salk®
HARNESSING PLANTS INITIATIVE

HARNESSING PLANTS, SAVING THE PLANET

"Our greatest responsibility is to be good ancestors."
—Jonas Salk

We invite you to join us.

Humanity faces an unprecedented threat caused by climate change and a burgeoning global population. To solve this imminent crisis, atmospheric CO_2 levels must be decreased and agricultural production must be increased. These are two daunting challenges, but our team of Salk scientists offers an elegant solution – harness the natural power of plants to rebalance the earth's carbon cycle and feed the world.

Salk's #1 rated plant biology group* is commanding the advanced genetics and biochemistry expertise to optimize a plant's natural ability to capture and store carbon and adapt to diverse climate conditions.

This effort will leverage nature's photosynthetic process to move much more carbon into plant roots and soils to solve the carbon imbalance on a truly global scale and in time to make a profound difference.

By understanding and optimizing just a few genetic pathways we can simultaneously:

1. Draw down CO_2, a "negative emission" technology
2. Improve soil quality to boost plant yields
3. Restore severely threatened aquatic ecosystems

Salk's Harnessing Plants Initiative will have an outsized impact because of two fundamental and complementary characteristics: The solution is **scalable** because it is based on widespread existing infrastructure and resources, and it advances **sustainability** because healthier soils and coastal aquatic regions will provide more resources to feed the world.

* Thomson Reuters 2000–10, Top Institutions by citations per highly cited papers

Earth's plants can be our strongest allies in averting climate disaster.

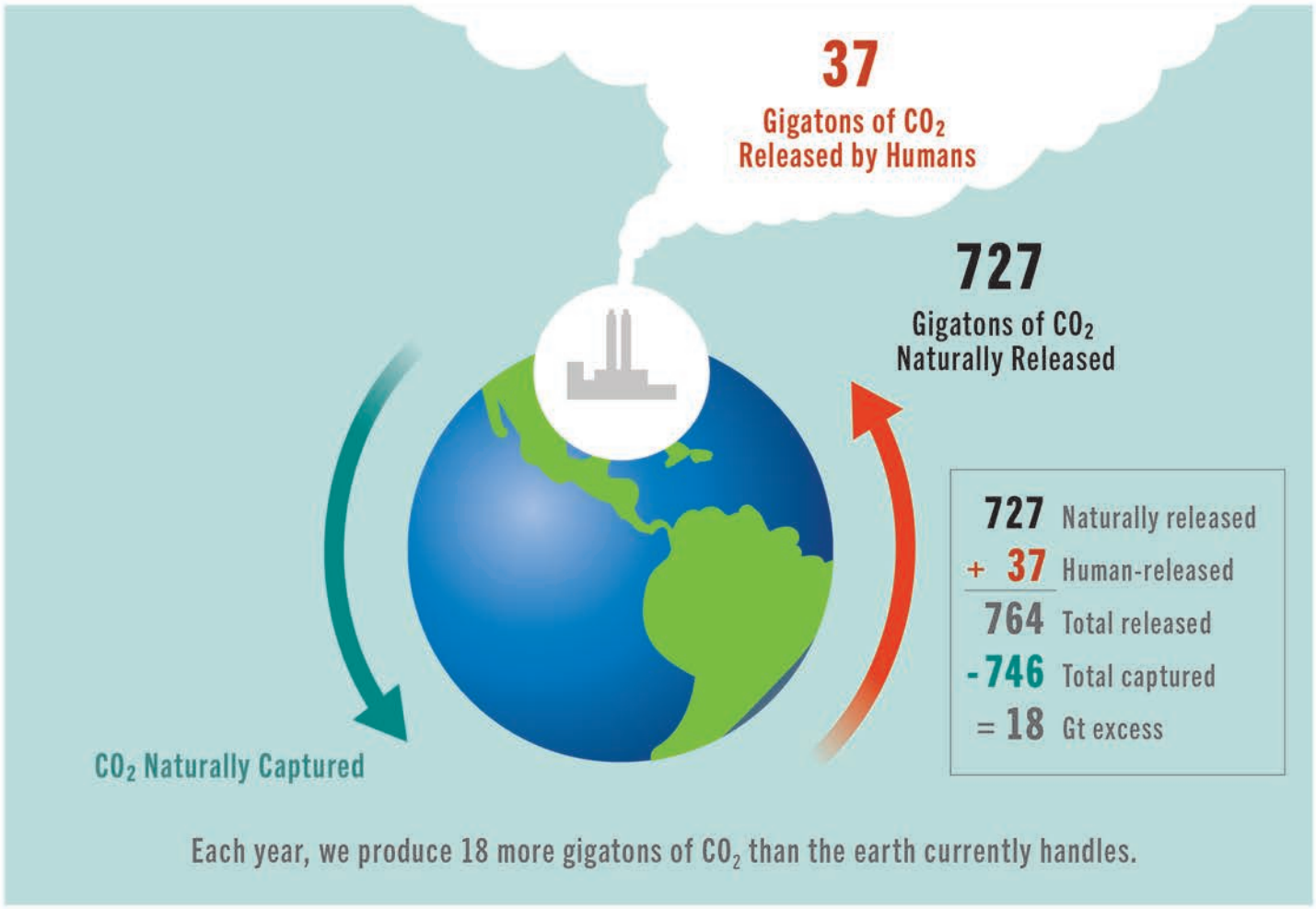
A GLOBAL IMPACT

Our solution to climate change has been hiding in plain sight: the plants that surround us.

Based on existing research and our own analysis, we believe that a plant-based approach to climate change has the potential to achieve a 20-46 percent reduction in the excess CO_2 emissions produced each year by human activity.

To understand the power and feasibility of our approach, one must consider the global carbon cycle. Each year, 746 billion tons (Gt) of CO_2 are captured and 764 Gt of CO_2 are released, resulting in a net excess of 18 Gt. While reducing this number by ~50 percent may seem daunting, 9 Gt is only a small fraction of the total CO_2 naturally captured each year. Furthermore, plants are major drivers of this natural carbon cycle; they "breathe" in CO_2—converting it into carbon-based plant biomass—and "exhale" oxygen. Simply put, if we can even slightly improve the natural ability of plants to do this, we can have a significant global impact.

The Harnessing Plants Initiative aims to use a combination of strategies to coach plants to function at the level of Olympic athletes and increase their carbon-storing potential. These plants would be able to sequester significantly greater amounts of carbon than they do now and bury it in the ground for hundreds of years.



SALK'S CORE IDEA: USING PLANTS TO OUR ADVANTAGE

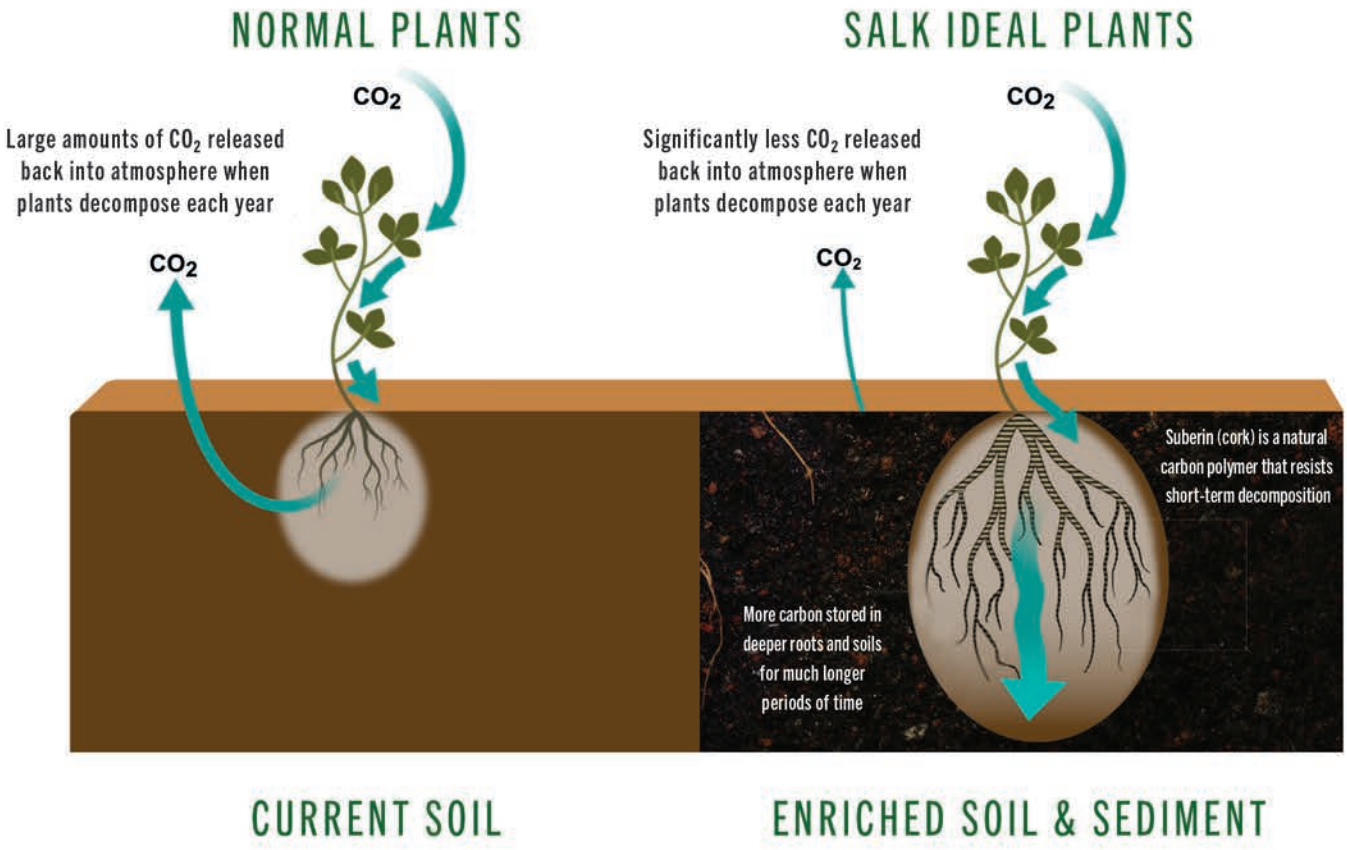
Salk's solution is based on the natural ability of plants to breathe in CO_2 and deposit large amounts of carbon in soils via root systems composed of stable plant polymers. One of these is called suberin, which is an essential, naturally occurring, carbon-rich substance commonly seen in cork, cantaloupe rinds and potato skins. What is suberin's answer to climate change and food security? It resists decomposition, enriches soil, and helps plants resist stress. By dramatically increasing suberin production in roots, plants will stably store large quantities of carbon underground, revitalize soils and protect plants from disease, droughts and floods.

We will develop these Salk Ideal Plants™ by influencing the genes that control root size, root suberin and other root polymers. One benefit of our approach is that we will not be limited to a single species of plant; rather our genetic toolkit can be deployed in many different plants to generate a cadre of Salk Ideal Plants with improved CO_2 drawdown capabilities and the resilience to grow in stressful environments.

Seeds from Salk Ideal Plants can be planted across the globe on the same lands that currently grow crops; they will not require any special technologies to plant, maintain or harvest. Salk will collaborate and partner with NGOs and agribusinesses worldwide to produce, market and distribute the seeds from Salk Ideal Plants at scale.

Salk's Ideal Plants will:

- **Have deeper, bigger and more robust root systems** where plants will store significantly more carbon coming from CO_2 as biomass.
- **Possess suberin-rich roots that stockpile carbon in forms that naturally resist decomposition** to slow the re-release of CO_2 back into the atmosphere.
- **Make soils more productive by restoring lost soil carbon, which is key to soil health.**



SALK IDEAL PLANTS

Developing Salk Ideal Plants is the critical first step in the Salk Harnessing Plants Initiative. At the highest level, this involves identifying and modifying genetic pathways to amplify root systems and suberin production. Once these pathways are identified, we will begin transferring the ideal traits to nine crops—six of the most important row crops (corn, soybeans, rice, wheat, cotton/cottonseed and rapeseed/canola) and three cover crops (radish, crimson clover and annual rye grass).

As detailed below, this will be a highly iterative process. With adequate resources, we will have prototypes of these crops within five years.

The Harnessing Plants Initiative action plan to combat climate change

1. **Enhancing root systems**
   We are selecting genes that confer deep rooting and high root mass without adversely affecting crop yield. Through genetic screening, we will identify and control these genes in our model species and select crops.

2. **Enhancing suberin production**
   Increasing suberin production to achieve a meaningful impact on carbon sequestration requires us to identify and control specific genetic machinery. We are identifying the master regulators of genes for suberin biosynthesis and assembly.

3. **Understanding suberin's carbon-storage capabilities**
   We are assessing different forms of suberin and developing quantitative models to better understand exactly how much extra carbon Salk Ideal Plants can store, and for how long.

4. **Stacking and transferring genetic traits**
   Once we have identified genes that confer deep, robust rooting and high suberin content in model plants, we will use two parallel approaches to transfer these traits into our target crops. First, we will combine root and suberin traits into portable gene stacks and transfer them into crops. Second, we will use genome editing to accelerate trait adoption—which has traditionally taken centuries or millennia—and create Salk Ideal Plants crop strains.

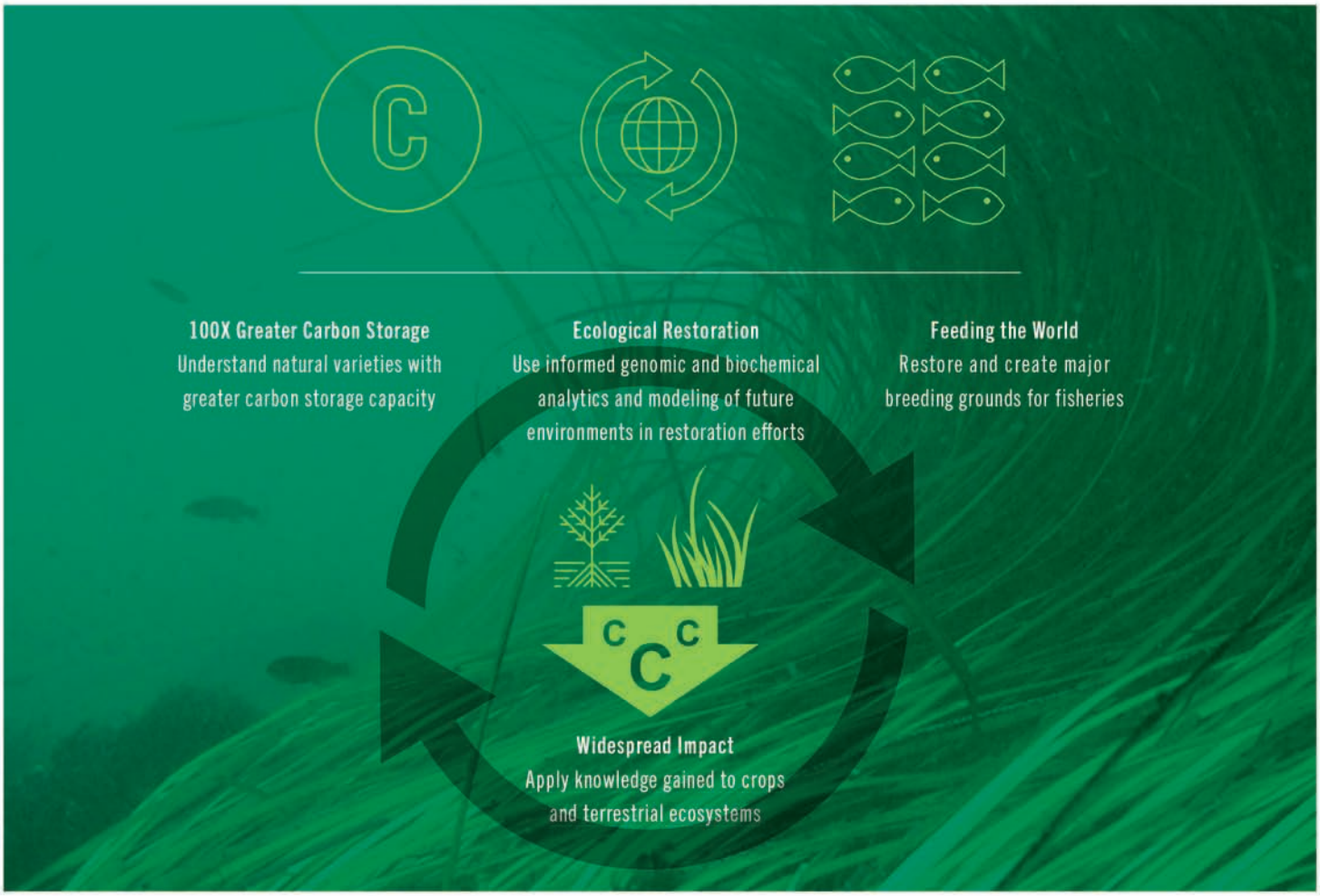
5. **Developing supplemental tools**
   We are identifying chemicals and microbial strains to augment our increases to root mass and suberin content. These tools already exist for enhancing roots, and we will develop methods to measure and quantify the decomposition rates of suberin in many root samples. Salk's computational scientists will use the data to generate predictive models of suberin's behavior in widely varying environments.

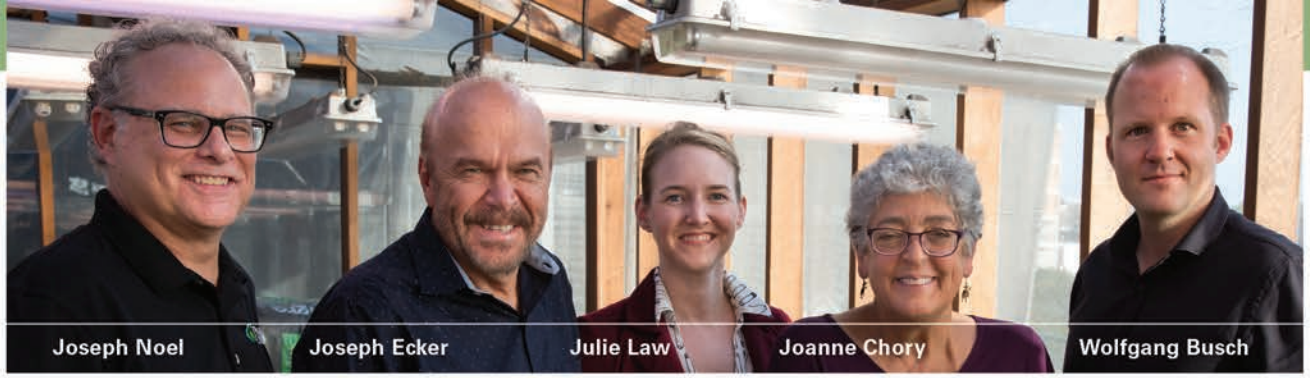
6. **Field testing and improvements**
   Once we have the first prototype Salk Ideal Plants, we will test them across a range of real-world topographies, climates, soils and other relevant environmental conditions. We will incorporate that feedback into our ongoing development and refinement of Salk Ideal Plants.

AN AQUATIC ALLY

Earth possesses another enormous natural carbon sink—aquatic environments. Our oceans, rivers and wetlands have the capacity to store upwards of 100 times more carbon per unit of area than equivalent terrestrial ecosystems. Unfortunately, due to human impact and climate change, these aquatic plant systems have been decimated and those that remain are declining more rapidly than ever. Because these plants are similar to land plants, we can use our knowledge and our Salk Ideal Plants genetic toolbox to reverse their decline, restore their habitats and tap into their potential for storing more carbon from the atmosphere. We will:

1. Use genetically informed restoration to naturally rebuild these severely degraded ecosystems that are the foundations of all fisheries.
2. Unravel the genetic components used by these systems to sequester carbon in amounts greater than equivalent terrestrial systems to further enhance the capacity of crop plants to store carbon.





OUR PEOPLE: The top plant biology team in the world

The Harnessing Plant Initiative builds on the recent revolution in genomic and genetic plant biology, and on 30 years of molecular plant genetics. We now know the biological mechanisms of how plants grow, and understand the biochemical mechanisms of how plants convert CO_2 into recalcitrant carbon-based molecules. What used to take thousands of years of breeding can now be done in just a few years with new genetic techniques. The Salk team is at the cutting edge of these advances and has all the sophisticated multidisciplinary expertise required for success. **Its position at the forefront of plant biology is illustrated by its ranking as the number one plant biology program by Thomson Reuters.***

Joanne Chory, PhD: Chory, professor and director of Salk's Plant Molecular and Cellular Biology Laboratory, is known for her decades of research on the genetic pathways through which plants can adapt to changing environments. Chory, who won a 2018 Breakthrough Prize for her work, is leading the team and is responsible for the group's efforts to understand the genetic pathways through which plants grow and adapt. **Key discovery:** Chory pioneered the use of molecular genetics and natural variation to study how plants respond to their environment.

Joseph Noel, PhD: Director of the Jack H. Skirball Center for Chemical Biology and Proteomics, Noel is leading the group's biochemistry work to better understand key features of suberin. **Key discovery:** Noel and his team discovered the key to mass producing terpenoids, highly beneficial compounds used in everything from fragrances and flavorings to biofuels and pharmaceuticals.

Wolfgang Busch, PhD: An associate professor in the Plant Molecular and Cellular Biology Laboratory, Busch is leading the work to enhance plant roots, bringing extensive experience in root biology to the project. **Key discovery:** Busch developed novel methods to understand how plant root growth is determined.

Julie Law, PhD: An associate professor in the Plant Molecular and Cellular Biology Laboratory, Law is leading efforts to regulate genes that control suberin production. **Key discovery:** Law identified mechanisms controlling the targeting and modulation of DNA methylation in *Arabidopsis*.

Joseph Ecker, PhD: The Salk International Council Chair in Genetics and director of the Genomic Analysis Lab, Ecker is a world leader in genomics and epigenomics. **Key discovery:** Ecker sequenced the first plant genome as part of a multinational effort.

At Salk, we know what to do and how to do it, but we need the philanthropic resources to get it done. And our costs will be far lower than the current alternatives. Once Salk Ideal Plant row and cover crops are fully developed and planted at scale, we could achieve global impact within fifteen years—just in time to avert the predicted climate change crisis from which there may be no return.

salk
Where cures begin.

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JOIN US

Your tax-deductible support helps Salk scientists better understand plants deep down—from their root systems to their epigenomes.

To learn more about Salk's **Harnessing Plants Initiative** or to donate now, contact Brent Wakefield, senior director of External Relations, at **(858) 453-4100 x1556** or **bwakefield@salk.edu**.