Bioeconomy World Tour: Bioeconomy Innovations – Challenges and Opportunities

Glaucia Mendes Souza, SCOPE Program for Bioenergy & Sustainability (Brazil)

Ning Li, Beijing Genomics Institute (China)

Jack Bobo, Intrexon (USA)

Ben Durham, South African Department of Science & Technology

Marc Palahí, European Forest Institute

Chairs: **Eduardo Trigo**, Ministry of Science, Technology and Innovation of Argentina,
Hannelore Daniel, German Bioeconomy Council

Bioenergy and the bioeconomy The São Paulo Research Foundation, FAPESP

Glaucia Mendes Souza

President

FAPESP Bioenergy Research Program

State of São Paulo, Brasil

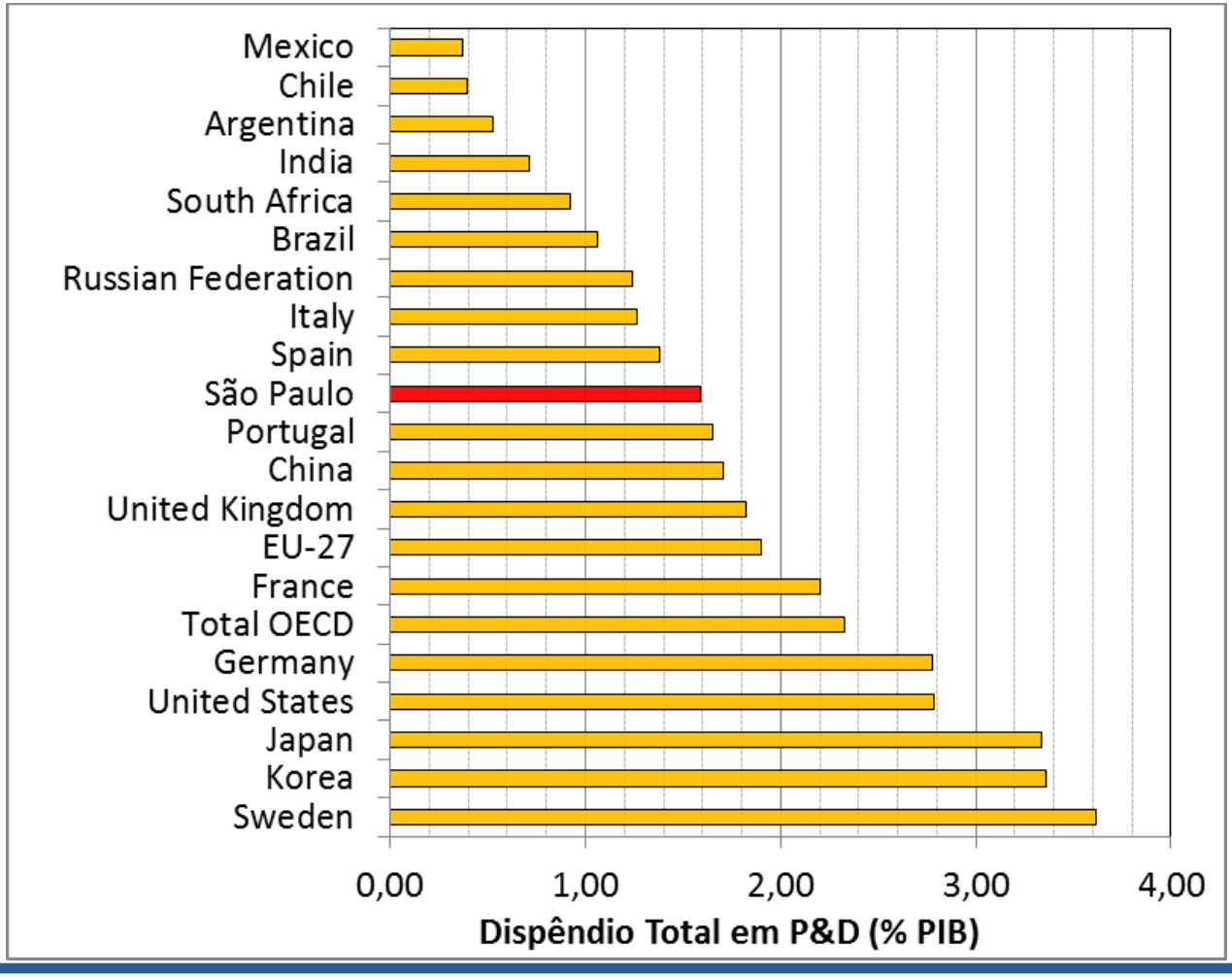
42	Million people
32%	of Brazil's GDP
45%	of Brazilian science
13%	of State budget to High Education and R&D
80+	Research Institutions

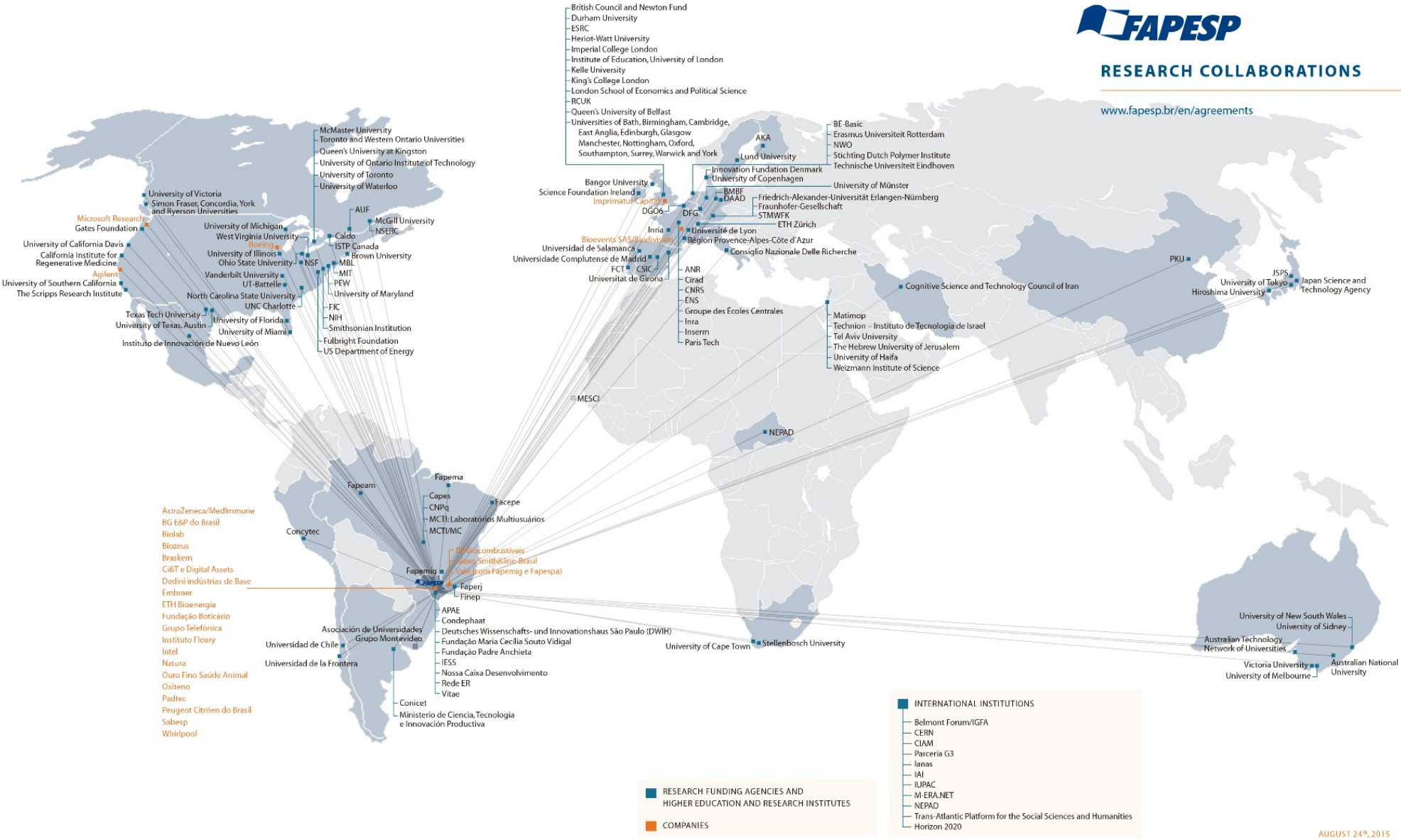
3	State Universities
3+1	Federal HE institutions
52	State Tech Faculties
45%	of the PhDs graduated in Brazil (5,754 in 2013)
22	Research Institutes (19 state/3 federal)

Research Grants and Scholarships funded by FAPESP since 1992

Health Sciences, Biological Sciences, Agricultural, Veterinary Sciences and Biomedical Engineering

BIOECONOMY	
2,552	Ongoing research grants
40,212	Completed research grants
5,076	Ongoing scholarships in Brazil
53,249	Completed scholarships in Brazil
399	Ongoing scholarships abroad
2,640	Completed scholarships abroad
104,128	All Research Grants and Scholarships




FAPESP
RESEARCH COLLABORATIONS
www.fapesp.br/en/agreements
British Council and Newton Fund
Durham University
ESRC
Heriot-Watt University
Imperial College London
Institute of Education, University of London
Kelle University
King's College London
London School of Economics and Political Science
RCUK
Queen's University of Belfast
Universities of Bath, Birmingham, Cambridge, East Anglia, Edinburgh, Glasgow Manchester, Nottingham, Oxford, Southampton, Surrey, Warwick and York
AKA
Lund University
BE-Basic
Erasmus Universiteit Rotterdam
NWO
Stichting Dutch Polymer Institute
Technische Universiteit Eindhoven
Innovation Fundation Denmark
University of Copenhagen
University of Münster
Bangor University
Science Foundation Ireland
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Fraunhofer-Gesellschaft
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Inria
Université de Lyon
Région Provence-Alpes-Côte d'Azur
Consiglio Nazionale Delle Richerche
Bioevents SAS/Biodivision
Universidad de Salamanca
Universidade Complutense de Madrid
FCT
CSIC
Universitat de Girona
ANR
Cirad
CNRS
ENS
Groupe des Écoles Centrales
Inra
Inserm
Paris Tech
Matimop
Technion – Instituto de Tecnologia de Israel
Tel Aviv University
The Hebrew University of Jerusalem
University of Haifa
Weizmann Institute of Science
Cognitive Science and Technology Council of Iran
PKU
JSPS
University of Tokyo
Hiroshima University
Japan Science and Technology Agency
McMaster University
Toronto and Western Ontario Universities
Queen's University at Kingston
University of Ontario Institute of Technology
University of Toronto
University of Waterloo
University of Victoria
Simon Fraser, Concordia, York and Ryerson Universities
Microsoft Research
Gates Foundation
University of California Davis
California Institute for Regenerative Medicine
Agilent
University of Southern California
The Scripps Research Institute
AUF
McGill University
NSERC
University of Michigan
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Brown University
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MIT
PEW
University of Maryland
Vanderbilt University
UT-Battelle
North Carolina State University
UNC Charlotte
FIC
NIH
Smithsonian Institution
Fulbright Foundation
US Department of Energy
Texas Tech University
University of Texas, Austin
University of Florida
University of Miami
Instituto de Innovación de Nuevo León
MESCI
NEPAD
Fapema
Fapeam
Capes
CNPq
Facepe
MCTI: Laboratórios Multiusuários
MCTI/MC
Concytec
AstraZeneca/MedImmune
BG E&P do Brasil
Biolab
Biozeus
Braskem
CI&T e Digital Assets
Dedini indústrias de Base
Embraer
ETH Bioenergia
Fundação Boticário
Grupo Telefônica
Instituto Fleury
Intel
Natura
Ouro Fino Saúde Animal
Oxiteno
Padtec
Peugeot Citröen do Brasil
Sabesp
Whirlpool
BP Grocombustíveis
Glaxo SmithKline Brasil
Vale (com Fapemig e Fapespa)
Fapemig
FAPESP
Faperj
Finep
APAE
Condephaat
Deutsches Wissenschafts- und Innovationshaus São Paulo (DWIH)
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Conicet
Ministerio de Ciencia, Tecnologia e Innovación Productiva
University of Cape Town
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RESEARCH FUNDING AGENCIES AND HIGHER EDUCATION AND RESEARCH INSTITUTES
COMPANIES
INTERNATIONAL INSTITUTIONS
Belmont Forum/IGFA
CERN
CIAM
Parceria G3
Ianas
IAI
IUPAC
M-ERA.NET
NEPAD
Trans-Atlantic Platform for the Social Sciences and Humanities
Horizon 2020
AUGUST 24th, 2015

FAPESP Bioenergy Research Program

Academic and applied research, US$ 200 million
Since 2009, 578 grants, over 400 researchers
170 graduate degrees

BIOMASS

BIOFUEL TECHNOLOGIES

ENGINES

BIOREFINERIES

SUSTAINABILITY

Collaboration Network

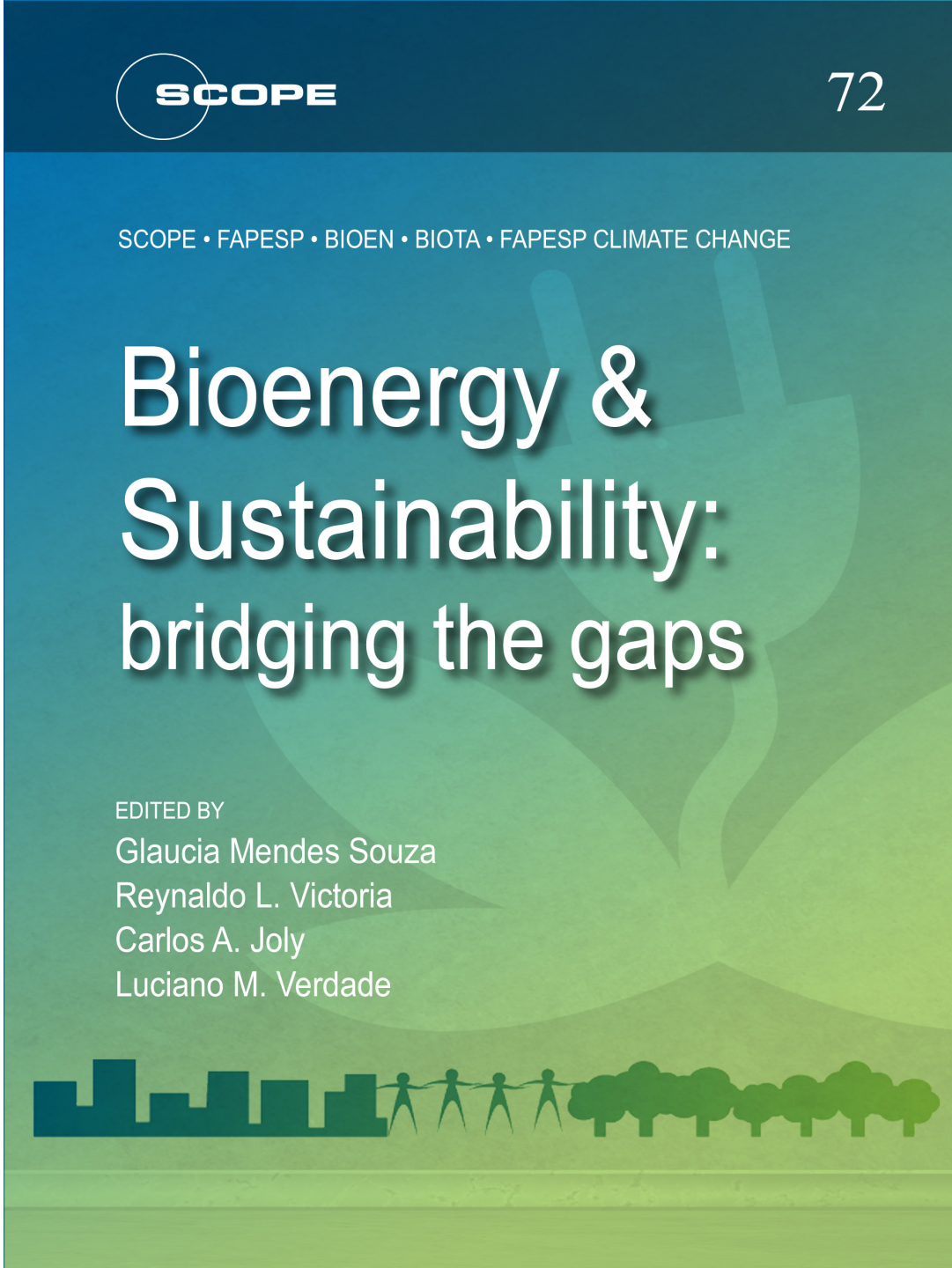
The map graph below displays (up to) the top **500 geographic locations** for this researcher's co-authors. Scroll over the map and place your cursor on a pin to view city, state, and country information. Clicking on the pin will display bibliographic data for the paper that has cited the researcher's publication(s).

SCOPE-FAPESP
Reporting a global assessment of
Bioenergy & Sustainability
137 experts from 24 countries

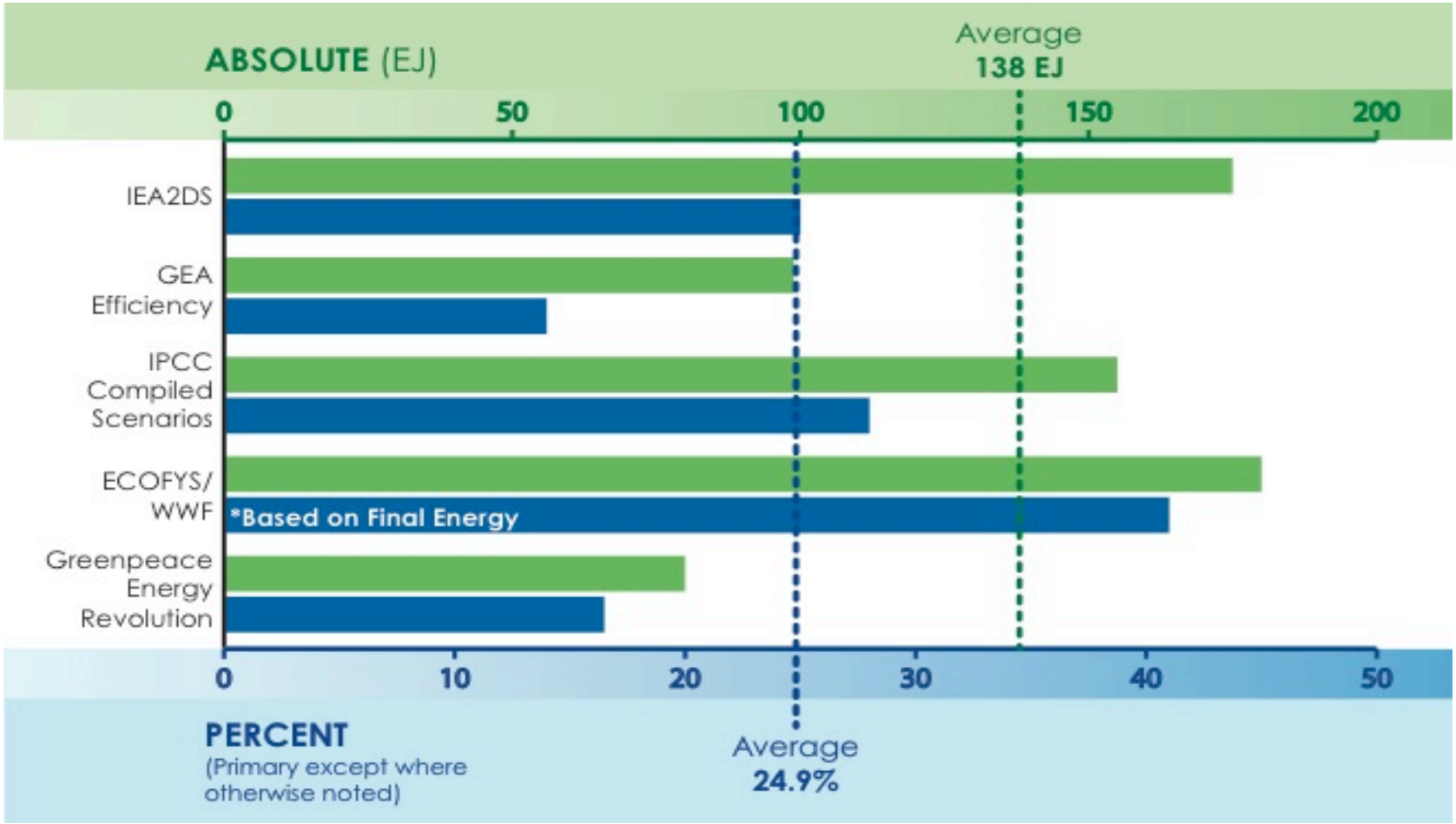
Bioenergy now
Bioenergy expansion
Energy security
Food security
Environmental and climate security
Sustainable development and Innovation
The much needed science

Developed and developing regions
Numbers, cases, issues, solutions

779-page Ebook
Download at http://bioenfapesp.org



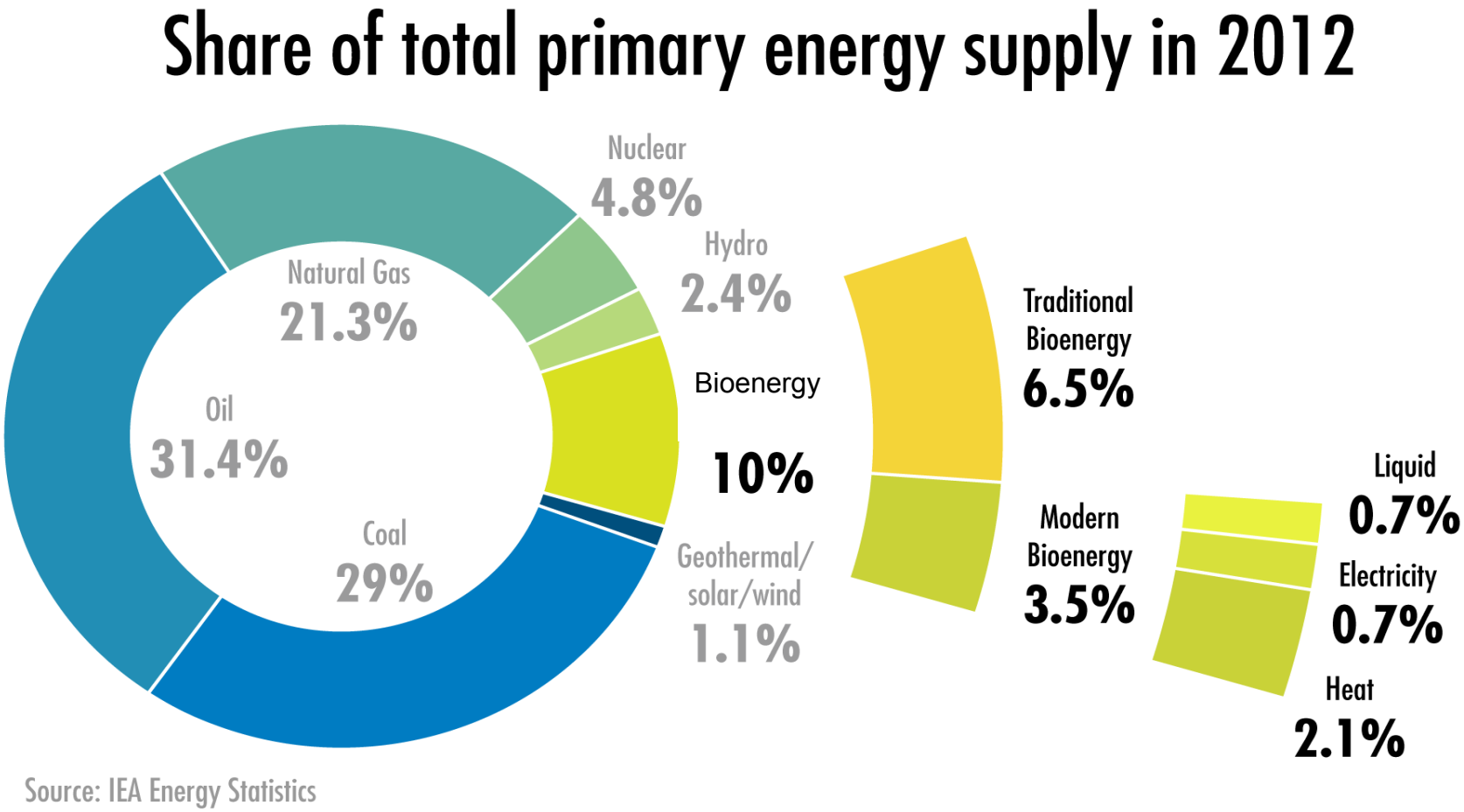
Bioenergy Contribution in 2050: Five Low-Carbon Energy Scenarios



Bioenergy Contribution in 2012:

Liquid biofuels - over 100 Billion L – 4.2 EJ

Biopower – 1 EJ



World Road Transport Liquid Biofuels Demand

2010

2050

3% ..... Biofuels 27%

800 million cars

100-million

50 countries, including many developing countries, now have biofuels mandates with blends of 5-27%, many driven by climate change

2.1 billion cars

Advanced automotive technology has expanded the use of ethanol
Biofuels could contribute to up to ~30%
Electricity, hydrogen, CNG/LPG to ~20%

Advanced Research Centers: 10-year contracts, researchers from universities and from company

FAPESP+Peugeot-Citroen: biofuel engines

Natura: cosmetics and biodiversity

Glaxxo-Smith-Kline, GSK: Green Chemistry and Target Discovery

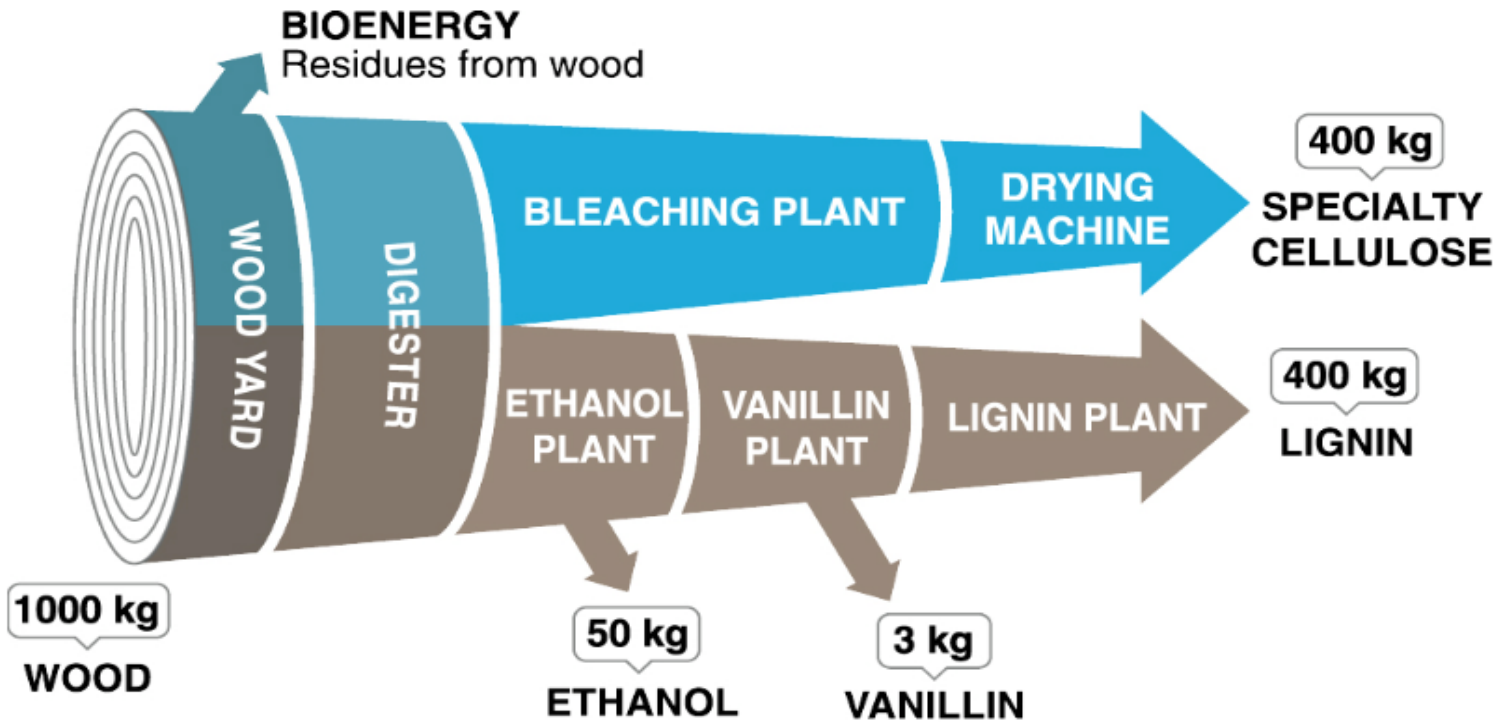
British Gas, BG: natural gas from renewable sources

FAPESP inaugura Centro de Pesquisa em parceria com a PSA Peugeot Citroën

Iniciativa apoiará o desenvolvimento de motores movidos a biocombustíveis com participação de pesquisadores da USP, Unicamp, ITA e Instituto Mauá de Tecnologia

A Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) e a PSA Peugeot Citroën do Brasil anunciaram ontem, dia 04 de novembro de 2014, na sede da FAPESP, o lançamento do Centro de Pesquisa em Engenharia "Professor Urbano Ernesto Stumpf", para desenvolvimento de motores de combustão interna, adaptados ou desenvolvidos especificamente para biocombustíveis e de estudos sobre a sustentabilidade dos biocombustíveis.

Integrated new biorefinery systems are on the way: no carbon waste!



Specialty cellulose	Lignin	Vanillin	Bioethanol
Construction materials	Concrete additive	Food	Car care
Cosmetics	Animal feed	Perfumes	Paint/varnish
Food	Agrochemicals	Pharmaceuticals	Pharmaceutical industry
Tablets	Batteries		Biofuel
Textiles	Mining		
Filters	Oil field chemicals		

Opportunities to diversify our use of biomass!

Despite many ups and downs, ethanol has been successful in sustainably displacing gasoline without subsidies through technology improvements

Since 2003, Brazil's use of sugarcane ethanol has avoided **242 million tons of carbon dioxide emissions**

76% reduction in emissions in relation to gasoline

mechanization of harvesting

balanced conditions between sugarcane producers and millers

waste recycling to reduce demand for chemical fertilizers

improved land use by implementing crop rotation between sugarcane cycles

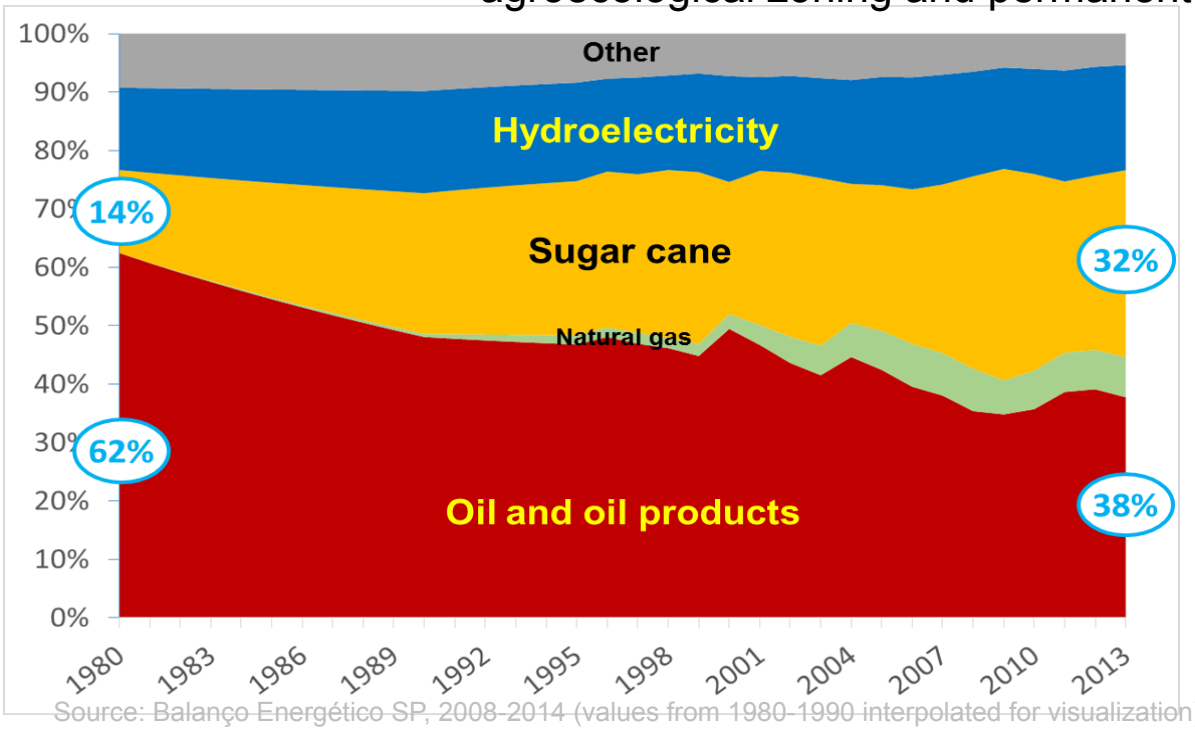
production of bioelectricity through co-generation

significant improvements in energy balance of sugarcane ethanol

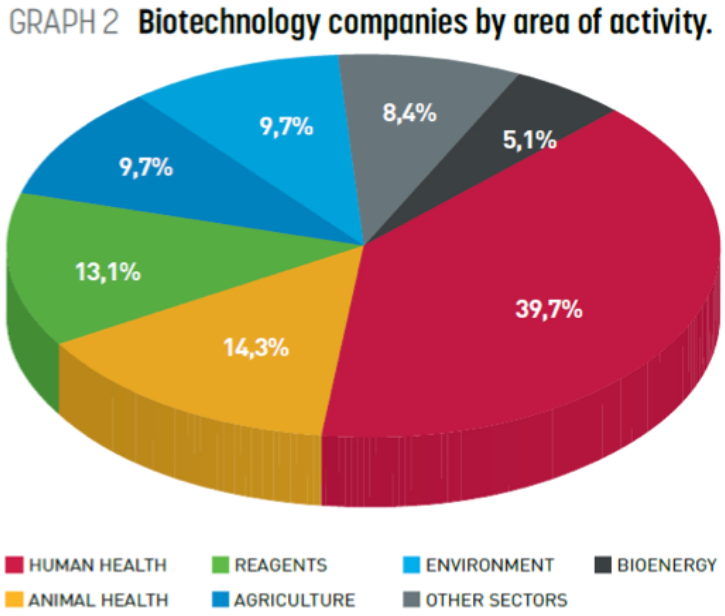
reduction in the use of water with recycling through fertirrigation

reduction of pollution in the urban areas

agroecological zoning and permanent protection areas



Source: Balanço Energético SP, 2008-2014 (values from 1980-1990 interpolated for visualization)



Source: BRBIOTEC Brasil / Cebrap, "Brazil Biotech Map 2011" (n=237).

Newly created biomass and bioenergy centers

SP BIOEN
RESEARCH CENTER
USP - UNICAMP - UNESP

Biomass

Biomass
Systems and Synthetic Biology
Center

SCOPE-FAPESP Bioenergy & Sustainability Policy Brief

Bioenergy, a renewable energy source, has the potential to move the planet into a more sustainable future. Today fossil fuels supply almost 82% of the world's energy demand. The resulting green house gas emissions (GHG) impact Earth's systems and human health and wellbeing.

Currently bioenergy contributes approximately 10% of the world's primary energy supply. Bioethanol and biodiesel provide about 3% of the world's transportation fuels, but biofuels could provide up to 30 % by 2050 with projected improvements in technology. Bioenergy - developed knowledgeably and implemented considering local and regional needs - can help:

- increase resilience in food supply both locally and globally
- decrease pollution
- preserve biodiversity
- improve human health
- rehabilitate degraded land
- mitigate climate change
- provide economic and business oportunities

http://bioenfapesp.org/scopebioenergy/index.php

华大基因 BGI

big data and synthetic biology for a better life

Ning LI

Read

Epigenetic level
BS/RRBS
MeDIP/ChIP-Seq

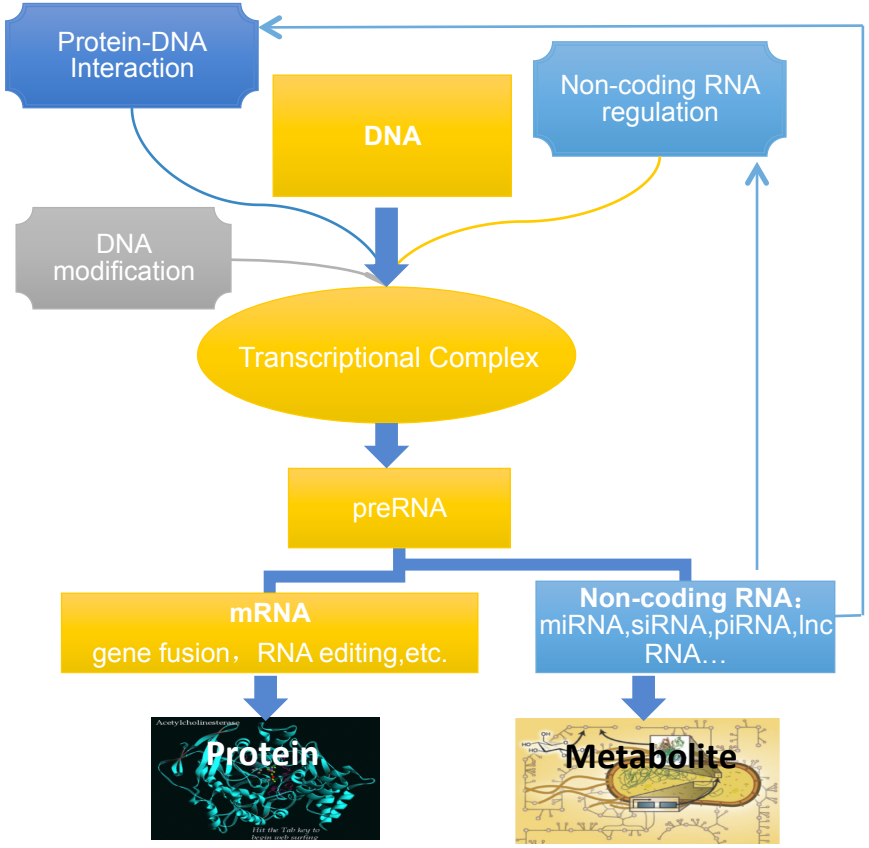
DNA level
Whole genome Resequencing
Exome/All-In-One/Target region seq

RNA level
Transcriptome seq
RNA-Seq / miRNA seq/ lncRNA seq

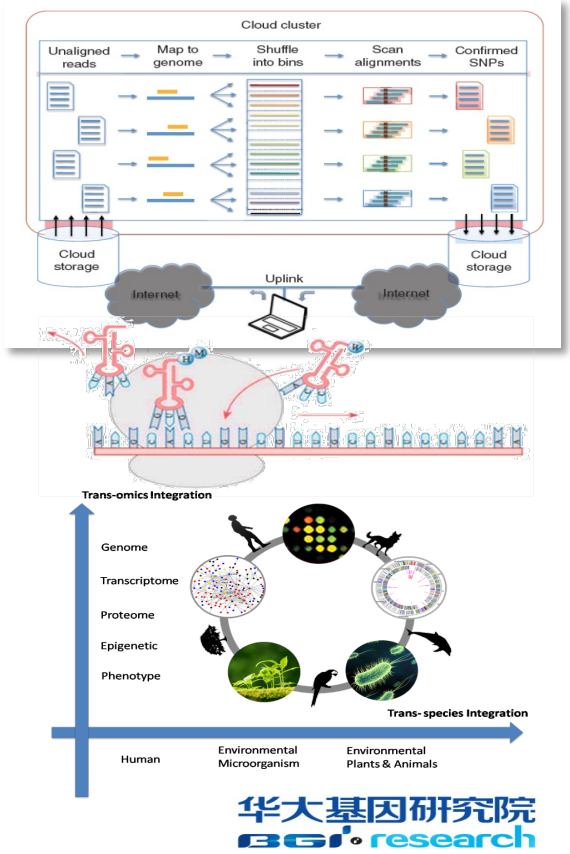
Protein level
Proteome profiling
Quantitative proteomics
Target proteomics

Metabolite level
Metabolites identification
non-targeted metabolomics
targeted metabolomics

Interpret



Apply



Read

Technology Platforms

Sequencing Platform

BGI owns 230 sequencers, with the data output capability of ~16T/Day (as of June 2014).

Platforms include Complete Genomics, Illumina HiSeq 2500, Illumina HiSeq 2000, Illumina Miseq, Ion Torrent, PacBio, BioNano Irys, ABI3730XL and Genotyping platform.

Certifications: ISO9001 ISO14001 OHSAS18001 ISO27001 ISO17025

Mass Spectrometry Platform

BGI has 13 MS sequencers, including Triple Quadrupole Mass Spectrometer (QMS), MALDI mass spectrometer, Orbitrap and Q-TOF mass spectrometer (as of June 2014).

The platform is used for industrial-scale proteomics, metabolomics research and targeted molecule detection.

Certifications: OHSAS18001 ISO14001 ISO9001

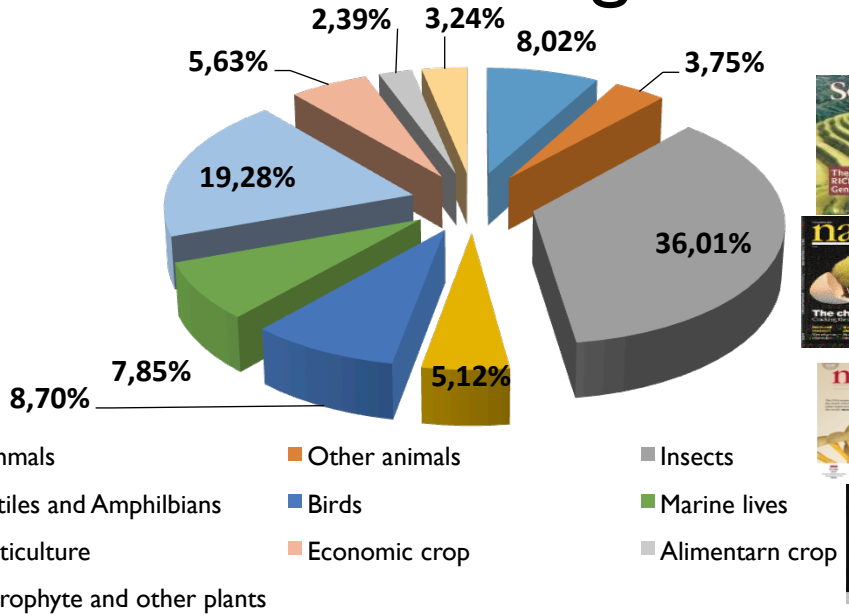
Computing Platform

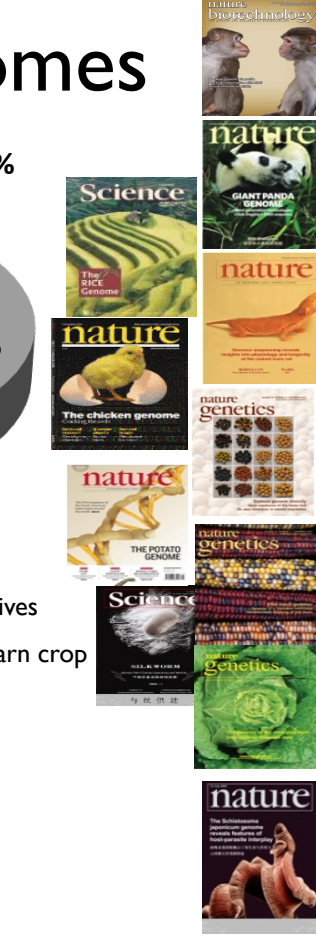
BGI's total peak performance of computing is up to 248 Tflop, the total memory capacity 46.3 TB and the total storage capacity 22.7 PB (as of May 2014).

BGI has several supercomputing centers, located in Shenzhen, Hong Kong, Beijing, Wuhan, and Hangzhou. It has established the TH-BGI Bioinformatics Union Lab with the National Supercomputing Center in Tianjin.

Generated 586 Plant & animal reference genomes

Technology	Classification	Species
de novo	Animal	407
	Plant	179
	Total	**586**





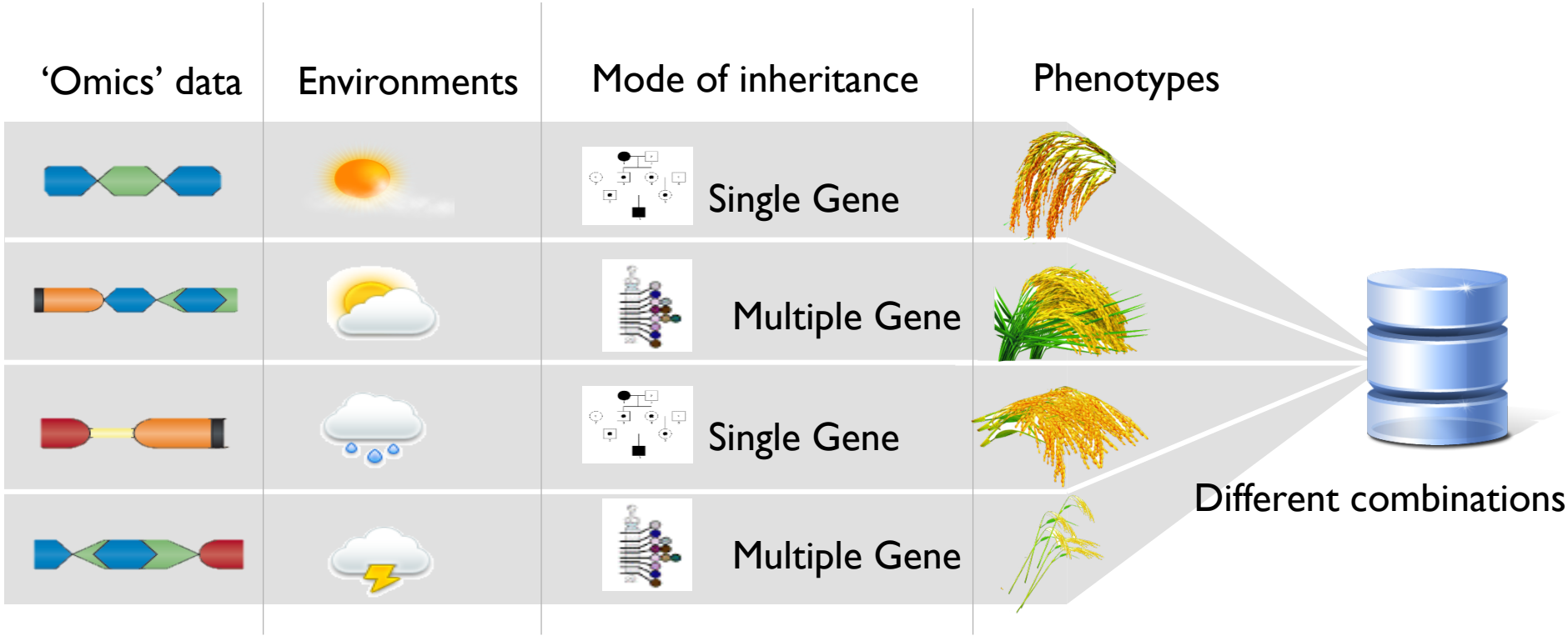
Importance of the species:

- Taste good species: agriculture: rice, potato, cabbage, chicken, pig…
- useful species: Industrial: Silkworm, Palm Oil tree, Macaque…
- Cute species: digital library : G10K, i5K, 1KBird…

Technological difficulties: Highly repetitive, Heterogeneity, Polyploidy: wheat, Oyster…

华大基因研究院 BGI research

Interpret



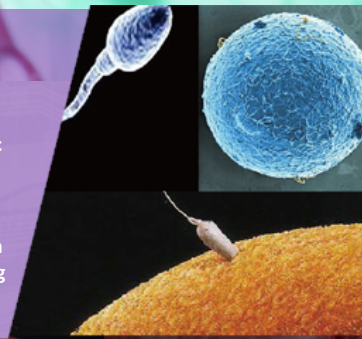
X Omics condition + Y environment condition = Z phenotype

Clinical Medicine

Genetic Diagnostics Excellence

- BGI Diagnostics aims to apply high genetic research capacity and a well-developed global network to solving current health issues worldwide.
- It is committed to raising genetic health awareness and reducing the rate of major disease by offering an array of accurate, reliable and affordable genetic tests and molecular diagnostics services.

- Preconception Genetic Testing
- Newborn Genetic Testing
- Cancer Genetic Testing
- Prenatal Genetic Testing
- Blood Diseases Genetic Testing
- Pathogenic Microorganism Genetic Testing



Genomics Assisted Breeding

- BGI Agro carries out genomics guided plant germplasms development and application, plant variety improvement and modern agriculture industrialization promotion.
- It has a lab area of over 8000 square meters, over 1200 mu breeding field, well equipped with advanced experimental instruments.
- BGI Agro has 4 production bases: Baguang & Dapeng base in Shenzhen, Luoyang base in Henan province and Laos's base.

Baguang Aquatic Base

Dapeng Breeding Base

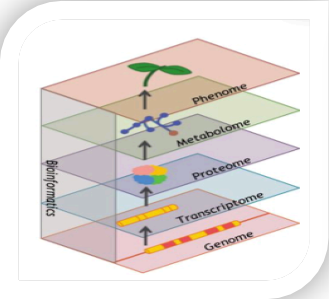
Luoyang Breeding Base

Laos Agroforestry Demonstration Base

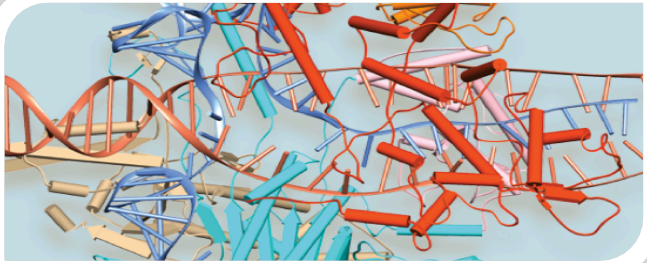
Apply

Big data, Synthetic Biology, Bio-manufacturing

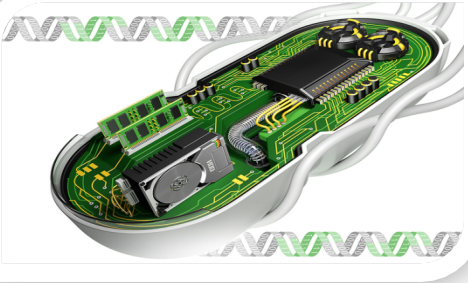
BENCH



Omics Analysis



Gene/Genome Design & Synthesis



Chassis Design

BOTTLE

Cost effective bio-manufacturing

华大基因研究院
BGI research

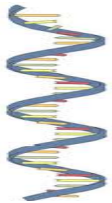
What Bio-manufacturing needs from Synthetic Biology

- DNA synthesis and assembly techniques

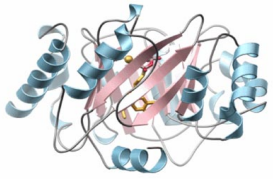
DNA synthesis　　DNA assembly　　Genetic system reconstruction

- Knowledge

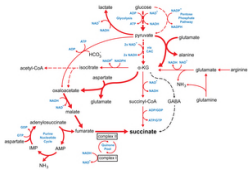
Genome



Transcriptome

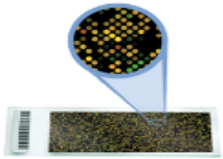


Proteome

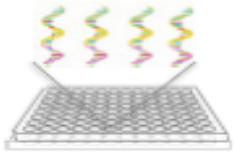


Metabolome

Microarray based DNA synthesis



- Parallel Chip synthesis
- 12k /94k oligos synthesized simultaneously

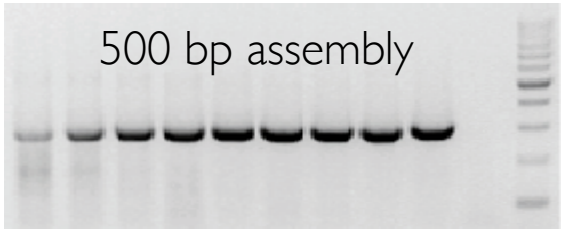


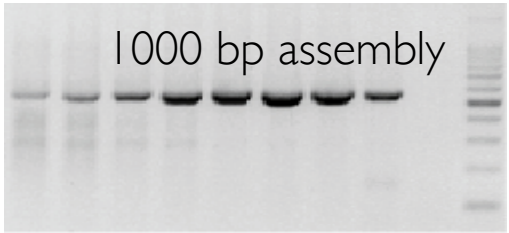
- Pooled Assembly
- Enzymatic Error Correction
- 1,00s parallel synthesis

- Next-Gen Sequence Verification
- Low cost

Oligo Synthesis → **Gene Assembly** → **Quality Control**

- **High yield/run**
- **High efficient assembly**
- **Low cost**
- **Fast turn arround time**

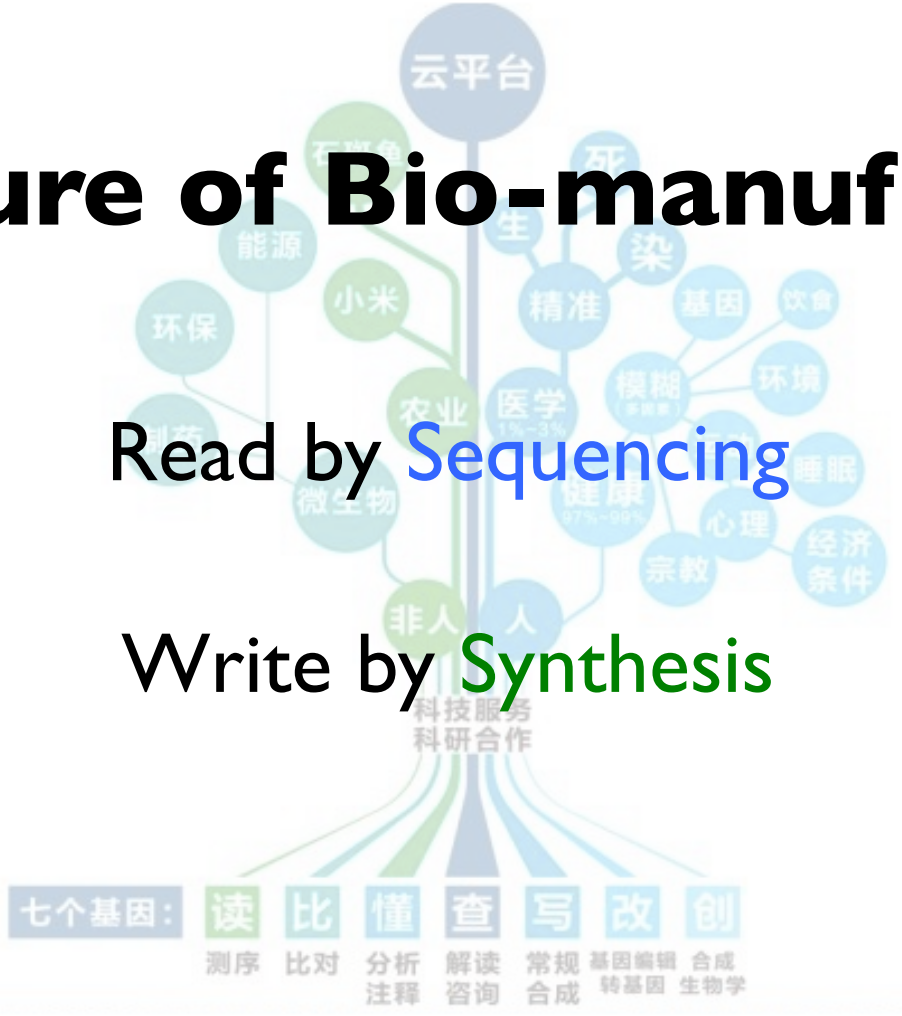




The future of Bio-manufacturing

Read by Sequencing

Write by Synthesis



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BGI research

China National Genebank

Big Resource · Big Data

- The China National Genebank (CNGB) was initiated in 2011 and is the first national genebank in China integrating a large-scale bio-repository and an omics database.
- The mission is to collect, preserve and exploit genomics resources, and to build a network fostering global communication and collaboration on biodiversity conservation and genetic resources utilization.

Biological Bank

Bioinformatics Bank

Consortium Network

8.4 million
human, plant, animal and microbe samples

40+ reference genome database

52PB data storage
Peak performance 227T

CNGB has preserved thousands of genomes, representing 80% of the finished large genome projects in the world.

The total storage capacity is 52 PB and the peak computing performance 227 T FLOPS.

60+ organization in consortia

40+ collaborative institutions

By the end of 2015:

- Store 30 million copies of the traceable biospecimens;
- Build 1EB accessible genetic information database.

华大基因
BGI

BGI (Headquarters)
Hotline: 400-706-6615 / 400-605-6655
Tel: 86-755-36307888
Fax: 86-755-36307273
Address: Building 11, Beishan Industrial Zone, Yantian District, Shenzhen (518083)
Website: http://www.genomics.cn/
Email: info@genomics.cn

From Burgers to Biomes: Food Agriculture and the Bioeconomy

Jack A. Bobo | Senior Vice President

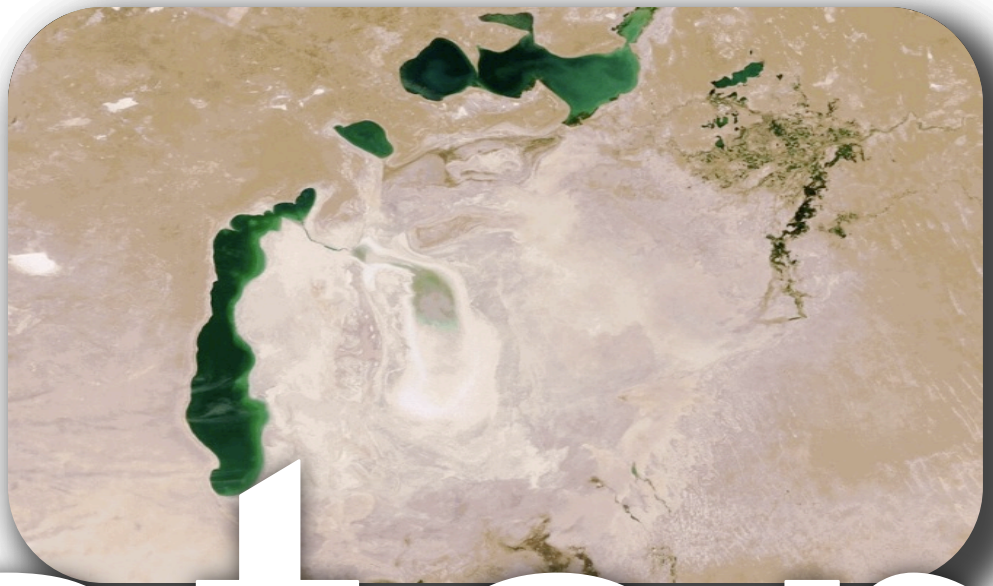
INTREXON®

40% Land

Jack A. Bobo | Senior Vice President | Intrexon

70%

Aral Sea
Today
1973

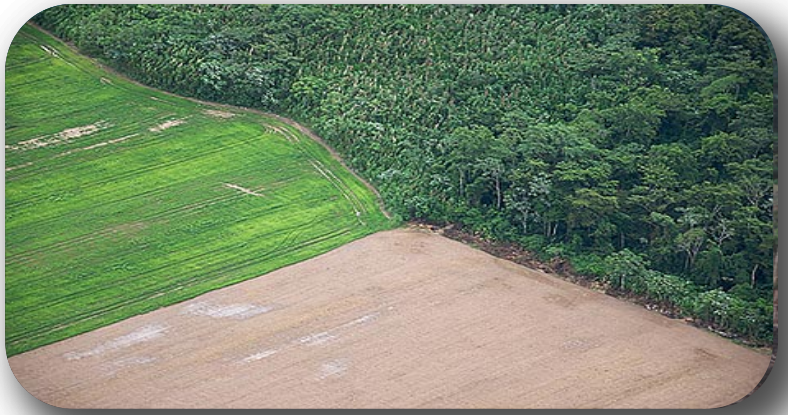


Water

Jack A. Bobo | Senior Vice President | Intrexon

25%

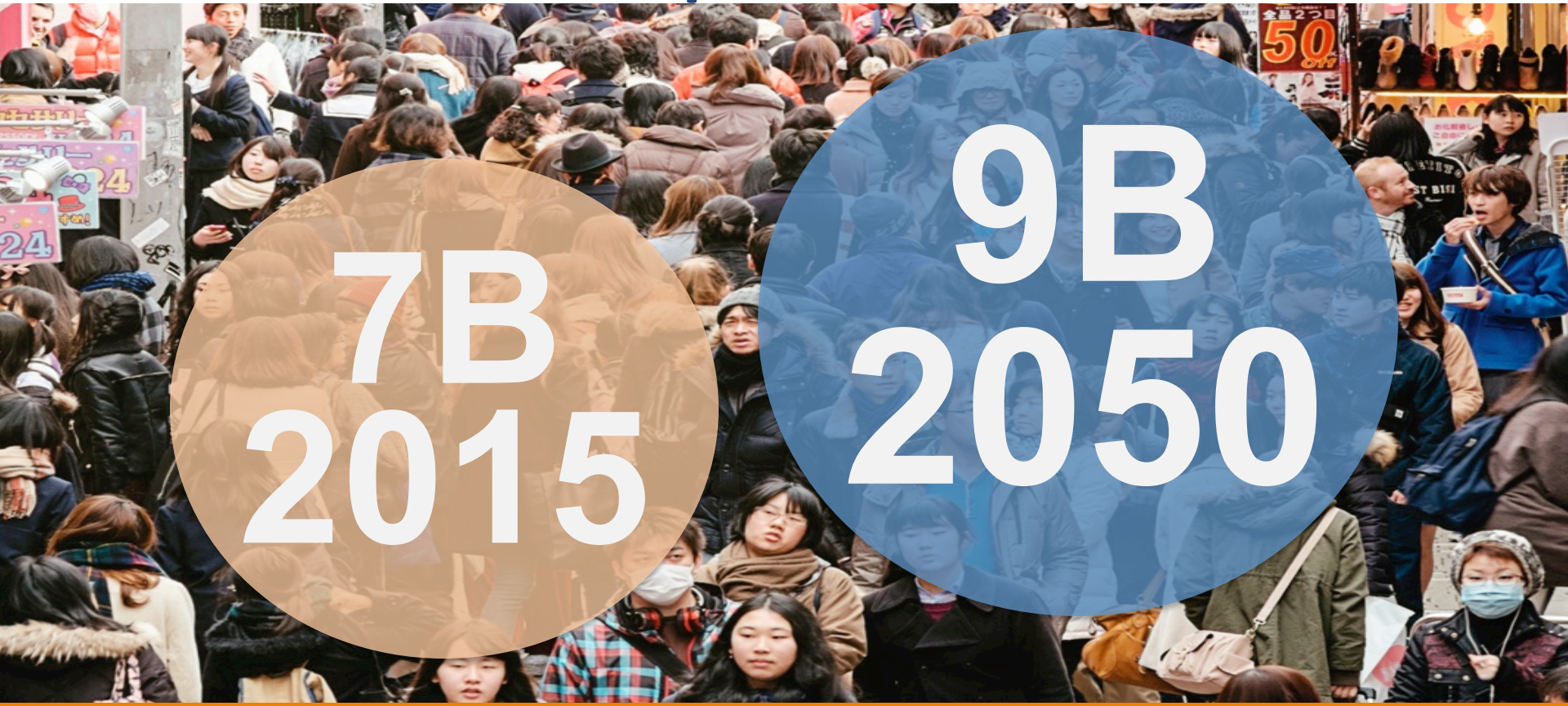
Greenhouse gas emissions from agriculture and deforestation



Climate

Jack A. Bobo | Senior Vice President | Intrexon

Global Population Growth



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Wheat

Vegetables

Cheese

Beef

Clara Foods

Global Fisheries

85%

AquaBounty

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Young Entrepreneurs

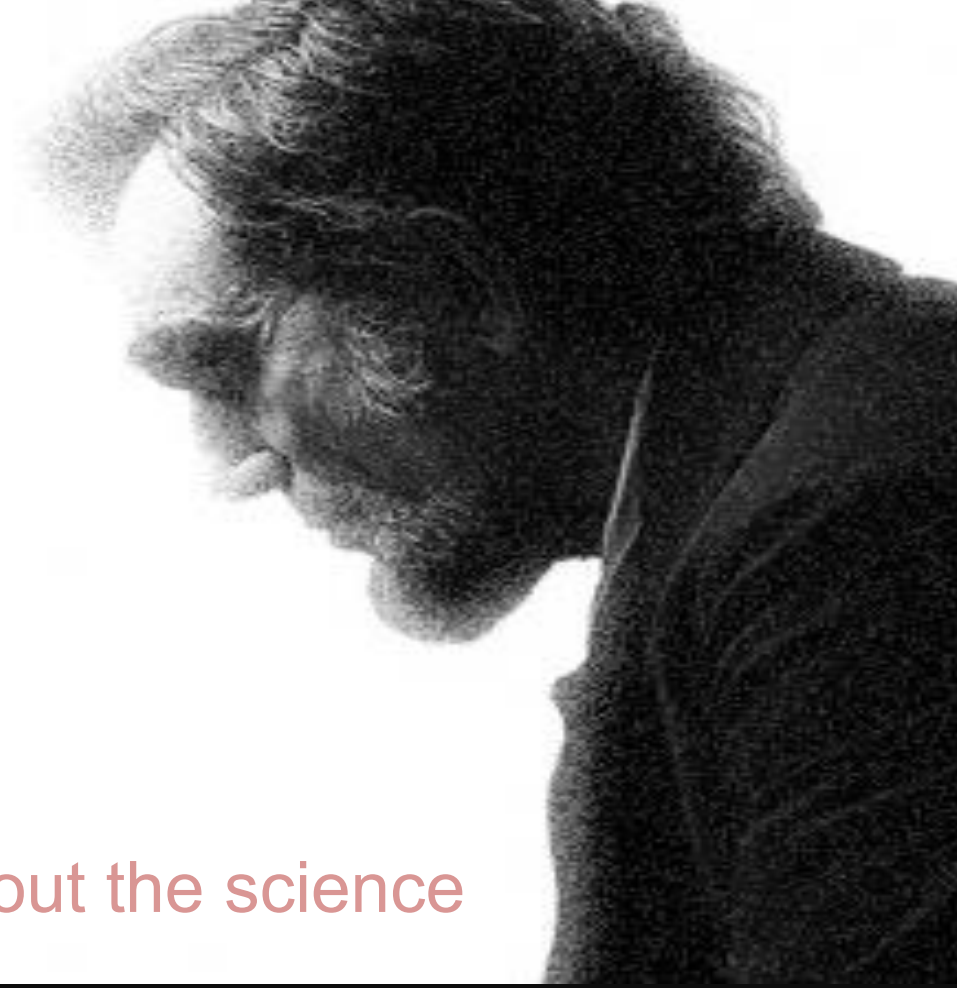
synbiobeta

April 6th – 8th April, Imperial College London

Investors

Scientist as Storyteller

Personalize
Acknowledge
Connect
Build Trust



Only then can we talk about the science

Jack A. Bobo | Senior Vice President | Intrexon

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Bio-economy Strategy

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

Ben Durham: Chief Director: Bio-innovation
Global Bioeconomy Summit 24-26 Nov '15

Background

- 1994 – Democracy
- 1996 - White Paper on Science & Technology
- 2001 - National Biotechnology Strategy
  - Number of mini-agencies created
  - Based on technology commercialisation
- 2014 Bio-economy Strategy

- **Population: 54.96 million**
- **GNI/capita: $12 240**
- **Unemployment: 25.5%**
- **9th largest producer of GMO's**

Lessons learned

a) The **full pipeline**, from research to commercialisation, needs to be considered to ensure sustainable 'through-flow' and desired outcome.

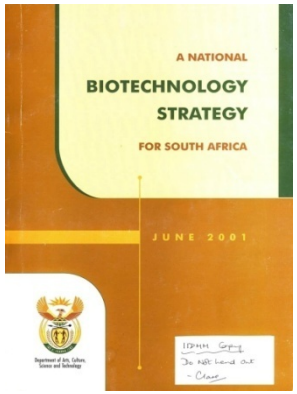
b) **Coordination** between academic and science council researchers, public and/or private sector institutions is vital to ensure teamwork, efficiency, and to avoid fragmentation of effort.

c) Focus on areas of **comparative advantage** and/or **national priority**. In SA - health & agric, but harness indigenous knowledge towards the development of products and empowering communities.

d) The absence of local medium to large biotechnology companies creates a challenge both for investors to 'exit' their investments, and to 'scale up' industry-relevant start-ups.

e) Under-investment in technology commercialisation seriously hampers start-ups from being competitive globally (local market size is usually insufficient for sustainable commercialisation).

The Bio-economy Strategy



Technical, opportunistic

Planned, consulted, coordinated, process focus

1) Developing World perspective
2) Sustainable livelihoods - Jobs, Jobs, Jobs
3) Poverty, inequality, unemployment

The Strategy

Input

- 3 thematic docs that outline landscape and strategic priorities
- An 'implementation plan' that reviews & provides interventions across the value chain
- Steering committees: govt, industry, science councils, academia

The Strategy

Some enabling priorities

- Future skills
- Technology Service Platforms
- Entrepreneurialism
- Seed funding (poc)
- Rapid advance off-take
- VC seeded
- Marketing & promotion

- Coordination

The Strategy

Some competitive advantages

- Human genome
  - Clinical trials, precision/genomic medicine
  - SHIP; H3D; ICGEB; BTRI (precision cancer); CPGR; UCT; WITS;
- Indigenous biodiversity mainstreaming (Cape Floral Kingdom)(CSIR; Universities)
- Indigenous knowledge (ATM; cosmeceuticals; neutraceuticals; infusions)

Some National priorities

- Agricultural sector, agroprocessing (related to access to land, the job multiplier of Agric, and rural development)
- Infectious disease burden (SA creating capabilities for manufacture and expanded trialling).

Implementation:

Detailed plans for each thematic area identified in the Strategy

Ag: New crop & plant and commercialisation; Crop/plant improvement, molecular breeding and genome engineering; Animal improvement, health and aquaculture; Biocontrol agents and Biofertilisers; Food safety and food nutrition; Agro-processing and agro-engineering; Natural Resource Management and Climate Smart Agriculture; Indigenous African Knowledge (IAK)-Based Agriculture

Health: New or improved drugs, therapeutics and drug delivery systems; New vaccines and other biologicals; New or improved diagnostics; New medical devices.

Industry & Environment: Bio-based chemicals and biologics; Biomaterials; Bio-energy; Biomining; Waste and Waste-water.

- **SA researchers- amongst most productive (publications & citations) per $.**
- **Very strong international collaboration.**
- **Proximity of world class institutions and genomically diverse populations.**
- **A key gateway into Africa.**
- **A land of unparalleled beauty!**

Thank you

Baie dankie

Ke a leboga

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EUROPEAN FOREST INSTITUTE

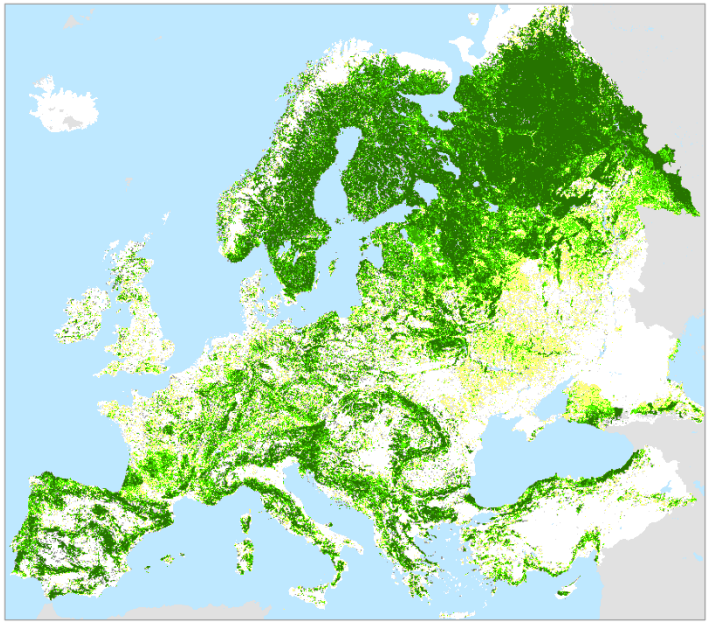
Marc Palahí, Director

Building the European bioeconomy: a forest perspective

Global Bioeconomy Summit 2015
25-26 November 2015, Berlin

www.efi.int

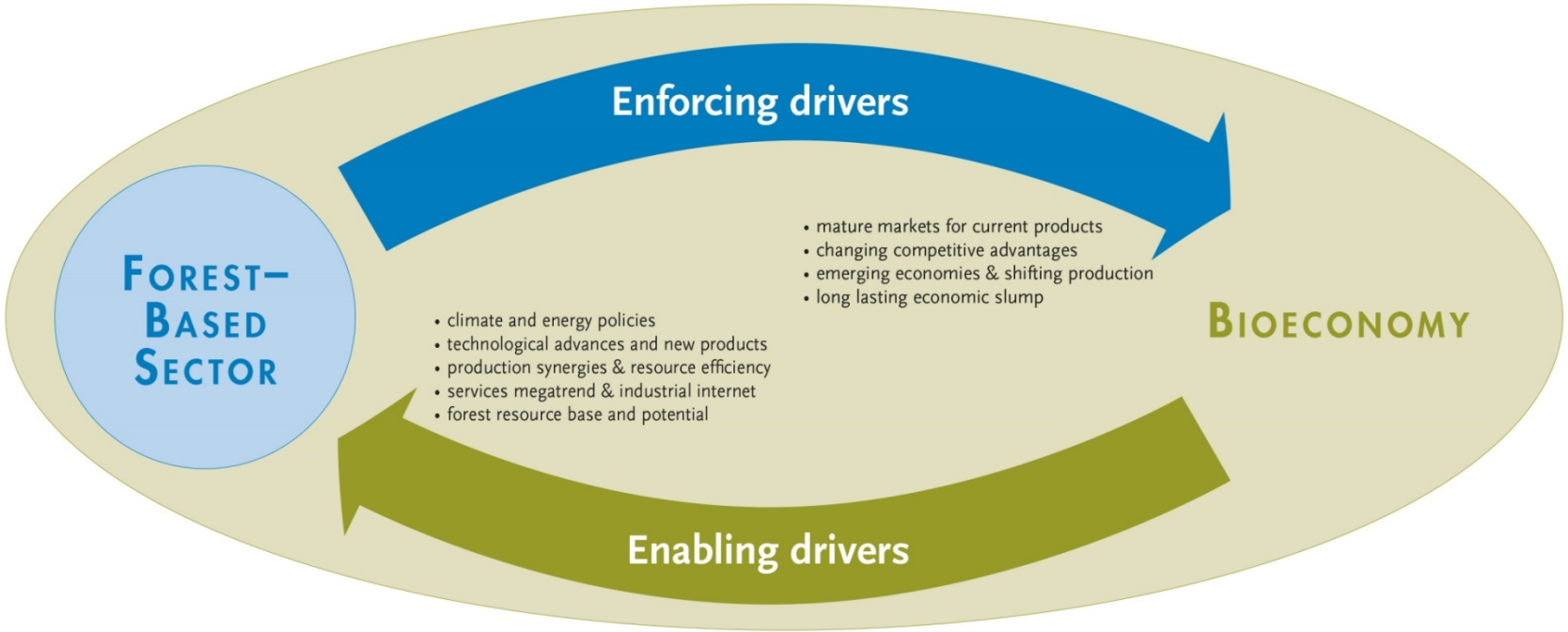
European forests: our most important bio-infrastructure



- Covering **40% of EU** land
- Delivering **50% of renewable energy**
- Capturing **9% of CO_2 emissions**
- Representing **25% of EU Biomass supply**
- Resources for **25% of EU Bioeconomy**

Key for the sustainability of:
biodiversity, water and soil

Towards a cross-sectoral forest-based bioeconomy



Wood construction: the beginning of the timber age?

Cross Laminated Timber (CLT) production: (> 15 % annually)

=> **28**% less primary energy

=> **45**% less carbon emissions

Substituting concrete by **1 m³ of wood = saves 1 tonne of CO_2**

Erkki Oksanen / Luke

Wood-based textile fibres for a growing population

- Only 5% of world textile's are wood-based, but expected to grow at 10% per year
- The textile market to triple by 2050: from 80 Mt to 250 Mt
- The share of cotton (now 30%) to decrease due to competition for arable land and water

Zsolt Nyulaszi/Fotolia

First biorefinary producing wood-based diesel

- UPM ’s biorefinery: 100,000 tonnes of second generation biodiesel for transport
- Decreasing transport emissions up to 80% compare to fossil fuels
- 25% of Finland’s biofuel target

UPM Biofuels

Concluding remarks

- A coherent, well coordinated **International Bioeconomy policy framework**
  - sustainability and resource efficiency
  - regulatory and market failures
  - long-term predictability for investments
- A new scale of **research and innovation** investments and cooperation
- An effective **science-policy-society interface**: reflective governance

B-C-designs – Fotolia

We cannot solve our problems with the same thinking we used when we created them

- Albert Einstein

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