“Data Science and the Clinical Quantified Self”

Contribution

Precision Medicine in Gastroenterology and Hepatology

13th Annual Research Symposium of the UCSD Division of Gastroenterology

University of California San Diego

June 7, 2019

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technology

Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

Jacobs School of Engineering, UCSD

http://lsmarr.calit2.net

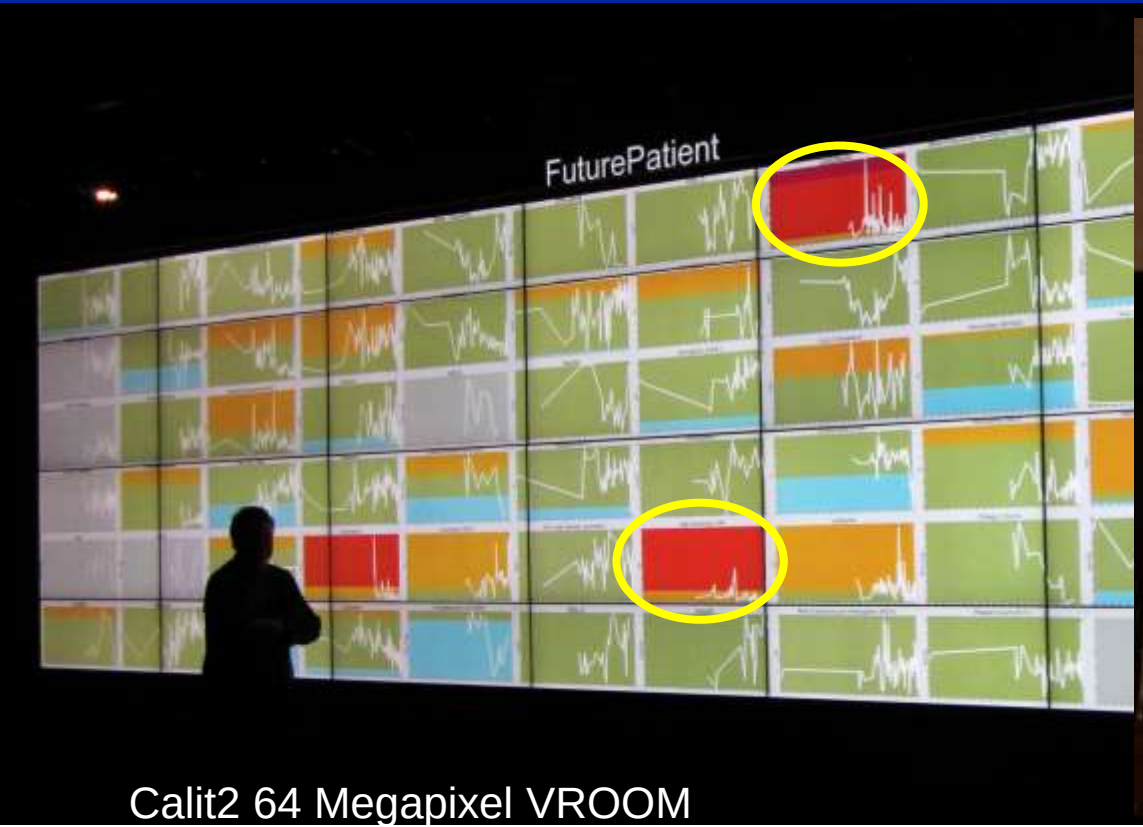
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Larry Smarr
Disclosure Slide

- **Private Sector SAB Member**
  - MD Revolution
  - Mint Health
  - AV Lab, Inc.
  - Torrent Ventures
  - Hu-manity.co
- **Shares in Public Traded Stock:**
  - Tocagen
- **Consultant**
  - Fellow, Price Waterhouse Coopers
- **Nonprofit Boards**
  - Corporation for Education Network Initiatives in California (CENIC)

I Have Been Exploring for a Decade the Application of Data Science to Combining Biomarker Time Series with Digital Imaging in a Clinical Setting



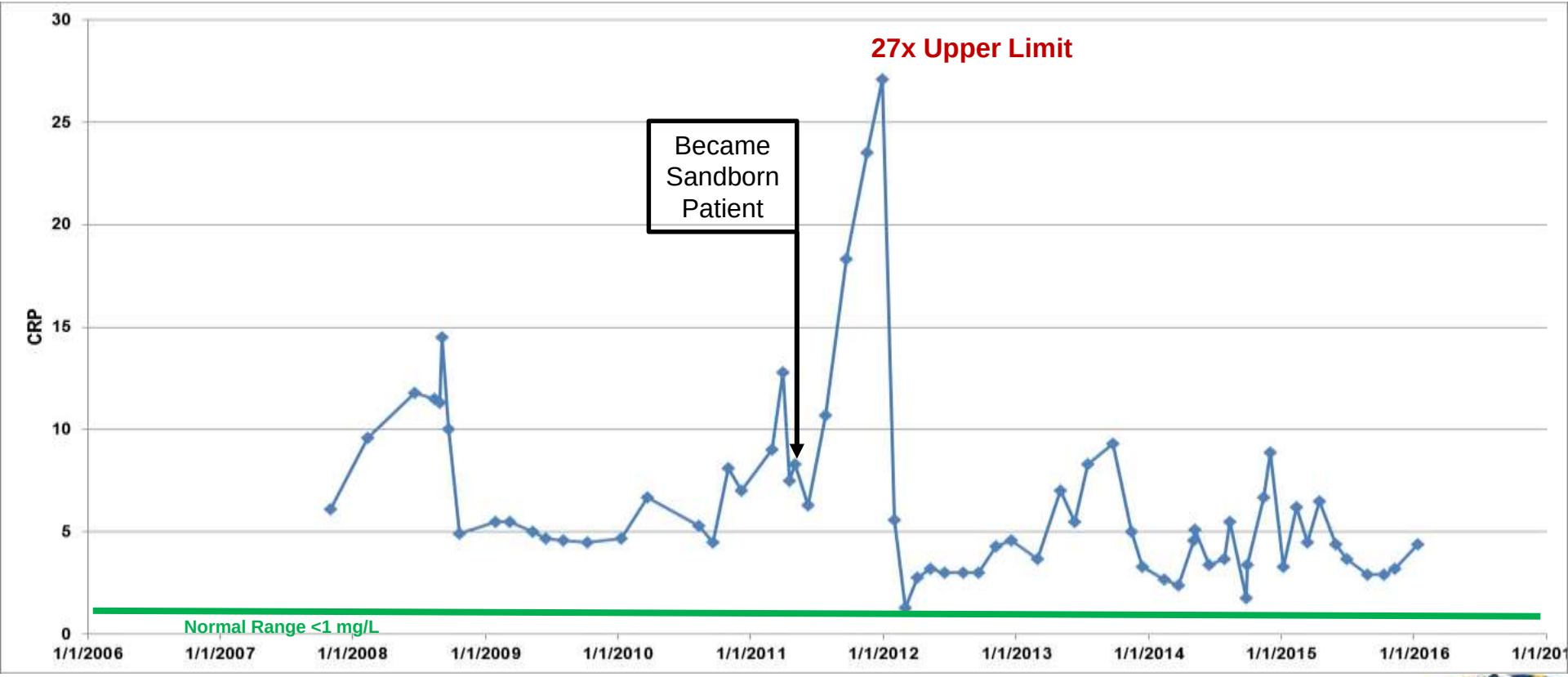
Calit2 64 Megapixel VROOM



My Quarterly Blood Draw

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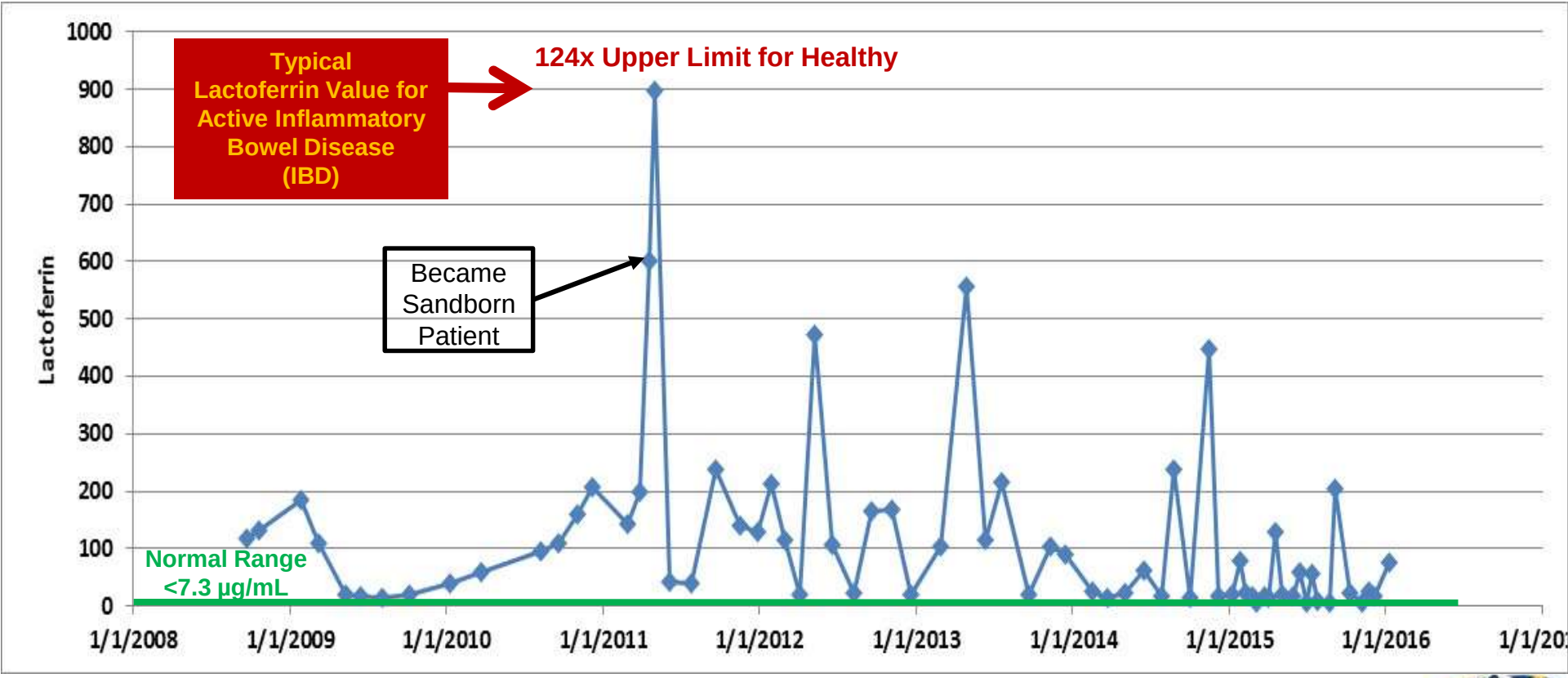
Only One of My Blood Measurements Was Far Out of Range--Indicating Chronic Inflammation



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Complex Reactive Protein (CRP) is a Blood Biomarker for Detecting Presence of Inflammation

Longitudinal Stool Tests Revealed Large Excursions in My Immune System: Inflammatory Bowel Disease (IBD)

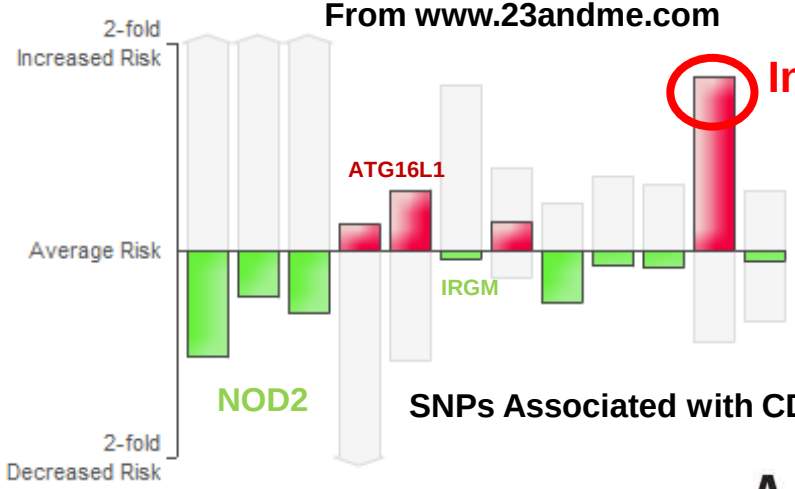


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Lactoferrin is a Protein Shed from Neutrophils - An Antibacterial that Sequesters Iron

I Found I Had One of the Earliest Known Human Genetic SNPs Associated with Crohn's Disease

From www.23andme.com



SNPs Associated with CD

Polymorphism in Interleukin-23 Receptor Gene — 80% Higher Risk of Pro-inflammatory Immune Response rs1004819

A Genome-Wide Association Study Identifies *IL23R* as an Inflammatory Bowel Disease Gene

Richard H. Düerr, *et al.*
Science **314**, 1461 (2006)

News and Views

Nature Medicine **13**, 26 - 28 (2007)
doi:10.1038/nm0107-26

IL-23: a master regulator in Crohn disease

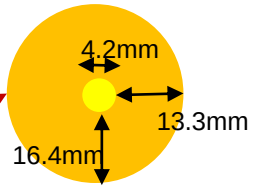
Markus F Neurath[1]

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2016 MRI Slice Through Sigmoid Colon Reveals Thick Walls and Very Narrow Lumen



Source: Smarr MRI Oct. 25, 2016
Reading by Cynthia Santillan,
MD Radiologist, UCSD

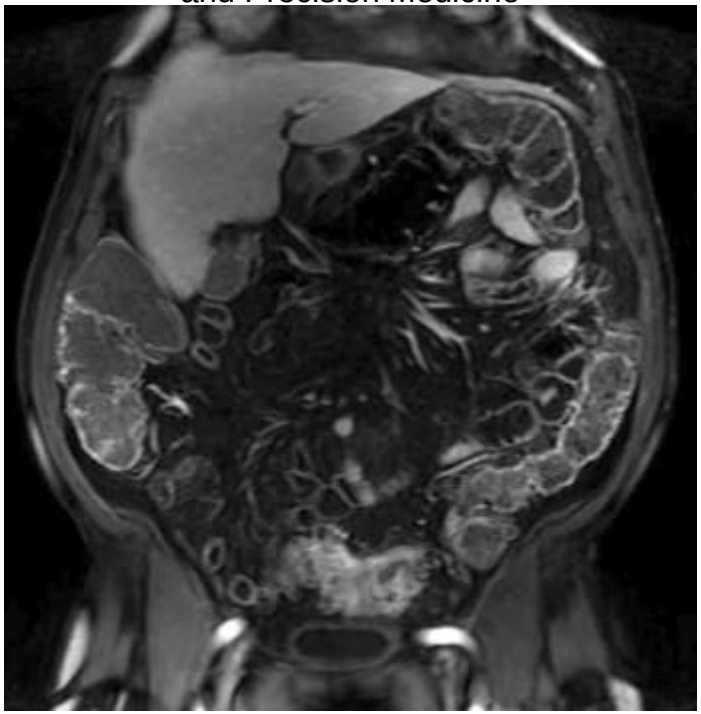


Normal opening (bright yellow) is 40mm, so mine is 1/10 the diameter it should be.

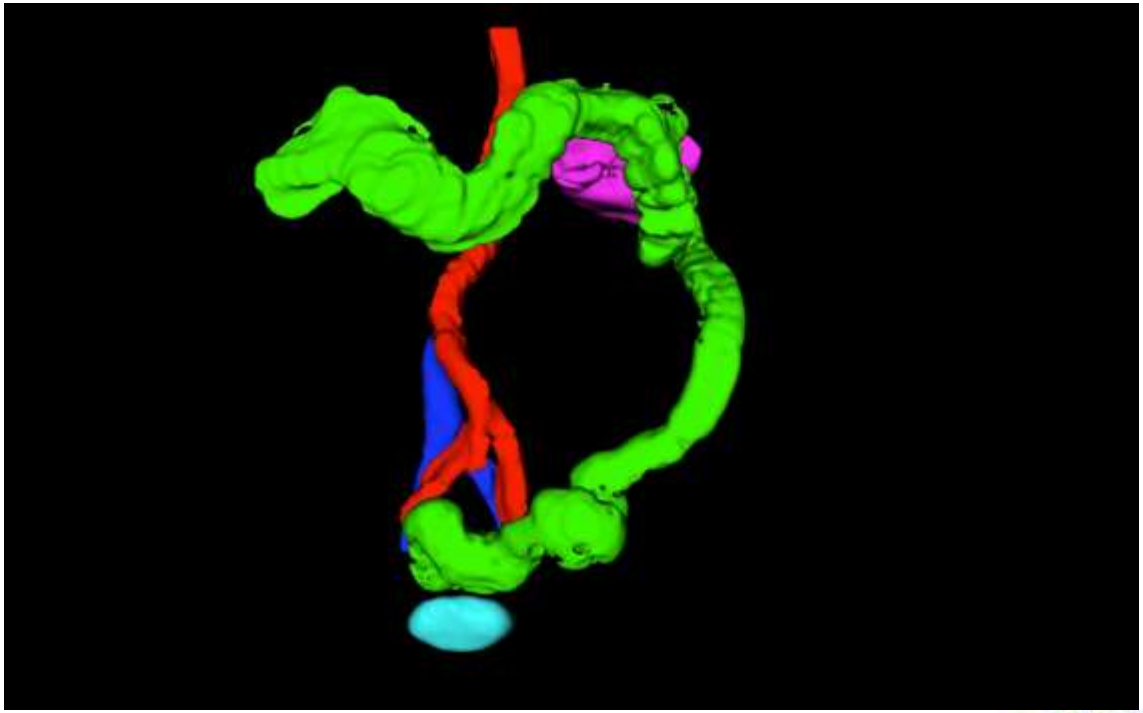
Normal wall thickness (dark yellow) is 3mm, so wall thickness is 4-5 times as thick as it should be.

From Quantified Self to Quantified Surgery: Converting MRI Slices to 3D Organ Segmentation for Surgical Pre-Planning

High Resolution 3 Tesla MRI in
UCSD's Center for Translational Imaging
and Precision Medicine



Calit2's Dr. Jurgen Schulze Developed Software to Convert
150 2D MRI Slices to 3D Organs



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MRI Radiology Team to Enable 3D:
Dr. Anders Dale, Dr. Stephen Dorros, Dr. Christine Chung, and Dr. Cynthia Santillan

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Pre-Surgical Planning in QI Virtual Reality:
Using Virtual Reality As Input for Positioning The Two Resection Cuts



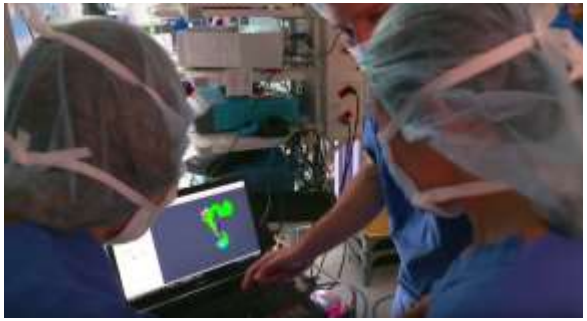


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Colon Visualization by Jurgen Schulze, Calit2;
Photo Credit Tom DeFanti, Calit2

Using Calit2 Organ Segmentation
During My Sigmoid Colon Resection Surgery on November 29, 2016

Dr. Schulze Rotating 3D Organs To Match Up
With da Vinci Arms and Internal Camera





Patient Smarr
With da Vinci Robot
Arms Inside Him





Dr. Ramamoorthy Operating
Da Vinci Xi Robot During Surgery

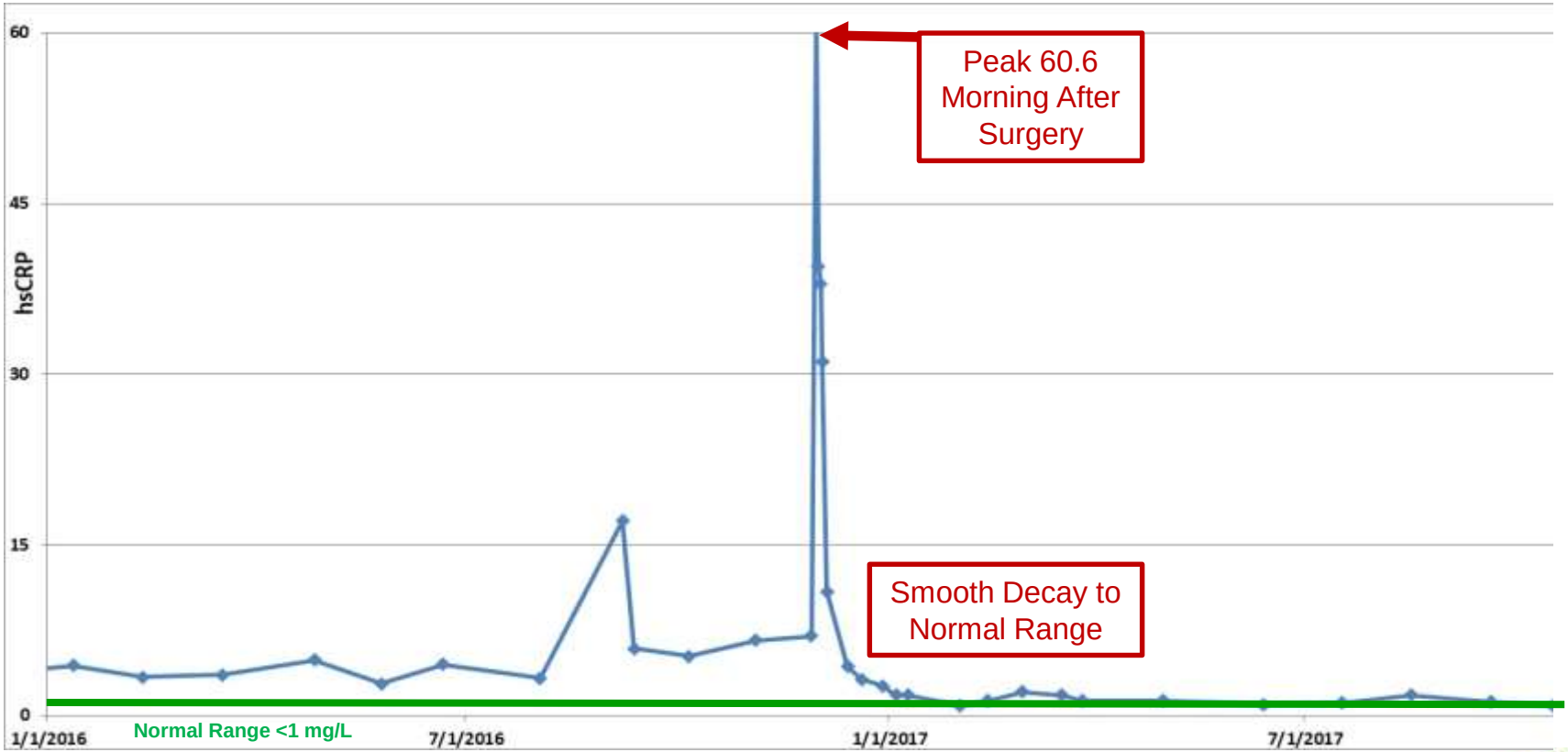


OR Team Using Large Screens
To Watch Dr. Schulze's da Vinci Images

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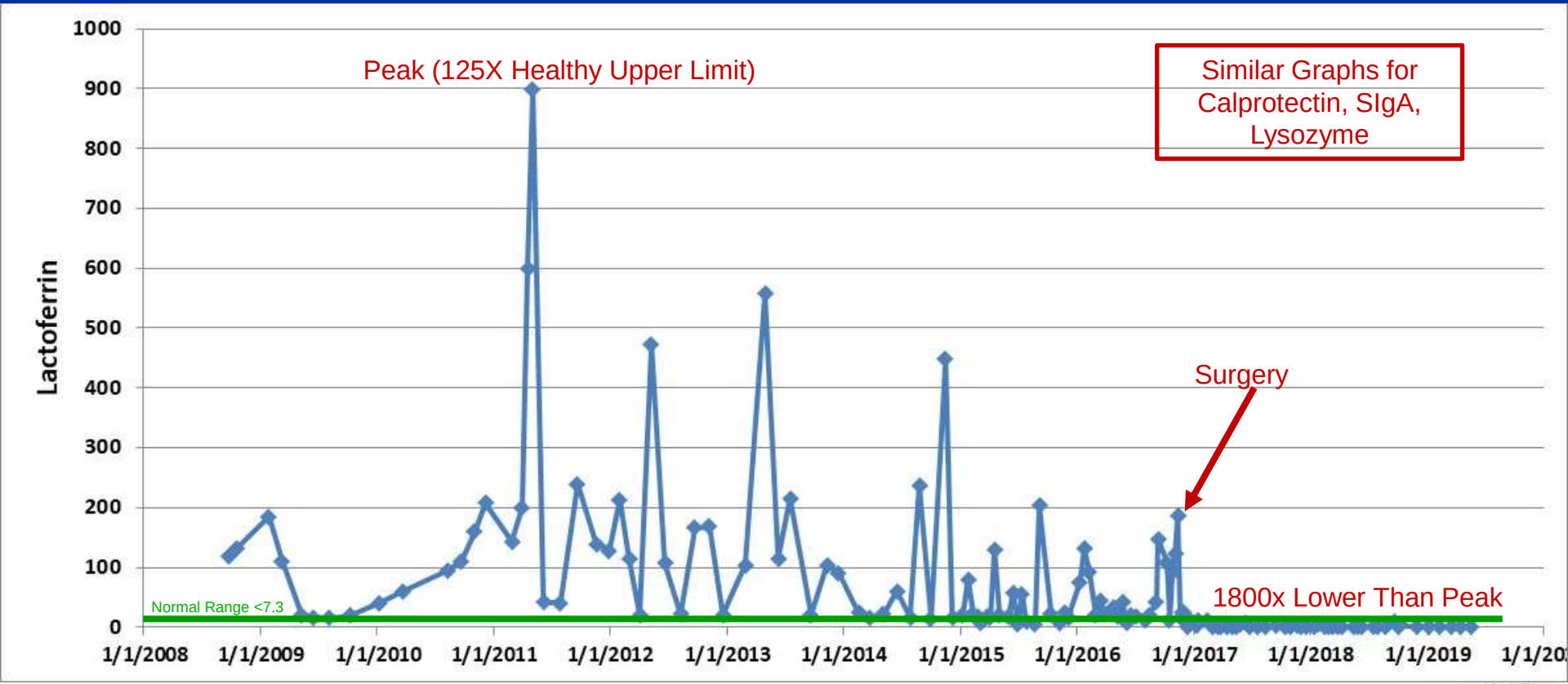
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Using hsCRP Daily Time Series Following Surgery to Detect Post-Surgical Complications



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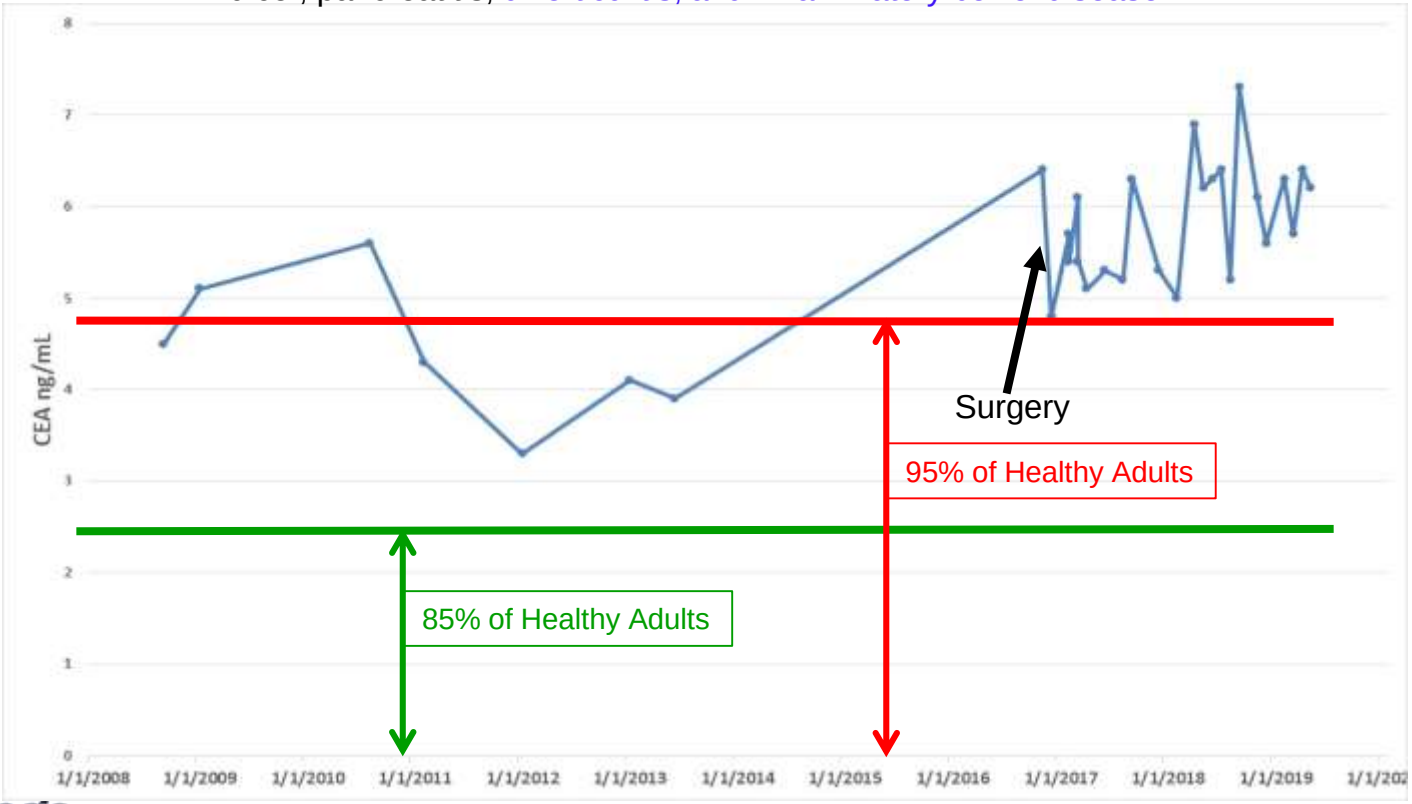
Colonic Inflammation:
Abrupt Shift to Healthy Following Surgical Resection



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Outlier: Carcinoembryonic Antigen (CEA) Screening Test for Colon Cancer Continues to Rise, Even After Sigmoid Colon Resection Surgery

"Elevated levels are also frequently seen in other gastrointestinal diseases including peptic ulcer, pancreatitis, diverticulitis, and inflammatory bowel disease."



Question: Why Didn't CEA Drop Into Normal Range Post-Surgery?

Ranges from Exeter Clinical Labs www.exeterlaboratory.com/test/carcinoembryonic-antigen-cea/

From N=1 Experiment to Clinical Tool: 3D Medical Imaging Pilot to Improve Surgical Outcomes for Patients with Crohn's Disease (CD)

- **$1.2 M Grant From the Helmsley Charitable Trust**

THE LEONA M. AND HARRY B. HELMSLEY CHARITABLE TRUST

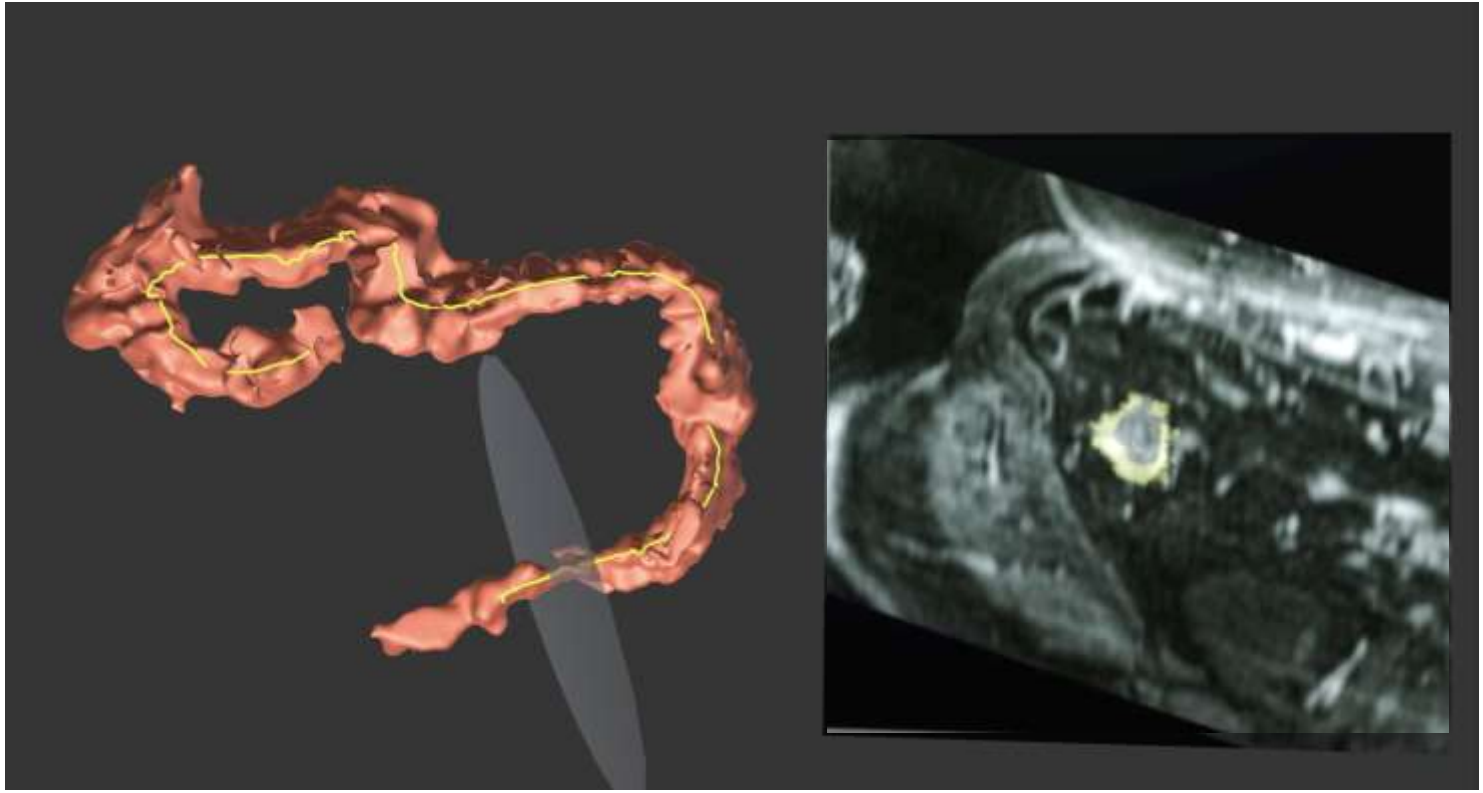
- **UC San Diego Collaborative Team:**
  - PI Larry Smarr, PhD, Director Calit2
  - Jurgen Schulze, PhD, Virtual Reality Research Scientist, Calit2
  - Ramesh Rao, PhD, Director, Calit2's Qualcomm Institute
  - Sonia Ramamoorthy, MD, Chief of Colorectal Surgery
  - Bill Sandborn, MD, Chief of Gastroenterology
  - Cynthia Santillan, MD, Chief of Body Imaging
  - Anders Dale, PhD, Co-Director of the Multimodal Imaging Laboratory

- **Pilot Will:**
  - Integrate 3D Medical Imaging Within Clinical Practice
  - Evaluate 10 CD Patients Having Small Bowel or Colonic Strictures Using 3D Imaging
  - Assess Software Usability in the UCSD IBD Clinic & Operating Room for Both Physician & Patient

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Helmsley Grant Enables Use of Machine Learning on MRI Slices To Locate 3D Colon, Trace It's Centerline, and Get Colon Wall Cross-Section



Source: Jurgen Schultz, Russell Xie, Zifeng Li, Larry Smarr

Helmsley Grant Enabled
Undergraduate to Bring 3D MRI into Head Mounted Displays

UCSD Undergrad Trevor Hedstrom



Berkeley Grad Student Azure Grant



Larry's Spinal MRI Data

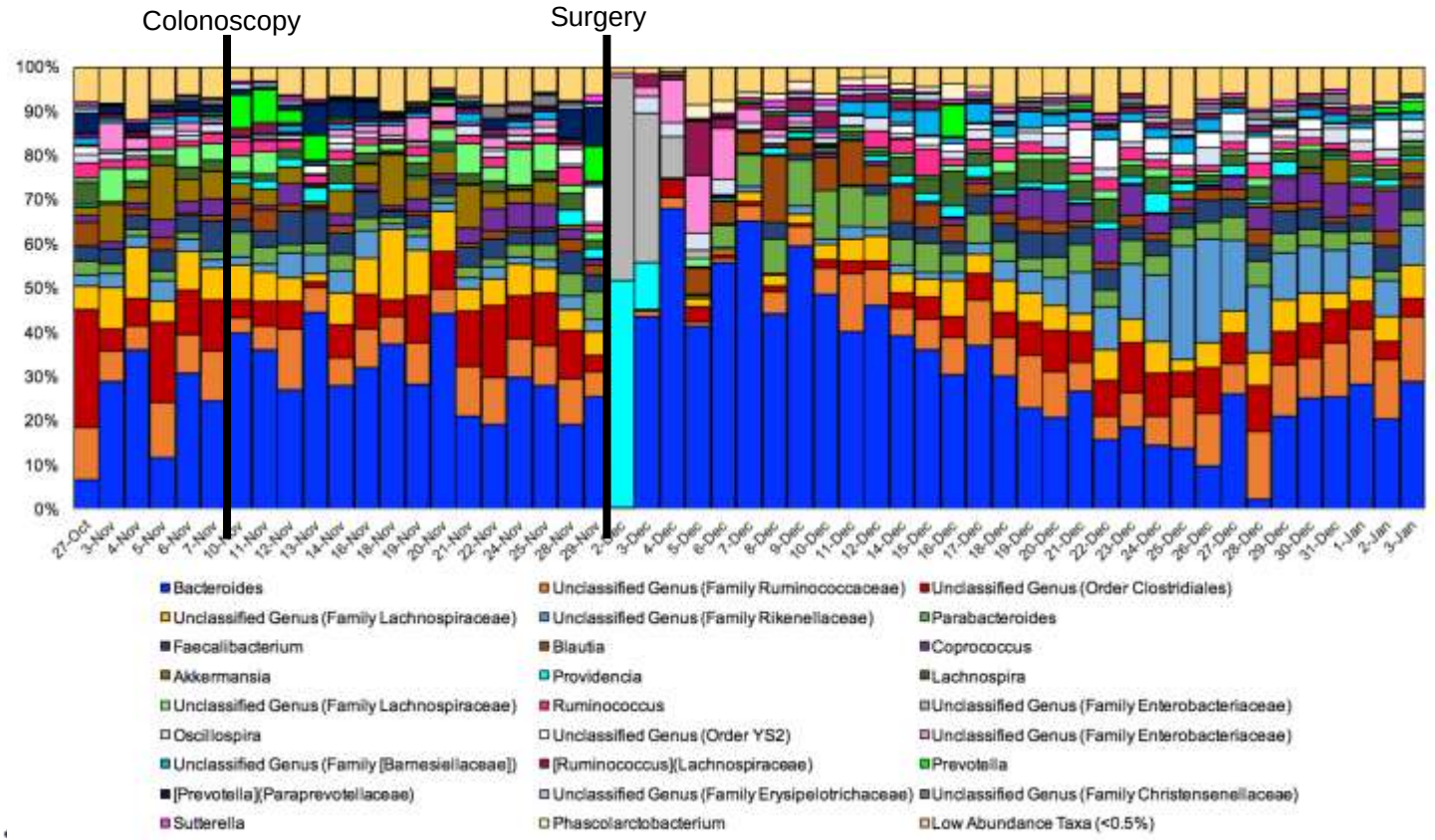
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DICOM Volume Renderer

Look Inside Your Body With Your Phone



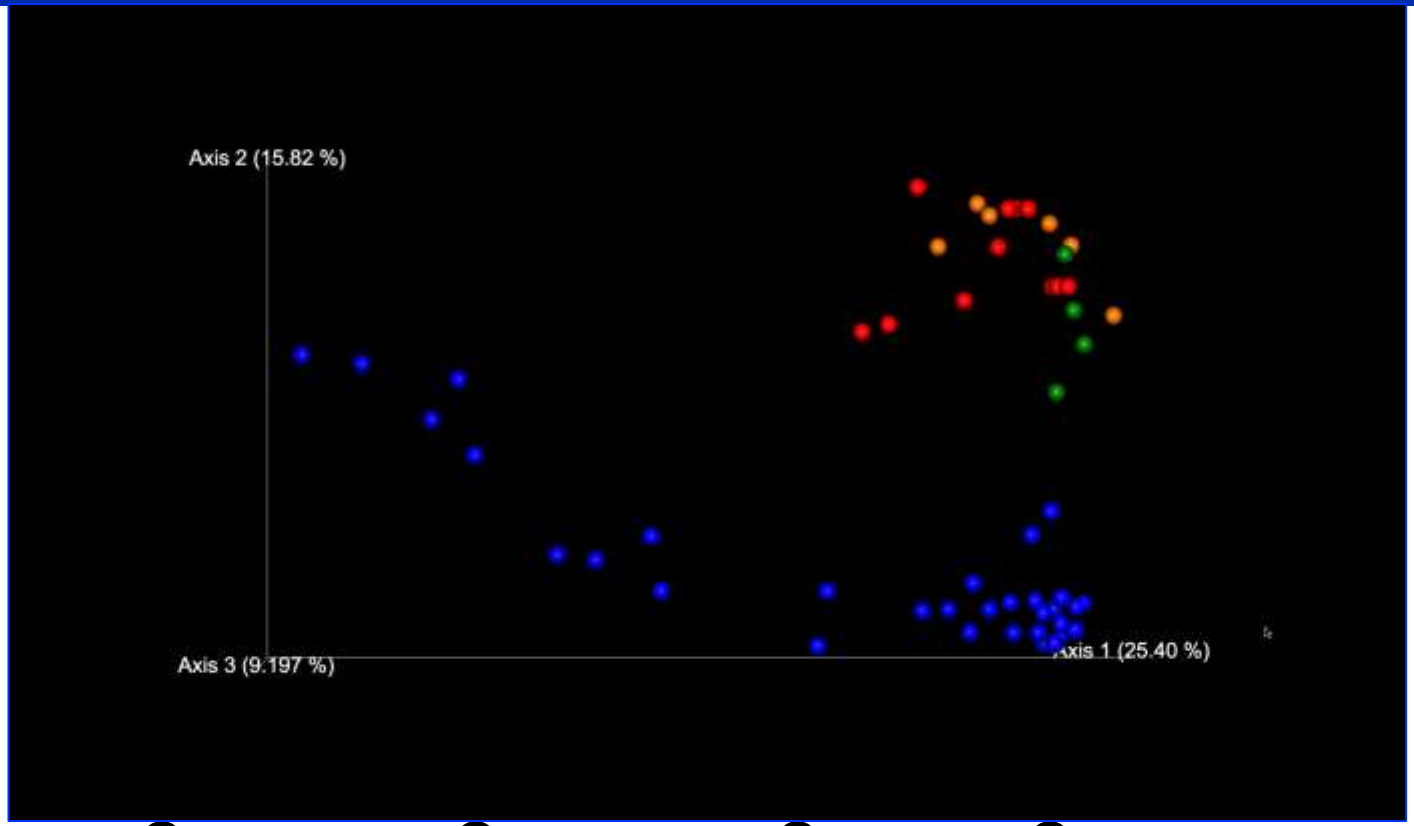
Gut Microbiome Genus-Level Profiles
Daily Samples Before and After Abdominal Surgery



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Source: Embriette Hyde, UCSD

Major Shift in Gut Microbiome Ecology
Following Abdominal Surgery With Return to New Equilibrium State



Inflamed Disease State

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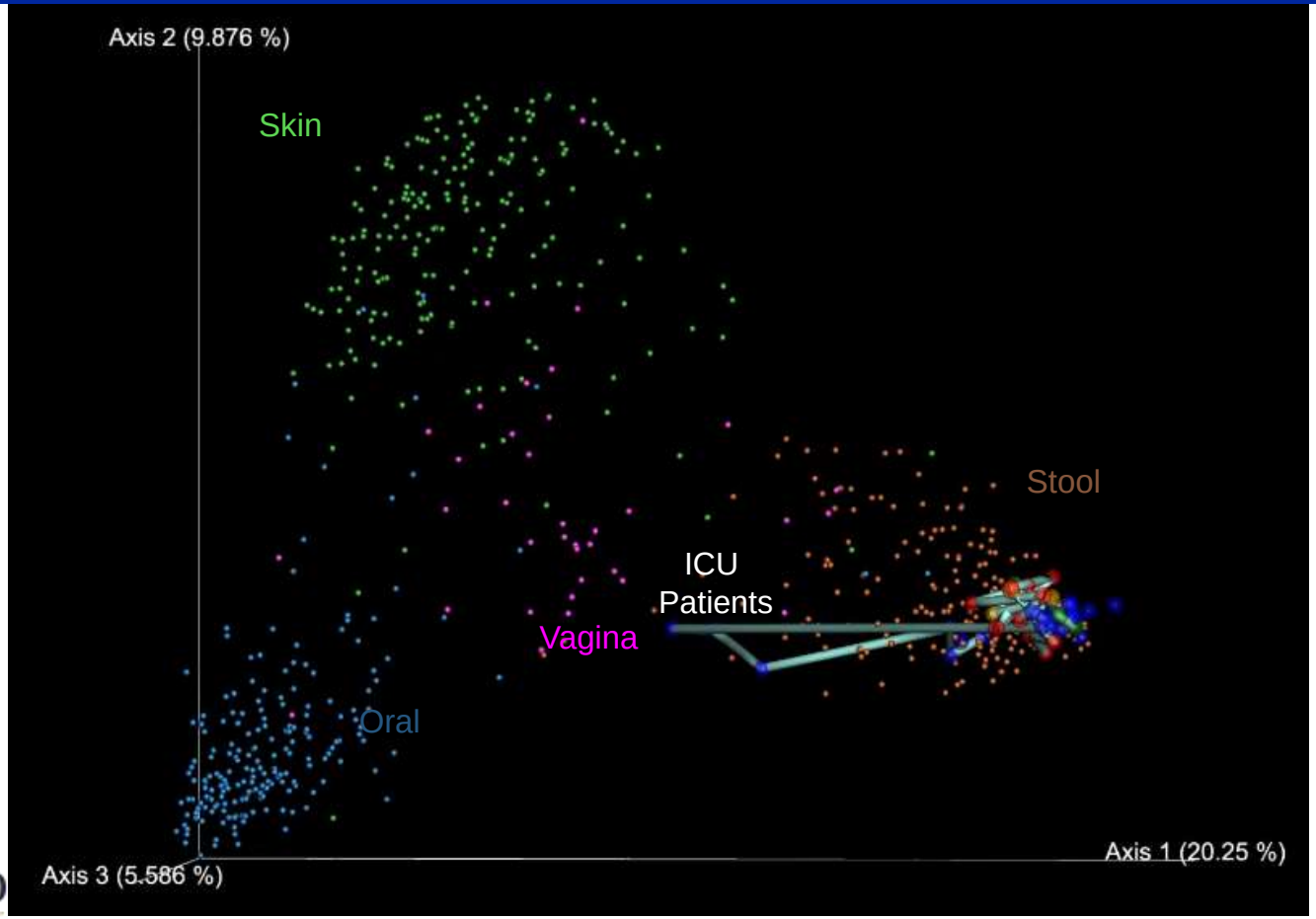
Healthy Post-Surgery State

Pre-colonoscopy Post-colonoscopy Pre-surgery Post-surgery

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Source: Embriette Hyde, Yoshiki Vázquez Baeza, Knight Lab, UCSD

My Gut Microbiome Changed More After Surgery Than the Difference Between 10,000 Individuals!

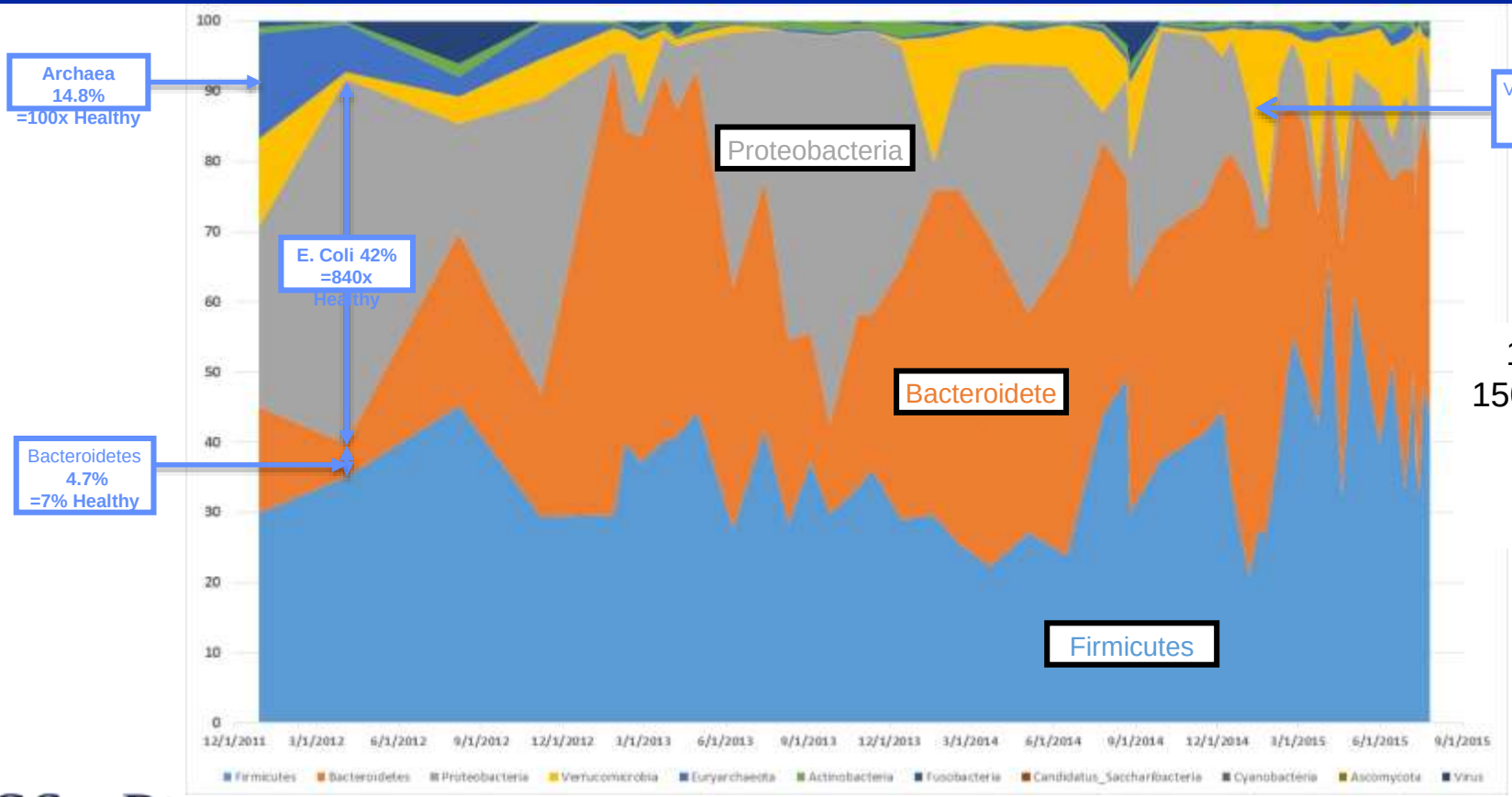


Data From American Gut Project, UCSD. Rob Knight, Director

Published 2018 mSystems

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Metagenomically Sequencing Long Time Series Stool Samples to Reveal Patient Gut Microbiome Ecology Dynamics During Disease



1st 50 of 150 Samples at Phylum Level

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Sequencing Rob Knight Lab; Analysis Xin Fang, UCSD