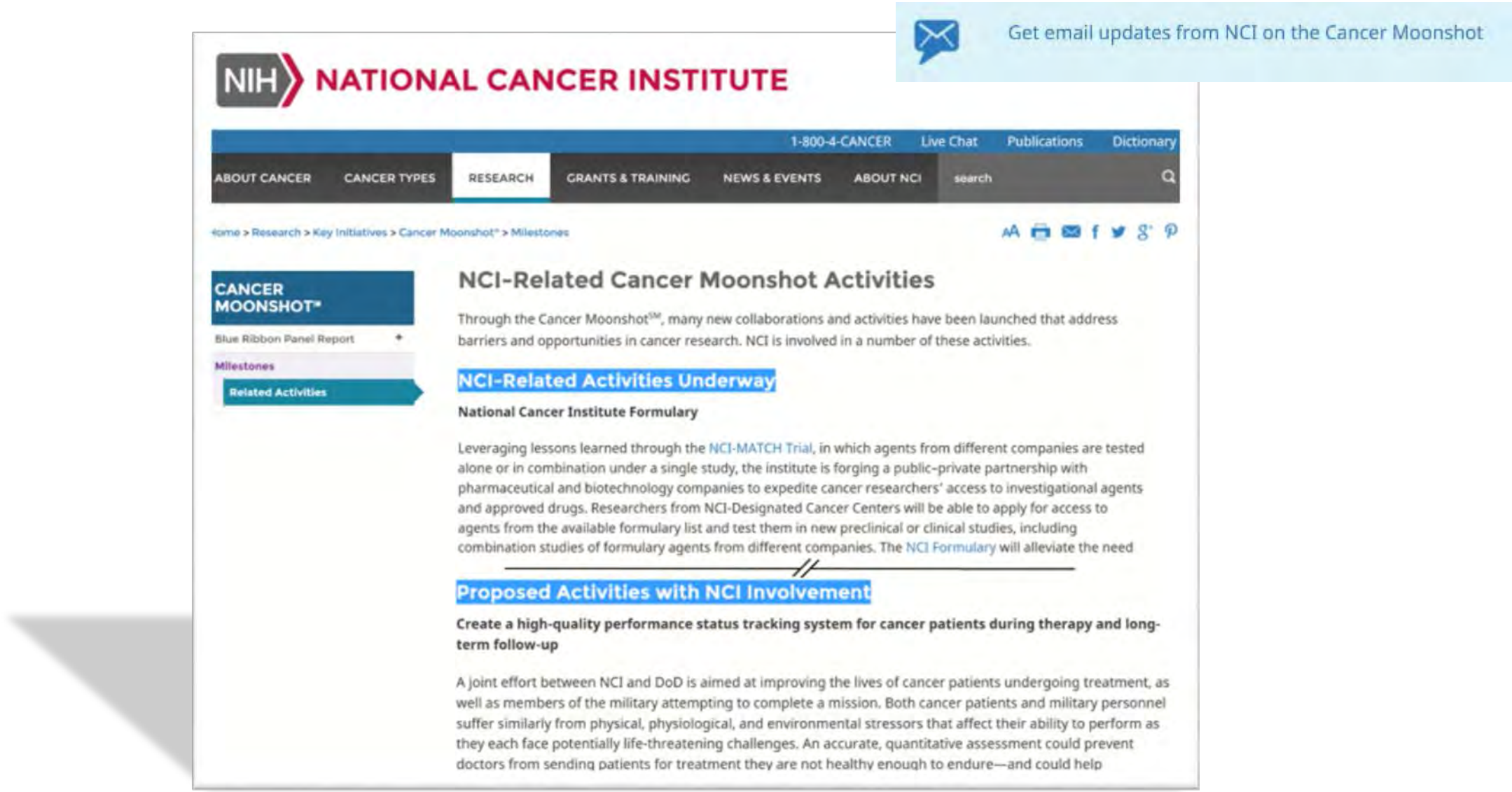
Cancer Moonshot℠ Funding vs. NCI Fiscal Year Funding

CANCER MOONSHOT: THE RESEARCH EXPRESS LANE

Cancer Moonshot funds will boost spending in fiscal year (FY) 2017 for selected areas of NCI's research portfolio. Experts identified these areas as poised for success—ripe for making near-term advances with potential for big impact. The Cancer Moonshot aims to accelerate progress and do in 5 years what would otherwise take 10 years.



Updated: January 11, 2017



https://www.cancer.gov/research/key-initiatives/moonshot-cancer-initiative/milestones/nci-activities

01/11/2017

https://nciformulary.cancer.gov/

NCI Press Release

New Drug Formulary Will Help Expedite Use of Agents in Clinical Trials

Posted: January 11, 2017

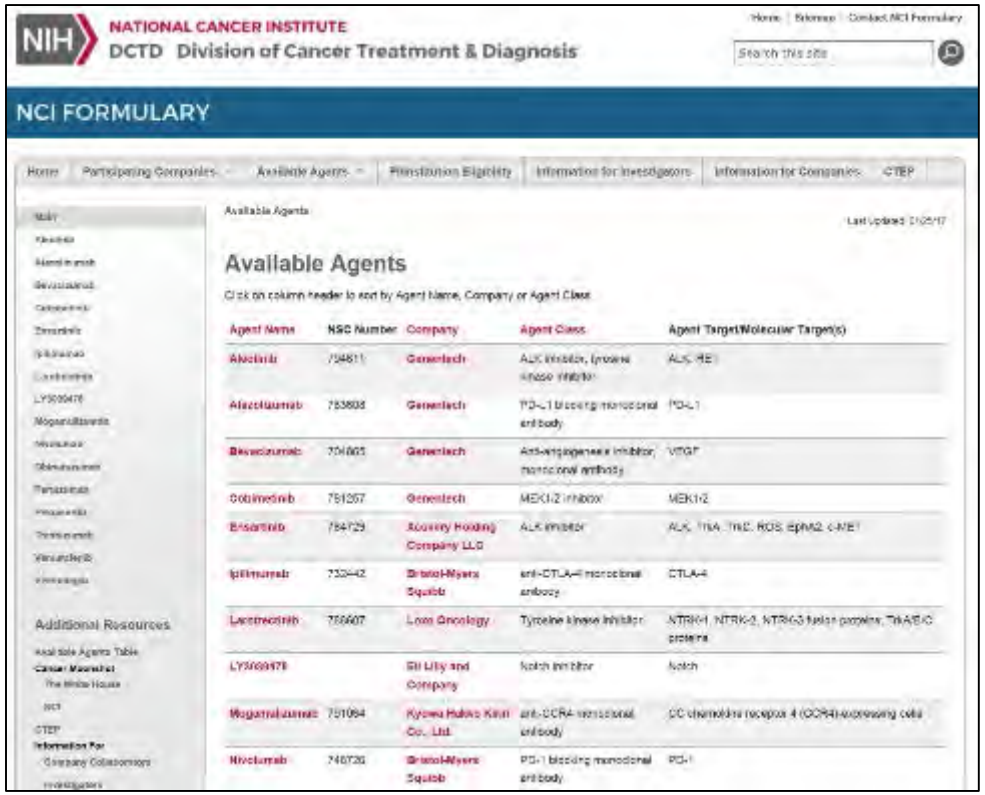
Contact: NCI Press Office
301-496-6641

Credit: iStock

The National Cancer Institute (NCI) today launched a new drug formulary (the "NCI Formulary") that will enable investigators at NCI-designated Cancer Centers to have quicker access to approved and investigational agents for use in preclinical studies and cancer clinical trials. The NCI Formulary could ultimately translate into speeding the availability of more-effective treatment options to patients with cancer.

The NCI Formulary is a public-private partnership between NCI, part of the National Institutes of Health, and pharmaceutical and biotechnology companies. It is also one of NCI's efforts in support of the Cancer Moonshot, answering Vice President Biden's call for greater collaboration and faster development of new therapies for patients. The availability of agents through the NCI Formulary will expedite the start of clinical trials by alleviating the lengthy negotiation process—sometimes up to 18 months—that has been required for investigators to access such agents on their own.

"The NCI Formulary will help researchers begin testing promising drug combinations more quickly, potentially helping patients much sooner," said NCI Acting Director Douglas Lowy, M.D. "Rather than spending time negotiating agreements, investigators will be able to focus on the important research that can ultimately lead to improved cancer care."



Participating Companies (as of 01/11/2017)

- Bristol-Myers Squibb
- Eli Lilly and Company
- Genentech
- Kyowa Hakko Kirin Co., Ltd.
- Loxo Oncology
- Xcovery Holding Company LLC

BCRF NEWS
SCIENCE NEWS

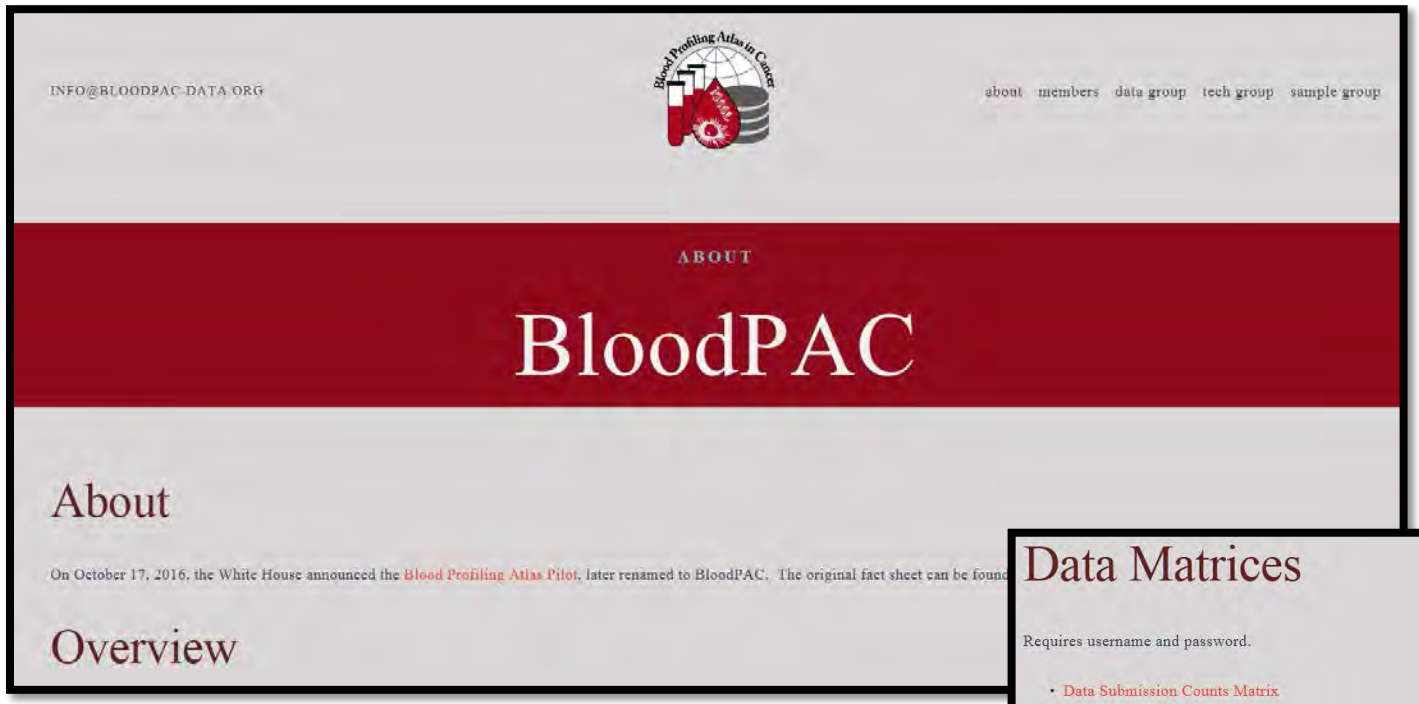
PRESS RELEASE: Breast Cancer Research Foundation and Prostate Cancer Foundation Announce Their Commitment to Support the Blood Profiling Atlas in Cancer

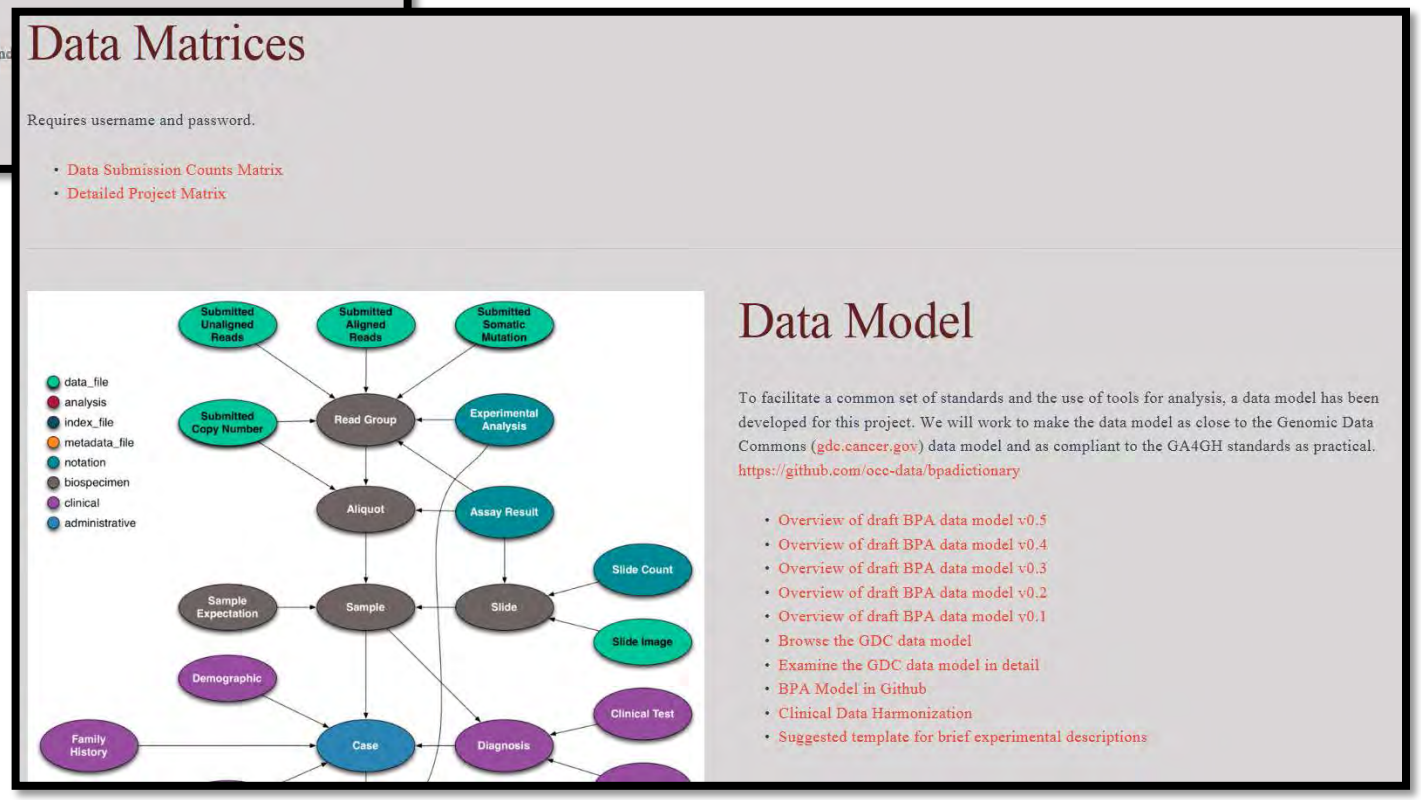
In alignment with VP Biden's Cancer Moonshot initiative, the Blood PAC formed in October 2016 to support progress towards patient benefit through research

By *BCRF* | December 20, 2016

BCRF has awarded a team science grant to **Drs. Shriver and Kuhn from the Department of Defense's Murtha Cancer Center and the University of Southern California**, while PCF is supporting **Dr. Howard I. Scher of Memorial Sloan Kettering Cancer Center (MSKCC) and the Prostate Cancer Clinical Trials Consortium (PCCTC).**

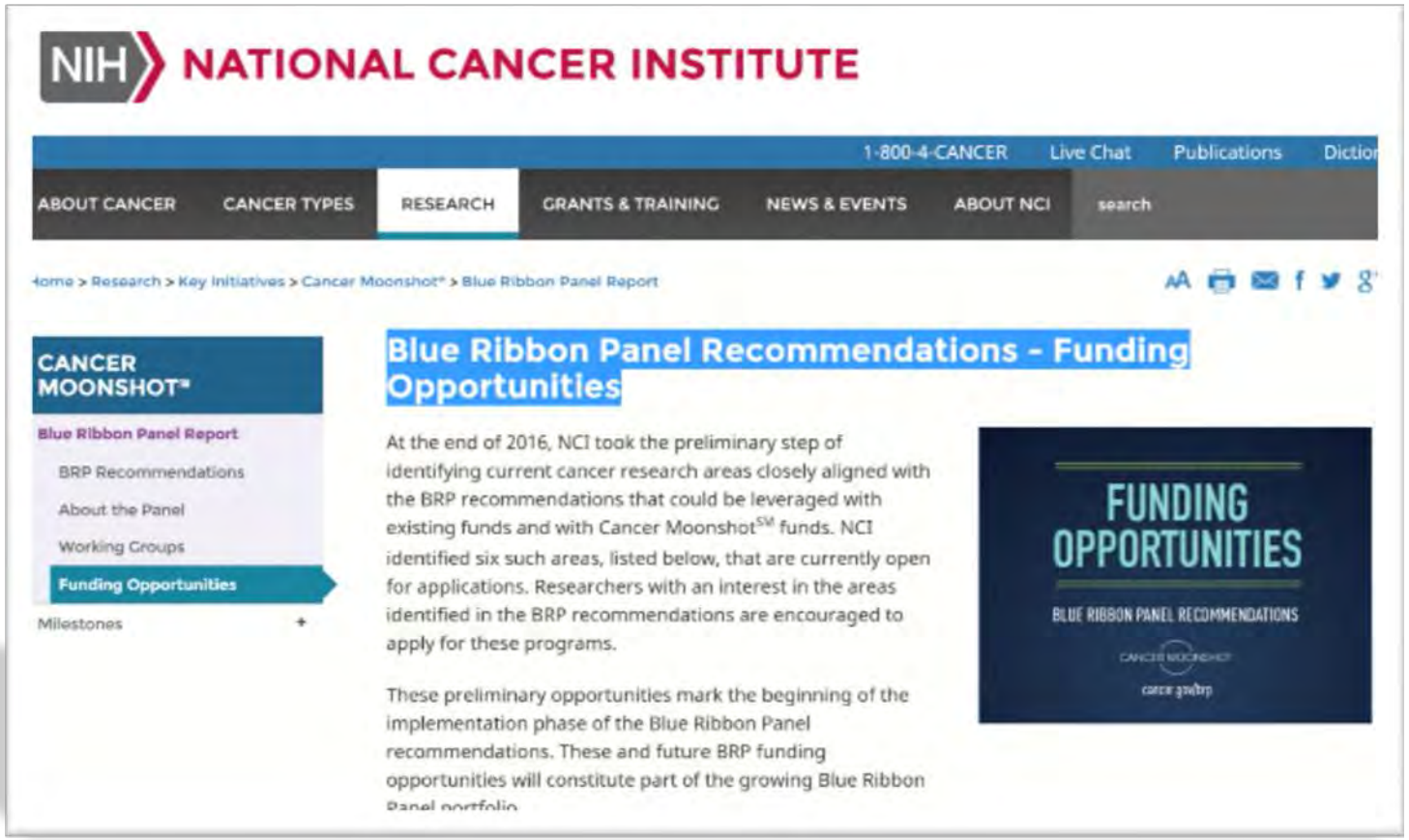
The funds have been awarded to recognized leaders in biomarker assay validation and are intended to **support pilot projects that will utilize multiple technologies for analyzing rare events in the blood of cancer patients and subsequently deposit the data and associated protocols into the Blood PAC commons.**





Lauren Leiman
Executive Director
lauren@bloodpac.org

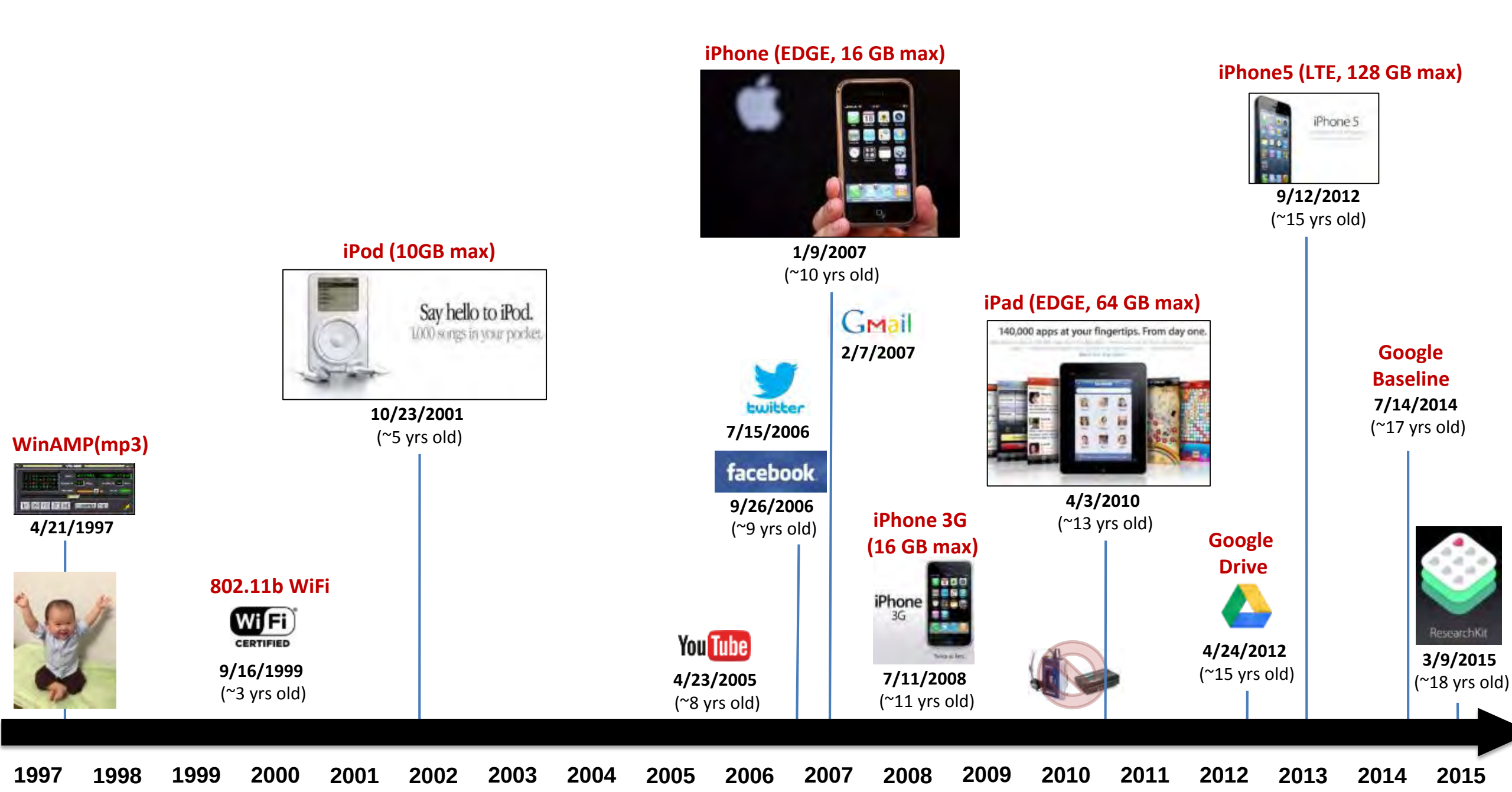
Updated: December 12, 2016



Currently **9** opportunities addressing **4** BRP recommendations

Please check back regularly as additional Funding Opportunity Announcements are posted.

https://www.cancer.gov/research/key-initiatives/moonshot-cancer-initiative/blue-ribbon-panel/funding


iPhone (EDGE, 16 GB max)
1/9/2007
(~10 yrs old)
iPhone5 (LTE, 128 GB max)
iPhone 5
9/12/2012
(~15 yrs old)
iPod (10GB max)
Say hello to iPod.
1,000 songs in your pocket.
10/23/2001
(~5 yrs old)
Gmail
2/7/2007
iPad (EDGE, 64 GB max)
140,000 apps at your fingertips. From day one.
4/3/2010
(~13 yrs old)
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Baseline
7/14/2014
(~17 yrs old)
twitter
7/15/2006
facebook
9/26/2006
(~9 yrs old)
WinAMP(mp3)
4/21/1997
802.11b WiFi
Wi Fi
CERTIFIED
9/16/1999
(~3 yrs old)
YouTube
4/23/2005
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A History of Cancer Chemotherapy

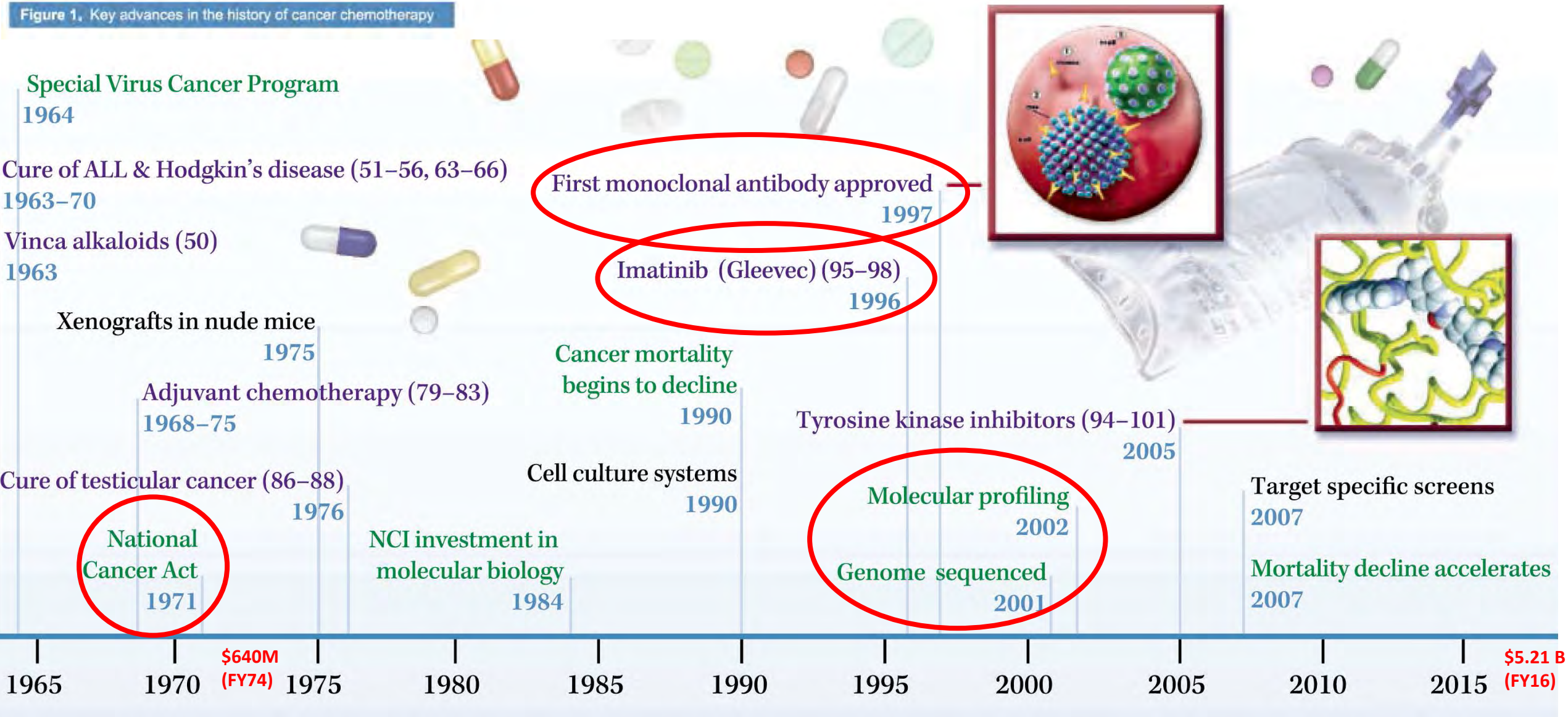
Vincent T. DeVita, Jr. and Edward Chu

Yale Cancer Center, Yale University School of Medicine, New Haven Connecticut

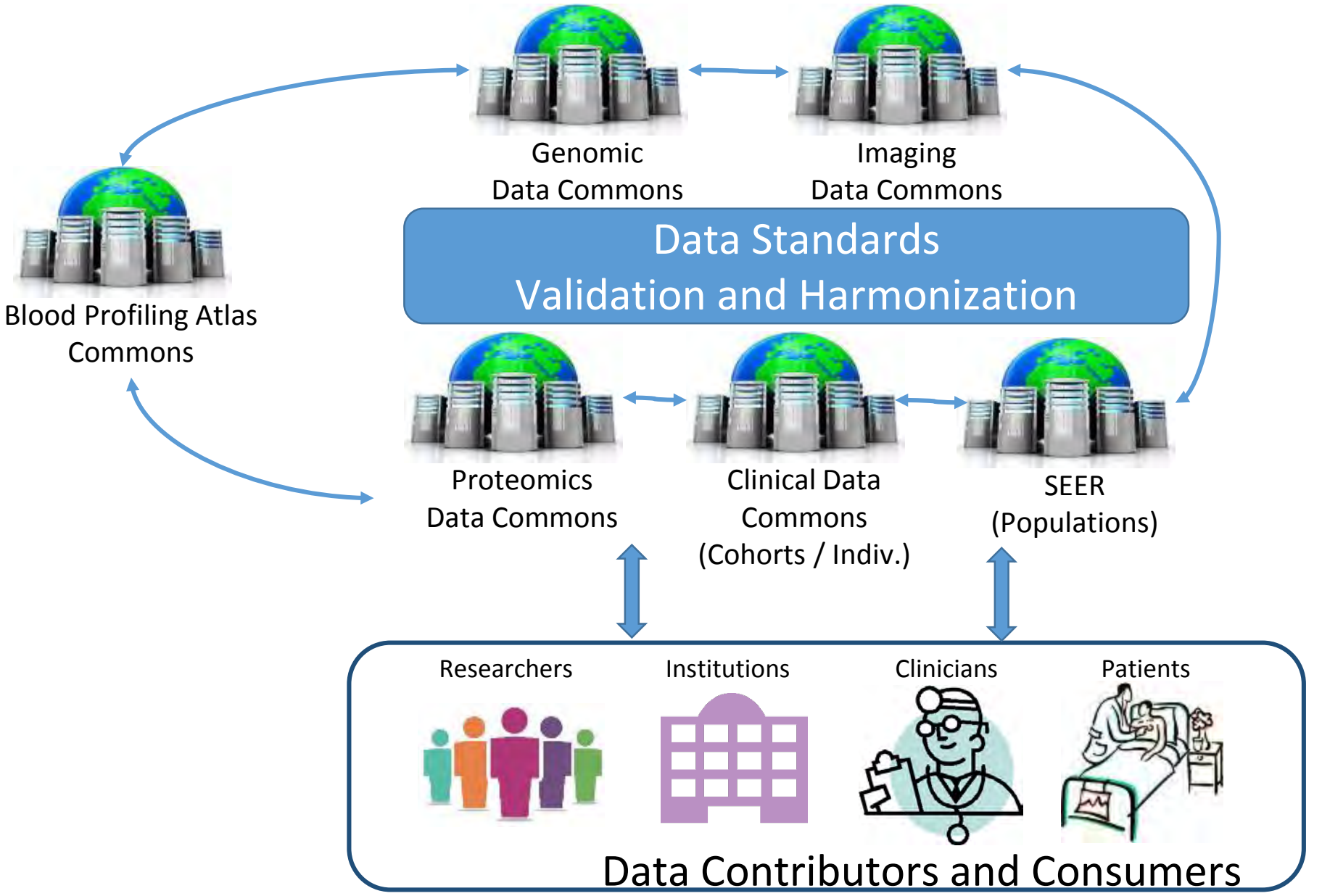
AACR Centennial Series

Cancer Res 2008

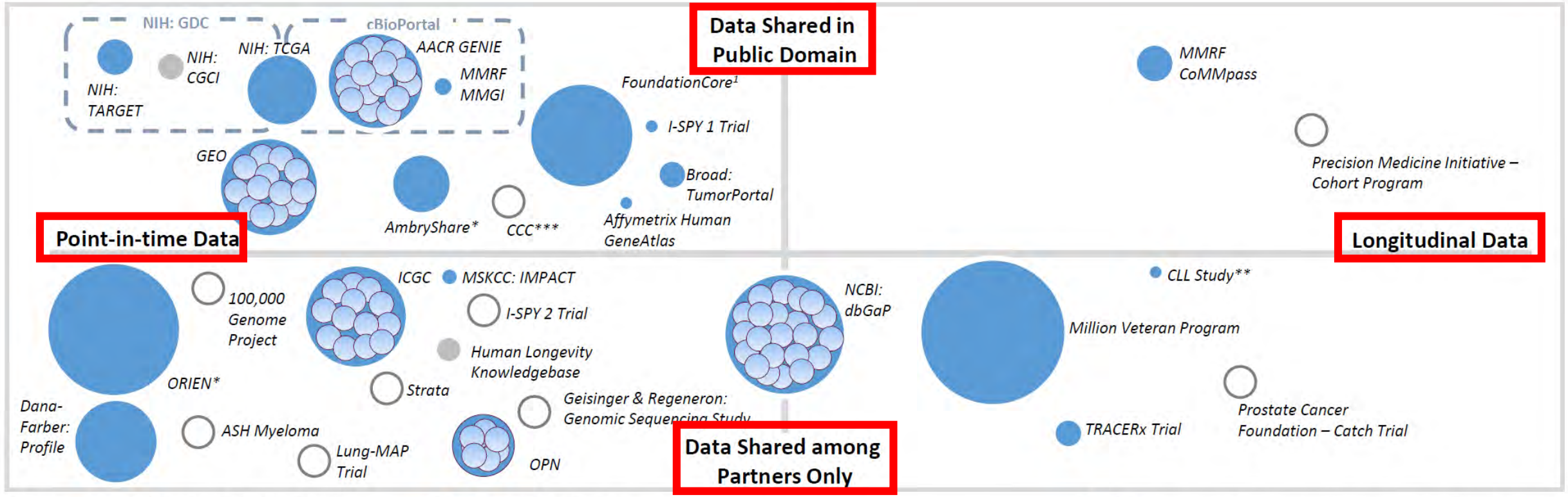
Figure 1. Key advances in the history of cancer chemotherapy



Cancer Research Data Commons Ecosystem



10/14/2016



Bubble size = estimated size of available dataset
Note: Representative selection of landscape, not all inclusive

Available datasets, size known
Available datasets, size unknown
Dataset in development
Available datasets that comprise multiple smaller datasets
Portals that are currently active/utilized in the public domain

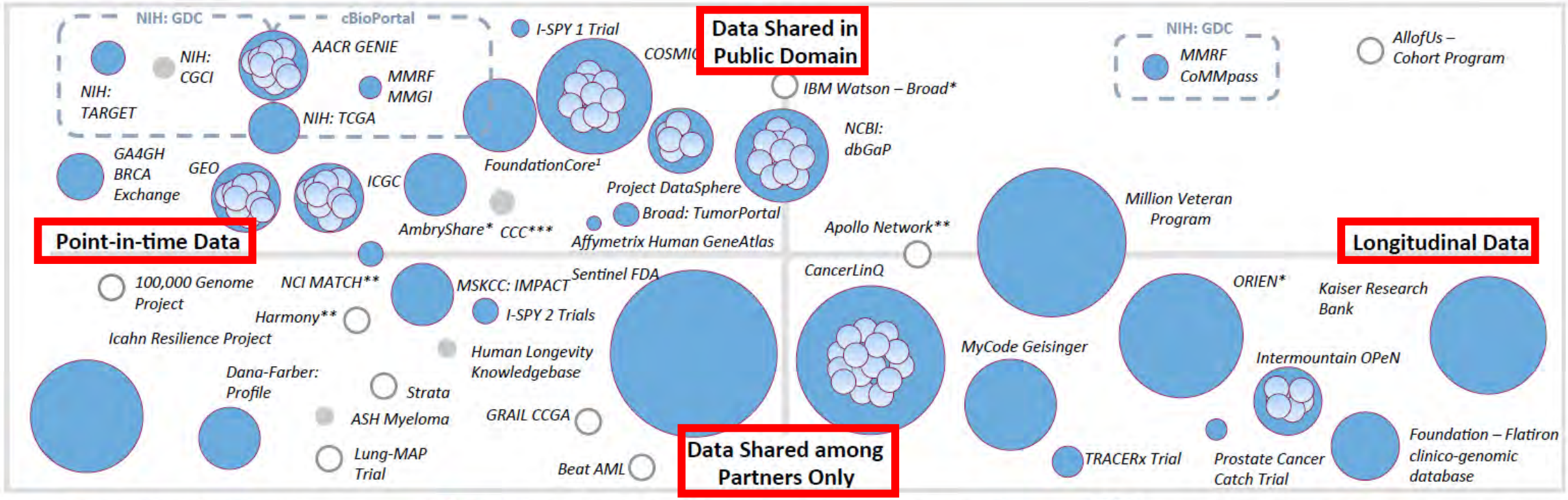
Opportunity exists to generate publicly available longitudinal data to drive understanding of genetic mutations and find Precision Medicine cures

*Datasets have potential to include longitudinal data in the future
**Public/private information not available
***Serves as a portal also, has potential to include longitudinal data in the future

1. FoundationCore's pediatric cancer data has been made public

HARVARD BUSINESS SCHOOL
Kraft Precision Medicine Accelerator

Oncology Precision Medicine Data Landscape:
December 2016 Update



Bubble size = estimated size of current dataset
Note: Representative selection of landscape, not all inclusive
Note: Dataset selection focused on oncology specific and oncology-inclusive datasets

Available datasets, size known
Available datasets, size unknown
Data initiative announced. Recruiting planned
Independent initiatives as part of larger dataset
Portals that are currently active/utilized in the public domain

Opportunity exists to generate publicly available longitudinal data to drive understanding of genetic mutations and find Precision Medicine cures

*Datasets have potential to include longitudinal data in the future
**Public/private information not available
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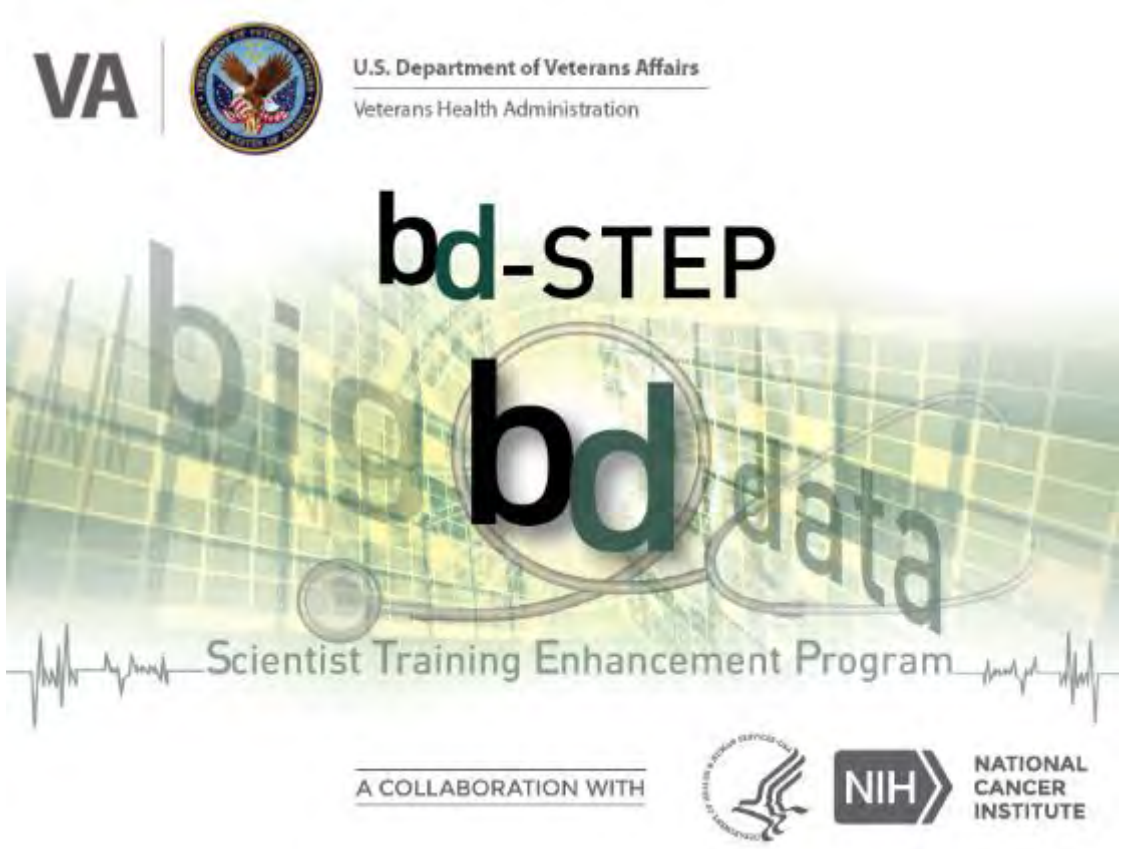
HARVARD BUSINESS SCHOOL
Kraft Precision Medicine Accelerator

Big Data Scientist Training Enhancement Program (BD-STEP)



Graduates of BD-STEP would:

- have skillsets to perform next-generation **patient-centered outcomes research** by manipulating and analyzing large-scale, multi-element, patient data sets to **develop novel disease signatures or unique performance-based clinical benchmarks**

- have an understanding of real-time, performance-driven health care delivery in the VA systems

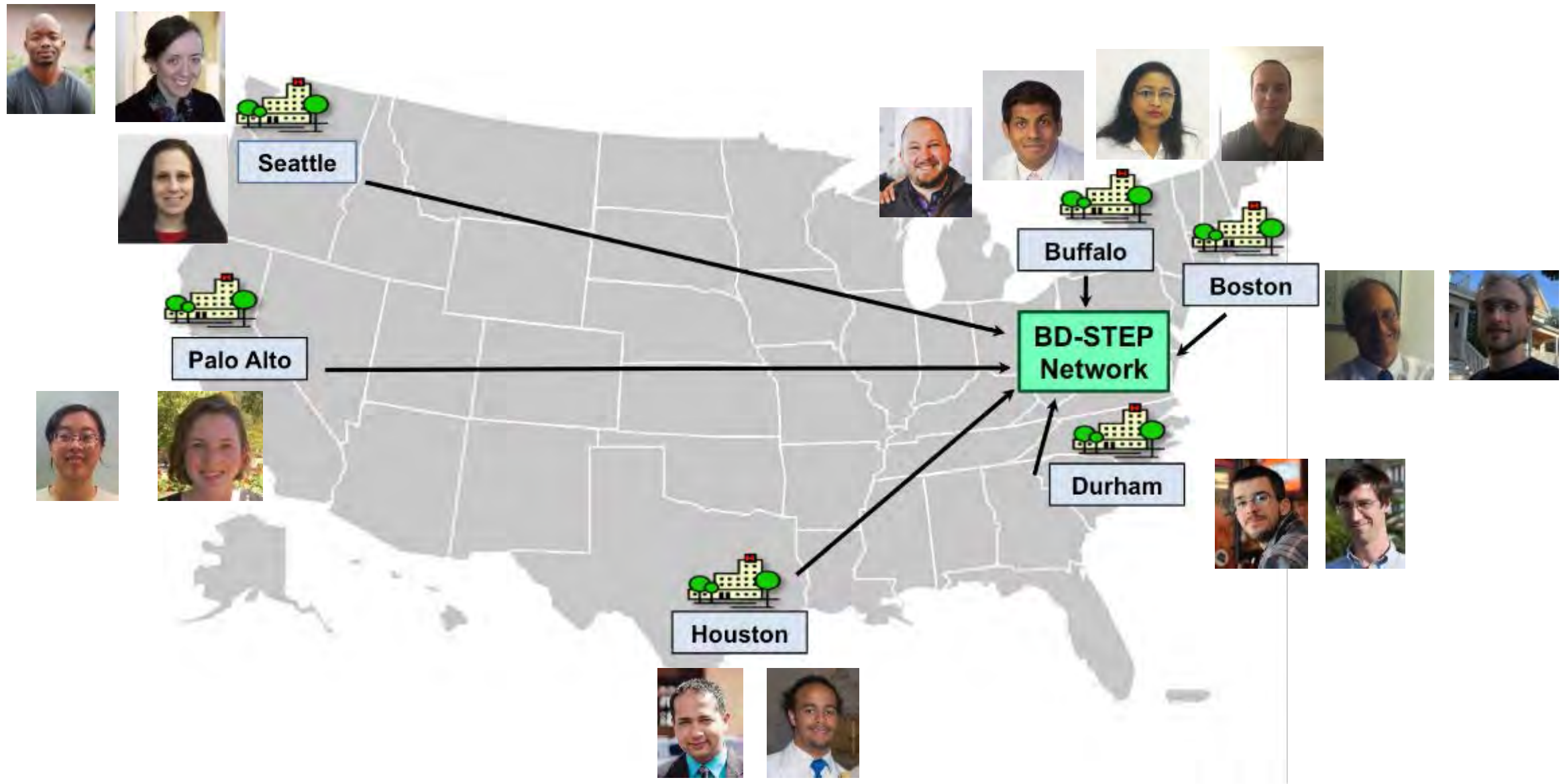
2017 Potential Partners:

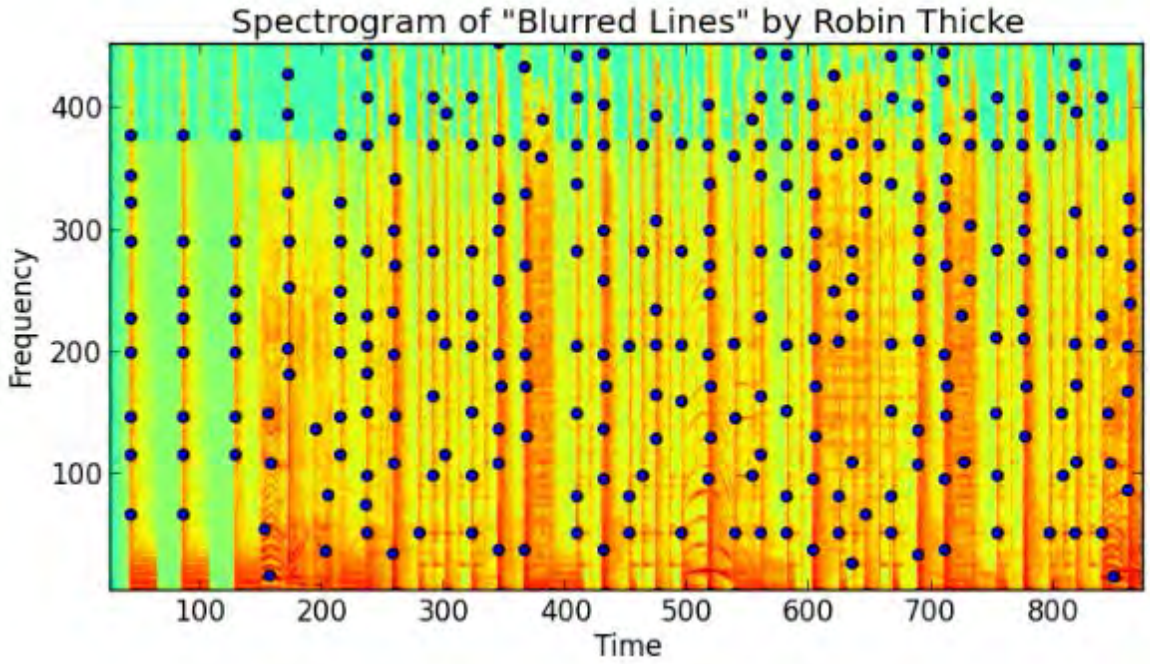
NSF FDA CDC

Connie Lee, VHA/EES

Michelle Berny-Lang, NCI

BD-STEP Sites and Fellows: 2016-2017




Spectrogram of "Blurred Lines" by Robin Thicke
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500
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700
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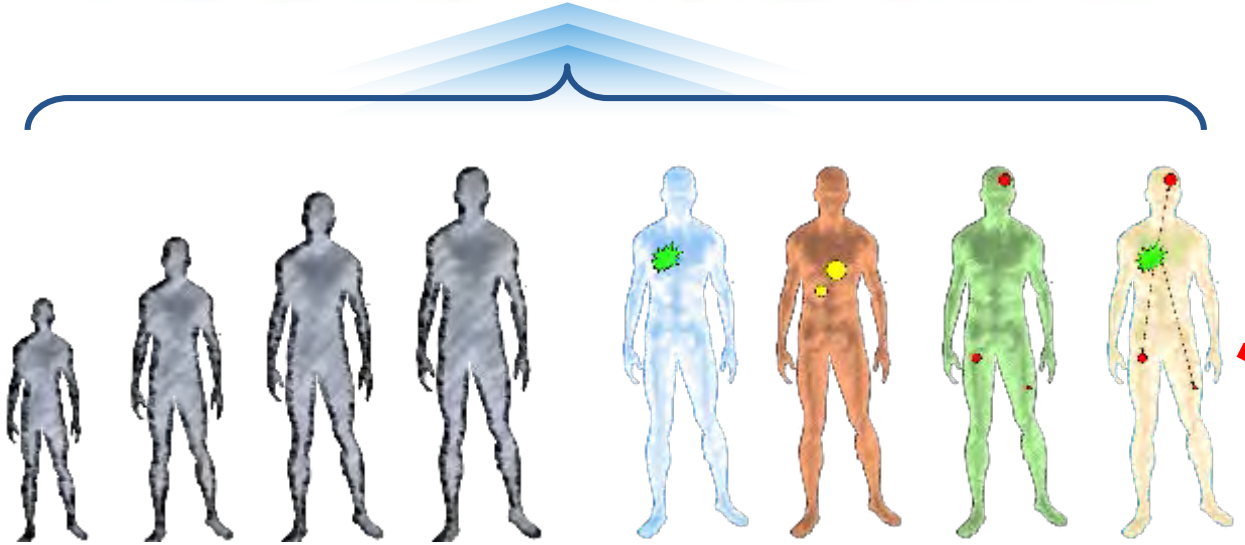
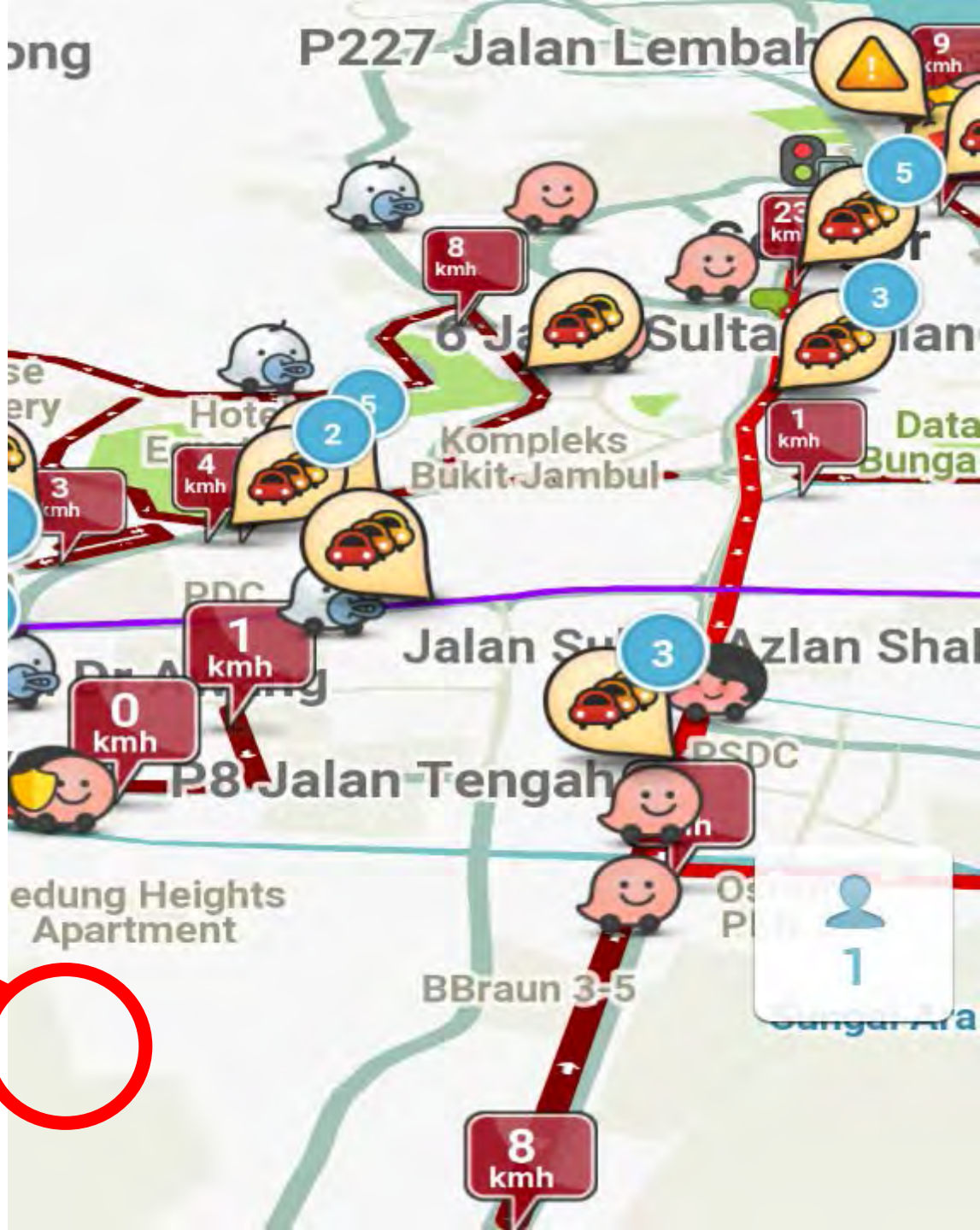


Time →


P227 Jalan Lembah
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edung Heights Apartment
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Home About Join/Login See

CancerBase

Share, Discover & Change

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Facebook

Twitter

Or with email

Inviting those with cancer to join a global effort to make our data count.

When patients share real-time data with patients, the world changes.

http://www.cancerbase.org

Our worldwide map of real-time information.

Each dot is one of us. The clickable tabs for the different cancer types will light up when enough of us with that particular cancer have joined.

Acknowledgements/Thanks to the "Secret Ingredients"

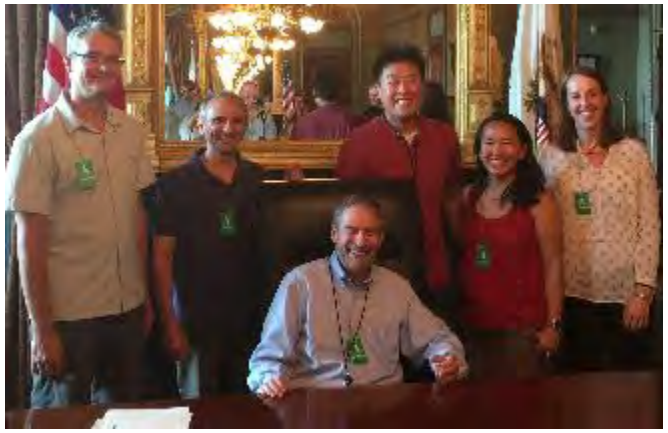
Clinical Sciences

Life Sciences

Physical Sciences


#CanServe


ANN B. BARSHINGER CANCER INSTITUTE



Learn More About Us…

http://cssi.cancer.gov

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jerry.lee@nih.gov