The power to...
Optimize plants to help save the planet

In the face of a crisis, we can’t simply maintain the status quo—Salk scientists are taking steps to build resiliency and mitigate climate change now.

The challenge
Global climate change is here. Each day, new headlines describe record-high temperatures, melting ice caps, coastal flooding, brush fires and persistent droughts. And as temperatures rise, crops fail and malaria, dengue fever and other diseases spread to new locations. Climate change is a dozen different crises all rolled into one.

Approximately two-thirds of the total energy imbalance that is causing Earth’s temperature to rise is due to increases in carbon dioxide in our atmosphere, says the US National Oceanic and Atmospheric Administration.

The planet absorbs around 746 gigatons of carbon dioxide each year through photosynthesis and other mechanisms (one gigaton is 2 trillion pounds). Much of that carbon is pushed back into the atmosphere when plants die or shed their leaves each fall. This natural cycle has been thrown out of balance by human activity that currently releases 18 gigatons more carbon than the planet can absorb.

We must find ways to adapt to a warming planet. At the same time, we must take steps to reduce the amount of carbon in our atmosphere and mitigate the effects of climate change.

The Salk approach
Salk scientists have never been content to simply keep doing things the way they’ve always been done. While some researchers are focused on preserving habitats, plants and animals as they exist today—a noble cause, to be sure—we believe that won’t be enough to ensure survival in this century and beyond.

That’s why scientists in our Harnessing Plants Initiative are developing Salk Ideal Plants®, a new generation of food crops that are better equipped to survive—and even thrive—in hotter, drier, less-than-hospitable environments.

Salk Ideal Plants are also being engineered to sequester excess carbon from the atmosphere. The key is longer, deeper roots and molecules such as suberin, a carbon-rich polymer found in cork, avocado skins and plant roots. Because suberin is mostly carbon and is more resistant to decomposition than most plant material, it is very good at capturing and storing carbon from the atmosphere—and thus has great potential to help stabilize our climate.

See the Salk approach at work
Investigating how plants grow and thrive is a lot like studying neurology, metabolism, immunity or any other networked system: many components contribute to the system’s ultimate function.

This gives Salk a tremendous advantage.

In our Harnessing Plants Initiative, experts bring deep knowledge in genetics, genomics, epigenomics, plant biology, computational biology and many other disciplines. They leverage Salk’s greenhouse facilities to interrogate specific plant genes and study the traits they produce. They can reproduce the climate of almost any location on Earth in climate-simulation chambers. They use X-rays, machine learning and other tools to measure root growth and suberin content.

Together, this team provides an interdisciplinary framework to assess how plants operate and to reprogram them with two goals: to withstand and restore Earth’s climate.

Optimizing plants to thrive in harsh conditions. For more than 30 years, Professor Joanne Chory, founding director of the Harnessing Plants Initiative, has studied Arabidopsis thaliana, a small flowering mustard plant, to understand plant growth and adaptation. She pioneered the use of genetics to study how plants alter their sizes, shapes and forms to optimize growth and maximize photosynthesis. Her work has illuminated the complex signaling networks that control plant growth and development.

Chory, Professor Joseph Ecker and team recently showed that shade from close-growing neighbors causes plants to grow taller. The study looked at the role of proteins called transcription factors in activating this growth response. Transcription factors are proteins that turn genes on or off by binding to DNA.
The team worked with mutant Arabidopsis seedlings that lacked transcription factors called PIFs. When the team grew these plants in simulated shade, the plants without certain PIFs did not elongate or speed up their growth, suggesting that those PIFs are necessary for rapid growth. Further experiments showed that within five minutes of shade onset, one particular PIF gets activated and removes a molecular brake sitting on growth genes. With the brake lifted, shaded plants are free to shoot up. Chory and Professor Wolfgang Busch also identified PIFs that help regulate root growth in response to temperatures.

In addition, Associate Professor Julie Law recently discovered the genes that are turned on or off, and in which order, to orchestrate the cellular processes required to protect and repair plant genomes in response to DNA damage—something that happens more frequently in stressful environments.

These findings provide examples of how plants respond to subtle environmental changes on a molecular level, as will increasingly occur as plants adapt to global climate changes. Studies such as these also open new avenues for scientists to optimize plants to grow in less-than-ideal lands (including shady areas) and withstand heat waves, droughts, floods and pests.

**Engineering deeper, carbon-capturing roots.** The Harnessing Plants Initiative comprises two projects aimed at enhancing carbon sequestration:

1. CO₂ Removal on a Planetary Scale (CRoPS) scientists are developing Salk Ideal Plants, which can capture carbon in their roots and keep it underground for a longer time. In a landmark advance, Busch and team identified a gene that can lead to deeper rooting. Researchers are now using this information to transform wheat, rice, corn, sorghum and other crops into carbon-storing vehicles. As an added bonus, more carbon in the ground will improve soil health, benefiting farmers.

2. Coastal Plant Restoration (CPR) scientists are identifying wetland plants that retain carbon, purify water, preserve land and thrive in challenging environments around the world. Wetlands store as much as 100 times more carbon per acre than dry land, but they’re disappearing fast. We want to play a major role in restoring them.

In both projects, Salk experts are combining genetics, epigenetics, computational biology and other disciplines to understand how a plant’s genes determine root growth and suberin content in various environments.

When these scientists find they need technology that doesn’t yet exist, they often build it themselves. Harnessing Plants Initiative researchers are developing new gene editing and other tools to precisely manipulate plant traits. They have even custom-built a seed-planting robot that can accomplish in one day what would take a human five weeks.

Through these and other efforts, we plan to develop and disseminate Salk Ideal Plants in just a few years.

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**Why Salk**

For more than 60 years, the Salk Institute has pursued Jonas Salk’s vision of fearless, interdisciplinary science tackling some of the biggest challenges facing humankind.

**Some of our past plant biology breakthroughs include the following:**

1987 – Chris Lamb and colleagues showed that different plant defense genes activate by various forms of stress.

2003 – Joseph Ecker and colleagues created a vast collection of mutant plant cell lines, known as T-DNA insertion lines, that can be used to locate and identify genes in plant genomes. These insertions are now known around the world as “Salk lines” and can be ordered from a Salk website. To date, the database has been accessed more than 11 million times, typically 4,000 times per month.

Now, climate change may be the most significant challenge Salk scientists have ever tackled, and we are committed to giving it our all. For years we have been augmenting our teams, adding new technologies, and partnering with groups around the world to accelerate and scale-up efforts to mitigate climate change—rapidly moving our discoveries from lab to greenhouse to farm.

**Why now**

In 2019 the Salk Institute launched the Campaign for Discovery—a seven-year, $750 million effort to accelerate Salk’s critical research.

The Campaign is focused on driving discoveries in six Centers of Excellence: Cancer Center, Center for Healthy Aging, Hess Center for Plant Science, Center for Neuroscience, NOMIS Center for Immunobiology and Microbial Pathogenesis, and Crick-Jacobs Center for Theoretical and Computational Biology.

To continue to lead the field in these areas, Salk is recruiting new faculty and other experts, investing in new technologies, and creating new collaborative spaces, including construction of the Joan and Irwin Jacobs Science and Technology Center.

As it has always been at Salk, there will be no barriers between disciplines. New ideas from multiple areas can mix and flourish, generating the most innovative, multipronged approaches to preparing for and mitigating climate change.

**Join us**

Science is a collaborative pursuit, and we invite you to join us in accelerating life-changing discoveries: [www.salk.edu/campaign](http://www.salk.edu/campaign).