The National Association of Plant Breeders in partnership with the Plant Breeding Coordinating Committee and The Plant Breeding Genomics Community of Practice presents

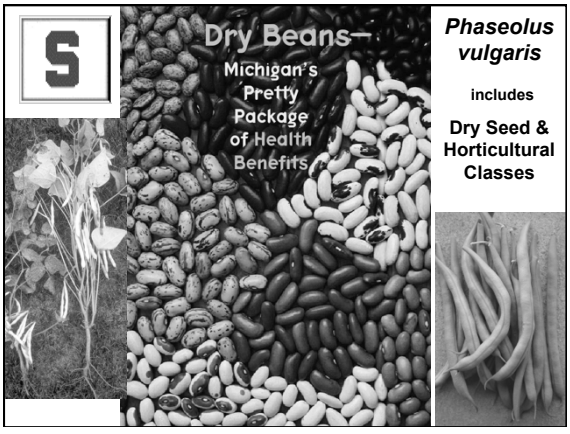
How to breed new plant varieties: imagining and engineering crops

James D. Kelly,
Michigan State University

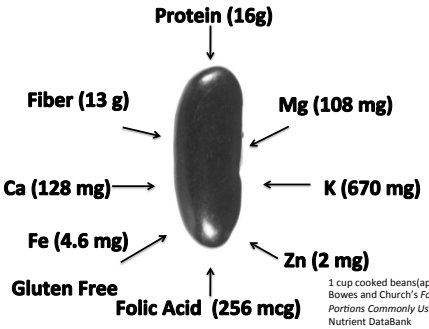
The National Association of Plant Breeders in partnership with the Plant Breeding Coordinating Committee and The Plant Breeding Genomics Community of Practice presents

Dry Bean Breeding isn't a Dry Topic

James D. Kelly,
Michigan State University



Nutritional Profile of one cup cooked beans



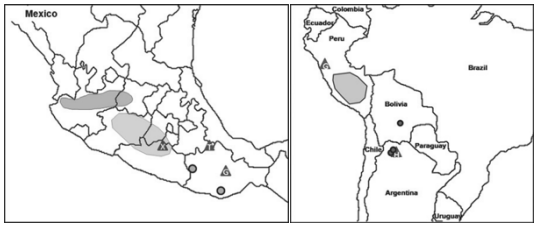
1 cup cooked beans(approx. values Bowes and Church's *Food Values of Portions Commonly Used*, USDA Nutrient DataBank

Phaseolus vulgaris L.
Common Bean

- One of 5 species of *Phaseolus* domesticated
- Found from Mexico to Argentina
- An annual legume in subfamily Fabaceae
- A species variable for growth habit, seed color and ecological adaptation
- An important food crop, a source of protein
- Nitrogen fixer similar to other grain legumes
- Includes horticultural garden, green, snap beans

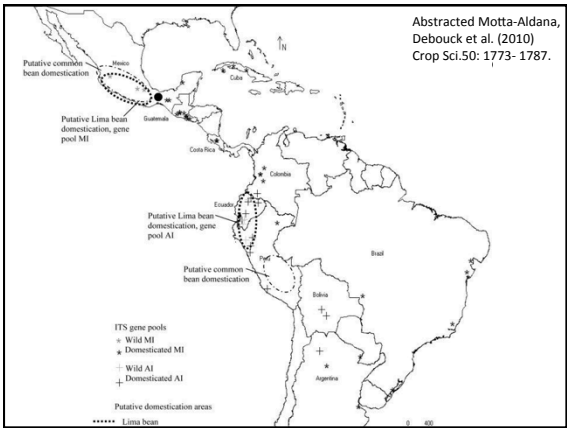
Where was common-bean domesticated?

New Origin of Common Bean



Common Bean Origin & Domestication - green area – Jalisco, Mexico
Common Bean Domestication in Andes – violet area – Southern Peru
Maize Domestication - orange area – Michocan, Mexico, Guerrero

Abstracted: Bitocchi, Papa et al. 2012



Abstracted Motta-Aldana, Debouck et al. (2010) Crop Sci.50: 1773- 1787.

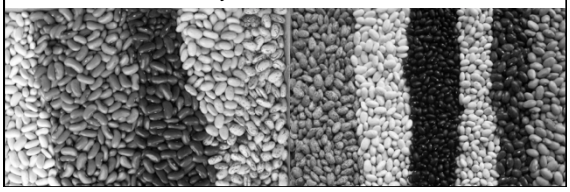
Two Gene Pools and Six Races

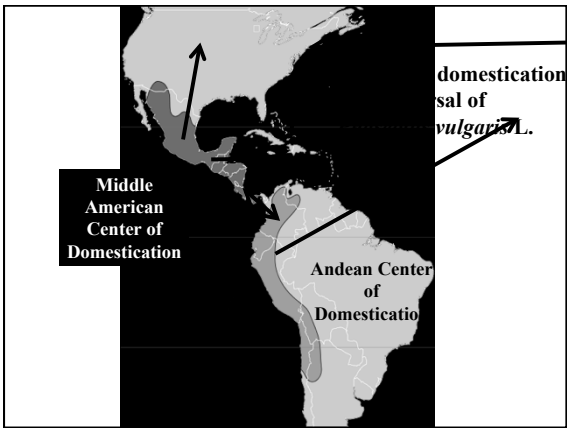
Andean Gene Pool
Larger Seeded Types

- Race Nueva Granada--White & Red Kidneys
- Race Peru--Yellow
- Race Chile--Cranberry

Middle American Gene Pool
Small & Medium Seeded Types

- Race Durango--Pinto and Great Northern
- Mesoamerica--Navy and Black
- Race Jalisco--Reds and Pinks




domestication
sal of
vulgaris L.
Middle
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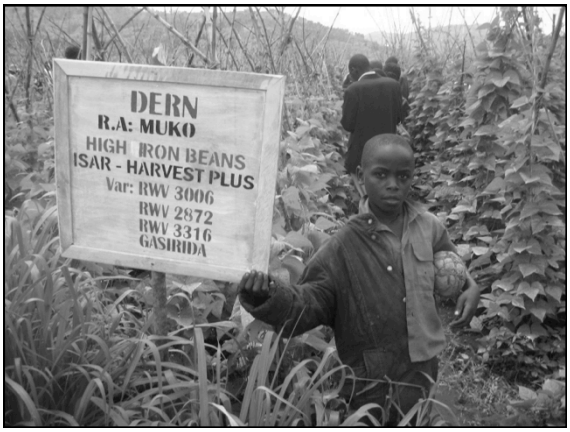
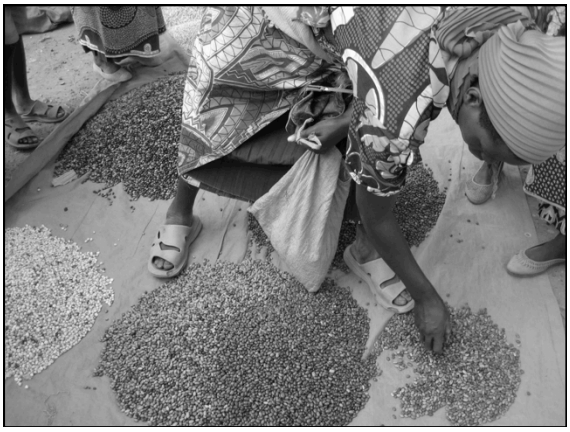

DERN
R.A: MUKO
HIGH IRON BEANS
ISAR - HARVEST PLUS
Var: RWV 3006
RWV 2872
RWV 3316
GASIRIDA



Dry Beans in the US Today

- The US is the 6th leading producer of dry beans
- Production in Northern & Higher Altitudes Zones
- Michigan and North Dakota together produce half of the total US production – rainfed conditions
- Western production – irrigated
- 20% of production is exported
- Nationwide value of $790 million in 2011

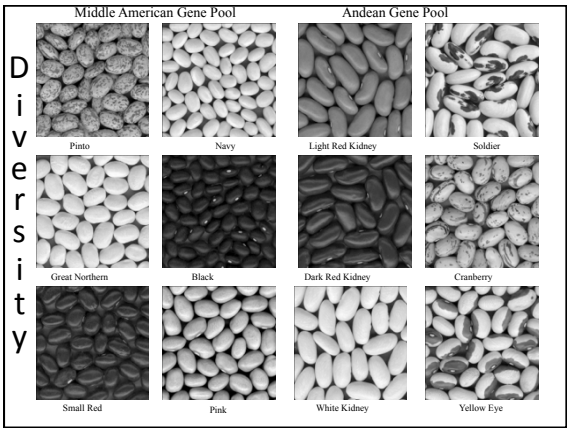
Source USDA/ERS accessed April 2012

Dry Beans in Michigan

- Production value of $134 million in 2011
- Michigan is the leading producer of:
- --Black beans
- --Cranberry
- --Small Reds
- Michigan is second leading producer of:
- --Navy
- --Kidney
- Non GMO Crop

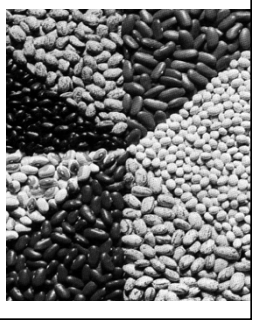
Source USDA/ERS accessed April 2012

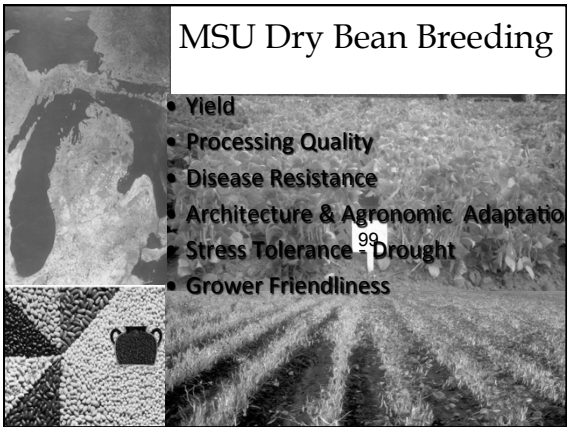
Need for Diversification



Common Bean Genetics

- Diploid, Self Pollinating
- Annual Species, 2n=2x=22
- 11 chromosomes Pv01-Pv11
- No natural outcrossing
- Near Homozygous Pure Line Varieties
- Bean Genome Sequenced
- Small Genome ~ 587 Mb
- Genetic Synteny with Soybean



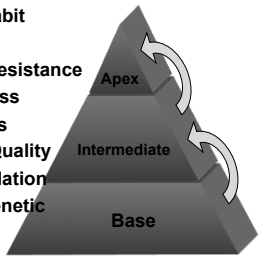


Breeding Systems - Traits

- Twelve different commercial seed classes
- Pedigree breeding - Yield & Quality
- Backcross -Disease Resistance
- Recurrent Selection -Architecture
- Inbred BC – Introduce Diversity
- Marker-Assisted Selection: MAS – Disease Resistance
- QTL Analysis for Quantitative Traits
- Genome Wide Association Mapping

Bean Breeding Pyramid

- **Yield Improvement**
  - **Growth Habit**
  - **Maturity**
  - **Disease Resistance**
  - **Market class**
  - **Seed Traits**
  - **Canning Quality**
- **Broad Foundation**
- **Adequate Genetic Variability**

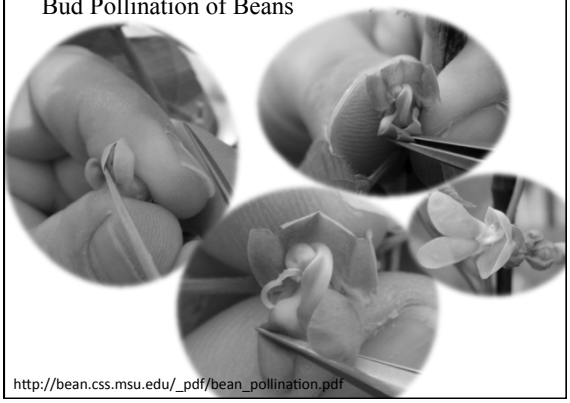


Adapted from Kelly et al. (1998) Breeding for yield in dry bean. Euphytica 102:343-356

Breeding Time Line

Year	Activity
1- 3	Crossing & Early Generation Selection Single Plant Selection - F2-F4 generations – Shuttle Breeding…….MI-PR
4-6	Yield Testing in Replicated Plots F6 – Canning Tests
7-9	Seed Increases, Breeder, Foundation, Certified – Continue yield testing and canning evaluation
10	Certified Seed Available to commercial growers

Bud Pollination of Beans



http://bean.css.msu.edu/_pdf/bean_pollination.pdf

Breeding Time Line

Year	Generation	Activity	Location
1- Fall	Parents	Crossing	GH
1- Spring	F1 plants	Selfing	GH
1- Summer	F2 plants	SPS	Field - MI
2-Winter	F3 plant rows	MS	Field - PR
2- Summer	F4 plant rows	SPS	Field - MI
3- Winter	F5 plant rows	MS	Field - PR
3- Summer	F6 yield trial	PYT	Field - MI
4- Summer	F7 yield trials	AYT	Field - MI
5- Summer	F8 yield trials	RYT	Field MI +
6- Winter	Pre -Release of Breeding line as new Variety		

SPS –Single Plant Selection, MS – Mass Selection: PYT – Prelimin Yield Trial, Advanced & Regional

Shuttle Breeding

MICHIGAN

F2; F4 - SPS

F6- PYT

Yield Trials

www.uprm.edu
universidad de puerto rico
RECINTO UNIVERSITARIO DE MAYAGÜEZ

PUERTO RICO

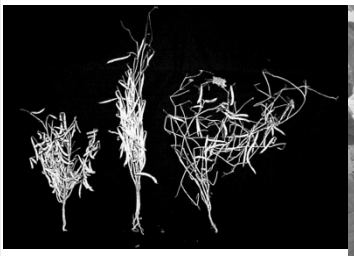
F3; F5 - MASS

Seed Increase Time Line

Year	Generation	Activity	Location
6-Summer	Pre-breeder	Establish	western seed
7- Summer	Breeder seed	Increase	Field - ID
8- Summer	Foundation seed	Increase	Field - ID
9-Summer	Certified seed	Increase	Field - ID
10-Summer	Distribution of commercial		seed in MI

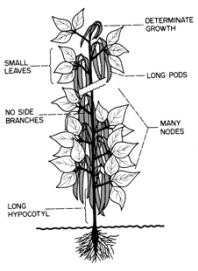
MICHIGAN STATE UNIVERSITY

Bean Plant Architectural Types



Type I, bush | Type II, upright | Type III, vine | Type IV, climber

Bean Ideotype



HEIGHT
MATURITY
STEM STRENGTH
LODGING RESISTANCE
DEEP TAP ROOT

Source; Adams 1982

Bean Plant Types by Market Class

Navy, Black Pinto, Great Northern Small Red, Pink

Upright Eldorado Pinto Architectural Avoidance to White Mold

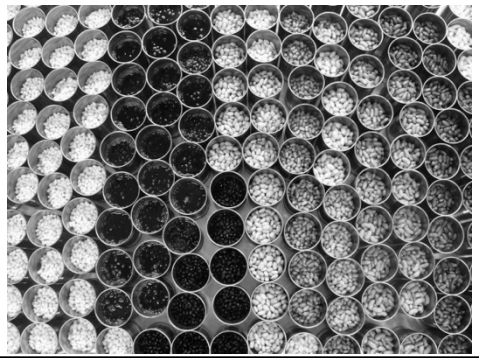
Decumbent Vine Pinto

Conventional Bean Harvest

1. **Pulling or knifing followed by windrowing**
2. **Harvest – pick up reel**

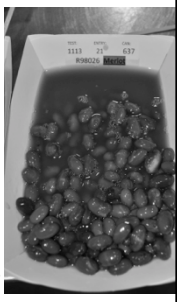
Direct harvest

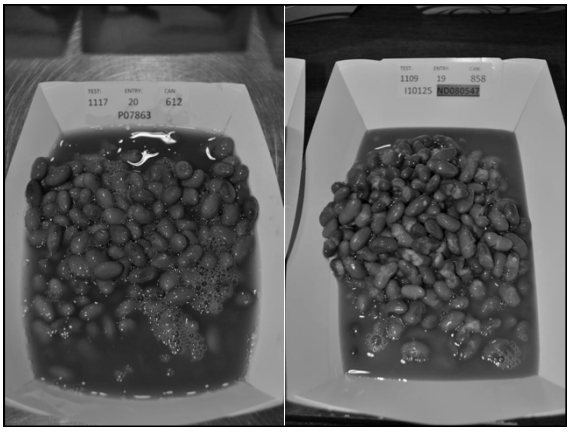
Determining Canning Quality of Beans

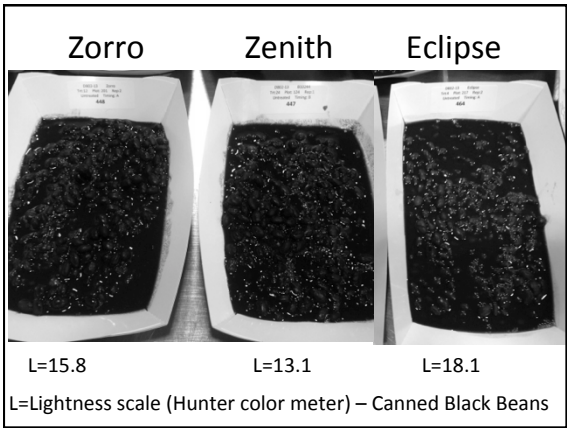


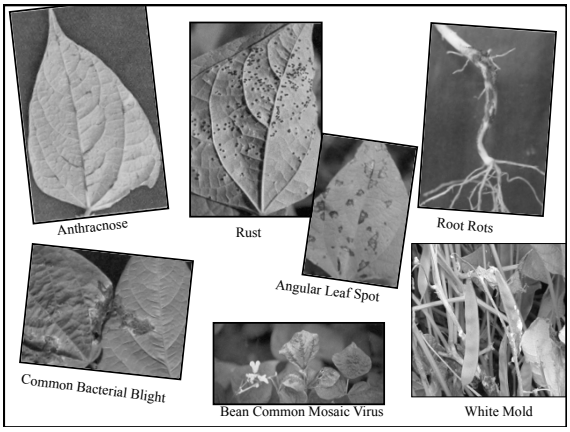
Selection for Canning Quality Traits

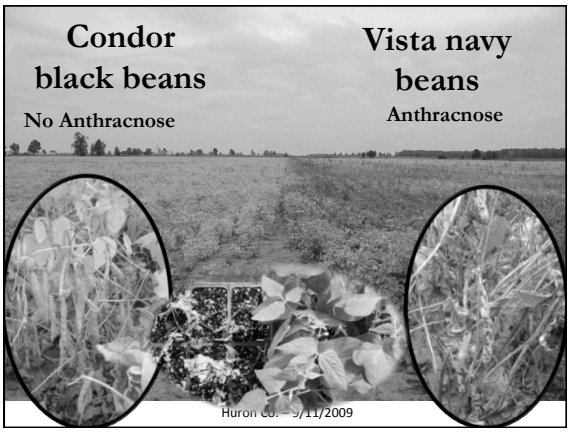
- Visual selection – trained judges
- Whole seed integrity
- Color retention, uniformity
- Clear brine – no starch extrusion
- Measure color of canned product
- Hydration ratios, drained weights
- Texture - Kramer Shear Press
- Commercial evaluation – elite lines




1117 20 612
P07863
1109 19 858
I10125 ND080547


Zorro
Zenith
Eclipse
L=15.8
L=13.1
L=18.1
L=Lightness scale (Hunter color meter) – Canned Black Beans


Anthracnose
Rust
Root Rots
Angular Leaf Spot
Common Bacterial Blight
Bean Common Mosaic Virus
White Mold



Resistance to Common Bacterial Blight

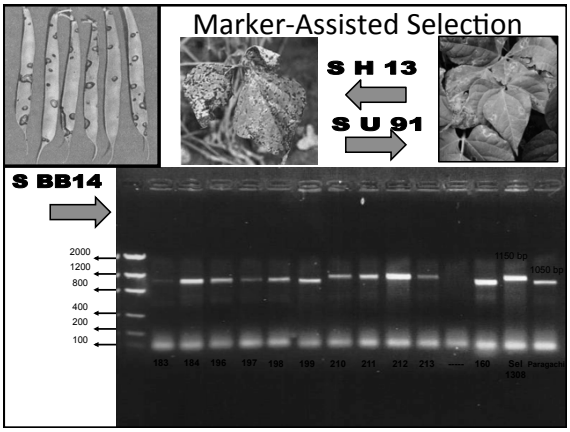
New Tools for Bean Breeders

Can we Improve Phenotypic Selection with Marker Assisted Selection – MAS ?

Resistance Genes in Common Bean with Tightly Linked Markers

Gene	Disease	Gene	Disease
Co-1	Anthracnose	*Mp-1*	Macrophomina
Co-2	"	*Mp-2*	"
Co-4	"	*Ur-3*	Rust
Co-4²	"	*Ur-4*	"
Co-5	"	*Ur-5*	"
Co-6	"	*Ur-7*	"
Co-9	"	*Ur-9*	"
I	BCMV	*Ur-11*	"
bc-1²	"	*bgm-1*	BGMV
bc-3	"	*Phg-1*	ALS
		Phg-2	ALS

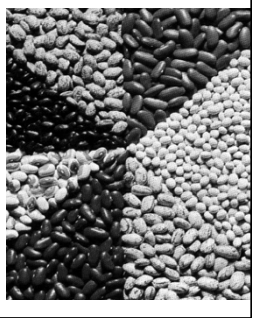
Marker-Assisted Selection



Marker –Aided Bean Breeding

Using molecular markers to select for resistance to:

- Anthracnose
  Colletotrichum lindemuthianum
- Bean Common Mosaic Virus
- Rust
  Uromyces appendiculatus
- Common Bacterial Blight
  Xanthomonas axonopodis



Bean Germplasm Releases (52)

Illumina Infinium Genechip BARCBEAN6K_3 SNP

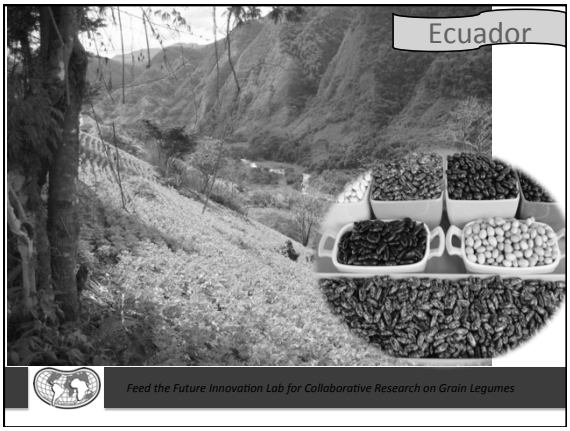
2,687 InDel Markers NDSU_IND_3_10.8903

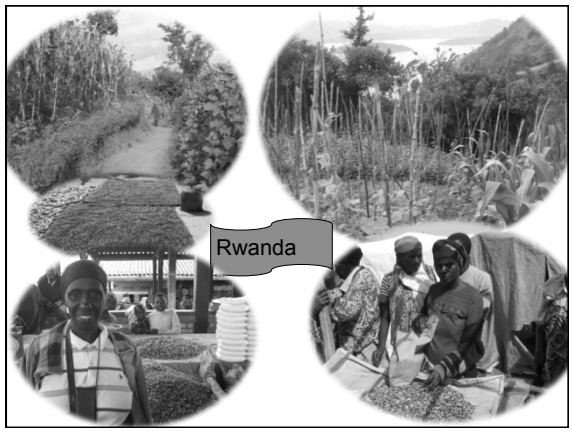
www.beancap.org

USDA

United States Department of Agriculture
National Institute of Food and Agriculture

This project is funded by the USDA National Institute of Food and Agriculture. Project number 2009-01929.





Beans are Nutrient Dense Food Great to Eat !!

Bean
Frijol
Frejol
Feijao
Poroto
Judia
Haba
Habicuela
Ejotes

Additional Information – Bean Breeding

Bean Improvement Cooperative
http://bic.css.msu.edu/

BeanCAP Plant Architecture
http://www.youtube.com/watch?v=wf_nOs7DP-o

Plant Breeding Science + Creative Problem Solving
http://www.youtube.com/watch?v=wiMI-uGcsIk&feature=youtu.be

Bean Genome, Schmutz et al. Nature Genetics (2014) doi:10.1038/ng.3008

Thanks for joining us today.

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http://www.extension.org/plant_breeding_genomics

http://www.extension.org/pages/60426/webinar-registration-and-archive

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