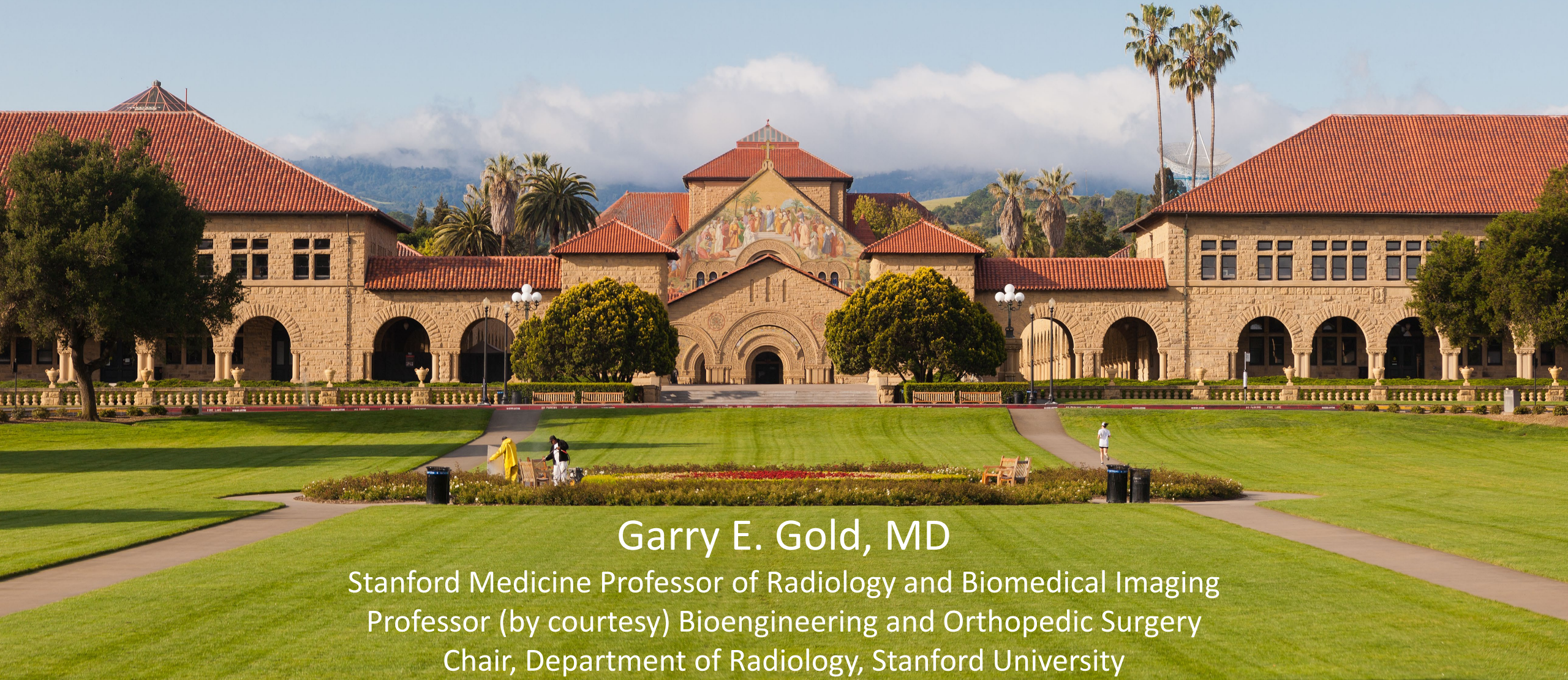


The Future of Radiology and Integrated Diagnostics: Building on Sam Gambhir's Vision

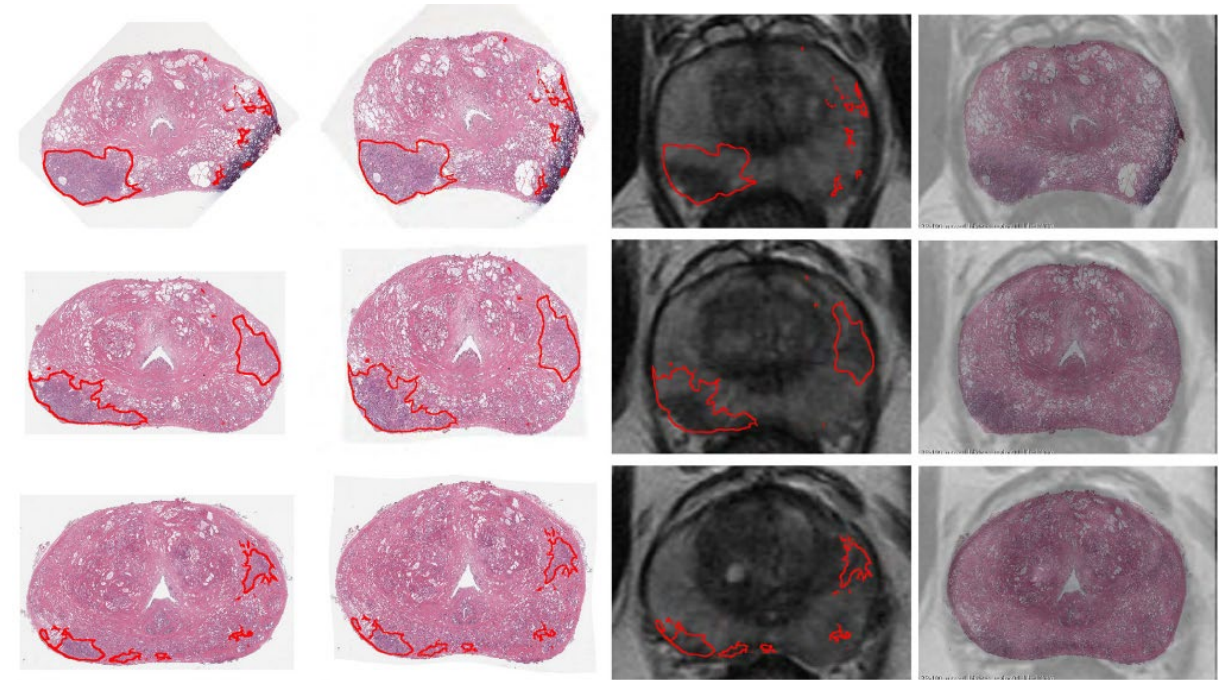
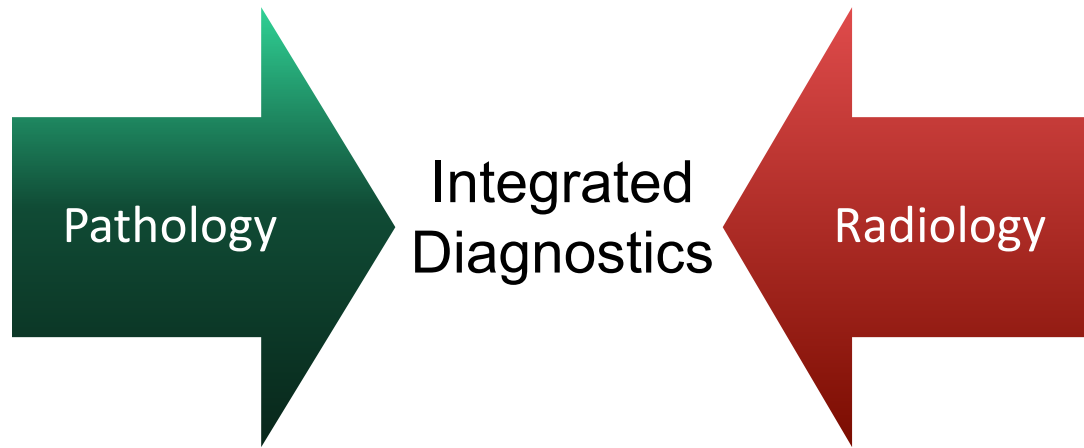


Garry E. Gold, MD

Stanford Medicine Professor of Radiology and Biomedical Imaging
Professor (by courtesy) Bioengineering and Orthopedic Surgery
Chair, Department of Radiology, Stanford University

Integrated Diagnostics

Pathology and Radiology are both dedicated to developing, managing and communicating diagnostic data and associated clinical implications



- Proliferation of diagnostic technology
- Emergence of digital pathology
- Big data analytics, machine learning, sophisticated image analysis

Rusu, M. et al. Aligning MRI and histopathology
Medical Physics 47 (9), 2020.



Mirabella Rusu, PhD



Sanjiv “Sam” Gambhir MD PhD



Non-Small Cell Lung Cancer

Sam Gambhir MD, PhD

An Observational Study of Circulating Tumor Cells and ^{18}F -FDG PET Uptake in Patients with Treatment-Naive Non-Small Cell Lung Cancer

Viswam S. Nair^{1*}, Khun Visith Keu², Madelyn S. Luttgen³, Anand Kolatkar³, Minal Vasanawala⁴, Ware Kushner^{1,5}, Kelly Bethel⁶, Andrei H. Iagaru², Carl Hoh⁷, Joseph B. Shrager^{8,9}, Billy W. Loo Jr.¹⁰, Lyudmila Bazhenova¹¹, Jorge Nieva¹², Sanjiv S. Gambhir^{13,14}, Peter Kuhn³

Circulating Tumor Microemboli Diagnostics for Patients with Non-Small-Cell Lung Cancer

Anders Carlsson, PhD,* Viswam S. Nair, MD, MS,† Madelyn S. Luttgen, BS,* Khun Visith Keu, MD,‡ George Horng, MD,§ Minal Vasanawala, MD,||¶ Anand Kolatkar, PhD,* Mehran Jamali, MBBS,¶ Andrei H. Iagaru, MD,¶ Ware Kushner, MD,†# Billy W. Loo Jr., MD, PhD,** Joseph B. Shrager, MD,††‡‡ Kelly Bethel, MD,§§ Carl K. Hoh, MD,||| Lyudmila Bazhenova, MD,¶¶ Jorge Nieva, MD,## Peter Kuhn, PhD,* and Sanjiv S. Gambhir, MD, PhD,¶***†††

HD-CTC number weakly correlated with SUV and not correlated with Tumor diameter (2013)

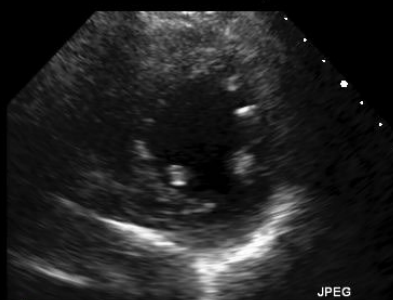
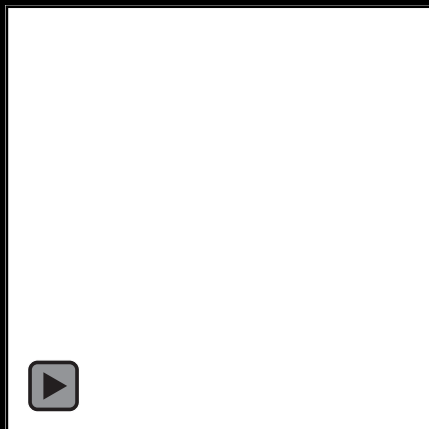
CTM with clinical and imaging data improve Dx accuracy compared with CTM alone (2014)

Courtesy of Sanjiv (Sam) Gambhir, MD, PhD



Kenneth Mahaffey, MD

BASELINE STUDY

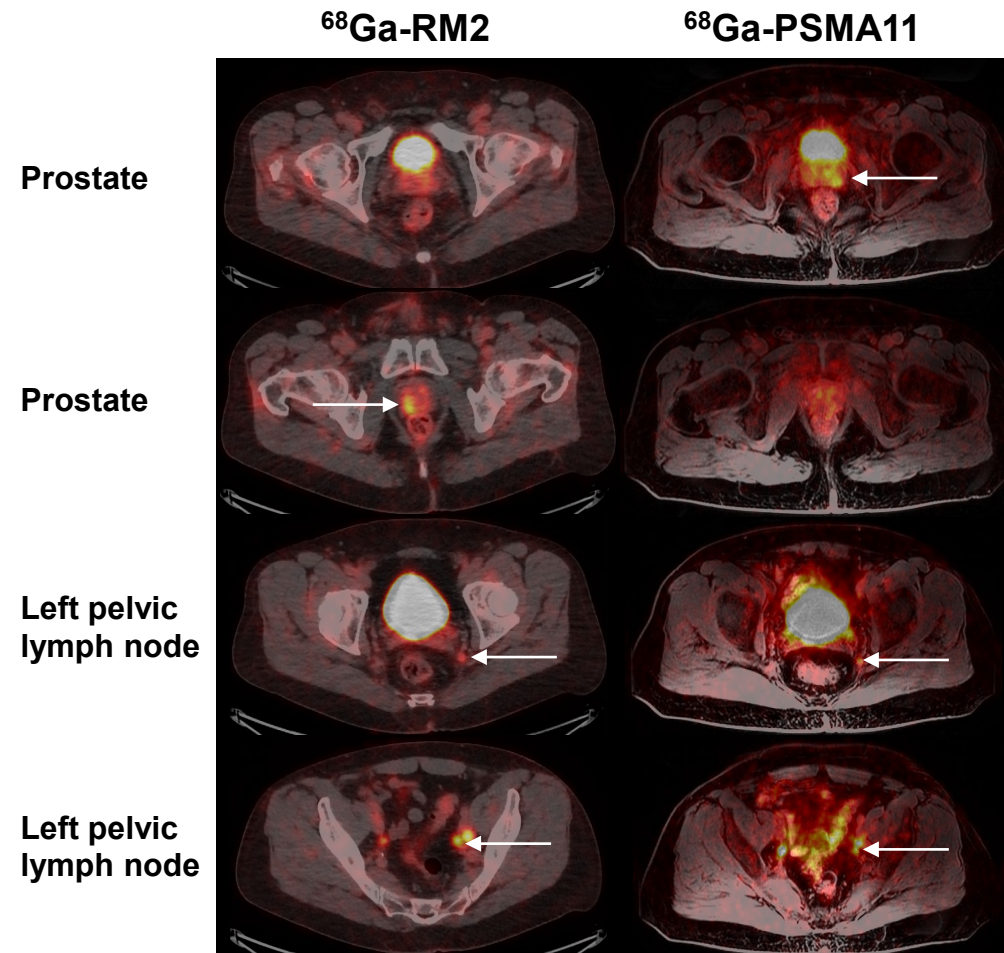


A comprehensive study of human health and transition to disease

A longitudinal cohort study to extensively characterize participants at baseline and serially using a battery of clinical, imaging, psychosocial, behavioral, socioeconomic, geospatial, physiometric, and molecular tools

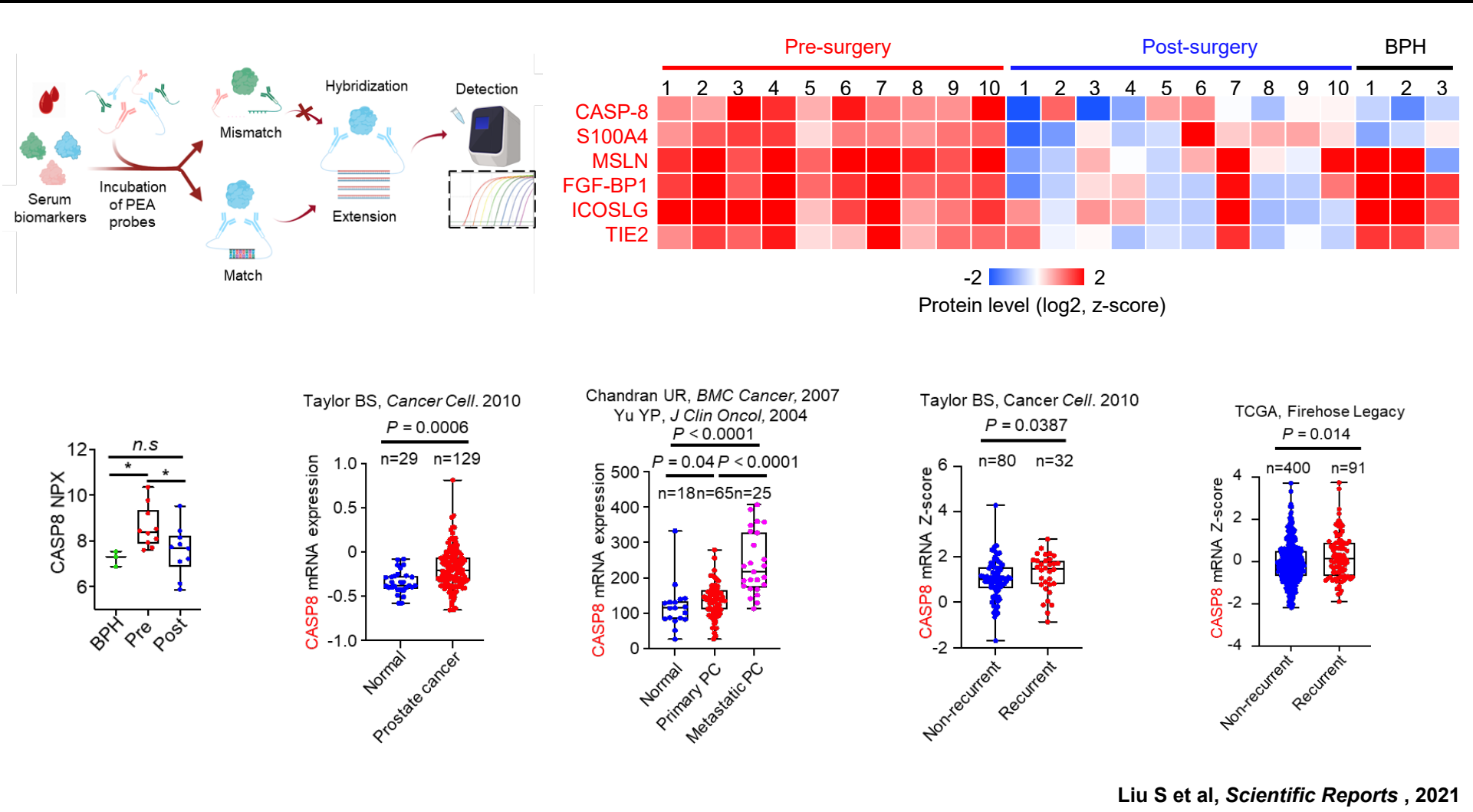


Novel Molecular Imaging of Prostate Cancer



Courtesy of Andrei Iagaru, MD

Discovery of CASP8 as a Potential Biomarker for High-risk Prostate Cancer



Liu S et al, *Scientific Reports*, 2021



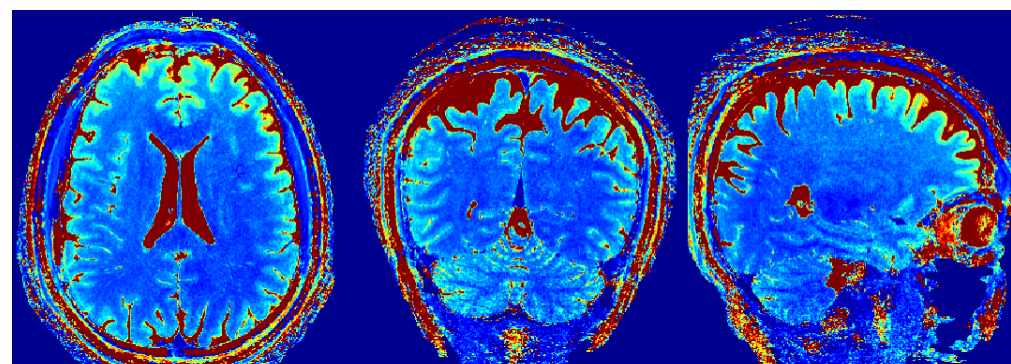
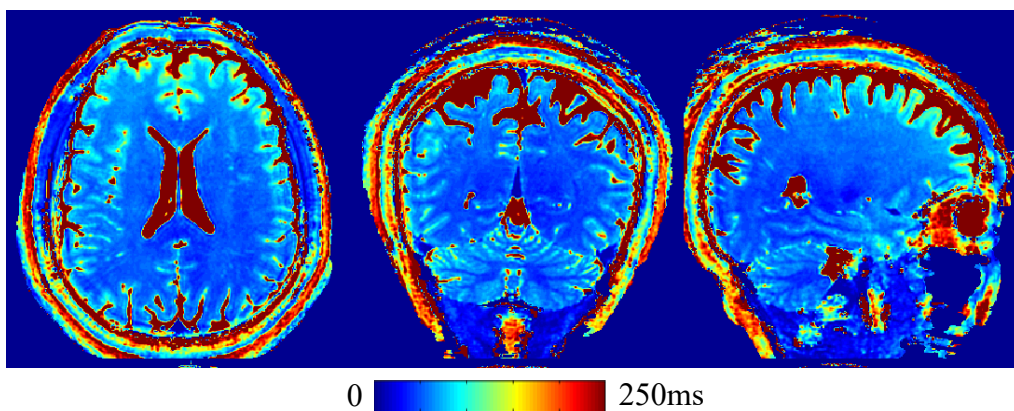
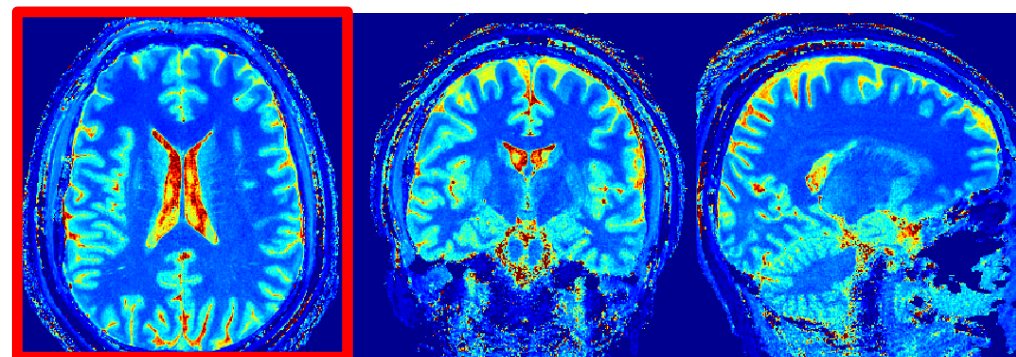
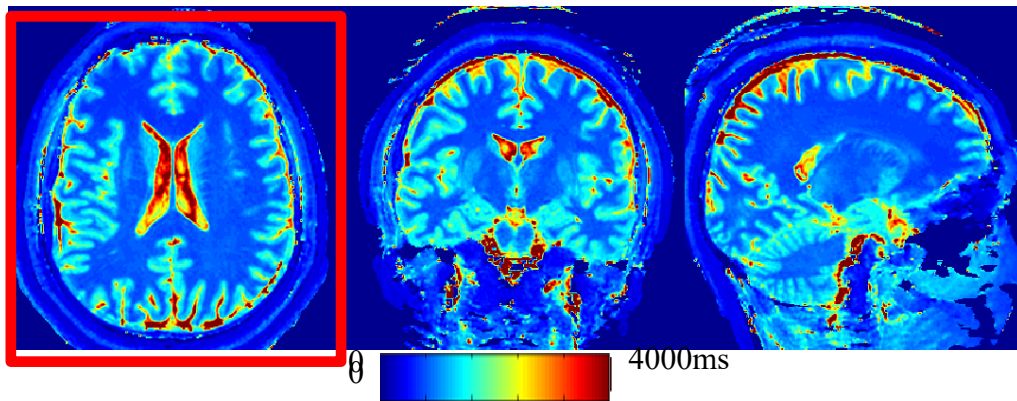
Novel Imaging



Faster, Lower-Cost Imaging Exams

1 mm whole-brain in 1 min and 55s

0.66mm whole-brain in 4 min



X. Cao et al, ISMRM 2021

Theragnostics



Andrei Iagaru, MD



Carina Mari Aparici, MD



Before Lutathera® #1



After Lutathera® #2



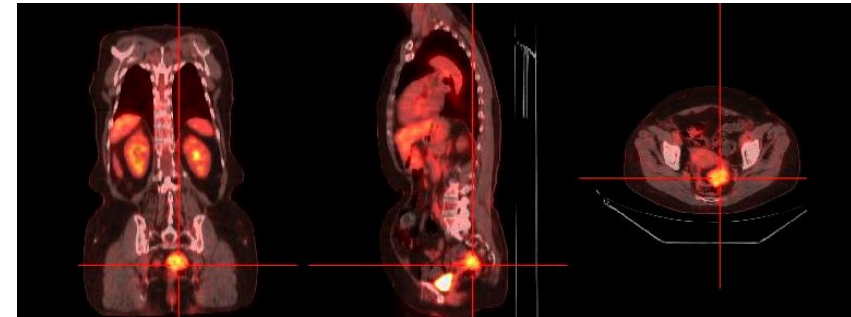
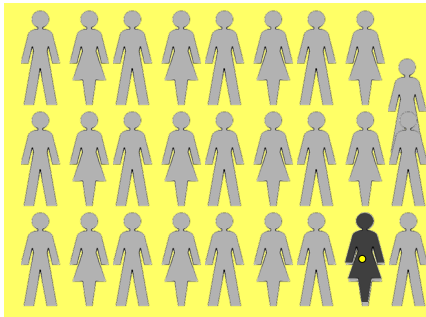
After Lutathera® #4

Theragnostics: $^{68}\text{Ga}/^{177}\text{Lu}$ DOTATATE for Neuroendocrine Tumor

New In-Vitro Diagnostics

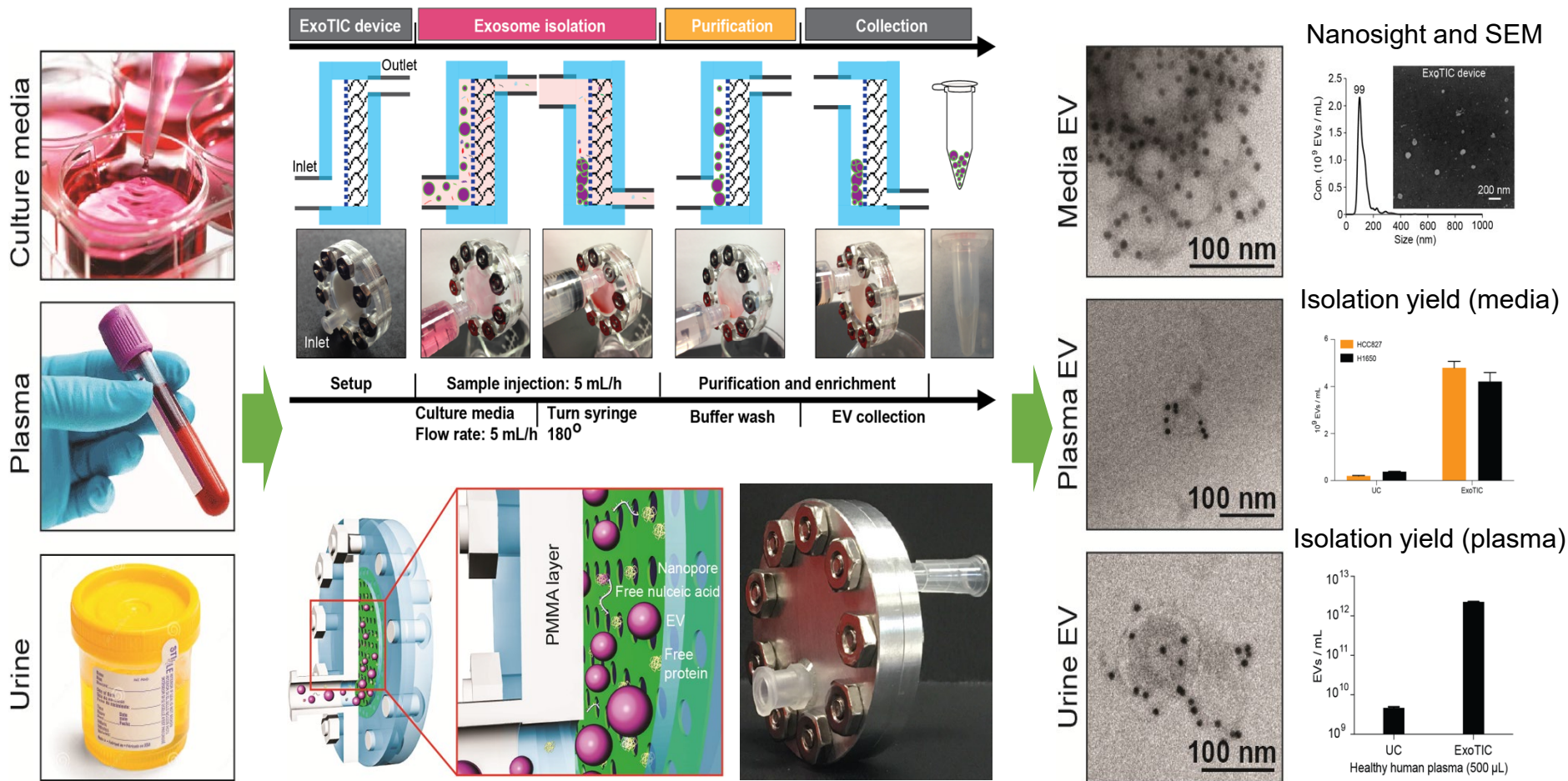
Canary Center at Stanford for Cancer Early Detection

Mission: Discover and implement minimally invasive diagnostic and imaging strategies for the detection and localization of aggressive cancers at early curable stages.

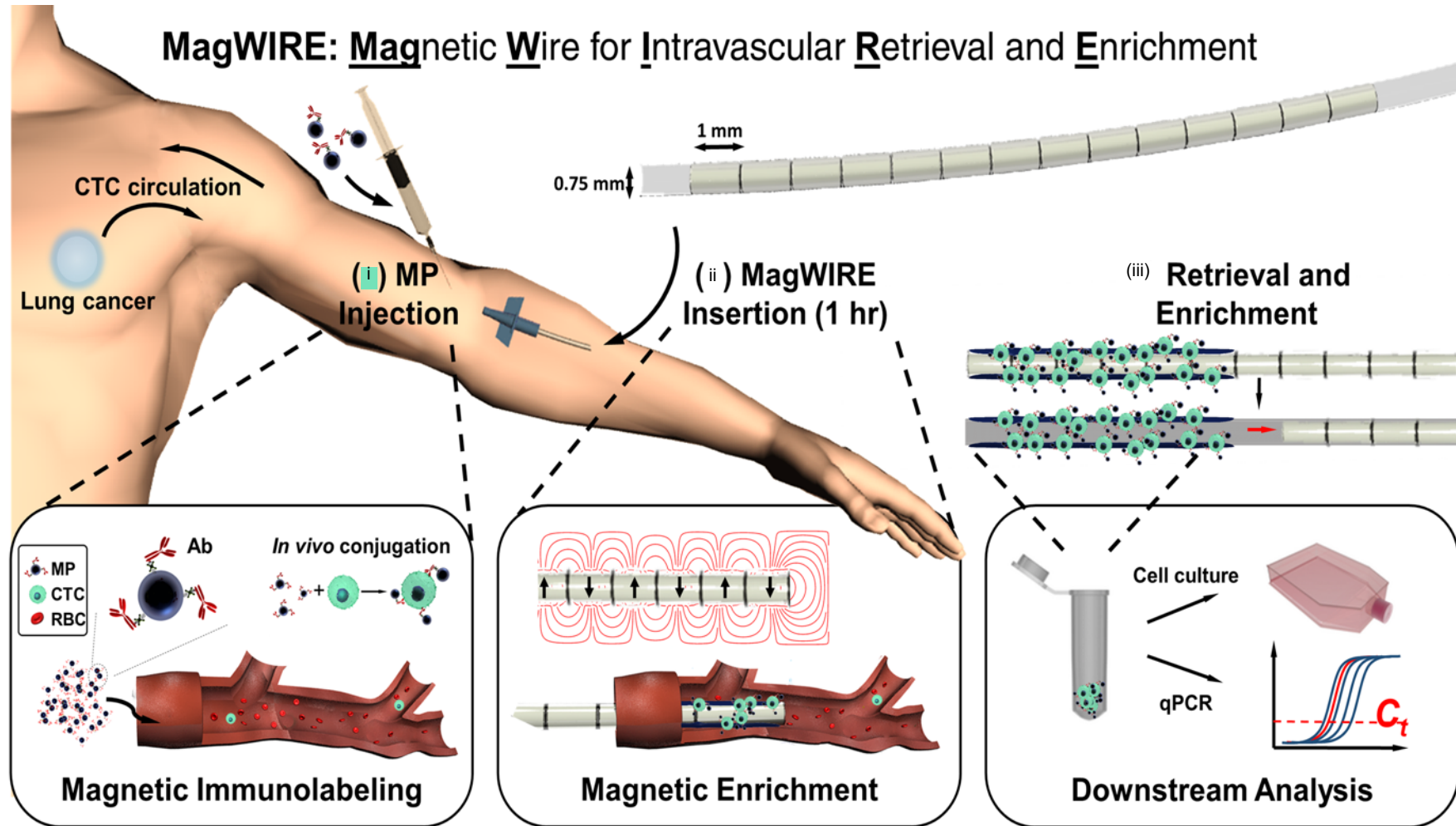


Exosome Total Isolation Chip (ExoTIC)

Illustration of ExoTIC device for extracellular vesicle (EV) isolation



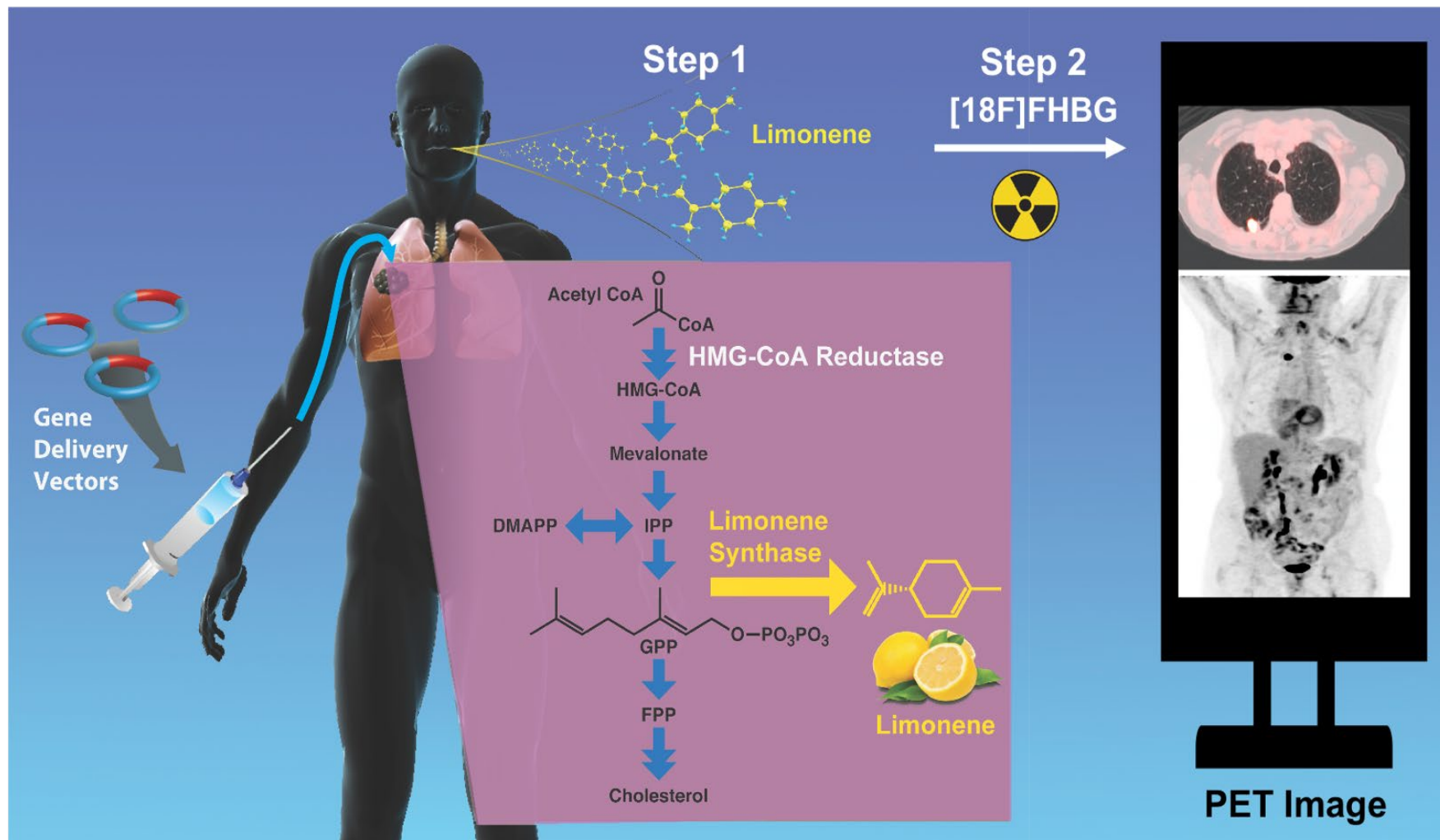
Full Blood Biomarker Sampling



Volatile Organic Compounds with Imaging



Ophir Vermesh, MD, PhD

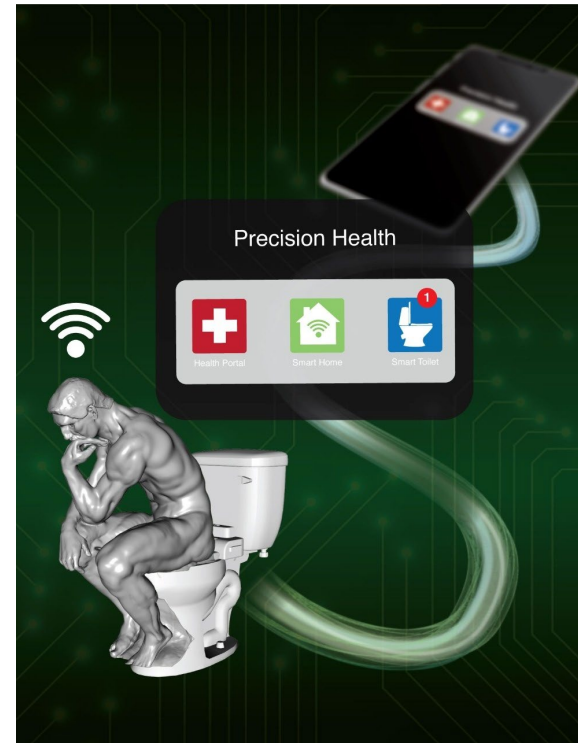


2022 RSNA Research & Education Award

[18F]FHBG: 9-(4-(18)F-Fluoro-3-[hydroxymethyl]butyl)guanine

Wearables and In-Home Monitoring

Wearable and In-Home Technology



ARTICLES
<https://doi.org/10.1038/s41551-020-0534-9>
nature
biomedical engineering



A mountable toilet system for personalized health monitoring via the analysis of excreta

Seung-min Park^{1,2,17}, Daeyoun D. Won^{1,3,4,17}, Brian J. Lee^{1,2,17}, Diego Escobedo¹, Andre Esteva⁵, Amin Aalipour^{1,2}, T. Jessie Ge⁶, Jung Ha Kim³, Susie Suh⁷, Elliot H. Choi⁷, Alexander X. Lozano^{8,9}, Chengyang Yao¹⁰, Sunil Bodapati¹¹, Friso B. Achterberg^{1,2,12}, Jeesu Kim^{1,2,13}, Hwan Park¹⁴, Youngjae Choi¹⁴, Woo Jin Kim¹⁴, Jung Ho Yu^{1,2}, Alexander M. Bhatt¹, Jong Kyun Lee^{3,4}, Ryan Spitler^{1,15}, Shan X. Wang^{8,10,16} and Sanjiv S. Gambhir^{1,2,8,11,15,16} ✉



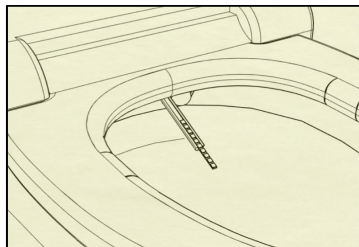
Sam Gambhir, MD, PhD



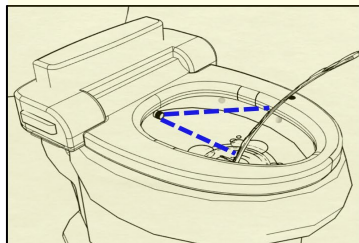
Sam Gambhir MD, PhD



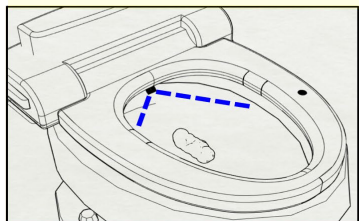
Seung-min Park, PhD



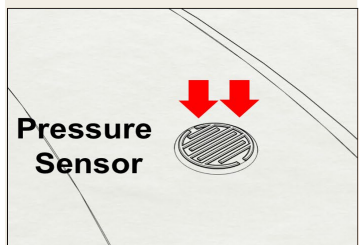
Urinalysis



Uroflowmetry



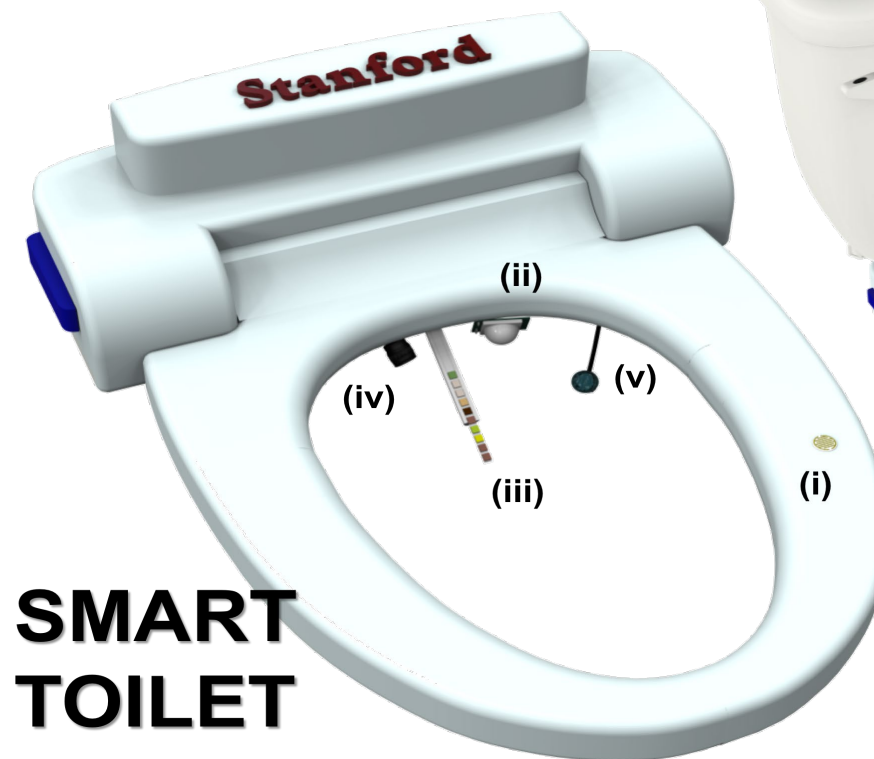
Bristol Stool Scale



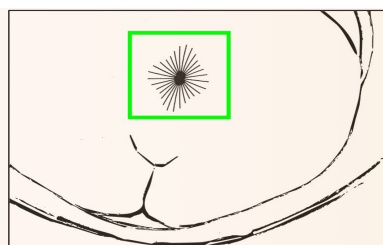
Pressure Sensor

Seating Time
Defecation Time

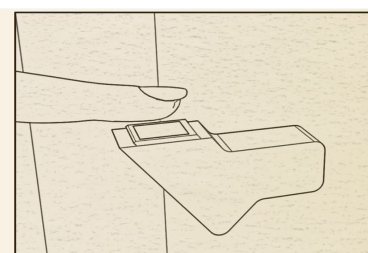
- (i) Pressure Sensor
- (ii) Motion Sensor (PIR)
- (iii) Urinalysis Strip
- (iv) Stool Camera
- (v) Anus Camera



SMART TOILET



Analprint Scan



Fingerprint Scan



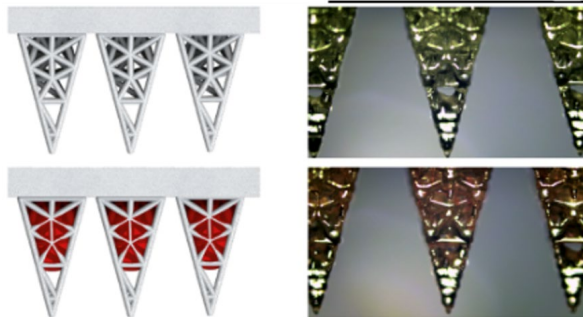
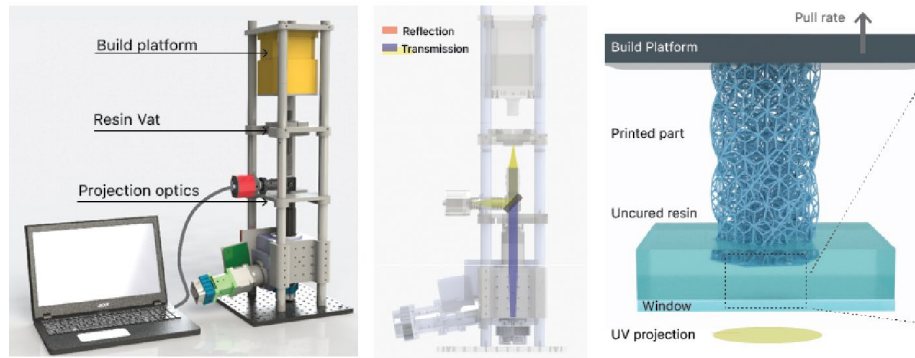
Health Portal
(Cloud)

Courtesy of Sanjiv (Sam) Gambhir, MD, PhD

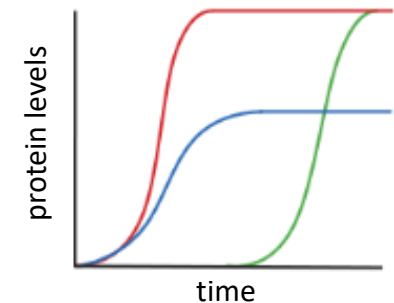
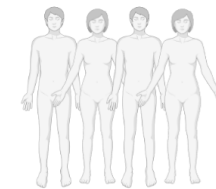
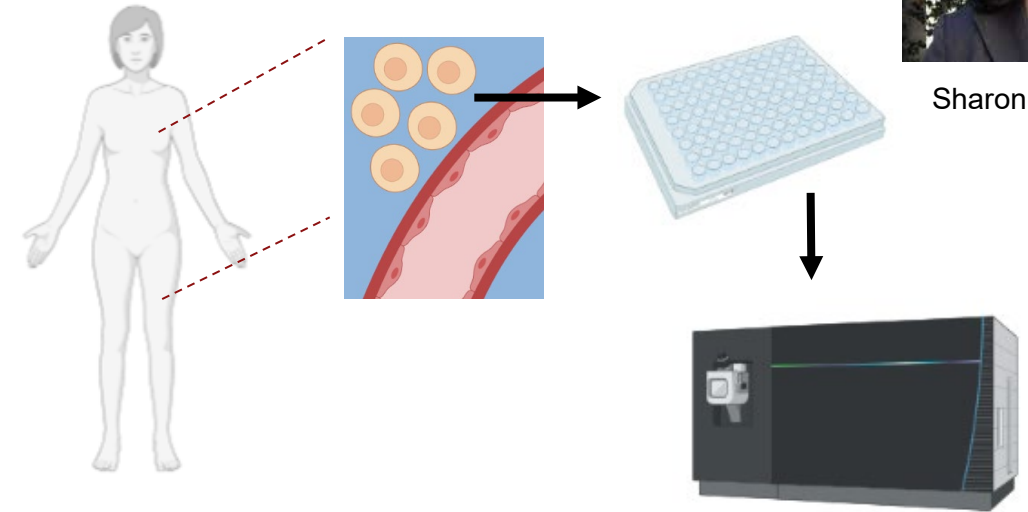
Interstitial Fluid for Cancer Detection

PIs: Sharon Pitteri, Joseph DeSimone

Design and Optimization of an
ISF Collection Device



Protein Analysis of ISF Collected
from a Site Proximal to the Tumor



Sharon Pitteri, PhD



Joe DeSimone, PhD

Wearable Sensors for Interstitial Molecules



Tom Soh, PhD



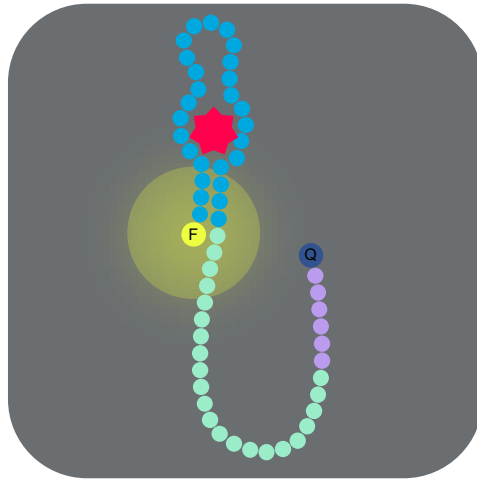
Joe DeSimone, PhD



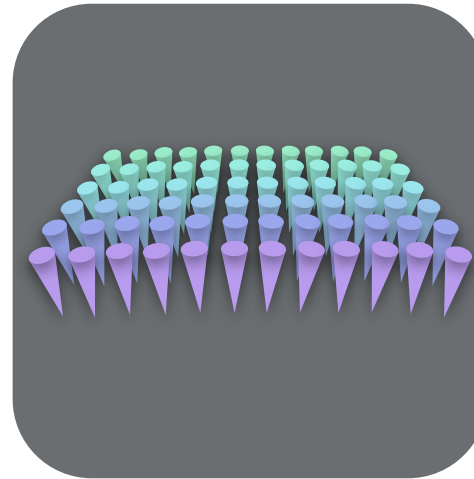
MEASURE ANY MOLECULE

SIMULTANEOUS DETECTION

MODULAR AND LOW-COST



**Molecular Recognition
Platform Using Aptamers**



**Direct Write Microneedle
Technology**

Integrated Diagnostics Outside Cancer

Linking Neuroimaging and Biomechanics with Traumatic Brain Injury Pathologies in Repetitive Head Impacts



Erin Gibson, MD

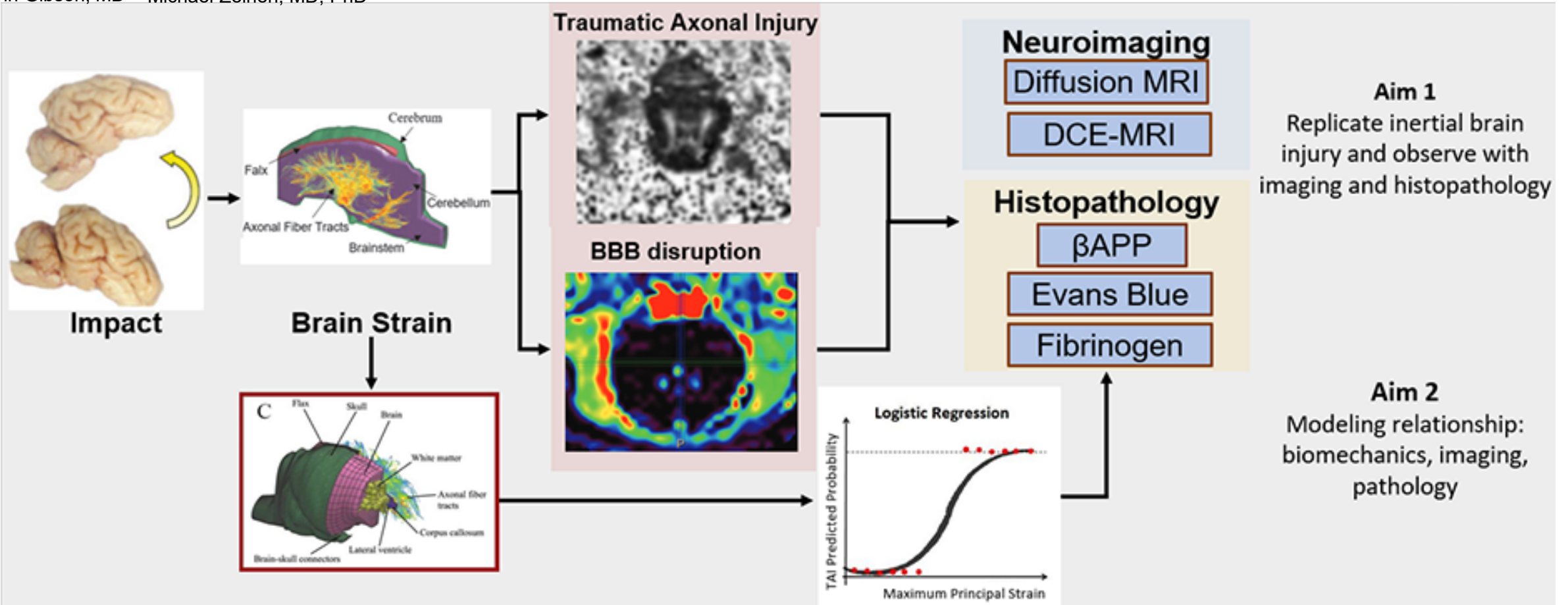


Michael Zeineh, MD, PhD

PIs: Erin Gibson, Michael Zeineh, David Camarillo

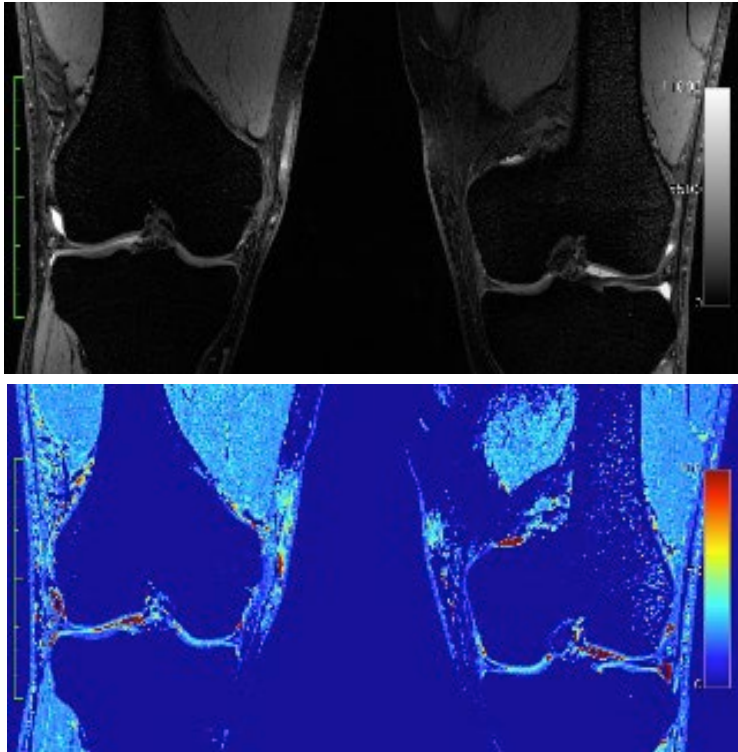


David Camarillo, PhD



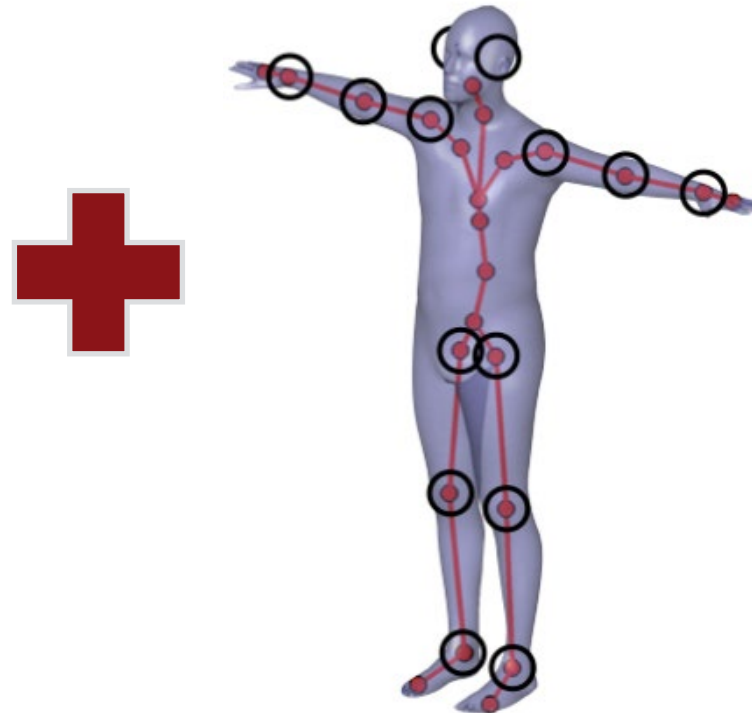
Monitoring the Knee: Imaging and Biomechanics

5-Minute Quantitative MRI



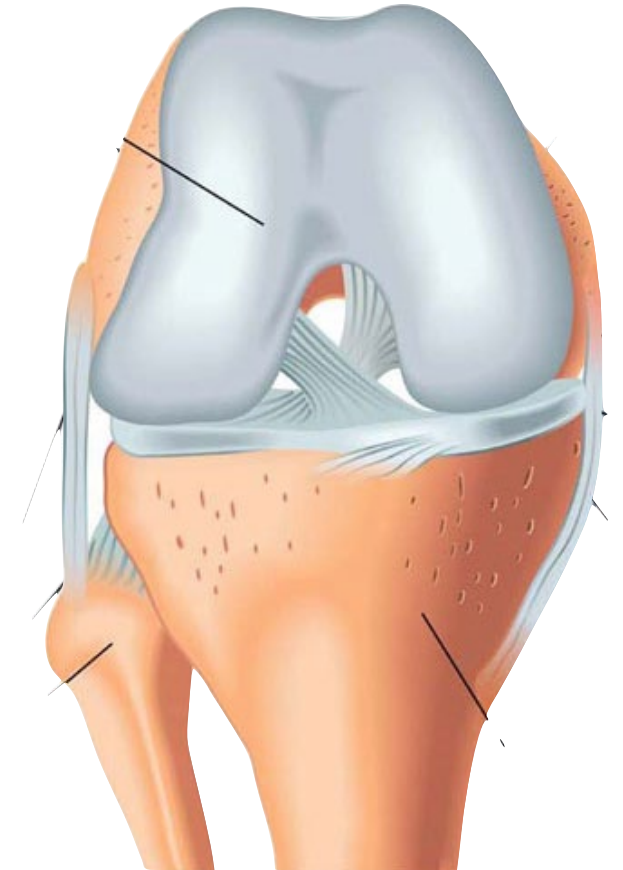
- Fast, Low-cost
- Large scale

Video and IMU Analysis of Gait



- Early changes
- Different pathways

Healthy-to-Arthritic Knee



Adapted from Nestor Rodriguez

Take home points

- Cancer is current detected late in the disease process when it is most difficult to treat
- Early detection through imaging, in-vitro diagnostics, or other combined methods offers the promise of early detection
- Wearable and in-home technology also presents opportunities for detection
- Testing of integrated diagnostic methods requires awareness of multiple approaches and interdisciplinary collaboration

Thank You

Precision Health and Integrated Diagnostics Center (PHIND)

Vision

Predict. Prevent. Diagnose. Cure.
Precisely.

PHIND Website:

<http://med.stanford.edu/phind.html>

Gambhir et al. Science Translational Medicine

Science
Translational
Medicine

28 FEBRUARY 2018

