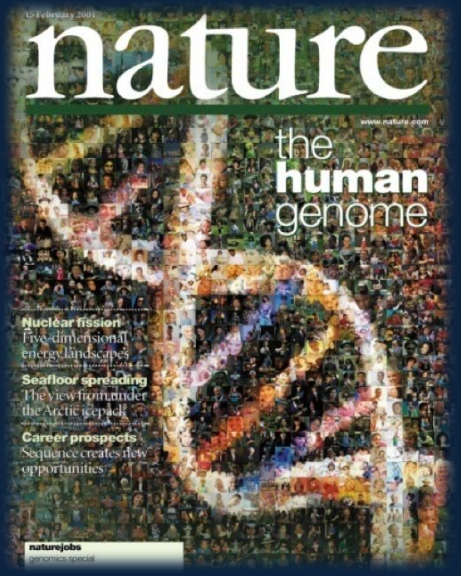
National Human Genome Research Institute

En Route to a "2020 Vision for Genomics": The Next Round of NHGRI Strategic Planning

Eric Green, M.D., Ph.D.
Director, NHGRI

Human Genome Project: Began October 1, 1990...



...10,000 Days Later!!!

Forever Linked: NHGRI and Human Genome Project

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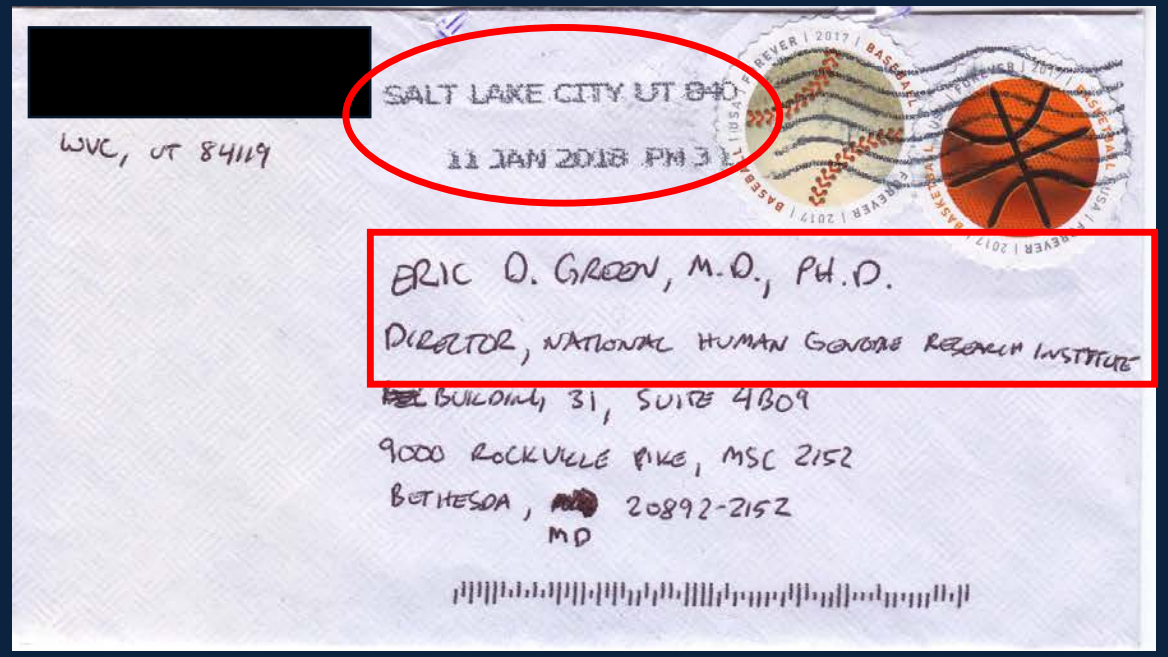
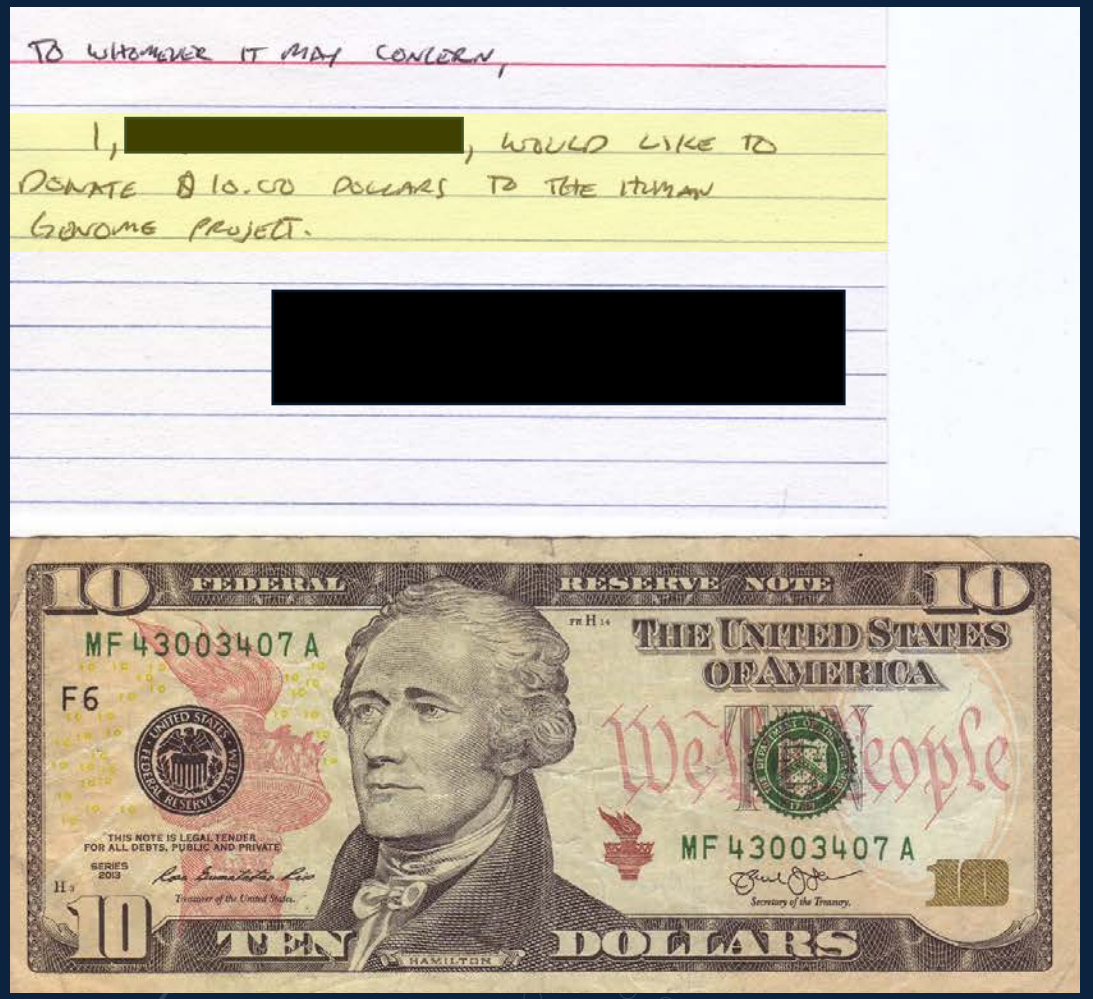
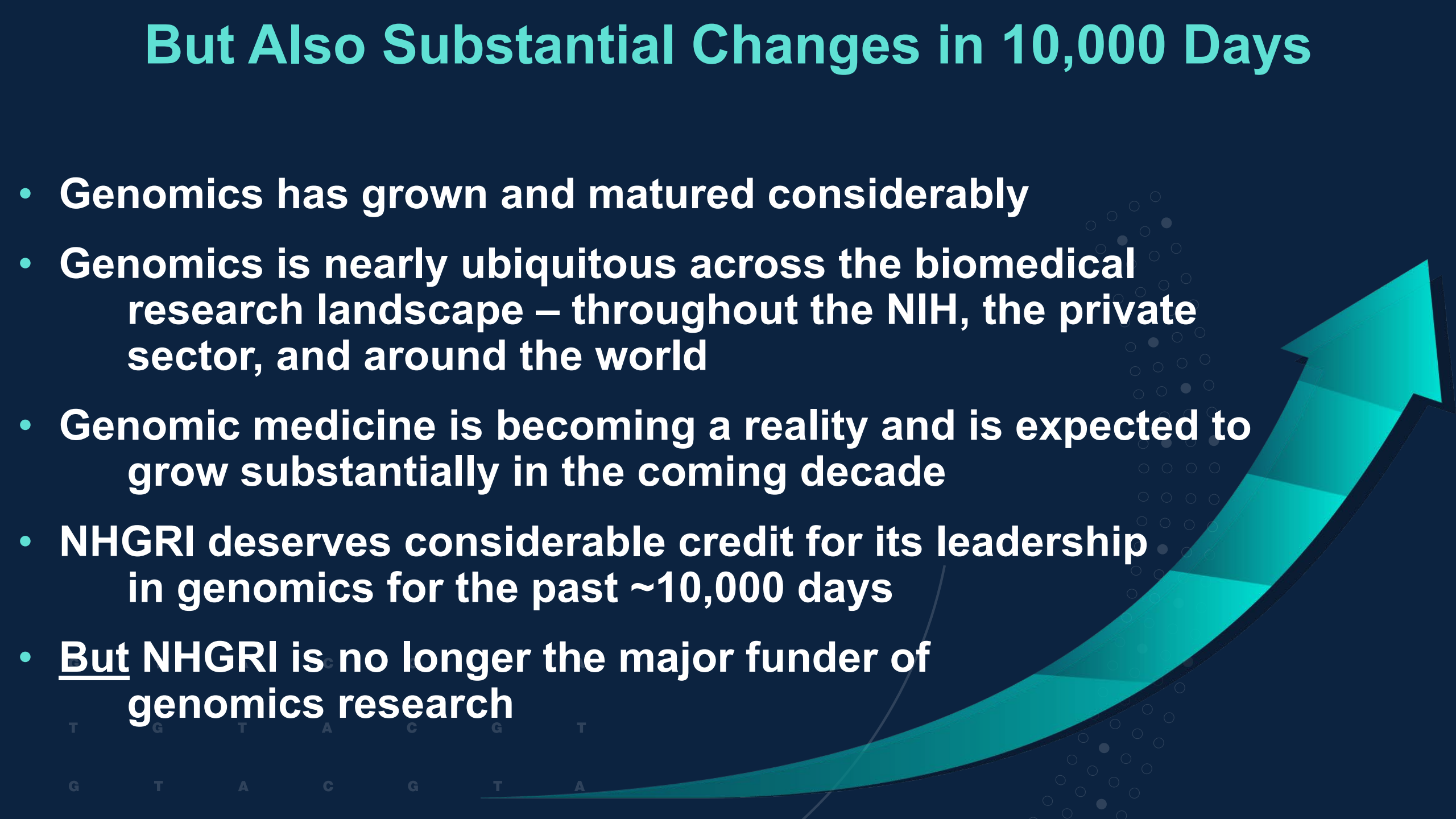




But Also Substantial Changes in 10,000 Days

- Genomics has grown and matured considerably
- Genomics is nearly ubiquitous across the biomedical research landscape – throughout the NIH, the private sector, and around the world
- Genomic medicine is becoming a reality and is expected to grow substantially in the coming decade
- NHGRI deserves considerable credit for its leadership in genomics for the past ~10,000 days
- <u>But</u> NHGRI is no longer the major funder of genomics research



Tackling Two Inter-Related Topics

NHGRI's current place in the genomics ecosystem

NHGRI's vision for the future of genomics research

Part 1: Modernizing NHGRI's Identity

Defining our current place in the genomics ecosystem

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T G T A C G T

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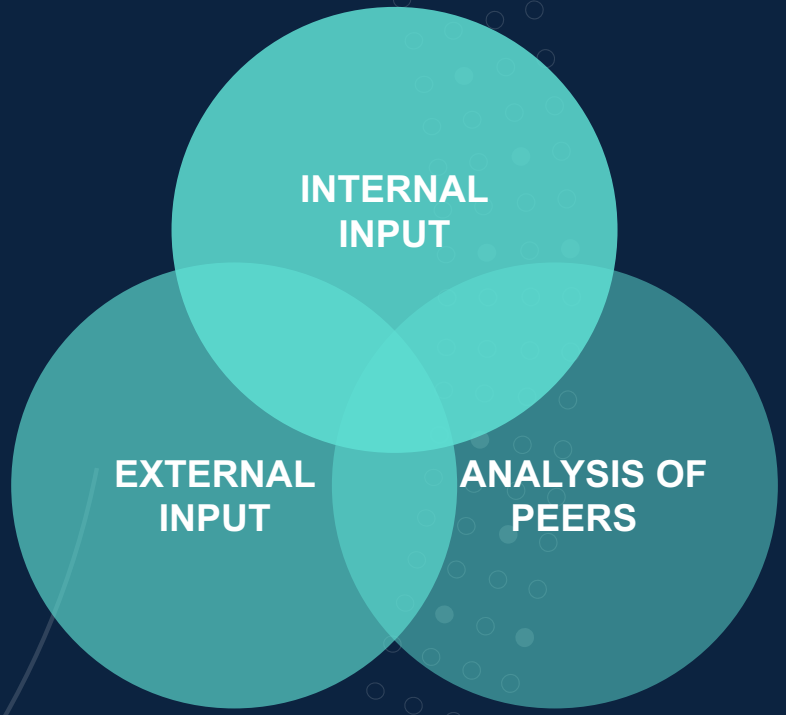
The Process

‘Discovery process’ captured input from both internal staff and external stakeholders (from NIH and beyond)

- Established a trans-NHGRI steering team
- Internal input: ~40 interviews, including all leadership and every division
- External input: colleagues in academia, industry, education, policy, and healthcare settings
- Analysis of how peer organizations in genomics tell their story



Shaping Genomics

NHGRI has played an integral leadership role in genomics since the inception of the field

Accelerating Breakthroughs

NHGRI is a model for learning, collaboration, and support

- World-class interdisciplinary research groups are tackling increasingly complex biological challenges
- ‘Team science’ approach has fostered a spirit of collaboration at NIH and led to a cultural change in biomedical research
- Fund the critical research efforts of scientists at NHGRI and at institutions across the world
- Power the field by providing access to shared tools and data that can transform genomic advances into health discoveries

Improving Patient Care

NHGRI is helping to ready front-line healthcare professionals to use genomics in routine patient care

- Enabling healthcare professionals to provide personalized treatments
- Creating partnerships to study rare and common diseases and to expand knowledge about the genomic bases of disease
- Bringing patients and families hope by diagnosing and treating previously unnamed diseases

Advancing Genomics in Society

NHGRI is a trusted resource of up-to-date information and expertise for the public, educators, healthcare professionals, and policymakers

New NHGRI Vision and Mission Statements

Important to articulate our identity clearly to all internal and external stakeholders

VISION

To improve the health of all humans through advances in genomics research.

MISSION

As a leading authority in the field of genomics, our mission is to accelerate scientific and medical breakthroughs that improve human health. We do this by driving cutting-edge research, developing new technologies, and studying the impact of genomics on society.

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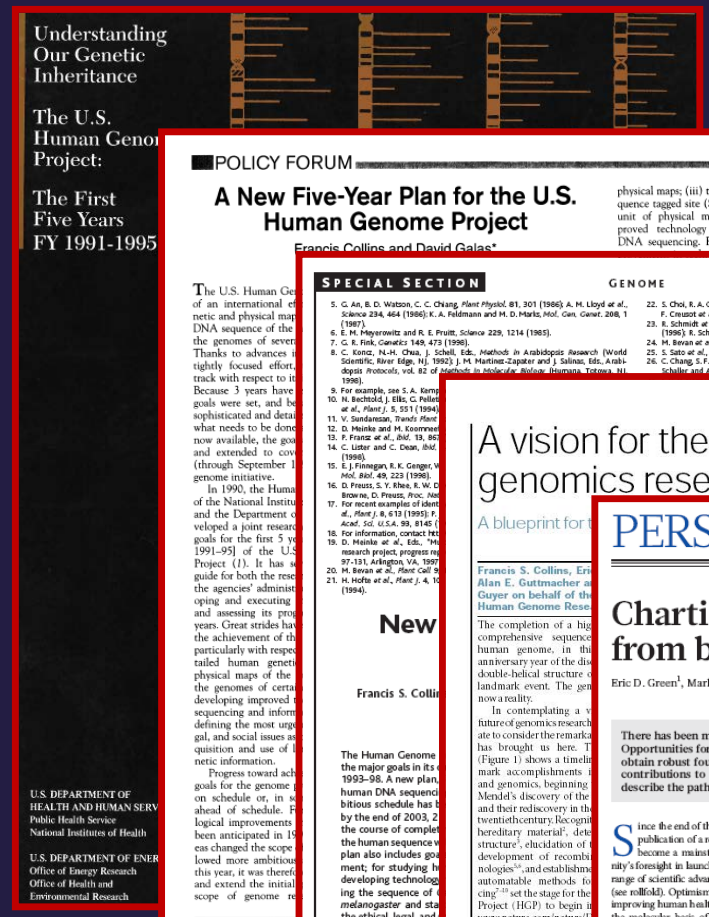
Part 2: En Route to a “2020 Vision for Genomics”

The next round of NHGRI strategic planning



1991-1995

1993-1998

1998-2003

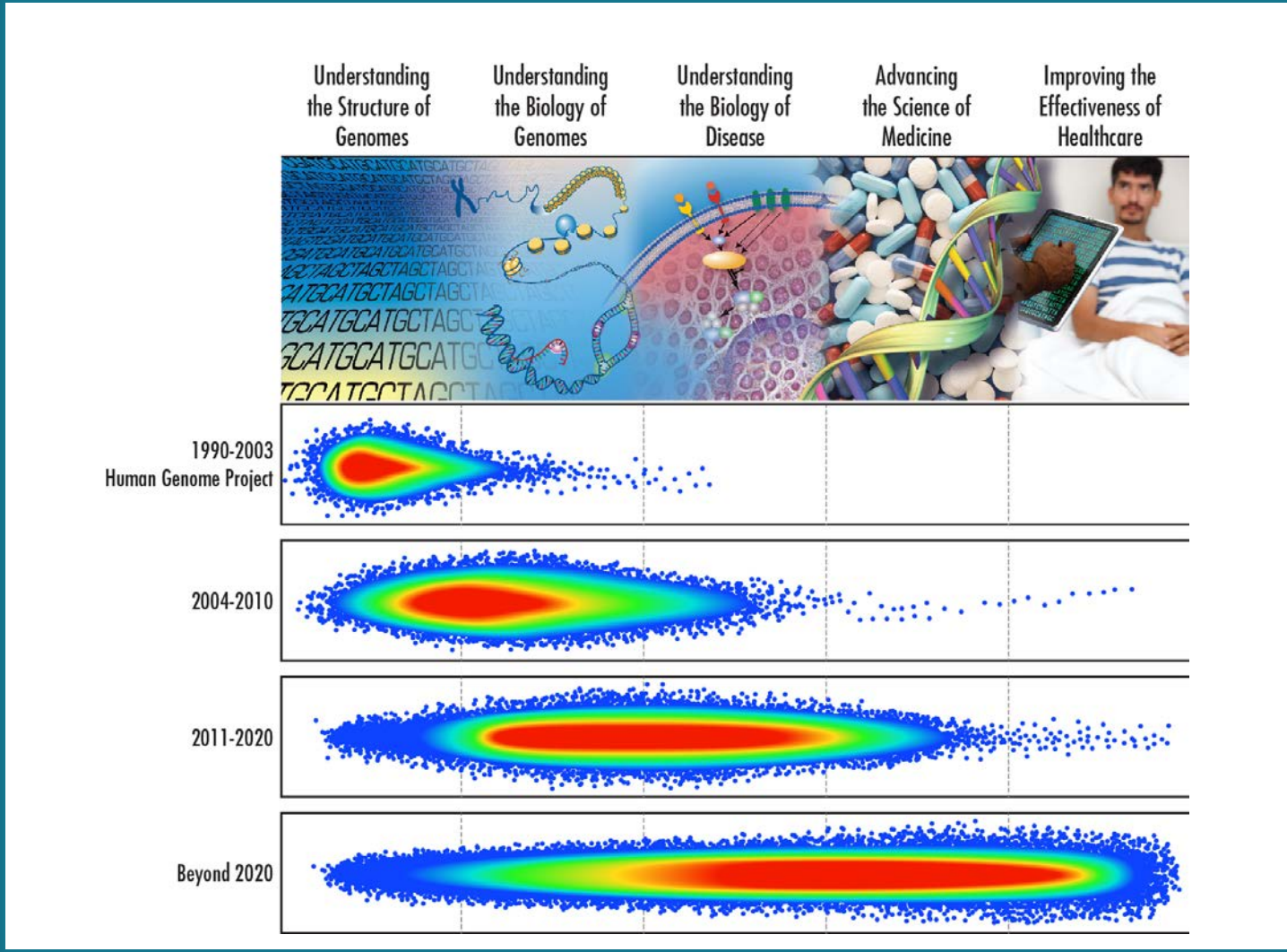
2003-2010

2011-Present

1990-2003
Human Genome Project

2003-2010
Immediate Post-Human Genome Project

2011-Present
En Route to Genomic Medicine



NHGRI Strategic Planning Processes

NIH National Human Genome Research Institute

Developing the 2011 NHGRI Strategic Plan for Genomics

Initial Internal Planning

Kick Off

Initial White Papers Posted

Revised White Papers Posted

Public Comment

Internal Discussion of White Paper Comments

NACHGR Briefings

NACHGR Endorsement

Journal Submission

2008

2009

2010

Decade of ELSI

Social and Behavioral Research in Genomics

Health Disparities, Race, and Genomics

Dark Matter of Genomic Associations with Complex Disease

Future of Sequencing

Genomics of Gene Regulation

Cloud Computing

Informatics Analysis

Finale Meeting

It is hard to claim (or believe) that a 2011 strategic plan represents a suitable blueprint for genomics or NHGRI in 2020 (and beyond)

Official Launch: February 12, 2018

U.S. DEPARTMENT OF HEALTH & HUMAN SERVICES
NATIONAL INSTITUTES OF HEALTH

National Human Genome Research Institute
www.genome.gov

FOR IMMEDIATE RELEASE
Monday, February 12, 2018
11 A.M. Eastern

Contact:
NHGRI Communications
(301) 402-0911
NHGRIPress@mail.nih.gov

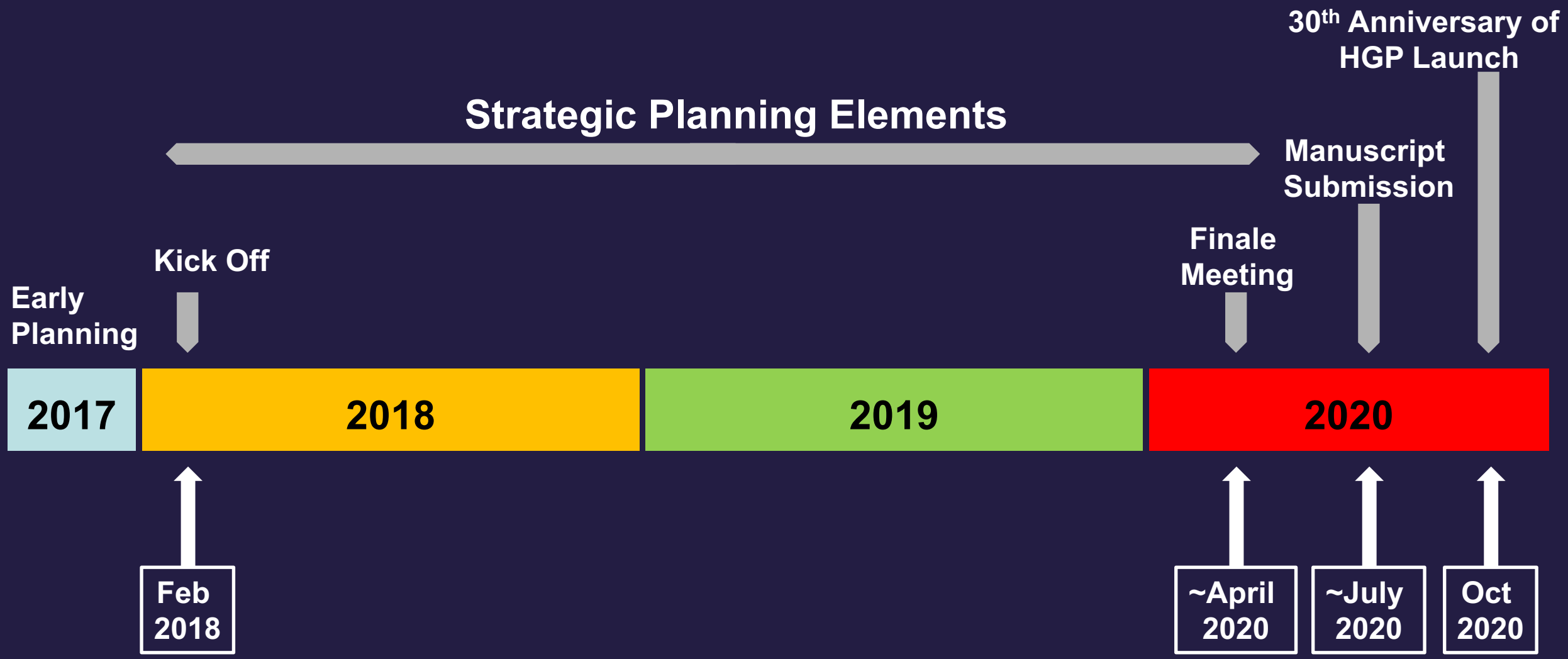
Developing a 2020 vision for genomics: NHGRI launches new round of strategic planning

The National Human Genome Research Institute (NHGRI) today launched a new round of strategic planning that will establish a 2020 vision for genomics research aimed at accelerating scientific and medical breakthroughs. In developing the strategic plan, the institute will engage experts and diverse public communities to identify paradigm-shifting areas of genomics that will expand the field into new frontiers and enable novel applications to human health and disease.

Developing a “2020 Vision for Genomics”

- Timeline
- Elements
- Initial Internal Organization
- Scope

Strategic Planning Timeline



Strategic Planning Elements

- Workshops
- Town Halls

Town Halls

- **Purpose: Engage stakeholders to collect ideas and information that informs the strategic planning process (in a general or targeted fashion)**

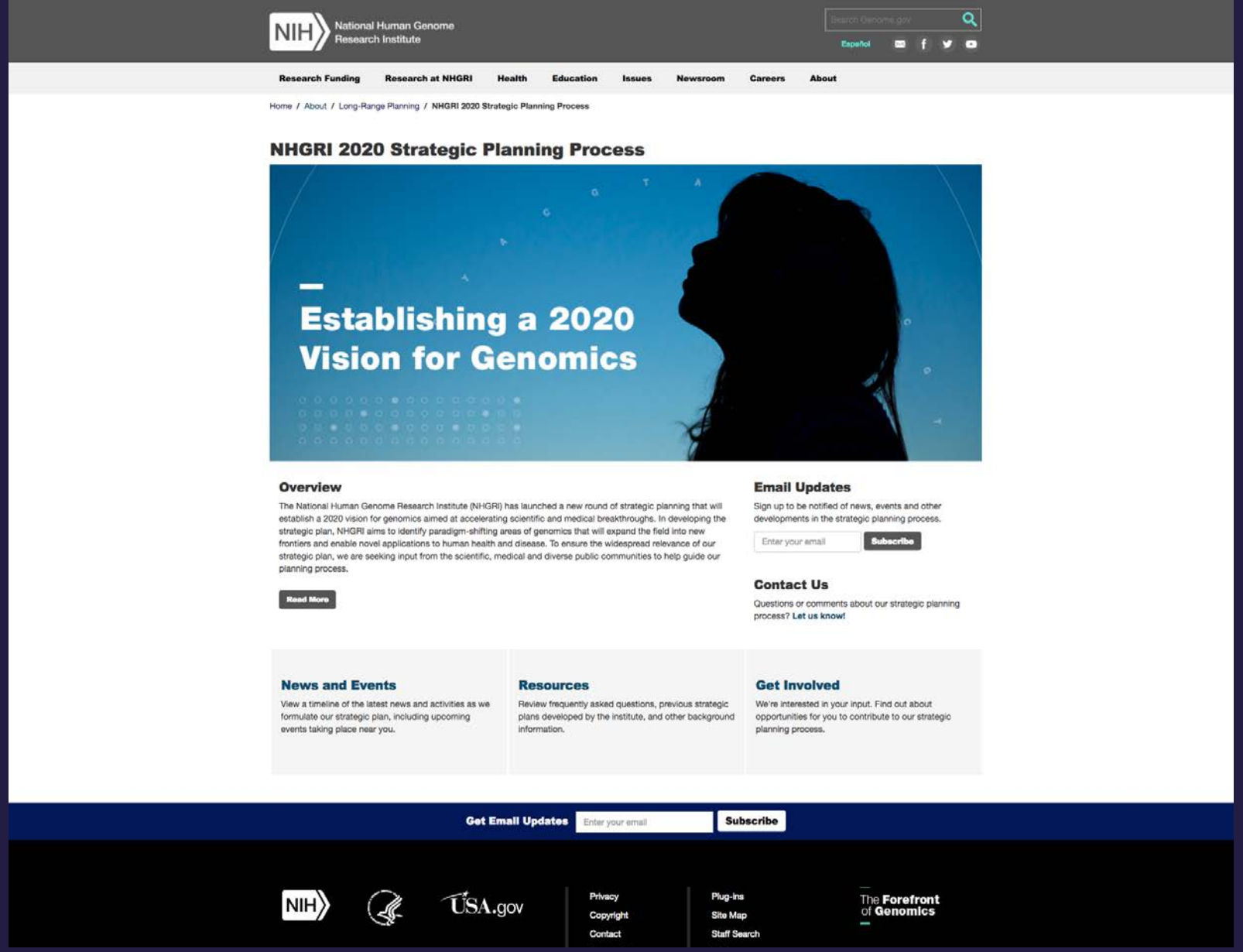
- **Types:**

  1. **Traveling**
     Likely Locations: San Francisco, Houston, Chicago, Boston, and DC Area
  2. **Satellite Gathering at Major Meetings**
     Candidate Examples: ASHG, AGBT, ACMG, CSHL, NHGRI Trainee Meeting, etc.
  3. **NIH-based**
  4. **Virtual**

- **Aim to engage researchers, trainees, and communities**

Strategic Planning Elements

- Workshops
- Town Halls
- Dedicated Web Page

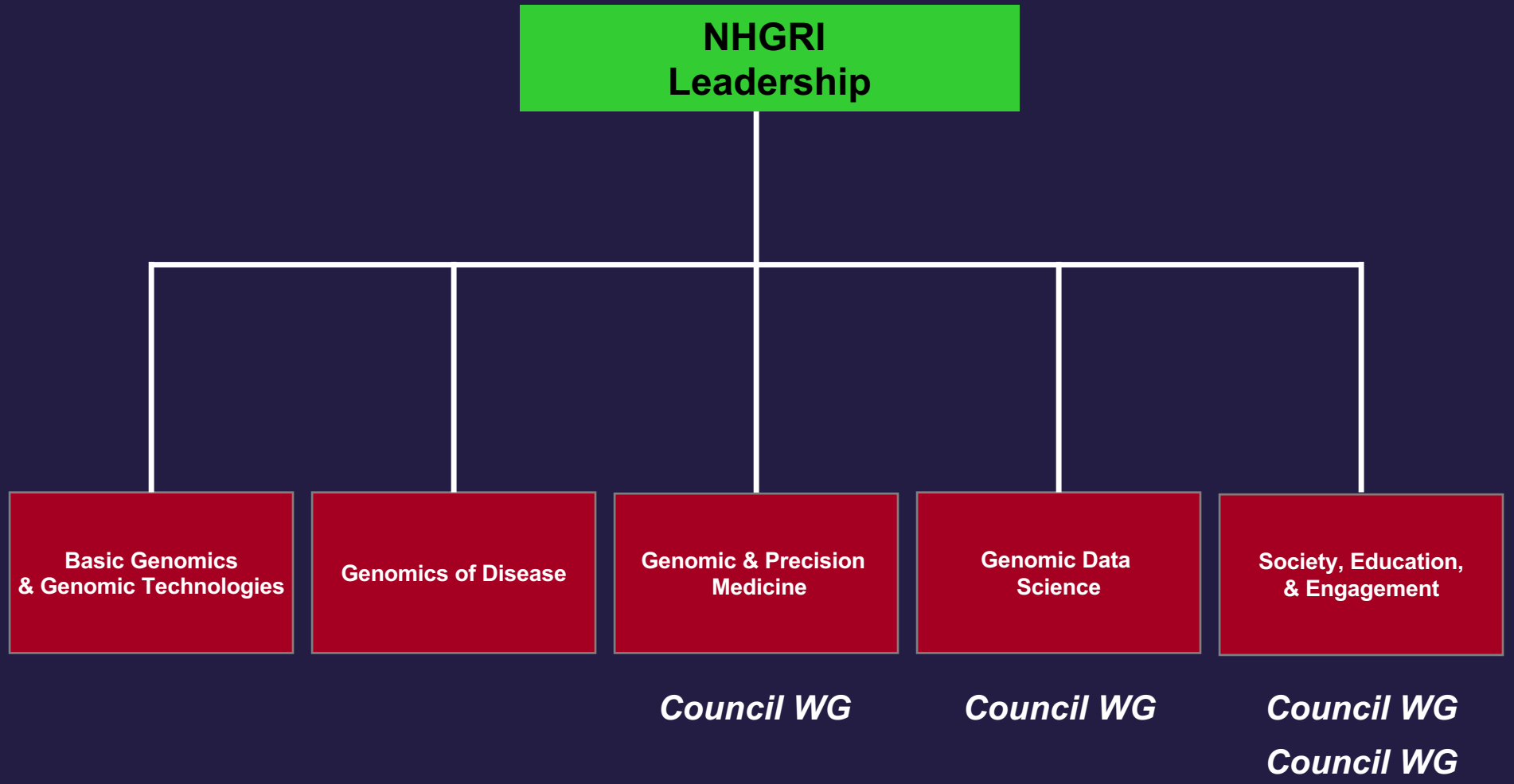


genome.gov/genomics2020

Strategic Planning Elements

- Workshops
- Town Halls
- Dedicated Web Page
- Tools of Social Media (e.g., #genomics2020)
- Engagement of Advisory Groups
- Finale Meeting

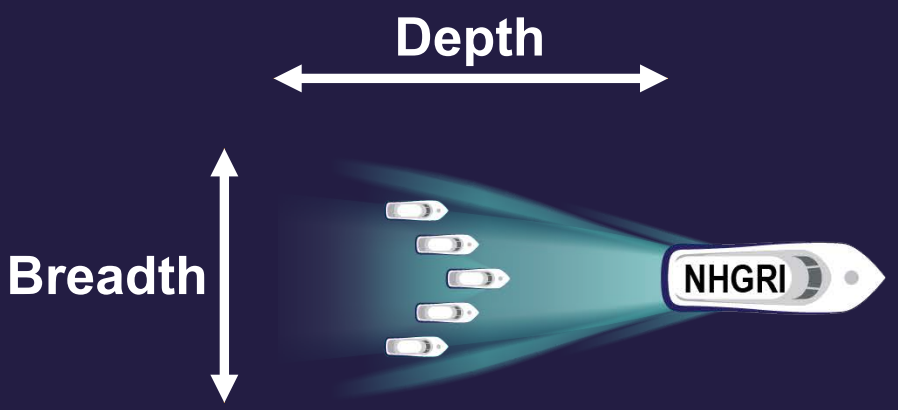
Initial Internal Organization

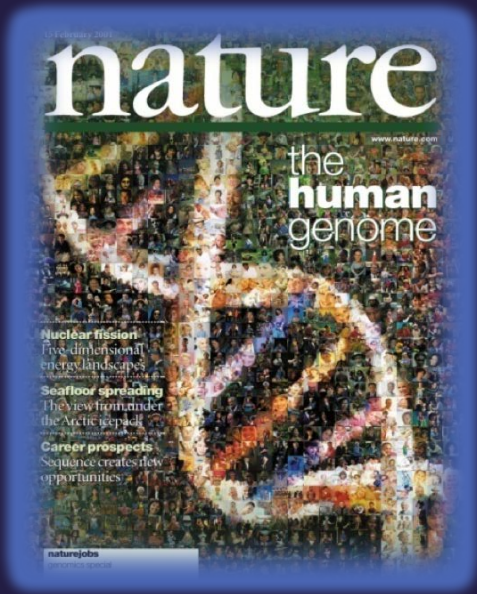


Overarching (and Difficult) Issue: Scope

Is the strategic planning process about
the future of genomics as a field – OR –
the future of NHGRI-supported genomics research?

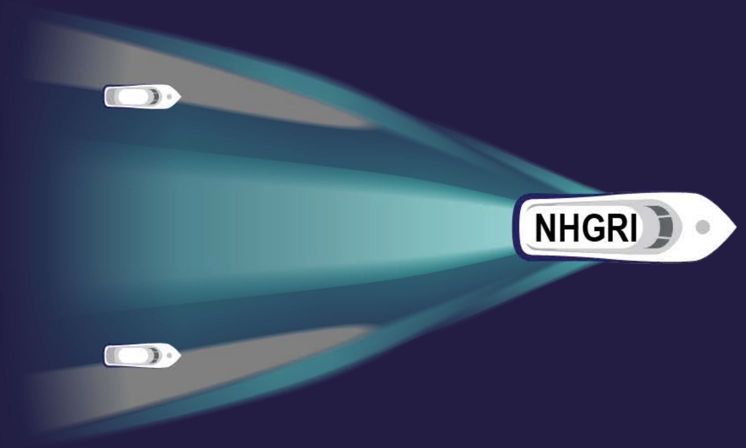
1990-2003
Human Genome Project

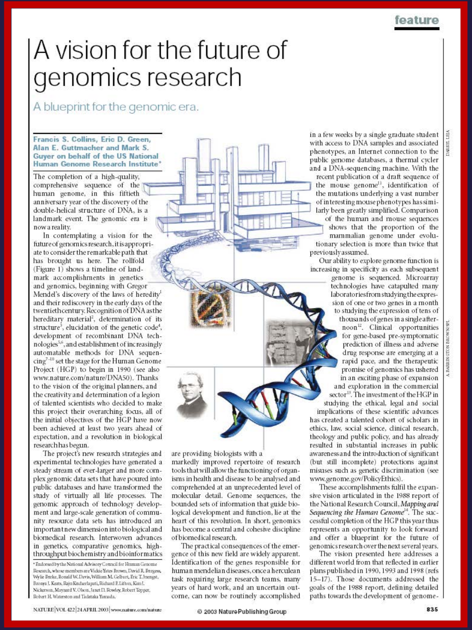




2003-2010

Immediate Post-Human Genome Project





feature

A vision for the future of genomics research

A blueprint for the genomic era.

Francis S. Collins, Eric D. Green, Alan E. Guttmacher and Mark S. Guyer on behalf of the US National Human Genome Research Institute*

The completion of a high-quality, comprehensive sequence of the human genome, in this fiftieth anniversary year of the discovery of the double-helical structure of DNA, is a landmark event. The genomic era is now a reality.

In contemplating a vision for the future of genomics research, it is appropriate to consider the remarkable path that has brought us here. The rollfold (Figure 1) shows a timeline of landmark accomplishments in genetics and genomics, beginning with Gregor Mendel's discovery of the laws of heredity[1] and their rediscovery in the early days of the twentieth century. Recognition of DNA as the hereditary material[2], determination of its structure[3], elucidation of the genetic code[4], development of recombinant DNA technologies[5,6], and establishment of increasingly automatable methods for DNA sequencing[7–10] set the stage for the Human Genome Project (HGP) to begin in 1990 (see also www.nature.com/nature/DNA50). Thanks to the vision of the original planners, and the creativity and determination of a legion of talented scientists who decided to make this project their overarching focus, all of the initial objectives of the HGP have now been achieved at least two years ahead of expectation, and a revolution in biological research has begun.

The project's new research strategies and experimental technologies have generated a steady stream of ever-larger and more complex genomic data sets that have poured into public databases and have transformed the study of virtually all life processes. The genomic approach of technology development and large-scale generation of community resource data sets has introduced an important new dimension into biological and biomedical research. Interwoven advances in genetics, comparative genomics, high-throughput biochemistry and bioinformatics are providing biologists with a markedly improved repertoire of research tools that will allow the functioning of organisms in health and disease to be analysed and comprehended at an unprecedented level of molecular detail. Genome sequences, the bounded sets of information that guide biological development and function, lie at the heart of this revolution. In short, genomics has become a central and cohesive discipline of biomedical research.

The practical consequences of the emergence of this new field are widely apparent. Identification of the genes responsible for human mendelian diseases, once a herculean task requiring large research teams, many years of hard work, and an uncertain outcome, can now be routinely accomplished in a few weeks by a single graduate student with access to DNA samples and associated phenotypes, an Internet connection to the public genome databases, a thermal cycler and a DNA-sequencing machine. With the recent publication of a draft sequence of the mouse genome[11], identification of the mutations underlying a vast number of interesting mouse phenotypes has similarly been greatly simplified. Comparison of the human and mouse sequences shows that the proportion of the mammalian genome under evolutionary selection is more than twice that previously assumed.

Our ability to explore genome function is increasing in specificity as each subsequent genome is sequenced. Microarray technologies have catapulted many laboratories from studying the expression of one or two genes in a month to studying the expression of tens of thousands of genes in a single afternoon[12]. Clinical opportunities for gene-based pre-symptomatic prediction of illness and adverse drug response are emerging at a rapid pace, and the therapeutic promise of genomics has ushered in an exciting phase of expansion and exploration in the commercial sector[13]. The investment of the HGP in studying the ethical, legal and social implications of these scientific advances has created a talented cohort of scholars in ethics, law, social science, clinical research, theology and public policy, and has already resulted in substantial increases in public awareness and the introduction of significant (but still incomplete) protections against misuses such as genetic discrimination (see www.genome.gov/PolicyEthics).

These accomplishments fulfil the expansive vision articulated in the 1988 report of the National Research Council, *Mapping and Sequencing the Human Genome*[14]. The successful completion of the HGP this year thus represents an opportunity to look forward and offer a blueprint for the future of genomics research over the next several years.

The vision presented here addresses a different world from that reflected in earlier plans published in 1990, 1993 and 1998 (refs 15–17). Those documents addressed the goals of the 1988 report, defining detailed paths towards the development of genome-

*Endorsed by the National Advisory Council for Human Genome Research, whose members are Vickie Yates Brown, David R. Burgess, Wylie Burke, Ronald W. Davis, William M. Gelbart, Eric T. Juengst, Bronya J. Keats, Raju Kucherlapati, Richard P. Lifton, Kim J. Nickerson, Maynard V. Olson, Janet D. Rowley, Robert Tepper, Robert H. Waterston and Tadataka Yamada.

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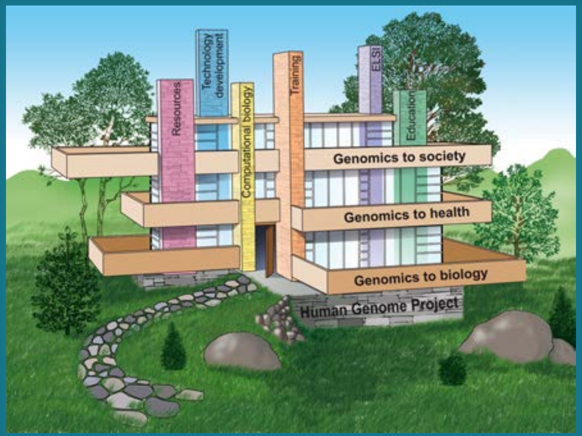
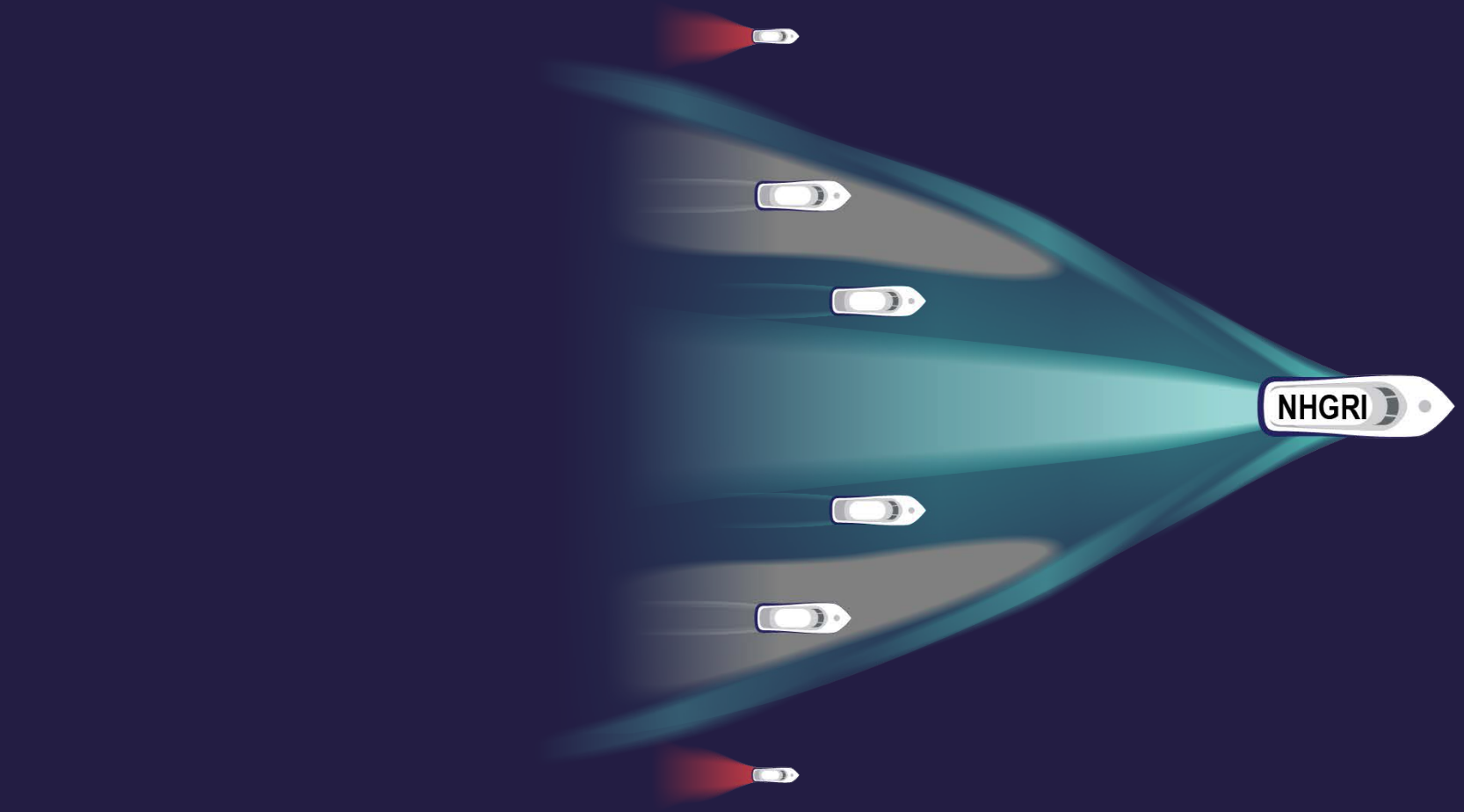
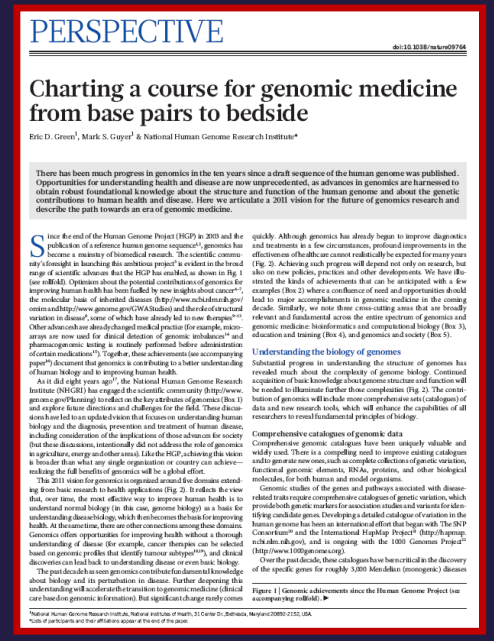


2011-Present

En Route to Genomic Medicine





PERSPECTIVE

doi:10.1038/nature09764

Charting a course for genomic medicine from base pairs to bedside

Eric D. Green[1], Mark S. Guyer[1] & National Human Genome Research Institute*

There has been much progress in genomics in the ten years since a draft sequence of the human genome was published. Opportunities for understanding health and disease are now unprecedented, as advances in genomics are harnessed to obtain robust foundational knowledge about the structure and function of the human genome and about the genetic contributions to human health and disease. Here we articulate a 2011 vision for the future of genomics research and describe the path towards an era of genomic medicine.

Since the end of the Human Genome Project (HGP) in 2003 and the publication of a reference human genome sequence[1], genomics has become a mainstay of biomedical research. The scientific community's foresight in launching this ambitious project[2] is evident in the broad range of scientific advances that the HGP has enabled, as shown in Fig. 1 (see rollfold). Optimism about the potential contributions of genomics for improving human health has been fuelled by new insights about cancer[3–7], the molecular basis of inherited diseases (http://www.ncbi.nlm.nih.gov/omim and http://www.genome.gov/GWAStudies) and the role of structural variation in disease[8], some of which have already led to new therapies[9,10]. Other advances have already changed medical practice (for example, microarrays are now used for clinical detection of genomic imbalances[11] and pharmacogenomic testing is routinely performed before administration of certain medications[12]). Together, these achievements (see accompanying paper[13]) document that genomics is contributing to a better understanding of human biology and to improving human health.

As it did eight years ago[17], the National Human Genome Research Institute (NHGRI) has engaged the scientific community (http://www.genome.gov/Planning) to reflect on the key attributes of genomics (Box 1) and explore future directions and challenges for the field. These discussions have led to an updated vision that focuses on understanding human biology and the diagnosis, prevention and treatment of human disease, including consideration of the implications of those advances for society (but these discussions, intentionally did not address the role of genomics in agriculture, energy and other areas). Like the HGP, achieving this vision is broader than what any single organization or country can achieve—making the full benefits of genomics will be a global effort.

This 2011 vision for genomics is organized around five domains extending from basic research to health applications (Fig. 2). It reflects the view that, over time, the most effective way to improve human health is to understand normal biology (in this case, genome biology) as a basis for understanding disease biology, which then becomes the basis for improving health. At the same time, there are other connections among these domains. Genomics offers opportunities for improving health without a thorough understanding of disease (for example, cancer therapies can be selected based on genomic profiles that identify tumour subtypes[18,19], and clinical discoveries can lead back to understanding disease or even basic biology).

The past decade has seen genomics contribute fundamental knowledge about biology and its perturbation in disease. Further deepening this understanding will accelerate the transition to genomic medicine (clinical care based on genomic information). But significant change rarely comes quickly. Although genomics has already begun to improve diagnostics and treatments in a few circumstances, profound improvements in the effectiveness of health care cannot realistically be expected for many years (Fig. 2). Achieving such progress will depend not only on research, but also on new policies, practices and other developments. We have illustrated the kinds of achievements that can be anticipated with a few examples (Box 2) where a confluence of need and opportunities should lead to major accomplishments in genomic medicine in the coming decade. Similarly, we note three cross-cutting areas that are broadly relevant and fundamental across the entire spectrum of genomics and genomic medicine: bioinformatics and computational biology (Box 3), education and training (Box 4), and genomics and society (Box 5).

Understanding the biology of genomes

Substantial progress in understanding the structure of genomes has revealed much about the complexity of genome biology. Continued acquisition of basic knowledge about genome structure and function will be needed to illuminate further those complexities (Fig. 2). The contribution of genomics will include more comprehensive sets (catalogues) of data and new research tools, which will enhance the capabilities of all researchers to reveal fundamental principles of biology.

Comprehensive catalogues of genomic data

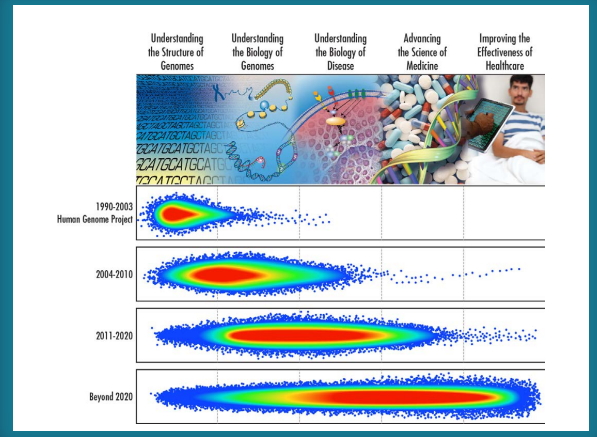
Comprehensive genomic catalogues have been uniquely valuable and widely used. There is a compelling need to improve existing catalogues and to generate new ones, such as complete collections of genetic variation, functional genomic elements, RNAs, proteins, and other biological molecules, for both human and model organisms.

Genomic studies of the genes and pathways associated with disease-related traits require comprehensive catalogues of genetic variation, which provide both genetic markers for association studies and variants for identifying candidate genes. Developing a detailed catalogue of variation in the human genome has been an international effort that began with The SNP Consortium[20] and the International HapMap Project[8] (http://hapmap.ncbi.nlm.nih.gov), and is ongoing with the 1000 Genomes Project[21] (http://www.1000genomes.org).

Over the past decade, these catalogues have been critical in the discovery of the specific genes for roughly 3,000 Mendelian (monogenic) diseases

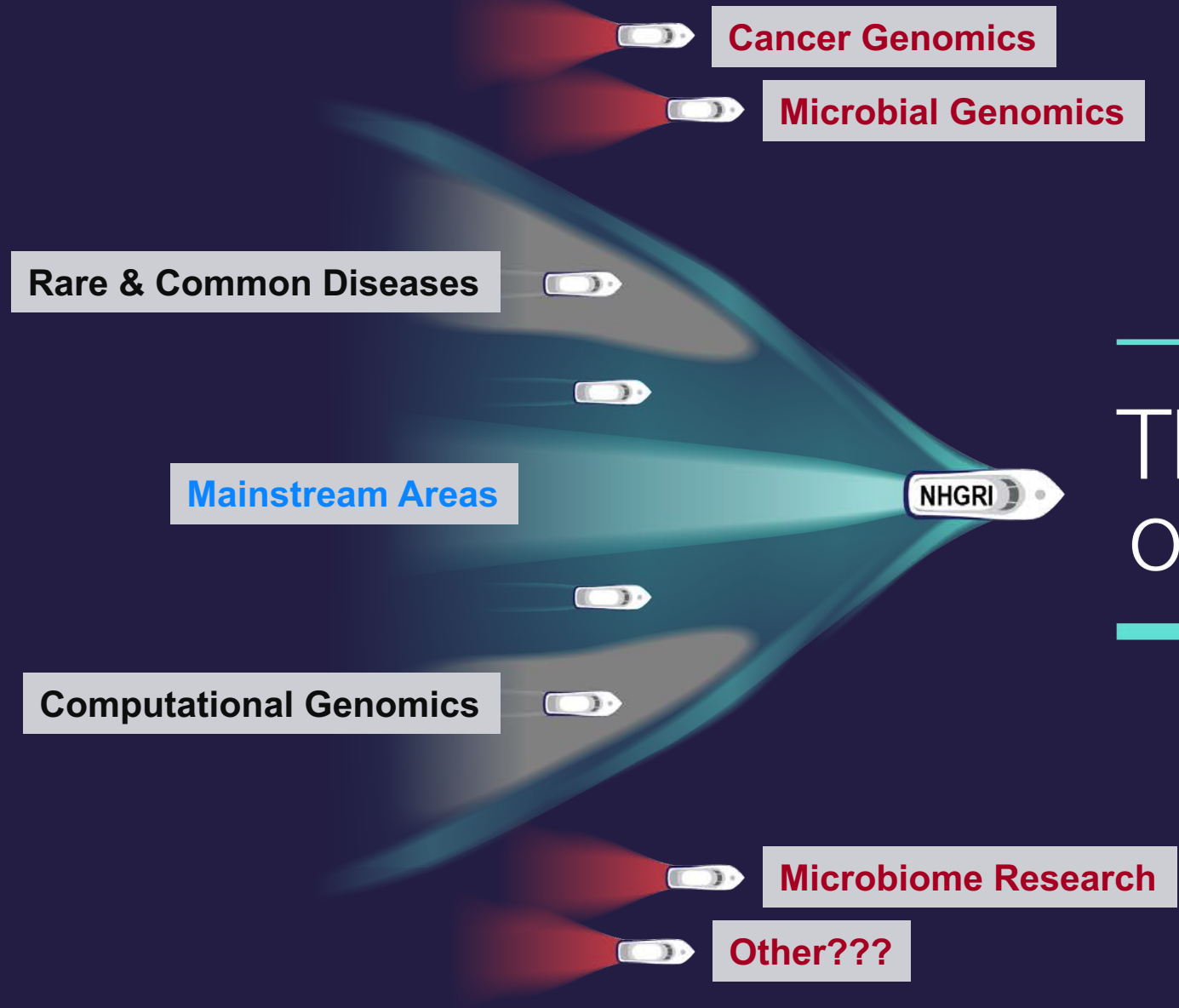
Figure 1 | Genomic achievements since the Human Genome Project (see accompanying rollfold). ▶

[1]National Human Genome Research Institute, National Institutes of Health, 31 Center Dr, Bethesda, Maryland 20892-2152, USA.
*Lists of participants and their affiliations appear at the end of the paper.



2020 and Beyond

NHGRI-led Genomics Efforts Starting Next Decade



The **Forefront** of **Genomics**®

Overarching (and Difficult) Issue: Scope

Is the strategic planning process about
the future of genomics as a field – OR –
the future of NHGRI-supported genomics research?

Evolving Answer:

The strategic planning process will focus on
***The Forefront of Genomics* –**
as it pertains to human health and disease

Your Input and Engagement

- Should be intellectually stimulating
- Has the potential to be incredibly impactful
- Will be much-appreciated

The 2020 NHGRI Strategic Plan will Aim to…

- Be the driving force for much of genomics at NIH and around the world
- Provide a clear (i.e., 2020) vision for using genomics to advance human health
- Guide NHGRI's scientific priorities and shape our research portfolio
- Foster partnerships within research, healthcare, education, policy, and various general-public communities

- Help to define NHGRI's position at:

The **Forefront** of **Genomics**®

Staying Connected with ‘genomics2020’

Website: genome.gov/genomics2020

Email: genomics2020@mail.nih.gov

Hashtag: #genomics2020

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