salk®
HARNESSING PLANTS INITIATIVE

HARNESSING PLANTS BI-ANNUAL IMPACT REPORT

JANUARY 1, 2025 TO JUNE 30, 2025

We appreciate your generosity and commitment to the Salk Institute.

Private philanthropy supports research that directly addresses pressing global challenges. Your contributions are essential to the Institute and its extraordinary scientists.

FOREWORD

The Harnessing Plants Initiative (HPI) is a scientific research program launched in 2017 at the Salk Institute for Biological Studies. Its goal is to develop crop and wetland plants that can store carbon more efficiently and for longer duration to reduce atmospheric CO_2 and mitigate climate change. Since the date of the funding announcement from The Audacious Project (housed at TED) in April 2019, HPI research has developed two tracks.

The first track is funded by The Audacious Project and is known as the CRoPS (CO_2 Removal on a Planetary Scale) program. CRoPS research is addressing climate change by enhancing the natural capacity of Earth's major crop plants to incorporate atmospheric carbon into stable, carbon-rich polymers, which would bury that carbon deep in the soil. These Salk Ideal Plants® are expected to improve soil quality, thereby boosting plant yield and increasing the sustainability of the world's food supply.

A second track, known as CPR (Coastal Plant Restoration), entails enabling genetically informed preservation, restoration, and expansion of the world's coastal and inland wetlands, which serve as significant long-term carbon sinks. Moreover, many of these plants have evolved root systems already enriched in stable biopolymers, like suberin, as a protective mechanism for surviving in water saturated environments. Their genomes will likely provide additional genes and mechanisms for enriching crop plants with suberin.

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LETTER FROM SALK PRESIDENT

Dear Supporters,

At the Salk Institute, we believe bold science is the surest path to addressing the global challenges of our time. Nowhere is this more evident than in our Harnessing Plants Initiative (HPI), where researchers are reimagining the role of plant science and agriculture in the fight against climate change.

Thanks to our depth of foundational research, unparalleled vision, and pioneering role in this field, HPI remains at the forefront of plant-based carbon removal. The crops we are developing will store more carbon for longer while simultaneously improving soil health and showing greater resilience against drought and disease. We are now focused on accelerating and scaling our program to ensure the world sees these meaningful climate benefits in time.

The scientific achievements described in this report are not only extraordinary—they are urgently needed. Today, there is no federal funding stream to support climate research of this kind. While public investment falters, the window to act grows smaller. In this moment, climate solutions are driven by the support of a few visionary leaders. To put it simply, philanthropy is indispensable.

Thanks to your generosity, the Harnessing Plants Initiative has advanced a scalable, sustainable, and affordable solution at a pace unmatched by any other approach. With your continued support, our research can take root in the real world.

The challenge before us is clear: if we are to bend the curve of climate change, we must continue to push discovery into delivery. That is why your partnership matters so profoundly. Together, we can ensure that the groundbreaking science of Salk Ideal Plants® reaches fields and farms around the world—providing food security and a safer climate to current and future generations.

With gratitude,

Gerald Joyce
President, Salk Institute for Biological Studies

MESSAGE FROM THE DIRECTOR

Dear Supporters,

This November will mark one year since the passing of our founding director, Joanne Chory. She was a brilliant, kind, and generous leader, with an extraordinary vision for a world where plants help solve our greatest challenges. We miss her deeply, but we know she would be proud of how far we have come in the period you will read about in this report.

At Climate Week NYC 2025, I witnessed again what Joanne always knew: the demand for our work has never been greater and will only continue to grow. Accessible, scalable, and sustainable carbon capture technology is urgently needed to achieve the CO_2 reductions necessary to combat climate change. This is especially true in the face of substantial headwinds for both climate mitigation and public science funding.

In just six years, HPI has become one of the world's leading projects in carbon sequestration research and the premier plant-based program. Recent modeling shows that Salk Ideal Plant® technology is projected to outperform any other proposed approach in both speed and effectiveness—reinforcing our confidence that this strategy can make a decisive difference.

We are proud to share some of our recent successes in this report, made possible by your support. In 2025, we surpassed our original gene discovery goal by a wide margin, identifying more than 350 promising genetic candidates that can enhance root depth, root mass, and suberin content—three critical traits for long-term carbon storage. For the first time, these traits have been successfully stacked into single plant lines, marking a breakthrough in the development of Salk Ideal Plants that can simultaneously deliver multiple climate and agricultural benefits. Genetically enhanced versions of all five target crops—rice, canola, pennycress, soybean, and sorghum—are now in development, with several advancing to our first large-scale field trials. These tests, in combination with our new soil studies, are demonstrating the strong link between enhanced root traits and greater permanence of soil carbon storage, validating our strategy in preparation for commercialization.

Our next steps are ambitious and transformative. We are moving from pioneering discovery to accelerated innovation and delivery. Powered by RootGPT, our open-access AI-engine for trait discovery, and a refined pipeline for rapid Design–Build–Test–Learn cycles, we will cut years off our crop development timelines. Together with our spin-out company, Cquesta, and other partners, we are creating commercial pathways to deploy Salk Ideal Plants worldwide. Within this decade, farmers could grow crops that not only provide sustainable food supplies but also remove carbon at a scale that changes the climate equation.

HPI is making a significant impact on the future of our planet, but we cannot do this alone. As a nonprofit initiative experiencing a major funding transition, we need your support to continue this work. Please reach out and join us in shaping a future where agriculture drives climate solutions at a global scale.

Warmly,

Wolfgang Busch
Executive Director, Harnessing Plants Initiative

EXECUTIVE SUMMARY

General progress to date on the project's "Goals, Objectives & Milestones"

The overall objective of the Harnessing Plants Initiative (HPI) is to develop enhanced crop and wetland plants that will sequester more carbon and store it in the soil longer to reduce atmospheric CO_2 levels and mitigate climate change. This is the final update in this report series to be followed by a cumulative report on progress across the grant period. Thanks to TED funders, HPI has achieved the majority of its goals ahead of schedule, with the remaining goals on track to be accomplished in the coming years. The work of the Initiative will continue beyond June 2025, as current and future funding permits.

There are seven goals of the Initiative aligned with this specific grant:

Goal 1: Identify 50 gene candidates per trait by 2025.
Status: Goal achieved.

The goal has been met across the target traits (Table 1), with results surpassing expectations: we have now exceeded the original benchmark by 200 gene candidates. In the past six months, two additional genes have advanced into crop translation, with more expected as the Initiative progresses through 2025.

TRAIT	TOTAL CANDIDATES	IN TRANSLATION	DEPRIORITIZED
Deep Roots	205	7	52
More Roots	88	15	24
More Suberin	57	2	7
Total	**350**	**24**	**83**

Table 1. Status of gene candidates within the Harnessing Plants Initiative.

Goal 2: Stack different traits in model plants.
Status: Goal achieved.

Combining multiple traits—deep roots, increased root mass, and higher suberin content—into a single *Arabidopsis thaliana* (thale cress, referred to here as the model organism *A. thaliana*) line is a complex undertaking. In the first half of 2025, significant progress was made in developing and evaluating methods to integrate gene edits across traits, resulting in the first lines containing edits for multiple traits. This is discussed more in the "Crop Translation" section of the report on page 20.

Goal 3: Create genetically altered crop lines for rice, canola, and pennycress in 2023 and for soybean and sorghum in 2024.
Status: Goal achieved.

Genetically altered versions of all the target crops have been created, and work is ongoing to develop additional engineered varieties. So far in 2025, two additional genes have been moved into this phase of testing. Table 2 below shows the most advanced versions for each gene and crop combination.

TRAIT	GENE	PENNYCRESS	CANOLA	RICE	SOYBEAN	SORGHUM
Deep Roots	**EXOa**	Complete*				
Deep Roots	**"REEL"**	Validation**	Validation*	In progress	Validation**	In progress
Deep Roots	**"SCAR"a**			Validation		
Deep Roots	**"SCAR"b**			Validation		
Deep Roots	**SDHa**	Design		Design		In progress*
Deep Roots	**MADSa**	Design				Design
Deep Roots	**OREa**	Design				Design
More Roots	**IPTa**	In progress	Complete*	In progress	Complete*	
More Roots	**"CRBX"**		In progress	In progress	In progress	
More Roots	**miRa**				In progress	
More Roots	**GDSLa-f**	Validation**		In progress		
More Roots	**PINa**	In progress				
More Roots	**BUBa**	In progress	In progress			
More Roots	**RLUAa**	In progress		In progress*		Design*
More Roots	**SAMa**	In progress		In progress*		Design*
More Suberin	**MYBa**	Validation	Validation*			
More Suberin	**WRKYa**	Validation	Validation			

Table 2. Genes in translation, through transgenic or CRISPR approaches. Projects in the "design" stage are being planned and prepared for transformation; "in progress" indicates that once transformed, the lines move through multiple generations until stable lines are reached, then go through "validation", or final testing to confirm the desired results.* Indicates new projects or milestones achieved since the previous report. ** Indicates parallel preliminary field validation, the majority in close collaboration with Cquesta. All gene names have been anonymized—see note at end of report.

Goal 4: Obtain proof of concept field results from breeding-improved lines or existing germplasm for sorghum in 2024 and for wheat in 2025.

Status: On track.

Field work is the most time-intensive component of the Harnessing Plants Initiative. Because crops are seasonal, only one field trial can be conducted at a given location each year, and fully evaluating crop performance typically requires multi-year studies. As of June 2025, all sorghum and wheat trials assessing biodiversity and gene discovery have been completed, with final data analysis now in progress.

Goal 5: Better understand soil carbon accumulation rates and permanence due to Salk Ideal Plants, including assessing different forms of suberin.
Status: In progress.

Soil-associated carbon is especially valuable because it can remain stored for decades to centuries. However, the transition from root-associated carbon to soil-associated carbon is complex, and understanding this process requires multi-year experiments. These are underway across several plant species in the lab, greenhouse, and field. These studies focus on how plant traits and decomposition rates influence the conversion of root carbon into more stable soil carbon.

Notably, one completed study has already confirmed that higher suberin levels lead to greater soil carbon permanence, regardless of soil type.

In 2024, a new multiyear study was launched to provide the first proof of concept for how engineered plants can enhance soil carbon storage. This study uses mesocosms—large containers that mimic natural field conditions—along with isotope labeling and decomposition tracking to test and measure how Salk Ideal *A. thaliana* lines accumulate and stabilize additional carbon in soil. It will conclude in 2026, with the first rounds of samples already collected and undergoing analysis.

Goal 6:Identify chemicals and microbial strains to augment increases in root biomass and suberin content.
Status: Amended; goal achieved.

Please see adjustment question for additional information and updates on progress.

Goal 7: Conduct field testing of improved lines in real world topographies, climates, soils, and other relevant environmental conditions.
Status: On track.

Several small-scale field trials were completed in early 2025, which helped establish the necessary infrastructure and workflow for future trials. A larger field trial with an academic partner was launched during the summer of 2025, and several other trials with a commercial partner are planned for the fall. These new trials will be focused on confirming the persistence of the desired traits and identifying any beneficial agronomic changes in the engineered lines.

Significant Successes
We have also had several significant successes over the last six months of the TED Audacious funding that go beyond our initial seven goals.

- Bloom and RootGPT: HPI has produced the most comprehensive collection of plant genome sequences, powerfully paired with additional molecular and phenotypic information. We have made significant headway on organizing this Initiative-wide data into a central repository called Bloom. This includes single-cell data, which allows scientists to understand gene expression within individual cell types across various root tissues. This database allows all scientists to access and manipulate the data without needing in-depth training. It also enables the development of our next innovation: RootGPT. This custom AI engine will help us analyze this massive dataset to quickly identify the optimal genetic candidates to enhance carbon sequestration in each crop species and climate, rapidly accelerating our path to market.

- Five Salk Ideal crop lines: The first cohort of translated genes has made it to final experiments within the Initiative, with great success. With stringent testing for agronomic penalties and root phenotypes, five lines have now reached a point of either commercial handoff or additional field trialing.

Significant Challenges

Now in the final year of our TED Audacious funding, the Harnessing Plants Initiative is facing external challenges. Changes in federal funding policies have had a significant impact on all involved in the climate space. The impact that these changes will have on the Initiative remains unknown.

Amended Goal 6: Expand to include the study of microorganisms, namely fungi, for further enhancing root carbon sequestration.

The previous repositioning regarding Goal 6 led to the launch of a new HPI laboratory at Salk in 2024. The Mueller lab studies the molecular mechanisms of plant-fungal symbiosis. The team is identifying strategies to enhance plant control over fungal root colonization and plant-fungus crosstalk. These processes represent excellent targets for improving plant nutrient uptake and underground carbon sequestration. This new line of research is intended to produce a fourth Salk Ideal trait: enhanced root-microbe interactions.

Brief Risks Overview & Mitigation Strategy

Our major risks remain unchanged from the previous reports. The second risk—funding—has grown larger due to the recent actions taken by the federal government to eliminate research funding associated with climate change.

- Soil carbon quantification: Understanding what percentage of carbon being stored in the soil can be attributed to Salk Ideal Plants is challenging, as soils vary widely in composition and behavior, and already have organic carbon present in multiple forms. To accurately assess carbon accumulation in soils, Salk Ideal Plants must be grown in partially controlled conditions, in specific soil types. Carbon isotope labeling of plants has also been discussed as a preferred method to better identify and attribute carbon to Salk Ideal Plants. The last year focused on addressing this risk, and a portfolio of long-term experiments is now underway to quantify both baseline and Salk Ideal Plant carbon accumulation and permanence in the soil.

- Funding: The greatest risk to our goal of removing gigatons of carbon dioxide from the atmosphere is a lack of funding. The Harnessing Plants Initiative has been fortunate to receive grants from donors who recognize the vision of the program and understand the major role that carbon capture plays in climate change mitigation. As several of our major grants reach the end of their five-year period, HPI is actively engaged in fundraising to secure the future of the Initiative. Over the past five years, we have met or exceeded the majority of our goals, with final goals well on track. We believe that our accomplishments, made possible through the generous support of philanthropic donors, speak for themselves. Salk Ideal Plants are the most feasible and effective carbon removal technology, and are positioned to be a significant contributor to climate change mitigation. Looking ahead, we are actively fundraising for our next round of discovery and deployment, and have included a subset of our 2030 milestones below.

PHASE I MILESTONES (2025)	PHASE II MILESTONES (2030)	QUANTIFIED GOALS (2030)
Develop genomic and phenomic platforms to sequence and compare the genomes of model and target crop plants and their Salk Ideal Plant traits.	"RootGPT": Use AI to analyze sequencing and trait data and develop carbon sequestration enhancements using CRISPR/Cas9-based genetic and synthetic biology interventions.	Generate cell-resolution functional genomics maps and AI training sets for each crop. Reach 80% accuracy in AI-predicted genetic interventions for Salk Ideal Plant trait outcomes across three species.
Discover carbon sequestration-enhancing genes.	Continue discovery of carbon sequestration enhancing genes, including root architecture, root exudates (fluids or secretions released by plants), beneficial microbes, and biochemical pathways.	Identify 100 new gene candidates for Salk Ideal Plant traits to sequester 1 ton CO_2/acre.
Stack carbon sequestration traits to maximize impact.	Stack different traits in model plants and crops to produce additive or multiplicative carbon sequestration capacity.	Stack traits in three species, doubling biomass with 2x root suberin increase below 30 centimeters of soil.
Generate proof-of-concept genetically enhanced crops.	Conduct comprehensive field testing of our proof-of-concept genetically enhanced crops in relevant environments, climates, and soils.	Implement proof of concept at scale of 1 ton CO_2/acre sequestration for three crop species in three relevant soil types.
Evaluate root carbon sequestration across lab, greenhouse, and field studies.	Build models for soil carbon sequestration across species and environments.	Create carbon sequestration models that predict impact of Salk Ideal Plant traits with 80% accuracy from the lab and greenhouse to the field.