Food and Agriculture Organization of the United Nations

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Convention on Biological Diversity

International Treaty on Plant Genetic Resources for Food and Agriculture

CABI

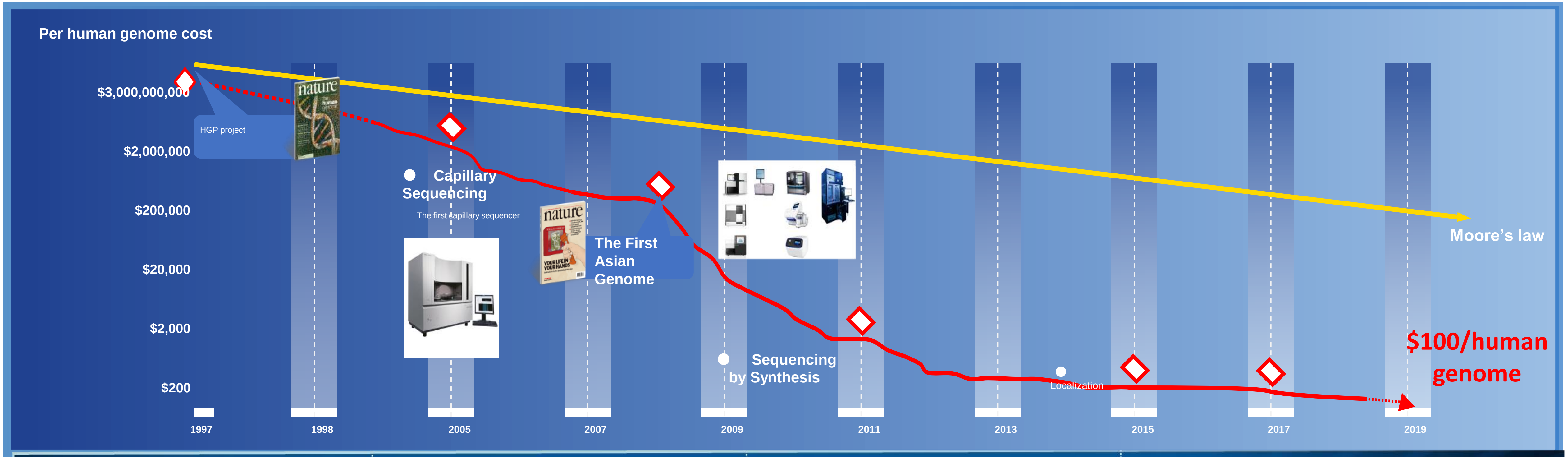
CGIAR INITIATIVE ON Genebanks

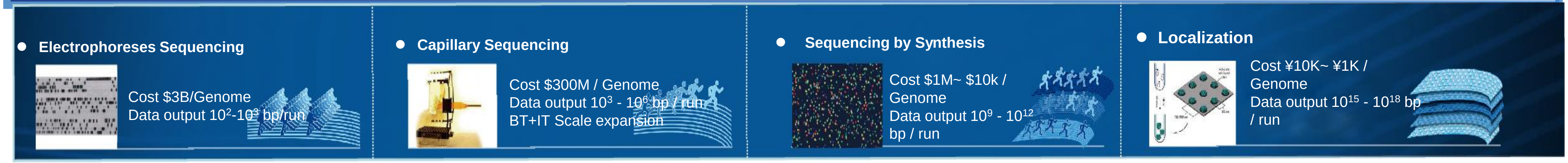
DSI – An expressway or a bottleneck for sustainable use of plant genetic resources in the Omics era?

Ren Wang
Chinese Academy of Agricultural Sciences

High throughput and low-cost genome sequencing

allows new data-driven research launched at unprecedented large scale that was previously unimaginable





The BGI high throughput sequencing factory

DSI increases the value of genetic resources

- The **genome editing technology** allows researchers to modify the plant genome in the laboratory based on DSI, to directly obtain the desired traits of the plant.
- In **biomedicine**, new medicinal compounds can be discovered from the genome sequence analysis of special microorganisms carried by some wild plants.
- In **industrial biotechnology**, new product manufacturing processes can be developed using DSI.
- In **biodiversity conservation** and taxonomy, it can be used to quickly identify the evolutionary path and related relationships of species.

UK Biobank – The largest biomedical database for global open access

- ✓ 500,000 participants recruited in 4 years (2006-2010)
- ✓ With the participants' consent, they regularly provide blood, urine and saliva samples, as well as detailed information about their lifestyle which is then linked to their health-related records to provide a deeper understanding of how individuals experience diseases.
- ✓ Data storage projected to exceed 15 petabytes by 2022
- ✓ Over 30,000 global registrations
- ✓ Over 5,000 scientific published papers

World Food Prize Laureate , 1996

2001 CGIAR Annual General Meeting

Food Security by Design: Reinventing the Rice Plant in Partnership with NARES

Gurdev Singh Khush
Former Principal Plant Breeder
International Rice Research Institute (IRRI)

With an introduction by

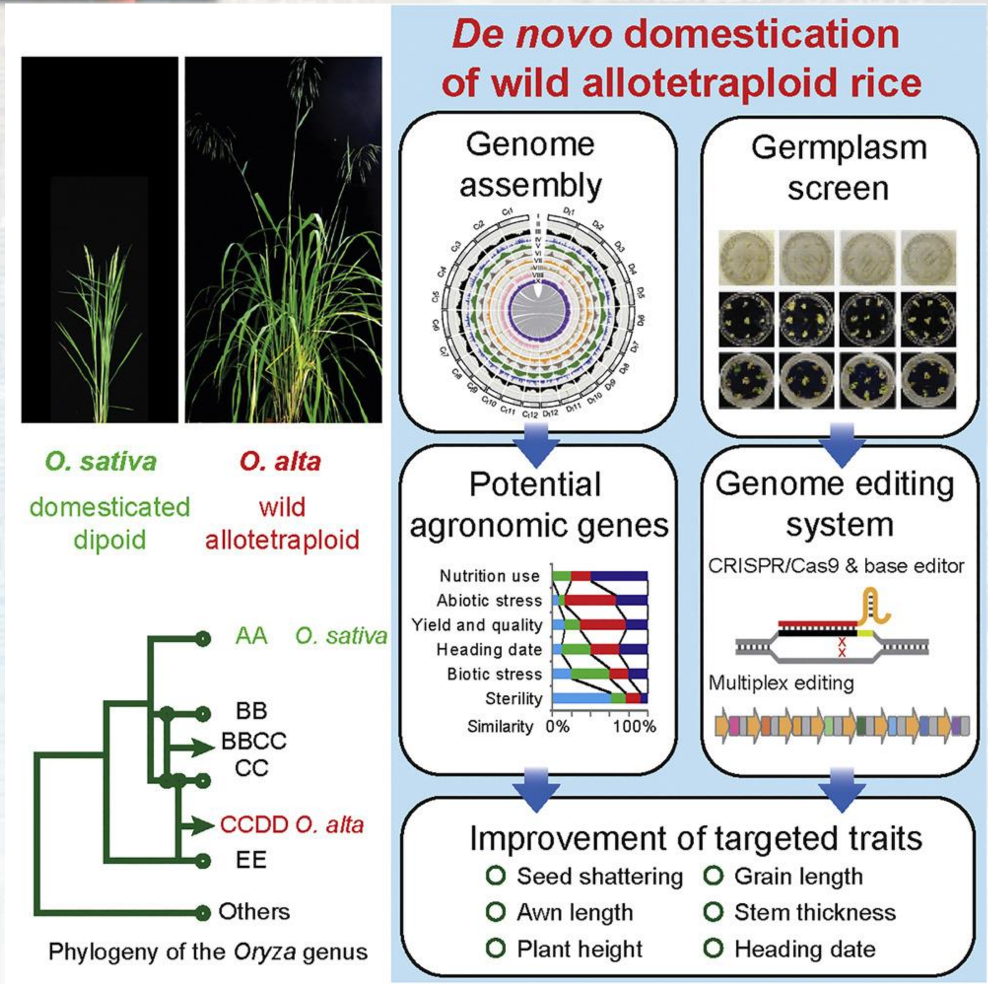
Ren Wang
IRRI Deputy Director General for Research

ARTICLE| VOLUME 184, ISSUE 5, P1156-1170.E14, MARCH 04, 2021,
Hong Yu, Caixia Gao, Jiayang Li, *et al*

Re-design rice from its wild relatives

Cultivated rice varieties are all diploid, and polyploidization of rice has long been desired because of its advantages in genome buffering, vigorousness, and environmental robustness.

Demonstrate the possibility that *de novo* domesticated allotetraploid rice can be developed into a new staple cereal to strengthen world food security.



Genome Design of Hybrid Potato
– the most important tuber crop

Sanwen Huang, *et al*, CAAS

- ✓ **The potato genome was deciphered in 2011**
- ✓ **Potato Genome Sequencing Consortium**
  14 countries and 28 institutions

"They essentially reinvented potato from scratch!"

- Sophien Kamoun，Sainsbury Laboratory

Two structural barriers to the potato industry:

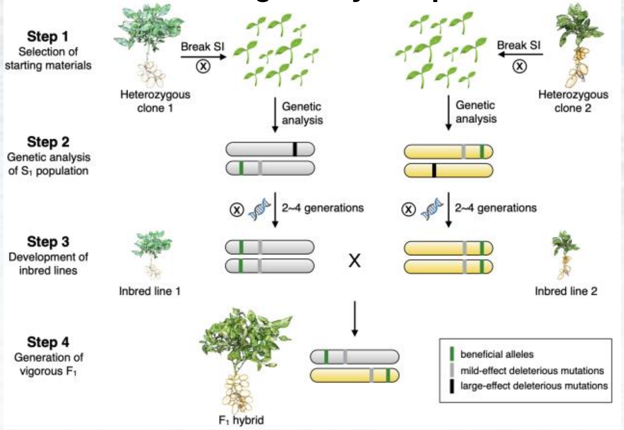
1. **Potato genome is autotetraploid**
   - highly heterozygous and complicated for genetic analysis.
   - Breeding is not cumulative, making breeding cycle very long (10-15 years)
2. **Clonal propagation**
   - Low reproductive coefficient (1:10)
   - The cost of use (transportation etc.) is high
   - Susceptibility to pests and diseases,
   - High carbon foot-print

Diploid hybrid "Upotaoto 1" developed by Sanwen Huang's team, Chinese Academy of Agricultural Sciences

- ✓ **Created using genome design breeding**
- ✓ **Fast-iterative breeding, breeding cycle of 3-5 years.**
- ✓ **Using seeds for propagation**
- ✓ **Avoid tuber-born diseases**
- ✓ **Easy to ship and store with low carbon footprint.**
- ✓ **Yield potential: 35-40 tons/ha**

Hybrid potato seeds

Genome design of hybrid potato



CGIAR distribution of plant genetic resources as global public goods

- 2012-2017 distributed 700,000 germplasm of 35 crops
  - CGIAR centers: 44%
  - Non- CGIAR research institutes: 56%
    - Developing countries: 67% (41,336 份)
    - Developed countries: 33% (20,040 份)
- Types of distributed germplasm:
  - Land races: 42%
  - Pre-breeding materials: 28%
  - Wild relative species 12%
  - Advanced breeding lines 7%

11 Gene Banks of CGIAR

Examples of national agricultural germplasm gene banks

- **National Crop Genebank of China — Beijing**
  - Established in Oct 1986 at the Chinese Academy of Agricultural Sciences with a phase I storage capacity of more than 400,000 accessions
  - Construction of its new project started in Feb 2019, planning to quadruple the capacity to 1.5 million accessions


- **U.S. National Center for Genetic Resources Preservation — Fort Collins**
  - Opened in 1958 and expanded in 1992
  - Conserving over 500,000 germplasm accessions belonging to 12,000 plant species, mainly including corn, wheat, beans, sorghum, rice, cotton, etc.

- **National Agriculture and Food Research Organization (NARO) Genebank, Japan — Tsukuba**
  - NARO was established in 1985 to conserve plant, microbial and animal genetic resources. Its DNA Bank was built in 1993.
  - Housing 224,000 accessions of plant resources, 32,500 accessions of microbial resources, 1,900 accessions of animal resources, and 909,000 accessions of DNA resources


- **Rural Development Administration (RDA) Gene Bank, Korea**
  - Collected about 237,000 accessions of germplasm resources belonging to 1,599 plant species, of which about 75% are grains

Conservation & sustainable utilization of germplasm resources in the genomics era: digital sequence information (DSI)

Rice Wheat Corn

Genome 0.4 Gb	Genome 17 Gb	Genome 2.3 Gb
Rice	Wheat	Corn

Upgrade from traditional seed banks to the advanced seeds + DNA + DSI (3 in 1) model of an integrated gene bank for crop germplasm resources

Germplasm bank

Raw materials, high-generation breeding materials, varieties

Traditional gene banks

1) Conservation: high space requirement, risk of seed viability loss
2) Redistribution: high cost of regular seed multiplication

Increase potential parents' breeding values through systematic conservation of germplasm

Database

Crop phenotypes - gene sequence information (DSI)

DNA + DSI database

1) Conservation: lower space requirement, permanent conservation
2) Redistribution: lower cost, high sharing efficiency, greater help to discovery of functional genes

The increasing importance as well as complexity of Digital Sequence Information (DSI)

- There is exponential growth of the deposit of DSI into openly accessible databases. Since 2010 , the amount of molecular data available has been doubling every 14 to 18 months.
- The current uncertainty/ disagreement regarding the legal status of DSI threatens technical progress, global public health and world food security.
- There is a need to rethink access and benefit-sharing, in particular when considering DSI in the context of health and food security.

It is time for joint endeavours of the international community to achieve consensus on DSI

- **Open Letter to the CBD, Mar 2022, by 32 organizations and individuals:**
  - **Balanced and sensible solutions must be found that ensure fair and equitable benefit sharing from DSI,** while recognizing the sovereign right of nations over their natural resources, including their genetic resources, and the role and interests of indigenous peoples and local communities**;**
  - **Support open access to DSI,** avoid new systems for DSI that would increase regulatory complexity and costs of research, disproportionately affecting developing countries where resources are particularly scarce. Without an open and equitable solution to DSI, the scientific community will be hindered in its ability to conduct research and develop solutions for current environmental and health crises.
- **Stakeholder Meeting "The Implications of Digital Sequence Information on the Governance of Plant & Genetic Resources", May 2022, Bellagio Center, Italy:**
  - Explore options for coordinating and aligning the various processes studying policy options for access and use of digital sequence information and benefit sharing
  - Discussed the possibility of a multilateral system combined with certain elements of bilateral system of governance for DSI;
  - Proposed the idea of establishing a "Global Benefit Sharing Fund"

THANK YOU!

From tradition to the Future …