PINE BROOK

The Carbon Problem: A New Perspective

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HARNESSING
PLANTS
To Fight
Climate
Change
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Where cures begin.

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Jonas Salk

"What people think of as the moment of discovery is really the discovery of the question."

Sometimes, It Depends on How You Look at Something

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For Example…

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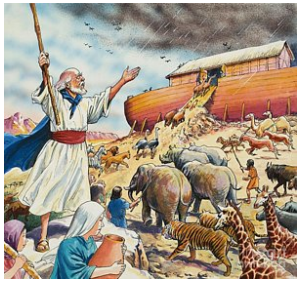
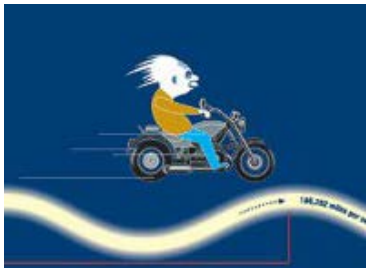
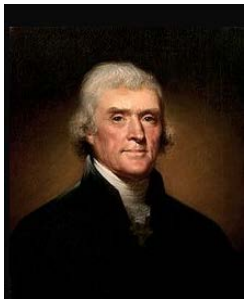
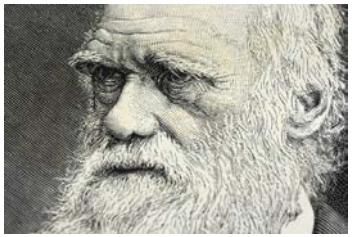
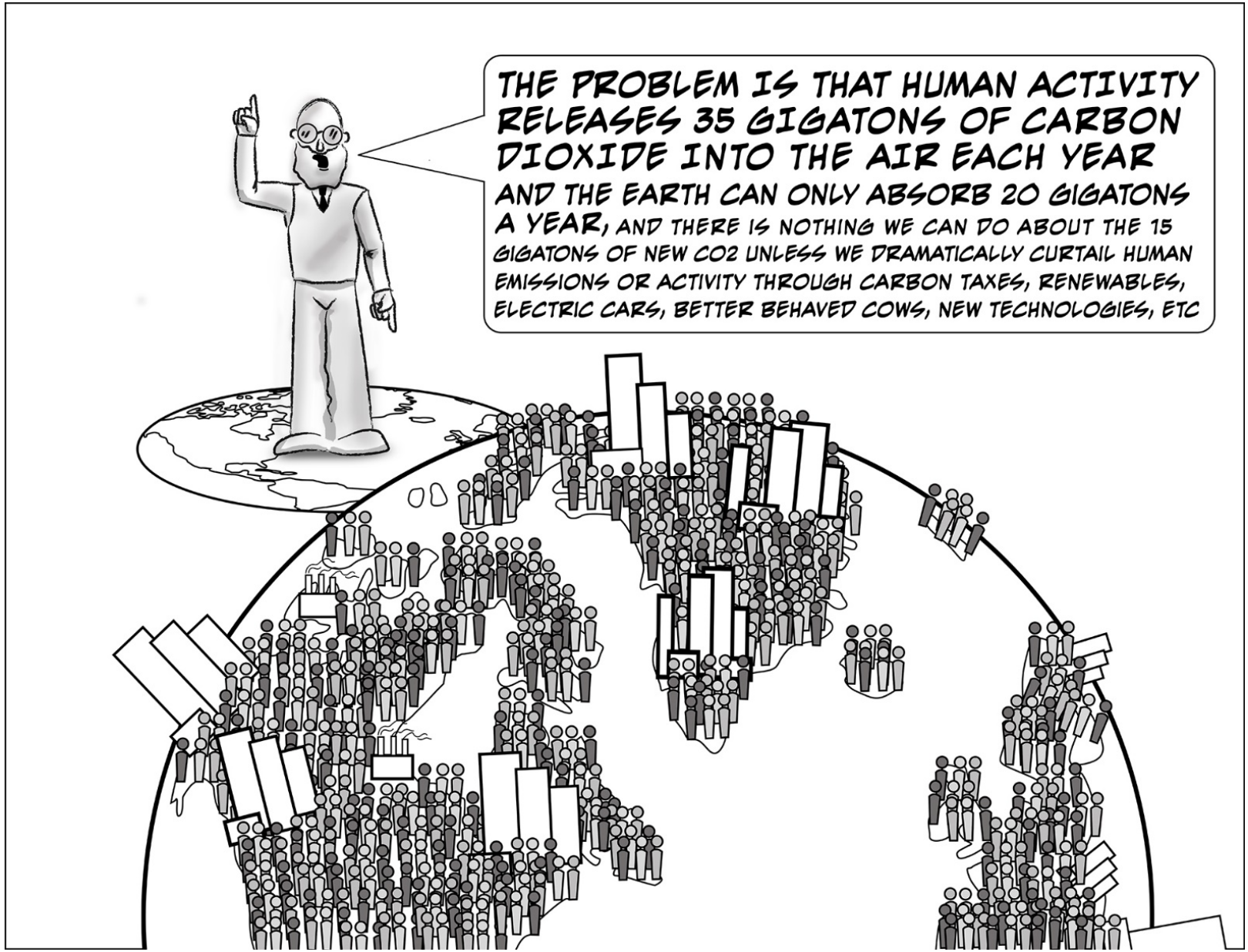
Gravity	Rights of Man	Speciation	Computing
			
Newton	***The Divine Right of Kings***	***Noah's Ark***	***Bill Gates***
			
Einstein	***Certain Unalienable Rights***	***Darwin***	***Steve Jobs***

The Problem as We See it Today



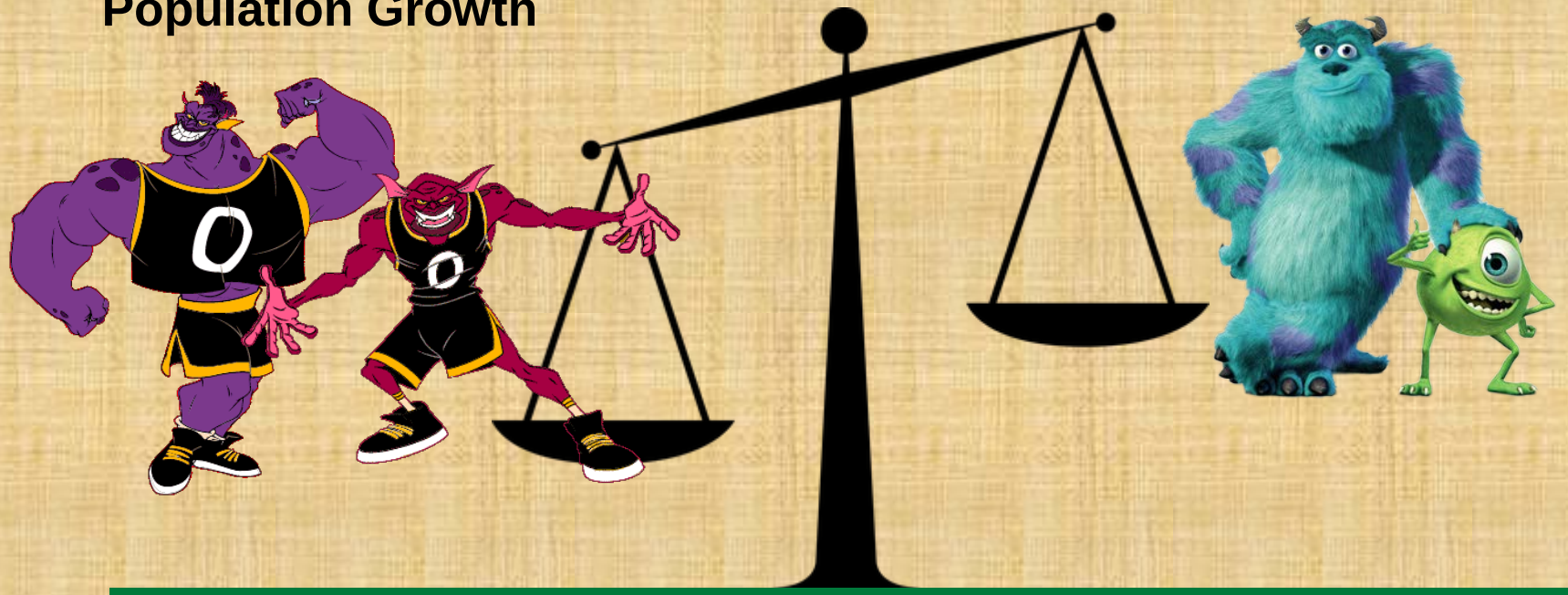
Conventional Math

(in $GtCO_2$)	
Human Emissions	37
Natural Absorption	(19)
Net Increase	**18**

Difficult Imbalance to Overcome

Income Growth
Population Growth

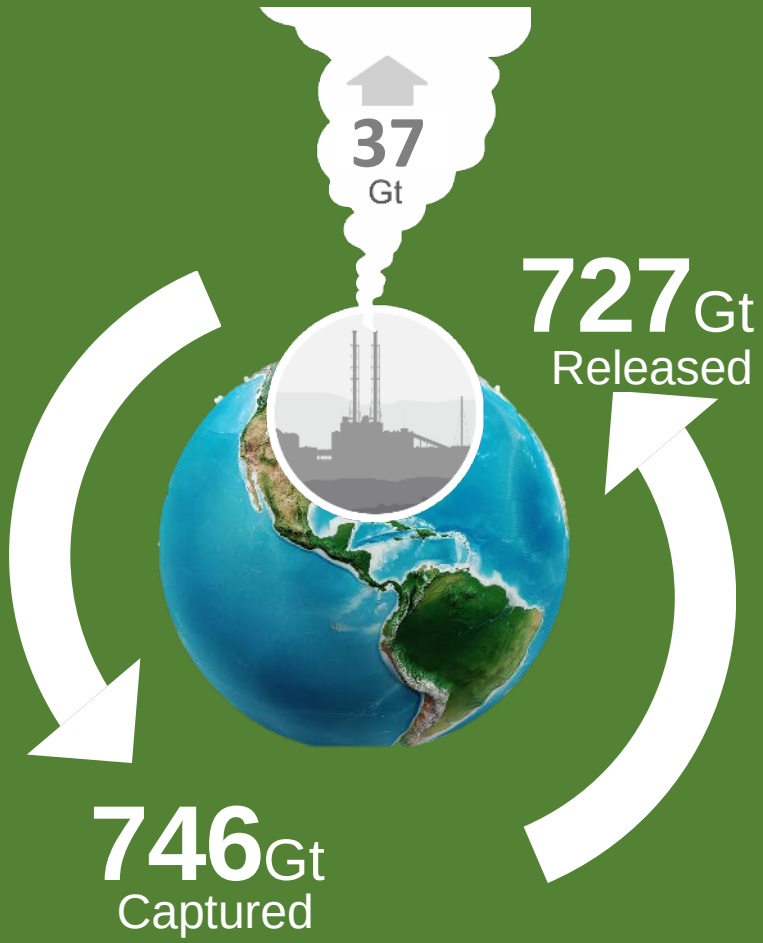
Behavioral Change
Conservation Technology



Year	Global GDP *($ in trillions)*	Emissions *(Gt)*	Emissions / GDP *(lbs per $)*	Population *(billions)*	Emissions / Capita *(lbs per person)*
1988	$19.2	21.8	2.42	5.1	9,400
2017	$80.7	38.8	1.06	7.5	11,380
Compound Growth	5.1%	2.0%	(2.8%)	1.3%	0.7%

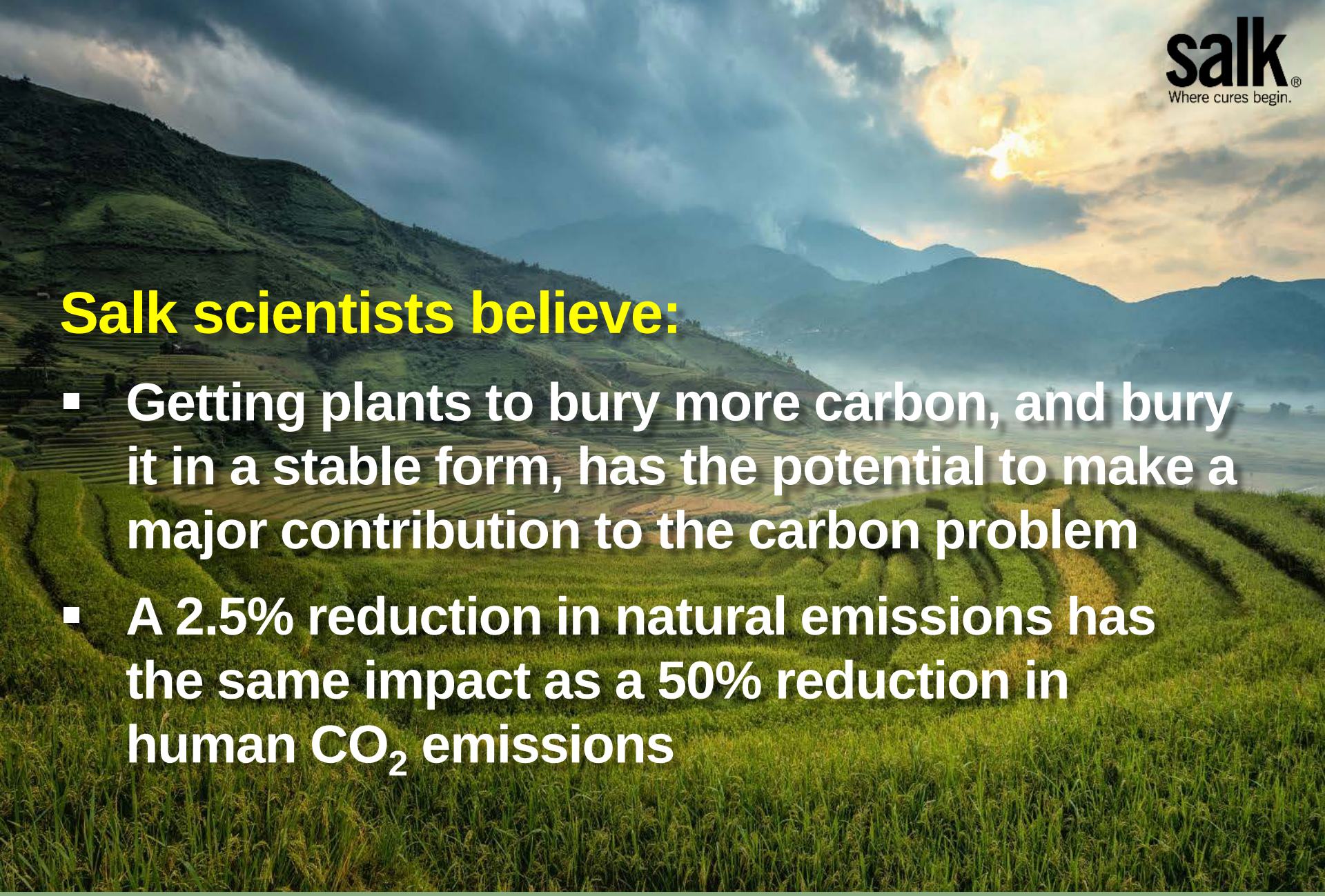
Sources: GDP: St. Louis FRED, PwC. Population: The World Bank, United Nations Population Division, Census reports from national statistical offices, Eurostat, U.S. Census Bureau, Secretariat of the Pacific Community.
Emissions: Global Carbon Project, National Oceanic and Atmospheric Administration.
Note: GDP reflects market exchange rates in current US $.

The New Math



(in $GtCO_2$)	
Natural Absorption	(746)
Natural Release	727
Human Emissions	37
Net Increase	**18**

18 Gt of CO_2 more per year than the earth can handle



Salk scientists believe:

- Getting plants to bury more carbon, and bury it in a stable form, has the potential to make a major contribution to the carbon problem
- A 2.5% reduction in natural emissions has the same impact as a 50% reduction in human CO_2 emissions

Better Way to Get to 20 Gt per Year

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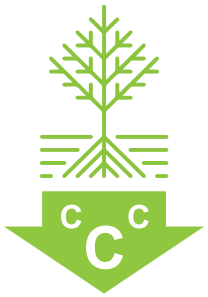
Approach One
TERRESTRIAL
Goal: 25% of human emissions

1.



Create Ideal Plants™ to store carbon in soil

Approach Two
AQUATIC
Goal: 25% of human emissions

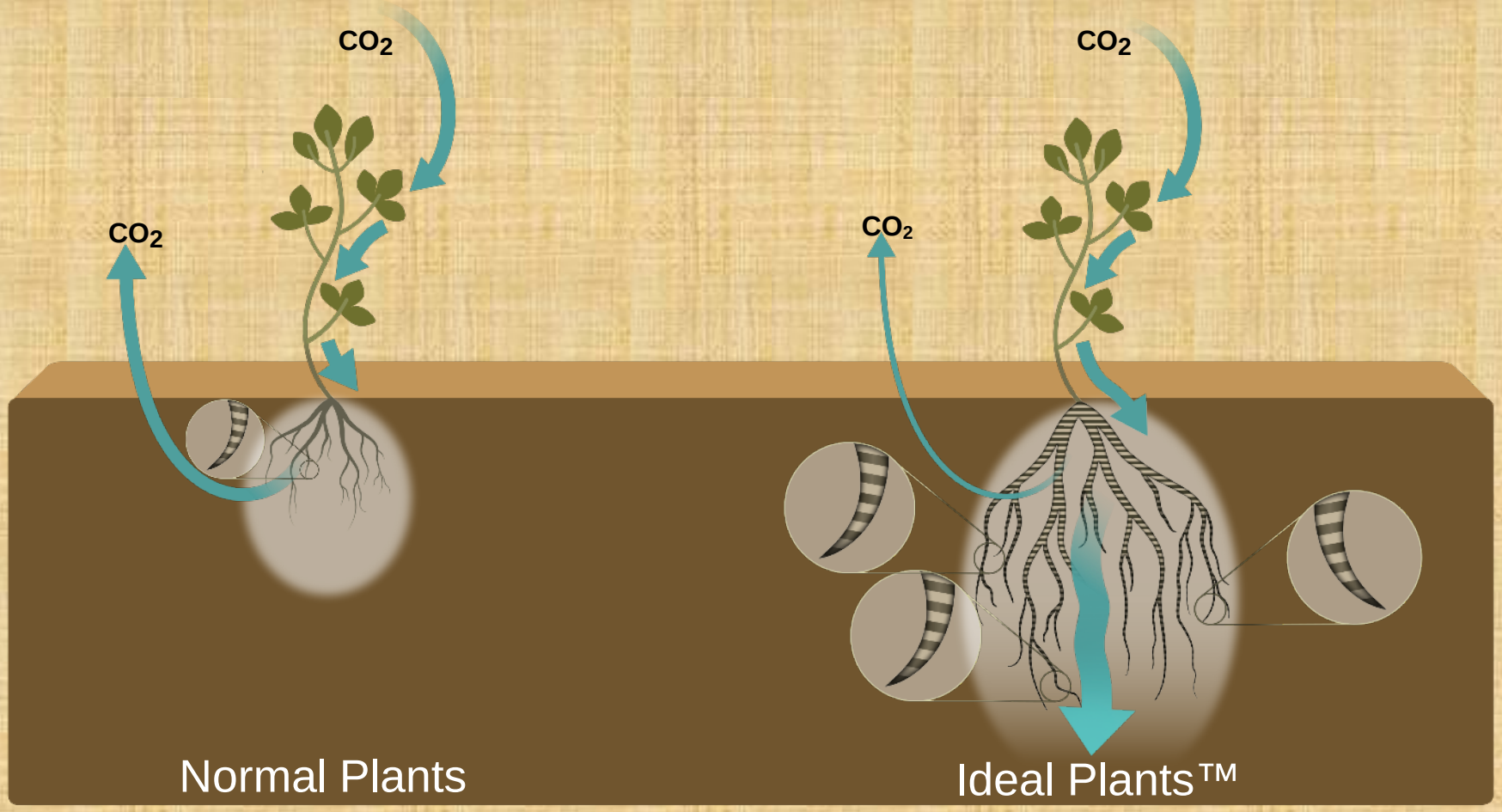
2.

Adaptive Aquatic Restoration to store carbon in sediments

The Salk Solution: Ideal Plants™

- Genes for deep and more extensive roots
- Genes for stable carbon compounds (suberin)
- Stacked genes for increased suberin in deep and extensive roots

Keeping Carbon Underground



Deeper Roots

- Engineered expression of a single gene **alters** root architecture

Wild Type

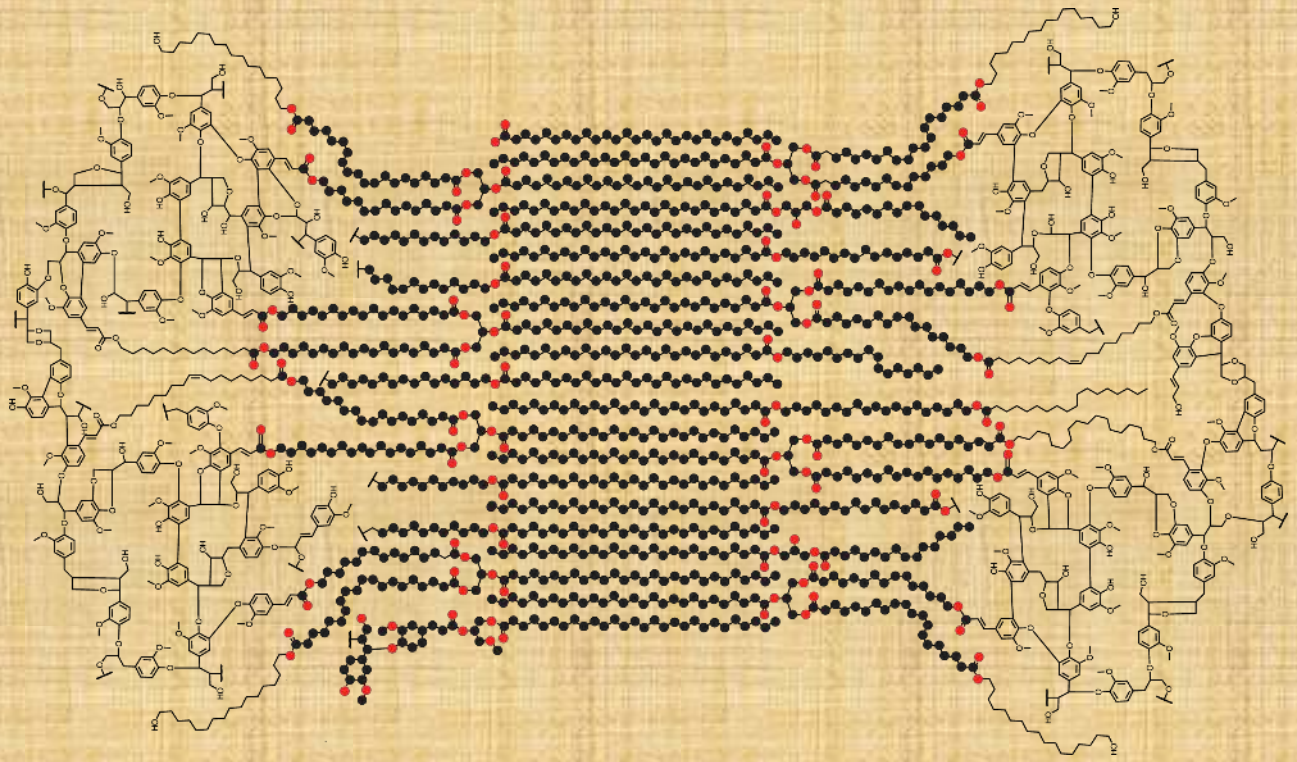
Gene Edited

More Extensive Roots

- Engineered expression of another single gene **doubles** root biomass

Stack identified genes

Suberin:
A Natural Carbon-Storage Device



Benefits of Ideal Plants™: Sequestration Potential From 9 Crops

- 3 – 8 Gt per year from 6 row crops
  - Corn, wheat, soybeans, cotton seed/cotton, rice, rapeseed
- Doable in 10 – 15 years
- Cost of $0 – $10 per ton sequestered

- Similar potential from 3 cover crops
  - Tillage radish, crimson clover, annual ryegrass

Benefits of Ideal Plants™: Increased Soil Carbon

- Improved soil health
- Increased crop yields
- Increased resistance to drought, flooding and disease
- Improved water-use and nutrient efficiency

Adaptive Aquatic Restoration

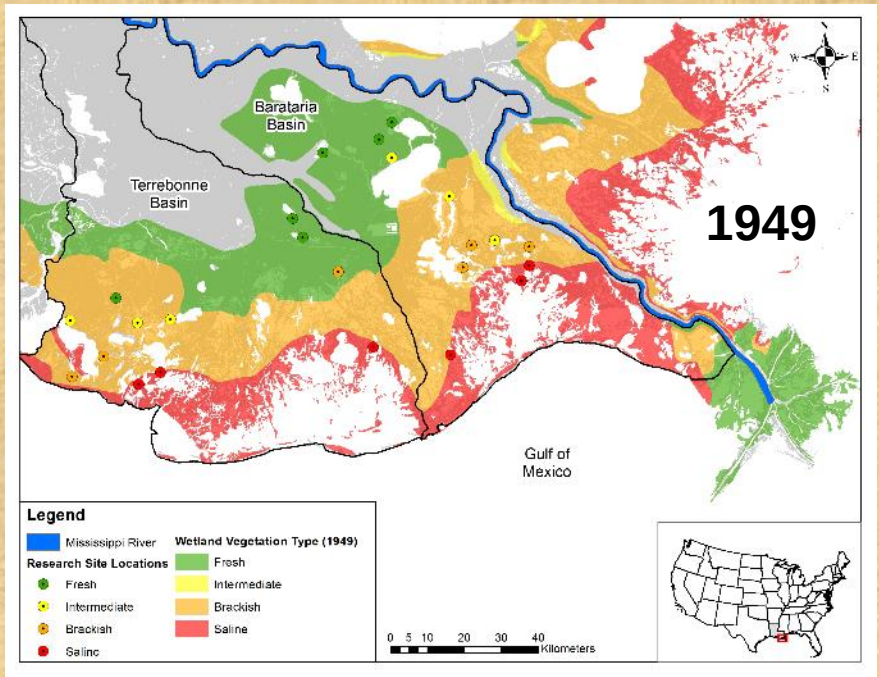
- Aquatic plants are natural Ideal Plants™
  - 30X or more greater carbon storage than land plants
  - Rebuild lost land
  - Fish breeding begins here
- 50% of habitats lost over past 30 years

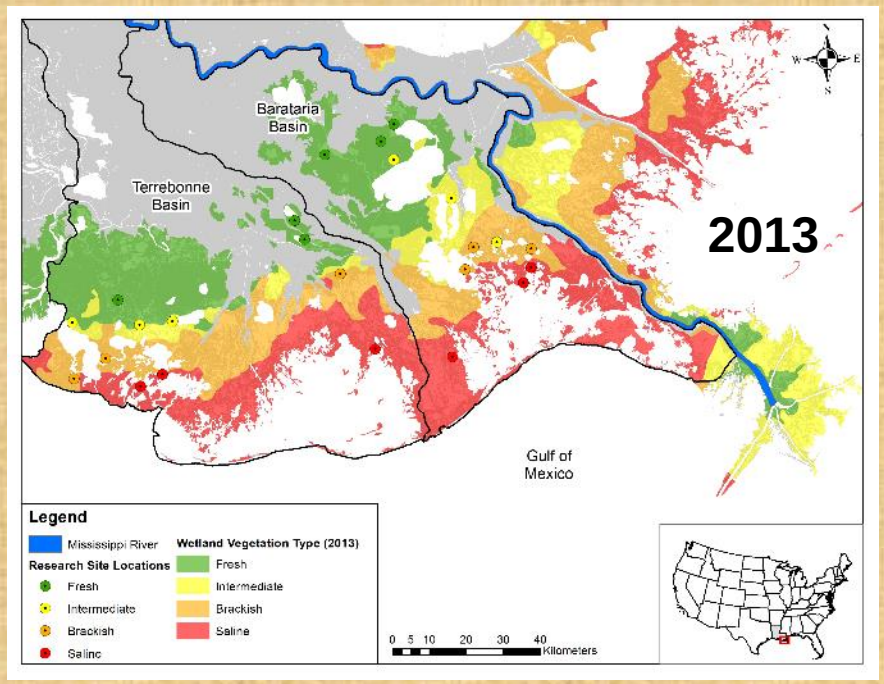
The Salk Solution: Adaptive Aquatic Restoration

- Local aquatic populations are genetically identical (clones)
- Small environmental changes destroy entire populations
- Aquatic species have extensive natural variation
- Informed genetics identifies the best genotype/phenotype for native recolonization

The Mississippi River Delta

Soil carbon dynamics in four marsh habitats of coastal Louisiana





The Mississippi River Delta

Exploiting natural variation to select appropriate genotypes

Adaptive Aquatic Restoration: Progress To-Date Mississippi Delta

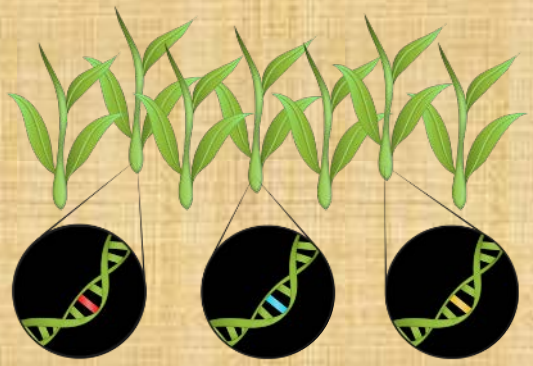
- Established Aquatic Plant Consortium
  - Louisiana Universities Marine Consortium
  - Tulane ByWater Institute
  - Water Institute of the Gulf
  - Lake Pontchartrain Basin Foundation
  - Joe W. and Dorothy Dorsett Brown Foundation
- Identified critically threatened species
  - Established growing conditions for these species
  - Begun sequencing genomes
  - Begun measuring root suberization

Why now?

Molecular biology meets plant breeding meets synthetic biology…

1980's
Molecular Genetics Revolution

2000's
Genomics Revolution



2010
Precision Breeding & Genome editing

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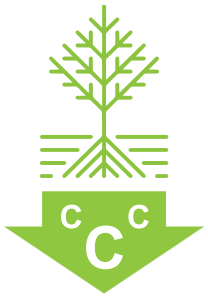

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Adaptive Aquatic Restoration to store carbon in sediments

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“Our greatest responsibility is to be good ancestors.”