Supercharging Science for the Superorganism

Francis S. Collins, M.D., Ph.D.
Director, National Institutes of Health

Human Microbiome Science: Vision for the Future

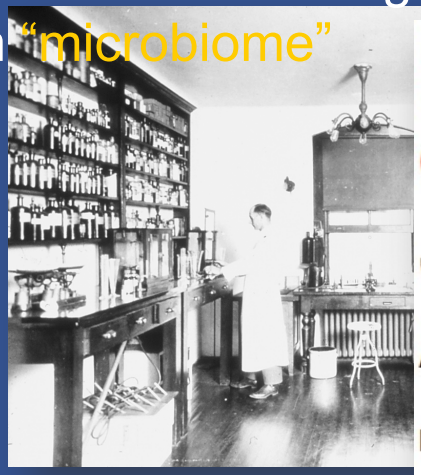
July 24, 2013

NIH: Steward of Medical and Behavioral Research for the Nation

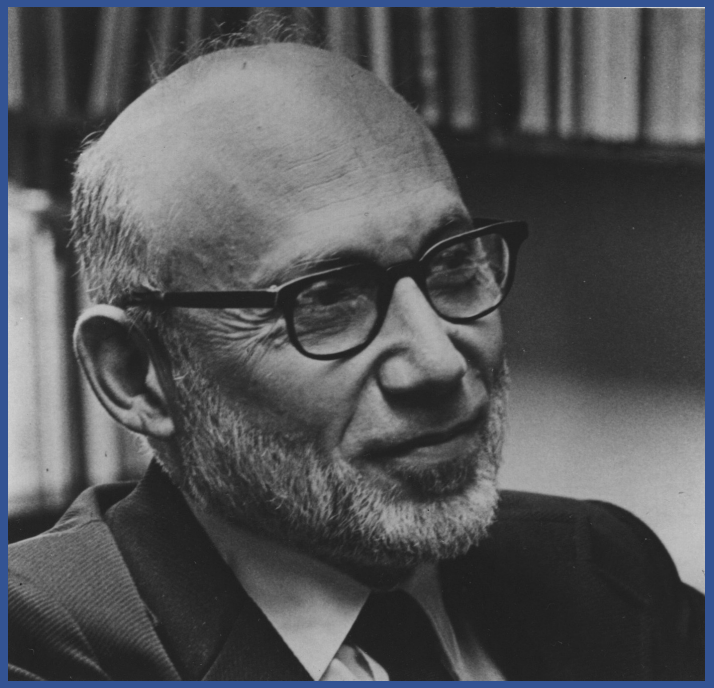
"Science in pursuit of fundamental knowledge about the nature and behavior of living systems… and the application of that knowledge to extend healthy life and reduce illness and disability."

Human Microbiome at NIH: Coming Full Circle

- New science of microbiology: NIH established 1887
  - "Hygienic lab" tests samples for infectious diseases
- New understandings of genetics
  - Mid 20th century: NIH helps crack genetic code
  - 1990-2003: NIH leads Human Genome Project
- 21st century: genomic return to microbiology
  - Ecological approach to our "fellow travelers"
  - Nobel Prize winner – and NIH grantee – Joshua Lederberg proposes term "microbiome"



Understanding the Human Microbiome: From Lederberg's Concept … to HMP



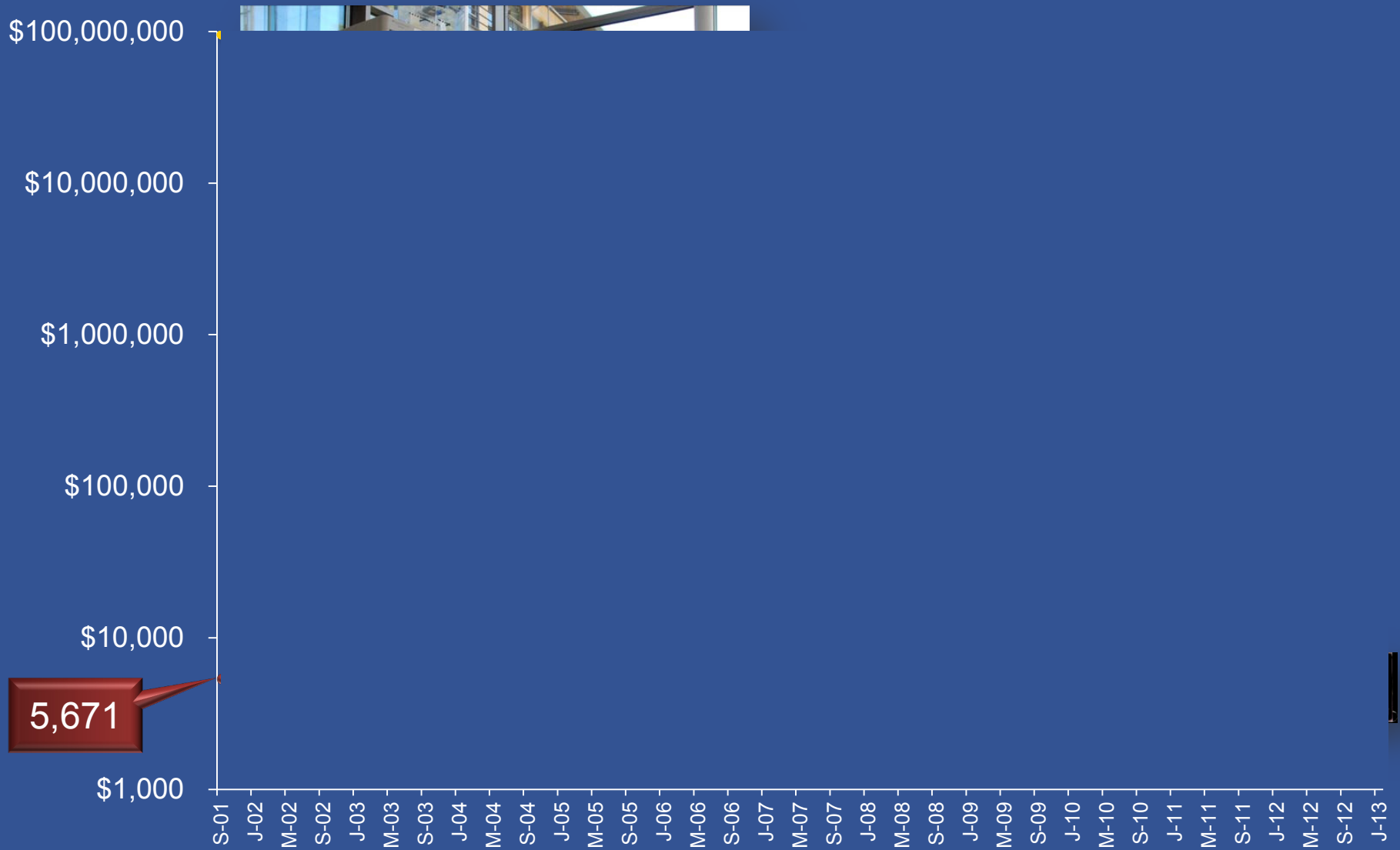
Joshua Lederberg (1925-2008)

"… *microbiome*, to signify the ecological community of commensal, symbiotic, and pathogenic microorganisms that literally share our body space and have been all but ignored as determinants of health and disease."

"We should think of each host and its parasites as a superorganism with the respective genomes yoked into a chimera of sorts."

Cost of Sequencing a Human Genome

September 2001–January 2013



Demonstrating Feasibility

First Analysis of Genes of a Community of Human Microbes

Science

VOL 312 2 JUNE 2006

Metagenomic Analysis of the Human Distal Gut Microbiome

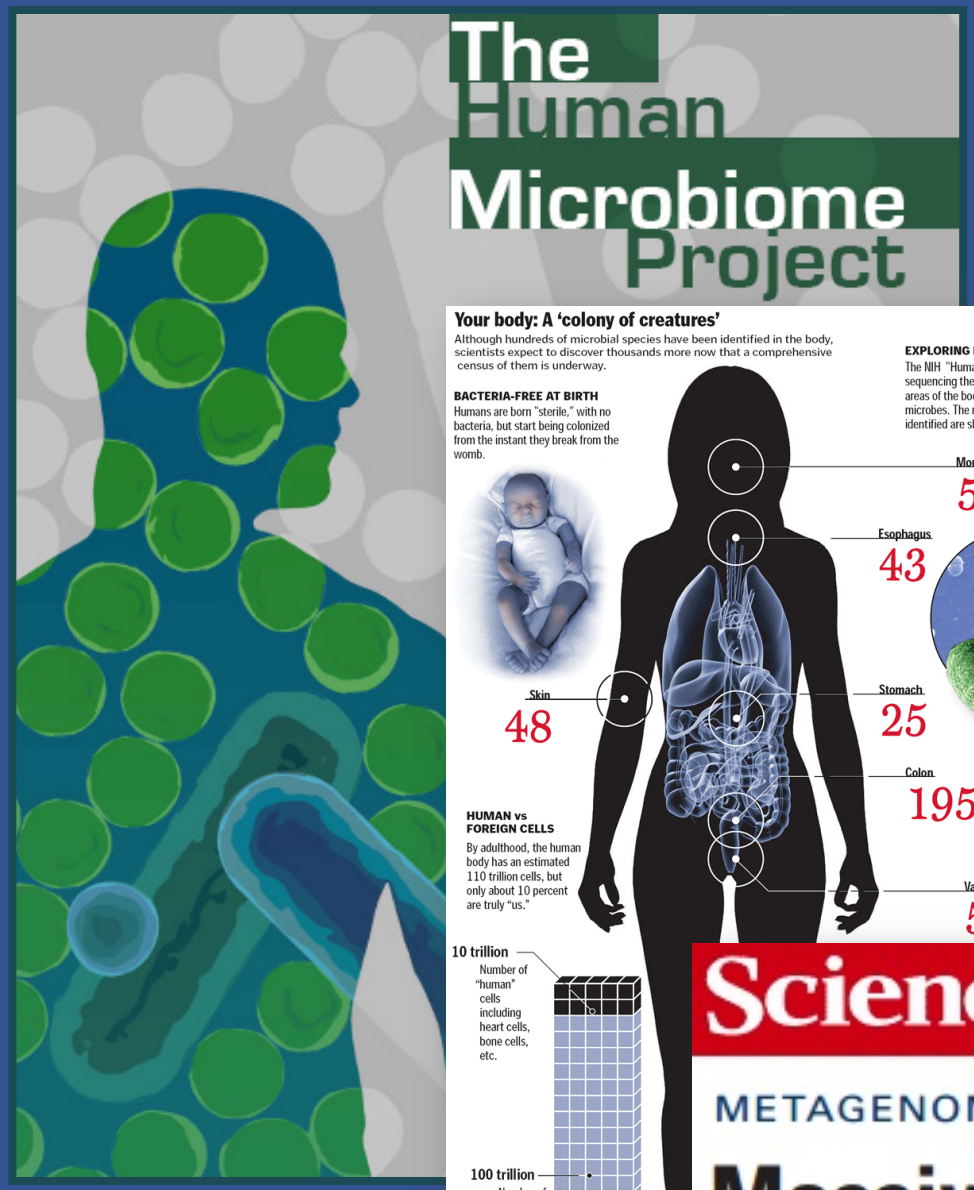
Steven R. Gill,[1*‡] Mihai Pop,[1†] Robert T. DeBoy,[1] Paul B. Eckburg,[2,3,4]
Peter J. Turnbaugh,[5] Buck S. Samuel,[5] Jeffrey I. Gordon,[5] David A. Relman,[2,3,4]
Claire M. Fraser-Liggett,[1,6] Karen E. Nelson[1]

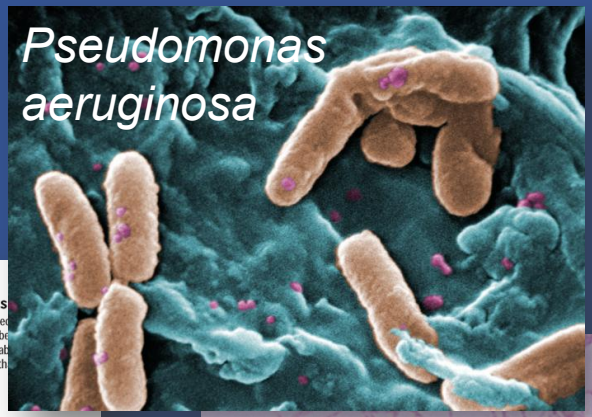
NIH Human Microbiome Project and the NIH Common Fund *(and its predecessor, the NIH Roadmap)*

Facilitating Research Across Disciplines

Projects must be:

- Truly transforming
- Require participation of NIH as a whole
  - Address gaps no single IC or outside entity is likely to fill
- Place outcomes in public domain
- Need development in “incubator space” to jumpstart field





Science
VOL 315 30 MARCH 2007

METAGENOMICS

Massive Microbial Sequence Project Proposed

The Human Microbiome Project

INSIGHT FEATURE NATURE|Vol 449|18 October 2007|

nature

The Human Microbiome Project

Peter J. Turnbaugh, Ruth E. Ley, Micah Hamady, Claire M. Fraser-Liggett, Rob Knight & Jeffrey I. Gordon

A strategy to understand
how they contribute to no

2007 Release: NIH Launches Human Microbiome Project

National Human Genome Research Institute

National Institutes of Health
U.S. Department of Health and Human Services

U.S. Department of Health and Human Services
NIH News
National Institutes of Health

NIH Launches Human Microbiome Project

NIH Roadmap Effort to Use Genomic Technologies to Explore Role of Microbes in Human Health and Disease

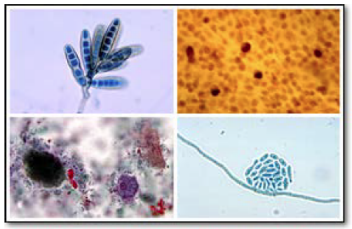


Photo courtesy of the Centers for Disease Control and Prevention.

Bethesda, Md., W
microorganisms, l
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Zerhouni, M.D. "I

The Washington Post

SCIENCE NOTEBOOK

SCIENCE NOTEBOOK

Monday, December 24, 2007

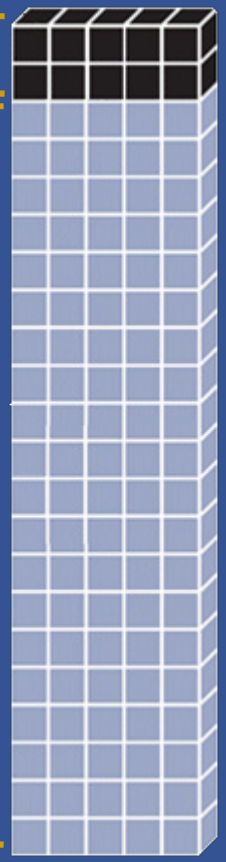
The Inhuman DNA in Every Person

-- Rick Weiss

Total # cells

"Us"

"Them"



Human Microbiome Project Contributes to International Effort

Research programs and members include:

HMP, NIH Common Fund

Canadian Microbiome Initiative

Korean Microbiome Diversity Using Korean Twin Cohort Project

Australian Jumpstart Human Microbiome Project

Metagenomics of the Human Intestinal Tract, European Commission

MicroObes, Human Intestinal Microbiome in Obesity and Nutritional Transition, French National Agency for Research

http://www.human-microbiome.org/

ARTICLE

14 JUNE 2012 | VOL 486

Structure, function and diversity of the healthy human microbiome

The Human Microbiome Project Consortium*

ARTICLE

14 JUNE 2012 | VOL 486

A framework for human microbiome research

The Human Microbiome Project Consortium*

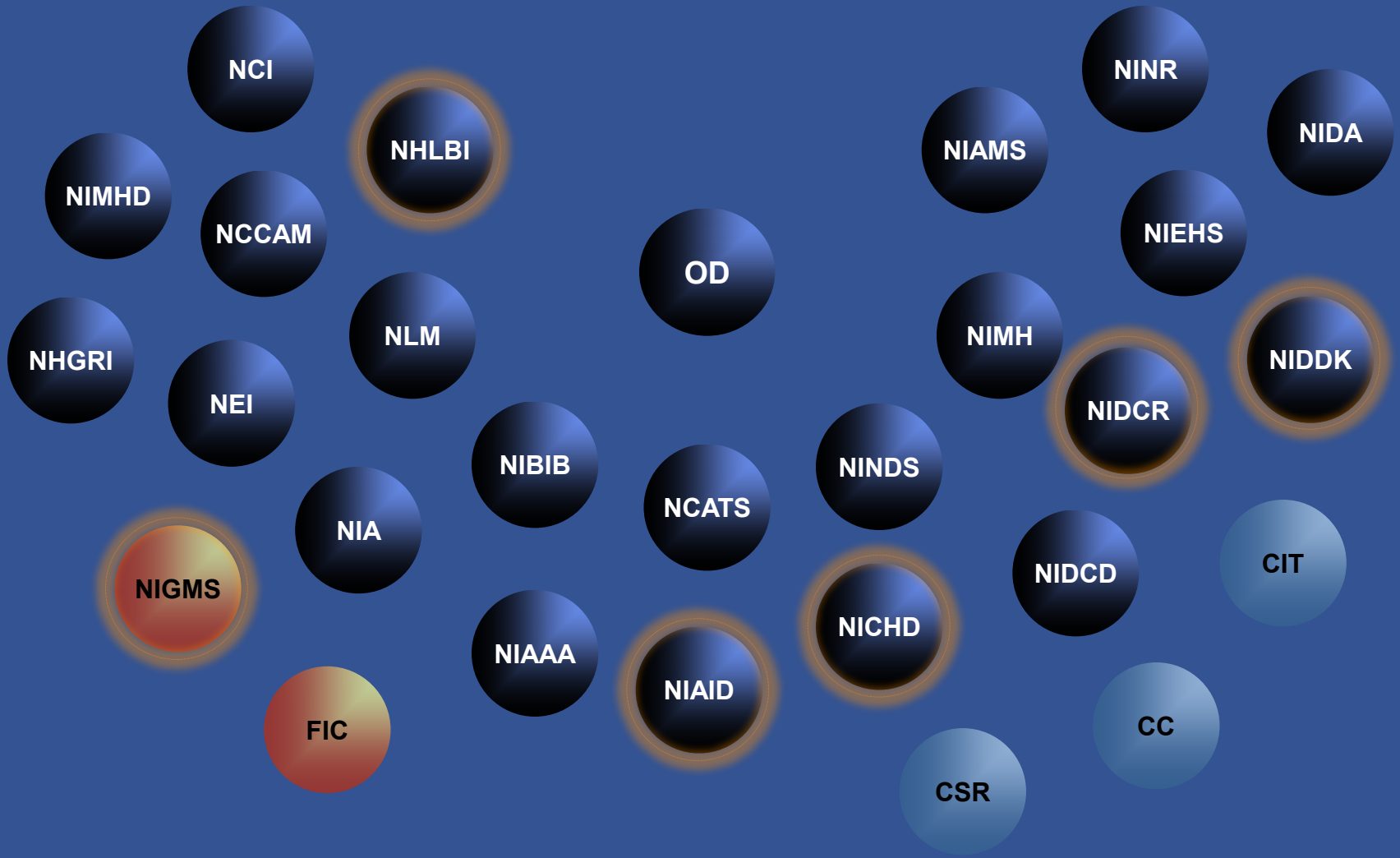
HMP

PLOS | COLLECTIONS

Table of Contents: The Human Microbiome Project Collection

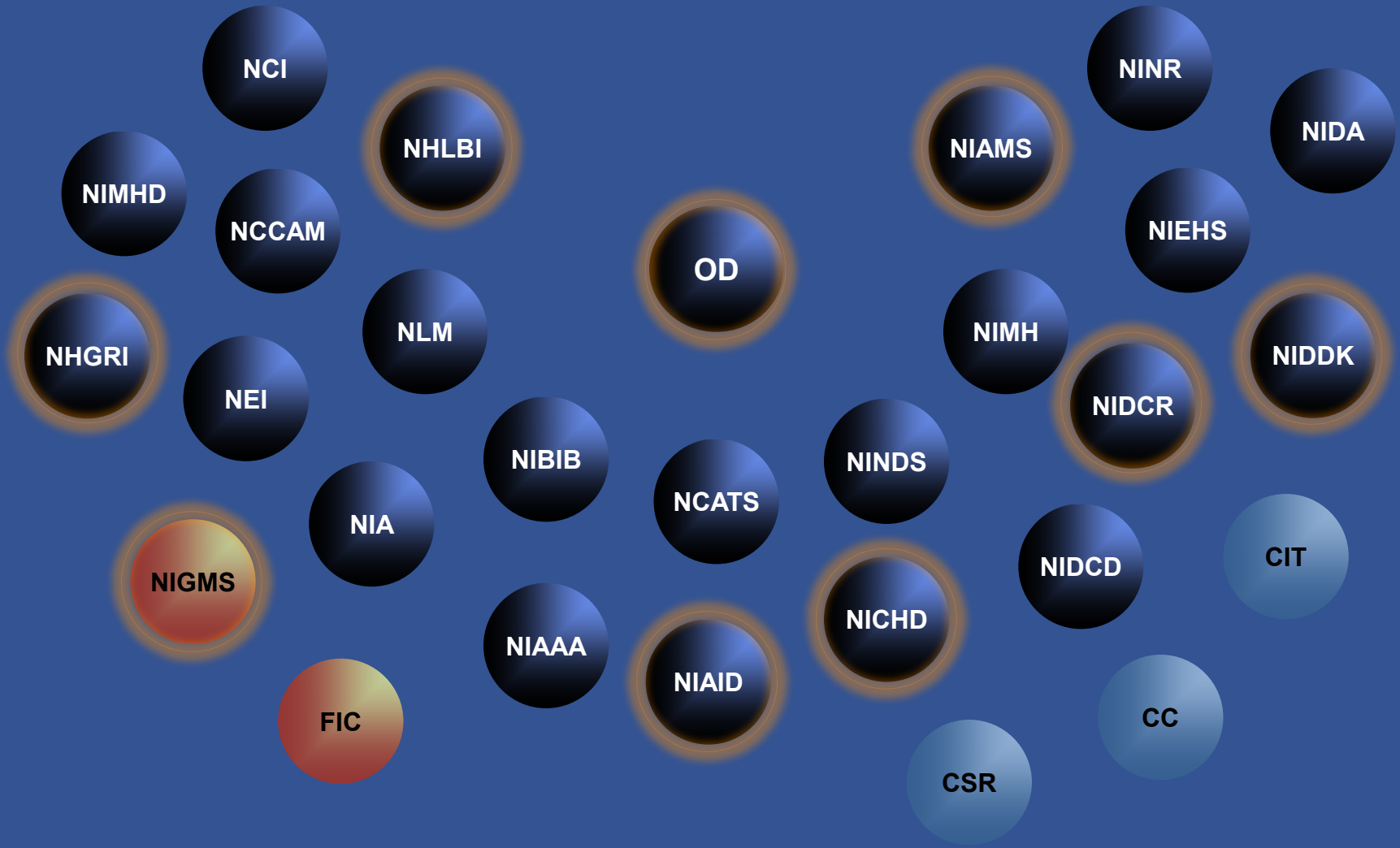
HMP Support from ICs

Before 2008



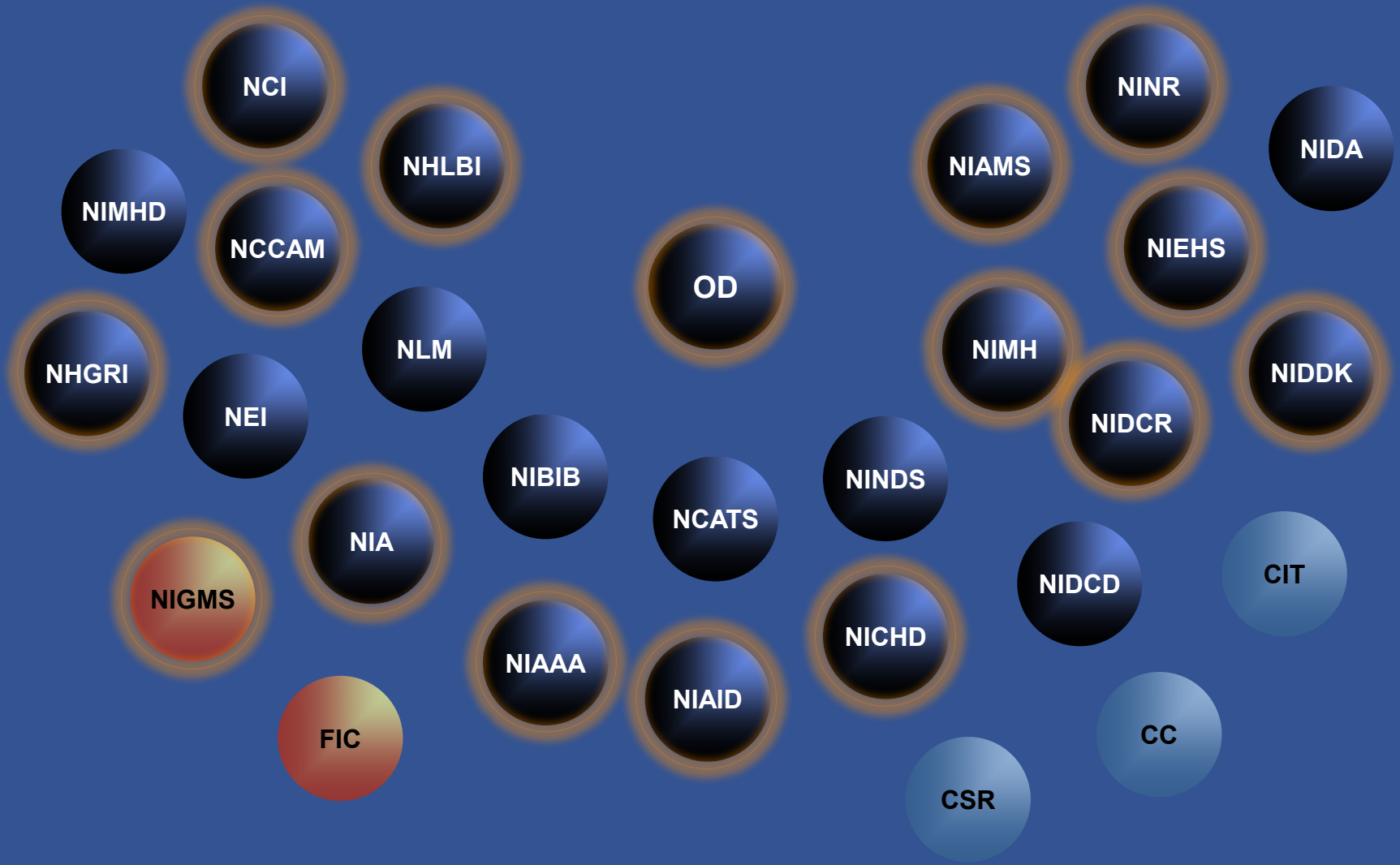
HMP Support from ICs

2008–2012



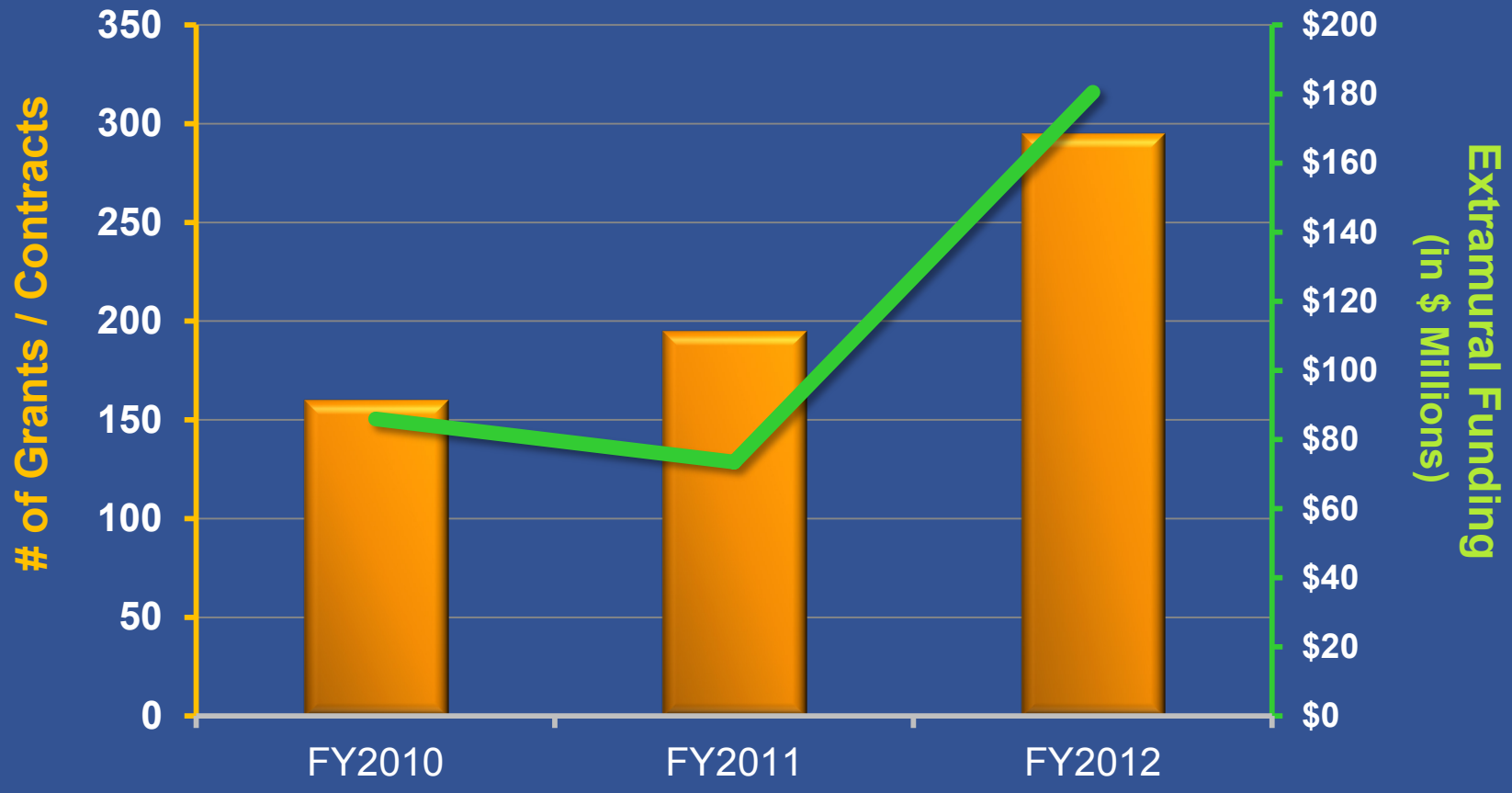
HMP Support from ICs

2013



Beyond HMP: Additional NIH Support for Human Microbiome-related Research

FY2010–FY2012




4 September 2008 | www.nature.com/nature | $10
THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE
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Viral infections for viruses
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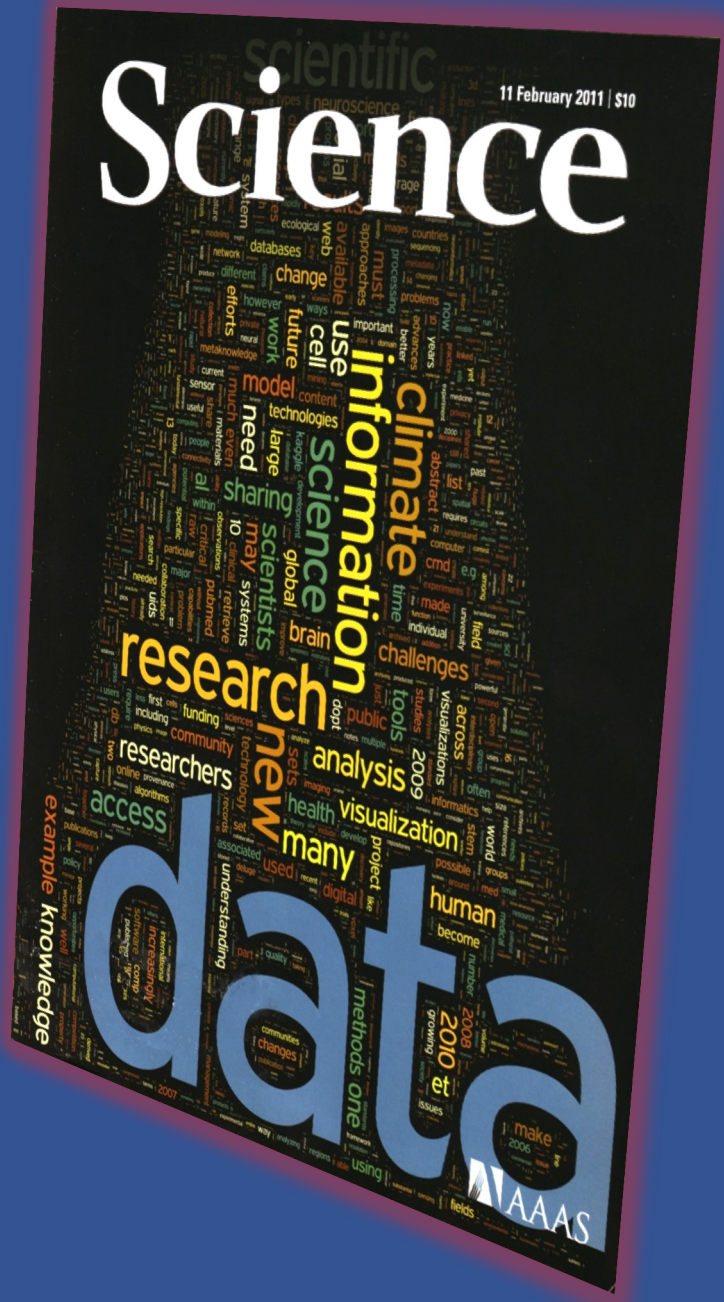
SCIENCE IN THE PETABYTE ERA


Science
11 February 2011 | $10
data
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The Human Microbiome: Transforming Our Understanding of Health and Disease

NIH National Institutes of Health
Turning Discovery Into Health

BLOG NIH HOME PRIVACY & COMMENTS

NIH DIRECTOR'S BLOG

Who Knew? Gut Bacteria Contribute to Malnutrition

By Dr. Francis Collins, on February 5th, 2013

Here's
severe
with a

Most o
bacter

nature Vol 457 | 22 January 2009 | doi:10.1038/nature07540

LETTERS

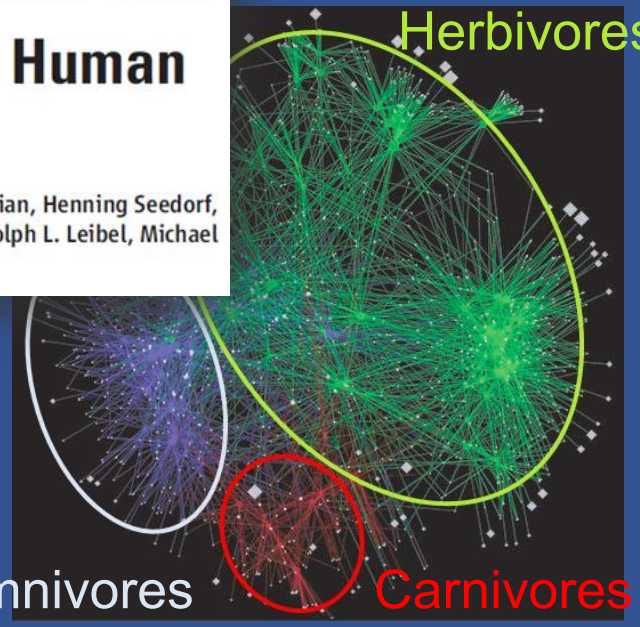
A core gut microbiome in obese and lean twins

Peter J. Turnbaugh[1], Micah Hamady[3], Tanya Yatsunenko[1], Brandi L. Cantarel[5], Alexis Duncan[2], Ruth E. Ley[1], Mitchell L. Sogin[6], William J. Jones[7], Bruce A. Roe[8], Jason P. Affourtit[9], Michael Egholm[9], Bernard Henrissat[5], Andrew C. Heath[2], Rob Knight[4] & Jeffrey I. Gordon[1]

Science 5 JULY 2013 VOL 340

The Long-Term Stability of the Human Gut Microbiota

Jeremiah J. Faith, Janaki L. Guruge, Mark Charbonneau, Sathish Subramanian, Henning Seedorf, Andrew L. Goodman, Jose C. Clemente, Rob Knight, Andrew C. Heath, Rudolph L. Leibel, Michael Rosenbaum, Jeffrey I. Gordon*



VOLUME 19 | NUMBER 5 | MAY 2013 nature medicine

Intestinal microbiota metabolism of L-carnitine, a nutrient in red meat, promotes atherosclerosis

Robert A Koeth[1,2], Zeneng Wang[1,2], Bruce S Levison[1,2], Jennifer A Buffa[1,2], Elin Org[3], Brendan T Sheehy[1], Earl B Britt[1,2], Xiaoming Fu[1,2], Yuping Wu[4], Lin Li[1,2], Jonathan D Smith[1,2,5], Joseph A DiDonato[1,2], Jun Chen[6], Hongzhe Li[6], Gary D Wu[7], James D Lewis[6,8], Manya Warrier[9], J Mark Brown[9], Ronald M Krauss[10], W H Wilson Tang[1,2,5], Frederic D Bushman[5], Aldons J Lusis[3] & Stanley L Hazen[1,2,5]




NIH…

Turning Discovery Into Health