"Machine Learning
in Healthcare Diagnostics"

Machine Learning is Rapidly Disrupting Major Areas of Medicine

Deep Patient: An Unsupervised Representation to Predict the Future of Patients from the Electronic Health Records

SCIENTIFIC REPORTS

www.nature.com/scientificreports

Published online: 17 May 2016

Riccardo Miotto, Li Li, Brian A. Kidd & Joel T. Dudley ✉

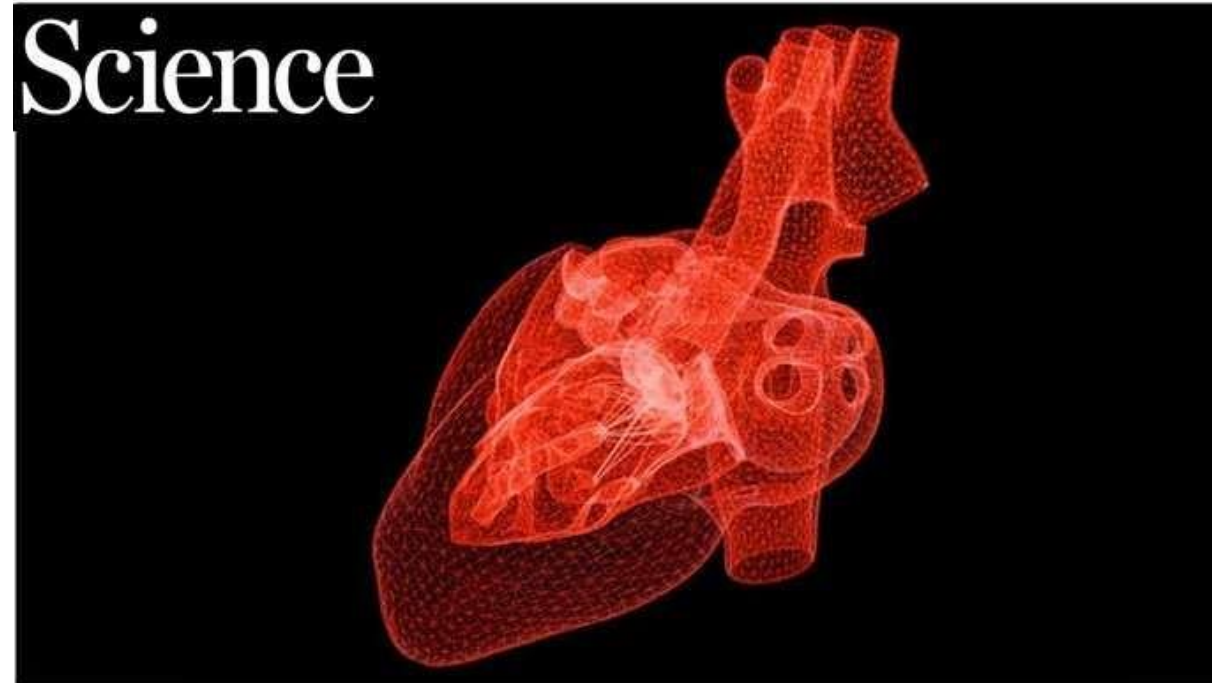3 ways machine learning will disrupt radiology—and the rest of medicine with it

HealthImaging

Oct 03, 2016 | Dave Pearson

JANUARY 25, 2017

Deep learning algorithm does as well as dermatologists in identifying skin cancer
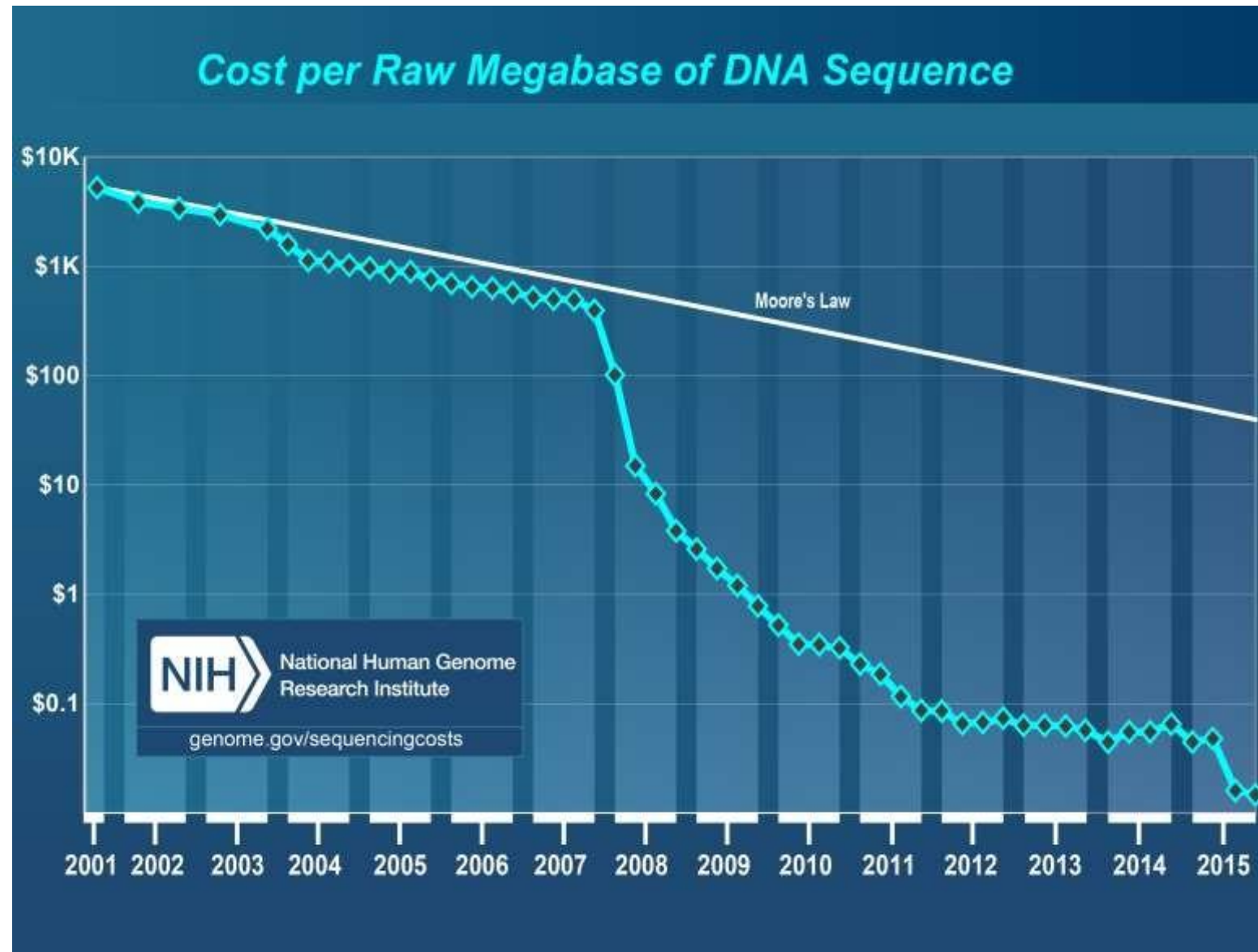
Science

Artificial intelligence may help prevent heart failure.

Devrimb/iStockphoto

Self-taught artificial intelligence beats doctors at predicting heart attacks

By Matthew Hutson | Apr. 14, 2017 , 3:30 PM

Reading the Software of Life Requires Genetic Sequencing:
The Cost of Sequencing DNA Has Fallen Over 100,000x in the Last Ten Years

Cost per Raw Megabase of DNA Sequence

Moore's Law

NIH National Human Genome Research Institute

genome.gov/sequencingcosts

See Talks by: Illumina Arivale

This Has Enabled Sequencing of Both Human and Microbial Genomes

To Map Out the Dynamics of Autoimmune Microbiome Ecology Couples Next Generation Genome Sequencers to *Big Data* Supercomputers

Source: Weizhong Li, UCSD

Our Team Used 25 CPU-years
to Compute
Comparative Gut Microbiomes
Starting From
2.7 Trillion DNA Bases
of My Samples
and Healthy and IBD Controls

Illumina HiSeq 2000 at JCVI

SDSC Gordon Data Supercomputer

Dell Solutions Center
Industry Solutions Lab
SANGER DSU

DNA-bearing Cells in Your Body:
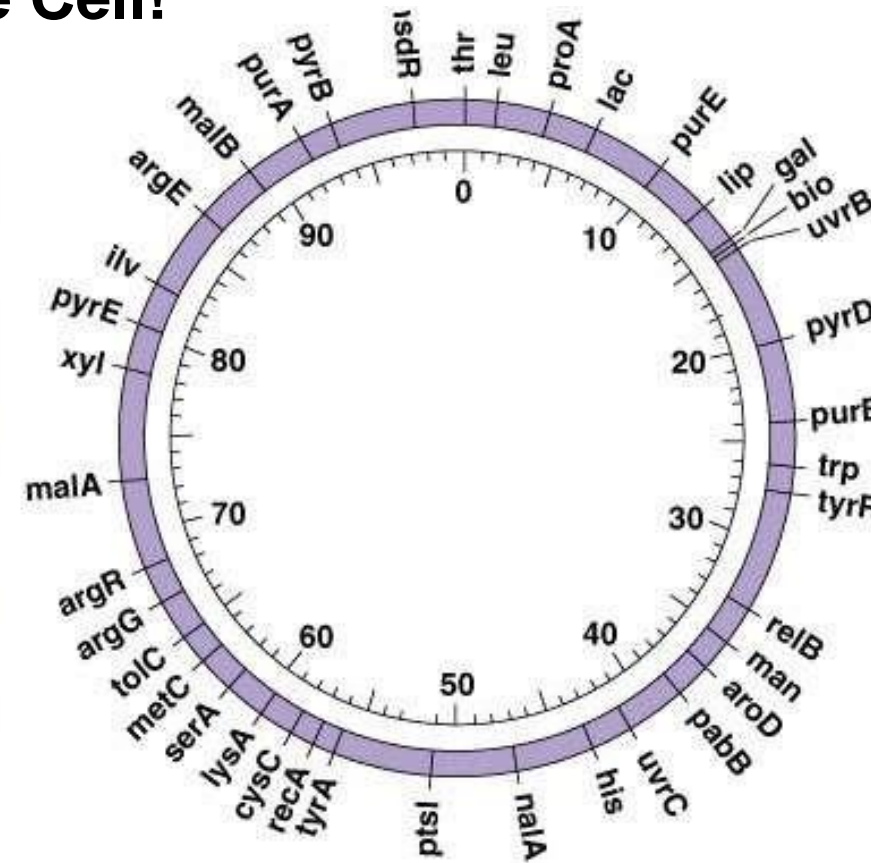# More Microbe Cells Than Human Cells

**Your Microbiome is
Your "Near-Body" Environment
and its Cells
Contain 200-2000x
as Many DNA Genes
As Your Human Cells**

Each Microbe Contains a Few Thousand Genes on Its DNA

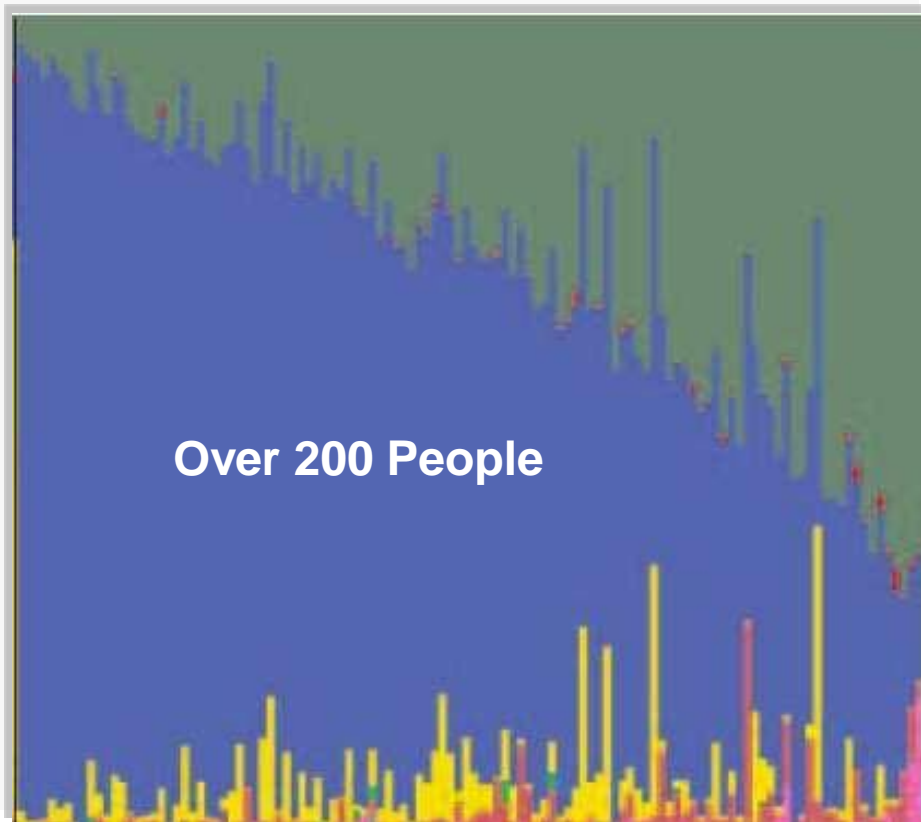**E. Coli Contains ~5000 Genes on its Circular Chromosome, Which is 1000x the Length of the Cell!**
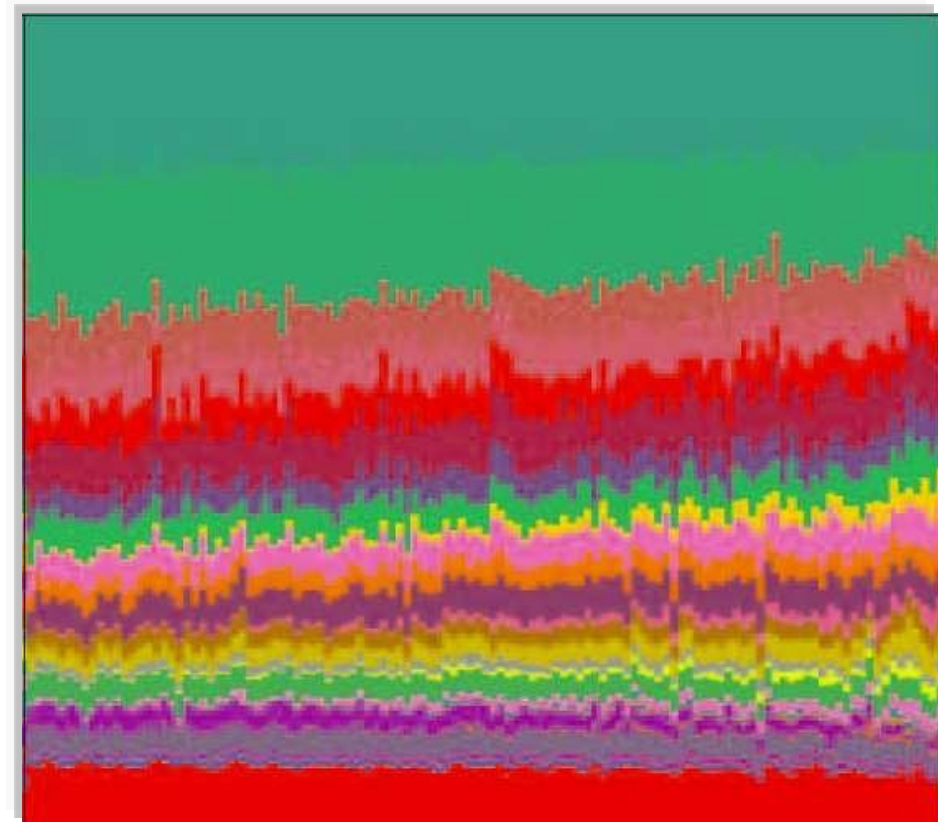

(a)

(b)

Copyright © 2004 Pearson Education, Inc., publishing as Benjamin Cummings.

Several Million Genes Can Occur in the Human Gut Microbiome

Over 200 People

Firmicutes
Actinobacteria
Bacteroidetes
Proteobacteria
Fusobacteria
Tenericutes
Spirochaetes
Cyanobacteria
Verrucomicrobia
TM7

Central carbohydrate metabolism
Cofactor and vitamin biosynthesis
Oligosaccharide and polyol transport system
Purine metabolism
ATP synthesis
Phosphate and amino acid transport system
Aminoacyl tRNA
Pyrimidine metabolism
Ribosome
Aromatic amino acid metabolism

Source: Nature, 486, 207-212 (2012)

Using Machine Learning to Determine Major Differences Between Gut Microbiome in Health and Disease

Using Machine Learning to Identify Major Shifts in Human Gut Microbiome Protein Family Abundance in Disease

Mehrdad Yazdani*[†], Bryn C. Taylor[‡], Justine W. Debelius[‡], Weizhong Li[§], Rob Knight[¶] and Larry Smarr*[||]

*California Institute for Telecommunications and Information Technology, UC San Diego, California, USA
[†]Open Medicine Institute, Mountain View, California, USA
[‡]Biomedical Sciences, UC San Diego, California, USA
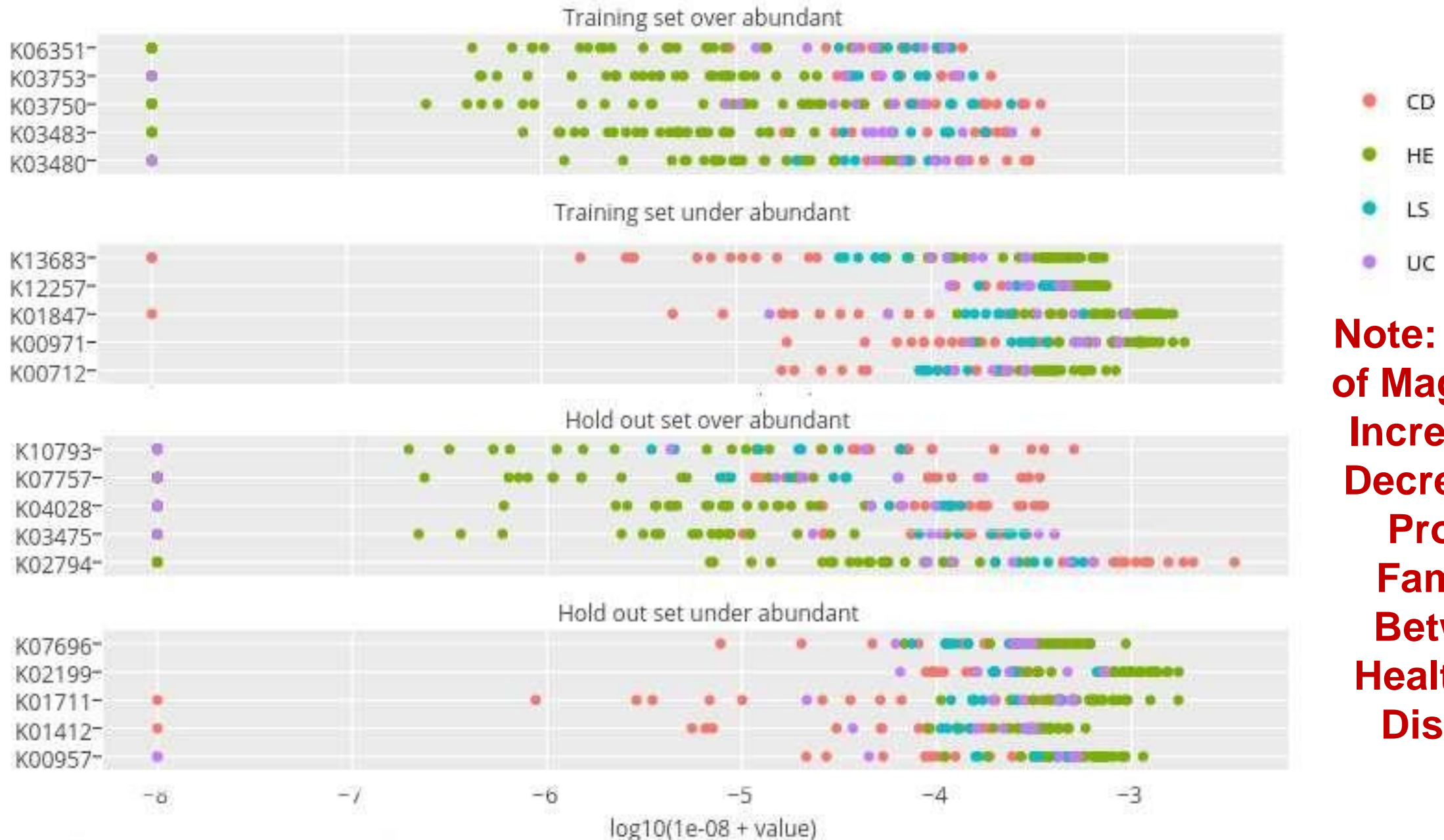[§]J. Craig Venter Institute, La Jolla, California, USA
[¶]Department of Pediatrics, UC San Diego, California, USA

Center for Microbiome Innovation

Using Kolmogorov-Smirnov Test and Random Forest Machine Learning to Discover the Protein Families That Differentiate Between Disease and Health

- **Smarr Gut Microbiome Time Series**
  - **From 7 Samples Over 1.5 Years**
  - **To 85 Samples Over 5 Years**

- **IBD Patients: From 5 Crohn's Disease and 2 Ulcerative Colitis Patients to ~100 Patients**

- **New Software Suite from Knight Lab**
  - **Re-annotation of Reference Genomes, Functional / Taxonomic Variations**
  - **From 10,000 KEGGs to ~1 Million Genes**
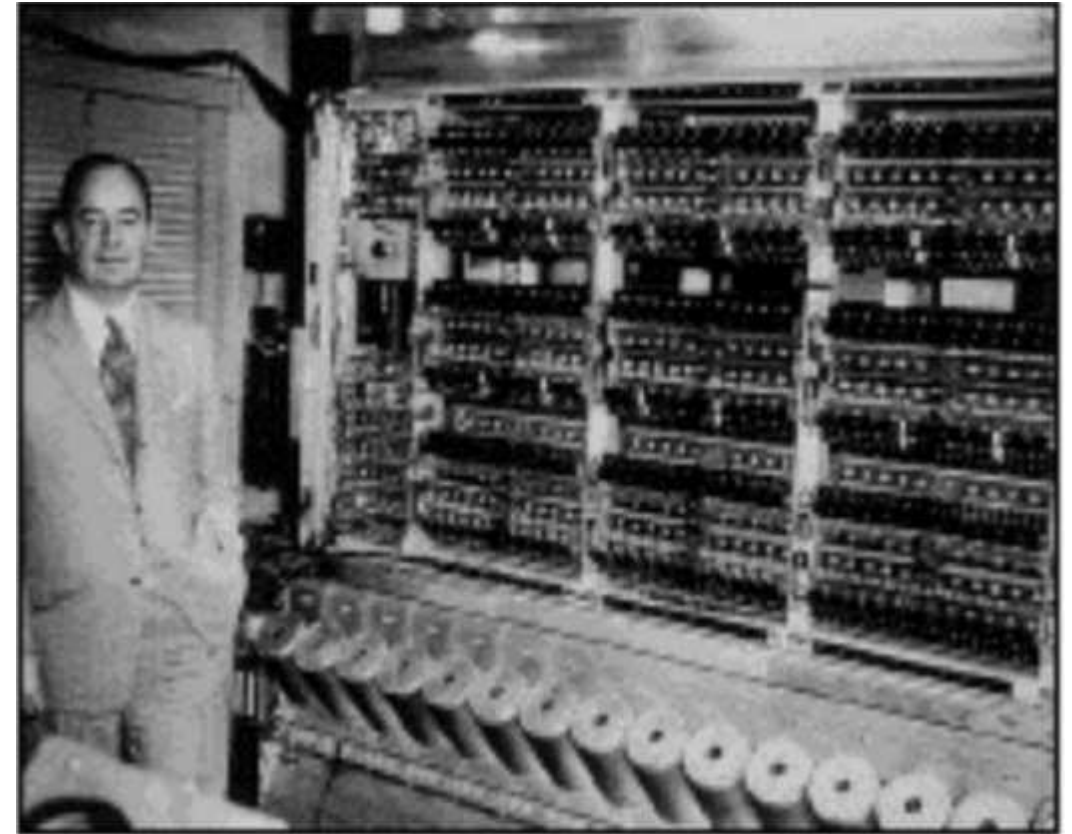 - **Novel Compute-Intensive Assembly Algorithms from Pavel Pevzner**

8x Compute Resources Over Prior Study
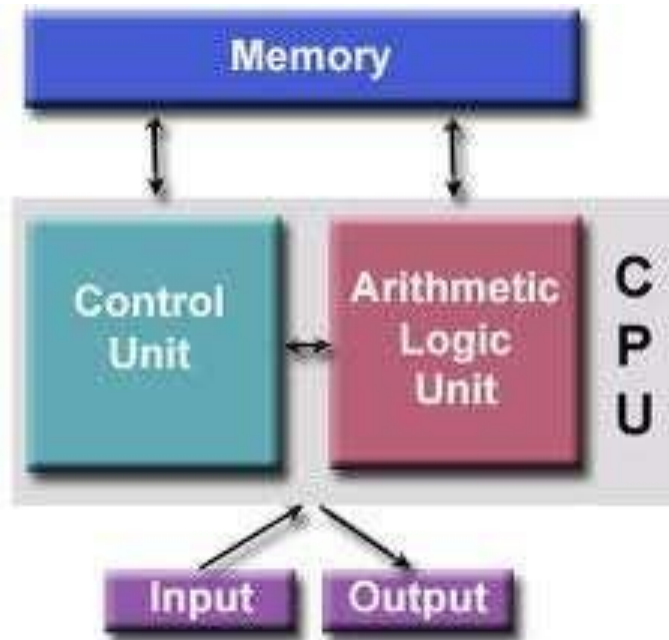
The Von Neumann architecture is a design model for a stored-program digital computer that uses a processing unit and a single separate storage structure to hold both instructions and data.

John Von Neumann

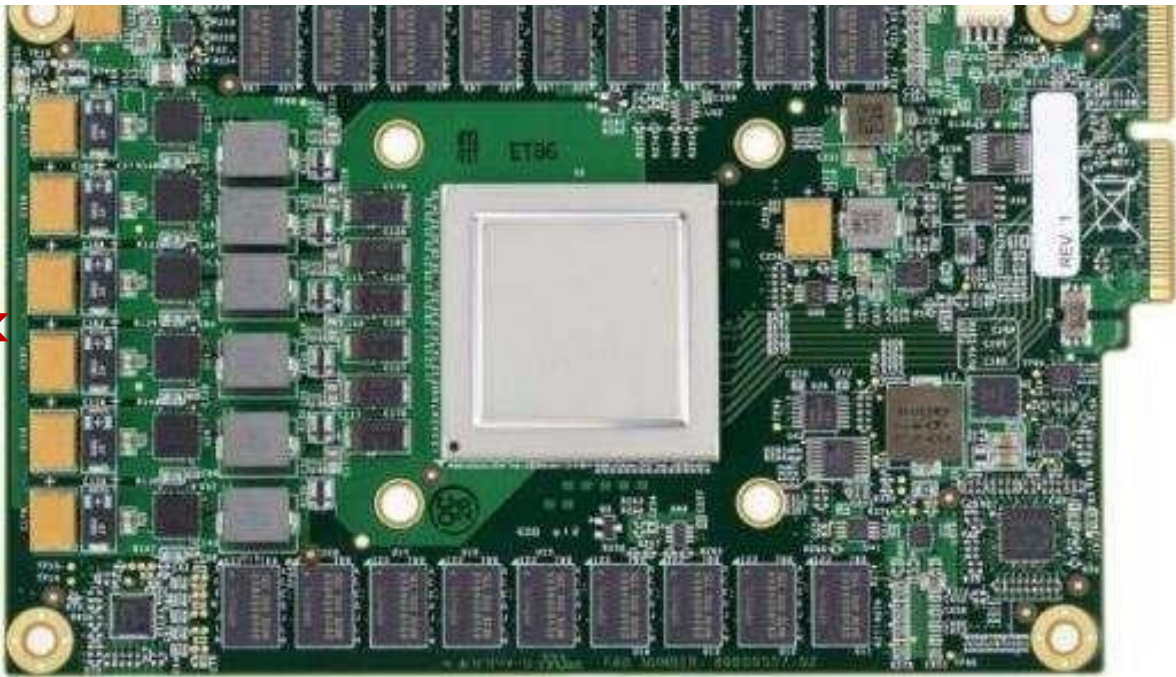BUILDING AN AI CHIP SAVED GOOGLE FROM BUILDING A DOZEN NEW DATA CENTERS

WIRED

Google's First Machine Learning Chip (TPU) Is 30x Faster Than CPUs And GPUs

They didn't have to make a lot of new data centers.

April 7, 2017

Google server racks loaded with TPUs [○] GOOGLE

AI is Advancing at an Unprecedented Pace:
Deep Learning Algorithms Working on Massive Datasets

ALAN LEVINOVITZ   BUSINESS   05.12.14   6:30 AM   WIRED

THE MYSTERY OF GO, THE ANCIENT GAME THAT COMPUTERS STILL CAN'T WIN

1.5 Years!

<re/code>

Exclusive: Google to Buy Artificial Intelligence Startup DeepMind for $400M

January 26, 2014, 4:25 PM PST

CADE METZ   BUSINESS   01.27.16   1:00 PM   WIRED

IN A HUGE BREAKTHROUGH, GOOGLE'S AI BEATS A TOP PLAYER AT THE GAME OF GO

Training on 30M Moves, Then Playing Against Itself

Google Used TPUs to Achieve the Go Victory

Adapted from D-Wave

Brain-Inspired Processors
Are Accelerating the non-von Neumann Architecture Era

Mar. 29, 2016

Lawrence Livermore and IBM collaborate to build new brain-inspired supercomputer

Lawrence Livermore National Laboratory

IBM's $1m TrueNorth to be used in deep learning pattern recognition

NS16e
IBM

"On the drawing board are collections of 64, 256, 1024, and 4096 chips. 'It's only limited by money, not imagination,' Modha says."

Source: Dr. Dharmendra Modha
Founding Director, IBM Cognitive Computing Group

Calit2's Qualcomm Institute Has Established a Pattern Recognition Lab For Machine Learning on non-von Neumann Processors

UCSD ECE Professor Ken Kreutz-Delgado Brings the IBM TrueNorth Chip to Start Calit2's Qualcomm Institute Pattern Recognition Laboratory September 16, 2015

See Talks: KnuEdge Intel/Nervana

Source: Dr. Dharmendra Modha
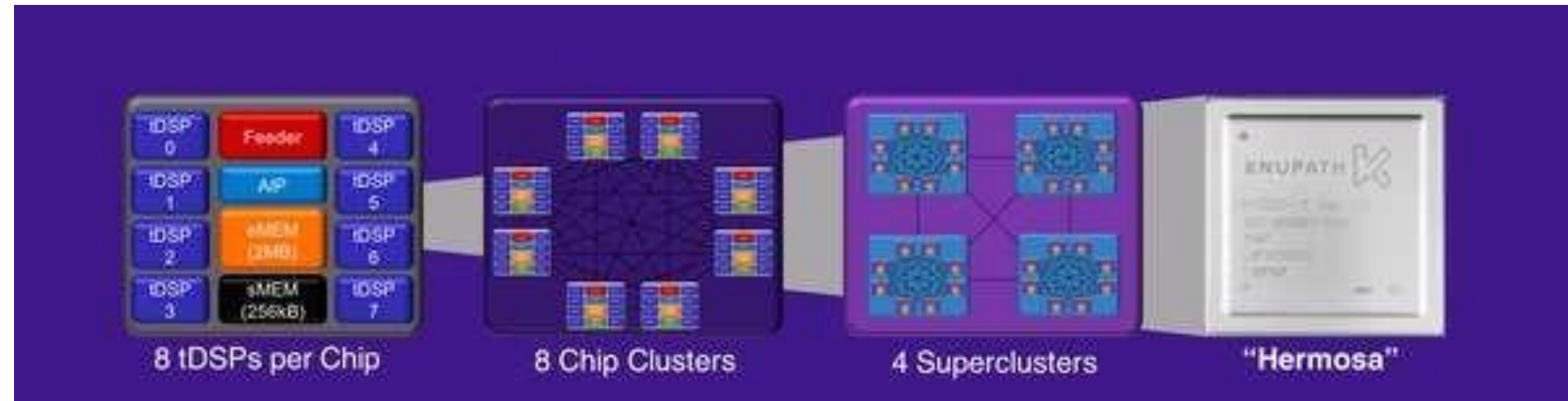**Founding Director, IBM Cognitive Computing Group**

New Brain-Inspired Non-von Neumann Processors Are Emerging: KnuEdge is Essentially a Cloud-on-a-Chip That Scales to 512K Chips

Former NASA Chief Develops Brain-Like Chips

Dan Goldin's startup, KnuEdge, has been working in secret for 10 years on a new kind of computing that mimics the human brain

THE WALL STREET JOURNAL.

June 6, 2016

"KnuEdge and Calit2 have worked together since the early days of the KnuEdge LambdaFabric processor, when key personnel and technology from UC San Diego provided the genesis for the first processor design."

www.calit2.net/newsroom/release.php?id=2726

8 tDSPs per Chip   8 Chip Clusters   4 Superclusters   "Hermosa"

www.tomshardware.com/news/knuedge-announces-knuverse-and-knupath,31981.html

KnuEdge Has Provided Processor to Calit2's PRL

www.calit2.net/newsroom/release.php?id=2704

KNU EDGE

Our Pattern Recognition Lab is Exploring Mapping Machine Learning Algorithm Families Onto Novel Architectures

- **Deep & Recurrent Neural Networks (DNN, RNN)**

- **Graph Theoretic**

- **Reinforcement Learning (RL)**

- **Clustering and Other Neighborhood-Based**

- **Support Vector Machine (SVM)**

- **Sparse Signal Processing and Source Localization**

- **Dimensionality Reduction & Manifold Learning**

- **Latent Variable Analysis (PCA, ICA)**

- **Stochastic Sampling, Variational Approximation**

- **Decision Tree Learning**

From Self-Driving Cars to Personalized Medical Assistants
Deep Learning Will Provide Artificial Intelligence to Coach Us to Wellness
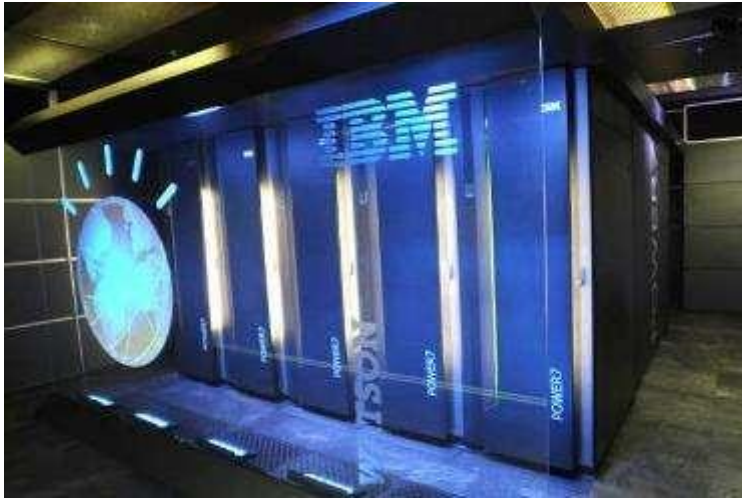
IBM's Watson supercomputer gets its own $1 billion business

IBN Live

January 10, 2014

Where Medicine Coaching is Now

JOAQUIN PHOENIX   AMY ADAMS   ROONEY MARA
OLIVIA WILDE   — SCARLETT JOHANSSON

her

A SPIKE JONZE LOVE STORY

Where Wellness Coaching is Going
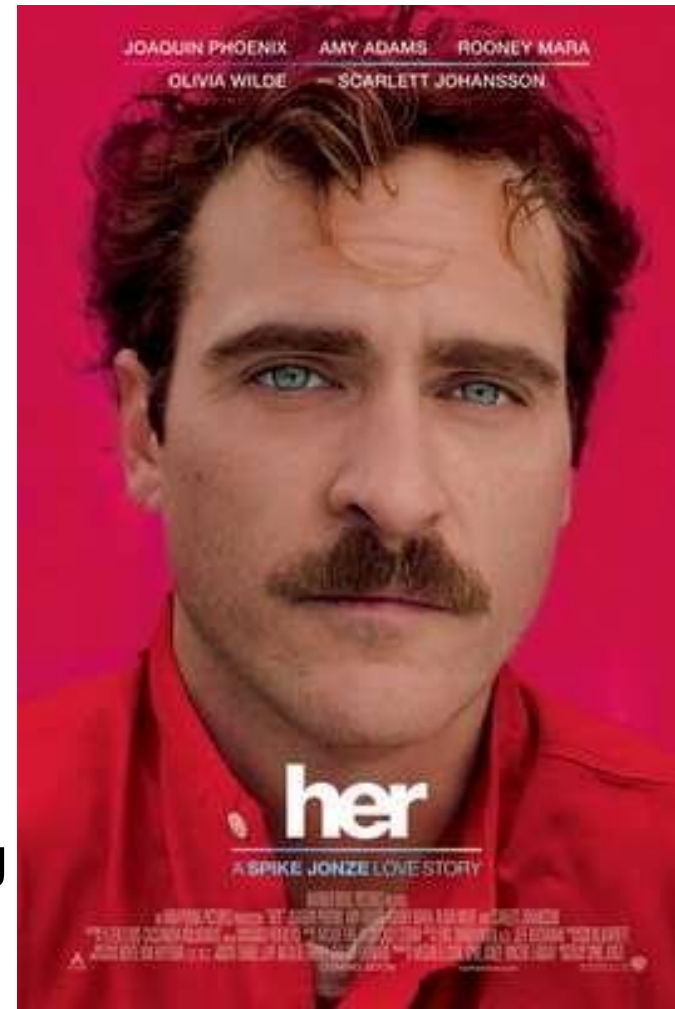
Can a Planetary Supercomputer with Artificial Intelligence Transform Our Sickcare System to a Healthcare System?

Using this data, the **planetary computer** will be able
to build a **computational model of your body**
and compare **your sensor stream** with millions of others.
Besides providing **early detection** of internal changes
that could lead to disease,
cloud-powered voice-recognition **wellness coaches**
could provide continual **personalized support on lifestyle
choices**, potentially **staving off disease**
and making **health care affordable** for everyone.

For Further Information:

http://lsmarr.calit2.net/