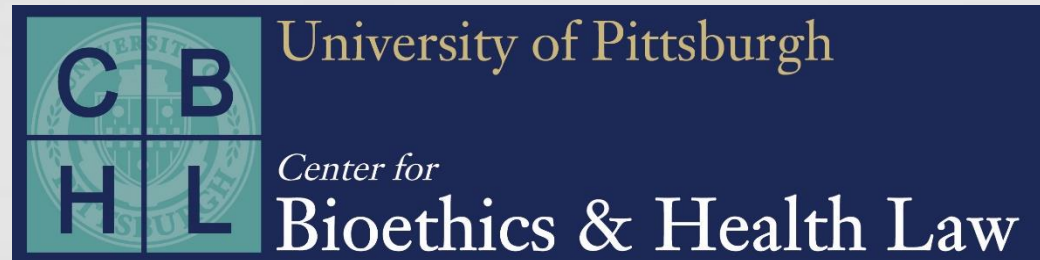


Personal Genomic Testing and Precision Medicine

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Goals

- Define precision medicine
 - ≠ genomic medicine
 - Types & uses of genetic testing /genomic sequencing
 - Understand the benefits and limitations of precision medicine
- Discuss direct-to-consumer genetic testing
 - Help to inform decisions about its use
- Discuss some concerns about genetic info
 - Privacy, security, accuracy
- Question whether, when, & how info is empowering

- ‘Genetics’ refers to the study of genes and their roles in inheritance—in other words, the way that certain traits or conditions are passed down from one generation to another.
 - Genetics involves scientific studies of genes and their effects.
 - Genes (physical units of heredity) carry the instructions for making proteins, which direct the activities of cells and functions of the body.
- ‘Genomics’ is a more recent term that describes the study of all of a person's genes (the genome), including interactions of those genes with each other and with the person's environment.
 - G x E — gene x environment interaction
 - Uterine, physical, chemical, social, behavioral environments

“We used to think that our fate was in our stars, but now we know that, in large measure, our fate is in our genes.”

James Watson, 1989, quoted by Leon Jaroff

“I think it won't be too many years before parents will be able to go home from the hospital with their newborn babies with a genetic map in their hands that will tell them, here's what your child's future will likely be like.”

President Bill Clinton, 1996



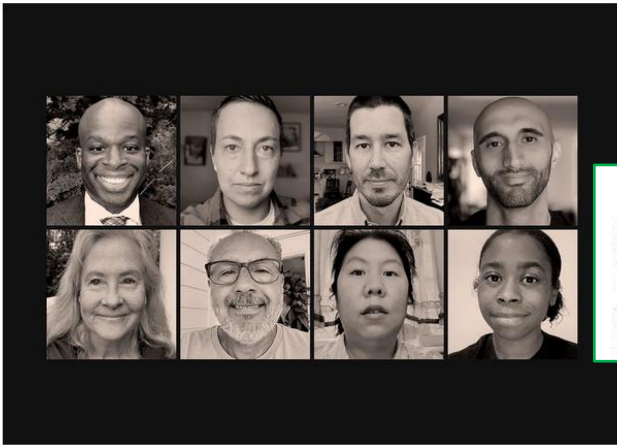
Zip code better predictor of health than genetic code

The New York Times

STUDENT OPINION

How Much Has Your ZIP Code Determined Your Opportunities?

To what extent has where you were born, and where you've grown up, affected who you are?

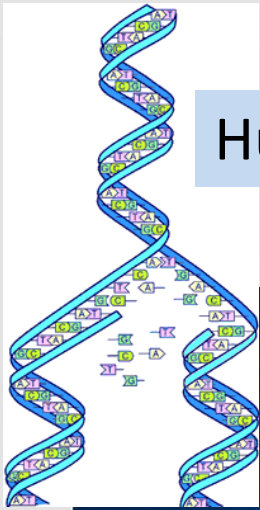


Form **1040** Department of the Treasury—Internal Revenue Service (99) **2019** OMB No. 1545-0074 IRS Use Only—Do not write or staple in this space.

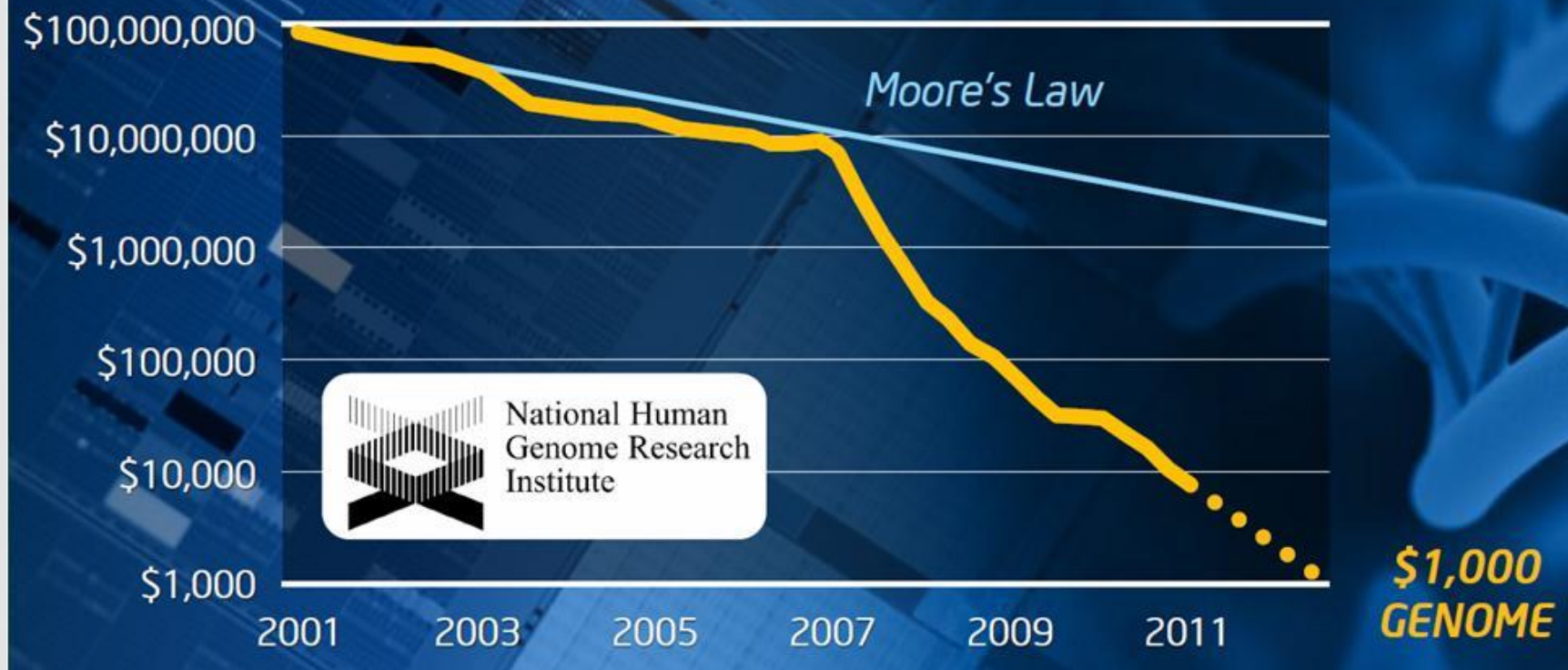
Filing Status Single Married filing jointly Married filing separately (MFS) Head of household (HOH) Qualifying widow(er) (QW)

Check only one box.
If you checked the MFS box, enter the name of spouse. If you checked the HOH or QW box, enter the child's name if the qualifying person is a child but not your dependent. ▶

Human Genome Project (1990 – 2003), \$2.7B



Reducing the Cost of Human Genome Sequencing



THE PRECISION MEDICINE INITIATIVE



THE PRECISION MEDICINE INITIATIVE



“Doctors have always recognized that every patient is unique, and doctors have always tried to tailor their treatments as best they can to individuals. You can match a blood transfusion to a blood type — that was an important discovery. What if matching a cancer cure to our genetic code was just as easy, just as standard? What if figuring out the right dose of medicine was as simple as taking our temperature?”

- President Obama, January 30, 2015

So what is Precision Medicine?

It's health care tailored to you.

In his 2015 State of the Union address, President Obama announced that he's launching the Precision Medicine Initiative — a bold new research effort to revolutionize how we improve health and treat disease.

Until now, most medical treatments have been designed for the “average patient.” As a result of this “one-size-fits-all” approach, treatments can be very successful for some patients but



Personalized, precision medicine

“Doctors have always recognized that every patient is unique, and doctors have always tried to tailor their treatments as best they can to individuals. You can match a blood transfusion to a blood type — that was an important discovery. What if matching a cancer cure to our genetic code was just as easy, just as standard? What if figuring out the right dose of medicine was as simple as taking our temperature?”

— President Obama, January 30, 2015

Medicine

conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients. The practice of evidence based medicine means **integrating individual clinical expertise with the best available external clinical evidence from systematic research.**

(BMJ 1996;312:71-72)

- Evidence-based
 - Epidemiologically based
 - Population-based
 - **Association, not causation**

● Personalized

● Precision

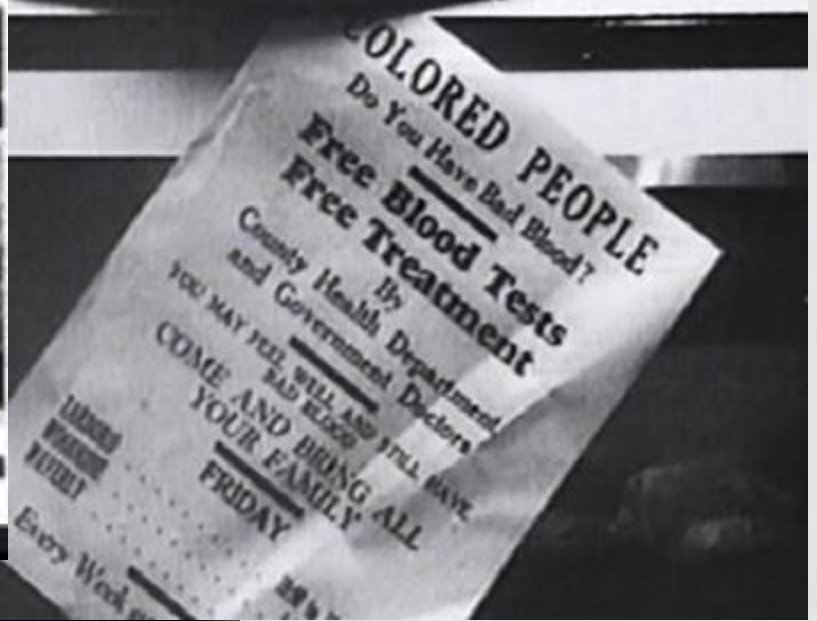
● Stratified

'Personalized medicine' refers to the tailoring of medical treatment to the individual characteristics of each patient. It does not literally mean the creation of drugs or medical devices that are unique to a patient, but rather **the ability to classify individuals into subpopulations that differ in their susceptibility to a particular disease, in the biology and/or prognosis of those diseases they may develop, or in their response to a specific treatment.** Preventive or therapeutic interventions can then be concentrated on those who will benefit, sparing expense and side effects for those who will not.
(President's Council of Advisors on Science and Technology)

US experience with stratification

“... the Human Genome Project will bring to the forefront of human consciousness awareness of the range of variability not only among individuals but among groups. To acknowledge these differences, while insisting on their irrelevance for individual dignity and equality of right, is a challenge we shall have to face.”

Harold Edgar, 1992



**HERMAN SHAW
TUSKEGEE STUDY SURVIVOR**



Entry of your email address is not necessary to redeem the offer. I consent to the



this email service. I understand that I may withdraw my consent



🌸 MOTHER'S DAY OFFER 🌸

Give your Supermom
even more power over
her health.

**\$50
OFF**

when you buy ONE
Health + Ancestry kit

**\$150
OFF**

when you buy TWO
Health + Ancestry kits

Shop now

Offer ends May 9





Three steps. It's simple.

All from home. No blood. No needles. Just a small saliva sample.

1

Order

Choose from our Health + Ancestry or Ancestry + Traits services. Your saliva collection kit is the same for both services and typically arrives within 3 to 5 days. Express shipping is available.

2

Spit

Follow kit instructions to spit in the tube provided – all from home. Register your saliva collection tube using the barcode so we know it belongs to you, and mail it back to our lab in the pre-paid package.

3

Discover

In approximately 3-5 weeks, we will send you an email to let you know your reports are ready in your online account. Log in and start discovering what your DNA says about you.



What's in the kit.



saliva collection kit



specimen bag

 A vertical sheet of paper containing the user instructions for the saliva collection kit. It features a 23andMe logo at the top, followed by the title "Saliva Collection Kit User Instructions". The instructions are presented in six numbered steps, each with a small illustration:

- 1** No food or drink for 30 minutes. (Illustration shows a glass and a cup with a red 'X' over them.)
- 2** Spit into the funnel until the amount of liquid saliva (not bubbles) reaches the fill line shown in picture #2. (Illustration shows a hand spitting into a funnel.)
- 3** Close funnel lid. (Illustration shows a hand closing the funnel lid.)
- 4** Screw on cap. (Illustration shows a hand screwing a cap onto the tube.)
- 5** Seal in bag. (Illustration shows the kit being placed into a specimen bag.)
- 6** Ship box. (Illustration shows the sealed bag being placed into a shipping box.)

 Additional text includes:

- Read all instructions prior to collection.**
- Indications for use:** Origen®-Cx OGD 500 001 is intended for use in the non-invasive collection of saliva samples. DNA from the saliva sample is isolated, stabilized, and suitable for over-the-counter use with FDA cleared, approved, or legally marketed exempt DNA carrier screening genotyping tests. Saliva samples collected using Origen®-Cx OGD 500 001 are stabilized and can be transported and/or stored long term at ambient conditions.
- Special conditions for use:** DNA carrier screening is intended for adults of reproductive age.
- Contents:** Kit contains stabilizing liquid.
- Warnings and precautions:** Wash with water if stabilizing liquid comes in contact with eyes or skin. Do NOT ingest. See MSDS at 23andme.com/safety-data-sheet. Small cap may pose a choking hazard.
- Storage:** 15°C (±30°C).
- Summary and explanation of the kit:** Origen®-Cx OGD 500 001 is a self-collection kit that provides the materials and instructions for collecting and stabilizing saliva samples.
- Register this kit at 23andme.com/kit** Your sample will NOT be processed unless it is registered.
- Procedure:** Most people take between 2 and 5 minutes to deliver a saliva sample following steps 1-6.

step by step instructions



funnel lid

saliva collection tube

tube cap

tube container

Ancestry Detail

Vietnam
Ho Chi Minh City

WEAKER STRONGER
Evidence of recent ancestry

Ancestry Composition

East Asian & Native American	58.6%
Chinese & Southeast Asian	53.4%
Vietnamese Ho Chi Minh City, Vietnam + 1 Region	46.3%
Indonesian, Thai, Khmer & Myanmar	7.0%

Cilantro Taste Aversion

YOUR RESULT

You have *slightly higher odds* of disliking cilantro.

Your genotype
AA
Marker rs2741762

C12H22O

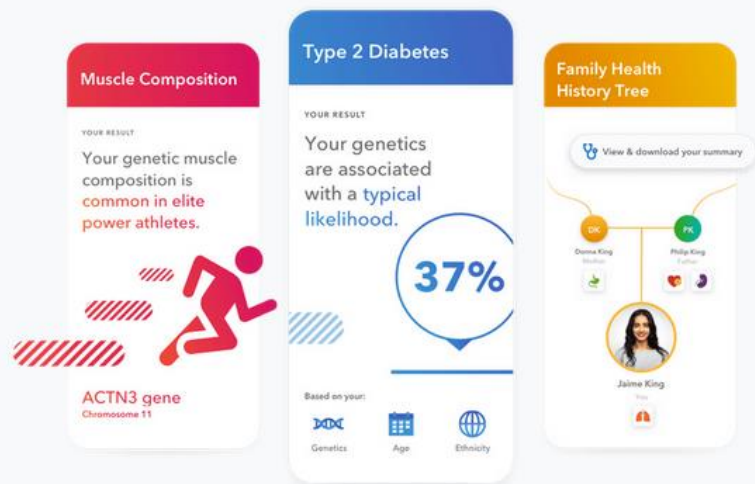
Ancestry + Traits Service

The best DNA kit with the most comprehensive ancestry breakdown and 30+ trait reports.

- 80+ personalized reports
- Ancestry percentages (to the 0.1%)
- 2000+ geographic regions
- Health upgrade available

Add to cart

\$99



Health + Ancestry Service

Get personalized genetic insights and tools that can help make it easier for you to take action on your health.

- 150+ personalized reports
- Includes Ancestry + Traits Service
- Includes FDA-authorized reports
- FSA/HSA eligibility*



Add to cart

~~\$199~~ **\$149**

There is a lot to consider with genetic testing. We encourage you to review relevant information about Carrier Status* and Genetic Health Risk* reports.

Important test info

2010: concerns about info accuracy



The screenshot shows the top of the GAO website. The header is blue with the GAO logo and the text "U.S. Government Accountability Office". To the right is a search bar with the text "Keyword or Report #" and "Advanced Search". Below the header is a navigation menu with several tabs: "Reports & Testimonies", "Bid Protests & Appropriations Law", "Key Issues", "About GAO", "Careers", "Multimedia", and "Resources".



MEDICAL NEWS
& PERSPECTIVES

Inconsistent Results, Inaccurate Claims Plague Direct-to-Consumer Gene Tests

Bridget M. Kuehn

the US Food and Drug Administration during his testimony at the house hear-




DIRECT-TO-CONSUMER GENETIC TESTS:

Misleading Test Results Are Further Complicated by Deceptive Marketing and Other Questionable Practices

GAO-10-847T: Published: Jul 22, 2010. Publicly Released: Jul 22, 2010.

Testimony of Gregory D. Kutz,
<http://www.gao.gov/products/GAO-10-847T>;

Kuehn BM. *JAMA*, 2010, 304(12):1313-1315.

- 4 DTC companies, 5 “customers,” 15 diseases
 - 4/5 results conflicted with actual disease
 - Male received    risk of prostate CA

FDA allows marketing of first direct-to-consumer tests that provide genetic risk information for certain conditions

April 6, 2017

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Immediate Release: April 06, 2017

[Español](#)

Content current

as of:
03/28/2018

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Press Announcements

The U.S. Food and Drug Administration today allowed marketing of 23andMe Personal Genome Service Genetic Health Risk (GHR) tests for 10 diseases or conditions. These are the first direct-to-consumer (DTC) tests authorized by the FDA that provide information on an individual's genetic predisposition to certain medical diseases or conditions, which may help to make decisions about lifestyle choices or to inform discussions with a health care professional.



Your health starts in your genes.

Invitae ("in-VEE-tay") makes it easy to access your unique genetic information, so you can take control of your health.

[Find out more](#)[Register a kit](#)

Build your blueprint for better health.

Have a health question? We have a test for you.



Pregnancy

Get helpful information to guide important health decisions before and during pregnancy.



Staying healthy

Get what you need to develop a personalized health plan for heart disease, cancer, and more.



Cancer

Understand your genes so you and your doctor can find the most effective treatments.



Genetic illness

Find a diagnosis or understand if a condition is hereditary so you can zero in on the right treatment

Are you a healthcare provider? Visit our [provider site](#) for more information.

Considering genetic testing for the first time? [Take a short quiz](#) to find the right test for you.

Types or uses of genetic/genomic testing

- Diagnostic testing (single-gene, panel, or whole exome/genome sequencing)
 - Carrier screening (inform reproductive decisions)
 - Resolve a “diagnostic odyssey” or confirm diagnosis
- Predictive testing for susceptibility to disease
 - Variants in single genes (BRCA1/2, APOE, HTT (for HD))
 - Polygenic risk scores (PRS) where multiple genes each as a small effect
 - Clinically “actionable” or informs decisions
- Pharmacogenomic testing
- Tumor testing (to guide treatment or research)

Privacy – right to control access to / use of personal information about oneself

Why care about privacy

- Protect from harm
 - Reputation, relationship, economic interests
 - Effects on employability, insurability, marriageability
 - Protect family relationships, friendships
- Protect oneself from the “crippling public gaze”
 - Allow crafting of life plans & development of values, ideals, personality
 - Allow flourishing as an individual
 - Take risks, have a child, be an artist

Sources of risk to privacy

- Self-disclosure



- Privacy breach due to another’s
 - Carelessness
 - Malice
 - Non-malicious, but unwelcome seeking of info (insurers)



Your privacy is our priority.

You are in control. You choose how your personal genetic information is used and shared.

- We will not share your individual data without your explicit consent
- A federal law (GINA) provides protection from employer and health insurance discrimination based on your genetics
- We do not provide information to law enforcement unless we are required to comply with a valid subpoena or court order

Learn more details about our [privacy practices](#).

GINA does not apply to life, long-term care, disability, or auto insurance

Note the subpoena & court order exception

Security matters.

We have measures in place to prevent unauthorized access and ensure appropriate use of your genetic information.

- Separate databases keep your genetic information decoupled from your personally identifiable information, protecting your identity
- External firewalls restrict unauthorized connections to our databases
- All connections to our website are encrypted using SSL (Secure Sockets Layer) technology



Data is not anonymized, but info is “decoupled” from identifying info

Encryption & firewalls attempt to prevent hacking and unauthorized use




WIKIPEDIA
The Free Encyclopedia

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Featured content
Current events

Article Talk



List of data breaches

From Wikipedia, the free encyclopedia

Most breaches occur in North America. It is estimated that the average cost of a data breach will be over \$150 million by 2020, with the global annual cost forecast to be \$2.1 trillion.^{[1][2]} It is estimated that in first half of 2018 alone, about 4.5 billion records were exposed as a result of data breaches.^[3] In 2019, a collection of 2.7 billion identity records, consisting of 774 million unique email addresses and 21 million unique passwords, was posted on the web for sale.^[4]

Entity	Year	Records	Organization type	Method	Sources
21st Century Oncology	2016	2,200,000	healthcare	hacked	[5][6]
Accendo Insurance Co.	2011	175,350	healthcare	poor security	[7][8]
Adobe Systems	2013	152,000,000	tech	hacked	[9][10]
Adobe Inc.	2019	7.5 million	tech	poor security	[11]
Advocate Medical Group	2013	4,000,000	healthcare	lost / stolen media	[12][13]
AerServ (subsidiary of InMobi)	2018	75,000	advertising	hacked	[14]
Affinity Health Plan, Inc.	2009	344,579	healthcare	lost / stolen media	[15]
Air Canada	2018	20,000	transport	hacked	[16]
Amazon Japan G.K.	2019	unknown	web	accidentally published	[17][18]
Ameritrade	2005	200,000	financial	lost / stolen media	[19]
Ancestry.com	2015	300,000	web	poor security	[20]

Genetic information exposed in privacy breach at Massachusetts General Hospital

PRIVACY BREACH

- ▶ Accessed computers used by Neurology Dept. researchers
- ▶ 9900 people affected
- ▶ Social Security & Insurance info NOT included



Ancestry.com	2015	300,000	web	poor security
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NEWS&ANALYSIS

GENETICS

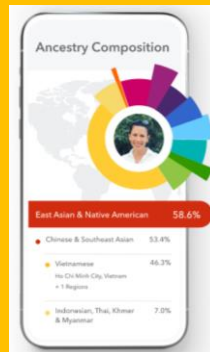
Genealogy Databases Enable Naming Of Anonymous DNA Donors

CAMBRIDGE, MASSACHUSETTS—One afternoon in March last year, Yaniv Erlich sat down at his computer to do an experiment. Before Privacy concerns have been raised about publicly accessible genome data before. A study 5 years ago showed that individuals records matching Y-STR to surnames. When he plugged the 10 genomes with the most recoverable Y-STR markers into those genealogy databases, eight strongly matched to surnames of Mormon families in Utah. Ultimately, he was confident of his guesses for the surnames of five of the genome donors. Erlich then gathered more information on each one using online resources such as

More for the month of May

#2—Who's your (fore)daddy?

- Parentage
- Ancestry
- Who participated in studies → stratification and risk estimates
- Value of predictive genetic testing & precision medicine



#3—The “missing link” (for precision medicine) is behavioral, not genetic

- Genes x Environment
- Individualizing social problems
- What makes genetic info “actionable” and valuable?
- The right-to-know & not-to-know

Category	Icon	Text
Pregnancy	Dollar sign	Get helpful information to guide important health decisions before and during pregnancy.
Staying healthy	Apple	Get what you need to develop a personalized health plan for heart disease, cancer, and more.
Cancer	Heart with DNA	Understand your genes so you and your doctor can find the most effective treatments.
Genetic illness	Magnifying glass	Find a diagnosis or understand if a condition is hereditary so you can zero in on the right treatment.

#4—Genetic Enhancement & the Myth of Merit Problems of Playing God & Parenting