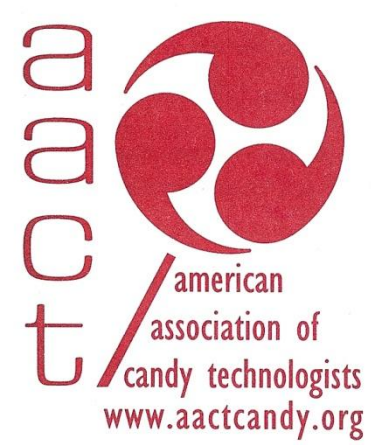
MARS

Cacao Genetics & Breeding

Past, Present, and what's to come!



AACT National Technical Seminar

Ed Seguine

Chocolate Research Fellow

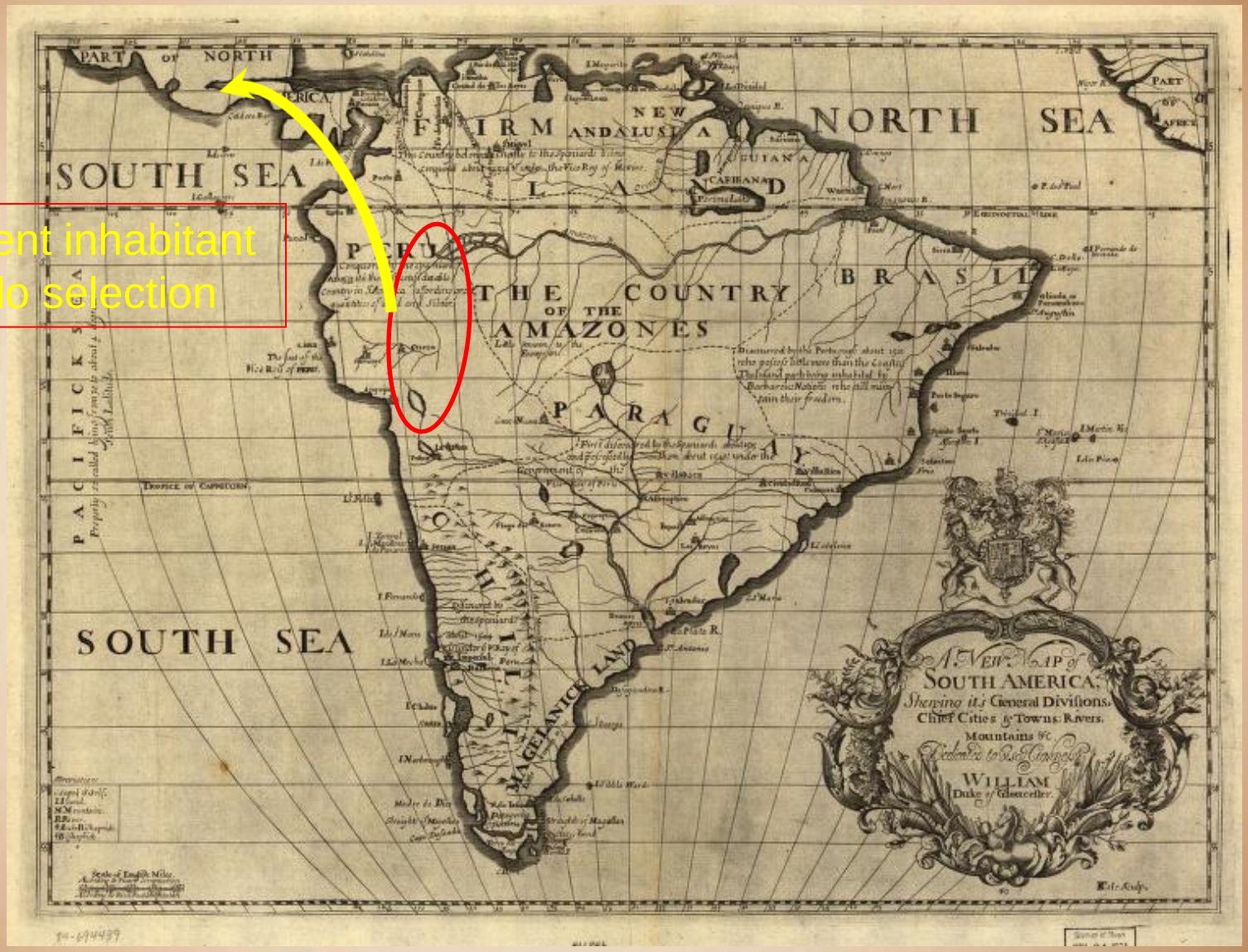
Mars Chocolate North America

Sept. 21, 2010

Agenda

- Early origins
- Breeding history
- Cacao population structure
- Breeding progress
- Barriers to breeding
- Molecular markers and association with tree traits
- New cacao population understanding
- Genome sequencing
- Directed breeding and benefit to breeders and farmers

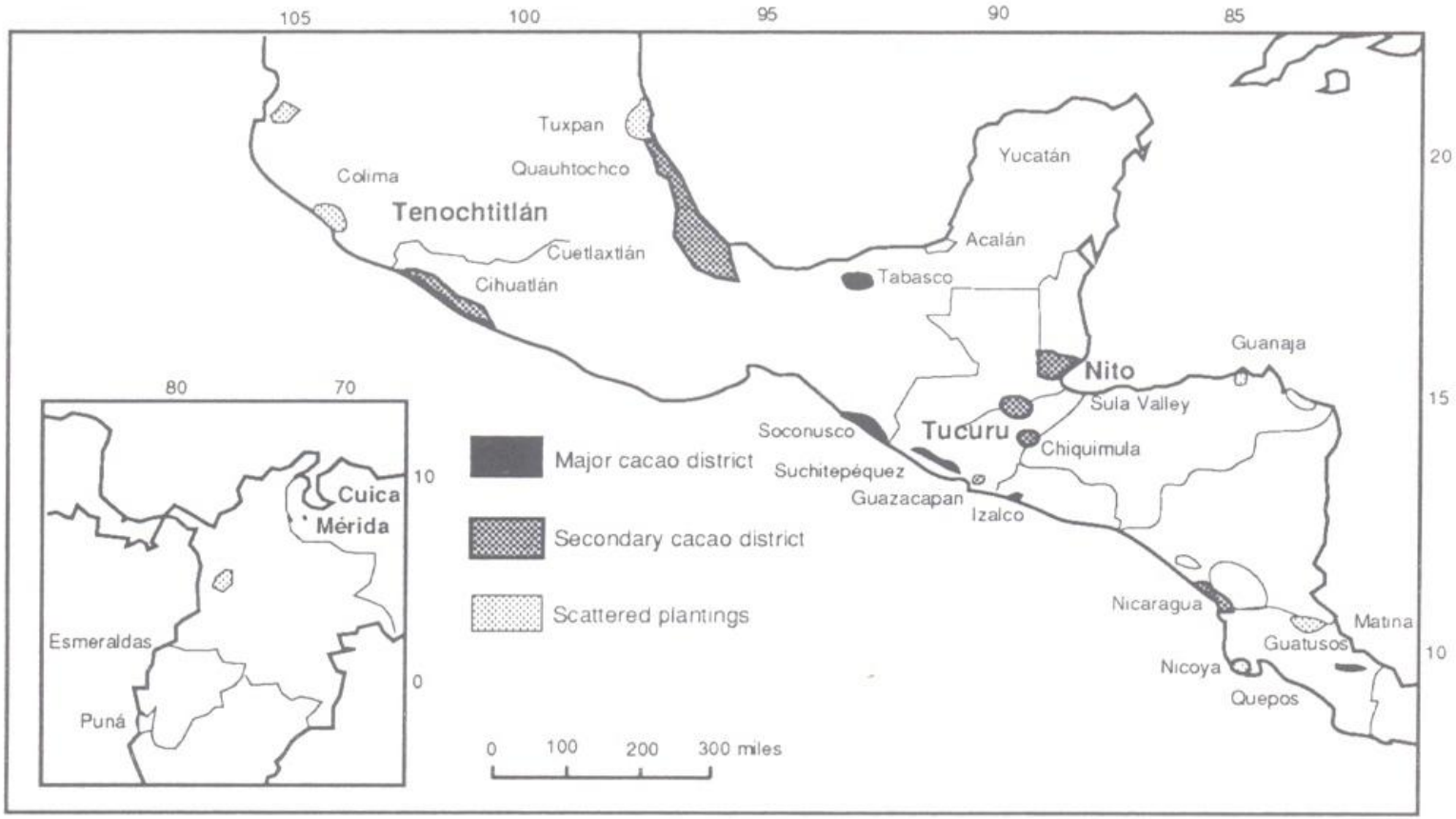
Paleohistory Origins of Cacao



Source: Library of Congress, G5200 1700.W4, Edward Wells, 1700?

Origins : Heredity (2002) **89**, 380–386. doi:10.1038/sj.hdy.6800156, **Cacao domestication I: the origin of the cacao cultivated by the Mayas,** J C Motamayor, A M Risterucci, P A Lopez, C F Ortiz, A Moreno and C Lanaud

Cocoa growing region in ancient Mesoamerica—1500s Aztec empire



The distribution of cacao cultivation in Pre-Columbian America. From Bergmann (1969). Reproduced with permission from the *Annals of the Association of American Geographers* 59:85–96.

History of Cocoa Production Exports in the World 1519 - 1870

Year	1519	1600	1765	1800	1870
World Total, tonnes	**500**	**100**	**6,162**	**11,022**	**24,019**
Mexico - Central America	100%	100%	4%	2%	0%
Venezuela + Caribbean	0%	0%	67%	52%	34%
Ecuador (New Spain: Col + Peru)	0%	0%	21%	25%	45%
Brazil	0%	0%	8%	21%	19%
Africa	0%	0%	0%	0%	2%
Asia & Oceania	0%	0%	0%	0%	1%

1825 - Sao Tome & Principe & Dutch East Indies starting, but no significant production yet

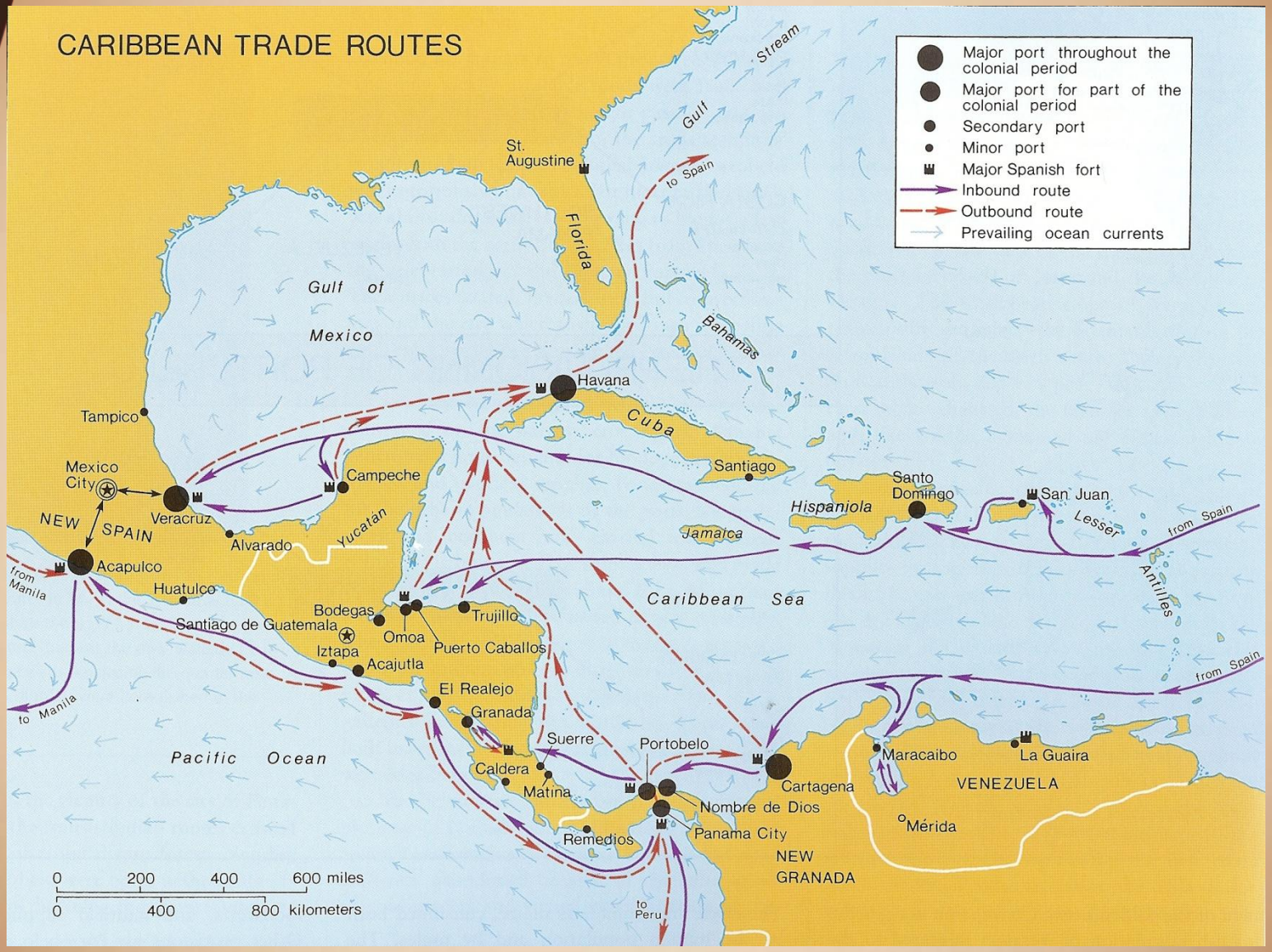
1888 - Nigeria starts

1893 - Gold Coast (Ghana) starts

1905 - Ivory Coast starts

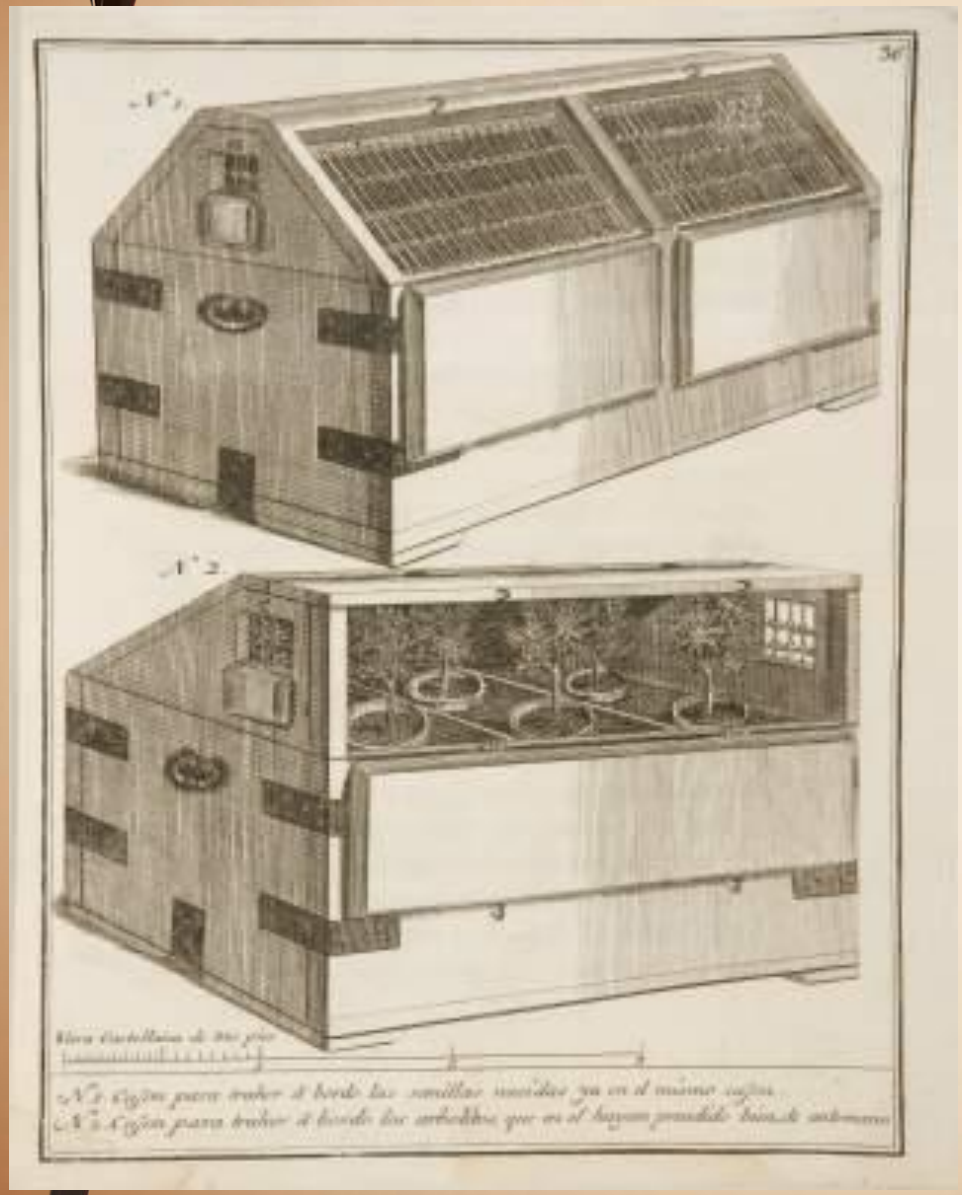
Sources: *Sacred Gifts, Profane Pleasures*, Marcy Norton, 2008
Cocoa and Chocolate: 1765-1914 by Clarence-Smith
Cocoa, G. A. R. Wood, 3rd Ed., 1975
ICCO QBCS, Vol. XXXVI No. 1, Cocoa year 2009/10, Estimates

Spanish trade routes mid-1500s



Source: *Historical Atlas of Central America*, Carolyn Hall and Hector Perez Brignoli, Cotter cartographer, 2003

Transportation of cacao trees aboard ships—



Avis Pour le transport par mer des arbres, des plantes vivaces. Date: 1779. Courtesy: Real Jardin Botanico (Royal Botanical Garden), Madrid, Spain.

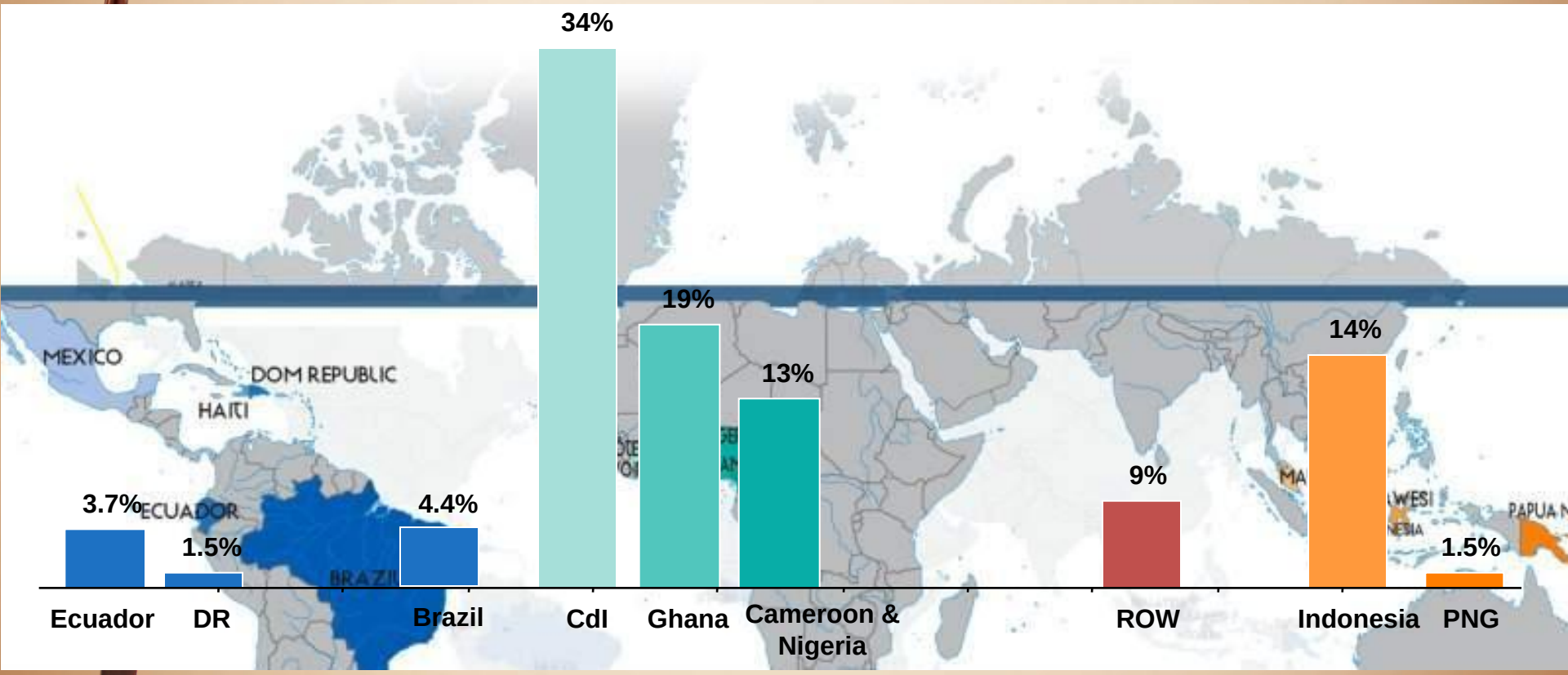
Cacao Cultivation in 1765
World Exports 6000 t

Source: Library of Congress, G5200 1700.W4, Edward Wells, 1700?

Spread of cocoa culture in Africa

Courtesy Claire Lanaud, CIRAD

Origin's Contribution to Total 08/09 World Cocoa Production



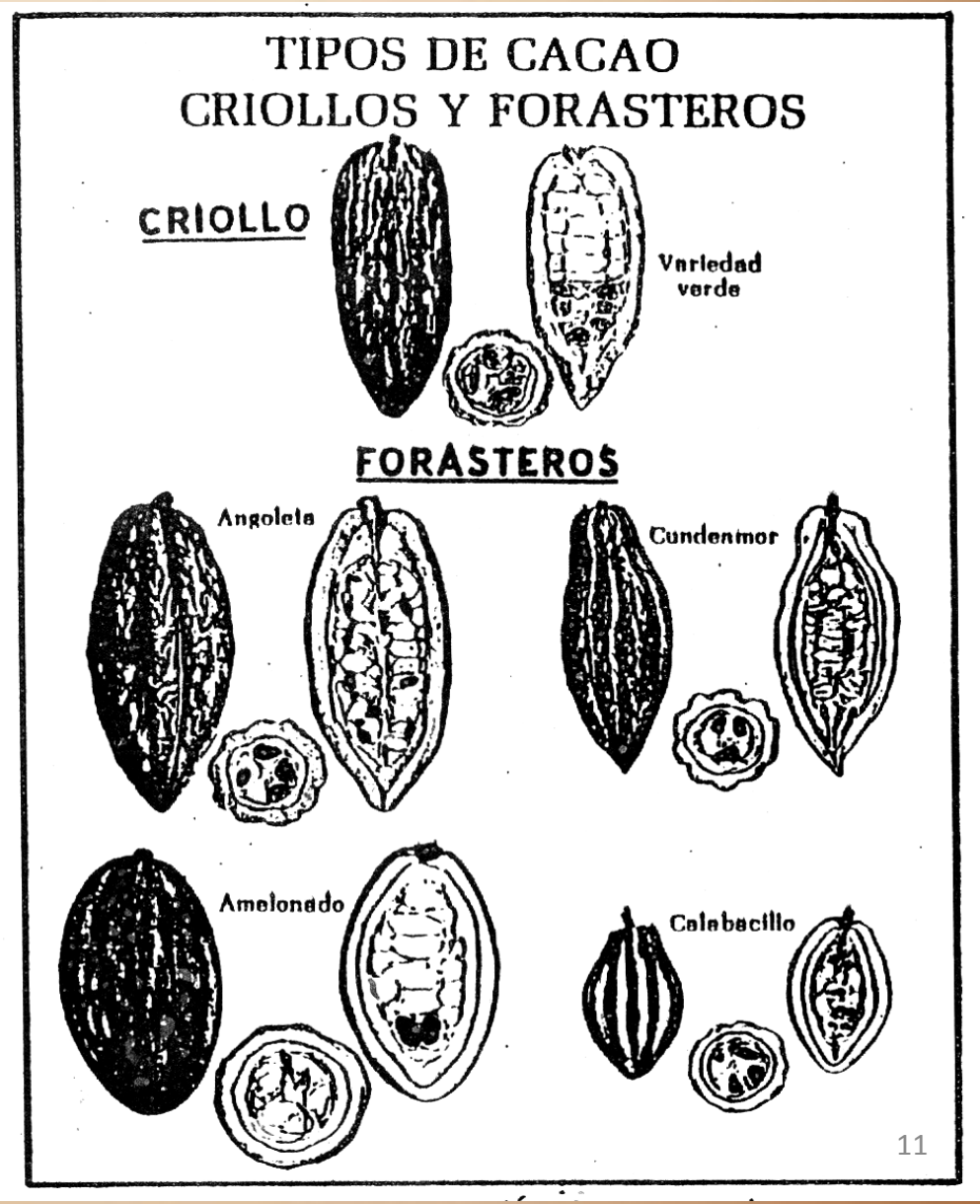
Americas 13.3% Africa 70.0% Asia & Oceania 16.7%

Source: ICCO QBCS, Vol. XXXVI No. 1, Cocoa year 2009/10, Estimates

Theobroma cacao L.

Genetic Groups
Cheesman (1944)

I Criollo
a) Central America
b) South America
II Forastero
a) Lower Amaz. F.
b) Upper Amaz. F.



Cheesman EE (1944). Notes on the nomenclature, classification and possible relationships of cocoa populations. Trop Agricult, 21: 144–159

Criollo

Forastero

Trinitario

Breeding

- Early Institutions –Imperial College “5 year scheme”
- Collecting and preservation begins, 1930-34 (Pound)
- CRIG created 1938 as CCRS-GC (research station Gold Coast)
- **Breeding begins in earnest in 1940s**
- CATIE created 1940
- INIAP created 1959
- CRU formed 1964

- What progress have we made??????

Major Germplasm Collection Trips:

-Pound (1930-4) Peru, Ecuador, Colombia

-Allen (1987): Ecuador, Colombia

-Almeida et al (1982-7): Brazil

-Barriga et al. (1985): Brazil

-Chalmers (1973): Ecuador, Peru

-Lachenaud and Sallee (1993): French Guiana

-Sallee (1987): French Guiana

-New collecting focus: Peru

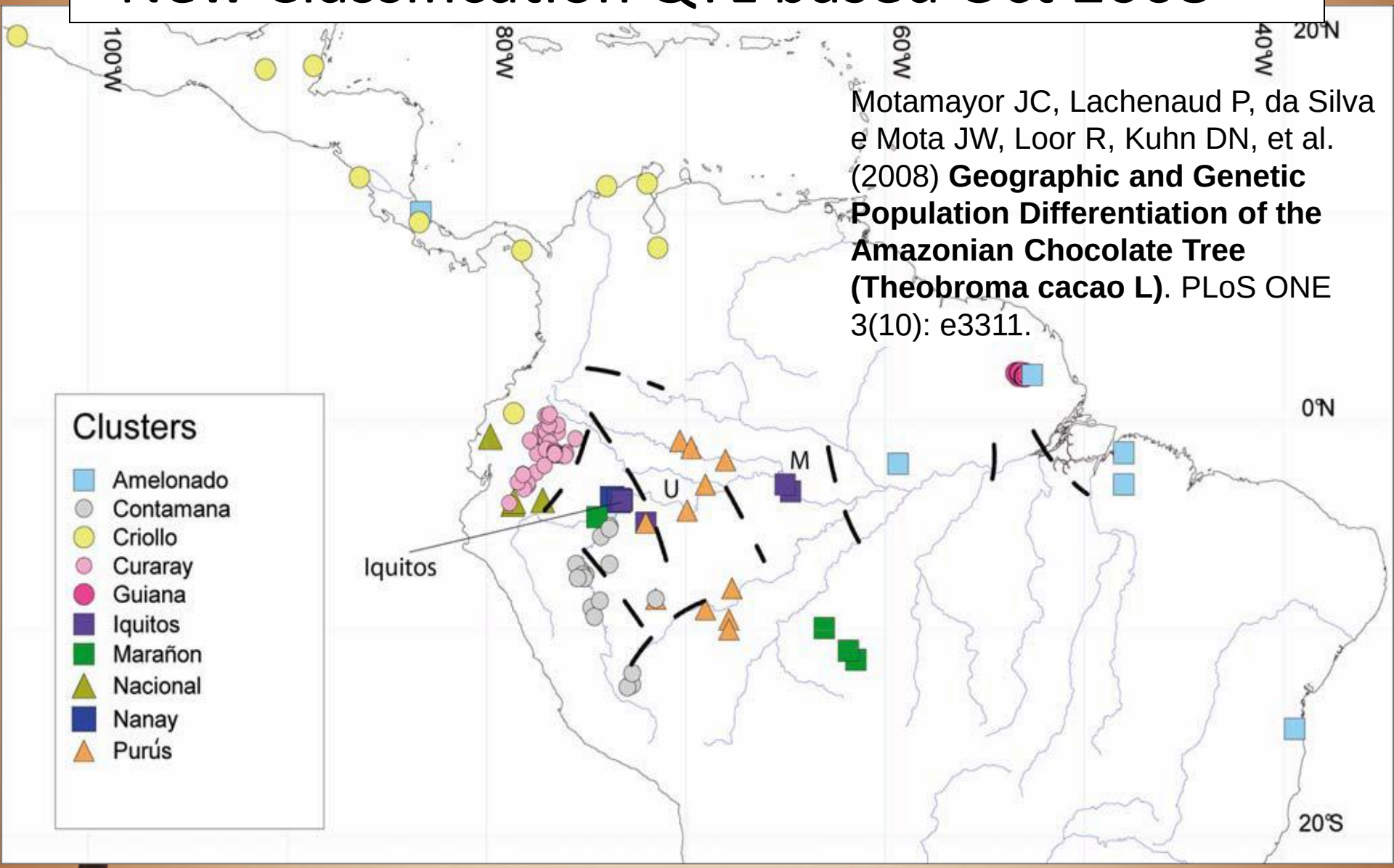
Breeding Progress—70 years

- Avg. world yields today 200-500 kg / ha
- Some exceptions to 2,000 – 3,000 kg / ha
- Disease problems
  - Black pod losses, est 700,000 mt (19%)
  - Total losses disease / pests, est 2.7 million mt
  - Total crop, 3.6 million mt

- Agricultural practices just not adequate
- How do we teach 6,500,000 small farmers?
- How do we make it sustainable?
- Will the next generation <u>want</u> to grow cacao?

The Day of Genetics—A new day is dawning

New Classification QTL based Oct 2008—



Motamayor JC, Lachenaud P, da Silva e Mota JW, Loor R, Kuhn DN, et al. (2008) **Geographic and Genetic Population Differentiation of the Amazonian Chocolate Tree (Theobroma cacao L)**. PLoS ONE 3(10): e3311.

Courtesy Juan Carlos Motamayor, Mars

Mislabeling—very challenging trees

New clones at 1.5 years (left) (TAP 6 x TIP 1) and 2.5 years (right) (AMAZ 14 x EBC 148) in Ecuador.

Courtesy Juan Carlos Motamayor, Mars

When a man is hungry,
he has but one dream.

When a man is full,
he has many dreams