"Quantifying and Visualizing the State of Your Body"

Remote Talk

To: TopCoder Innovation Summit, Orlando Fl

From: Calit2@UCSD

October 2, 2012

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technology

Harry E. Gruber Professor,

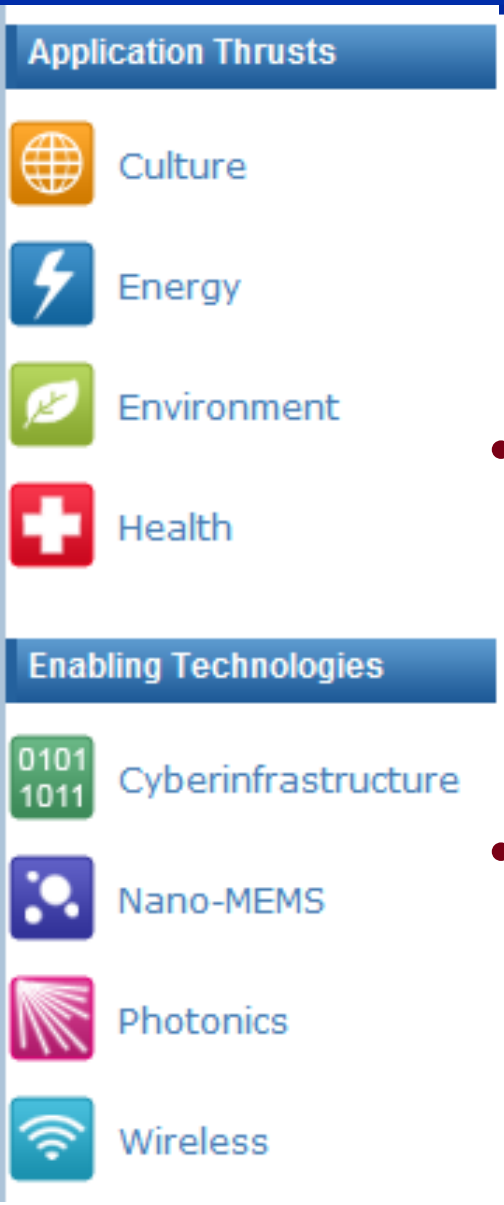
Dept. of Computer Science and Engineering

Jacobs School of Engineering, UCSD

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The Ten Year
Calit2 Path Forward



- **Ten-Year Vision of Digital Transformation**
  - **Affiliated Academic Units**
  - **Calit2 News and Videos**
- **This Talk Focuses in on:**
  - **The Digital Transformation of Health**

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www.calit2.net/research/index.php

it²

Where I Believe We are Headed: Predictive, Personalized, Preventive, & Participatory Medicine

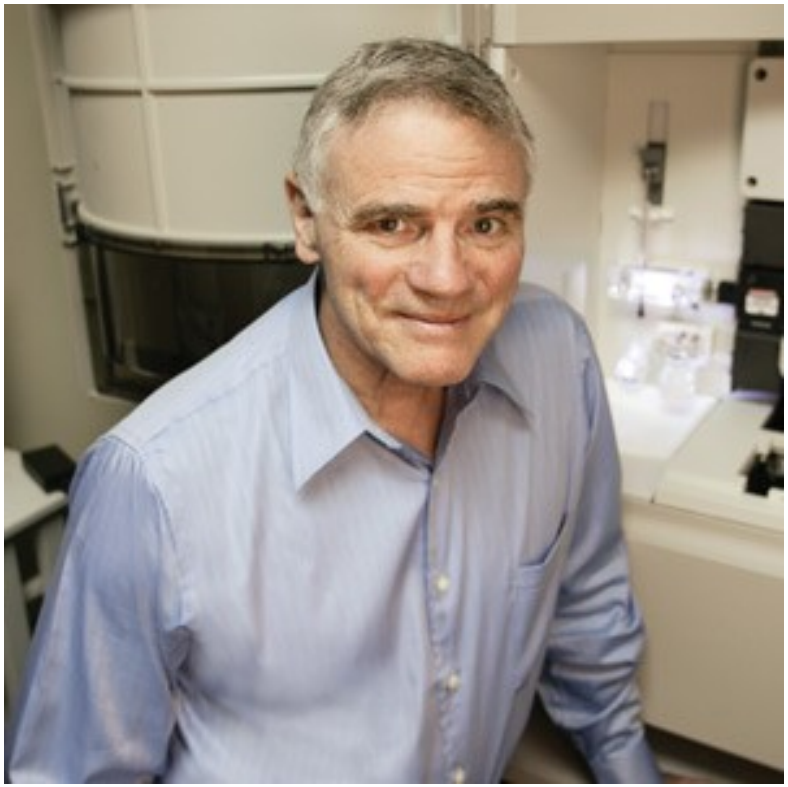
Newsweek

I am Leroy Hood's Lab Rat!

A Doctor's Vision of the Future of Medicine

Leroy Hood
NEWSWEEK

From the magazine issue dated Jul 13, 2009



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www.newsweek.com/2009/06/26/a-doctor-s-vision-of-the-future-of-medicine.html

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Invited Paper for Focus Issue of Biotechnology Journal, Edited by Profs. Leroy Hood and Charles Auffray.

Perspective

Quantifying your body: A how-to guide from a systems biology perspective

Larry Smarr

University of California, San Diego, CA, USA

Download Pdfs from my Portal:

http://lsmarr.calit2.net/repository/Biotech_J._LS_published_article.pdf

http://lsmarr.calit2.net/repository/Biotech_J._Supporting_Info_published.pdf



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Biotechnol. J. 2012, 7, 980–991

Calit2 Has Been Had a Vision of "the Digital Transformation of Health" for a Decade

www.bodymedia.com



- **Next Step—Putting You On-Line!**
  - Wireless Internet Transmission
  - Key Metabolic and Physical Variables
  - Model -- Dozens of Processors and 60 Sensors / Actuators Inside of our Cars
- **Post-Genomic Individualized Medicine**
  - Combine
    - Genetic Code
    - Body Data Flow
  - Use Powerful AI Data Mining Techniques

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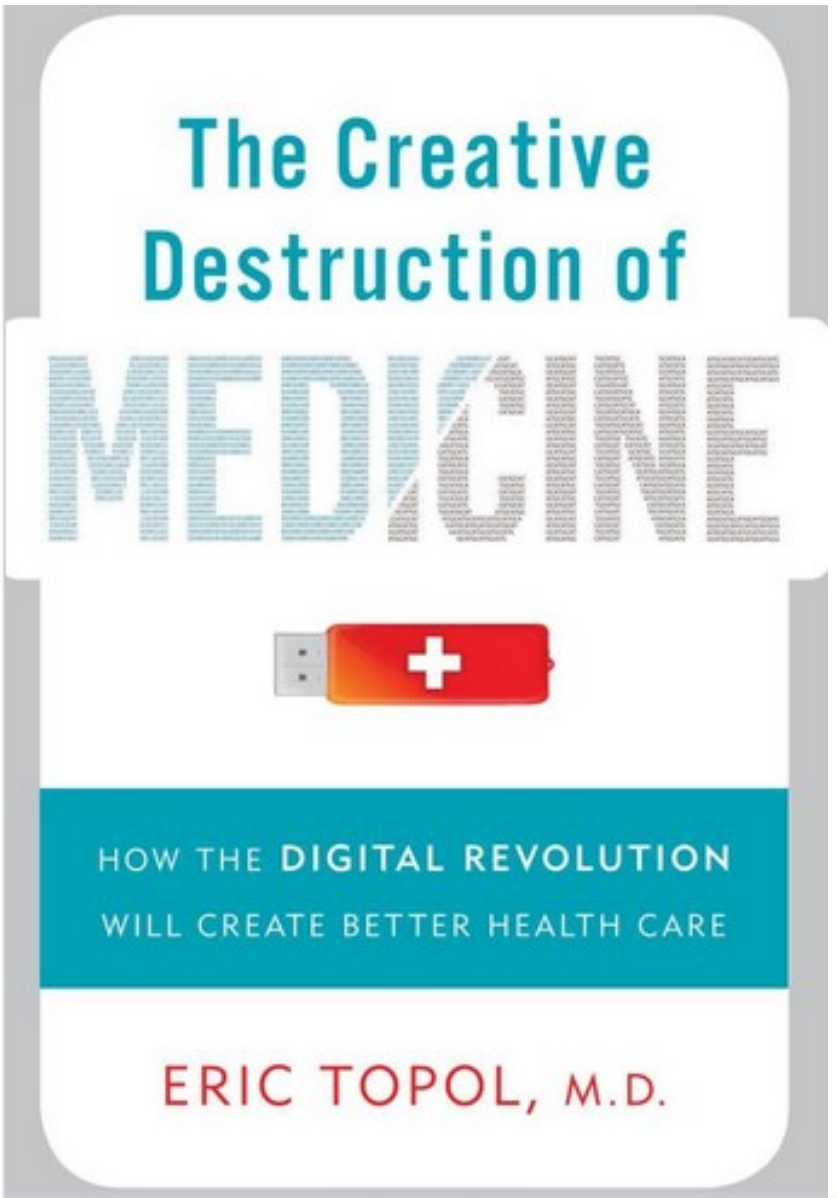
The Content of This Slide from 2001 Larry Smarr Calit2 Talk on Digitally Enabled Genomic Medicine

it²

The Calit2 Vision of Digitally Enabled Genomic Medicine is an Emerging Reality



July/August 2011

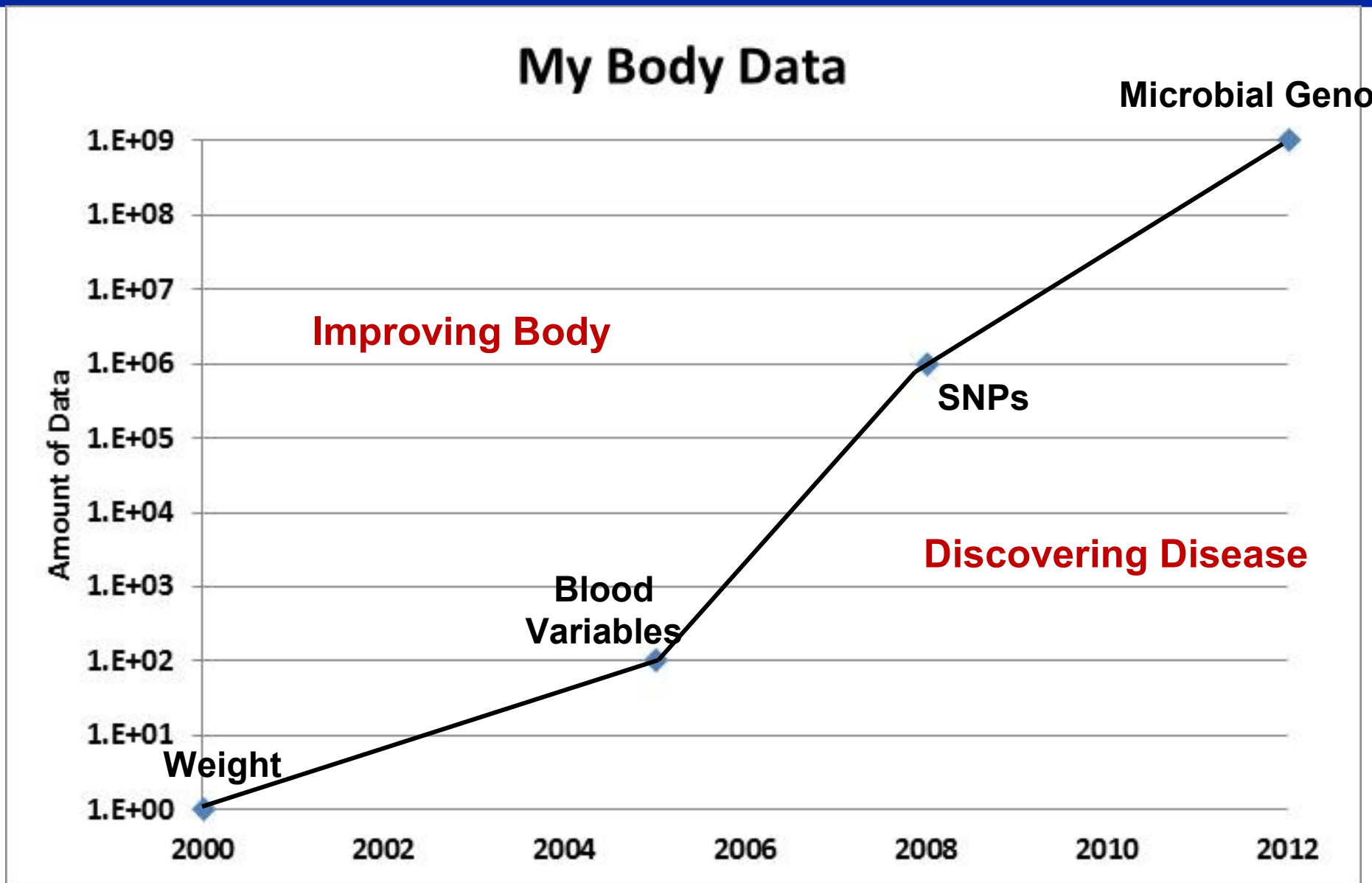


February 2012

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From One to a Billion Data Points Defining Me: The Exponential Rise in Body Data in Just One Decade!



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By Measuring the State of My Body and "Tuning" It Using Nutrition and Exercise, I Became Healthier

Age 51





Age 61

I Arrived in La Jolla in 2000 After 20 Years in the Midwest and Discovered I was Pre-Diabetic

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From Measuring Macro-Variables to Measuring Your Internal Variables

VO2 Stress Test With ECG



Zeo Sleep Monitor



Fitbit Caloric Burn



www.technologyreview.com/biomedicine/39636

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I Track 100 Variables in Blood Tests Done Quarterly to Annually

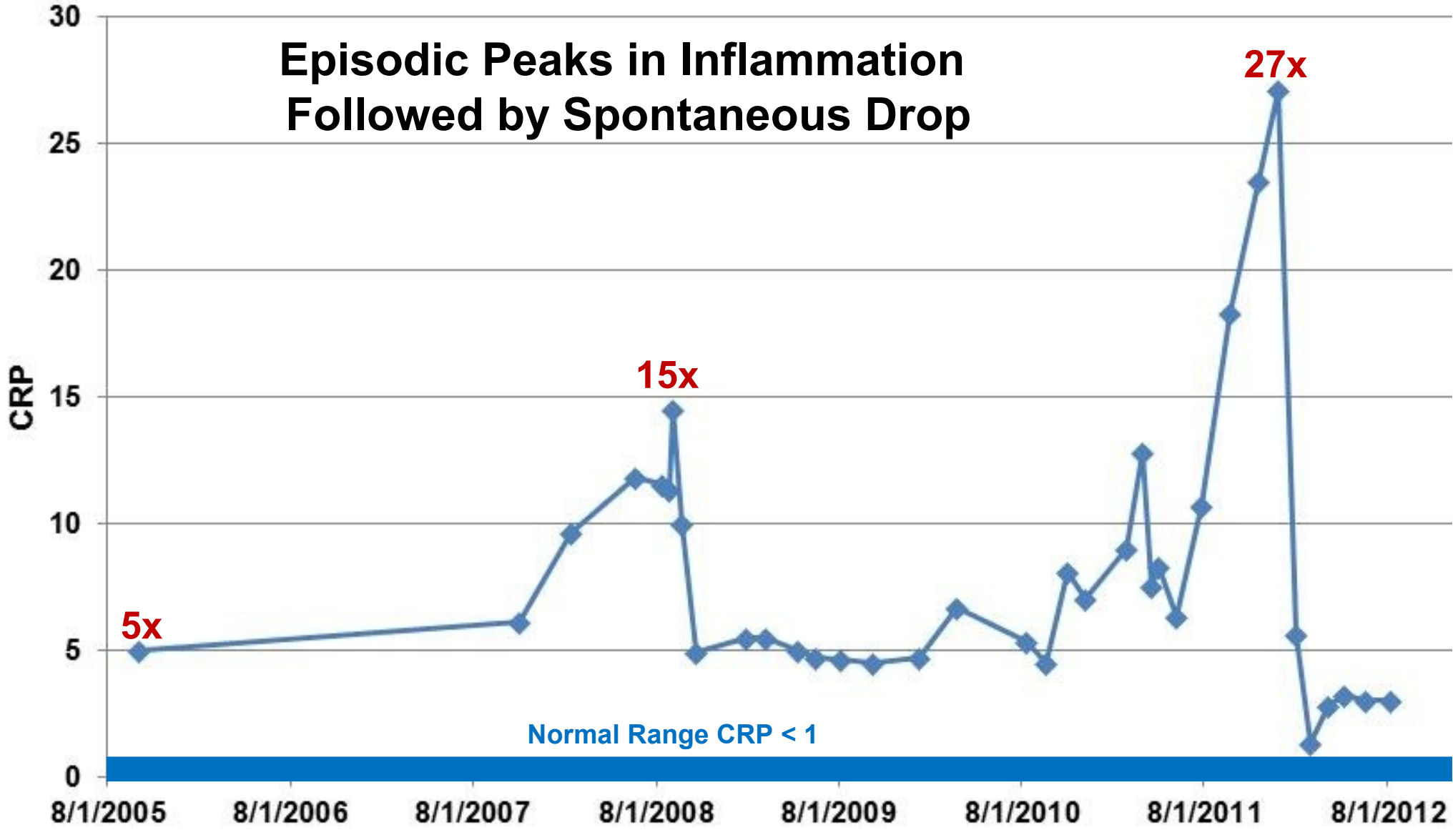
- **Electrolytes**
  - Sodium, Potassium, Calcium, Magnesium, Phosphorus, Boron, Chlorine, CO_2
- **Micronutrients**
  - Arsenic, Chromium, Cobalt, Copper, Iron, Manganese, Molybdenum, Selenium, Zinc
- **Blood Sugar Cycle**
  - Glucose, Insulin, A1C Hemoglobin
- **Cardio Risk**
  - Complex Reactive Protein
  - Homocysteine
- **Kidneys**
  - Bun, Creatinine, Uric Acid
- **Protein**
  - Total Protein, Albumin, Globulin
- **Liver**
  - GGTP, SGOT, SGPT, LDH, Total Direct Bilirubin, Alkaline Phosphatase
- **Thyroid**
  - T3 Uptake, T4, Free Thyroxine Index, FT4, 2nd Gen TSH
- **Blood Cells**
  - Complete Blood Cell Count
  - Red Blood Cell Subtypes
  - White Blood Cell Subtypes
- **Cancer Screen**
  - CEA, Total PSA, % Free PSA
  - CA-19-9
- **Vitamins & Antioxidant Screen**
  - Vit D, E; Selenium, ALA, coQ10, Glutathione, Total Antioxidant Fn.

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Only One of These Was Far Out of Normal Range

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In Spite of My Anti-Inflammatory Diet
My Blood Measurements Revealed Chronic Inflammation

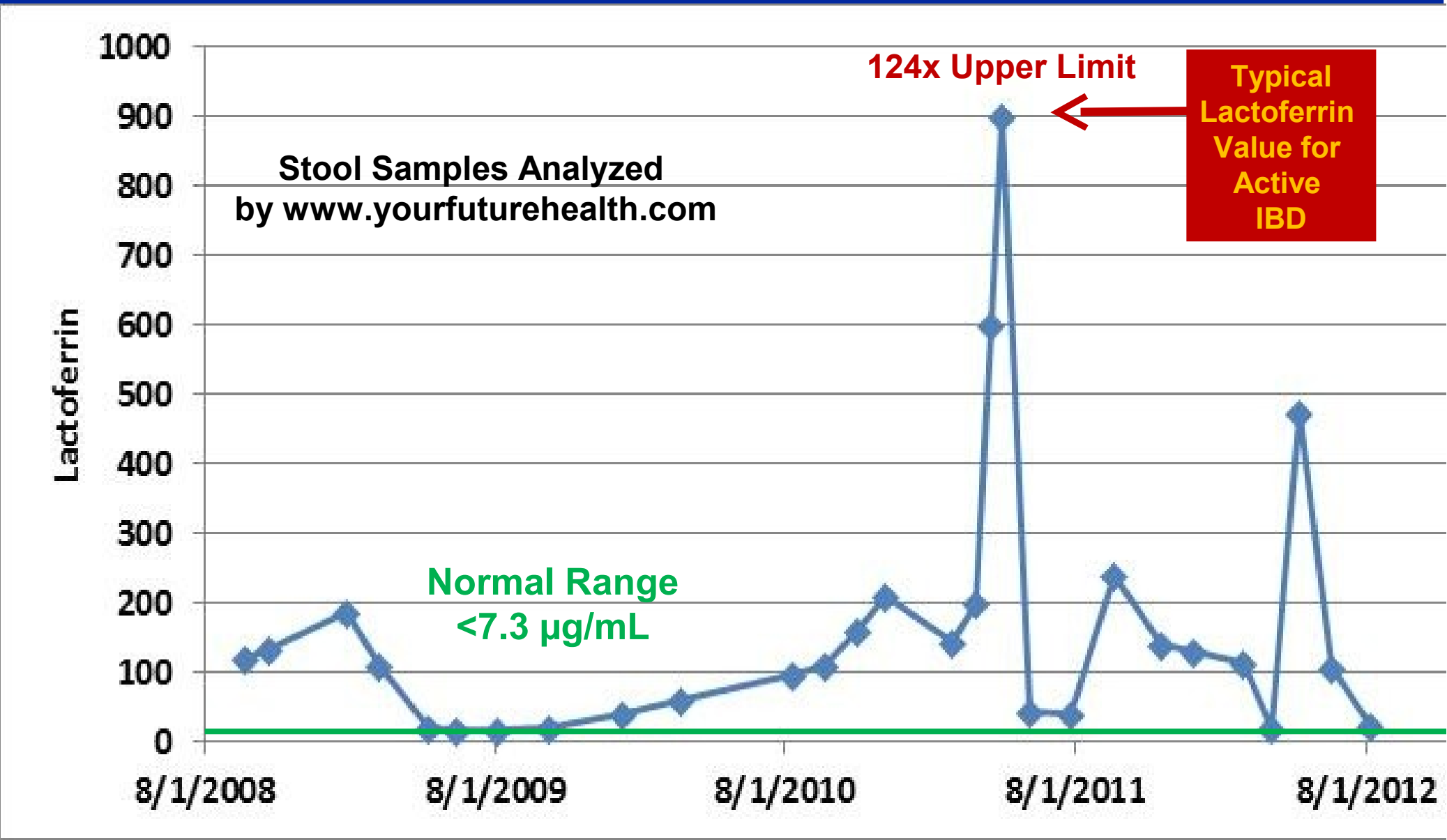


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Complex Reactive Protein (CRP) is a Blood Biomarker for Detecting Presence of Inflammation

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By Quantifying Stool Measurements Over Time I Discovered Source of Inflammation Was Likely in Colon

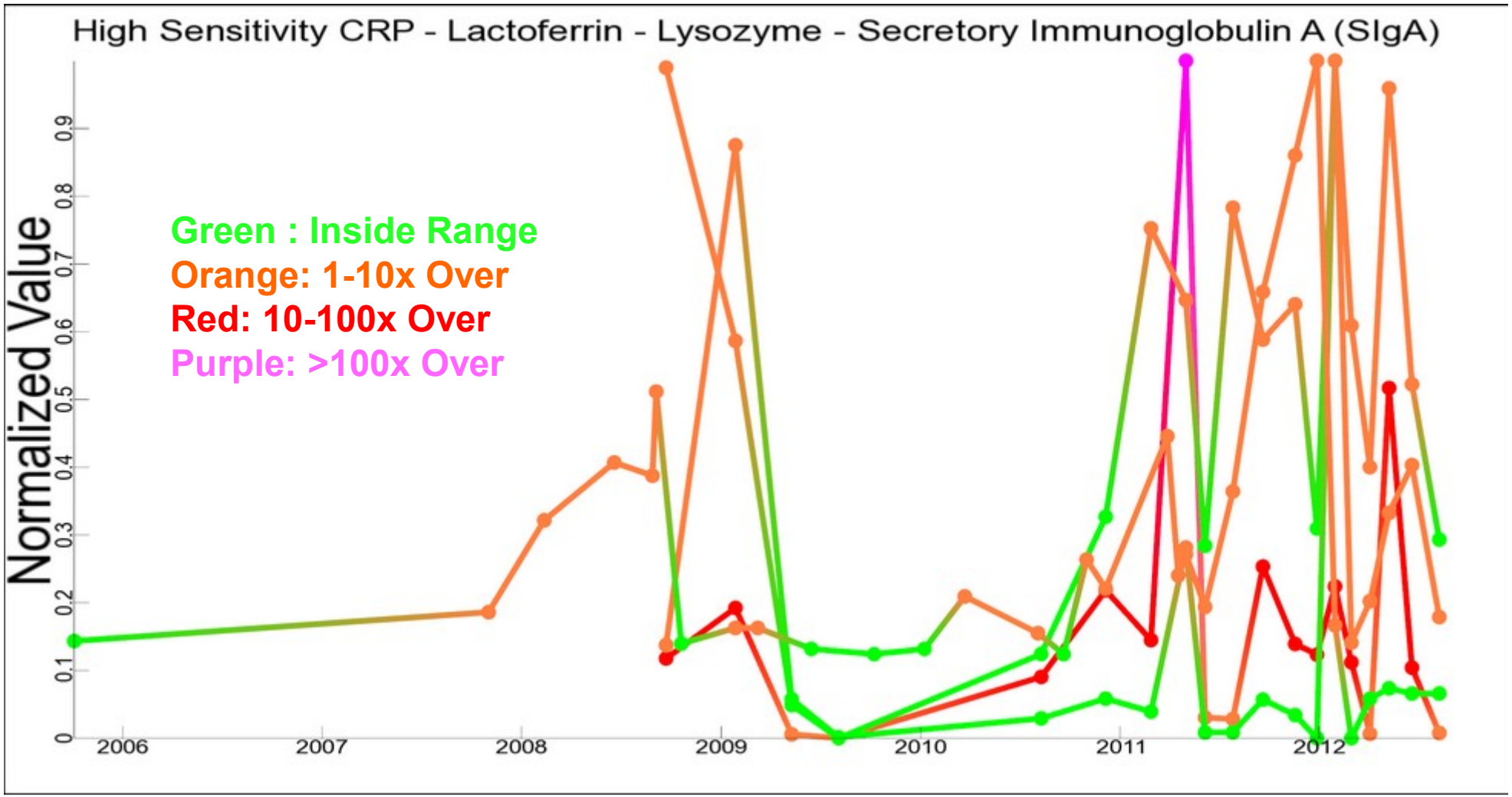


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Lactoferrin is a Sensitive and Specific Biomarker for Detecting Presence of Inflammatory Bowel Disease (IBD)

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Putting Multiple Biomarker Time Series Together, Gives an Quantitative Readout of Health or Disease

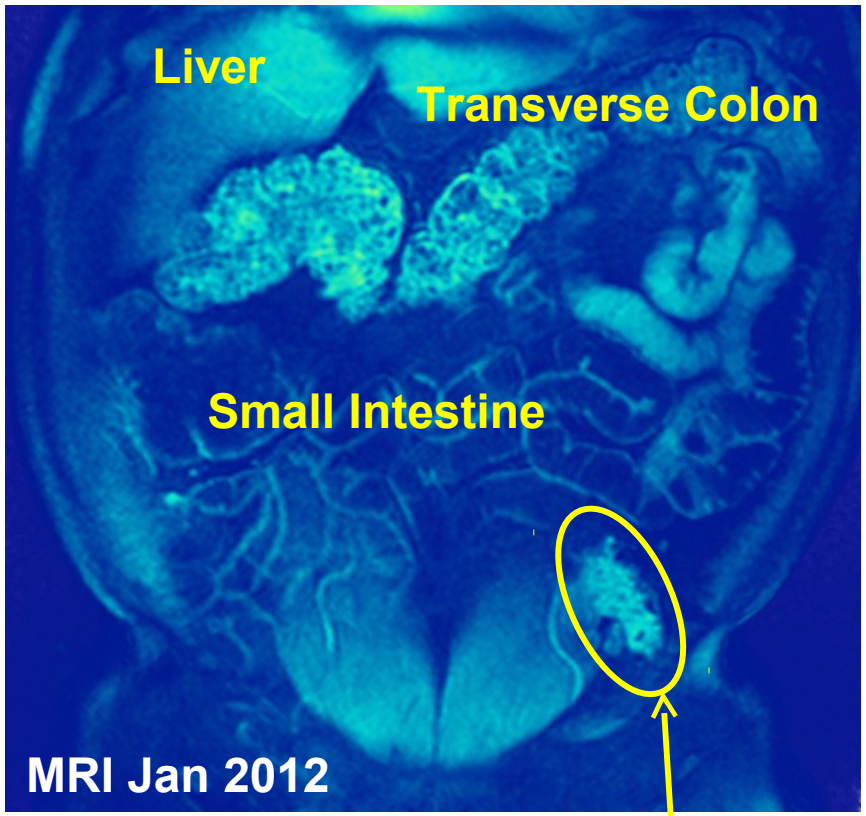


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Source: Calit2 Future Health Expedition Team

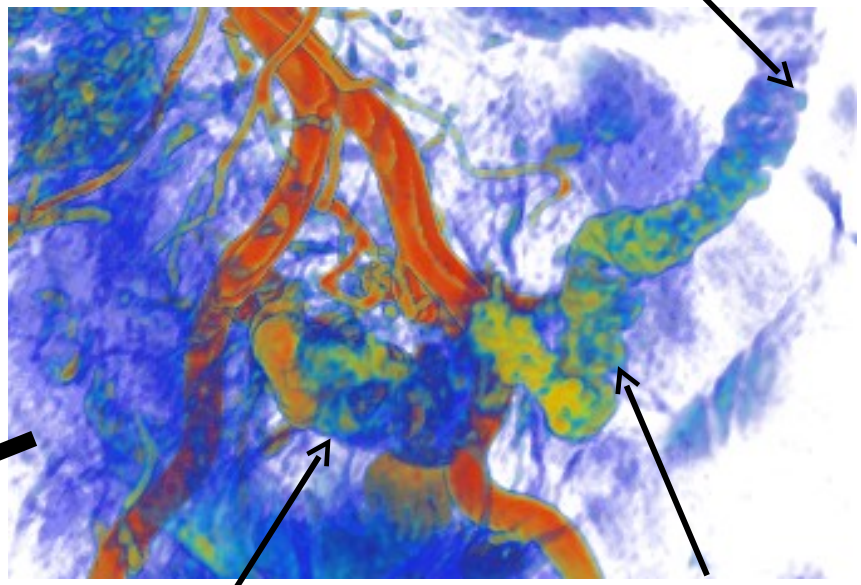
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Confirming the IBD (Crohn's) Hypothesis: Finding the "Smoking Gun" with MRI Imaging



I Obtained the MRI Slices From UCSD Medical Services and Converted to Interactive 3D Working With Calit2 Staff & DeskVOX Software

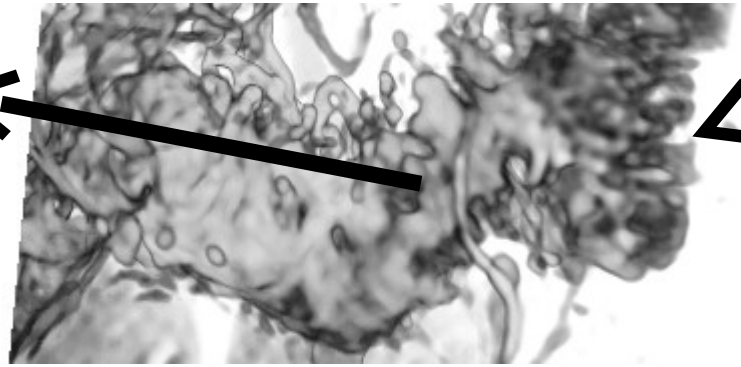
Descending Colon



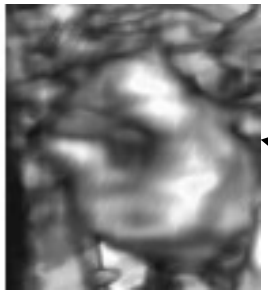
Major Kink

Sigmoid Colon Threading Iliac Arteries

Diseased Sigmoid Colon



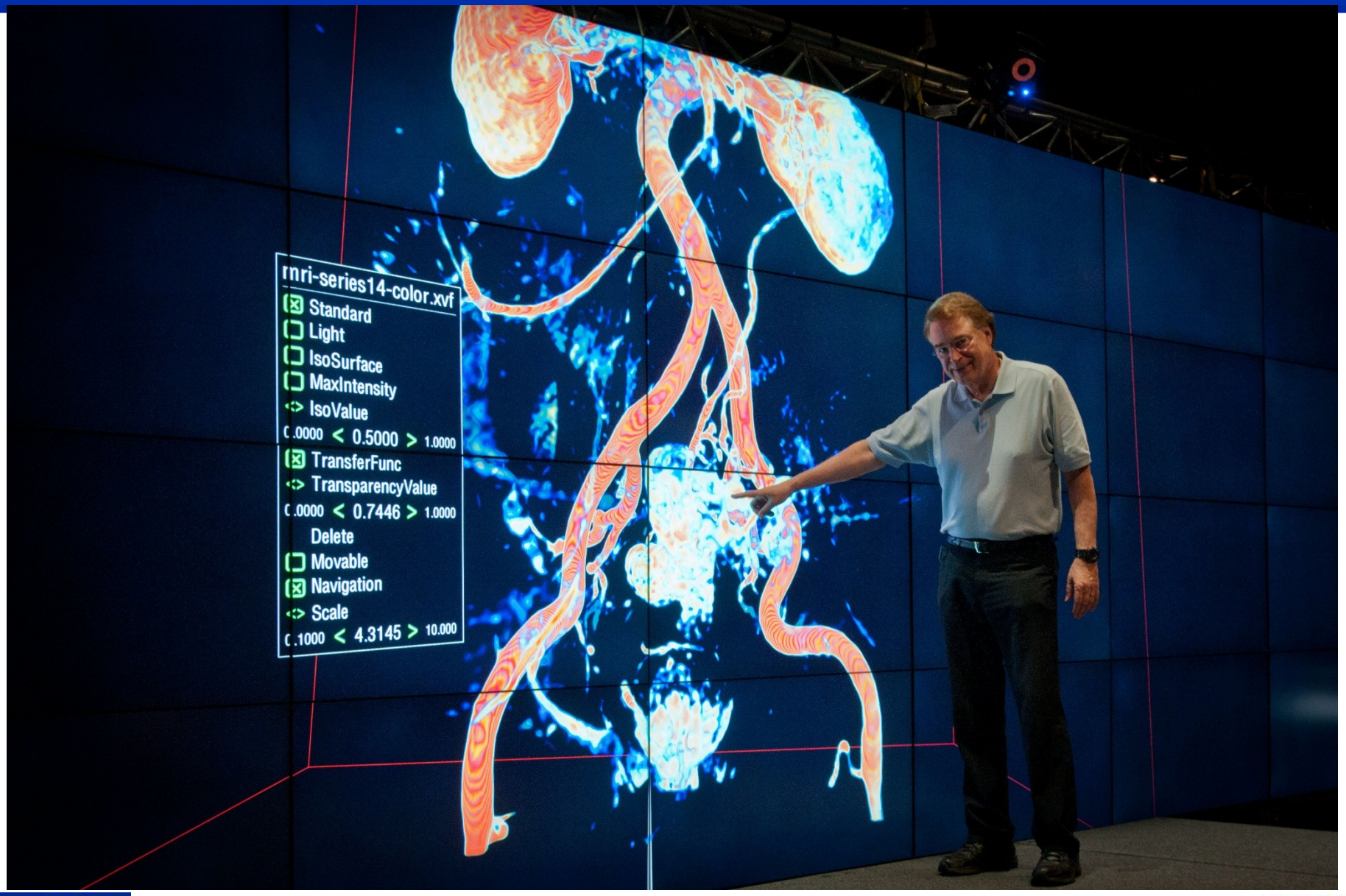
Cross Section



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Scalable Visualization for 3D Interactive Body Imaging



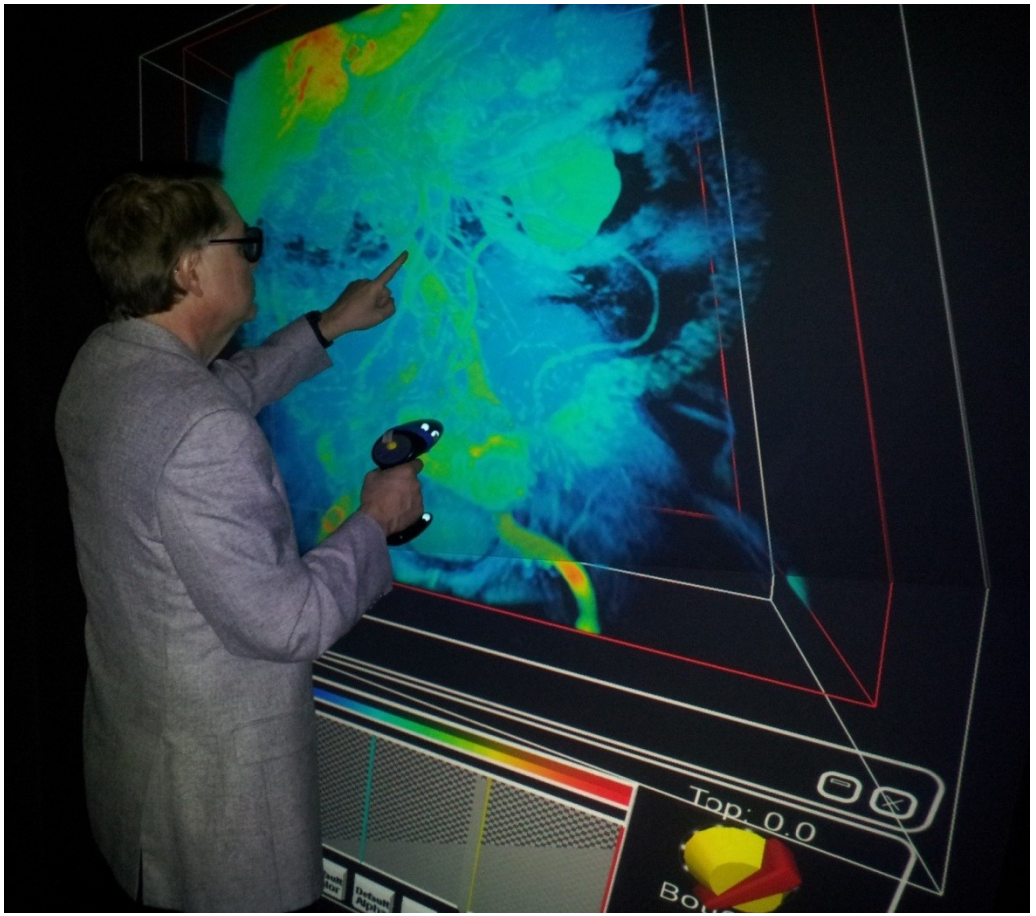
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DeskVOX Software Courtesy of Jurgen Schulze, Calit2

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3D Imaging of MRI Enterography Data: Turning My Body into an Interactive Video Game

- **Videos of Me Giving Tours of My Organs:**
  - http://www.youtube.com/watch?v=9c4DtJ_L_Ps [3D video]
  - www.theatlantic.com/magazine/archive/2012/07/the-measured-man/309018/



Virtual Reality Exploration



Hard Copy of Sigmoid Colon

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Photo & DeskVOX Software Courtesy of Jurgen Schulze, Calit2

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Why Did I Have an Autoimmune Disease like IBD?

Despite decades of research,
the etiology of Crohn's disease
remains unknown.
Its pathogenesis may involve
a complex interplay between
host genetics,
immune dysfunction,
and microbial or environmental factors.
--The Role of Microbes in Crohn's Disease

So I Set Out to Quantify All Three!

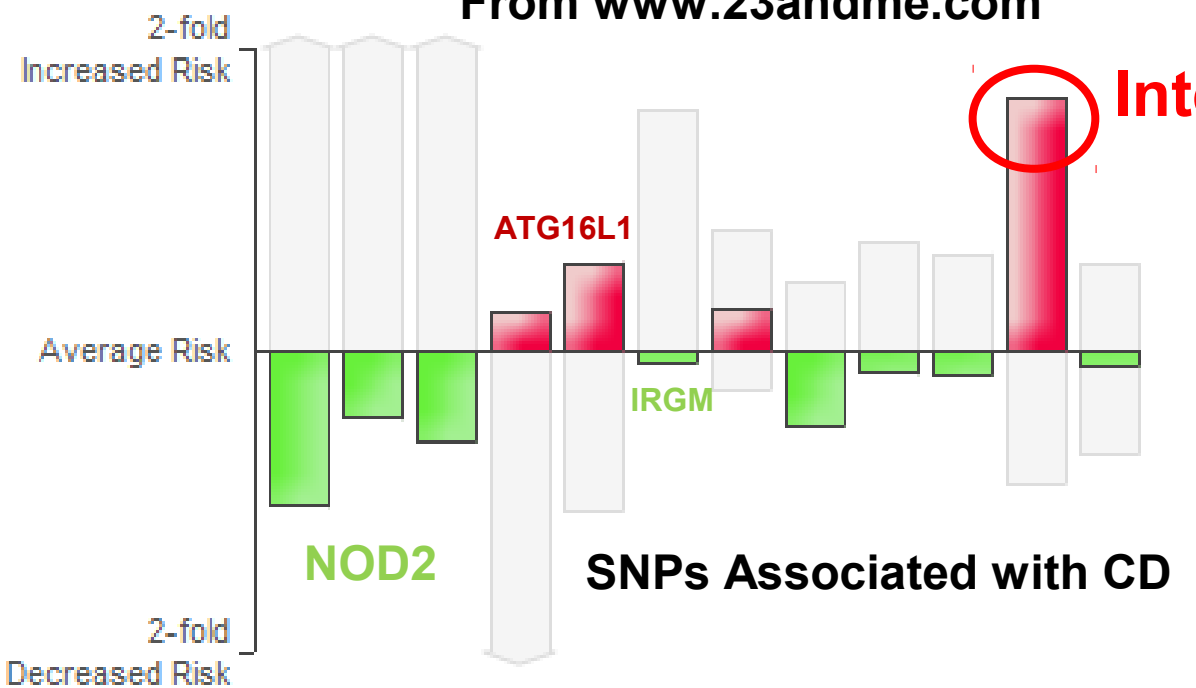
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Paul B. Eckburg & David A. Relman
Clin Infect Dis. 44:256-262 (2007)

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I Wondered if Crohn's is an Autoimmune Disease, Did I Have a Personal Genomic Polymorphism?

From www.23andme.com



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

News and Views

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

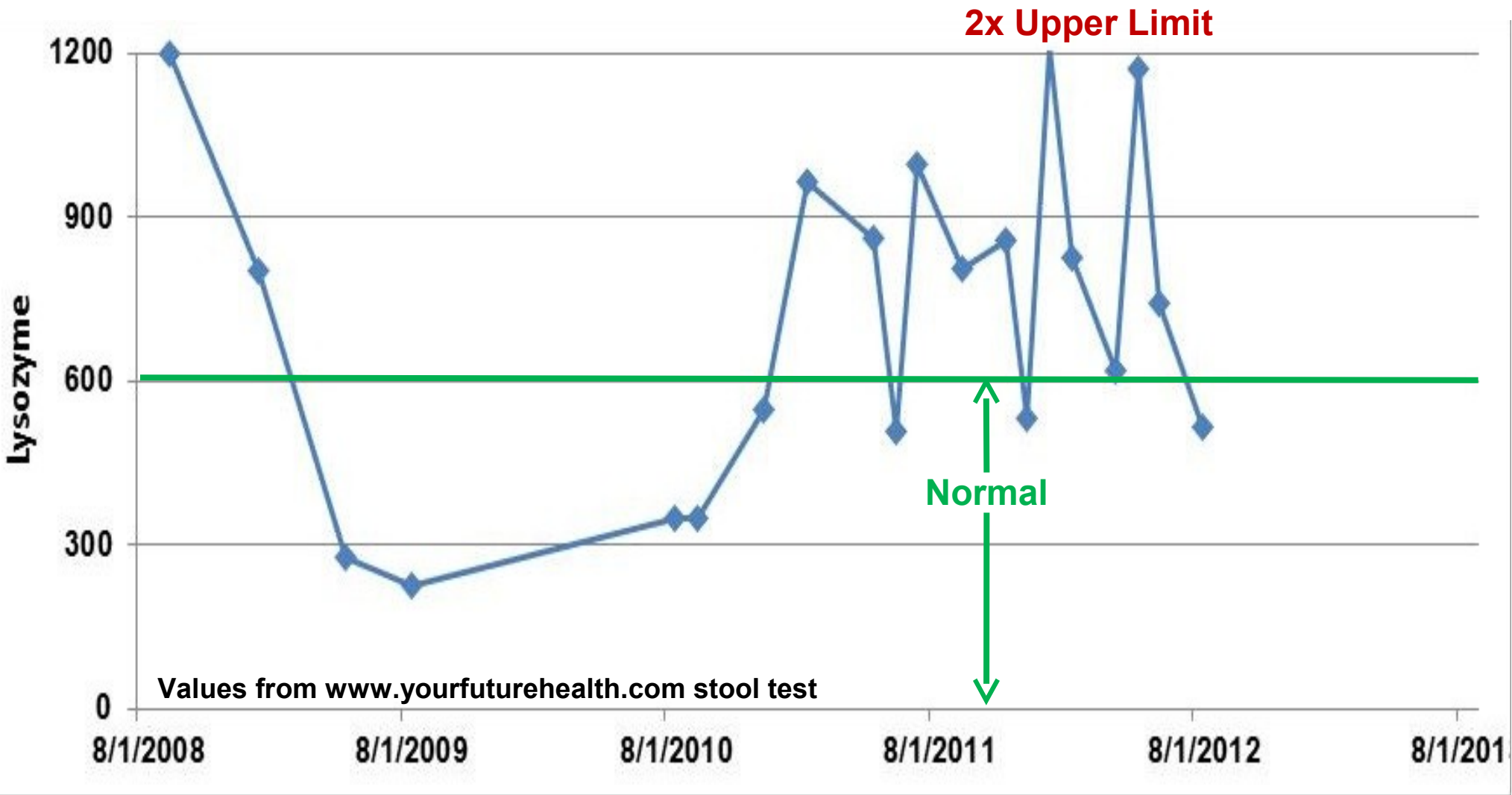
IL-23: a master regulator in Crohn disease

Markus F Neurath[1]

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I Tracked My Innate Immune System By Measuring Lysozyme From Stool Samples Over Time

My Immune System Seems to Be Fighting Bacteria Episodically

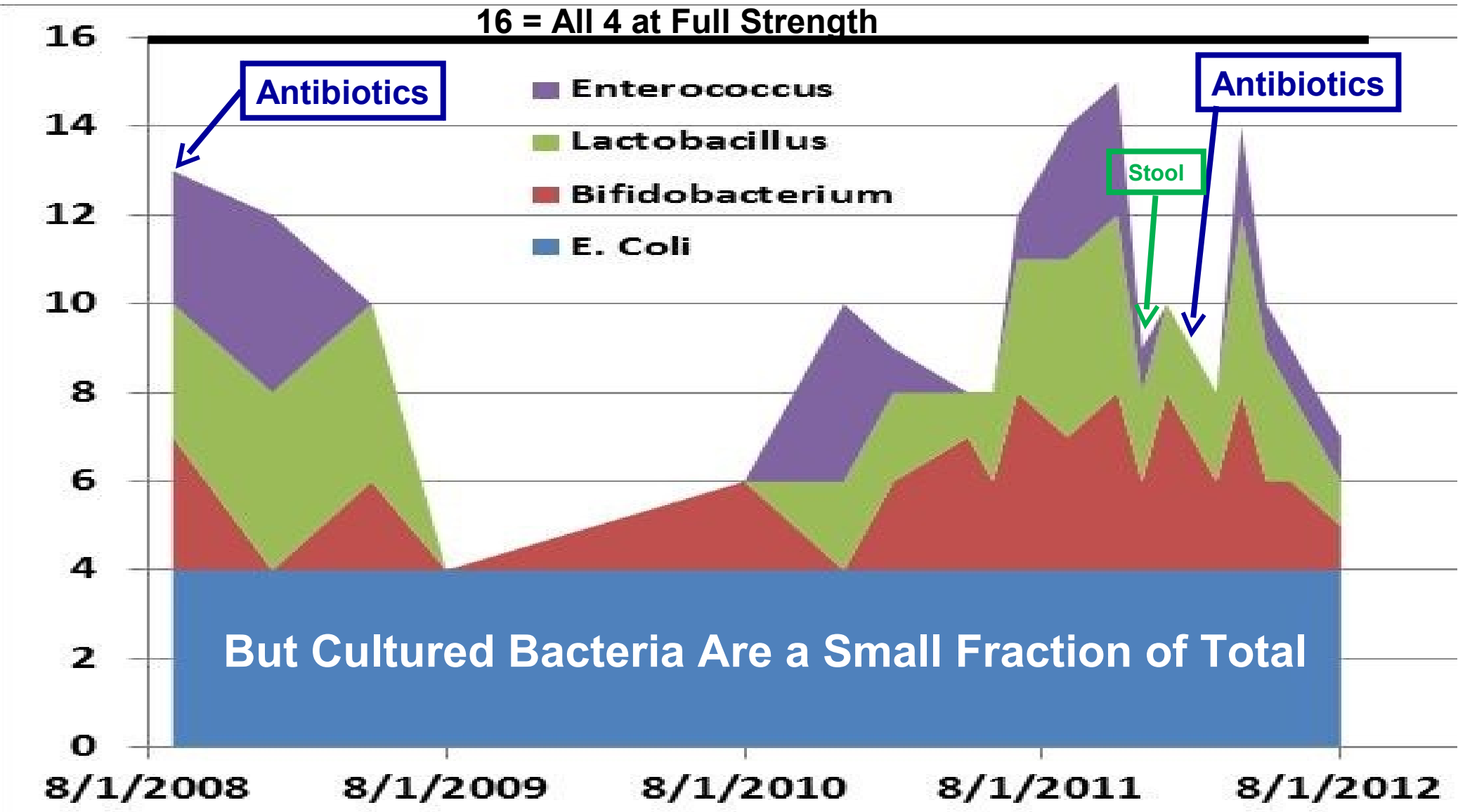


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Lysozyme is an Enzyme of the Innate Immune System that Attacks Bacterial Cell Walls

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Your Human Cells are Only 10% of Your Superorganism: How Can We Track the 90% which are Microbes?



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Values From www.yourfuturehealth.com stool test

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Determining My Gut Microbes and Their Time Variation



Shipped Stool Sample
December 28, 2011

I Received
a Disk Drive April 3, 2012
With 35 GB FASTQ Files

Weizhong Li, UCSD
NGS Pipeline:
230M Reads
Only 0.2% Human

Required 1/2 cpu-yr
Per Person Analyzed!

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HEALTH SCIENCES

J. Craig Venter
INSTITUTE

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Emerging Technology Will Enable You to Quantify Your SuperSelf !

- **Results of Whole Genome Sequencing Used on Jan 2012 Stool Sample**
  - Abundance of 2500 microbe species for 200 subjects and me
  - Generates a 500,000 cell spreadsheet!

- **Findings:**
  - Healthy Microbes Depleted
  - Unhealthy Microbes Took Over

- **Next Step:**
  - Repeat on April/August Samples
  - Continue Measuring
  - Evaluate Novel Therapies

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Next Step: Use Microarray to Measure Time Series of Microbial Diversity

www.secondgenome.com

SECOND GENOME
THE MICROBIOME COMPANY



LBL's Gary Andersen and his PhyloChip

"Second Genome has developed a sensitive, flexible and robust platform for the identification of microbiome-based signatures for the rapid identification of microbial gut health biomarkers."

DNA microarray that can identify, within hours, over 50,000 different microbes

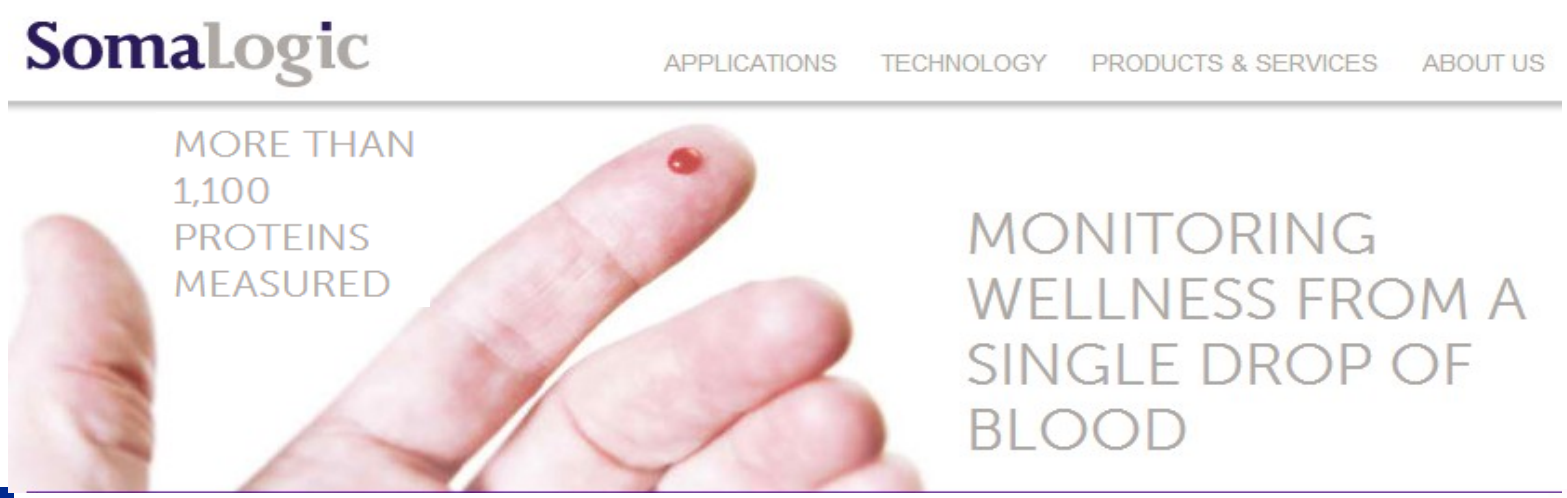


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From Vials of Blood for a Few Variables to Thousands of Proteins from a Single Drop





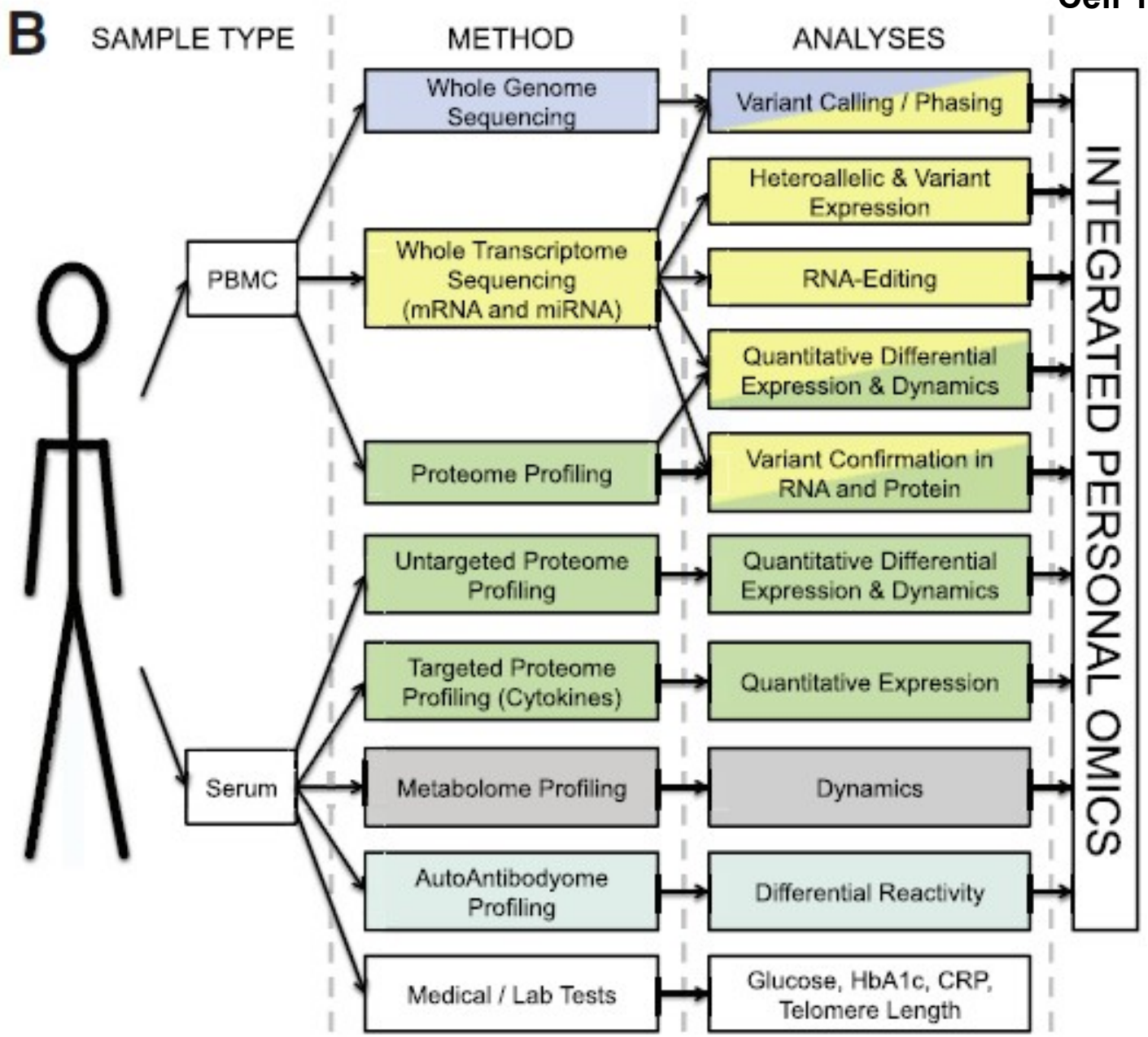
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www.somalogic.com/

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Integrative Personal Omics Profiling: 1000x More Data Than I Have Been Taking

Cell 148, 1293–1307, March 16, 2012



- **Michael Snyder, Chair of Genomics Stanford Univ.**
- **Genome 140x Coverage**
- **Blood Tests 20 Times in 14 Months**
  - **tracked nearly 20,000 distinct transcripts coding for 12,000 genes**
  - **measured the relative levels of more than 6,000 proteins and 1,000 metabolites in Snyder's blood**

Publically Sharing Your Genome and Medical Records: Is it Crazy or the Future?

World DNA Day: April 25, 2012

GET Genomes Environments Traits CONFERENCE

I Have Been Accepted by PGP and Spoke at GET 2012

Personal Genome Project

Posted 06.01.08 | NOVA scienceNOW

The Personal Genome Project, spearheaded by George Church of Harvard's Center for Computational Genetics, aims to recruit 100,000 people willing to offer up their DNA and personal life histories. It's all in an effort to further knowledge of human genetics and why we get—or don't get—diseases.

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