MAPPING FOR THE FUTURE OF OUR FOOD

National C-FAR
1302 Longworth
House Office Bldg
Washington DC
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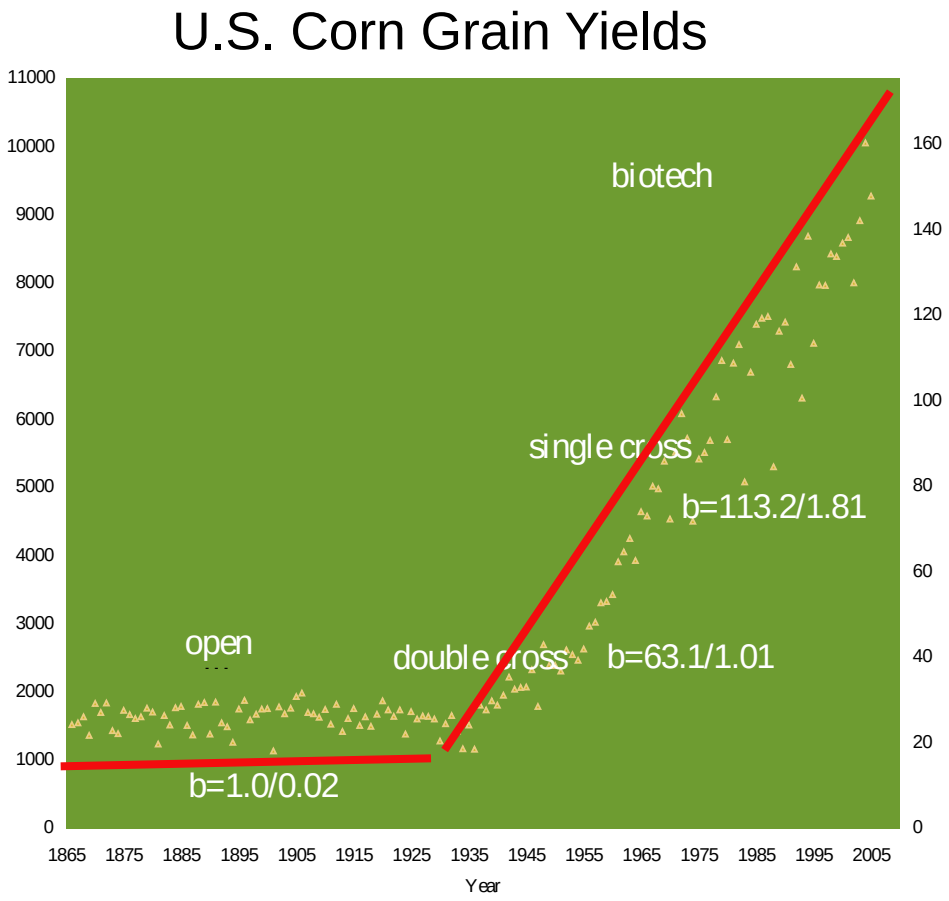
Some Definitions

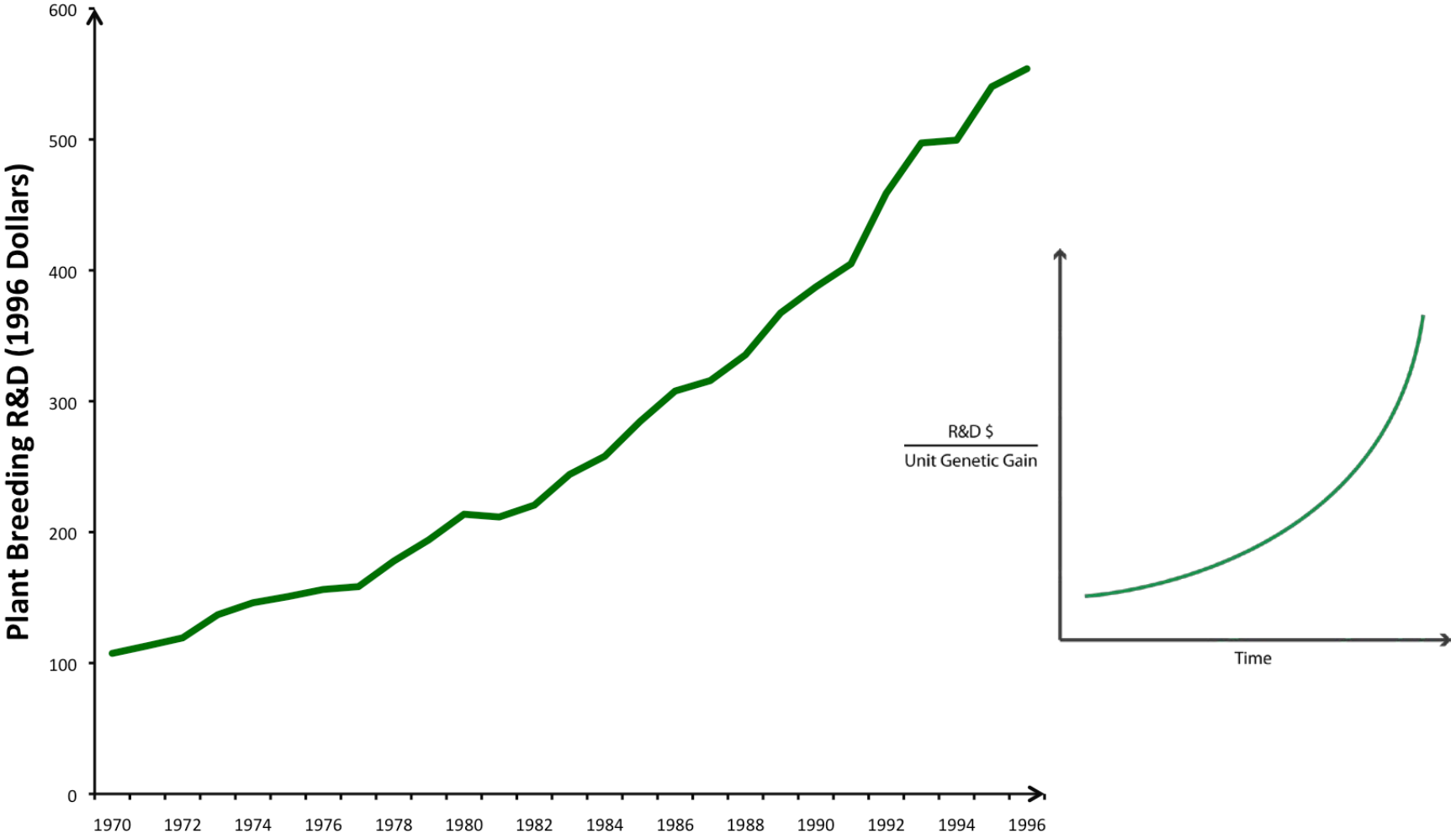
- **Genes:** composed of DNA (command lines within a computer program)
- **Genome:** collection of all genes that together control growth and development (computer program-collection of all command lines)
- **Genetics/Functional Genomics**: determining which genes control traits (debugging a computer program)

Plant breeders have been successful



Troyer (2006) Crop Sci. 46:528-543

Private-Sector R&D Investment in Plant Breeding is Increasing (constant dollars)



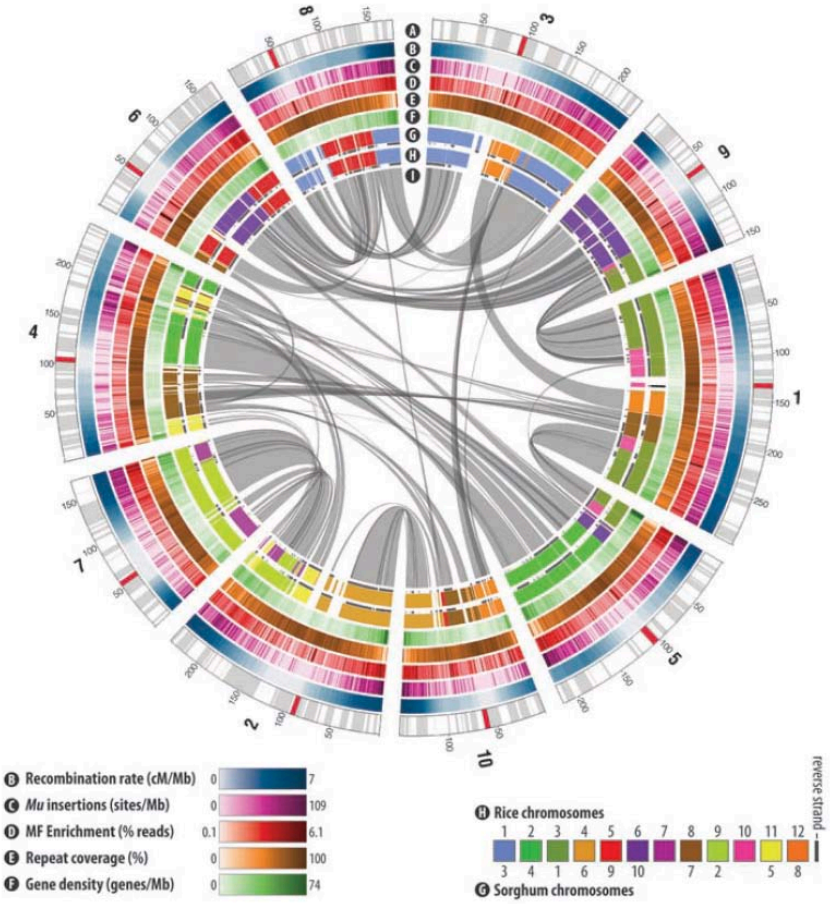
USDA Report: The Seed Industry in U.S. Agriculture

and new challenges await us…

- Increasing demands for food, feed, fiber and fuel
- Decreasing amounts of arable land
- Agricultural inputs:
  - Increasing costs (e.g., nitrogen)
  - Reduced availability (e.g., water)
  - Undesirable ecological impacts
- Increasing climate variability
  - Droughts/floods
  - Temperature extremes
  - Pests & diseases
- Need to be innovative

NYT, 1/23/06

The $30M B73 Maize Genome Sequencing Project



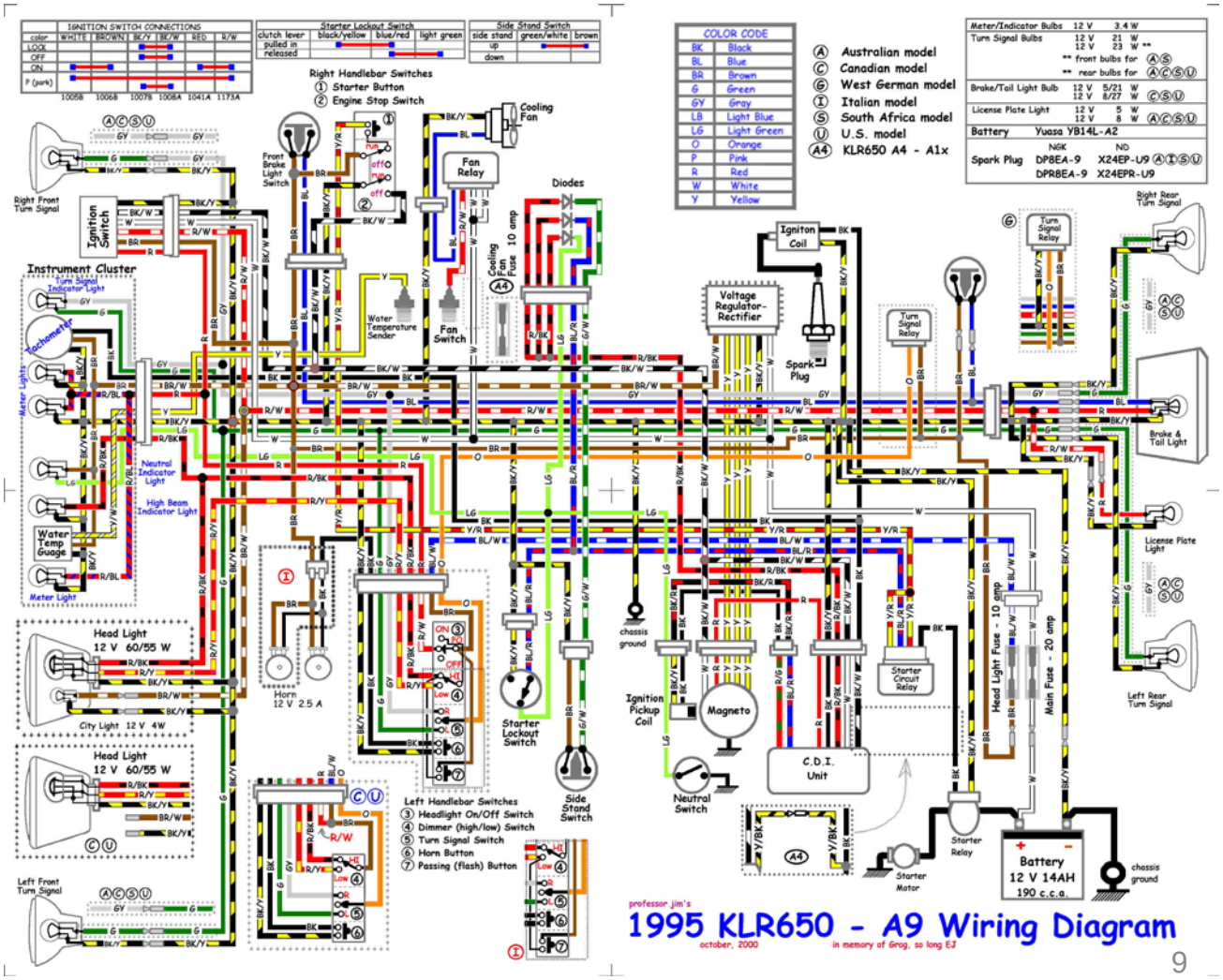
Schnable, Ware et al., 2009

The Maize Genome Sequencing Project, Rick Wilson, PI

Genome Projects are Analogous to the Lewis & Clark Expedition

- Expensive and require extensive planning/coordination
- Exploration of the unknown; expect surprises
- Generates lots of information *that requires subsequent analysis*

A Genome Sequence is Analogous to…



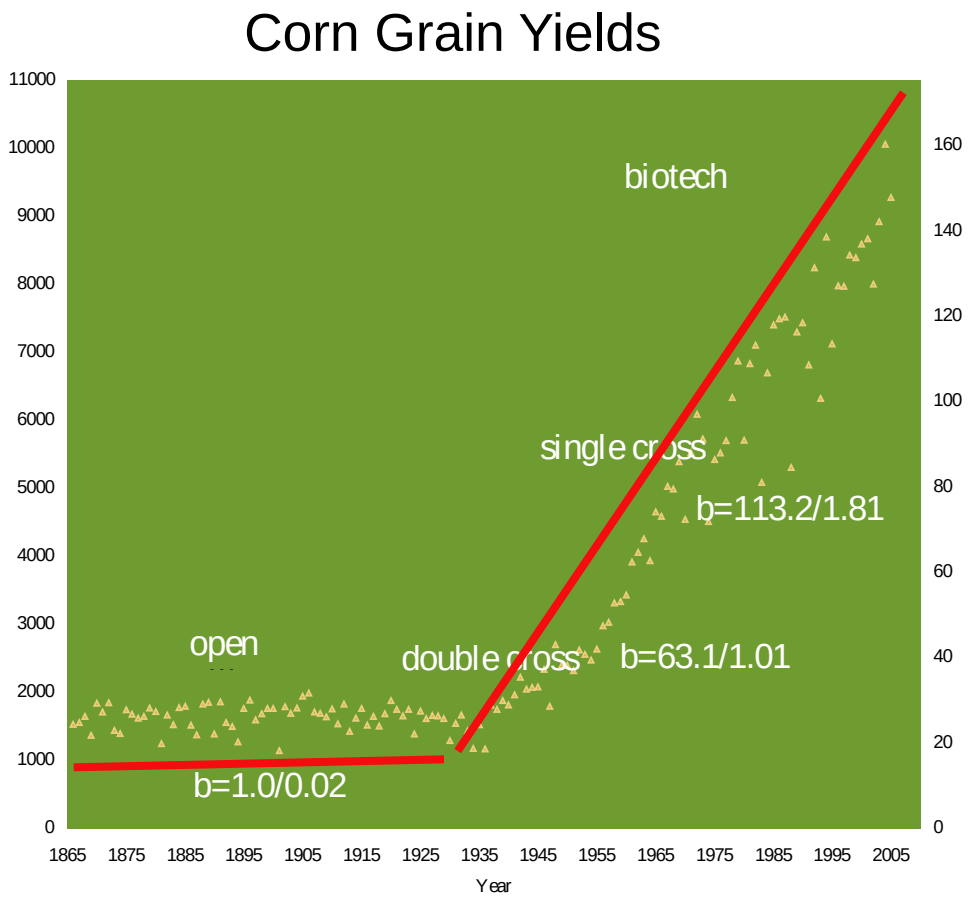
NCGA Workshop on Functionality and the Maize Genome, March 2009

- Participants: Growers, public-sector and private-sector researchers
- Goal: To understand the genetic basis of traits in maize -- traits that are the foundation for improving food, fuel, and fiber crop yields and to translate the answers into crop improvement.

A Major Recommendation from the NCGA Workshop

- In most species (including maize), 1/3-1/2 of genes do not have even a predicted function and the relationships of most others to traits is unknown
- Continued public-sector R&D investment to link the ~50,000 maize genes with “traits”

What does society get for this investment?



Troyer (2006) Crop Sci. 46:528-543

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- Increasing climate variability
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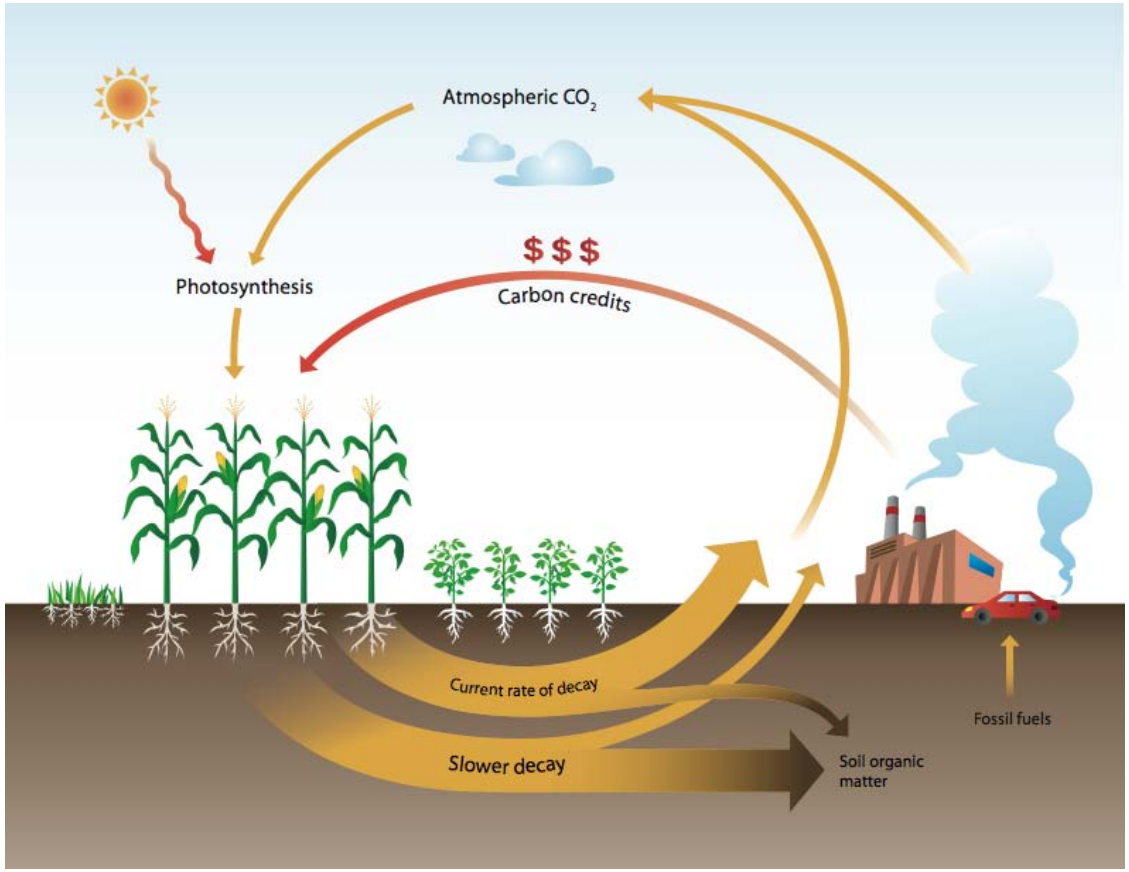
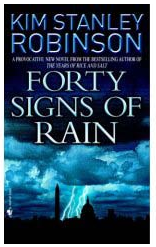
  - Temperature extremes
  - Pests & diseases
- Innovation (new traits)

Center for Carbon-Capturing Crops

Rising atmospheric CO_2 concentrations/global climate change
Produce crops with cell walls that are "resistant" to microbial degradation



- Sequester atmospheric carbon in soil
- Increase soil organic matter
- Increase farm income

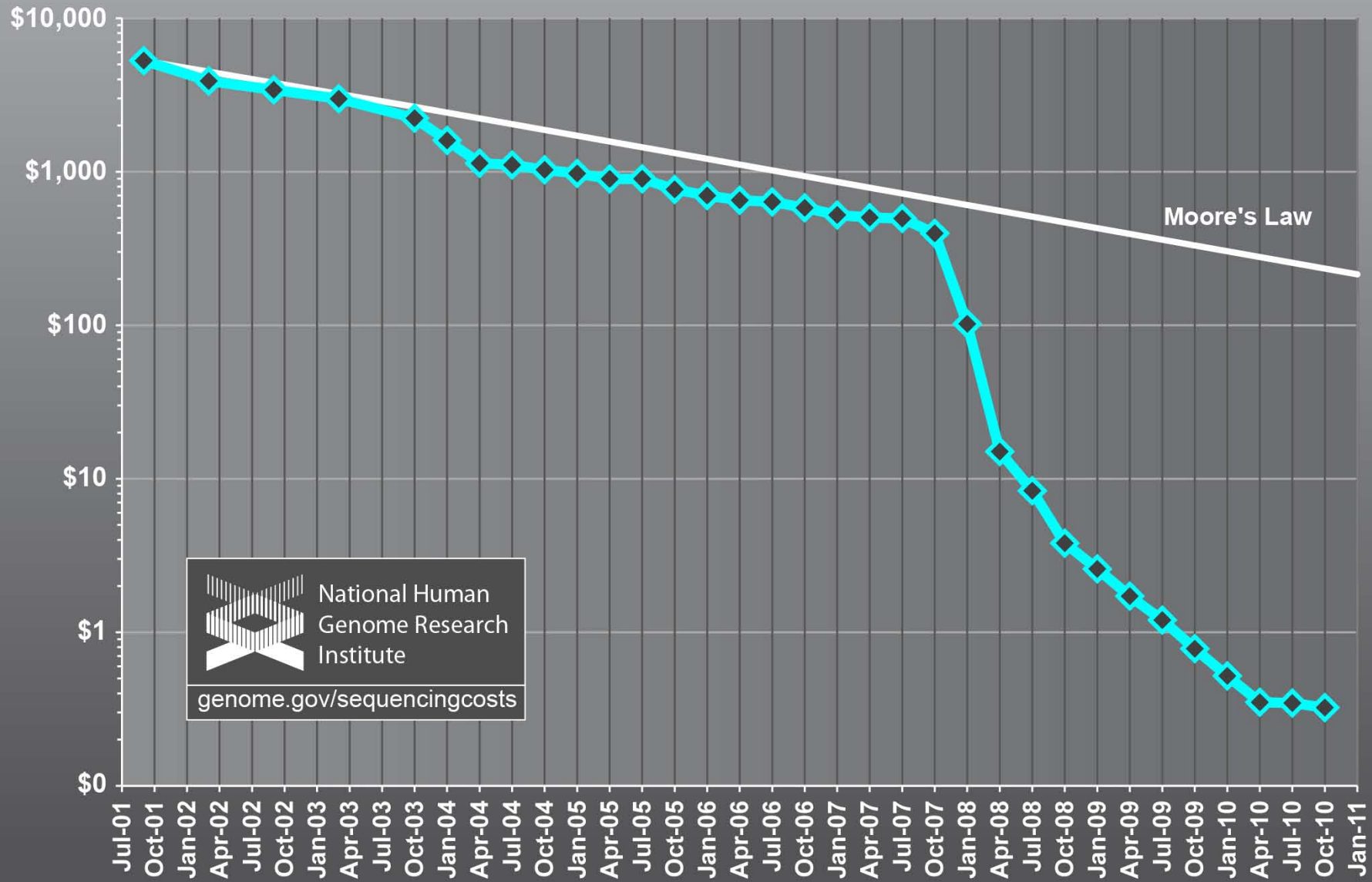


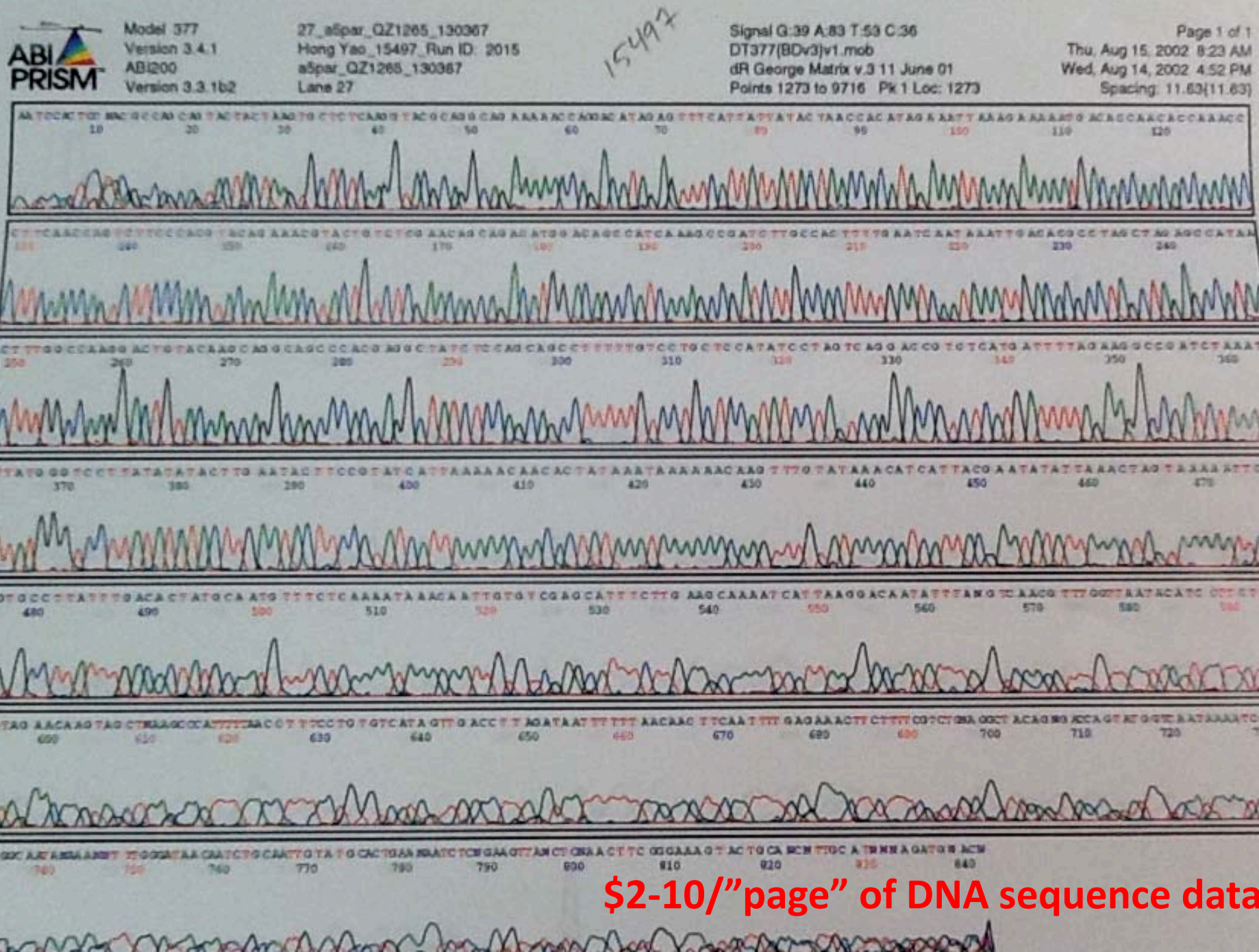
Maize is Genetically Diverse

=

Similar Amounts of Genetic Diversity

Cost per Megabase of DNA Sequence

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Page 1 of 1
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Spacing: 11.63(11.63)
$2-10/"page" of DNA sequence data

A Single Illumina HiSeq 2000 Paired-End Lane

Illumina HiSeq 2000

Sequencing Cost
$6,000

Paired-End Lane:
90 x 10^6 Reads
2 x 100 bp reads
18 x 10^9 bp
8 days

18 (50) GB data

Letter Size Paper

Letter Size Paper:
1" margins
12 pt font size
Times New Roman
~2,500 character (UPPERCASE)

HP LaserJet P4015 Black & White Printer

Printer:
~50 pages/min (single sided)

Cartridge:
~24,000 pages

$0.0008/"page" of DNA sequence data

How much paper is needed to print data from 1 paired-end lane of HiSeq?

18 x 10^9 bp / 2.5 x 10^3 = **7.2 x 10^6 pages**

Or

1 ream = 500 pages

7.2 x 106 / 500 = **14,400 reams**

Or

1 case = 10 reams

14,4000 / 10 = **1,440 cases** (12" x 10" x 18")
A pile of cases **12 ft x 12 ft x 12ft**

And

1 printer + 300 cartridges + 100 days

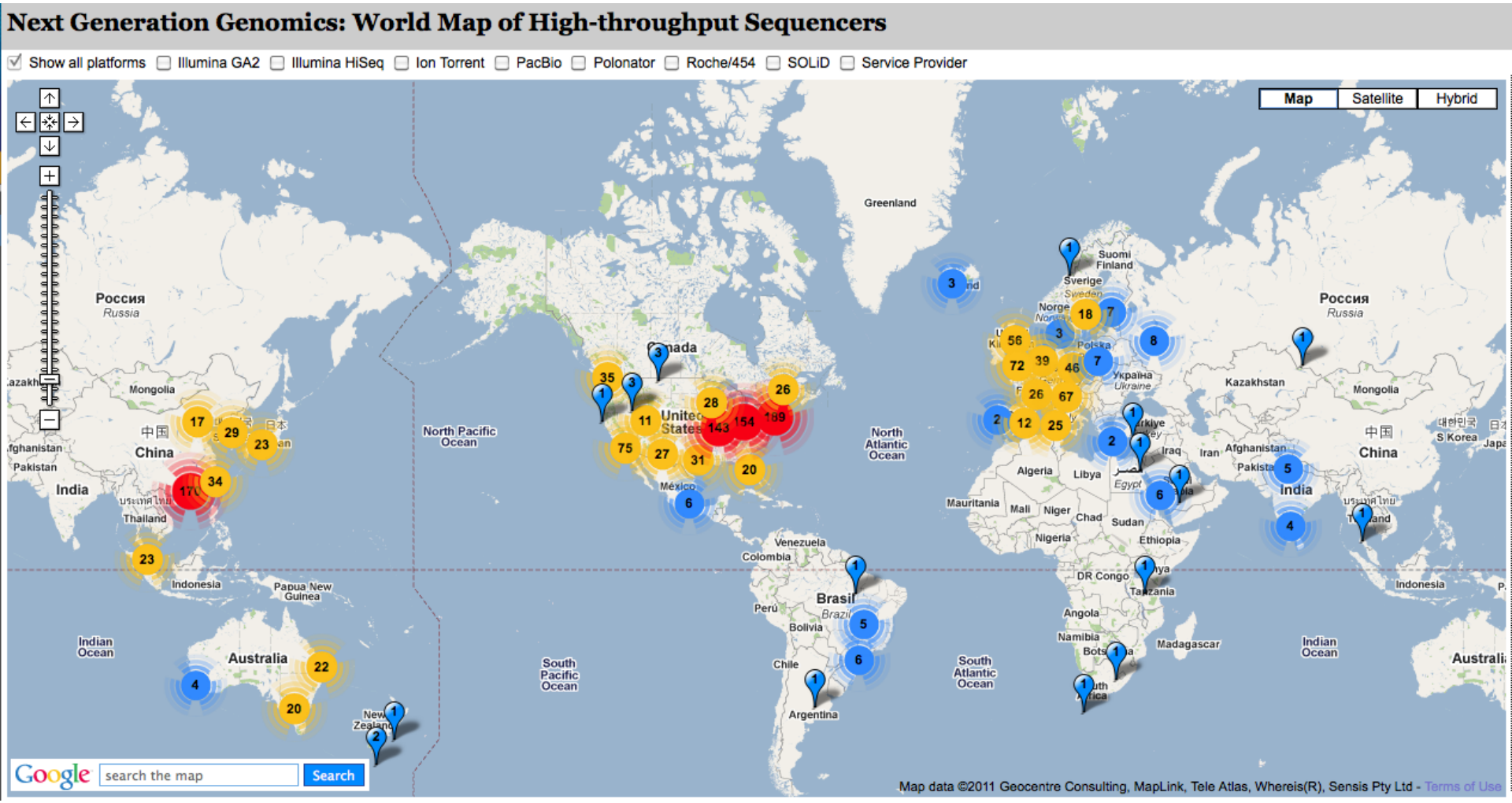
Supply Cost:

1,440 cases @ $40/each + 300 cartridges @ $300/each = **$147,600**

DATA2BIO™
http://www.data2bio.com

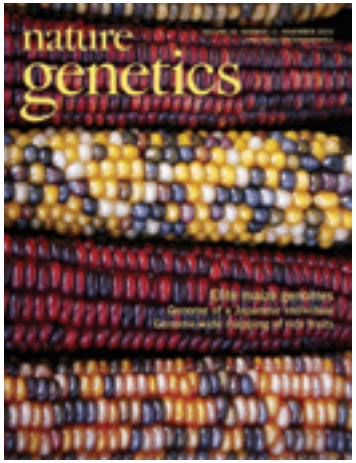
NGS Technologies are Changing the Game

>1,600 NGS Instruments



Source: pathogenomics.bham.ac.uk

Sequenced Six Add'l Maize Inbreds



Lai et al., 2010

Summary

- Applies to all crops
- Plant breeders have been very successful
- But it gets harder each year to maintain rate of yield increase
- Substantial prior Federal investments in plant genomics
- New challenges require continued public-sector investments in agricultural R&D

Travel Support from:

- National Corn Growers Association
- Iowa Corn Growers Association
- International Wheat Genome Sequencing Consortium
- Eversole Associates

Further Information

- USDA Report: The Seed Industry in U.S. Agriculture: http://www.ers.usda.gov/publications/aib786/aib786.pdf
- USDA Report “World Agricultural Supply and Demand Estimates” http://www.usda.gov/oce/commodity/wasde/latest.pdf