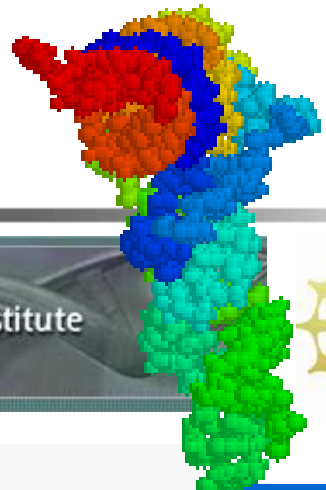


The Personal Genome Project

7-Dec-2009 4:15 Whitehead Institute



Edge

National Cancer Institute
U.S. National Institutes of Health | www.cancer.gov

genome.gov
National Human Genome Research Institute
National Institutes of Health



BILL & MELINDA GATES foundation

BRIDGING THE GAP
DARPA
POWERED BY IDEAS

National Heart Lung and Blood Institute

GENOMES to LIFE
BIOLOGICAL SOLUTIONS FOR ENERGY CHALLENGES
U.S. DEPARTMENT OF ENERGY
INNOVATIVE APPROACHES ALONG UNCONVENTIONAL PATHS

WYSS INSTITUTE LSRF

Complete Genomics

CORIELL INSTITUTE for Medical Research

OrbiMed
Healthcare Fund Management

molecular systems biology

A new type of online journal from EMBO and Nature Publishing Group

Google

RBH

Knome Roche

AFFYMETRIX

Counsyl

23andMe

Azco

Agilent Technologies

Helicos
BioSciences Corporation

Applied Biosystems

illumina

enzymatics

The Ellison Medical Foundation
A non-profit CORPORATION

DANAHER MOTION

LS9, INC.
the renewable petroleum company™

ISILON SYSTEMS

BEIJING INSTITUTE OF GENOMICS
CHINESE ACADEMY OF SCIENCES

QTEROS
Biofuels from advanced microbiology

HSCI
HARVARD STEM CELL INSTITUTE

BROAD INSTITUTE

PERSONALGENOMES.ORG

Human Genome Project

JOULE

**What inspires
us to
participate?**

To learn?

To take risks?

(Cultural, physical, financial)



Armstrong, Collins, Aldrin

\$3 billion



2003

\$100 million



2005

\$1 million



2007

\$5000



2009

\$0



2011

Shrinking cost of your genome

**Million-fold
in 6 years**

What does \$0 to the consumer mean?



Web 2.0,
Crowd-sourcing

2001 Wikipedia

1998 Search, Maps, Translation ..

But these new technologies (cell phone, fax, PC) are only as good as their communities.



Will genomes be like faces?



**Revealing our ancestry, personality, health ..
but still generally shared.**

The Personal Genome: Do I want to know?

1. Expensive
- 2. Discriminative**
3. Worthless

Genetic Information
Nondiscrimination Act of 2008
(**GINA**)

Employment & health insurance

Destigmatization vs enhanced hiding

(addressing causes vs symptoms)

- **Ethnicity**
- **Sexuality GLBT**
- **Cancer**
- **Facebook.com**
- **PatientsLikeMe.com**
 - **HIV-AIDS**
 - **Neurodegenerative Disorders**
 - **Psychiatric Meds**

**MY FIRST
DNA SEQUENCE**

The same tech megatrends that are reshaping grown-up gadgets are revolutionizing kids' toys. Nowadays, youngsters can race nitro-powered remote control trucks, fiddle with programmable robots, and guest-star in the latest sitcoms. If these aren't sophisticated enough for your brainiac tykes, the Discovery Kids DNA Explorer helps junior scientists extract and map real deoxyribonucleic acid. As third-grade science projects go, this is light-years beyond the of baking soda volcano. Next step: cloning Fido.

[DNA Explorer (ages 10 and up): \$80, www.discovery.com]

DIY Bio

DNA Explorer, \$80
(Ages 10 and up)



Genographic \$99

23andme \$399

**Spit Kit Instructions**

Do not eat, drink, smoke or chew gum for 20 minutes before collecting your saliva sample. Place the tube in the base during the collection process to prevent spills or mixing of samples. Strip the sample to the container with the shipping cap and additional instructions provided inside the envelope.

**Step 1**

1. Spit into the tube for 20 seconds. Do not eat, drink, smoke or chew gum for 20 minutes before collecting your saliva sample.

**Step 2**

2. Seal the tube with the cap. Do not touch the cap or the tube after sealing.

**Step 3**

3. Place the tube in the shipping container. Do not touch the cap or the tube after placing it in the container.

**Step 4**

4. Seal the shipping container. Do not touch the cap or the tube after sealing.

Remember, you are using the kit collected with your name.

► Prep the S
Before extracting
Dr. Frankenstein
specimen and pre
works on all kind
basics, or even lo

the Mystery
is later, Dr. F can
of stain (we recom
sured felt to explor
other - genetic
your health

Anonymity vs Open-access?

Trends in laws to make data public (not just at elite institutions): e.g. H.R. 2764, SEC. 218. 26-Dec-07 open-access publishing for all NIH-funded research.

(12) Identify individual case/control status from pooled SNP data Homer et al PLoS Genetics 2008 as this became known, NCBI pulled dbGAP data

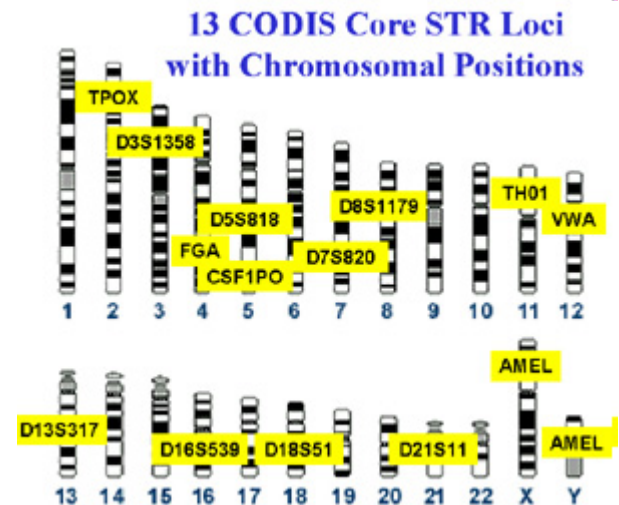
(11) Re-identification after “de-identification” using public data. Group Insurance list of birth date, gender, zip code sufficient to re-identify medical records of Governor Weld & family via voter-registration records (1998)

Self identification trend

(10) Unapproved self-identification. e.g. Celera IRB. (Kennedy Science. 2002)

(9) Obtaining data about oneself via FOIA or sympathetic researchers.

(8) DNA data CODIS data in the public domain.
even if acquitted



Anonymity vs Open-access?

Accessing “Secure data”

- (7) **Laptop loss**. 26 million Veterans' medical records, SSN & disabilities stolen Jun 2006.
- (6) **Hacking**. A hacker gained access to confidential medical info at the U. Washington Medical Center -- 4000 files (names, conditions, etc, 2000)
- (5) **Combination of surnames from genotype with geographical info** An anonymous sperm donor traced on the internet 2005 by his 15 year old son who used his own Y chromosome data.
- (4) **Identification by phenotype**. If CT or MR imaging data is part of a study, one could reconstruct a person's appearance . Even blood chemistry can be identifying in some cases.
- (3) **Inferring phenotype from genotype** Markers for eye, skin, and hair color, height, weight, geographical features, dysmorphologies, etc. are known & the list is growing.
- (2) **“Abandoned DNA** bearing samples (e.g. hair, dandruff, hand-prints, etc.)
- (1) **Government subpoena**. False positive IDs and/or family coercion



**Newborns are tested for up to 40 traits
(e.g. PKU)**

**1526 Highly Predictable & actionable
gene tests (not SNP chips)**

**As with security/insurance purchases, we
are all at risk, even though we don't
expect to see direct payback.**

The Personal Genome: Do I want to know, if there will be no medical action?

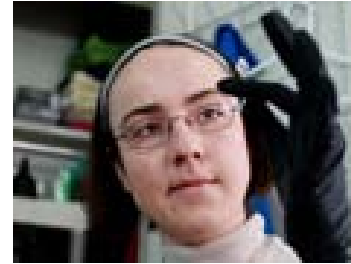
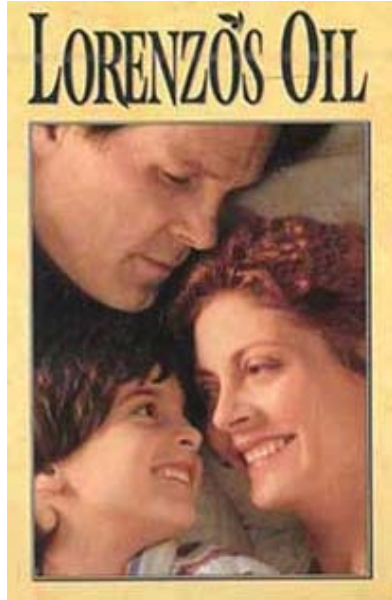
- 50% to 75% get good news

and for the rest:

- Planning – family, geography
- Research activism

Who can contribute to cures & prevention?

Motivating, donating, raising consciousness



HFE Aull
(engineer)



Huntington's Nancy Wexler
(psychologist)

Adrenoleukodystrophy
Odone (World Bank)



Parkinson's
Brin family
LRRK2 G2019S



Hugh Rienhoff, (MD)
MyDaughtersDNA.org



ALS Jamie
Heywood (engineer)
PatientsLikeMe.com

Genes environments traits, cells

Personal
Genome
Project

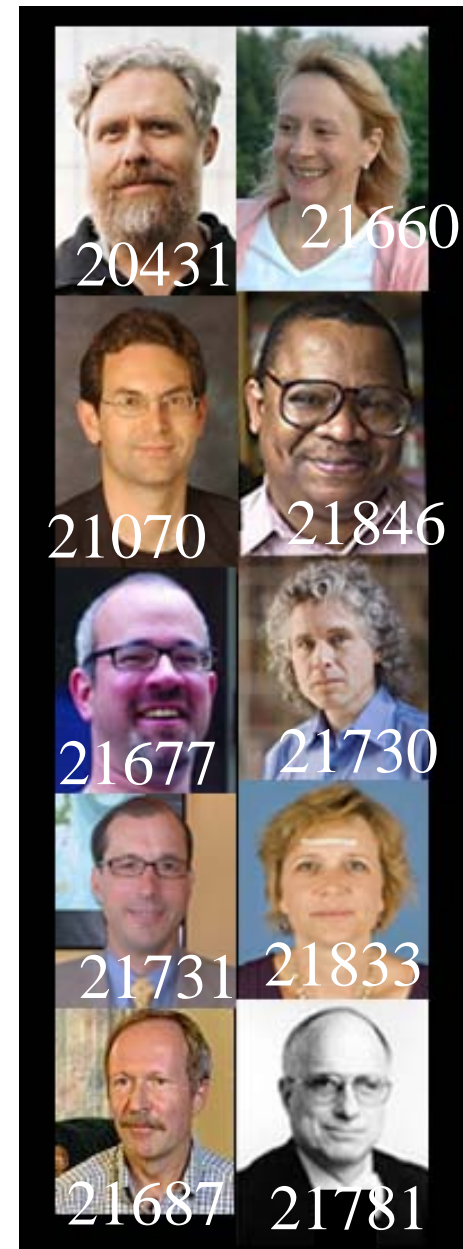


- 1) **Only open access db**
- 2) **Avoid over-promising on de-identification**
- 3) **100% on Exam** to assure informed consent
(*Educate pre-consent rather than post-discovery*)
- 4) **Low cost** whole genome sequences
- 5) **Multiple-traits**: images, stem cells, etc.
- 6) **IRB approval** for 100,000 diverse volunteers
15,000 since May 2009



PERSONALGENOMES.ORG™

501(c)(3)



Generic Health Advice

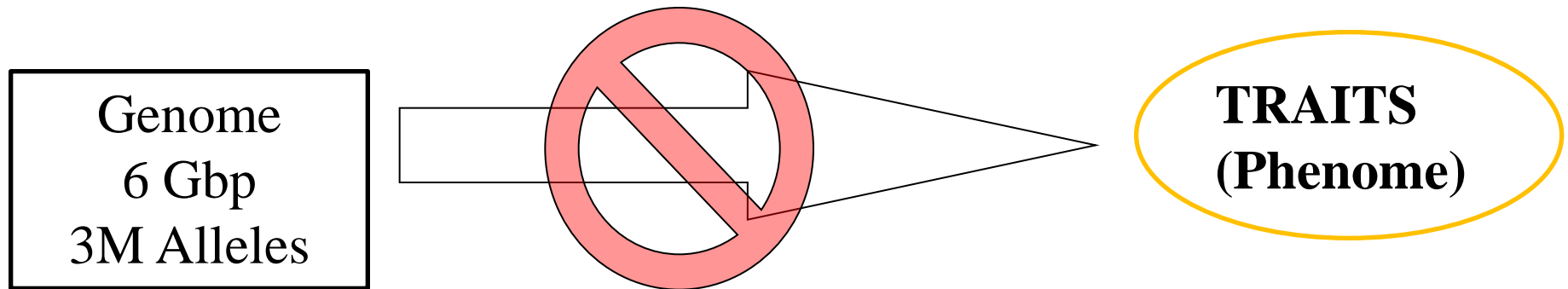
- **Exercise**
- **Drink your milk**
- **Eat your beans**
- **& your grains**
- **& your iron**
- **Get more rest**

UNLESS ...

- **Exercise** **HCM**
- **Drink your milk** **MCM6**
- **Eat your beans** **G6PD**
- **& your grains** **HLA-DQ2**
- **& your iron** **HFE**
- **Get more rest** **HLA-DR2**

Diagnostics Systems Biology Challenge

**NOT going from ONLY Genome Sequence
to Prediction**

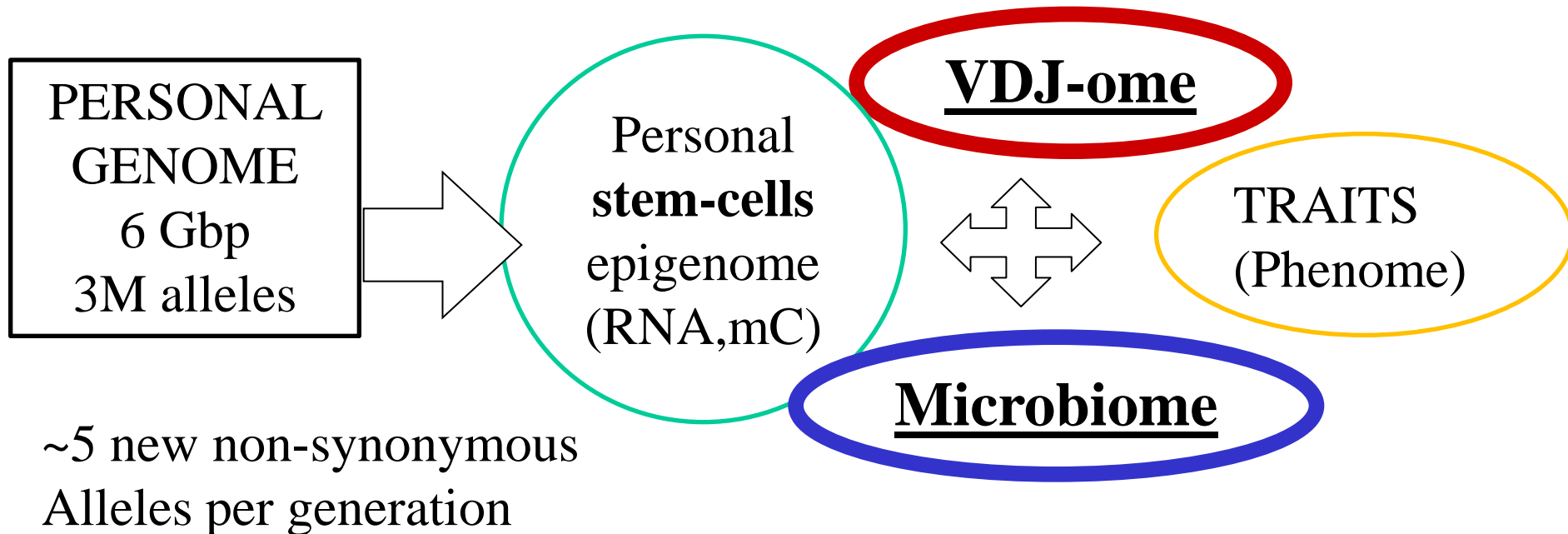


PersonalGenomes.org

Inherited, Somatic, Environmental Genomics

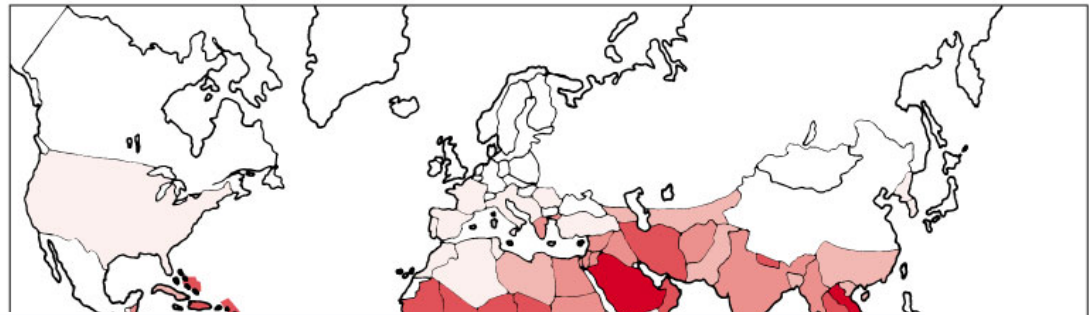
One in a life-time genome + yearly (to daily) tests

Public Health **Bio-weathermap.org** : Allergens, Microbes, Viruses



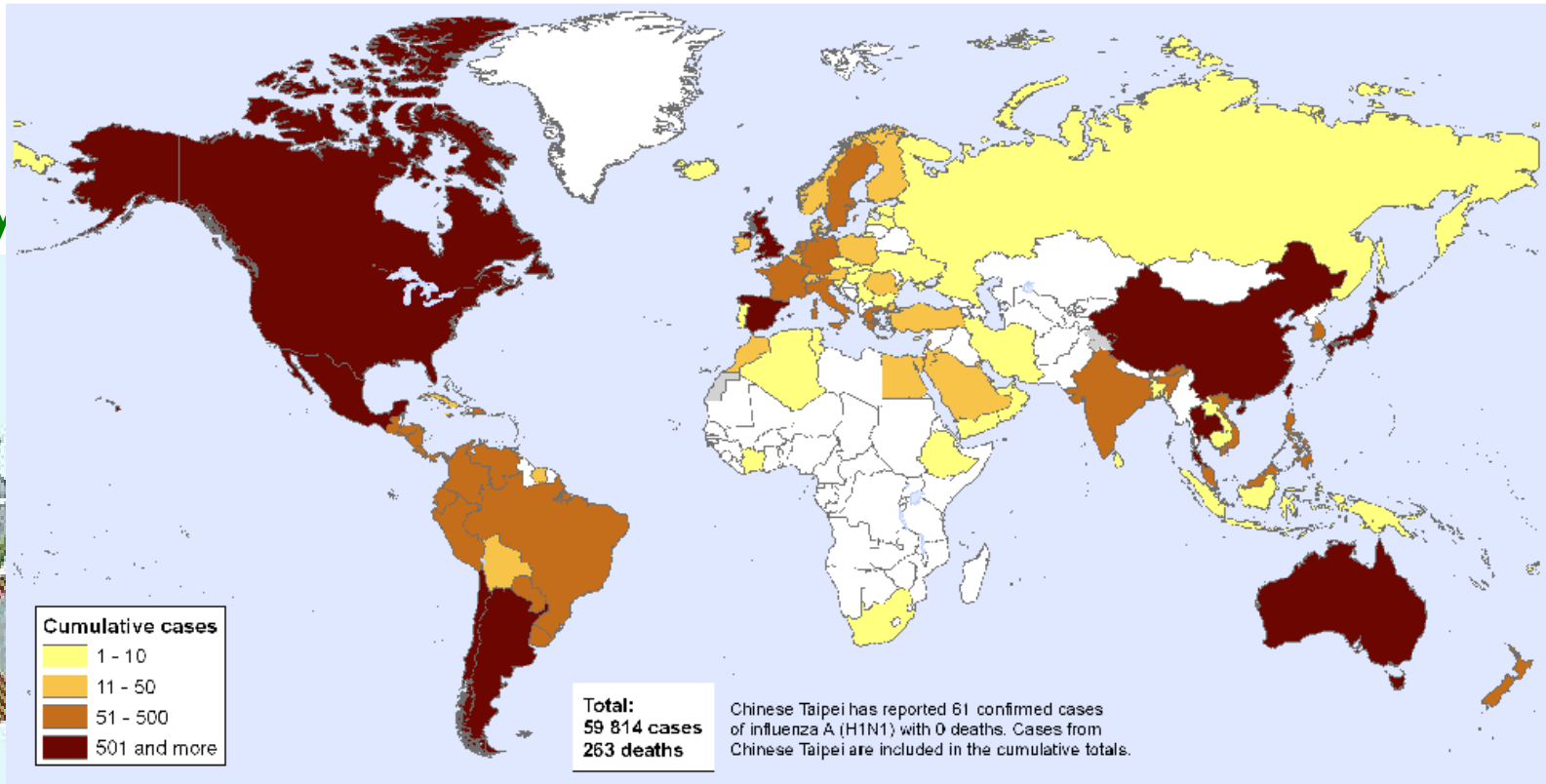
G6PD ..

(food/drug induced hemolytic anemia)



New Influenza A (H1N1),
Number of laboratory confirmed cases as reported to WHO

Status as of 26 June 2009
06:00 GMT

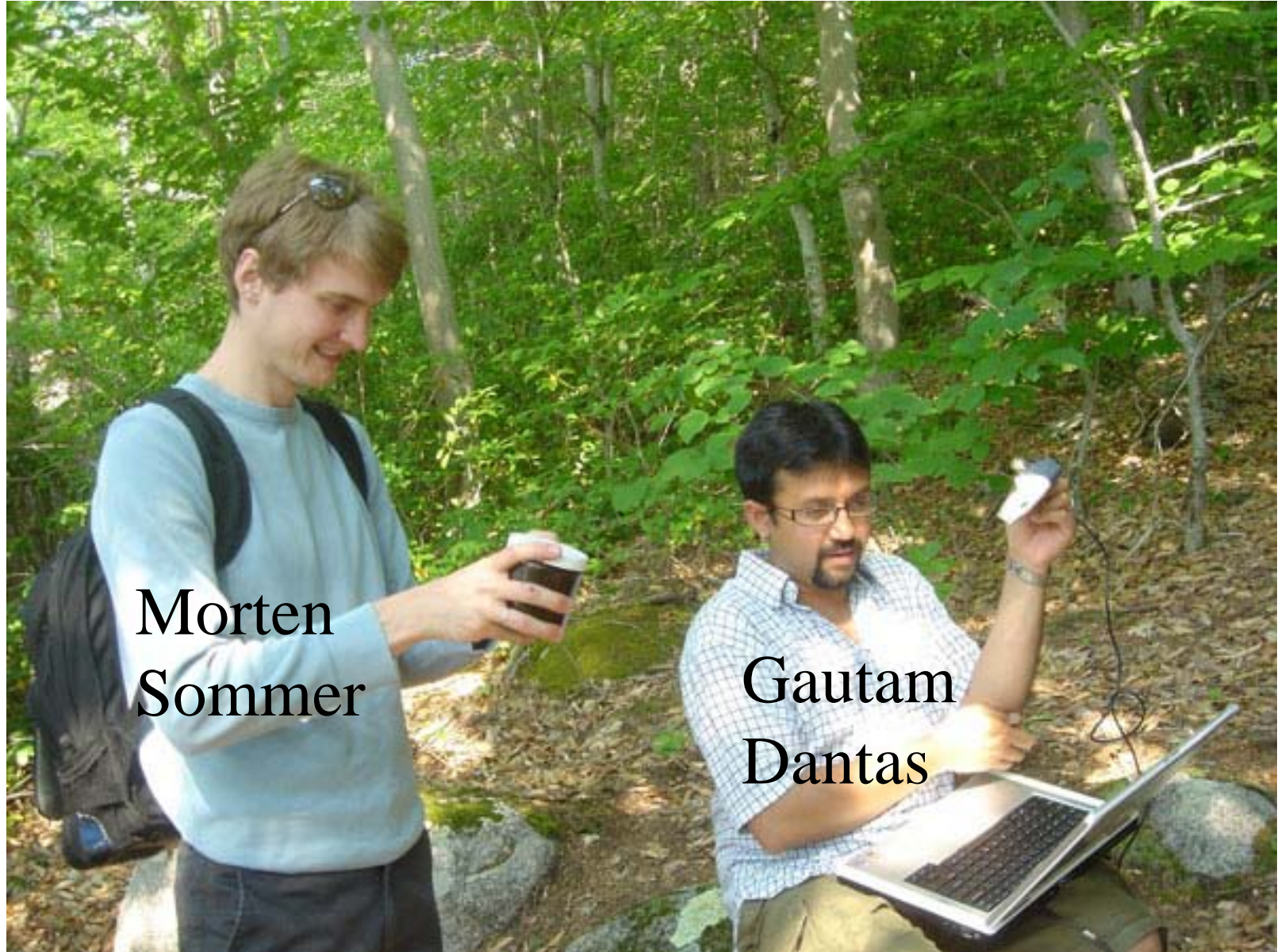


N

nia



Even far from hospitals & farms



Morten
Sommer

Gautam
Dantas

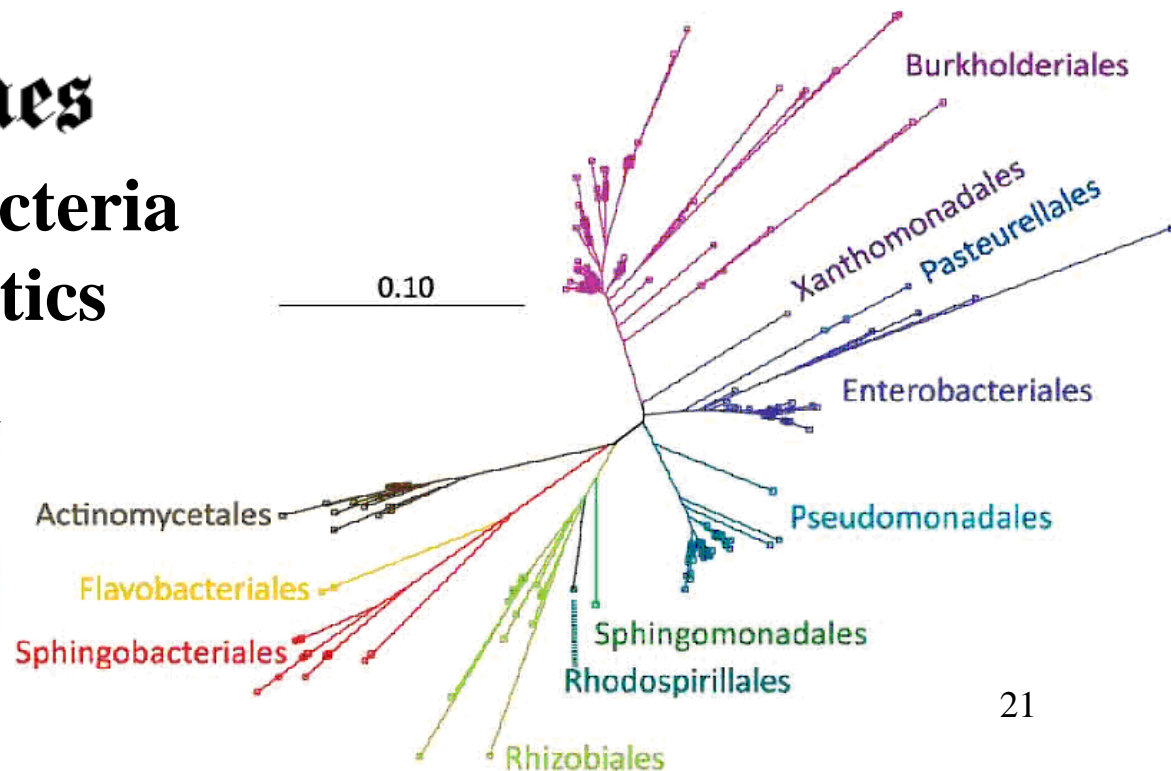
Even far from hospitals & farms are multi-drug resistant microbes

Bacteria Subsisting on Antibiotics

Gautam Dantas,^{1*} Morten O. A. Sommer,^{1,2*} Rantimi D. Oluwasegun,¹ George M. Church

VOL 320 SCIENCE www.sciencemag.org

The New York Times
Researchers Find Bacteria
That Devour Antibiotics



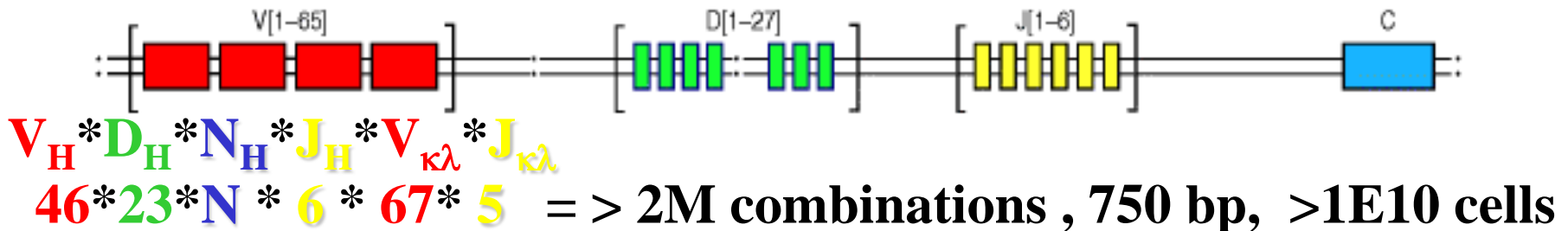
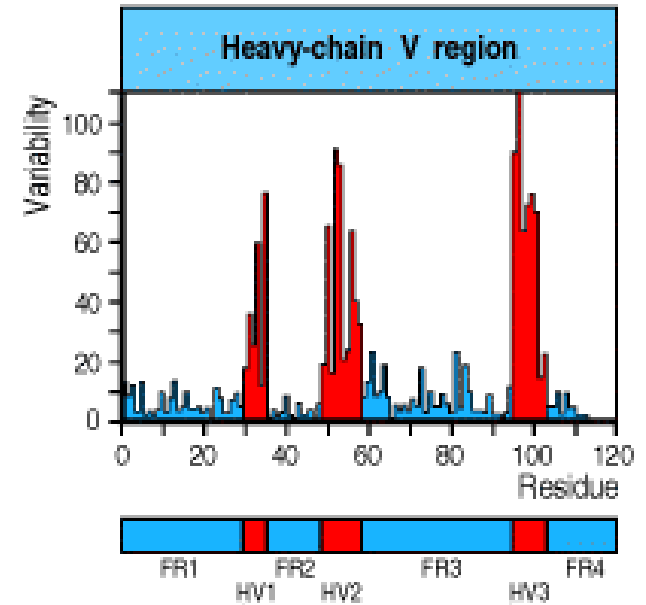
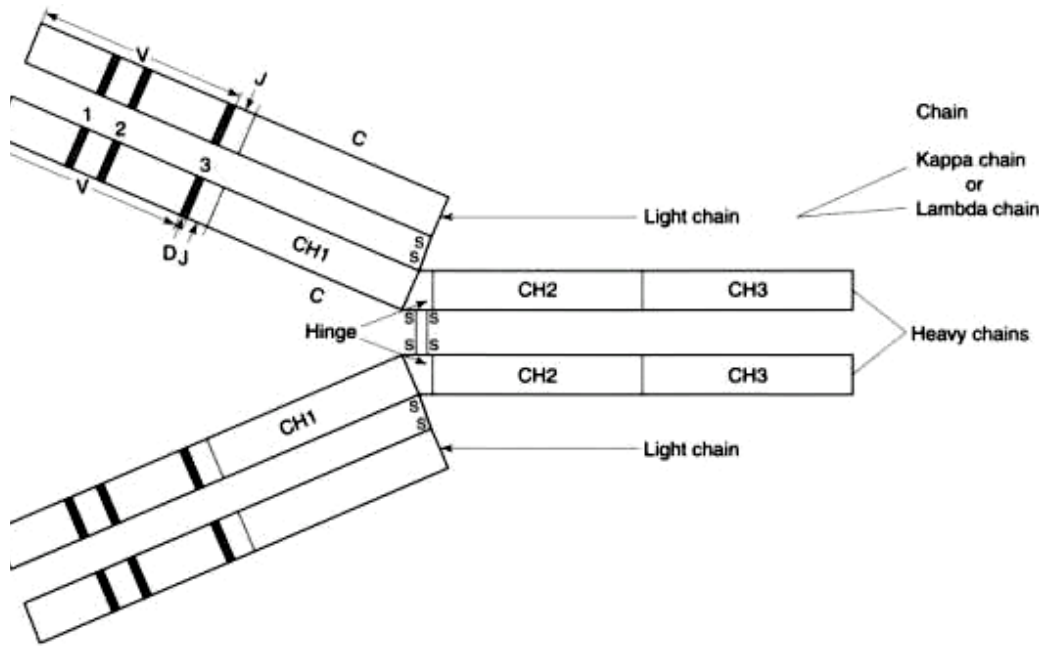
bioweathermap.org

Microbiome vs VDJ-ome

**Microbe tests: Detect Drug resistance spectrum
Earlier warning (e.g. meningitis)**

**Immune tests: Focus on response to exposure
Longer times to detect exposure (e.g. HIV, TB)**

Antibody (& TCR) VDJ regions



Roth DB et al Mol Cell Biol. 1989 9:3049 N (1-13): 14 22 13 15 10 4 5 4 2 2 3 2 1

Lefranc, The Immunoglobulin FactsBook; Janeway, Immunobiology 2001

Time Series Vaccine Experiment

Tracking human dynamic response to vaccination to 11 strains:

Hepatitis A+B, Flu A/Brisbane/59/2007 (H1N1)-like, 10/2007
(H3N2)-like, B/Florida/4/2006-like virus

Polio, Yellow fever

Meningococcus

Typhoid, Tetanus

Diphtheria, Pertussis

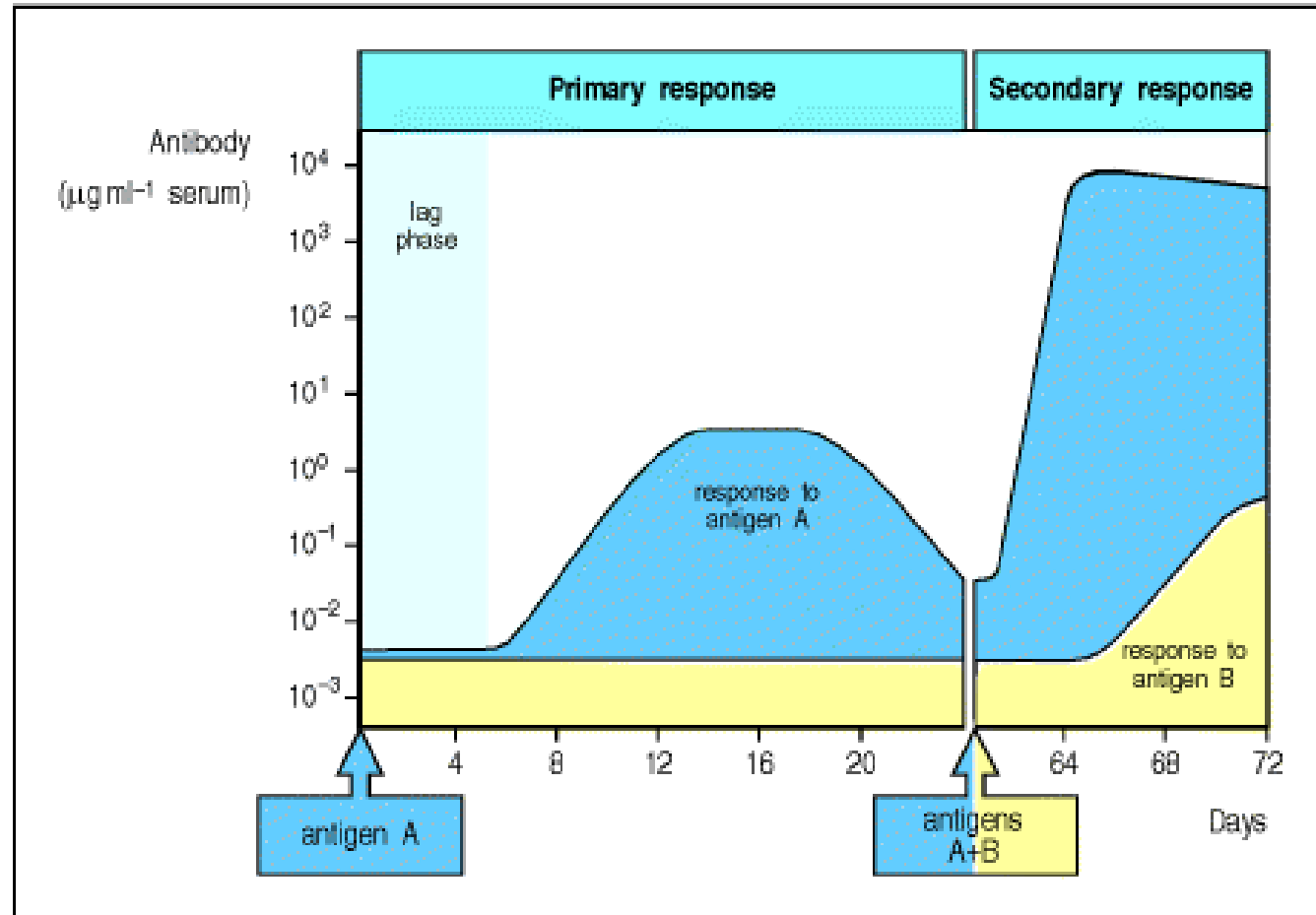
Collect samples at

-14d, 0d,

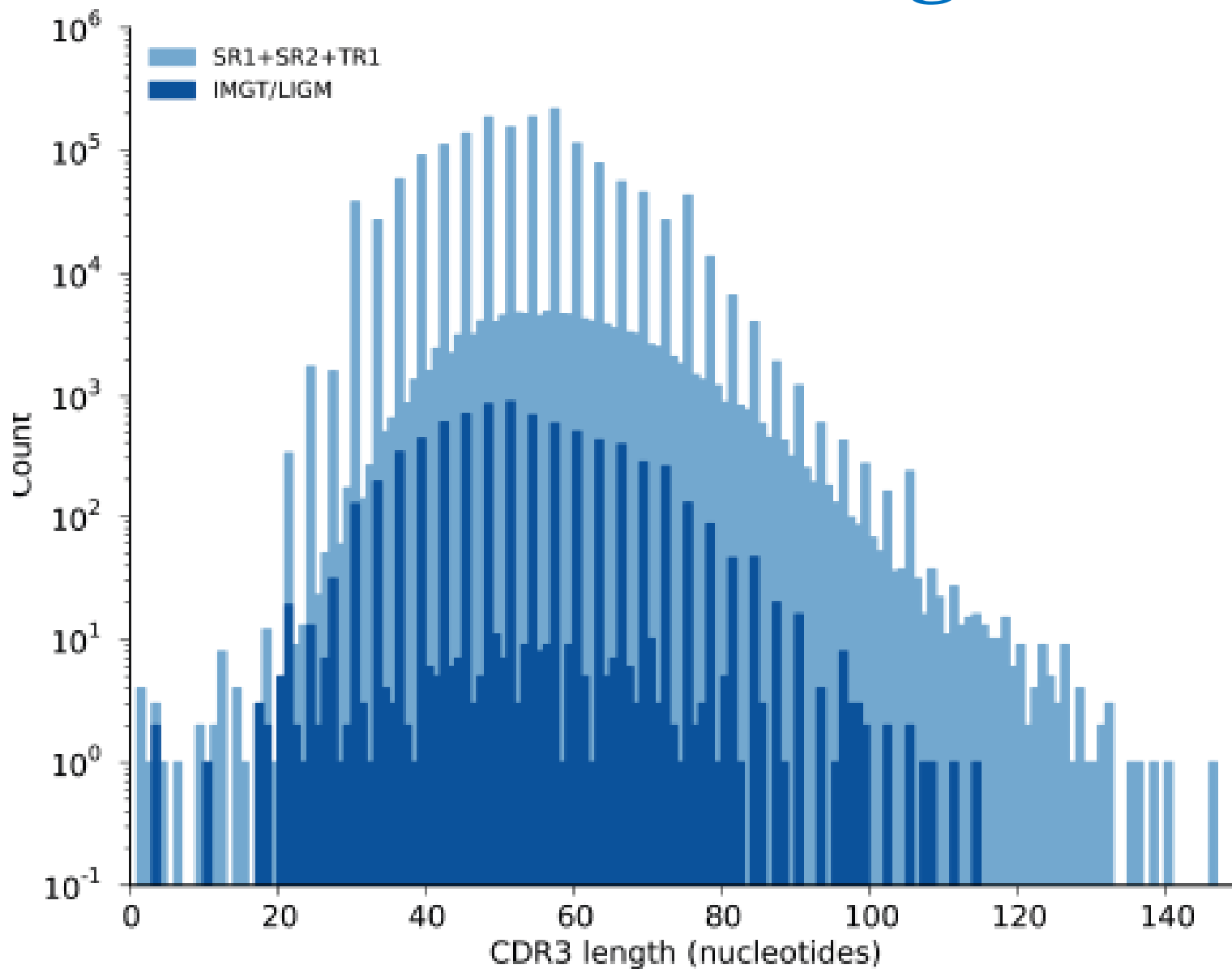
+1d, +3d,

+7d, +14d,

+21d, +28d



CDR3 length



The Personal Genome: Do I want to know?

- 1. Expensive: “If you think education is expensive .. try ignorance”**
- 2. Discriminative: Destigmatize, pass laws, educate**
- 3. Worthless: If we share, .. priceless**

Tools for Teachers (new!)

Outreach Program

We lead interactive workshops on topics related to personal genetics, bioethics and society.

[Learn more](#)

Personal genomes 101:

[▶ What is personal genome sequencing?](#)

[▶ Personal sequencing and medicine](#)

[▶ Genotype and phenotype](#)

[▶ Possible benefits](#)

[▶ Possible risks](#)

[▶ Ethical questions](#)

[▶ Time frame and stakeholders](#)

Tools for teachers: Lesson plans

This series of lesson plans is intended to facilitate the inclusion of ethics and personal genomes in the high school and college classroom. Each unit can function as a stand-alone lesson, or all units can be taught as a series. Lessons include a set of PowerPoint slides, suggestions for further reading, and materials for in-class and homework activities.

Unit Overview: Preparing to teach the lessons.

Download as a [Word Document](#) or [PDF](#).

1. Genome sequencing and ethical issues: Who, what, why, and when?

Download lesson plan as a [Word Document](#) or [PDF](#).

View Lesson 1 [slides](#).

2. How will knowing more about our genes change us? Exploring personal, family and psychological issues.

Download lesson plan as a [Word Document](#) or [PDF](#).

Download discussion scenarios as a [Word Document](#) or [PDF](#).

View lesson 2 [slides](#).

3. Genetics and reproduction: Ethical questions now and in the future.

Download lesson plan as a [Word Document](#) or [PDF](#).

Download discussion scenarios as a [Word Document](#) or [PDF](#).

Download teacher's notes for discussion as a [Word Document](#) or [PDF](#).

View lesson 3 [slides](#).

Four open-source resources



PERSONALGENOMES.ORG™



Polonator.org



bioweathermap.org

snp.med.harvard.edu

(Genes + Environment = Trait prediction)