How Much Did You Pay for Your Lunch Today?

Peggy G. Lemaux
University of California, Berkeley
http:/ucbiotech.org
http://pmb.berkeley.edu/!lemaux

What if I told you, I would give you $30 for lunch, would you take it?

But…

Actually it has to pay for a month of lunches…

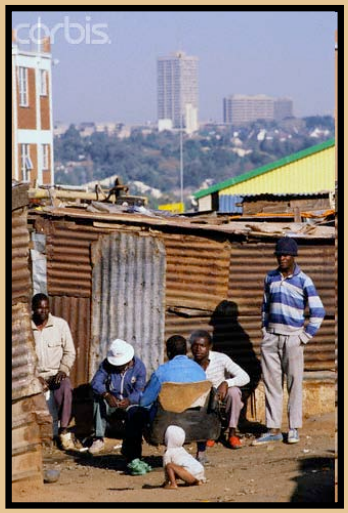
And dinners and everything else you need to live – food, shelter, transportation, clothing!!

Maybe it would make you think differently about growing your own food?

Maybe it would make you think differently about the fact that the average American spends <10% of their income on food!

Maybe it would make you think about the variety and quantity of food we eat – and don't have to produce!

Now consider this…



❖ One billion of the world's poorest people live on ≤ $1 per day.

❖ 820 million people go to bed hungry each day

❖ Malnutrition leads to stunted physical/ mental development, increased disease suceptibility

❖ No country has risen rapidly from poverty without increasing agricultural productivity

❖ Majority of small farmers are women, often with the fewest resources

Global Development Program, Gates Foundation: http://www.gatesfoundation.org

Why is there so much difference in food availability?

One reason: Crop production varies dramatically

CROP	YIELD (kilograms per hectare)			
	Kenya	Ethiopia	India	Developed World
Maize	1,640	2,006	1,907	8,340
Sorghum	1,230	1,455	797	3,910
Rice	3,930	1,872	3,284	6,810
Wheat	2,310	1,469	2,601	3.110
Chickpea	314	1,026	814	7,980

5X

3X

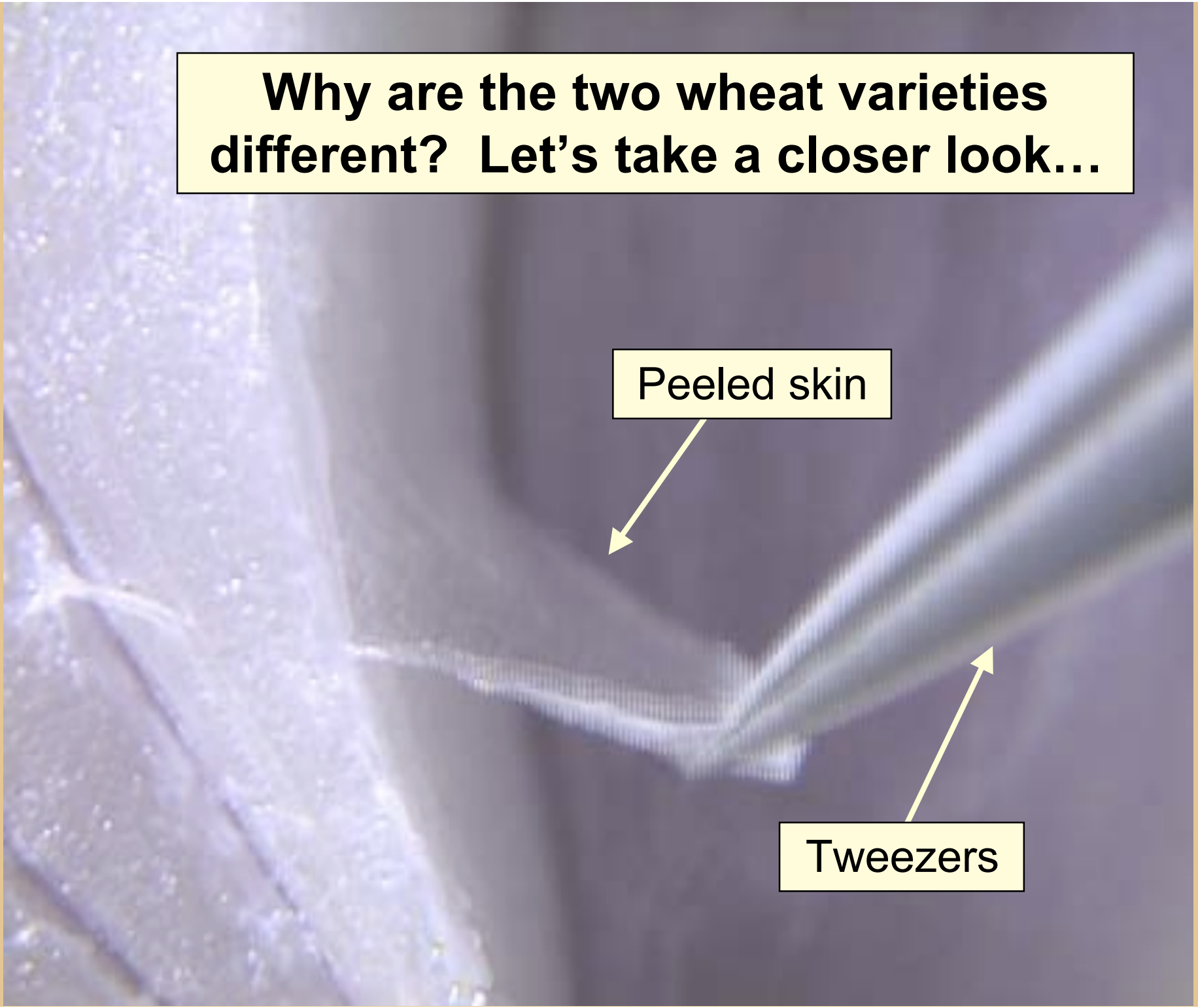
WHY?

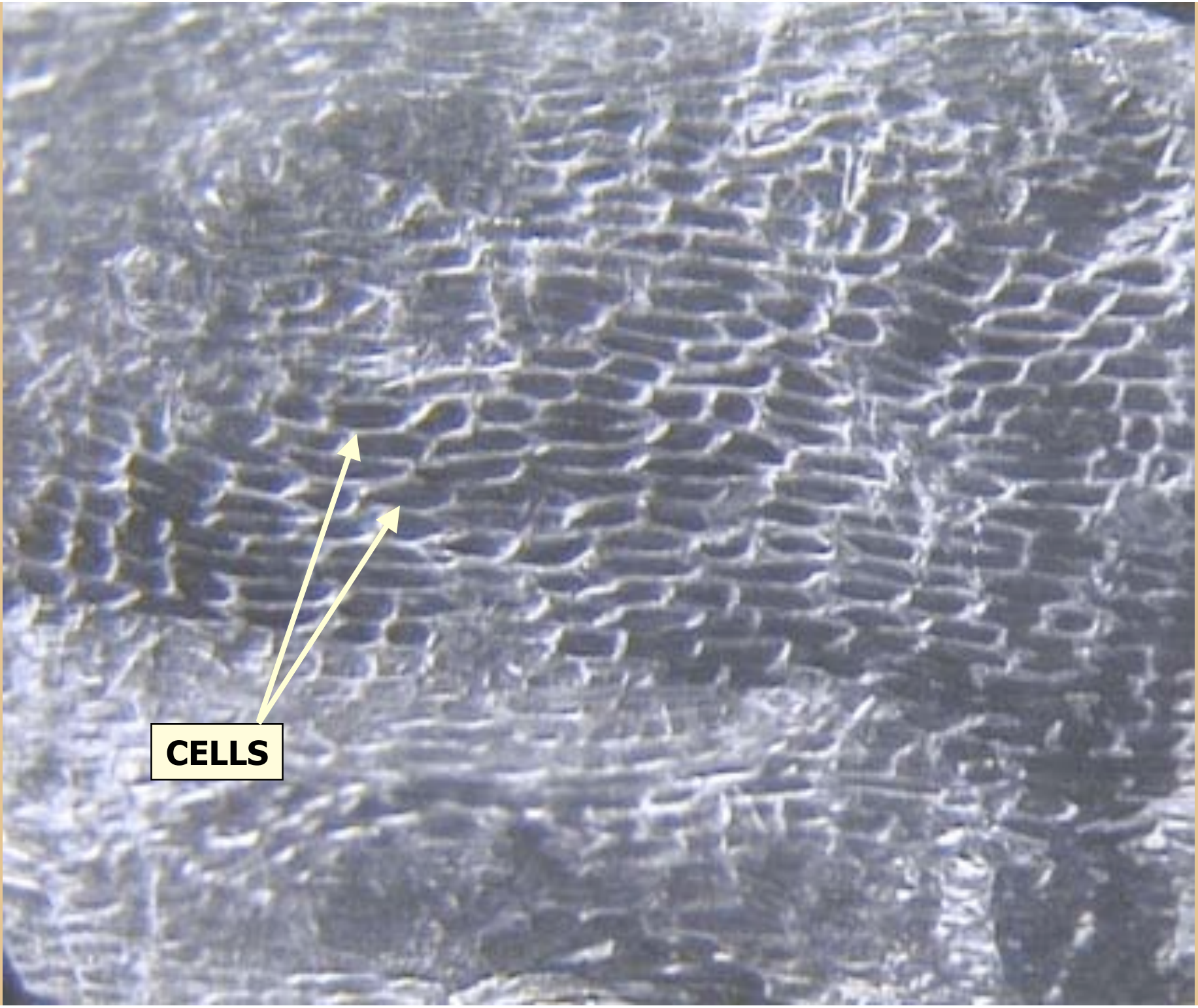
Many reasons…but among them is genetic improvement of varieties to give higher yields under specific growing conditions.

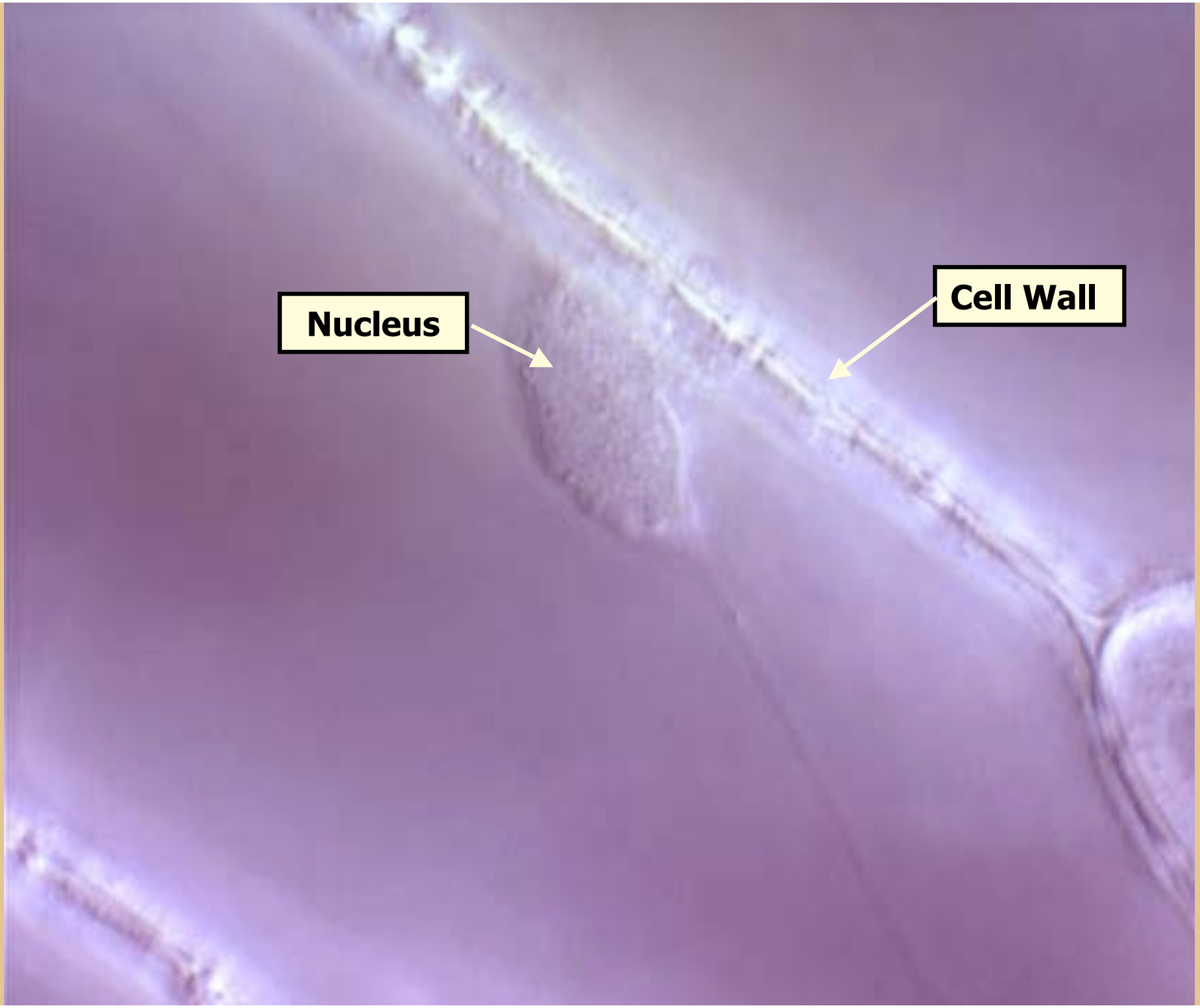
How are improved varieties created through genetic modification?

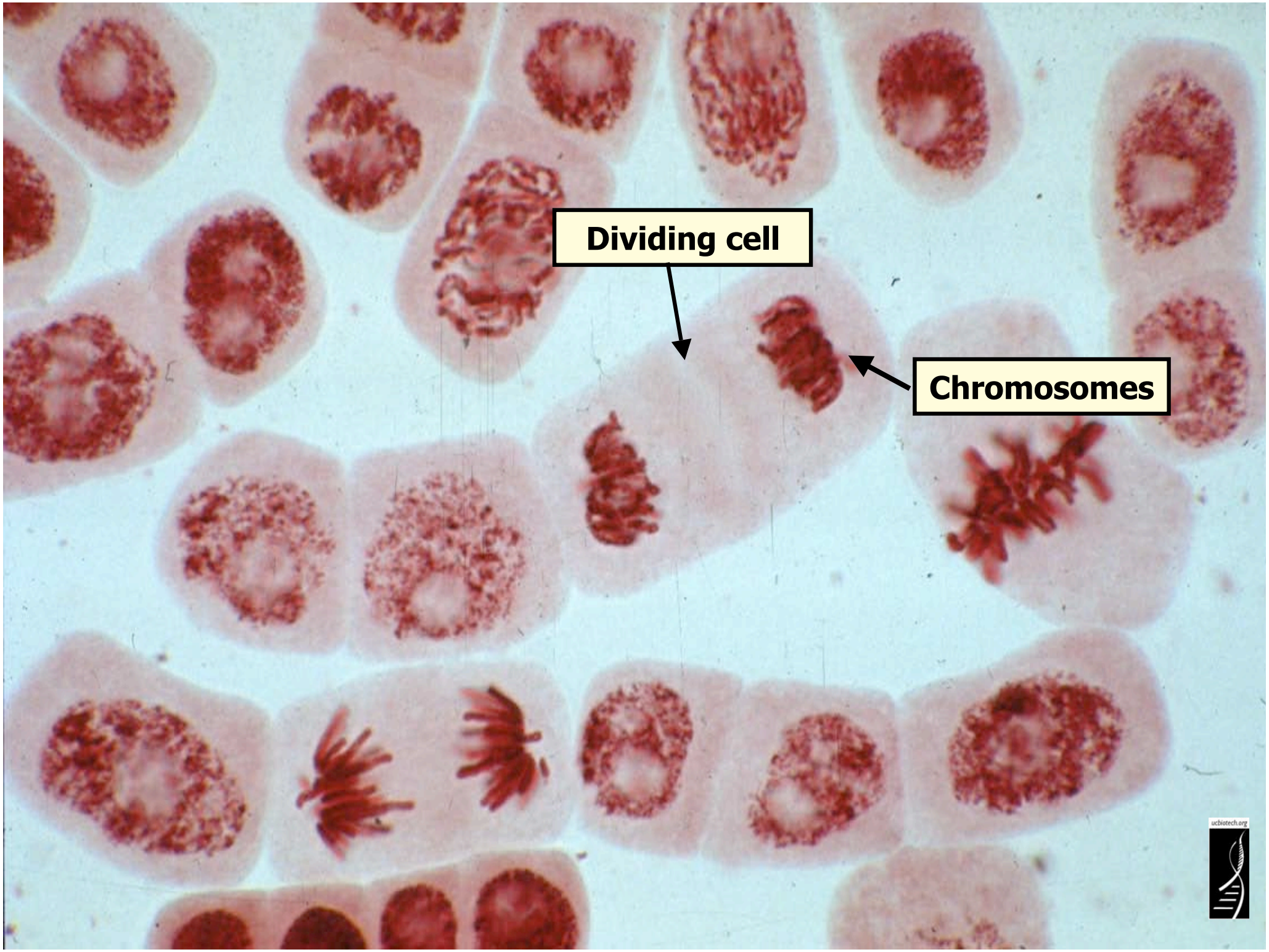
Triticum aestivum
Modern bread variety

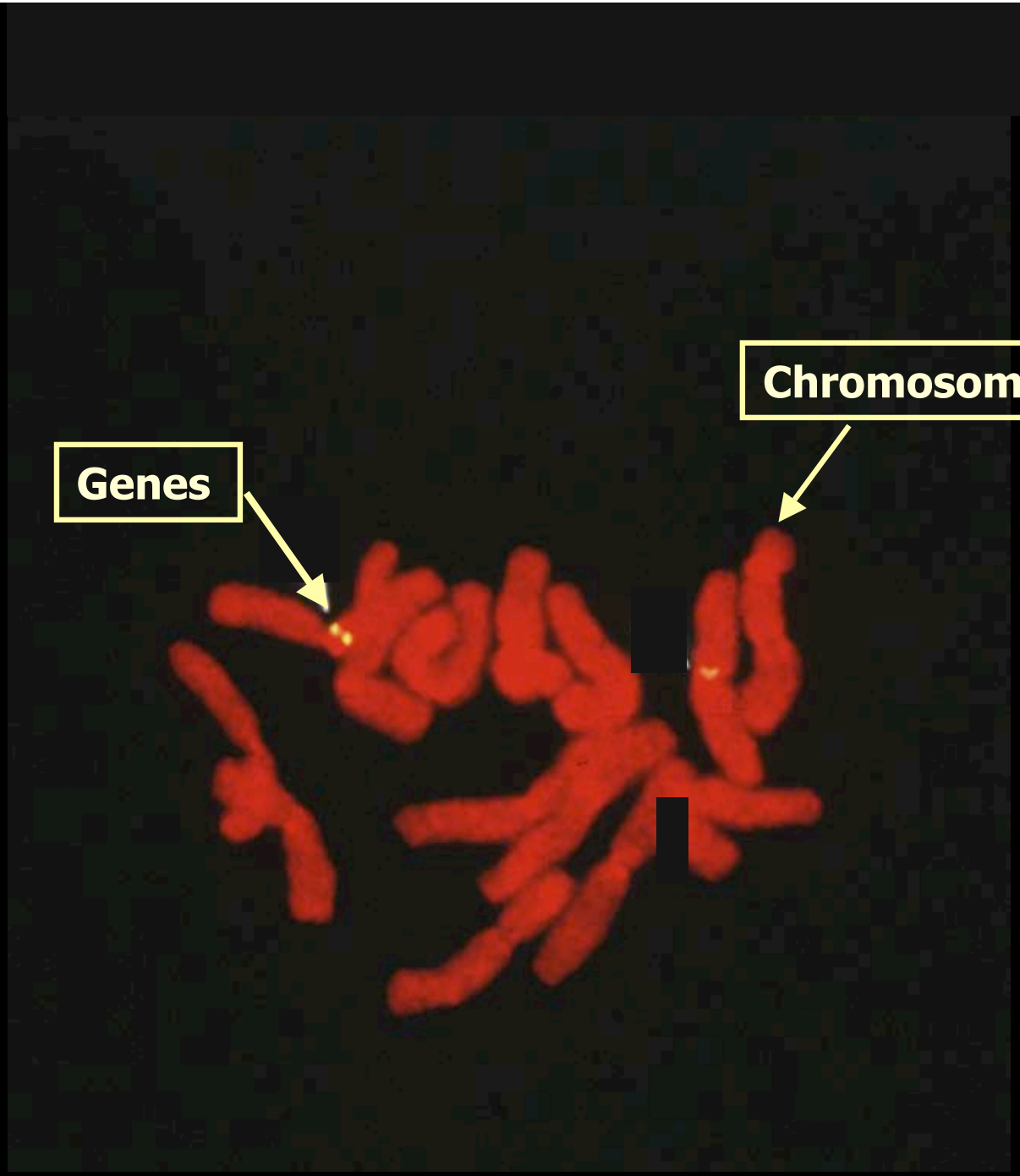
Triticum monococcum
Ancient variety


Why are the two wheat varieties different? Let's take a closer look…
Peeled skin
Tweezers


CELLS


Nucleus
Cell Wall


Dividing cell
Chromosomes
ucbiotech.org


Chromosome
Genes

Information in the wheat genome

Chemical units represented by alphabetic letters

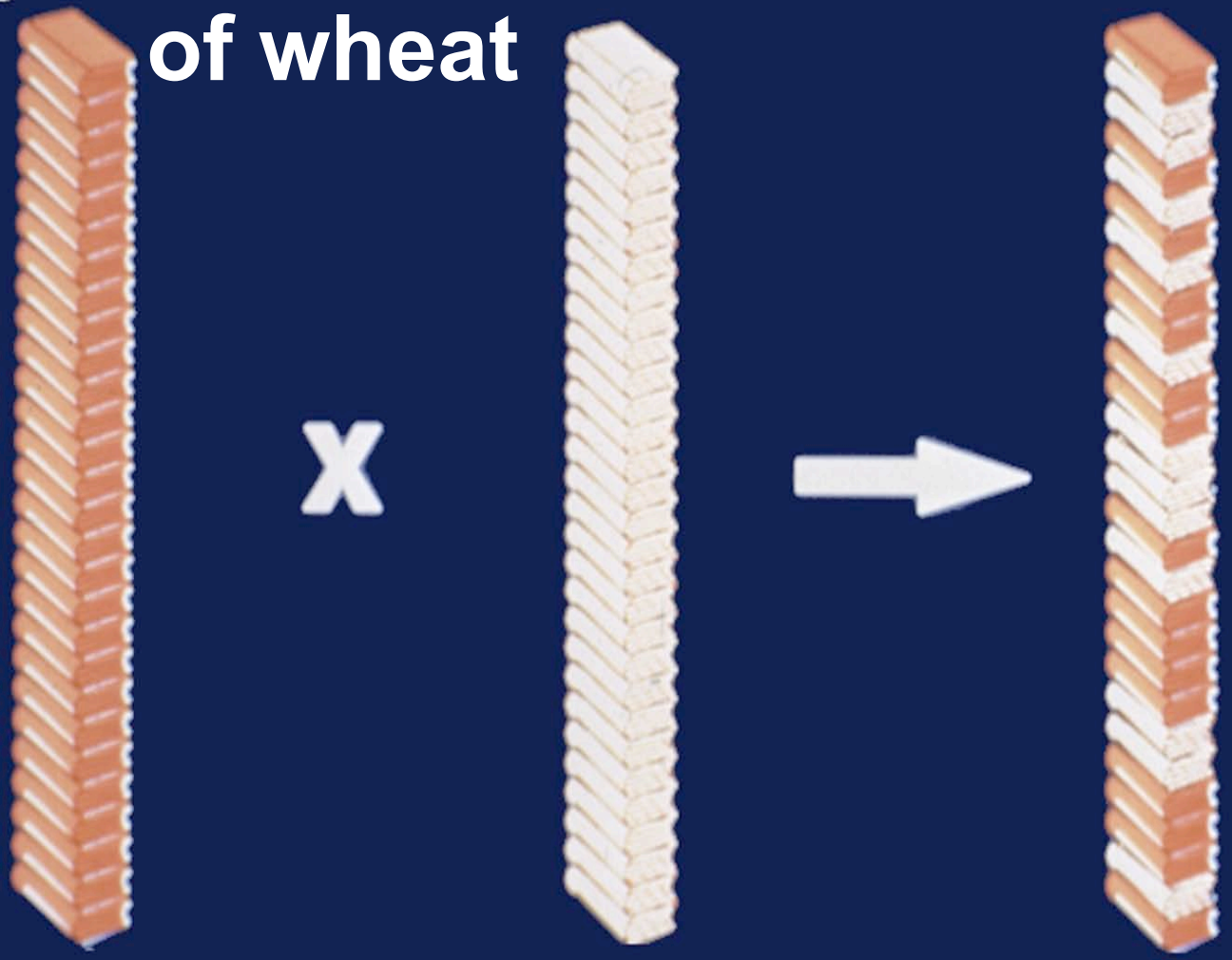
...CTGACCTAATGCCGTA...

1700 books
1000 pages each

1700 books
(or 1.7 milion pages)

ucbiotech.org

Hybridization or cross breeding of wheat

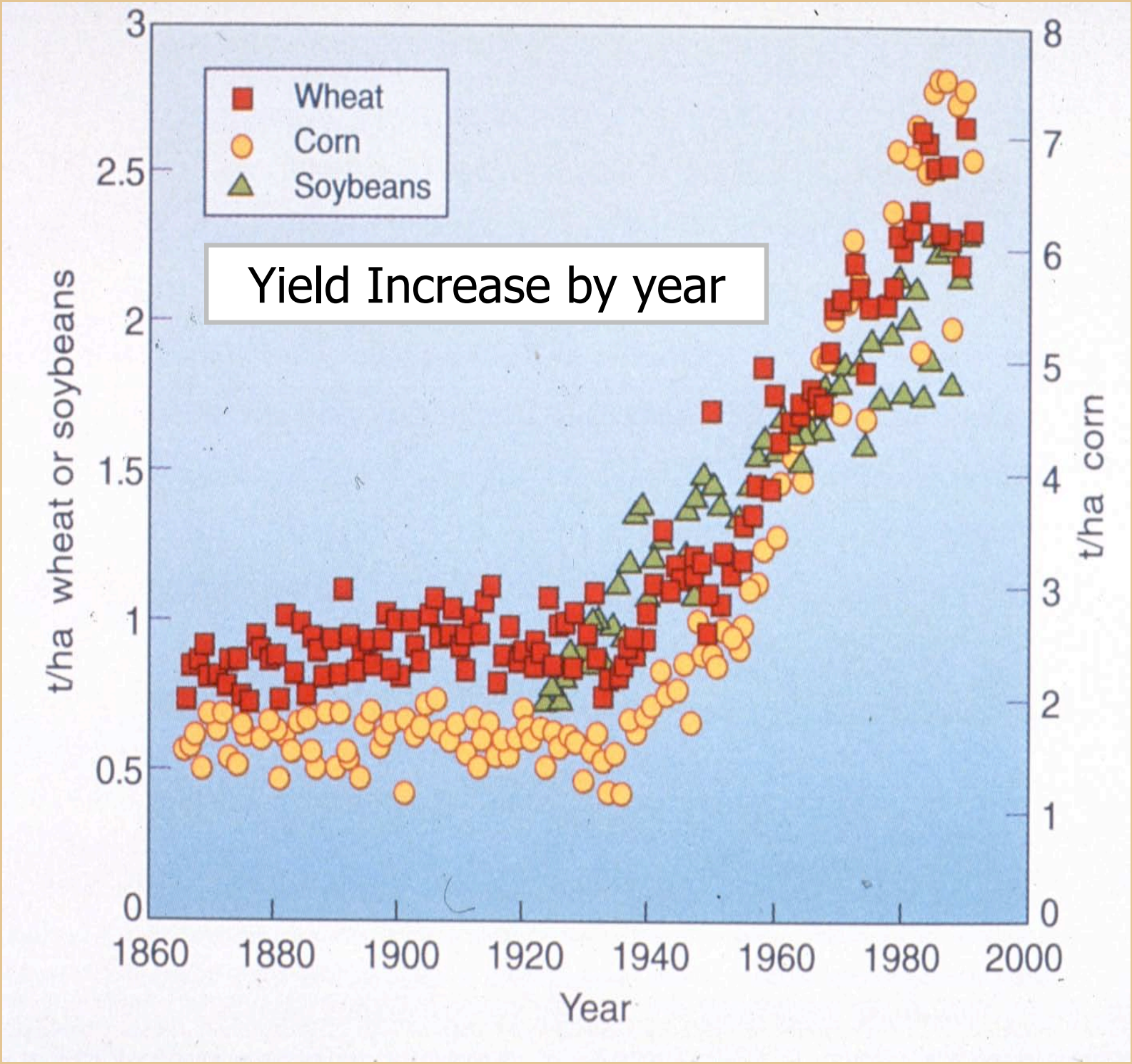


Random retention of information from each parent

1700 books (or 1.7 million pages)

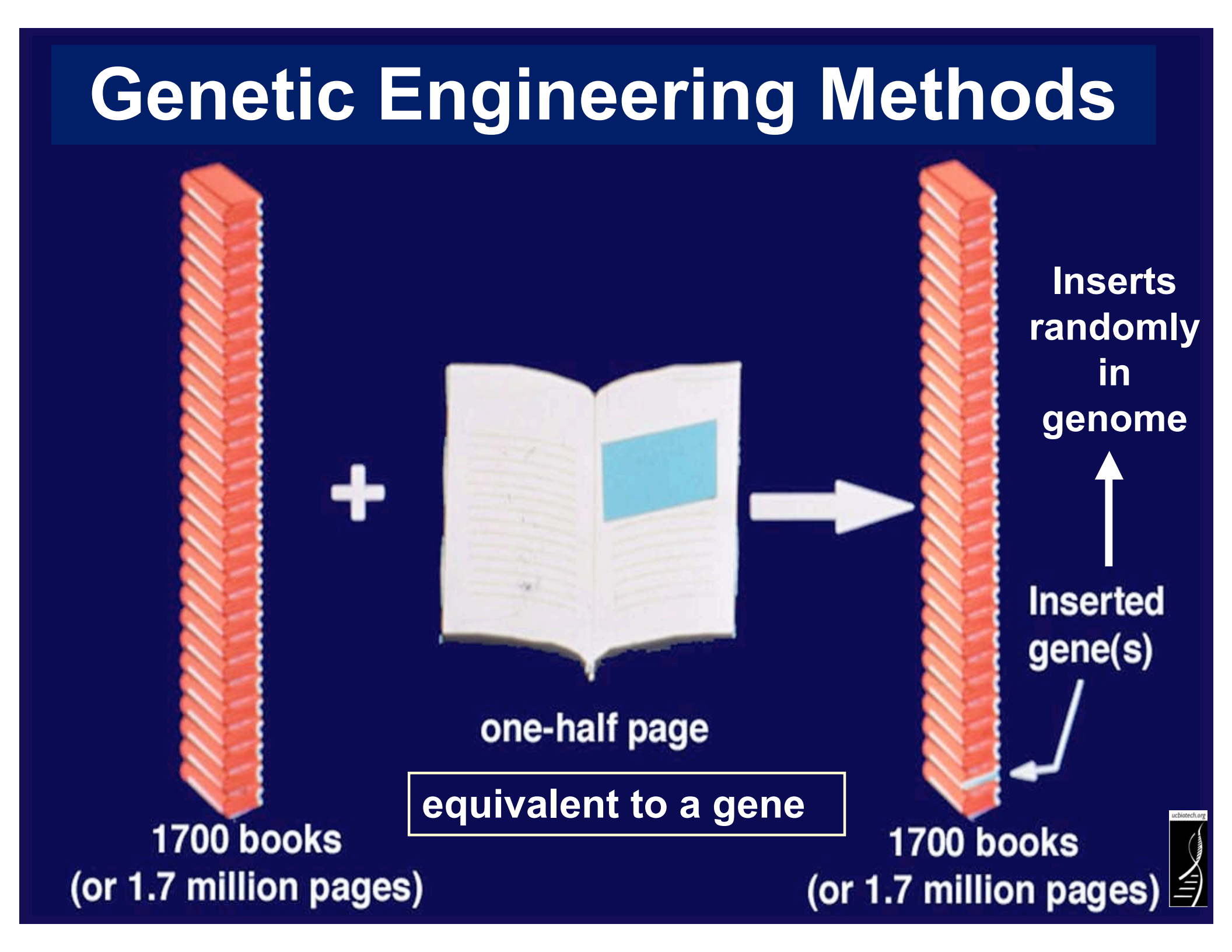
1700 books (or 1.7 million pages)

1700 books (or 1.7 million pages)


Wheat
Corn
Soybeans
Yield Increase by year
t/ha wheat or soybeans
t/ha corn
Year
0
0.5
1
1.5
2
2.5
3
0
1
2
3
4
5
6
7
8
1860
1880
1900
1920
1940
1960
1980
2000

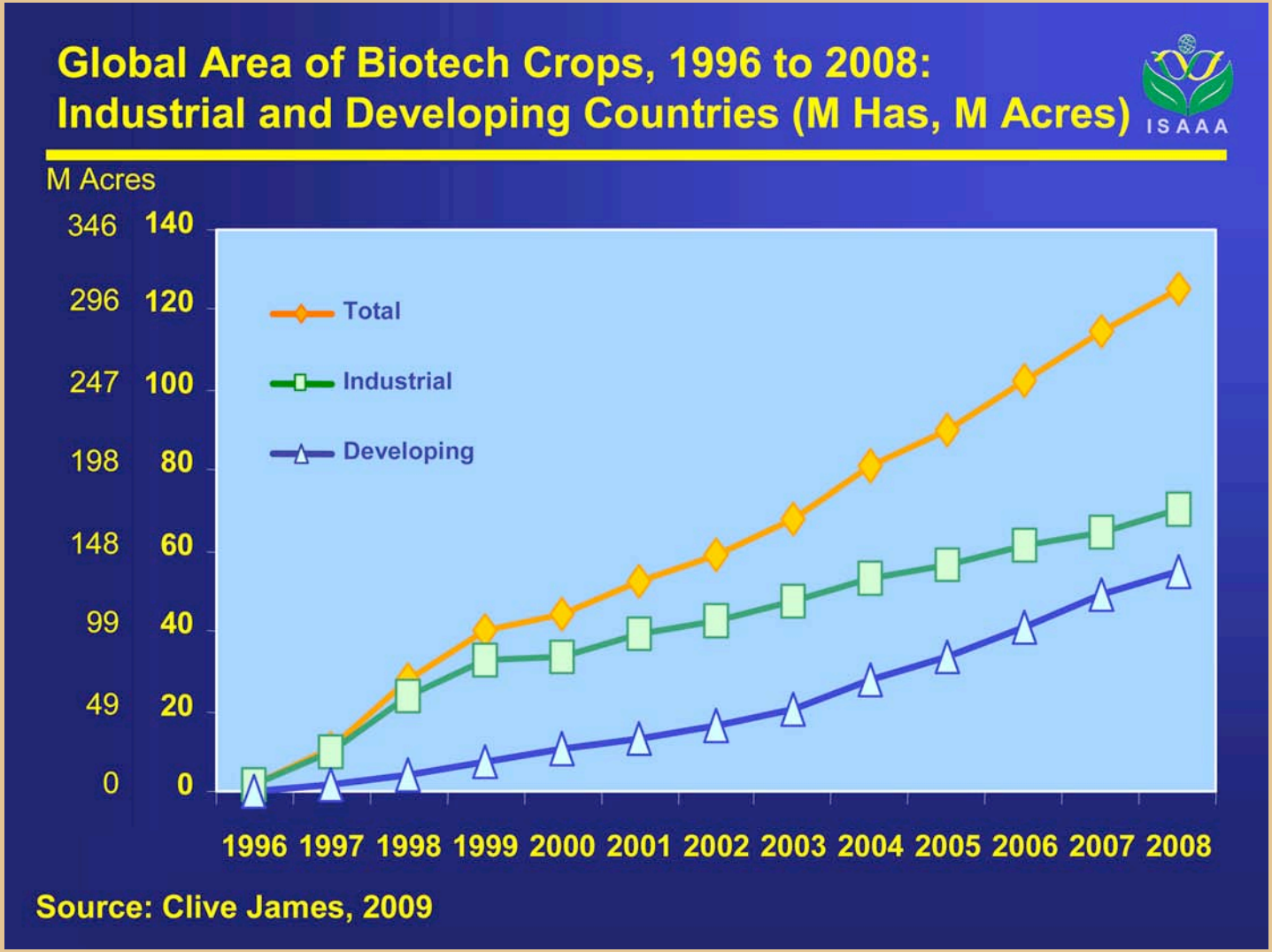

But there are other ways to create new varieties through genetic modification

Genetic Engineering Methods



Can Genetic Engineering of Crops Be Used to Benefit Africa?

GE crops are being grown in developing countries



25 industrial and developing countries in order of acreage:

United States, Argentina, Brazil, Canada, India, China, Paraguay, South Africa, Uruguay, Bolivia, Philippines, Australia, Mexico, Spain, Chile, Colombia, Honduras, Burkina Faso, Czech Republic, Romania, Portugal, Germany, Poland, Slovakia, Egypt.

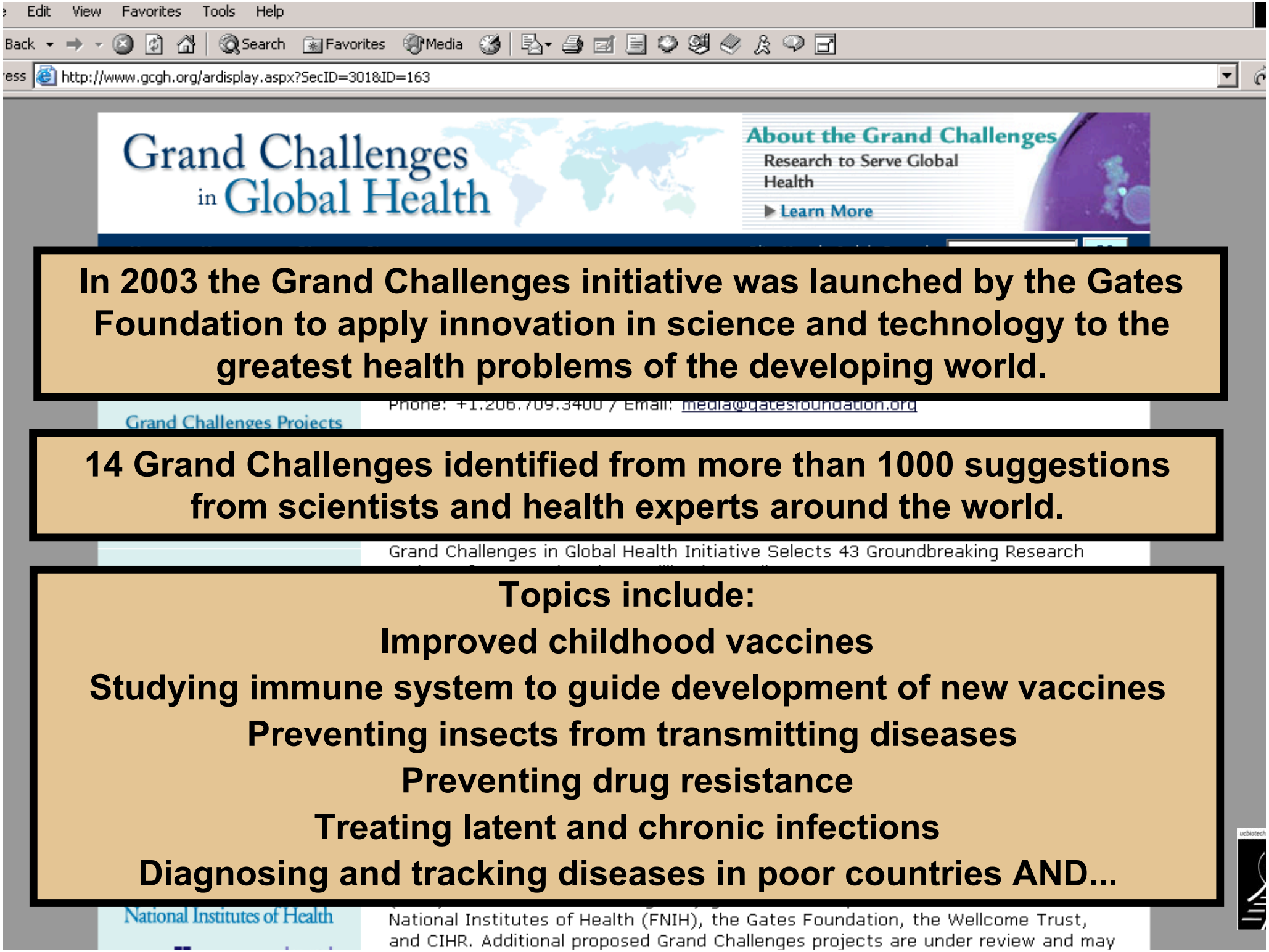
Three countries in the African continent grew them in 2008

Why did I become involved in a project to engineer sorghum for Africa?

Part of my mandate as a public sector scientist, doing research for the public good

The magnitude of the problem of food in Africa begs for solutions and it was something I wanted to do, but…

How did I become involved?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http://www.gcgh.org/ardisplay.aspx?SecID=301&ID=163
Grand Challenges in Global Health
About the Grand Challenges
Research to Serve Global Health
Learn More
In 2003 the Grand Challenges initiative was launched by the Gates Foundation to apply innovation in science and technology to the greatest health problems of the developing world.
Grand Challenges Projects
Phone: +1.206.709.3400 / Email: media@gatesfoundation.org
14 Grand Challenges identified from more than 1000 suggestions from scientists and health experts around the world.
Grand Challenges in Global Health Initiative Selects 43 Groundbreaking Research
Topics include:
Improved childhood vaccines
Studying immune system to guide development of new vaccines
Preventing insects from transmitting diseases
Preventing drug resistance
Treating latent and chronic infections
Diagnosing and tracking diseases in poor countries AND...
National Institutes of Health
National Institutes of Health (FNIH), the Gates Foundation, the Wellcome Trust, and CIHR. Additional proposed Grand Challenges projects are under review and may

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University of California, Berkeley joins Africa Biofortified Sorghum (ABS) project

Berkeley, California
April 10, 2006

Researchers at the University of California, Berkeley, are joining an ambitious project to improve nutrition for 300 million people in Africa who rely on sorghum as a principal source of food.

The Africa Biofortified Sorghum (ABS) project is funded by a $17.6 million grant from the Grand Challenges in Global Health initiative to Africa Harvest Biotechnology Foundation International, a non-profit organization dedicated to fighting hunger and poverty in Africa.

"Our goal is to develop sorghum that will provide increased calories and needed protein in the diet of African consumers," said Bob B. Buchanan, UC Berkeley professor of plant and microbial biology and one of the lead scientists on the project. "We are extremely happy to offer our expertise and materials for this important project for the public good."

The announcement of UC Berkeley's participation was made from Nairobi, Kenya, today (Monday, April 10) by project leader Florence Wambugu. "All the project consortium members are delighted that researchers from UC Berkeley will be joining the team," said Wambugu, who is a plant pathologist and CEO of Africa Harvest. "Their contribution will provide a second avenue to ensure success in achieving the important goal of increasing digestibility of sorghum."

Peggy G. Lemaux, UC Berkeley Cooperative Extension specialist in plant and microbial biology, and Bob Buchanan, professor of plant and microbial biology, inspect sorghum plants in a controlled temperature growth room. (Rosemary Alonso photo)

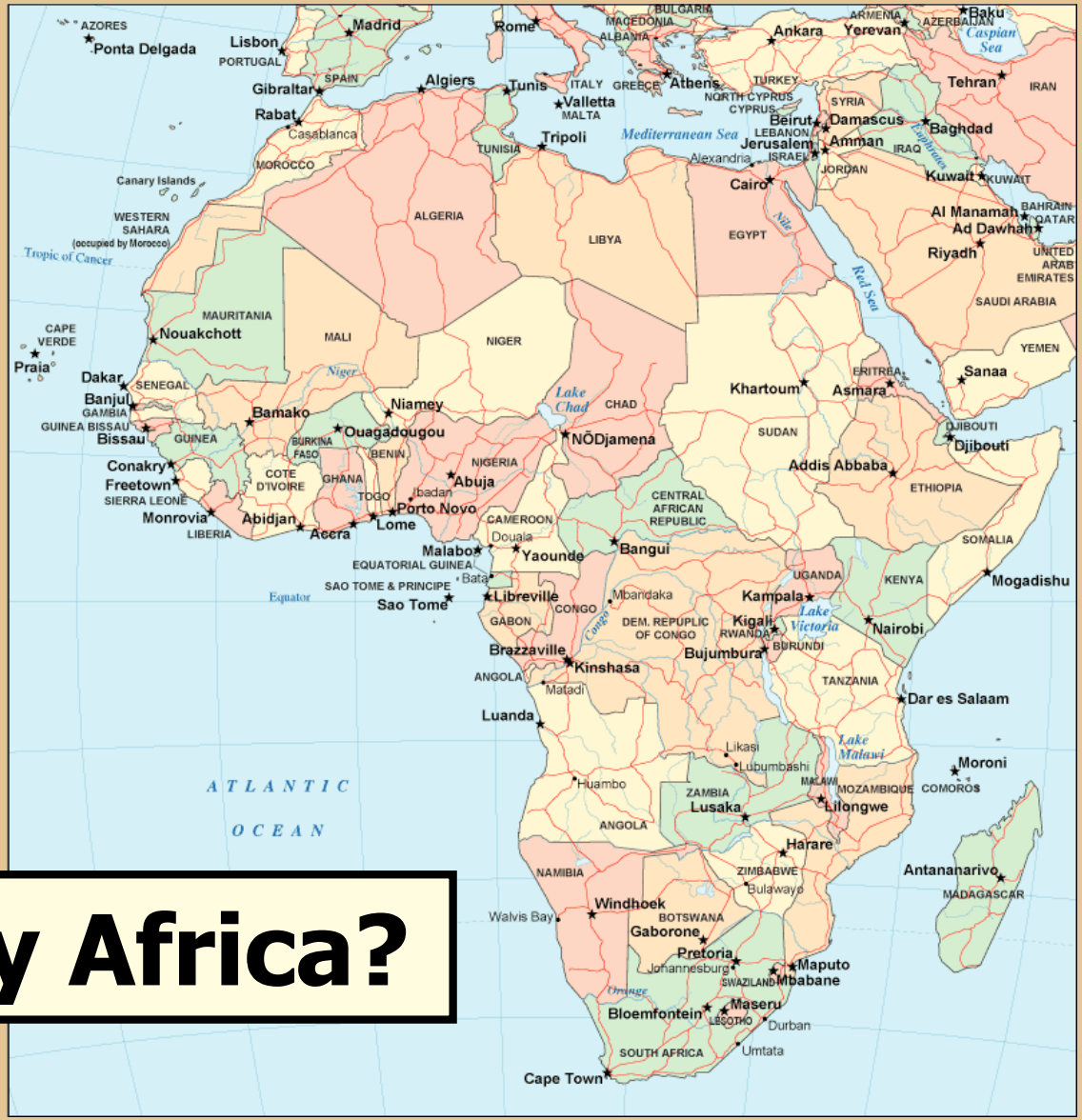
The Grand Challenges in Global Health initiative is supporting nutritional improvement of four staple crops - sorghum, cassava, bananas and rice - as one of its 14 "grand challenges" projects that focus on using science and technology to dramatically improve health in the world's poorest countries. The initiative is funded by the Bill & Melinda Gates Foundation, the Wellcome Trust, and the Canadian Institutes of Health Research.

In June 2005, the initiative awarded $16.94 million to Africa Harvest to head a consortium of public and private research institutes for the ABS project. The Gates Foundation has just supplemented this amount with $627,932

Grand Challenge #9: Growing more nutritious staple crops to combat malnutrition in Africa

Focused on 4 crops:

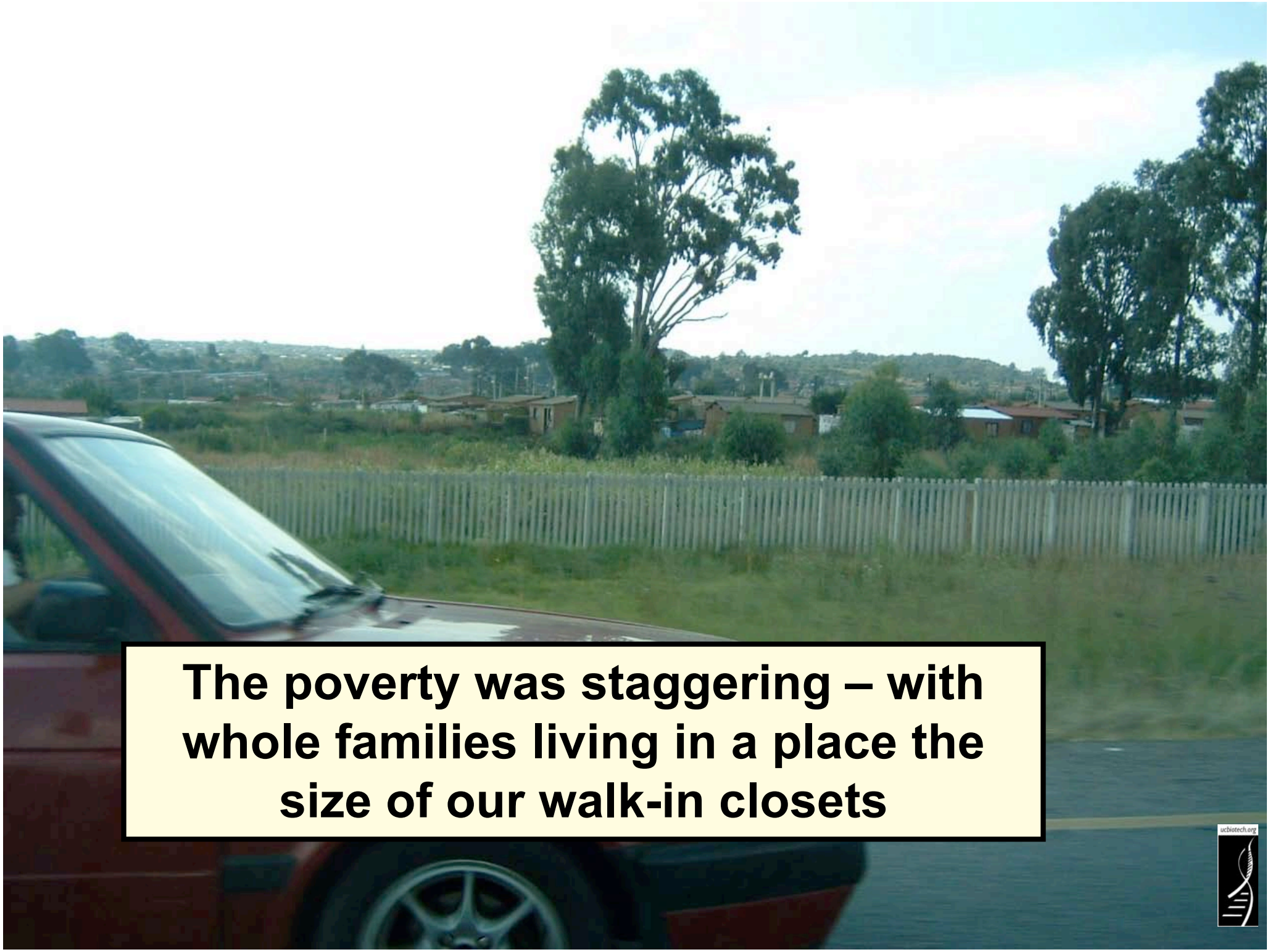
banana, cassava, rice and SORGHUM

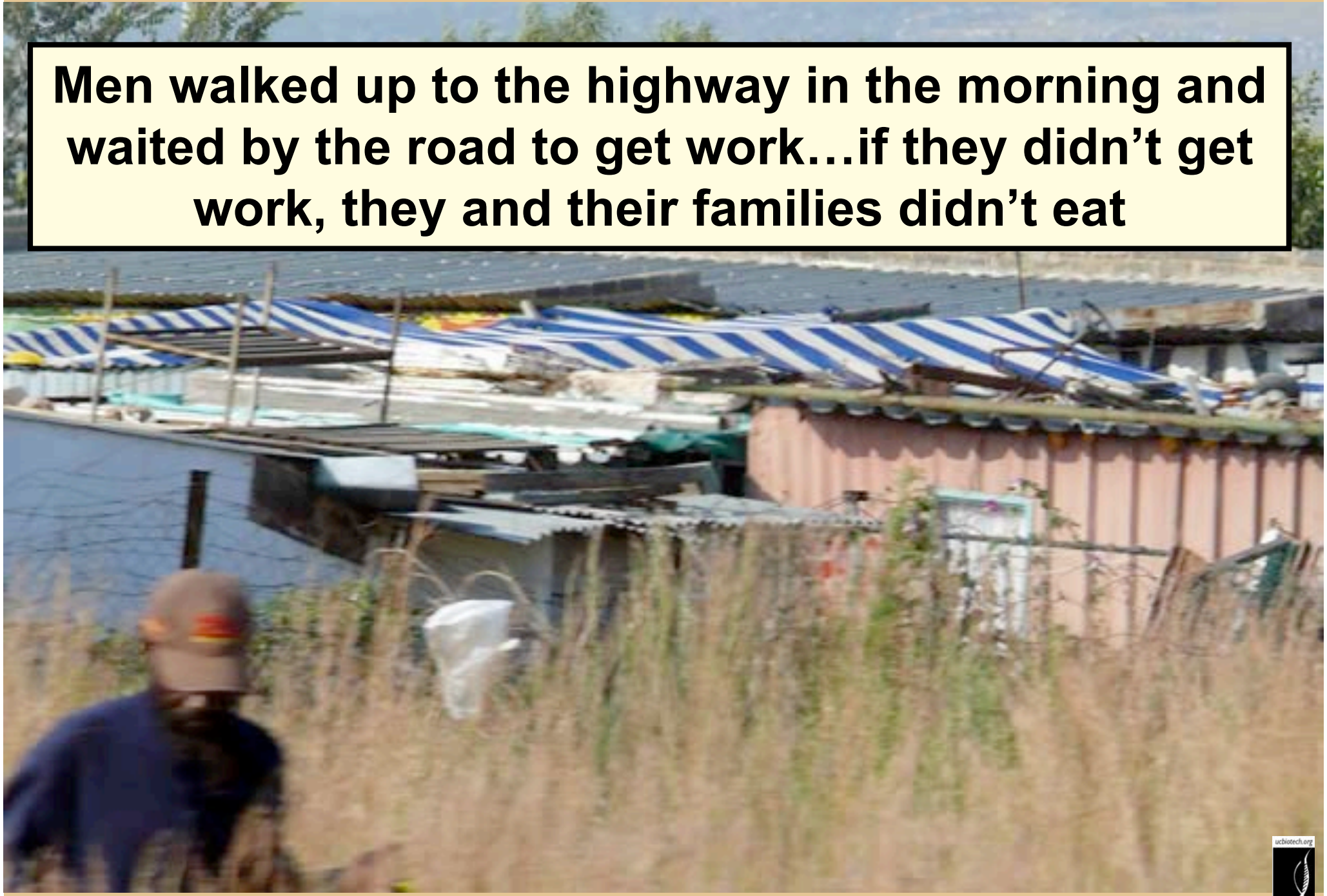


Why Africa?


Homes in rural communities are not spacious, but at least there are small spaces to grow food

Just outside cities – often juxtaposed next to modern suburbs –as far as the eye could see were tiny huts crammed together with no place to raise crops.


The poverty was staggering – with whole families living in a place the size of our walk-in closets
ucbiotech.org


Men walked up to the highway in the morning and waited by the road to get work…if they didn't get work, they and their families didn't eat

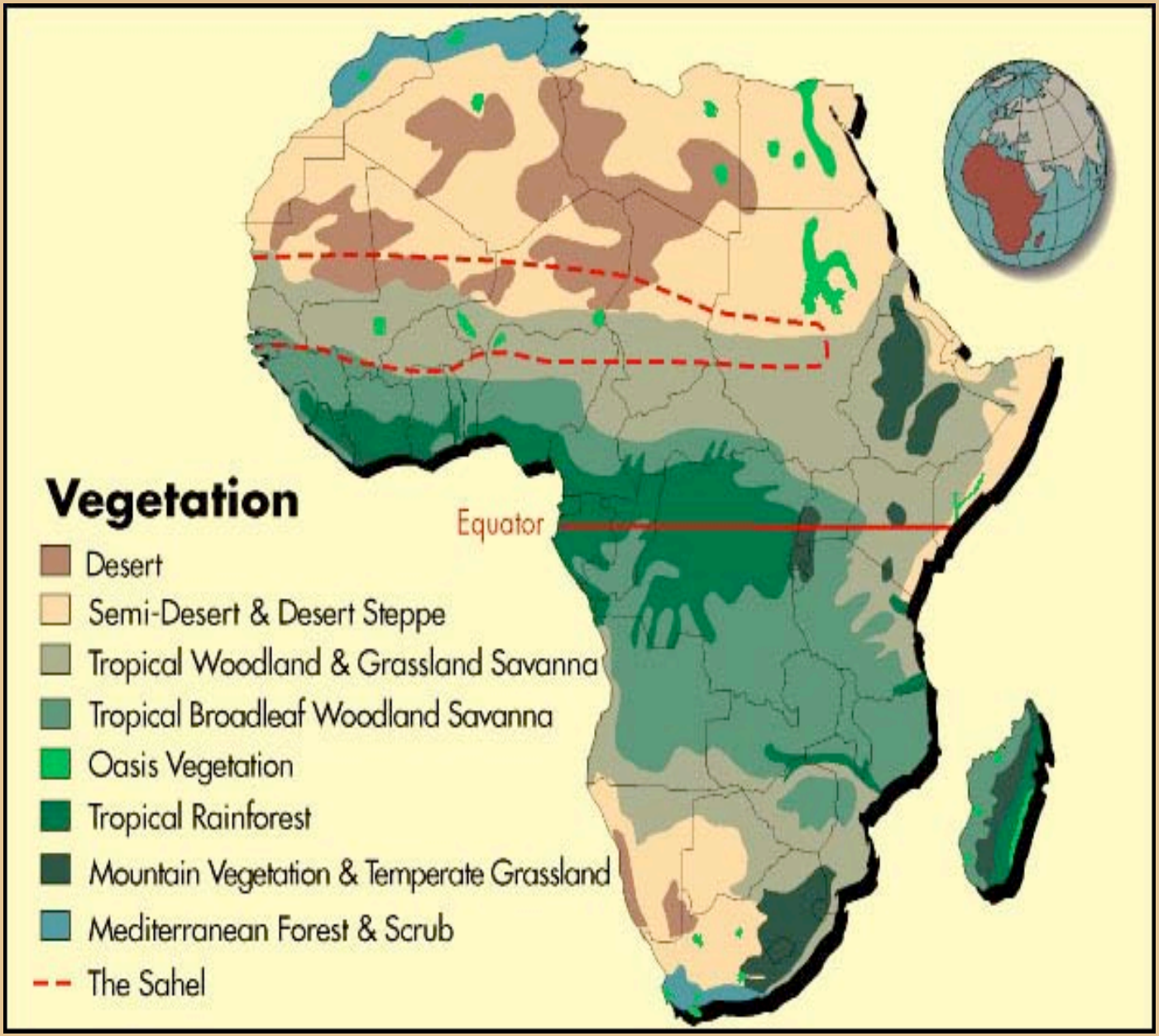
Why Is Sorghum the Target?

- **Fifth most important food grain**
- **90% grown in Africa and Asia in arid and semi-arid regions**
- **Staple food for 300 million in Africa**
- **In Africa, 74% of sorghum is consumed at home as cooked porridge**

Cultivated sorghum

Wild outcrossing species

Sorghum is uniquely adapted to Africa's climate – it withstands both drought and water logging



During prolonged drought in South Africa, sorghum thrived while maize struggled!

Maize

Sorghum

Potchestrom, South Africa Feb. 17, 2007

But sorghum is nutritionally deficient in:

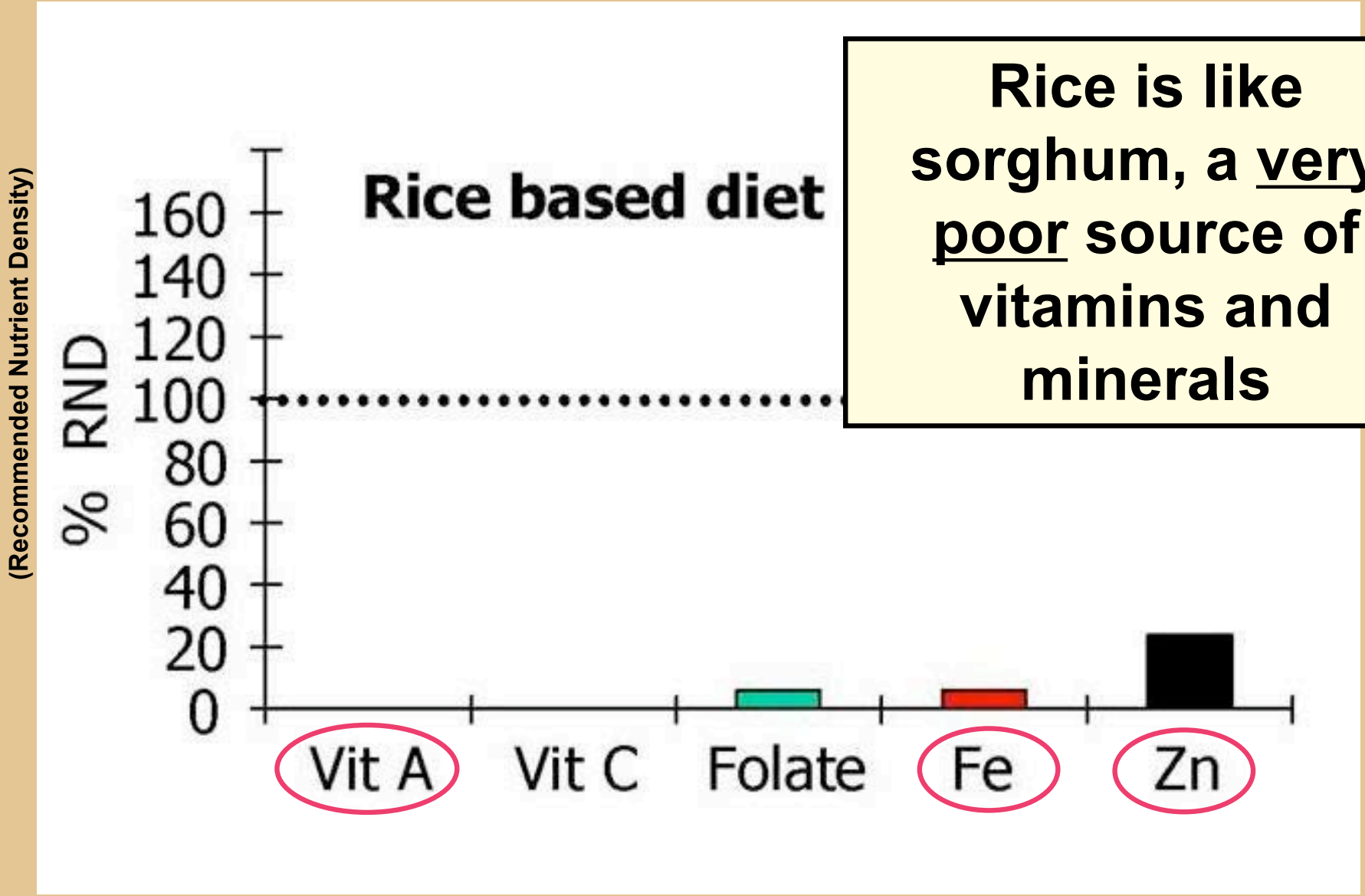
Vitamins
Minerals
Amino acids
(like most cereals)

Uniquely it is

Poorly Digested

Can't they just eat something else to make up for deficiencies?

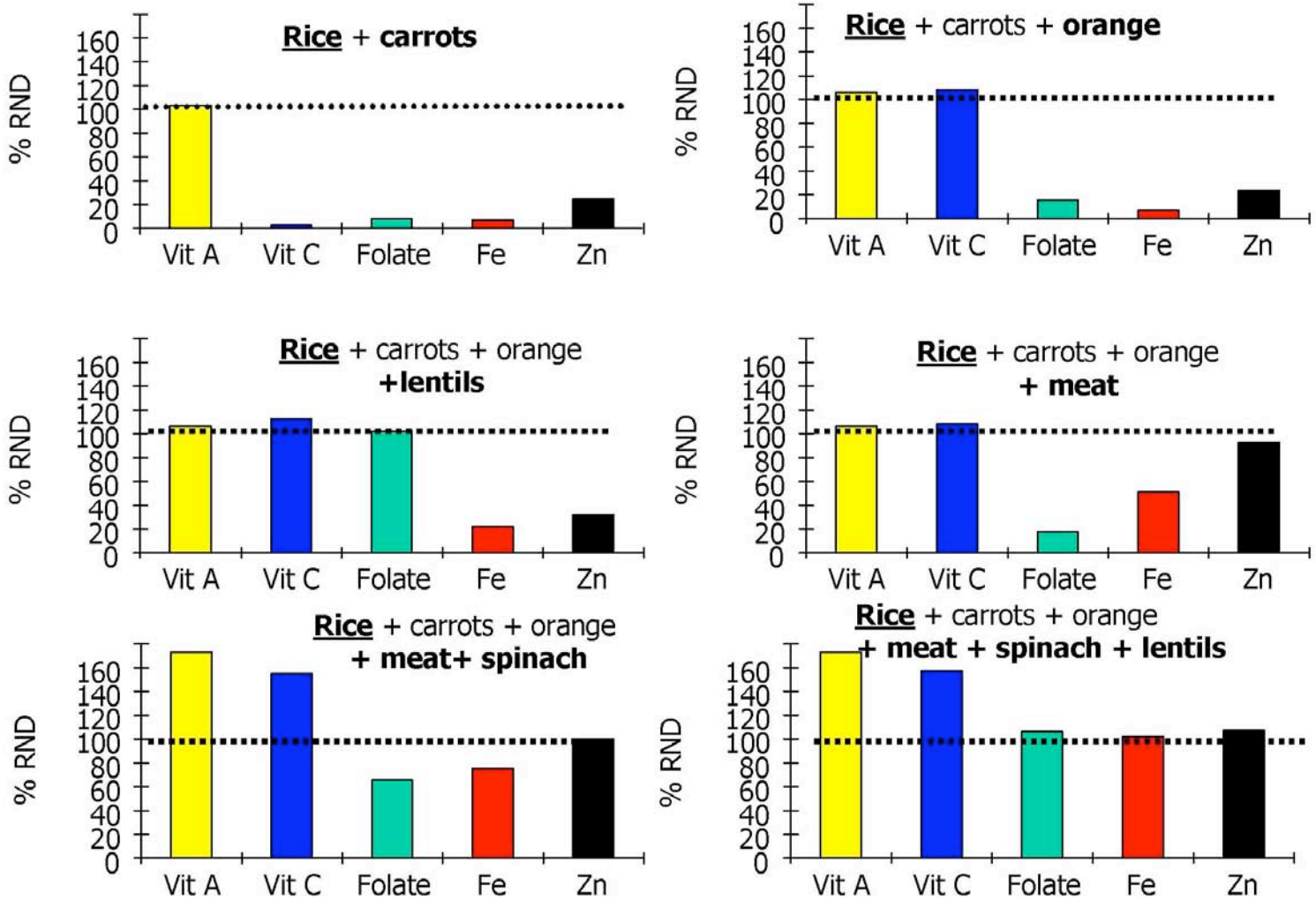
Rice Diet and Micronutrient Nutrition



Rice is like sorghum, a <u>very poor</u> source of vitamins and minerals

From: "Nutrition: A Cornerstone for Human Health and Productivity", Richard J. Deckelbaum. Seminar, Earth Institute of Columbia University, April 14, 2005

Modified from G. Barry, IRRI



Rice diet can be supplemented with other fruits, vegetables and meat to acquire needed nutrients…but not everyone has that luxury

Modified from G. Barry, IRRI

: "Nutrition: A Cornerstone for Human Health and Productivity", Richard J. Deckelbaum. Seminar at The Earth Institute of Columbia University, April 14, 2005

The FACTs are that in the Philippines…

2 of 3 infants (6mos.-1yr) have iron-deficiency anemia

1 of 3 Filipinos are at risk of low zinc intake

4 of 10 children are vitamin A deficient

Numbers are increasing since 1990s

Micronutrient malnutrition is a serious public health problem

Emilia Boncodin, Fedl Budget Secy Manila Philippines

What is biofortification? Incorporating nutrients directly in the grain.
Why is it necessary? It can complement other current interventions.

Supplementation

Food Fortification

Dietary Diversity

Biofortification

Modified from G. Barry, IRRI

HarvestPlus
Breeding Crops for Better Nutrition

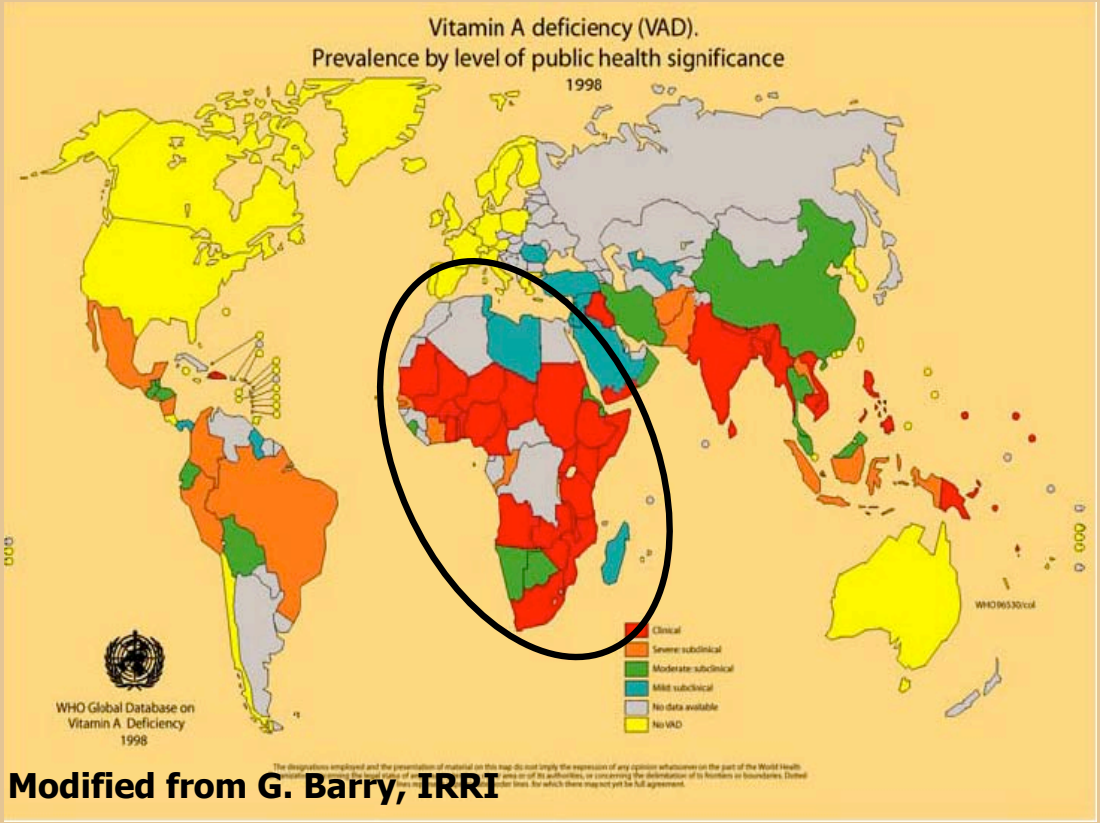
Addressing the nutritional challenge

Goal of Super Sorghum Project

Develop more nutritious, easily digestible, biofortified sorghum, containing higher levels of pro-vitamin A, vitamin E, iron, zinc, and deficient amino acids, lysine, tryptophan and threonine, for the arid and semi-arid tropical areas of Africa

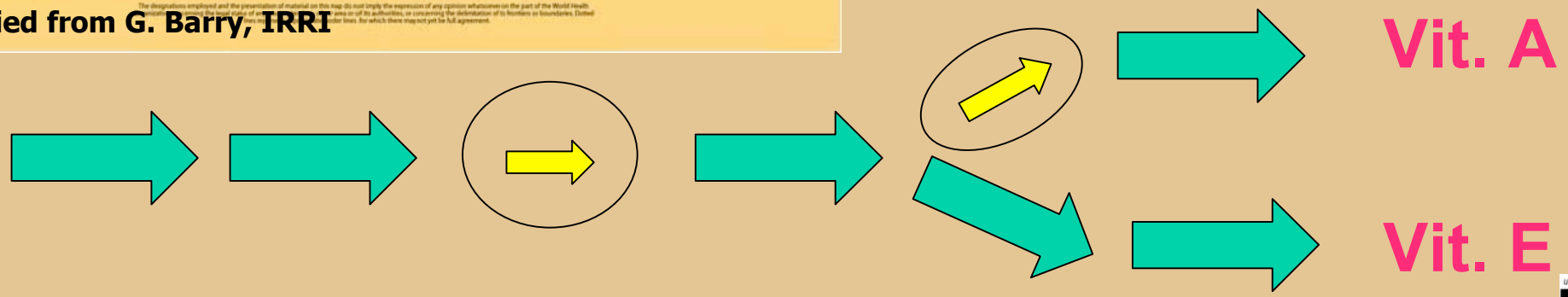
Super Sorghum nutritional targets are beyond the reach of plant breeding approaches so engineering of sorghum became necessary

Vitamin A Deficiency: Severe Health Problem in Africa

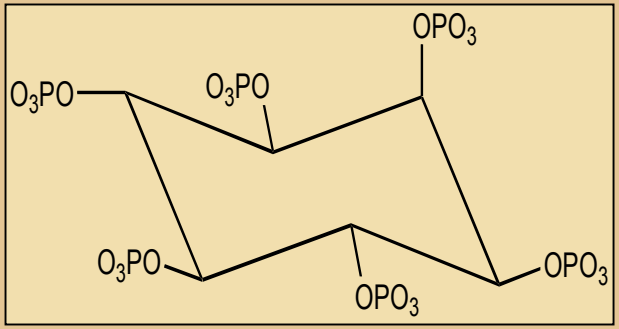


Modified from G. Barry, IRRI

- Sorghum grain - very low levels of Vit A and E
- Vit A critical for eyesight Vit E protects Vit A.
- Increase production by improving rate-limiting steps in biosynthesis



Improving Iron and Zinc Availability in Sorghum by Reducing Phytic Acid in Grain



Phytic Acid

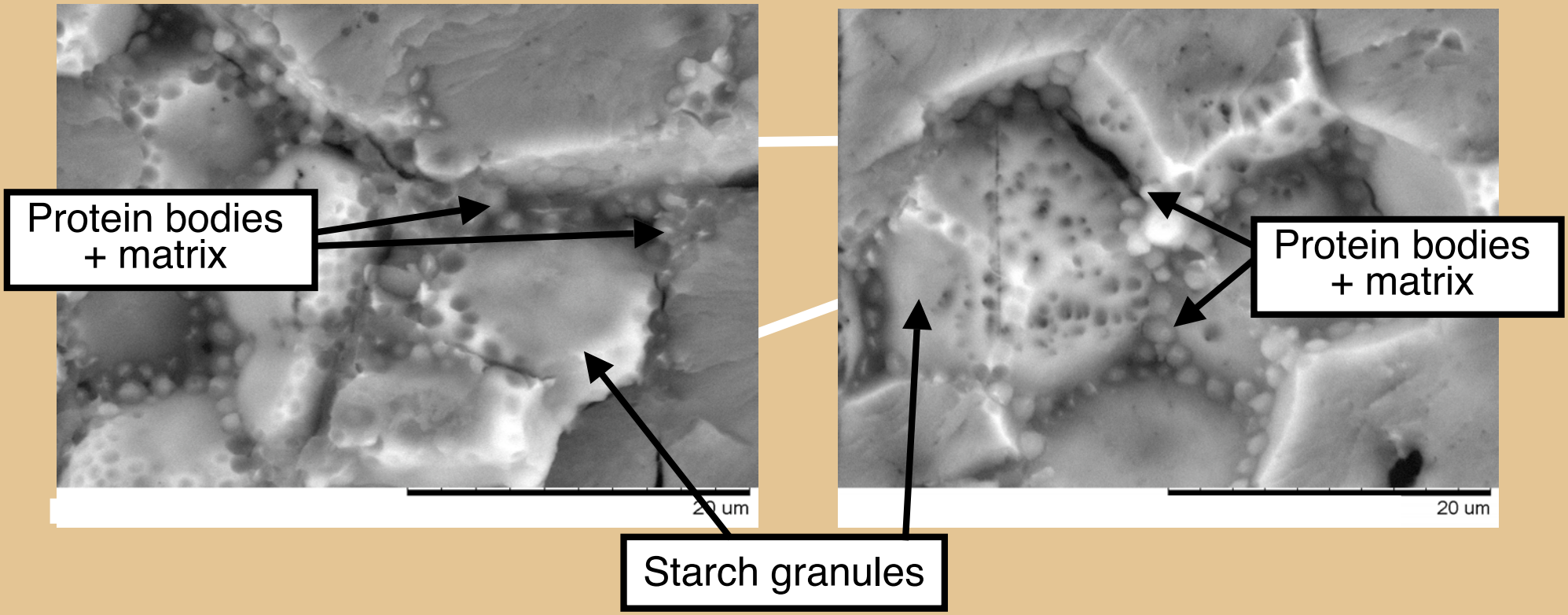
- **Phytic acid in the seed binds iron and zinc**
- **Reduce phytic acid by blocking production**
- **Lower phytic acid frees iron & zinc to be taken up from food**

Improving Protein Quality
UCB involvement

- **Improve Protein Quality**
  - Introduce new protein with increased Lys, Trp, Met, Thr
  - Decrease proteins with poor quality
- **Improve Protein Digestibility**
  - Decrease proteins negatively affecting digestibility
  - Alter digestibility of protein

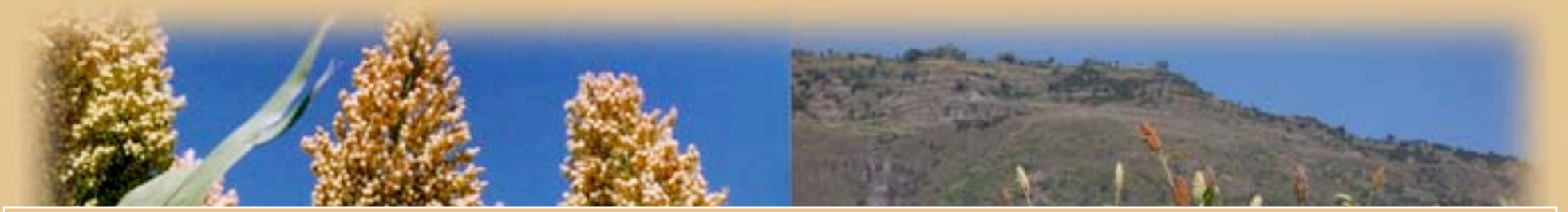
Improving Digestibility

Starch granules embedded in protein matrix



Disulfide bonds within and between kafirins hinder starch and storage protein digestibility upon cooking

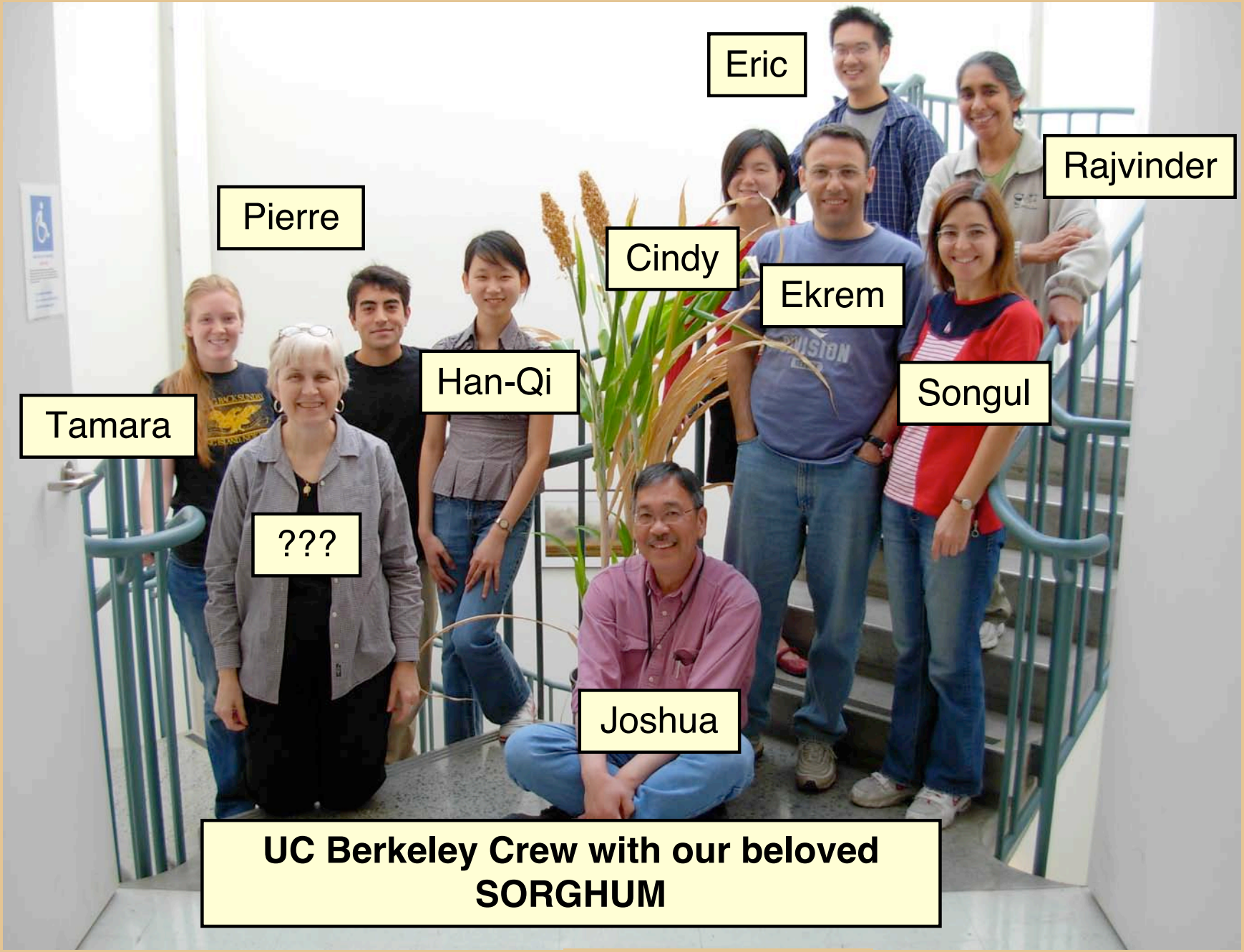
Super Sorghum



NO MAGIC BULLET

But it can help!

The Super Sorghum Team in Nairobi Kenya



UC Berkeley Crew with our beloved SORGHUM

Think what a $1 means to others, next time you buy food!

CAN YOU HELP?