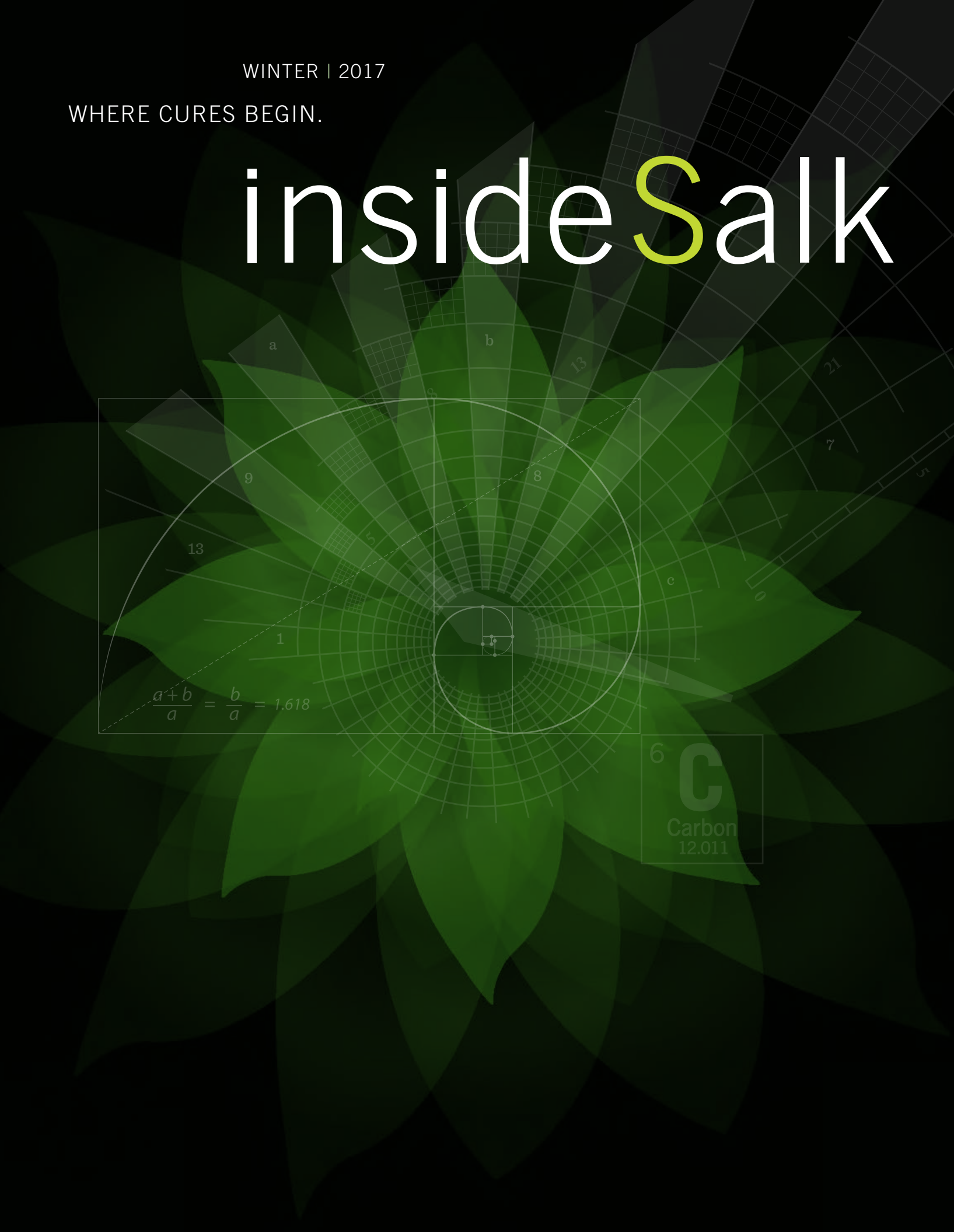
WINTER | 2017

WHERE CURES BEGIN.

insideSalk



CONTENTS

ON THE COVER:

Salk's **Harnessing Plants Initiative** takes a deeper look at developing "ideal plants" that help tackle increased challenges caused by human emissions of carbon dioxide, declining agricultural yields, and collapsing ecosystems.

PRESIDENT'S LETTER

Dear Friends,

I've been perusing a book authored by Jonas Salk more than 35 years ago (and currently being reprinted by his son Jonathan). I find myself impressed by our founder's foresight. Developing his arguments through an extensive series of graphs and visual concepts, Jonas points to "the danger of self-extinction" if humanity doesn't attend to the rapidly worsening problems of our planet. He proposes cross-disciplinary and collaborative scientific expertise as the solution:

> *"...there is a need for consideration of details in the continuum from the molecular level to the ecological. An approach to human problems now requires attention and understanding of not just one, but all levels, and solutions will require knowledge in all realms."*

The Salk Institute is answering Jonas' clarion call. Our scientists often join their expertise across this continuum in exciting ways. Such expertise ranges from human language and behavior to cellular control pathways and gene expression, with the goal of understanding our ability to be social, idea-expressing beings. Salk scientists are addressing other current challenges through a number of new science initiatives, one being Salk's Harnessing Plants Initiative. In this issue you'll learn how our world-renowned plant biologists are devising very promising strategies for combatting global warming and the related climate changes that threaten our food sources.

Salk's visionary supporters are also stepping to the fore, none more readily than Carol and Larry Greenfield. You'll read about how their consistent philanthropic efforts are already making a positive impact.

In our Observations feature, you'll get to know Assistant Professor Sung Han, who's developing critical insight into the brain's alarm system. And in our NextGen section, you'll meet multicultural dynamo Elena Blanco-Suárez. A Helmsley Postdoctoral Fellow in Nicola Allen's Molecular Neurobiology lab, she's illuminating the roles astrocytes perform in regulating brain function.

Looking ahead to a new year and all the promise it holds, we're thrilled to welcome two new members to our faculty: Susan Kaech and Gerald Shadel. Sue, an expert in immunology, will serve as director of the Nomis Center for Immunobiology and Microbial Pathogenesis. Gerry will join our Molecular and Cell Biology Laboratory, where he will continue his pioneering work on the surprisingly diverse roles that mitochondria (the cell's energy powerhouses) play in aging.

As this is our annual donor honor roll issue, allow me to thank the many, many generous supporters who understand that they have the power to help create a better future for all of humanity. As Jonas wrote, solutions arise "through the creativity, initiative, and shared responsibility of individuals." I salute you.

Sincerely,

Elizabeth Blackburn
President, Salk Institute
Irwin M. Jacobs Presidential Chair

"Our scientists often join their expertise across this continuum in exciting ways. Such expertise ranges from human language and behavior to cellular control pathways and gene expression, with the goal of understanding our ability to be social, idea-expressing beings."

STORE AND

The science of DNA organization and repair

NATURE
08/2017

Early gene-editing success holds promise for preventing inherited diseases

Professor Juan Carlos Izpisua Belmonte, co–first author Jun Wu and collaborators have corrected a disease-causing mutation in early stage human embryos. The technique, which uses the CRISPR-Cas9 system, corrected the mutation for a common heart condition called hypertrophic cardiomyopathy at the earliest stage of embryonic development so that the defect would not be passed on to future generations. The scientists were surprised by just how safe and efficient the method was. Not only did a high percentage of embryonic cells get repaired, but also gene correction didn't induce any detectable off-target mutations and genome instability—major concerns for gene editing. In addition, the researchers developed a robust strategy to ensure the repair occurred consistently in all the cells of the embryo.

WATCH | bit.ly/belmonte201712

U.S. News & World Report

The New York Times

NATURE
09/2017

The right way to repair DNA

Is it better to do a task quickly and make mistakes, or to do it slowly but perfectly? When it comes to deciding how to fix breaks in DNA, cells face the same choice between two major repair pathways. The decision matters, because the wrong choice could cause even more DNA damage and lead to cancer. Professor Jan Karlseder and first author Nausica Arnoult found that a tiny protein called CYREN helps cells choose the right pathway at the right time, clarifying a longstanding mystery about DNA repair and offering researchers a powerful tool that could guide better treatments for cancer.

RESTORE

SCIENCE
07/2017

Salk scientists solve longstanding biological mystery of DNA organization

Stretched out, the DNA from all the cells in our body would reach Pluto. So how does each tiny cell pack a two-meter length of DNA into its nucleus, which is just one-thousandth of a millimeter across? The answer to this daunting biological riddle is central to understanding how the three-dimensional organization of DNA in the nucleus influences our biology. Associate Professor Clodagh O'Shea, first author Horng Ou and collaborators have provided an unprecedented view of the 3D structure of human chromatin—the combination of DNA and proteins—in the nucleus of living human cells. In the tour de force study, the Salk researchers identified a novel DNA dye that, when paired with advanced microscopy in a combined technology called ChromEMT, allows highly detailed visualization of chromatin structure in cells in the resting and mitotic (dividing) stages. By revealing nuclear chromatin structure in living cells, the work may help rewrite the textbook model of DNA organization and even change how we approach treatments for disease.

WATCH | bit.ly/oshea201712

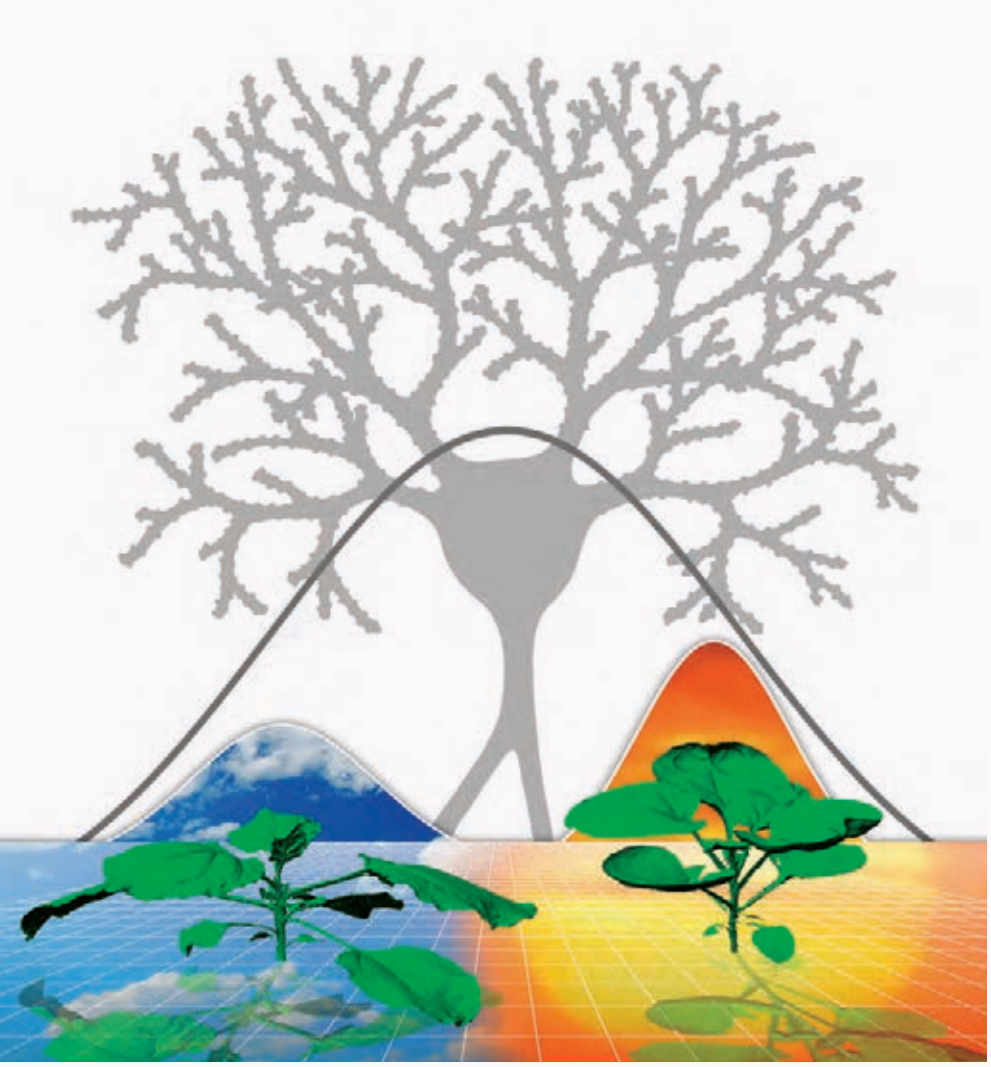
KPBS

REUTERS

READ | View the full news reports and more discoveries online at **www.salk.edu/news**

PLANT BIOLOGY

HOW PLANTS GROW LIKE HUMAN BRAINS

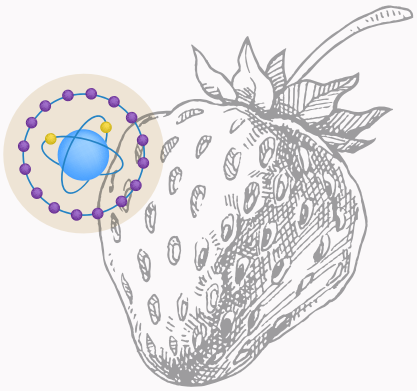


This illustration represents how plants use the same rules to grow under widely different conditions (for example, cloudy versus sunny), and that the density of branches in space follows a Gaussian ("bell curve") distribution, which is also true of neuronal branches in the brain.

Plants and brains are more alike than you might think.

Salk scientists Saket Navlakha, Charles Stevens, Joanne Chory and colleagues discovered that the mathematical rules governing how plants grow are similar to how brain cells sprout connections.

The team gathered data from 3D laser scans of plants to build a statistical description of theoretically possible plant shapes by studying the plant's branch density function, which depicts the likelihood of finding a branch at any point in the space surrounding a plant. Basically, this says that branch growth is densest near the plant's center and gets less dense farther out following a bell curve. This property turned out to be universal regardless of a plant's growth conditions (sun versus shade, for example). The work, published in *Current Biology* on July 6, 2017, and based on data from 3D laser scanning of plants, suggests there may be universal rules of logic governing branching growth across many biological systems.



NATURAL PLANT COMPOUND MAY REDUCE MENTAL EFFECTS OF AGING

Pamela Maher, a senior staff scientist in the lab of Dave Schubert, found further evidence that a natural compound in strawberries reduces cognitive deficits and inflammation associated with aging in mice. The work, which appeared in the *Journals of Gerontology Series A* in June 2017, builds on the team's previous research into the antioxidant fisetin, finding it could help treat age-related mental decline and conditions like Alzheimer's or stroke.

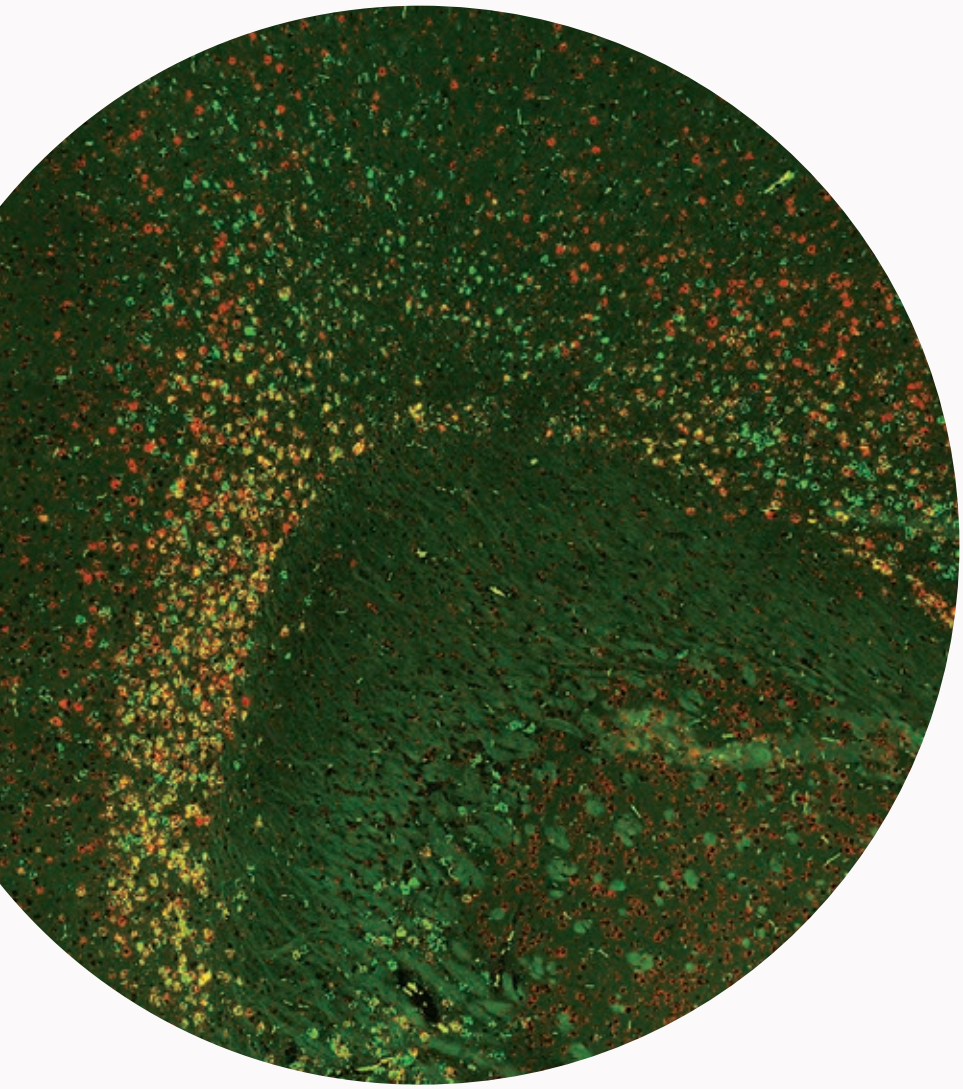
After doing 3D scans of plants for a month, scientists used the algorithms to look for patterns in the digital data.

SUBWAY NETWORKS MIMIC PLANT ARCHITECTURES

It might seem like a tomato plant and a subway system don't have much in common, but both, it turns out, are networks that strive to make similar tradeoffs between cost and performance. Using 3D laser scans of growing plants, Assistant Professor Saket Navlakha, Professor and HHMI Investigator Joanne Chory, first author Adam Conn and colleagues found that the same universal design principles that humans use to engineer networks like subways also guide the shapes of plant branching architectures. The work, which appears in the July 26, 2017, issue of *Cell Systems*, could direct strategies to increase crop yields or breed plants better adapted to climate change.

WATCH	bit.ly/navlakha201712

NEUROSCIENCE



NEW KINDS OF BRAIN CELLS REVEALED

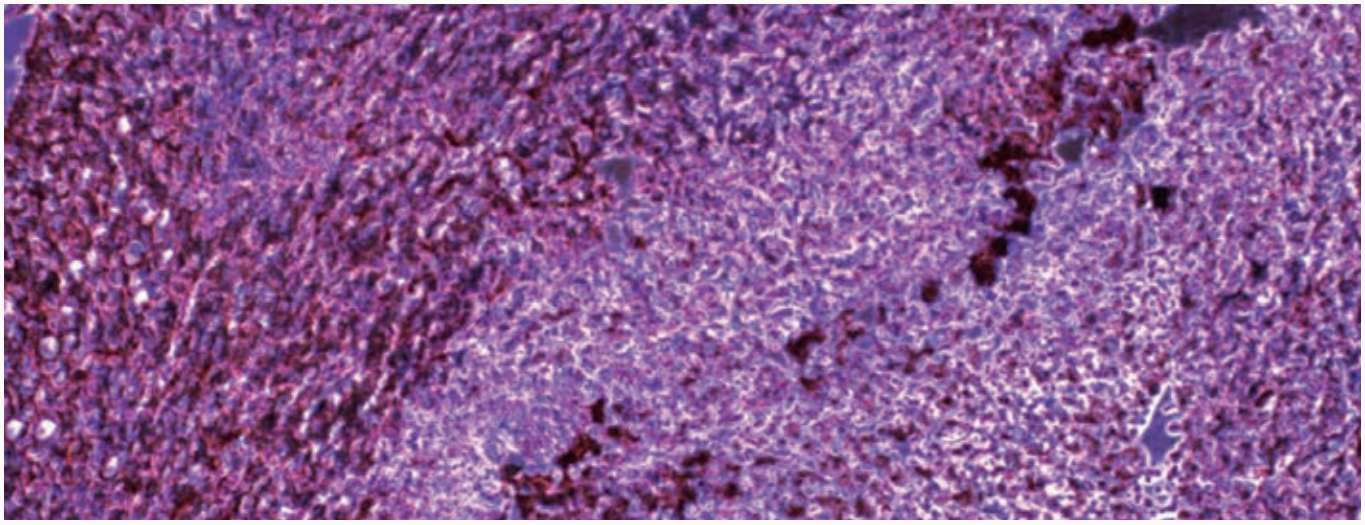
Under a microscope, it can be hard to tell the difference between any two neurons, the brain cells that store and process information. So scientists have turned to molecular methods to try to identify groups of neurons with different functions. Professor and HHMI Investigator Joseph Ecker, Senior Staff Scientist Margarita Behrens, Research Associate Chongyuan Luo and collaborators have, for the first time, profiled chemical modifications of DNA molecules in individual neurons, giving the most detailed information yet on what makes one brain cell different from its neighbor. The work appeared in *Science* on August 10, 2017.

WATCH | bit.ly/ecker201712

Salk and UC San Diego scientists identified neuron types predicted by epigenomic signatures. The image shows neuron populations expressing marker genes for specific neuron subtypes: Tle4 (red), Sulf1 (green) or both (yellow).

PARTNERSHIP FOR A HEALTHY BRAIN

Professor Rusty Gage, Professor and Chief Science Officer Martin Hetzer, first author Tomohisa Toda and colleagues have discovered that an interaction between two key proteins in the cell nucleus helps regulate and maintain the cells that produce neurons. The work, published in *Cell Stem Cell* on September 14, 2017, offers insight into why an imbalance between these precursor cells and neurons might contribute to mental illness or age-related brain disease.



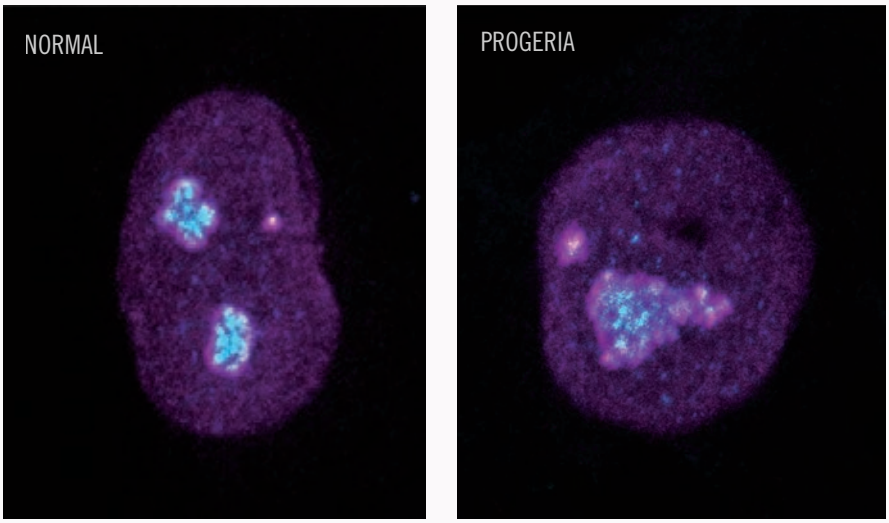
Visible regions of hypoxia in tumor samples correlate with cell signaling linked to suppressing the immune system.

MICRO-RNA HELPS CANCER EVADE IMMUNE SYSTEM

The immune system automatically destroys dysfunctional cells such as cancer cells, but cancerous tumors often survive nonetheless.

A study by Salk Professor Juan Carlos Izpisua Belmonte, former Salk Research Associate Min-Zu (Michael) Wu and collaborators shows one method by which fast-growing tumors evade anti-tumor immunity. The team uncovered two gene-regulating molecules that alter cell signaling within tumor cells to survive and subvert the body's normal immune response, according to a September 18, 2017, paper in *Nature Cell Biology*. These molecules, termed "microRNAs," regulate genes by silencing RNA and have increasingly been implicated in tumor survival and progression. The discovery could one day point to a new target for treatment in various types of cancer.

AGING



Nucleoli in the cell nucleus (purple), stained bright magenta and cyan are enlarged in the progeria cell (right) compared to the normal cell (left).

PROTEIN TURNOVER MAY BE USEFUL MARKER OF AGING

It may seem paradoxical, but studying what goes wrong in rare diseases can provide useful insights into normal health. Probing the premature aging disorder Hutchinson-Gilford progeria, Salk Vice President, Chief Science Officer and Professor Martin Hetzer and Staff Scientist Abby Buchwalter have uncovered an errant protein process in the disease that could help healthy people as well as progeria sufferers live longer. When a cell devotes too much time to protein production, other important functions may be neglected. The work, described in *Nature Communications* on August 30, 2017, adds to a growing body of evidence that reducing protein synthesis can extend lifespan—and thus may offer a useful therapeutic target to counter both premature and normal aging.

WATCH | bit.ly/hetzer201712

TILTED MICROSCOPY TECHNIQUE BETTER REVEALS PROTEIN STRUCTURES

The conventional way of placing protein samples under an electron microscope during cryo-EM experiments may fall flat when it comes to getting the best picture of a protein's structure. In some cases, tilting a sheet of frozen proteins—by anywhere from 10 to 50 degrees—as it lies under the microscope, gives higher quality data and could lead to a better understanding of a variety of diseases including influenza and HIV, according to new research led by Helmsley-Salk Fellow Dmitry Lyumkis. The work appeared in *Nature Methods* on July 3, 2017.

Just as looking at soup cans from different angles allows you to see different shapes, viewing proteins at a tilt reveals different aspects of their structure.

NEW METHOD TO RAPIDLY MAP THE "SOCIAL NETWORKS" OF PROTEINS

Professor Joseph Ecker and collaborators from UC San Diego developed a new high-throughput technique to determine which proteins in a cell interact with each other. Mapping this network of interactions, or "interactome," has been slow going in the past because the number of interactions that could be tested at once was limited. The new approach, published June 26, 2017, in *Nature Methods*, lets researchers test millions of relationships between thousands of proteins in a single experiment.

HARNESSING PLANTS FOR THE FUTURE

CONSIDER THIS:

By making the planet **2% more efficient**, we can help solve the problem.

Increased CO_2 emissions

Effects from global warming

Burgeoning population

Stressed crops

Collapsed ecosystems

Increased demand for food, fuel, feed and fiber

Get ready, sunny San Diego: Winter is coming.

We're not talking about a new season of *Game of Thrones*—although the story is one of epic proportions and high stakes.

Salk Institute scientists will soon have the ability to control the weather, to create at will frigid northern winters, baking desert summers and steamy jungle monsoons. In fact, they will be able to simulate nearly any climate on Earth in a state-of-the-art plant research facility slated to begin operation in November 2017.

In the facility's high-tech grow rooms and chambers, Salk's plant biologists will put plants through intense paces, subjecting them to temperature, light and moisture conditions that mimic everything from Spanish summers to Swiss winters. The new facility anchors the Institute's Harnessing Plants Initiative, an ambitious effort launched this fall to develop biology-based solutions to the urgent challenge of global climate change, one of the most serious threats facing humanity.

"Our world is at a crossroads," says Joanne Chory, director of Salk's Plant Molecular and Cellular Biology Laboratory, Howard Hughes Medical Institute (HHMI) investigator and mastermind of the initiative. "Over the next fifty years, the human population will grow to around 10 billion people. Right now we have 7 billion people and we have already strained the planet's ability to support us. Our action or inaction will determine our fate."

Chory, who holds the Howard H. and Maryam R. Newman Chair in Plant Biology, and her colleagues have chosen action. Over the past decades, Salk's plant biology team has emerged as a world leader in pioneering discoveries about the inner workings of plants. They have illuminated the molecular machinery inside plant cells that allows them to grow, survive stress and adapt to new environments. Now, Chory and her colleagues plan to apply their hard-won foundational knowledge of plant biology to the practical purpose of addressing the myriad disruptions posed by global warming.

The Harnessing Plants Initiative hinges on developing "ideal plants" to help tackle the critical and interlinked challenges of human emissions of carbon dioxide, declining agricultural yields and collapsing ecosystems. At the same time, these ideal plants will help meet the burgeoning demands of a rapidly growing human population for plant products.

Salk has a **two-pronged solution:**

1.

Use "ideal" terrestrial crop plants to capture a significant portion of human-emitted CO_2.

2.

Maintain sequestration capacity of coastal marine environments by reversing seagrass loss.

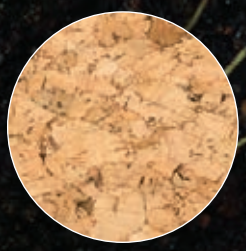
SOLUTION 1:

Breaking the cycle

Utilizing **suberin** to store more carbon without releasing it.

Plants are naturally very good at sequestering carbon; they have been doing it for millions of years.

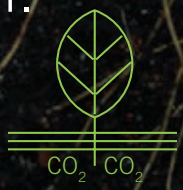
Suberin = Cork



Ideal plants will produce more suberin which removes CO_2 from the atmosphere, revitalizes ecosystems and improves agriculture.

THE 3-IN-1 SOLUTION

1.



Store carbon stably in roots (or root systems) deep in the soil.

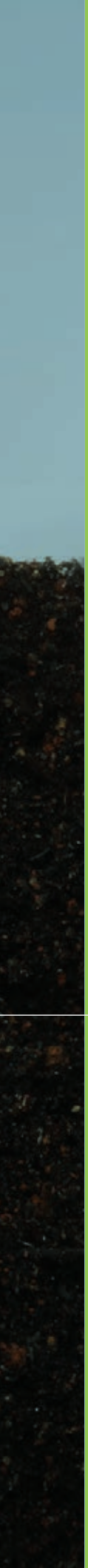
2.

Increase environmental stress tolerance.

- No tilling
- Less fertilizer

3.

Feed the world sustainably.



"Our world is at a crossroads... Our action or inaction will determine our fate."

Joanne Chory
Professor and Director
Plant Molecular and
Cellular Biology Laboratory

Carbon Conundrum

Life on Earth begins and ends with carbon. The stuff of life—proteins, carbohydrates, lipids and DNA—is built on a carbon backbone. Life emerged around three billion years ago and has since evolved into billions of species. The vast majority of species that have existed have since gone extinct. Interred in the earth ages ago, certain forms of life—plants and algae, in particular—left behind enormous concentrations of carbon: coal, petroleum and natural gas. Carbon made life possible, and the end of uncounted lives made concentrated, energy-rich carbon abundantly available for the most enterprising of species, *Homo sapiens*.

Since the dawn of the Industrial Revolution, humans have become very good at exhuming the remains of our carbonized predecessors for use as energy to power our modern societies. Too good, it seems. Over the past century, the concentration of greenhouse gases in the atmosphere has steadily increased, mostly from burning fossil fuels. Currently, humans emit around 35 gigatons of carbon dioxide into the atmosphere annually through industry, transportation, electricity generation and other activities. Greenhouse gases prevent light from the sun from reflecting back into space, effectively trapping heat. The result has been a 1.5-degree increase in average global surface temperature since the late 19th century—global warming.

The impact of this warming is unmistakable. The polar ice caps are melting with alarming rapidity and the oceans are swelling as they warm. Both factors raise sea level, which threatens coastal communities with erosion and flooding, and the warming oceans fuel massive storms and extreme weather. Recent summers have been the hottest and driest on record, resulting in increasing numbers of forest fires.

The same conditions are suppressing global agricultural yields, a trend that is likely to worsen if predictions of an additional global warming of 2 to 3 degrees over the next few decades prove accurate. "The human population will grow by around 40 percent over the next 50 years and the middle class may double," says Chory. "This puts human consumption and global warming on a dangerous collision course."

Many efforts are under way to reduce the amount of carbon we emit, but these initiatives have run into political, economic and technological obstacles. It has become clear, says Chory, that solely focusing on reducing emissions won't solve the problem. We simultaneously need to focus on removing the carbon that has accumulated in the atmosphere. By developing specialized crops capable of adapting to a changing climate, Chory and her colleagues believe they can substantially increase the amount of carbon captured and stored in the planet's soils. At the same time, they plan to identify varieties of seagrasses to maintain and restore coastal aquatic ecosystems, where massive amounts of carbon are stored in the roots of these grasses.

Corking Carbon

Plants are excellent at scrubbing carbon from the atmosphere. Every year, the world's plants breathe in around 64 gigatons of CO_2 from the air, storing the carbon in leaves, shoots and roots. To get a sense of the staggering amount of carbon plants absorb, consider that an adult African elephant at the San Diego Zoo can weigh up to 6.8 metric tons. One gigaton is equivalent to more than 100 million of those elephants. Now multiply by 64.

While plants store this carbon in the form of numerous biomolecules, almost all of these materials are degraded by animals, fungi and bacteria and the stored CO_2 thereby released. The Salk team has identified one particular plant-made molecule, called suberin, that is highly resistant to this degradation and can thereby remain in the soil. Suberin, better known to wine aficionados as cork, is a waxy, water-repellant and carbon-rich substance, and is at the heart of the Salk team's strategy to address the problem of meeting human needs while reducing carbon in the atmosphere. Each growing season, annual crops—plants that live only one season, such as corn or wheat—breathe in CO_2 to build plump leaves, tall stems and thick roots.

Joseph Noel

Uncovered the blueprints used by plants to produce chemical compounds

Joseph Ecker

Led sequencing of the first plant genome and mapped the first plant epigenome

Julie Law

Identified mechanisms for epigenetic regulation

At the end of the season, the plants die and rot, releasing much of that carbon back into the atmosphere.

"What if you could tweak this carbon cycle in the plant so that it absorbed more carbon and released less?" says Joseph Noel, a member of Salk's plant biology team and Howard Hughes Medical Institute investigator.

"We realized that a crop with a larger, suberin-dense root would capture more carbon in the ground," he says. "Roots last longer than other parts of plants, particularly in perennial plants that live multiple years. Even in dead roots, suberin decays very slowly."

Carbon stored in suberin could potentially stay in the soil for hundreds or even thousands of years. So you have two possible benefits: store more carbon and store it for a long time. An expert on the structure and chemistry of compounds produced by plants and on how plants have evolved unique ways to make their own specialized products to adapt to nearly every ecosystem on Earth, Noel is exploring how plant cells can be coaxed to produce more suberin—and thus capture more carbon.

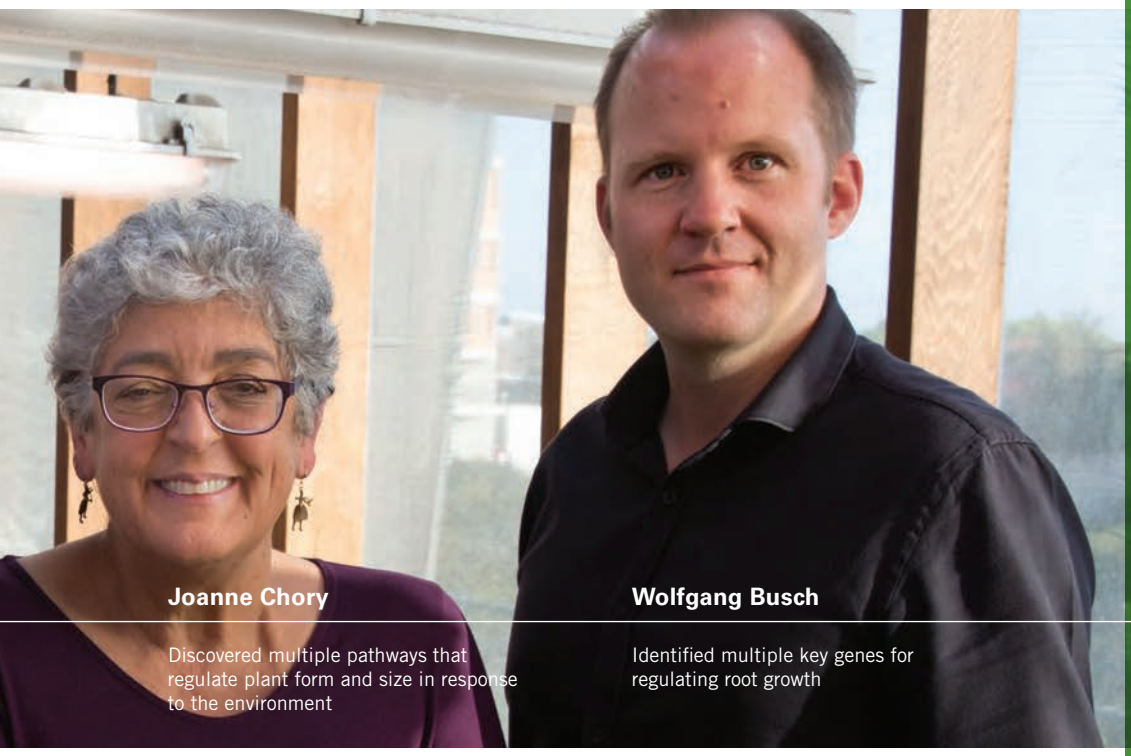
Increasing the amount of suberin each cell produces is one strategy; another is to increase the number of cells—in other words, to grow larger roots. In both cases, the newest addition to Salk's plant biology team, Associate Professor Wolfgang Busch, is providing critical expertise. Busch combines techniques from genetics, genomics and other science fields to understand how root growth in given environments is determined by a plant's genes.

"There is still a great deal we don't know about how genes and molecular mechanisms determine how a plant root decides to grow to a certain size or in a certain direction in the soil," Busch says. "To breed crops with large roots that produce a lot of suberin, we'll need a better understanding of how to influence both aspects at the genetic and molecular level."

In addition to his expertise, Busch brought a plant with him to Salk: *Lotus japonicus*. A native plant of Japan, known commonly in English as birdsfoot trefoil, *Lotus* is a wild legume that has become the laboratory stand-in—a "model organism" in scientific parlance—for studying the biology of all legumes, a group of plants that includes chickpeas, beans, peanuts and lentils. In their quest to develop the ideal plant, the Salk team will experiment with both *Lotus* and *Arabidopsis thaliana*, the common mustard weed that is the predominant plant research model. Much of what scientists know about the fundamentals of plant molecular and cellular biology has come from studying *Arabidopsis*. Adding *Lotus* to the research mix will allow the Salk team to expand its research to focus on a plant more closely related to crops. This is important to the Harnessing Plants Initiative, as the carbon-capturing plants the Salk team is designing would need to be food-producing crops deployed at a scale sufficient to put a significant dent in global warming.

"Most of the world's arable land is already being used for agriculture, and we are already straining our natural ecosystems and our capacity to generate food and other plant products," says Busch. "A legume crop bred with a large root could be planted on farms around the world and could potentially have multiple advantages over current crops."

Deploying an "ideal" legume crop on a relatively small portion of the world's farmland could capture a significant portion of global CO_2 emissions. Among the other advantages of legumes is that



Joanne Chory

Discovered multiple pathways that regulate plant form and size in response to the environment

Wolfgang Busch

Identified multiple key genes for regulating root growth

Salk's World-Class Plant Biology Team

crops could be perennials, surviving and producing year after year, which avoids annual replanting. The roots would remain undisturbed, keeping the plant's carbon haul locked underground. Legumes also tend to make friends. Most grow nodules on their roots as homes for bacteria called *rhizobia*, which convert nitrogen from the air into usable forms the plants need to thrive. This is why farmers include legumes in crop rotations with other plants to help replenish soil nitrogen. The crops envisioned by the Salk team thus require less fertilizer than normal crops, reducing the harmful farm run-off that damages aquatic ecosystems.

Learning from Nature

Salk's new plant growth facility will be critical to finding ways to turn crops into carbon warehouses. Just as important, it will help the researchers find ways to grow plants in a variety of conditions. Plants are highly attuned to specific climates, and subtle variations in temperature, rainfall, humidity and soil salinity can have a serious impact on their growth. Even within a species, plants can prefer very different environments. *Arabidopsis*, for instance, grows naturally around the globe, in climates ranging from arid regions of northern Africa to temperate northern Europe. In Japan, *Lotus* grows from tropical Okinawa to frigid Hokkaido, the northernmost of the country's major islands.

Julie Law, another member of the Salk plant biology team, says the natural variation that allows plants to live in very different conditions is a kind of evolutionary playbook that the Harnessing Plants Initiative can draw from. "As plants spread and adapted to new conditions, they evolved new survival skills," says Law, an assistant professor at Salk. "We can learn from these plants to design crops that will be highly adaptable and can grow in a range of climates."

For instance, the climate of the Midwest, the traditional breadbasket of the United States, is becoming hotter and drier. At the same time, flooding due to heavier rains has increased. Looking globally, a 2016 study estimated that drought and extreme heat reduced worldwide crop yields by as much as 10 percent between 1964 and 2007. Many plants developed to capture and store large amounts of carbon will need to be heat and drought tolerant to thrive. Resilience to flooding might also come in handy, as extreme

"To breed crops with large roots that produce a lot of suberin, we'll need a better understanding of how to influence both aspects at the genetic and molecular level."

Wolfgang Busch
Salk plant biology professor

SOLUTION 2:

An unexpected ally

Coastal **marine plants** can be transformative.

30X Greater Carbon Storage

Boosting carbon-storage capacity of seagrasses is key to fighting global warming.

Restoration

Better understanding of seagrass biology will enhance ecosystem restoration.

Fishery Breeding Grounds

Seagrasses are essential to healthy fisheries such as coral reefs.

Climate Adaptive

Restore global food-producing ecosystems.

Carbon Capture

Use coasts to capture and store for millennia.

rain events and resulting floods are also a growing threat to crops. By collecting varieties of *Arabidopsis* and *Lotus* from a range of different climates, then growing them under hot, dry conditions in the new climate simulation facility at Salk, the Institute's plant biologists can identify the plants best adapted to that situation. They can look for what makes plants resistant to flooding or cold snaps—or any other climate threats that seem to be increasing in frequency. They can then analyze the genetic and molecular makeup of these plants to find out what makes them durable, and use what they find to breed those traits into their "ideal plants."

"The ideal plant doesn't just capture carbon and produce food," says Law. "It also grows where you want it to grow. As climate changes, many regions are becoming hotter and drier, but others are getting colder and wetter. We need a toolbox of adaptive traits to draw from."

In addition to identifying key genetic traits for developing ideal plants, Law and Joseph Ecker, another Salk professor and HHMI investigator, are searching for key patterns of epigenomic modifications, chemical changes that alter a plant's genetic activity without changing the letters of the DNA alphabet (A-T-C-G). These patterns have allowed plants in nature to adapt to various environments, and will likely be crucial to developing the ideal plants envisioned by the Salk team.

"The essence of climate change from a plant's perspective is responding to stress, because changes in the plant's environment can represent an existential threat," says Ecker. "Developing a thorough understanding of the genetic and epigenetic mechanisms that control plants' stress responses will allow us to develop crops that are more resilient and precisely suited to specific climate regimes."

An Aquatic Ally

In addition to land plants, the Salk team plans to extend their research to seagrasses, one of the other major repositories of the planet's carbon. Coastal seagrass beds store nearly twice as much carbon per acre as terrestrial forests and account for about 10 percent of the carbon stored in the ocean. Unfortunately, due to dredging and pollution, seagrass ecosystems are seriously threatened around the world. About 1.5 percent of these ecosystems disappear each year. Changing water temperatures due to global warming accelerates this decline. As they go, so goes a range of important functions they serve: carbon sequestration, habitat for fish, and storm and flood protections for coastal communities.

Maintaining existing seagrass ecosystems and restoring others, says Noel, offers a clear-cut solution to addressing climate change. Similar to land plants, seagrasses grow in a range of climates, so as water conditions change and kill off grasses in a region, scientists can draw from the natural variation to identify replacements from other areas that are more likely to survive the new normal. A tropical seagrass, for instance, might grow well in an area where temperate waters are warming. Another tactic might be to restore ecosystems with carbon-hungry varieties of seagrasses.

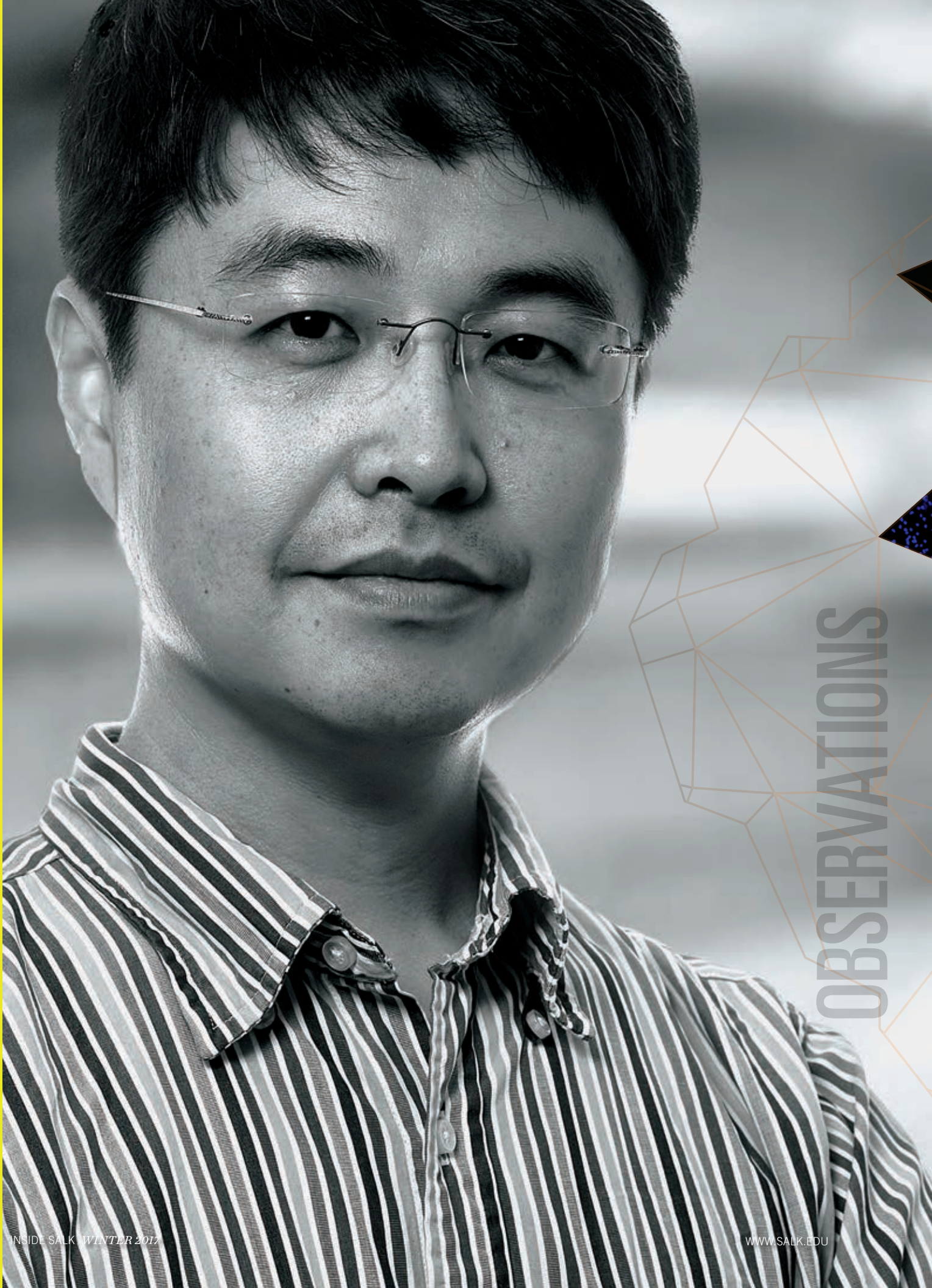
"Certain varieties of seagrass have greater carbon storage capacity," adds Noel. "If this trait was bred into other varieties of grasses, we could sequester far more carbon in coastal ecosystems."

The Salk team plans to identify what traits make certain seagrasses suited to various ecosystems, and to use that knowledge to identify what varieties could be transplanted to ecosystems where climate change is killing grasses. Restoring compromised aquatic ecosystems would have the double benefit of capturing more carbon in the sea and reestablishing ecosystems, such as coral reefs, that support fisheries."

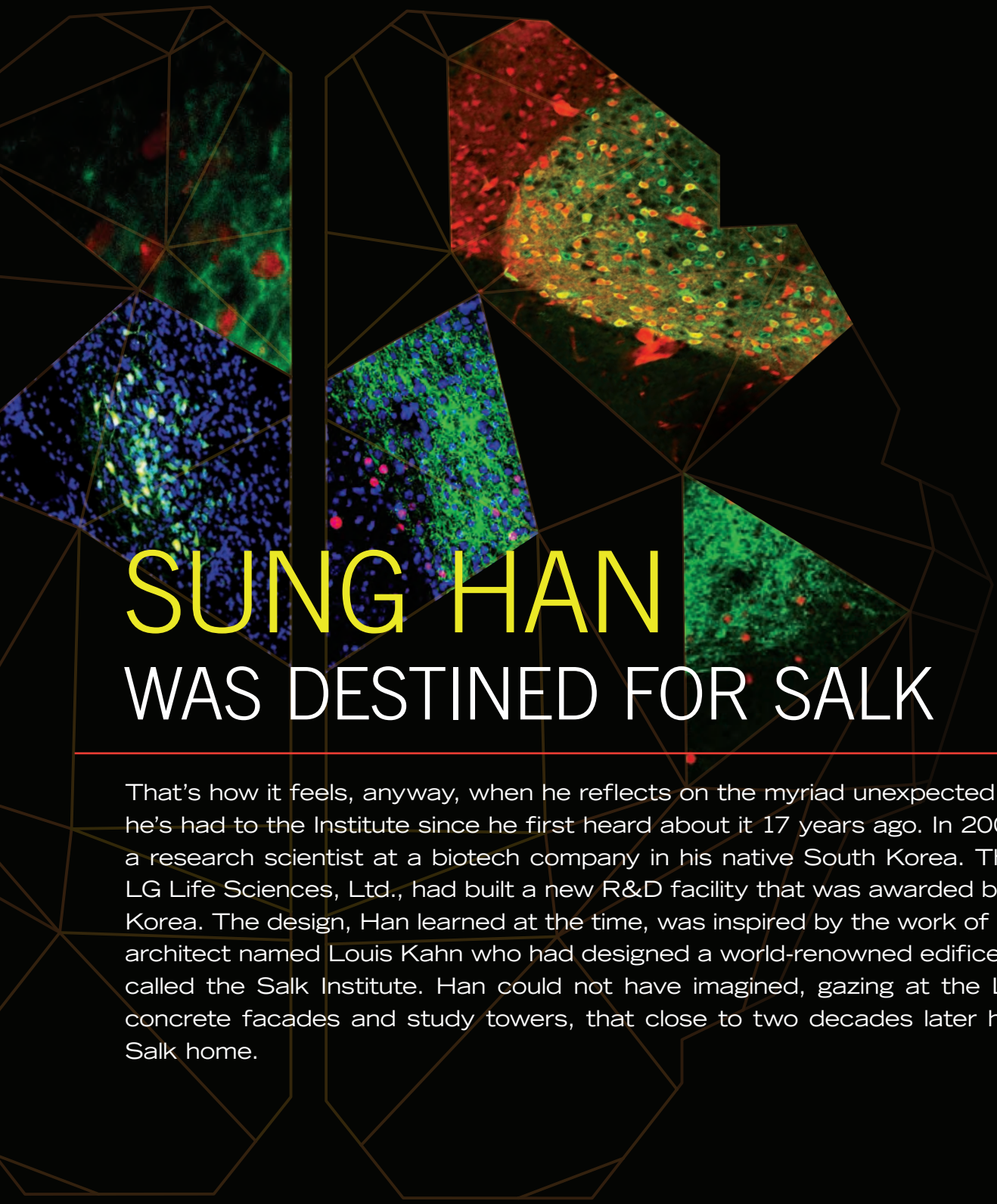
"That's the beauty of both our terrestrial and our aquatic strategies," says Noel. "They address the food problem and the climate change problem simultaneously, on the land and in the water. We humans are going to need to be very smart to get through the next century, and that means developing strategic solutions based on good science."

"The essence of climate change from a plant's perspective is responding to stress."

Joseph Ecker
Salk plant biology professor



OBSERVATIONS



SUNG HAN
WAS DESTINED FOR SALK

That's how it feels, anyway, when he reflects on the myriad unexpected connections he's had to the Institute since he first heard about it 17 years ago. In 2000, Han was a research scientist at a biotech company in his native South Korea. The company, LG Life Sciences, Ltd., had built a new R&D facility that was awarded best design in Korea. The design, Han learned at the time, was inspired by the work of an American architect named Louis Kahn who had designed a world-renowned edifice in California called the Salk Institute. Han could not have imagined, gazing at the LG building's concrete facades and study towers, that close to two decades later he would call Salk home.

Han, an assistant professor in the Clayton Foundation Laboratories for Peptide Biology, arrived at the Institute a year ago to study how the brain recognizes aversive sensory signals. For example, laboratory mice that have never been exposed to predators will still cower at the smell of a fox or the sound of a hawk, suggesting that brain circuitry devoted to parsing threats is innate, not learned. Han wants to understand the way such circuitry is genetically encoded and how it operates, because when these alarm systems are not functioning properly humans can suffer from neuropsychiatric conditions like panic disorder, migraine or autism.

Inside Salk sat down with Han to talk about how he came to the Institute, what he hopes to accomplish with his research and—despite the many simultaneous demands of getting a new lab off the ground—how he manages to recharge.

You first heard about Salk because of the new building at LG. What are some of the other times you heard about the Institute prior to becoming a faculty member here?

My first project at LG was in endocrinology, looking for a natural product that would secrete growth hormone. When I conducted background research for the project, I learned that Nobel laureate and Salk Professor Roger Guillemin discovered the molecule the brain releases to trigger the secretion of such hormones. [Guillemin came to Salk in 1970 to head the new Laboratories for Endocrinology.]

I noticed the name, but forgot about it until many years later, when I was applying to jobs after completing my postdoctoral training. I saw a position at Salk, applied and was invited to come and give a talk. I almost didn't make it, because I had an attack of vertigo from Meniere's disease the night before I had to travel for the interview. The next morning, I was about to email Alan Saghatelian and tell him I couldn't come but then decided, 'I'll give it one more hour.' The attack cleared up and I was able to travel. It felt like a miracle.

Another funny coincidence is that my main research project is related to a protein called CGRP, and in my job interview I learned the protein was discovered by Salk Professor Ron Evans! After I joined the Institute, I realized this is the ideal place for me as a junior faculty member. I am very inspired by Ed Callaway's neuroscience research—I'm doing something similar—and his office is right down the hall from mine.

What are you working on?

I'm working on three different projects, all related to the sensory encoding of aversive information. One is on migraine, another is on panic disorder and the third is on autism spectrum disorder. All three share similar symptoms, such as sensory hypersensitivity. Most migraine sufferers are very sensitive to light and sound, and sometimes even smell. People with autism are very sensitive to sounds that normal people don't notice. They can also be very picky eaters who are sensitive to touch and smell. Normal sensory stimuli are aversive to them, which I find very interesting.

How do you study these aversive stimuli?

I focus on a brain region called the brainstem. Thirty or forty years ago it was a very popular area for neuroscience, but then people started to focus on higher brain areas. But I think it's important to look at this area for encoding aversive signals to the brain. It's hard to study because it's very small, and lots of different cell types are intermingled, but I use recently developed cell type–specific tools. We have animal models for all three disorders and I use molecular and electrophysiological tools to study the neurocircuits involved and check whether they are dysfunctional.

Today is a golden age for studying neural circuits. We have tools to manipulate specific populations of neurons, selectively activating or deactivating them. Years ago, Francis Crick said that to understand how the brain works, you need to be able to manipulate and monitor—as well as to map—the anatomical connections only in certain types of neurons, leaving others unaltered. Later, Ed Callaway's lab modified the rabies virus to beautifully develop the tool Crick predicted would be needed. Now we can specifically manipulate, map and monitor the neural circuit. I can manipulate certain populations of neurons using light and check behavior outcomes and activity in awake, behaving animals. All these newly developed tools also make it possible to monitor specific neuronal populations in specific brain areas while animals perform specific behaviors. It's incredible.

You have such a historical awareness about science—did you always want to be a scientist?

My father was a veteran of the Vietnam War and he had PTSD. I often saw him having seizures, and initially I wanted to be a doctor to cure his symptoms. But when I was a student, I had the realization that even though doctors take care of

patients, cures come from research. So I decided to change direction and become a researcher.

In graduate school I studied epilepsy, but I also got interested in autism because the two disorders often go together. And from that my interest moved specifically to neural circuits because to understand brain disorders you really need to know how the brain works.

What do you find most challenging about your research?

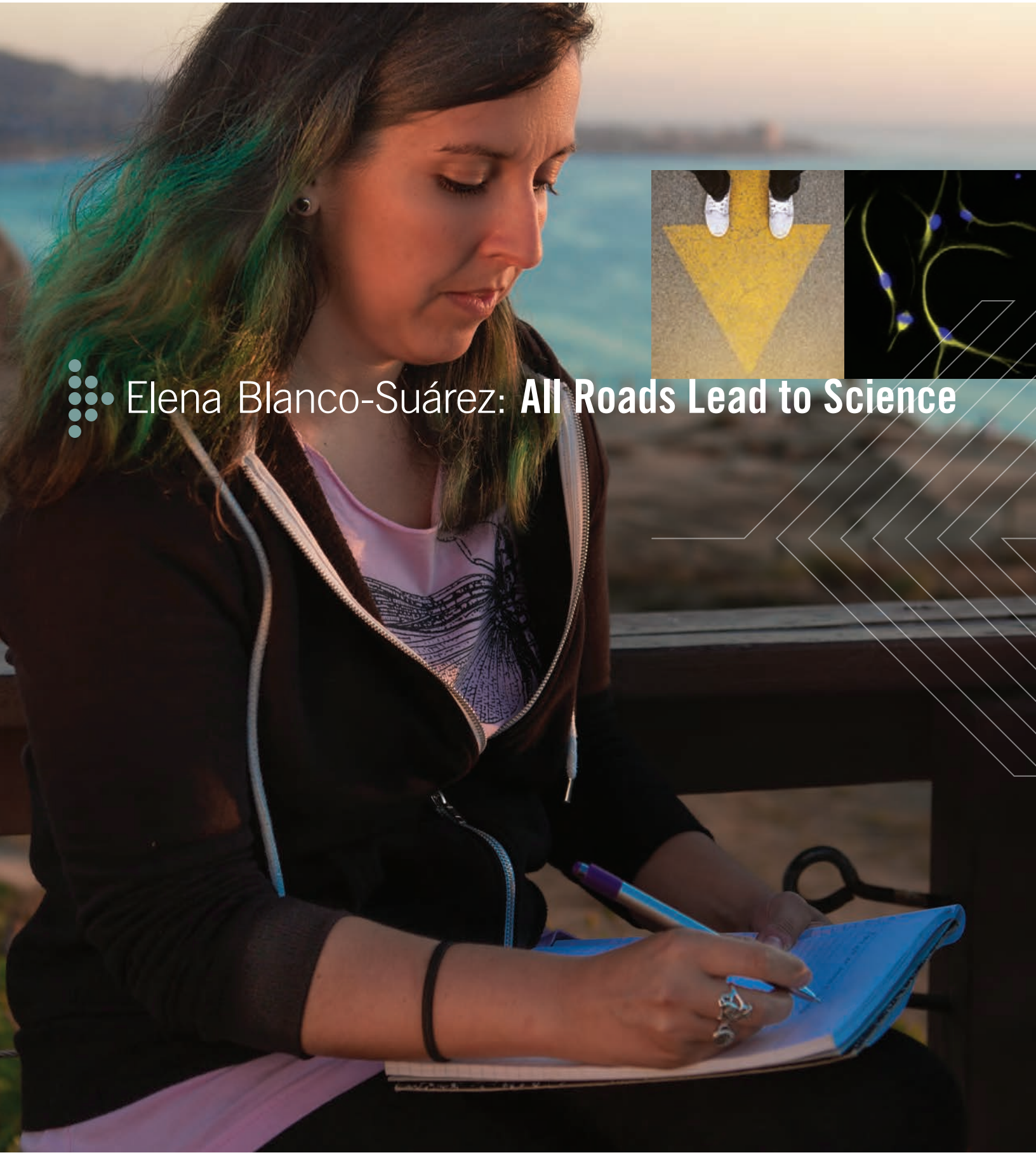
Failure of an experiment can be quite frustrating. But that can be compensated for by an experiment that succeeds or by data that supports a hypothesis. I don't want to bring lab work home, so when I leave I try to focus on my family.

I like cooking. Research experiments fail all the time—9 times out of 10. But cooking doesn't suddenly fail. As long as I follow the recipe, I can achieve a certain degree of flavor and my wife and kids really like my dishes, which is very rewarding.

What do you cook?

Well, Korean food, certainly—Korean barbecue or soups. There's a large Korean community in San Diego, so it's not hard to get the right ingredients. That's one of the reasons I chose to move to San Diego. I got my PhD in Seattle and also did my postdoctoral training there. We lived in Seattle for 10 years and my kids didn't want to leave their friends or their school. But it didn't take long for them to settle down here. In fact, I had a chance to go to Seattle recently and asked the family if they wanted to join me, and they didn't want to! They now like San Diego better.

Above from left to right:
Sukjae Kang, Shijia Liu, Sung Han, Sujean Oh, Valerie Tryon



Elena Blanco-Suárez: **All Roads Lead to Science**

From early on, it was pretty much a given that Elena Blanco-Suárez would be a scientist.

When she was three, she wanted to be a paleontologist. In grammar school, she was fascinated by parasites and endlessly drew the life cycles of the creatures in her favorite *Alien* movies.

By her early teens, she was obsessed with moving from her small hometown of Oviedo in northwestern Spain to America because she knew it was a great place for science— and all her favorite music and literature was there, too.

The land of some of her favorite post-hardcore punk groups would have to wait, however, for Blanco-Suárez to get her education, a travelogue in itself.

She first attended the yearlong ERASMUS European Exchange Program at the Aristotle University of Thessaloniki, learning to speak Greek from the elderly undertaker whose funeral home was below her apartment. She returned to Spain to get her bachelor's degree in biology from the Universidad de Oviedo and her master's in biochemistry from the Universidad Complutense de Madrid. Then, she was off to England to obtain her doctorate in biochemistry from the University of Bristol.

Blanco-Suárez's introduction to America essentially was the Salk Institute. She arrived in San Diego in July 2014 during Comic-Con weekend when nary a hotel room or Airbnb was to be found. Through Salk's Society of Research Fellows, which serves as ambassadors to new postdoctoral fellows, she was given a sofa to sleep on for a couple of days. "That saved my life," she says. "Otherwise, I was going to be sleeping on the beach." That Monday, she started working in Nicola Allen's lab.

While studying neurons at the University of Bristol, Blanco-Suárez read a *Nature* paper about Allen's research with astrocytes, the star-shaped cells discovered to be crucial to brain function and which may hold clues to understanding neurodevelopmental and degenerative diseases such as autism, epilepsy, schizophrenia, stroke and Alzheimer's. So impressed with the research and the fact Allen was a young investigator with her own lab, Blanco-Suárez made it her mission to become a research associate for Allen at Salk.

When she's not studying proteins in astrocytes, Blanco-Suárez is still all about the science. She likes to blog about science and advocates for young women to pursue careers in research. She regularly volunteers for Salk's Education Outreach program and the Saturday Science Club for Girls at the Fleet Science Center in Balboa Park. And this past fall, one of her microscopy images was the inspiration for a gown created for the Salk Women & Science Design and Discovery Fashion Showcase.

Blanco-Suárez does enjoy a break from the bench by exploring San Diego's craft beer culture and lively music scene. She hopes to stay in academia, preferably at an institution that models itself after Salk. "I love what we do," says Blanco-Suárez. "I like the idea that it is nonprofit in the classical way. I like to think that we are giving something to society."

PUSHING THE BOUNDARIES OF THE BRAIN

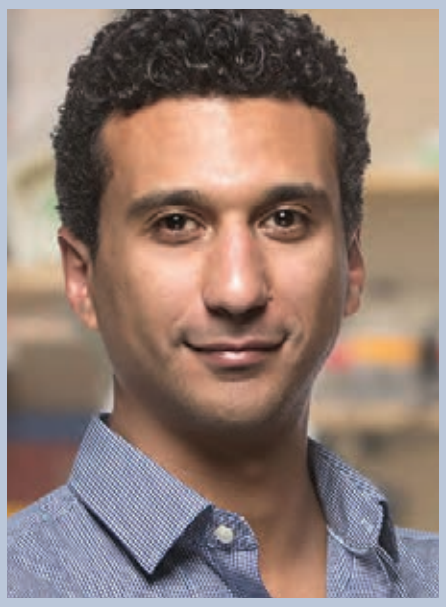
SPOTLIGHT

CATALOGING BRAIN-CELL TYPES

Salk Institute scientists will lead a $25 million, five-year initiative to revolutionize our understanding of the human brain by systematically identifying and cataloging cell types across the mammalian brain, the National Institutes of Health has announced. The effort, which is part of the Brain Research through Advancing Innovative Neurotechnologies® (BRAIN) Initiative, will be co-led by Salk Professors Joseph Ecker and Ed Callaway. Salk scientists Margarita Behrens, Xin Jin and Kuo-Fen Lee, along with researchers from USC and UC San Diego, will also participate in the collaboration.

From left to right: Joseph Ecker, Xin Jin, Ed Callaway, Margarita Behrens and Kuo-Fen Lee.

BRAIN INITIATIVE BRAIN RESEARCH THROUGH ADVANCING INNOVATIVE NEUROTECHNOLOGIES



EIMAN AZIM

REWARDING INNOVATION

Assistant Professor Eiman Azim was named an NIH Director's New Innovator for 2017 as part of the National Institutes of Health's High-Risk, High-Reward Research Program. The award provides $1.5 million for a 5-year project during which Azim will explore how the nervous system controls dexterous movements. The award is designed specifically to support a small group of creative scientists at an early stage of their career with an emphasis on innovative, high-impact projects.

PUSHING THE BOUNDARIES OF THE BRAIN

Tatyana Sharpee

PROCESSING SOUND

Associate Professor Tatyana Sharpee was awarded a grant by the National Science Foundation's Computer and Information Science and Engineering directorate of approximately $950,000 over four years to study how the brain processes sounds and to test theories about how different types of neurons work together in the brain. This grant is part of a multi-national project with groups in France and Israel.

Ed Callaway

CREATING NEW TOOLS

Two Salk scientists received a National Science Foundation BRAIN Initiative award to explore the brain. Ed Callaway, in conjunction with Stanford University, will use the award of over $9 million to develop a broadly applicable platform for discovering how neural circuit activity gives rise to complex cognitions and behaviors, which will lead to a better understanding of neurological and psychiatric diseases. Additionally, the University of Texas at Austin, Salk's Terrence Sejnowski and the Texas Advanced Computing Center (TACC) received a grant of over $9 million from the program to map synapses. Sejnowski's team will build a computational microscope to animate the electron microscope data from the project and probe the function of synapses at the molecular level.

Terrence Sejnowski

PURSUING ADVANCED MODELING

As part of the National Science Foundation's funding for new multidisciplinary approaches to neuroscience, Terrence Sejnowski together with the California Institute of Technology will receive more than $1 million over 3 years to pursue advanced modeling of the brain.

Axel Nimmerjahn

DEVELOPING SENSOR PROTEINS

Associate Professor Axel Nimmerjahn is part of a BRAIN Initiative grant with UC Davis, UCSF and the Oregon Health and Science University. The team was awarded almost $3 million over 3 years by the NIH to develop novel fluorescent sensor proteins for optically measuring the dynamic changes of neuromodulatory chemicals in the brain and spinal cord of awake, behaving animals. The work could yield important new insight into the cellular and molecular mechanisms underlying Parkinson's disease, depression, spinal cord injury and addiction.

Carol Marchetto

INCREASING REPRESENTATION

Carol Marchetto, a senior staff scientist in the lab of Rusty Gage, was selected as a 2017 BRAINS Fellow, which is a national program funded by the NIH to accelerate and improve the career advancement of neuroscience postdoctoral researchers and assistant professors from underrepresented groups.

Fellowship site: https://depts.washington.edu/brains/

BRAINS
Broadening the Representation of Academic Investigators in NeuroSciences

Silvana Konermann

SILVANA KONERMANN NAMED HHMI HANNA H. GRAY FELLOW

Silvana Konermann, a research associate in the lab of Helmsley-Salk Fellow Patrick Hsu, was chosen as one of 15 inaugural Howard Hughes Medical Institute Hanna H. Gray Fellows. Each fellow will receive up to $1.4 million in funding over eight years. The Hanna H. Gray Fellows program seeks to increase diversity in the biomedical research community by supporting talented early career scientists from groups underrepresented in the life sciences who have the potential to become leaders in academic research. In this two-phase program, fellows will be supported from early postdoctoral training through several years of a tenure-track faculty position.

Susan Kaech

Gerald Shadel

Prominent scientists in immunobiology and aging research to join Salk Institute

The Salk Institute is honored to welcome two new faculty with the rank of full professor, both of whom are highly respected and accomplished leaders in their fields. Susan Kaech and Gerald Shadel will inspire fresh collaborations and bring experienced perspectives to bear on Salk's approaches to health and disease. The researchers were hired through the Rockstar Fund, founded in honor of Salk Board Chair Emeritus Irwin Jacobs to recruit high-profile scientists to the Institute. Kaech was recruited thanks to a grant from the Nomis Foundation, designated for a senior investigator to lead the Nomis Center at Salk.

Kaech will serve as director of the Nomis Center for Immunobiology and Microbial Pathogenesis. She studies how immune cells called T cells remember infectious agents our bodies have previously encountered in order to mount a more rapid response the next time we're exposed to them.

Shadel will join Salk's Molecular and Cell Biology Laboratory, where he will focus on the surprisingly diverse roles of mitochondria in aging and disease using genetic, biochemical and molecular approaches.

The duo will arrive at Salk in early 2018.

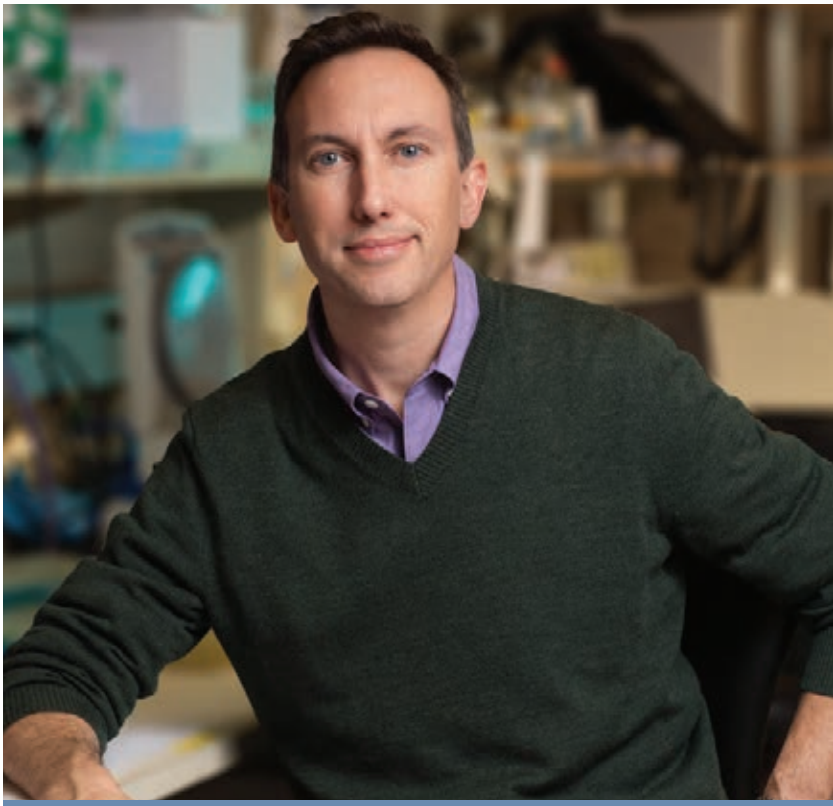
NICOLA ALLEN NOMINATED TO PRESTIGIOUS YOUNG SCIENTISTS GROUP

Assistant Professor Nicola Allen has joined one of the most elite global communities, the World Economic Forum's Young Scientists, who comprise today's "most forward-thinking and advanced scientific minds" under the age of 40. Allen spoke about the state of global neuroscience at the Annual Meeting of the New Champions, an event involving 90 countries and 2,000 participants convened by the forum, July 27–29, in Dalian, China.

Nicola Allen

REUBEN SHAW RECEIVES NATIONAL CANCER INSTITUTE OUTSTANDING INVESTIGATOR AWARD

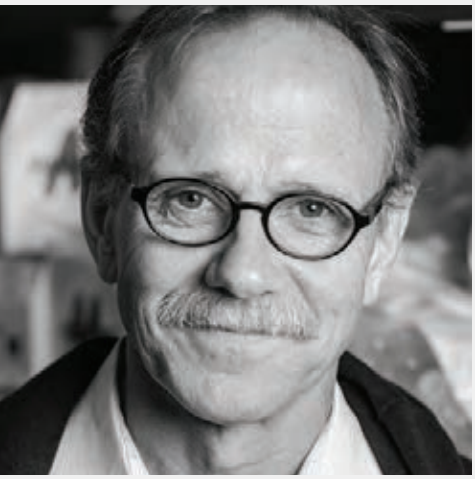
Professor Reuben Shaw, director of Salk's National Cancer Institute–designated Cancer Center, has received the National Cancer Institute (NCI) Outstanding Investigator Award (OIA), which encourages cancer research with breakthrough potential. Shaw, a member of Salk's Molecular and Cell Biology Laboratory and holder of the William R. Brody Chair, will receive $4.2 million in direct funding over the next seven years to further his work. The award is granted to innovative cancer researchers with outstanding records of productivity to allow them to take greater risks in their research that could lead to breakthroughs.



Reuben Shaw

GEOFFREY WAHL RECEIVES SUSAN G. KOMEN RESEARCH GRANT AWARD

Professor Geoffrey Wahl, who is a Komen Scholar and holder of Salk's Daniel and Martina Lewis Chair, was awarded $550,000 to continue to study the signaling pathways that help create and maintain mammary stem cells. By understanding these pathways and how disrupting them contributes to the development of breast cancer, Wahl's lab is working to identify new treatment targets.



RUSTY GAGE RECEIVES ALZHEIMER'S AWARD

Professor Rusty Gage has been named the 2017 Courage & Hope Researcher by Alzheimer's San Diego for his research on age-related neurodegenerative disease. Gage was among four San Diegans honored for their frontline work in healthcare, research, awareness and caregiving at the sixth annual Celebration of Courage & Hope ceremony on September 14 at the U.S. Grant Hotel in downtown San Diego. Alzheimer's San Diego selected Gage, who holds the Vi and John Adler Chair for Research on Age-Related Neurodegenerative Disease, for his discovery that neurons are capable of regenerating and the key role it plays in modern Alzheimer's and dementia research.

INDER VERMA NAMED A "GIANT OF SCIENCE"

The American Cancer Society has bestowed its Triumph Award on Professor Inder Verma for his seminal accomplishments in gene therapy and cancer research. Verma, who holds the Irwin and Joan Jacobs Chair in Exemplary Life Science, was honored at the Giants of Science gala on October 14 at the Four Seasons Hotel Los Angeles. In its second year, the event honors outstanding researchers and scientists in the cancer community and raises funds for cancer research.

SALK ESTABLISHES ARCHITECTURE ENDOWMENT, GARNERS AWARD FOR TEAK RESTORATION

The Institute has created an Architecture Conservation Program to address ongoing preservation of the nearly 60-year-old Modernist structure considered to be a masterwork of architect Louis Kahn.

With a lead gift by a son of Jonas Salk, Jonathan Salk, and his wife, Elizabeth Shepherd, the endowment was announced during the June 27 unveiling of a multi-year, $9.8 million project with the Getty Institute to conserve the building's signature teak window systems. On October 13, the Institute was honored with the California Preservation Foundation's Preservation Design Award in recognition of the completion of Salk's teak window system restoration. The Institute shared recognition for "excellence in craftsman and preservation technology" with teak project architects Wiss, Janney, Elstner Associates, Inc. The restoration was conducted in partnership with the Getty Conservation Institute (GCI) under its Conserving Modern Architecture Initiative. At the 34th annual awards ceremony in San Francisco, the Salk Institute also received the CPF's President's Award for establishing the endowment fund program to ensure responsible stewardship of Kahn's iconic buildings going forward.

Above: Elizabeth Shepherd and Jonathan Salk

Left: California Preservation Foundation's 34th annual award is accepted by Tim Ball.

Below: California Preservation Foundation's award ceremony.

CALIFORNIA PRESERVATION FOUNDATION

Since their first Science & Music series concert at Salk in 2013, Larry and Carol Greenfield have been committed to supporting Salk science, particularly when it comes to equipping the labs of researchers just starting out. Their many gifts of technology and instrumentation have included the equipment listed here:

- Cryostat
- Olympus QT High-Speed Camera
- IncuCyte Zoom Cell Imaging System
- Cryogenic Vapor Storage System (Freezer)
- Fluorescent Imaging System
- Tissue Culture Chamber
- Fluorescent Stereo Microscope
- Gel Imaging System
- Optogenetics 590 mm Yellow DPSS Laser System
- Centrifuge

Instrumental Philanthropy

Larry and Carol Greenfield

Larry D. Greenfield has always been partial to contraptions. As a teen in Canoga Park, California, in the mid- to late 1950s, he installed a closet door switch that would turn the closet light on and off when the door opened and closed. He also wired the whole backyard with lighting without any instructions—or his parents' permission, but with the tacit blessing of his mother.

Today, the retired radiologist and his wife, Carol, who worked at Eastman Kodak and the Orange County Visitor and Convention Bureau, satisfy their mutual affinity for apparatus by supporting the equipment and technological needs of Salk's scientists. The Carlsbad couple—who regularly attend Back to Basics lectures, Women & Science forums and Science & Music concerts—takes an especially keen interest in helping young researchers with labs to build.

"We like to give to things we can actually see," says the couple.

One such techy gift was to Assistant Professor Nicola Allen, who studies cells in the brain called astrocytes. At a Salk reception, Allen mentioned to the couple that the Institute had only one cryostat, a machine that slices tissue very finely, and it was in high demand by multiple labs.

They did not like hearing that the researchers had to wait their turn to use the machine or that "one of Nicola's postdocs was coming in at three in the morning just to have access to the machine," says Carol.

"The Greenfields' support of our science means a lot to my lab, both the interest they take in our work and the discoveries that we make, and their generous purchase of equipment that has allowed us to make scientific progress more rapidly," says Allen, whose lab has grown from two to eight researchers since she joined Salk in 2013. Allen's research has shown that astrocytes—star-shaped cells once thought to be "filler"—are crucial to brain function and they have significant potential for helping to understand neurodevelopmental and degenerative diseases like autism, schizophrenia, stroke and Alzheimer's.

The new $40,000 cryostat the Greenfields purchased was a game changer for Allen's research. The Greenfields have purchased other equipment for her lab, which they believe has been a boon to advancing her work.

The Greenfields say Allen has "blossomed into a tremendous researcher" in the short time they've been following her Salk career. It's one of the reasons they favor giving to new scientists over more established investigators who have the support of grants and foundations, although supporting postdoctoral researchers among established Salk scientists is also part of their instrumental philanthropy.

Equipment is one of the costliest factors in biological science, and can quickly devour nearly half of a laboratory's start-up budget, which conservative estimates place at about $1 million. Even with bargain hunting, new-faculty discounts or buying refurbished equipment, scientists shopping for big-ticket items such as centrifuges, tissue culture chambers and fluorescent stereo microscopes can expect price tags averaging $50,000 and soaring into hundreds of thousands of dollars.

In 2014, the Greenfields established the Larry D. Greenfield, MD and Carol A. Greenfield Technology Fund to help Salk scientists deal with these overwhelming costs. The couple believes funding for equipment often takes a back seat to other needs, such as salaries, but reasoned that biomedical breakthroughs can't be made if scientists don't have the right equipment. Besides one-time contributions, the technology fund matches gifts and creates challenges to fund expensive equipment.

Recently, the Greenfields' fund gave $175,000 to augment $625,000 from the H. A. and Mary K. Chapman Charitable Trust enabling Salk to purchase mass spectrometry, genome sequencing and super resolution microscopy instruments.

"I don't think people are aware of the important role that equipment plays in the advancement of science," says Larry. "On the news, you hear the end result of the work but not the background, or that the scientists need a $40,000 microscope or a $40,000 tissue slicer, for example. It's important for people to know science doesn't happen automatically."

When Assistant Professor Diana Hargreaves arrived at the Salk Cancer Center in 2014, the couple ensured that her lab was equipped with everything she needed to start her research. Hargreaves studies the cause and development of human tumors from a biochemical and epigenetic perspective.

It was the same kind of instrumental philanthropy they bestowed upon Sreekanth Chalasani when they underwrote the renovation of his first lab in 2014. Larry and Chalasani have maintained a pen pal-type correspondence ever since, one that runs heavy on the topic of zebrafish.

"The Greenfields have provided generous support for our zebrafish facility," says Chalasani, associate professor in the Molecular Neurobiology Laboratory, who now studies the nervous system of roundworms to learn about human aggression and fear. "This has been critical to our research in understanding how the brain processes sensory information. Apart from their support, Larry is an enthusiastic advocate for our science. He is constantly pointing out new results and is very excited about the progress we make."

Astrocytes and zebrafish aside, the Greenfields' scientific interests include cancer (especially pancreatic and glioblastoma), dementia, and developing viable organs in animals for human organ transplant. Lately, they have taken a fancy to plant biology, too.

For example, the Greenfields' generosity made it possible for Assistant Professor Julie Law to purchase a climate controlled plant growth chamber so she could investigate the connections between epigenetics, the environment and plant growth. In particular, Law focuses on characterizing several newly identified families of proteins involved with DNA packaging and gene expression, called chromatin binding proteins. Her studies will help expand current knowledge of epigenetic gene regulation and increase scientists' ability to understand and control the expression of existing and newly introduced genes—research that has broad implications in both agriculture and gene therapy. "Connections with the San Diego community, such as with the Greenfields, is part of what makes Salk great," says Law, who works in Salk's Plant Molecular and Cellular Biology Laboratory and holds the Hearst Foundation Development Chair. "Their interest in the science, the people and the technologies that drive innovative discoveries energizes the research and provides new opportunities for scientific breakthroughs."

"Their interest in the science, the people and the technologies that drive innovative discoveries energizes the research and provides new opportunities for scientific breakthroughs."

Associate Professor Wolfgang Busch, also in Salk's Plant Molecular and Cellular Biology Laboratory, is the latest Salk researcher to come under the Greenfields' philanthropic radar. With Busch, the couple recently embarked on a whole new fundraising strategy for Salk—a crowdfunding campaign to raise $314,000 for a seed-planting robot that would enable Busch to study more efficiently the root growth responses of *Arabidopsis thaliana* to the environment. A better understanding of root systems could help scientists grow more resilient food sources, an increasingly urgent problem in the face of the planet's shifting climate and extreme environments, such as drought.

"The Greenfields truly grasp how technology can change the way problems can be approached," said Busch.

Throwing down the gauntlet, the Greenfields vowed to match the first $150,000 raised. (At press time, the results of the crowdfunding campaign were not yet available.)

The return for the Greenfields' gifts of funds, interest and energy is manyfold. Besides the satisfaction of boosting the start of several early career scientists, they like the accessibility and intellectual stimulation of talking to Salk's researchers and touring their labs. They also delight in being patrons of the arts—while they don't attend Symphony at Salk, they always purchase a table so research associates can enjoy the gala evening. This past summer, they hosted the 10 young women who were the recipients of the 2017 Salk Women & Science Special Awards Initiative.

The walls of the Greenfields' La Costa Glen home are adorned with signed photographs of appreciative Salk scientists—and a picture of a glioblastoma cell culture from Research Associate Amy Rommel. The couple agrees with the metaphor of them being somewhat akin to fairy godparents to Salk's early career scientists.

"We don't have any kids," the Greenfields say, so purchasing "the equipment is like having our own children." S

The power of charitable gift annuities

Did you know a gift to the Salk Institute of $20,000 or more can provide fixed payments for you and your loved ones? Charitable gift annuities provide tax savings and an income for you, while benefitting research and discovery at the Salk Institute. You can feel confident knowing you've made smart decisions about your financial and philanthropic priorities.

Sample Rates

YOUR AGE (S)	RATE
70	5.1%
80	6.8%
90	9.0%

Learn more about the many benefits of a charitable gift annuity by contacting Cheryl Dean, Planned Giving Counsel, at (858) 500-4884 or cdean@salk.edu.

Your age(s) and current interest rates determine the rate Salk can offer.

salk®
Where cures begin.

EVENTS

From left: Janelle Ayres, Tatiana Hurtado de Mendoza, Tina Simner

SCIENCE BY DESIGN

Salk's Women & Science program held its first Design and Discovery Fashion Showcase on October 4, featuring 13 gowns inspired by Salk microscopy images and created by San Diego Mesa College design students and Salk scientists.

More than 300 people attended the showcase chaired by Salk supporter and event lead sponsor Tina Simner and Associate Professor Janelle Ayres to benefit the Salk Women & Science Special Awards Initiative, which provides awards to female scientists conducting high-risk research projects. Thirteen scientist-designer teams collaborated over the last year to create high-end gowns that communicate the visual splendor of scientific research.

Visit designdiscovery.salk.edu for photos and videos of the designs.

Photo courtesy Howard Max

DESIGN AND DISCOVERY FASHION SHOWCASE

Photo courtesy Howard Max

EVENTS

Top row, from left: Jonathan Kuo, Rehan Chinoy, Jack Knickrehm

Middle row, from left: Natassja Casillas, Nithya Krishnamurthy, Noa Dahan, Alexis Llamas

Bottom row, from left: Carolyn Cafro, Allison Bao, W. Robinson, Aida Razavilar, Madeleine Masser-Frye

FROM BENCH TO BEDSIDE

The Salk Women & Science summer forum drew a full house for a panel discussion by women health innovators on solutions for improving lives. The July 11 event in the Conrad Prebys Auditorium was held in conjunction with Women Innovating Together in Healthcare (WITH).

From left: Carol Gallagher, Esther Martinborough, Michelle Booden, Rafaéle Tordjman, Razelle Kurzrock and Sheila Gujrathi

Back to Basics

BACK TO BASICS—FROM CLIMATE TO CORK

Salk Professor Joseph Noel addressed nearly 300 people with his talk "Plants, Climate Change, Carbon, Cork and You!" at the September 20 Back to Basics lecture. Noel spoke about the scientific advances needed to solve larger issues of planetary health. The Back to Basics program offers lay science lectures to the public twice a year.

Photo courtesy Melissa Jacobs

HIGH SCHOOL SCHOLARS CLASS OF ‘17

Twelve teens attended the Institute’s eight-week Heithoff-Brody Scholars Program this past summer, working in labs side-by-side with Salk scientists on cutting-edge research, formulating and testing hypotheses, preparing experiments and attending lab meetings. An offering of Salk’s Education Outreach, the scholars program is more than 40 years old.

Photo courtesy Melissa Jacobs

Joseph Noel, center

EVENTS

PRELUDE TO A SEASON

Violinist Alena Baeva and pianist Vadym Kholodenko ushered in the fifth season of the Salk Science & Music Series with a concert of Stravinsky, Debussy, Beethoven and Tchaikovsky on October 22 in the Conrad Prebys Auditorium. Salk Associate Professor Wolfgang Busch delivered the science talk about plant root research. Two concerts in the series remain—February 4, 2018, and April 8, 2018.

For tickets, visit: www.salk.edu/music.

SYMPHONY IN RED

More than 750 guests attended the 22nd annual Symphony at Salk on August 26, raising $1 million for Institute research and education outreach programs. Guest artist David Foster, with "Friends" Eric Benét, Sheléa, and Jessica Sanchez, had the audience on their feet and dancing. This year's concert under the stars featured a red motif and a new visual system that projected the art of Françoise Gilot onto the concrete walls.

From left: Sara Linker, Silvana Konermann, Maya Ridinger, Graziana Gatto, Cynthia Reyes, Hermina Nedelescu, Claire Geddes, Annie Rathore, Swati Tyagi, Ceyda Coruh

From left: Adam Ayres, Elizabeth Keadle, Al Gore and Janelle Ayres

Alena Baeva and Vadym Kholodenko

Wolfgang Busch

From left: Eric Benét, Jessica Sanchez, David Foster, Sheléa and Nathan Granner

Every cure begins with you.

Salk giving programs offer a range of ways to get involved. Learn about Salk science and support vital research.

Education Outreach
Offering nearly half a century of programs to inspire—and launch—the next generation of scientists, Salk's Education Outreach includes a Mobile Science Lab, High School Scholars curriculum and SciChats@Salk.

Salk Women & Science
Showcasing the achievements of Salk's women of science, this program welcomes community and business leaders interested in inspiring others to embrace scientific research personally and philanthropically.

Salkexcellerators
Designed for young business professionals and community members committed to supporting Salk scientific discovery, *Salkexcellerators* offers a unique opportunity to support cutting-edge research while connecting with like-minded people.

Partners in Research
Invest in the future of cancer, aging, Alzheimer's disease and diabetes research by incorporating philanthropic support for Salk into your estate plans.

President's Club
Fuel Salk's ability to recruit top-tier scientists, acquire cutting-edge technology and embark on innovative research initiatives by joining the *President's Club.*

Chairman's Circle
Visionary donors in the *Chairman's Circle* provide the vital resources Salk researchers need to pursue breakthrough science.

Architecture Conservation Program
Ensuring the Modernist buildings envisioned by Jonas Salk and brought to life by Louis Kahn are preserved for generations to come.

Cancer Center Director's Fund
Dedicated to spearheading the ambitious new research directions Salk cancer researchers are pursuing in their continued quest for novel avenues into cancer therapies.

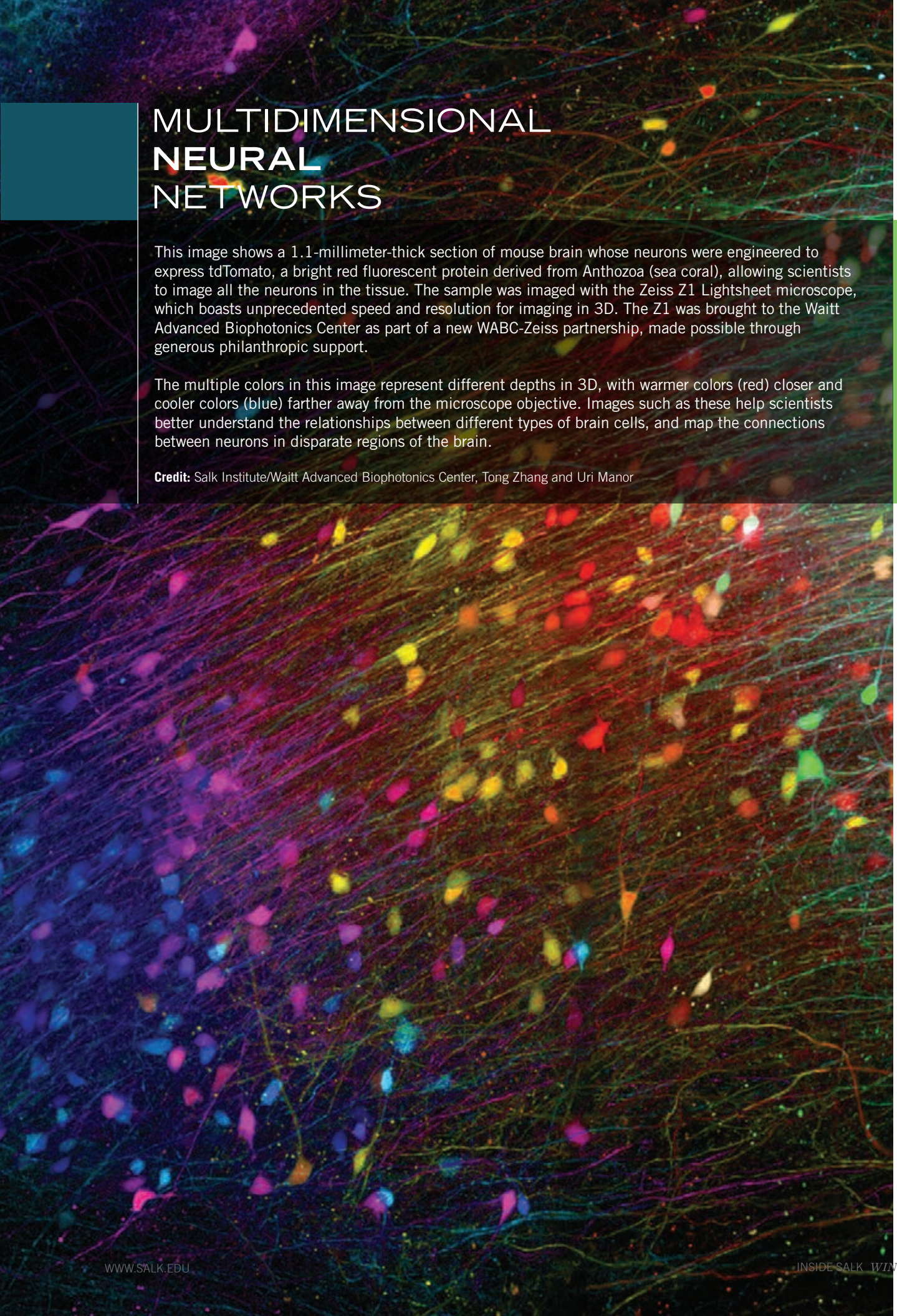
Alumni/Faculty Fellowship Fund
Training the next generation of scientists is central to Salk's mission. Contributions to the Salk Alumni program support the hundreds of research associates at the Institute.

Get involved.

Learn more about the many options for joining the Salk community by visiting **www.salk.edu/support** or calling **(858) 453-4100 x1201.**

salk®
Where cures begin.

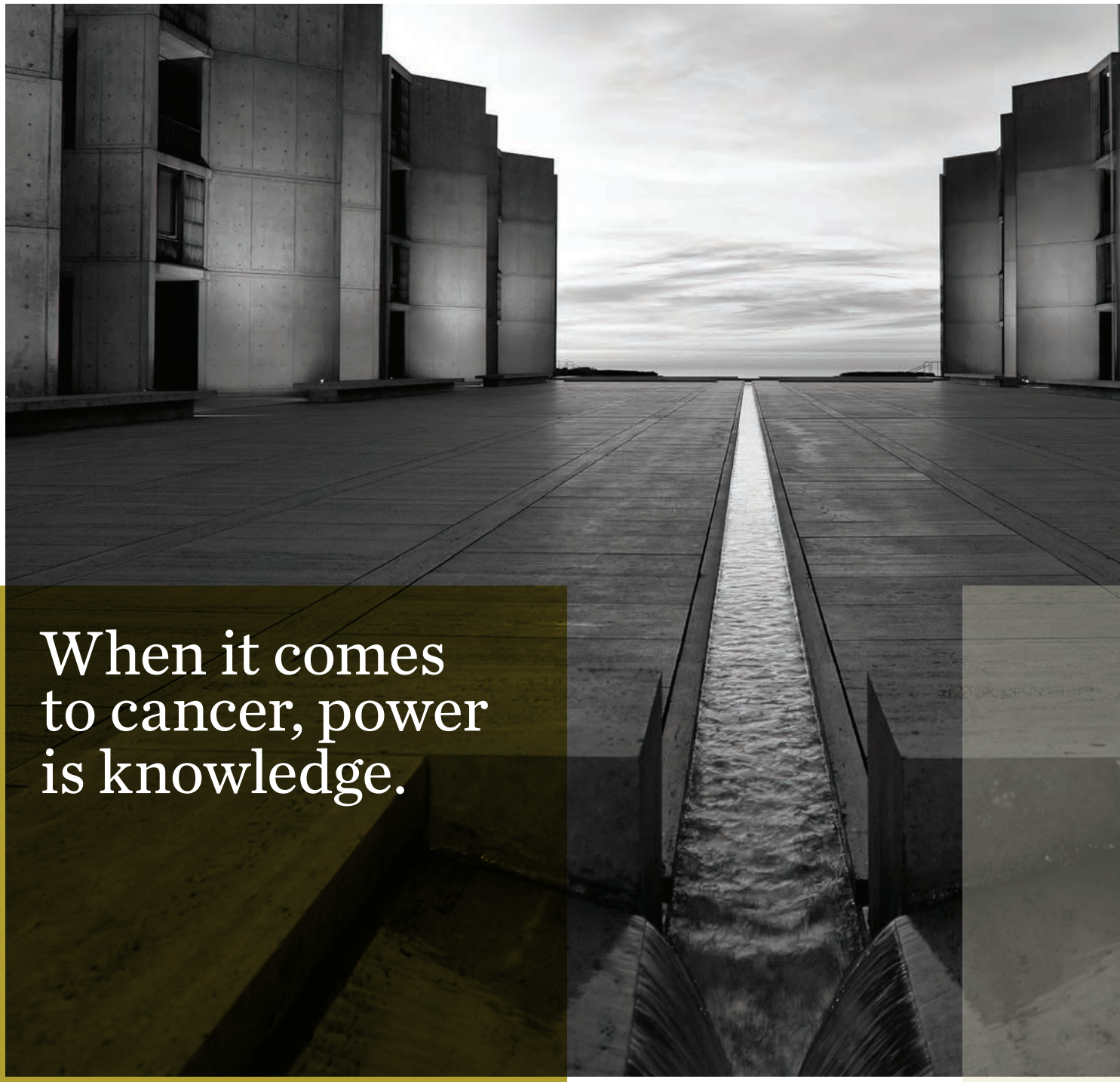
MULTIDIMENSIONAL **NEURAL** NETWORKS



This image shows a 1.1-millimeter-thick section of mouse brain whose neurons were engineered to express tdTomato, a bright red fluorescent protein derived from Anthozoa (sea coral), allowing scientists to image all the neurons in the tissue. The sample was imaged with the Zeiss Z1 Lightsheet microscope, which boasts unprecedented speed and resolution for imaging in 3D. The Z1 was brought to the Waitt Advanced Biophotonics Center as part of a new WABC-Zeiss partnership, made possible through generous philanthropic support.

The multiple colors in this image represent different depths in 3D, with warmer colors (red) closer and cooler colors (blue) farther away from the microscope objective. Images such as these help scientists better understand the relationships between different types of brain cells, and map the connections between neurons in disparate regions of the brain.

Credit: Salk Institute/Waitt Advanced Biophotonics Center, Tong Zhang and Uri Manor



When it comes to cancer, power is knowledge.

Home to one of only seven National Cancer Institute-designated cancer centers in the country, the Salk Institute is dedicated to pursuing novel avenues into cancer therapies.

By donating to **Salk Cancer Center Director's Fund** you are helping spearhead the ambitious new research directions that will shape the next generation of targeted cancer treatment.

For more information, call (858) 453-4100 or visit us online at www.salk.edu/support

salk®
Where cures begin.

Salk Science & Music Series

Presented by Exclusive corporate Sponsor
Charles Schwab

2017–2018 season

Produced for the Salk Institute by Karen Joy Davis

Sunday, October 22, 2017
VADYM KHOLODENKO & ALENA BAEVA,
piano and violin

Sunday, December 3, 2017
DASOL KIM,
piano

Sunday, February 4, 2018
ASI MATATHIAS, GABRIEL SCHWABE & KAREN JOY DAVIS,
violin, cello and piano

Sunday, April 8, 2018
ZLATA CHOCHIEVA,
piano

BE AMAZED AND INSPIRED

The ever-popular Salk Science & Music Series returns this fall for a fifth season of classical and jazz performances paired with riveting talks on the latest discoveries by the Institute's world-renowned scientists.

SALK SCIENCE & MUSIC SERIES

TICKETS & INFORMATION:
WWW.SALK.EDU/MUSIC
or contact MUSIC@SALK.EDU • (858) 597-0657

PERSPECTIVE

Elizabeth Blackburn

The Power of Many

You could say that the Salk Institute "began on a dime." Or millions of them.

In 1938, the nation's citizens were asked to send President Franklin D. Roosevelt, who had contracted polio as an adult, a birthday present of a single dime (or more, if they chose) to help fund his newly created National Foundation for Infantile Paralysis. Playing off a popular newsreel, "The March of Time," entertainer Eddie Cantor asked Americans to create a "march of dimes." And they did. That year alone people sent in more than two and a half million dimes, totaling $268,000. The foundation eventually changed its name to the March of Dimes and, later, after Jonas Salk's discovery of the polio vaccine, helped him finance the Institute that would continue to seek cures for disease.

It always amazes and pleases me when I see people come together in a united effort, each contributing what they can—be it a small monetary donation or a unique skill or the generous gift of their time—and thereby accomplishing remarkable works.

The Salk Institute welcomes every one of these heartfelt contributions. While larger gifts are memorialized at the Institute's entry or acknowledged via naming rights—deservedly so—less extravagant gifts, no matter the size, also serve to move science forward. And we are honored to receive them.

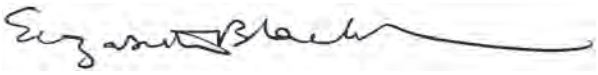
When Wendy Levy died of metastatic breast cancer in March of 2014, her family asked that, in lieu of flowers, donations be sent to The Wendy Levy Fund for Breast Cancer Research at Salk. Although most gifts were between $25 and $100, in just three months the Institute received over $9,900. By December of the following year, that number had risen to $31,500. What an honorable way to celebrate the life of a loved one while helping preserve the lives of others.

The people who work here daily are no less inspired to support the life-changing science that erupts all around us. When Ted Waitt initiated the Jacobs Rockstar Recruitment Fund in honor of Chair Emeritus Irwin Jacobs (the "original rock star," says Ted) many of our Board members made significant and much-appreciated contributions. Then our Salk scientists and staff began adding their own donations, many in the $50 to $500 range. I've personally contributed to this fund, too, because I know that an investment in top talent is an investment in saving lives.

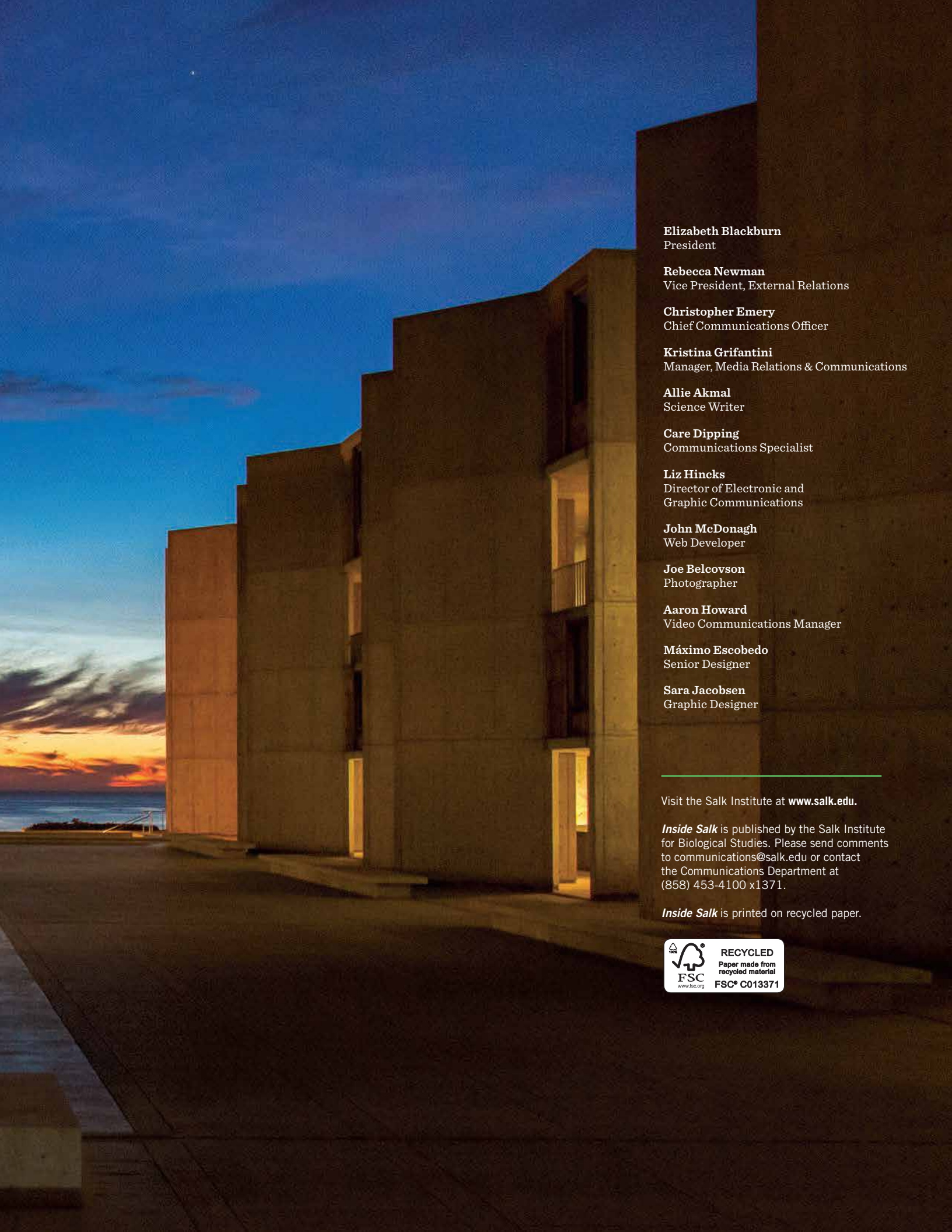
In this same spirit of crowdfunding, a concept that enables people of moderate means to financially impact the issues important to them, Wolfgang Busch recently initiated a crowdfunding campaign so that his lab can purchase a seed-planting robot. Salk supporters Carol and Larry Greenfield then made a matching gift challenge of $150,000, thus doubling the amount of each crowdfunding contribution.

And in yet another example of many coming together to make an impact, friends and family members of Salk scientists unite annually with teams from other organizations in a local cycling event called "Padres Pedal the Cause." The proceeds remain in San Diego to fund cancer research and the Salk Institute is one of the four beneficiaries. Since 2013, over 40,000 riders and donors have compiled nearly $5 million.

Parables throughout history reinforce the idea that small contributions from many regularly produce astonishing results. A delicious meal from "stone soup." A ball dress from scraps. Soldiers saved by the little ships of Dunkirk. Allow me to add the many, many lives saved by incremental advances in scientific discovery...funded, in part, by each of you. Thank you.



Elizabeth Blackburn
President, Salk Institute



Elizabeth Blackburn
President

Rebecca Newman
Vice President, External Relations

Christopher Emery
Chief Communications Officer

Kristina Grifantini
Manager, Media Relations & Communications

Allie Akmal
Science Writer

Care Dipping
Communications Specialist

Liz Hincks
Director of Electronic and
Graphic Communications

John McDonagh
Web Developer

Joe Belcovson
Photographer

Aaron Howard
Video Communications Manager

Máximo Escobedo
Senior Designer

Sara Jacobsen
Graphic Designer

Visit the Salk Institute at **www.salk.edu.**

Inside Salk is published by the Salk Institute for Biological Studies. Please send comments to communications@salk.edu or contact the Communications Department at (858) 453-4100 x1371.

Inside Salk is printed on recycled paper.

RECYCLED
Paper made from recycled material
FSC® C013371
FSC
www.fsc.org

salk®
Where cures begin.

Salk Institute for Biological Studies
10010 N Torrey Pines Rd
La Jolla, California 92037-1002
Telephone: (858) 453-4100
www.salk.edu

CALENDAR

FEBRUARY

4 Salk Science & Music Series featuring Asi Matathias, Gabriel Schwabe and Karen Joy Davis

MARCH

21 Salk Women & Science

APRIL

8 Salk Science & Music Series featuring Zlata Chochieva

11 Back to Basics

Salk Institute has received the highest rating 6 years in a row from Charity Navigator, the nation's foremost charity evaluator.

6 consecutive years
CHARITY NAVIGATOR
★★★★
Four Star Charity

Follow us on:
@salkinstitute

THERE ARE MANY WAYS TO SUPPORT SALK.

For detailed information on opportunities, please email giving@salk.edu or call (858) 453-4100 x1201 or visit www.salk.edu/support