Webinar Series Part 2: Smart Plants in a Changing World

00:00:00:00 - 00:00:08:04

Michelle Chamberlain

Good morning everyone. My name is Michelle Chamberlain and I have the pleasure of being the Vice President of Advancement at the Salk Institute.

00:00:08:04 - 00:00:22:00

Michelle Chamberlain

We're so grateful to have you here today for the second installment of our Science Can't Wait webinar series created in partnership with the Del Mar Foundation, a partnership that we're incredibly grateful to have.

00:00:22:00 - 00:00:37:00

Michelle Chamberlain

This collaboration brings together a community that values curiosity, connection, and impact and reflects our shared belief that scientific challenges we face truly cannot wait for more discovery.

00:00:37:00 - 00:00:52:12

Michelle Chamberlain

Through this series, we're opening a window into the Salk that addresses, and our research, excuse me, that addresses some of our most urgent issues from how daily habits shape long-term health to how plants can impact a changing world.

00:00:52:12 - 00:01:02:10

Michelle Chamberlain

We're deeply grateful, as I mentioned to the Del Mar Foundation for helping make this access possible and for standing with us in advancing discovery.

00:01:02:10 - 00:01:39:25

Michelle Chamberlain

I want to make sure that I mention that in gratitude to the Del Mar Foundation, we have a one-on-one on one match that is in place so gifts made during this webinar series will be matched instantly doubling your impact. I hope many of you will consider making that gift and gifts of specific amounts may qualify for our Discovery Society, a loyal community that makes sure we provide meaningful connections, exclusive invitations, and early access to our research updates.

00:01:39:25 - 00:02:02:00

Michelle Chamberlain

So let's get started. I'm excited to share more about the Salk Institute, who we are ,and what we are about. So as many of you know, the Salk Institute is a non-profit organization. We focus on foundational understandings to address fundamental biological challenges.

00:02:02:00 - 00:02:23:20

Michelle Chamberlain

Everything we do at the Institute is about our research. Our pursuit of this foundational science is deeply rooted in the questions, the big questions that our researchers ask and the understandings that they publish for the world to build on.

00:02:23:20 - 00:02:47:00

Michelle Chamberlain

We have many examples, a couple of which are on your screen, but you can see for yourself how questions that have been asked sometimes decades before, lead to understandings that lead to translational therapies, technologies, and other procedures that we all benefit from today.

00:02:47:00 - 00:03:05:15

Michelle Chamberlain

Our incredible institute is not organized by departments. We are one team, and that team is supported by the brilliant architecture of Louis Kahn that puts collaboration at the heart of everything we do at the Institute.

00:03:05:15 - 00:03:36:08

Michelle Chamberlain

A plant scientist's lab is next to an immunologist's lab is across from a neuroscience lab, organically providing these moments of cross-disciplinary discussion and prompting novel approaches to today's research. Additionally, without the responsibilities of administration or teaching, our scientists can devote all of their time to the research that they are pursuing.

00:03:36:08 - 00:04:02:17

Michelle Chamberlain

Here's a snapshot of some of the areas that we like to focus on. As one of only seven National Cancer Institute designated foundational research facilities in the country, cancer is a focus of nearly two-thirds of our researchers. This work is closely related to our focus on healthy aging, which is further supported on our emphasis on the impacts of inflammation and immunity.

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Michelle Chamberlain

As you can see, none of these disciplines are studied in a vacuum. They all overlap and build on one another. Neuroscience and computational applications to our work are very important. And uniquely, as you will hear today from Dr. Strader, Salk's strength in plant science is world-renowned and unlocks many of the secrets of life itself. It's very much an underpinning of biology.

00:04:28:08 - 00:04:44:28

Michelle Chamberlain

Today at the Salk Institute, there's a wide range of questions that are being asked, and I hope that you will take a moment to review this list and imagine a world that we would all live in where there were answers to these questions.

00:04:44:28 - 00:05:05:25

Michelle Chamberlain

Imagine how different our day-to-day lives would be, how different our children's lives and our grandchildren's lives would be if we had answers to these questions and all of the incredible therapies and understandings that flowed from them. This is the work of the Salk.

00:05:05:25 - 00:05:43:18

So today we're joined by Dr. Lucia Strader. She is an expert in plant biology and her research aims to understand how plants use environmental clues to help them grow. She recently joined the Salk Institute from Duke University, and hopefully in her remarks, she'll share a bit more about her reasons for making the big move. We're certainly very fortunate to have her at the Institute. Dr. Strader, thank you for spending some time today. We look forward to your presentation and some active Q&A at the end.

00:05:43:18 - 00:06:00:22

Lucia Strader

Thank you, Michelle. I'm, as Michelle mentioned, I'm Lucia Strader and I'm really delighted for the opportunity to tell you today about the exciting plant research happening here at the Salk.

00:06:00:22 - 00:06:35:19

Lucia Strader

Get this over. So I've been deeply interested in plant biology for an incredibly long time, in fact winning the seventh grade science fair in the plant biology category. And this deep early interest in plant biology really stemmed from the fact that I grew up on a cattle ranch. And unlike most children growing up on a cattle ranch, I was not interested in how the cattle grew. Instead, I was really curious about how the plants were growing that were supporting our cattle. And this stimulated me to embark on a career-long journey to understand how plants work.

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Lucia Strader

As Michelle mentioned, six months ago, I moved my research program from Duke University to the Salk Institute. This move was really motivated by the many years of foundational studies that have happened here at Salk.

00:06:50:02 - 00:07:15:23

Lucia Strader

And along with the opportunity to be embedded in a research environment that fosters creative thinking and interdisciplinary approaches. And I'm really incredibly excited and honored to contribute more foundational studies to this chart. So hopefully by the end of my career, there'll be more discoveries from my lab that can add to this list of really excellent science in plant biology coming from Salk.

00:07:15:23 - 00:07:23:24

Lucia Strader

Okay, so I want to start with this image. And I'm asking you to think to yourself, what is this an image of?

00:07:23:24 - 00:07:42:25

Lucia Strader

Now, most of you are looking at this and thinking, it's a giraffe. And you would be wrong. This is actually an image of a vicious attack. So this giraffe is eating this poor plant, and if this were happening to us, we would run away from this attack, but plants can't do that because they're sessile.

00:07:42:25 - 00:08:07:06

Lucia Strader

So sessile is just a fancy word for organisms that can't move, and this sessile nature of plants dictates every aspect of their biology. This is from organism-level requirements, such as, you know, their adjustment to environments at a given location, how they disperse their pollen and seeds, and how they interact with other organisms, such as this giraffe here.

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Lucia Strader

But this is also true at the cellular level, because unlike in animals, where there's cell movement to support development, plants don't have this. Every cell is encased in a cell wall, so it's also sessile within the organism.

00:08:21:03 - 00:08:38:22

Lucia Strader

And this means that all materials within the plant have to move by mass flow. So for example, the roots take up water, the water moves by hydraulic pressure to the upper parts of the plant to provide water to the leaves to enable them to do their function. And there's no cell turnover to support aging and development.

00:08:38:22 - 00:09:10:22

Lucia Strader

So what this means is, unlike you or I, where we're born with every organ intact at birth, plants have to do everything differently. So they're born with this very simplified body plan, as you can see here in this young seedling.

00:09:10:22 - 00:09:46:15

Lucia Strader

Unlike humans, where we have all of our organs intact, plants are initiating and developing these organs throughout their lives. And this flexible development allows for plants to adapt to their changing conditions as they go throughout their entire life. And so if you look at a young seedling, you can see that there are these different parts of the seedling. And what we know as a scientific community is that there's a little niche of cells here from which all of the above ground parts of the plant develop. And there's a little niche of cells here at the opposite end of the seedling where all of the root systems develop.

00:09:46:15 - 00:10:28:24

Lucia Strader

And this development is really driven by the conditions in which the plant finds itself. Now, my lab studies this one plant hormone, auxin, auxin, the chemical that is auxin is indole-3-acetic acid, or IA, and my lab jokes that IA does not actually stand for indole-3-acetic acid, but instead stands for involved in almost anything, because it's been discovered over the past century of work that this one molecule, this really simple molecule, is somehow involved and interpreting any cue you might imagine, whether it's an environmental cue like temperature or light, a developmental program or water or nutrient status into the correct developmental output.

00:10:28:24 - 00:10:52:02

Lucia Strader

These developmental outputs can be quite different from one another. And so a central question in my lab is how can you have this one molecule that's doing everything, but it somehow does the right thing in the right place and at the right time? So today I'll tell you a short story about one of the projects we're working on to understand this and to do our work we use a model plant called Arabidopsis.

00:10:52:02 - 00:11:02:15

Lucia Strader

Arabidopsis is great because it's small. You can grow it on agar media as you can see here to the right and there's a lot of development that happens in a very short time period.

00:11:02:15 - 00:11:50:03

Lucia Strader

Now you can imagine this Arabidopsis seed all the way to the left at day one is like a miniature peanut. I'm sure many of you have eaten a peanut before and so a peanut has two halves to it just like our Arabidopsis seed has two halves to it and those two halves of the peanut are actually the seedling leaves so after germination that is what is providing the early photosynthesis to drive growth so you can see this here in our Arabidopsis seedling and in every peanut you have this little nubbin and that nubbin is actually the embryonic axis so that from one side of the embryonic axis all of the new above ground growth happens all the new leaves and stems. And from the other side, all of the below ground parts of the plant, the root system emerges.

00:11:50:03 - 00:12:13:08

Lucia Strader

And so we have this beautiful system where you have oxen regulating all of these processes to integrate all of the environmental cues into the final form of the plant. And here at Salk, we're really interested in using this foundational discoveries using Arabidopsis as a model to improve other plants, including crop plants, to help our farmers. So farmers...

00:12:13:08 - 00:12:27:24

Michelle Chamberlain

Could I interrupt you? We're getting a ton of questions, which is fantastic. And some of them are specific to what you just went through. So really quickly, before we move forward, what are some examples of developmental cues?

00:12:27:24 - 00:12:37:08

Lucia Strader

Great. So as you can imagine, plants have several things they want to do during their life, right?

00:12:37:08 - 00:13:18:12

Lucia Strader

As a plant, you want to make sure that you produce children. and those children are the seeds right so you'll want to make sure that you're producing those children under the best conditions so you'll have a developmental cue that says you want to reproduce so that your your lineage can continue in the environment. But you're also integrating that drive to reproduce with like seasonal cues. So you don't want to produce your seeds at the wrong time where you're leaving your seeds in an environment that's not conducive to their growth. So that would be an integration of two opposing cues. Like you have this developmental program, but you also want to make sure you're doing that at the right time.

00:13:18:12 - 00:13:20:15

Michelle Chamberlain

Fantastic. And then one more question on this segment.

00:13:20:15 - 00:13:20:28

Lucia Strader

Yes.

00:13:20:28 - 00:13:38:12

Michelle Chamberlain

In terms of the grow organs as their needed strategy, is that because of plants' nature of not being able to move and respond? Or is that because they can produce their own energy unlike animals so a little clarification there.

00:13:38:12 - 00:14:11:18

Lucia Strader

Yeah it is all of that. So for example, you've probably seen trees growing in a city where a new skyscraper is built and all of a sudden that tree no longer gets the same light that it did before right so it's going to have to completely change its architecture and its growth pattern in order to be able to capture that sunlight in a new place where it wasn't before, right. So that's an example of the tree can't just pick up and move to the park next door. It's going to have to like figure out how to capture the energy it needs in the place that it's located.

00:14:11:18 - 00:14:17:06

Michelle Chamberlain

Thank you, Lucia. And I'm going to say if it's a question that can wait until the end, but when there are these clarifying questions, I appreciate your flexibility.

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Lucia Strader

Interrupt anytime.

00:14:19:20 - 00:14:21:10

Michelle Chamberlain

All right, back on.

00:14:21:10 - 00:14:24:00

Lucia Strader

All right. Right.

00:14:24:00 - 00:14:46:16

Lucia Strader

So these foundational discoveries that we're making are really critical for understanding how to have resilient crops. So my parents actually have a tomato farm in Louisiana. And, you know, there's a lot of variable weather conditions. There could be a hurricane. There could be water extremes. Some years there's a drought. Some years there's too much water.

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Lucia Strader

Actually, oftentimes there's too much water in Louisiana. There's increasing pest and disease pressure. The soil health is really critical. So like having soil that supports the nutrient needs of the plants is really critical. And there's all of these pressures, all these environmental pressures that farmers are facing.

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Lucia Strader

And so a core tenet of my lab's research, particularly because I come from a farming background, is to really understand fundamentally how plants are taking these cues and integrating them into the final form of the plant so that they're really tuned to the environment that they're in properly.

00:15:24:09 - 00:15:52:12

Lucia Strader

Okay, so what is that environment? Let's come back to our lovely giraffe and think about what constitutes the environment of the plant there's obviously light so this can be the fluence or direction as in that skyscraper example where the direction of the light has changed so the plant growth has to change to accommodate that new direction the soil so the water availability nutrients, if there's an obstacle in the soil that the plant has to grow around, are important.

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Lucia Strader

Plants are constantly sensing gravity cues to know which way is up and which way is down. They respond to touch. They respond to temperature. Both absolute temperature and temperature fluctuations are being sensed by the plants all the time. And then, of course, we have other organisms like our lovely giraffe here or insects or the microbes and fungi in the soil.

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Lucia Strader

So understanding how plants are integrating all these really complicated cues is critical for ideal crop improvement. And here at Salk, we feel that one of our greatest responsibilities is to be good ancestors.

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Lucia Strader

As someone from a farming background, I also feel very strongly that the fundamental work that I'm doing should be applicable to real-world problems, particularly those my parents are facing. And so studying auxin, since it's such a central cue for all of these things, is really critical.

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Lucia Strader

I really love this video. This is a bunch of corn seedlings that have just germinated, and in this room, they only have one light source. They have this light bulb in the middle, and I almost feel like they're all, they're growing towards this light bulb, and they're all like worshiping this little bulb in the center of this pot, but they have two opposing cues, right?

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Lucia Strader

They have gravity that's telling the shoots to grow up, and they have this light causing them to grow inward. So light is overriding that gravity cue, but once the overhead lights are turned on in this room, you can see now gravity is the cue that it's using instead, and it's making a different growth decision. Instead of like prioritizing getting to light, it's prioritizing growing up and away from gravity cues.

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Lucia Strader

If you were here for the last webinar, you also learned that animals have a circadian clock. Similarly, plants have a circadian clock.

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Lucia Strader

Here's a sunflower plant that is tracking the sun over the course of a day. By the way, this is being caused by small changes in auxin signaling. So auxin is really critical in this process. And then you can see at night, the sunflower takes a little up and then before the sun even comes up it is repositioning its leaves to be ready to capture those very early first rays of sunlight and then it repeats that process every day and this positioning during the um before dawn to capture the early rays of sunlight is really driven by the internal clock of this plant. So this is something that's shared between plants and animals. And understanding this in plants has actually informed a lot of what we know for the human clock as well.

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Lucia Strader

So I mentioned earlier that auxin is involved in all of these processes, all of these cues. And I talked a little bit about light. But today, I really want to focus on a critical cue that has immediate real-world relevance. And that's nutrient acquisition by plants.

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Lucia Strader

So the nutrient that my lab is most interested in is nitrogen. Nitrogen is the nutrient that affects plant growth the most. It is a core component of every amino acid. It is essential to make DNA, and it's also a key element of chlorophyll, which is the green pigment that allows plants to capture some light and turn it into oxygen, or to capture CO_2 and evolve oxygen.

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Lucia Strader

In fact, many plants use a variety of strategies focused on nitrogen acquisition. Here are some interesting examples where you have these left two images that are of carnivorous plants. And so the strategy that they use is to eat insects in order to get nitrogen from them. This is obviously not the most common way that plants get nitrogen.

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Lucia Strader

You also have some plants like this peanut to the right that has a symbiotic relationship with bacteria that allow them to get nitrogen from the soil that would otherwise be inaccessible. So everything about a plant lifestyle is really focused on nitrogen because that is the most limiting nutrient that the plant has.

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Lucia Strader

Nitrogen fertilizers are widely used to improve crop yields, and those nitrogen fertilizers are enabled by a chemical process that was created or developed by Nobel laureates Fritz Haber and Carl Bosch. And it's essentially taking elemental nitrogen from the air, combining it with some hydrogen and resulting in an ammonium fertilizer.

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Lucia Strader

So to this day, this has been such an instrumental part of improving crops and increasing yields that today, 50% of the nitrogen in your body originated from this chemical process, because this is what has really enabled us to feed today's world's population.

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Lucia Strader

However, this fertilizer use has negative consequences. Two percent of the global energy goes to support this chemical process to make fertilizer.

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Lucia Strader

Only half of the nitrogen applied to crops is absorbed by the plants. So there's a huge inefficiency at this step. And then when that nitrogen is not absorbed by the plants, then it results in runoff into water sources and causes huge ecological pollution.

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Lucia Strader

So, for example, here off the coast of my home state, Louisiana, you can see that there's a dead zone off the coast that is caused by these algal blooms that are enabled by all of this nitrogen runoff from agricultural fields.

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Lucia Strader

So this is a major problem. If we want to support the sustainability of agriculture and productivity, we need to both understand how plants sense and absorb nitrogen so we can have plants that are using more of the nitrogen that is provided and using that most efficiently to support agricultural productivity.

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Lucia Strader

So this is a question that's really motivated our lab as auxin biologists, and auxin is involved in everything, to understand how nitrate and auxin are related. So nitrate, which is a predominant form of nitrogen for plants, is a mobile element. So it's soluble in water. So as water filters through the soil, the nitrate is moved with it. And what that results in is close to the soil surface, nitrate levels are quite low.

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Lucia Strader

However, other nutrients are high because most nutrients are not moving with that water through the soil. So we have this disparity of low nitrate, but high other nutrients close to the soil surface.

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Lucia Strader

In contrast, deeper into the soil, nitrate levels are quite high, but the other nutrients are low because they're not moving down into that section. And so plants with shallow root systems can access other nutrients but not nitrate so well, and roots with deep root systems, or plants with deep root systems, can access nitrate easily, but the other nutrients are low. So there's this conflict of what plants should decide to do to optimize their nutrient acquisition.

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Lucia Strader

So in my lab, we're mostly using Arabidopsis for a fundamental understanding of this. And when you look at these Arabidopsis seedlings all the way to the left that are grown in the absence of any sort of nitrogen, you can see they look really sad.

00:23:18:13 - 00:23:34:17

Lucia Strader

They're unable to do photosynthesis because they don't have enough nitrogen to make the chlorophyll necessary to capture sunlight. But as we increase the levels of nitrogen that we're providing them, you can see that these plants become much healthier over time.

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Lucia Strader

However, we noticed something really surprising when we were doing these experiments. And that is there is an unusual root type here that's arising right at the root shoot junction that had never been seen before. So this high nitrogen level in the media for the plants was promoting this new root type that's really not well understood.

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Lucia Strader

So my lab wanted to understand what was driving this, why this anchor root was emerging at the soil surface, and we hypothesized that because nitrate is typically not available to soil surface, when it is, the plants might want to optimize their root systems to capture that as soon as it can before it moves down lower.

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Lucia Strader

So to understand this, we wanted to understand what genetic pathways were regulating this process. and as a first step we decided to look at this other hormone called cytokinin. So cytokinin is auxin's enemy and you might want to think of it as the Joker to auxin as Batman.

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Lucia Strader

So everything that auxin is trying to do, cytokinin is working behind the scenes to try to thwart all of its activity and so we first looked to see what cytokinin or Joker was doing in this case. So in our wild type seedlings, we see increases in these anchor roots at these elevated nitrate levels. And when we blocked cytokinin response, so these are seedlings that can't respond to cytokinin properly, we see an increased number in these special root types. However, when we increase cytokinin response, we actually have a decrease in this nitrate responsive formation of anchor roots.

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Lucia Strader

So this data allowed us to understand that cytokinin was really affecting the plant's ability to sense nitrogen and then have that result in formation of the specialized root. So this data and several other data sets that we collected allowed us to build this genetic pathway from nitrate at the top all the way through to anchor roots.

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Lucia Strader

However, there's a piece missing, which is the star of our show, auxin. So how was auxin integrated into this? When we looked at another mutant that is hypersensitive to the effects of auxin, what we can see is it forms anchor roots at concentrations much lower than what wild type does. So auxin is promoting these anchor roots while cytokinin is opposing them. So we now have a good understanding of how these are working.

00:26:04:22 - 00:26:28:19

Lucia Strader

Indeed, when we look at this one factor involved in auxin and where it's expressed in response to nitrate, we can see that it's being turned on, particularly at the spot in the plant where anchor roots are being made. This is using a fluorescently tagged recorder so we can see where this gene is being activated. And you can nicely see it right here at the root shoot junction.

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Lucia Strader

And so all of this data together is allowing us to tease apart this really complex genetic pathway of these two hormones that are finding it out continually and making finely tuned root systems to nitrogen levels.

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Lucia Strader

And so we now have a deeper understanding of the study of how the balance of these hormones along with the levels of nitrate are allowing plants to make the right root system decisions on whether to have roots that are deep to look for deep nitrate levels or shallow because there's evidence to them that there's a shallow nitrate source. And this entire pathway is actually conserved throughout the entire plant kingdom.

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Lucia Strader

And so we questioned whether if this is working in Arabidopsis, whether this also works in other plants. And so our early data showed that indeed, this nitrate responsive anchor root formation was happening in canola and also in tomato. So we're pretty confident that because the conservation of these factors these genetic factors is held in all of these crop plants and because we have this entire pathway that we can really start to understand how to develop crops that are more finely tuned to capturing nitrate when it's available so that perhaps we can have crops that we can fertilize less and have them more efficiently take up the fertilizer that we're using to decrease the downstream effects of environmental algal blooms from excess nitrate.

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Lucia Strader

And this has really aligned, this goal of taking these foundational discoveries and translating them into real world problems is really aligned with Salk's Harnessing Plants initiative. So this is an initiative, I'm not in this photograph, this was formed before my recruitment to Salk. Hopefully in the next photograph, you will see my face off to the side, joining this group.

00:28:30:21 - 00:28:42:26

Lucia Strader

Salk is really focused on advancing these fundamental discoveries to create solutions for global challenges. And that's what the Harnessing Plants Initiative is really focused on.

00:28:42:26 - 00:29:13:02

Lucia Strader

We believe collectively that plants have so much potential. They're so important to our food, our fiber and our fuel globally, but we really need to understand them better before we can harness the tremendous potential they have, not only for discovering basically how life works, but also to drive that towards understanding how those discoveries can be impactful in a real-world setting. And we're actually doing this collectively as a team.

00:29:13:02 - 00:29:46:04

Lucia Strader

Salk has a strong initiative to move these foundational discoveries into crop plants to help farmers with real-world problems. The first set of this, I will have to say, unlike most ag tech companies that are really strongly focused on what you can see above ground, because that's easy, the scientists at Salk have a deep and really unique expertise in what is happening below ground when it comes to plants. This is the only place in the world where the expertise on the below ground hidden half of the plant is so strong.

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Lucia Strader

And by focusing on this, we can really understand how to improve root systems that support everyaspect of plant growth and nutrient acquisition. And so this is a strong focus of the Harnessing Plants initiative. And I'm really delighted to have moved to Salk to participate in this.

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Lucia Strader

The motto of HPI is where research takes root in the real world. The goals of Salk have been tremendously successful in this HPI effort. and we are already doing field trials and showing real world benefits to the Salk ideal plants that we have been developing. When I say we, I really mean I'm going to be participating in the future with some of my discoveries, but this has been ongoing here at Salk for the past seven or eight years.

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Lucia Strader

Yeah, and so we're uniquely qualified to do this, and we really collectively as a group have a vision and motivation to see this through to real-world applications.

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Lucia Strader

With that, I would be happy to take any more questions you guys might have. I'm going to disclose something before I answer questions, which is, please do not ask me questions about gardening advice. I'm the worst gardener you might imagine. I neglect every plant I've ever grown. I can tell you a lot about the biochemical reactions happening as my plants die, but I, I'm not a good person for how to grow plants better.

00:31:18:27 - 00:31:21:20

Michelle Chamberlain

Well, there's something that we have in common, Lucia.

00:31:22:07 - 00:31:27:05

Michelle Chamberlain

So we have a lot of, we have many questions in the chat. Thank you, everyone.

00:31:28:07 - 00:31:32:08

Michelle Chamberlain

Please navigate your way to the Q&A box at the bottom of your screen, and that should open an ability to input a question.

00:31:32:08 - 00:32:02:14

Michelle Chamberlain

Let's start with something a little bit more specific, and then we'll broaden out from that. So we have a question about weeds. And is there any evidence that weeds are inherently better at helping in the auxin cytokinin war to develop anchor roots, to extract as many nutrients as they can at the soil surface, given their penchant to be climate hardy?

00:32:02:28 - 00:32:36:25

Lucia Strader

Right. So, I mean, there's so many plants, including weeds, like weed is just a plant you don't want growing in a place where it's sprouted up. But there's so many plants, they're so well adapted and so driven to get all the nutrients before the plants next to it can, that understanding that fundamentally absolutely will enable us to, you know, understand basically how plants are working generally, and perhaps move some of that knowledge into crop systems so the crops can outcompete the weeds instead of the other way around.

00:32:36:25 - 00:32:48:26

Michelle Chamberlain

Love it. A question about how you ended this presentation. How might your discoveries translate into real improvements around food security or climate stress?

00:32:48:26 - 00:33:31:00

Lucia Strader

That's a great question. So I think that one of the, so roots have been really overlooked by the biotech industry and, you know, soils across different farming areas are so different from one another so the more fundamental knowledge we can gain of how these different decisions are made to really adequately capture the water the nutrients in the soil to support plant growth is going to be critical because we need to understand like in one state or one region of the the world like what are what's the ideal root architecture to support growth there versus elsewhere and right now we don't have um i mean we're building the foundational knowledge, but we don't fully understand things yet.

00:33:31:00 - 00:33:54:12

Lucia Strader

And so the more fundamental knowledge we can gain, the more that we can say, oh, if you're growing your plants in Maine, you might need a different root architecture than if you're growing in the Midwest. And what does that look like? And can we really select plants that are adequately tuned for that environment instead of just using the same traits everywhere and hoping it works out?

00:33:54:12 - 00:34:17:19

Michelle Chamberlain

Fantastic. Lucia, this next question really is close to my heart. We have a guest that's asking where the motivation for your work started and what I love about it is it asked was it scientific interest commercial or environmental impact etc so I think this is a really great opportunity not only for you to answer the question but for us to speak to the foundational research that's happening.

00:34:17:19 - 00:34:42:23

Lucia Strader

You know I think you know growing up in a, and I to be honest, like I I did not understand that being a scientist could be a career when I was a young student. I grew up in rural Louisiana. There weren't any other scientists for me to use as role models. And so honestly, my entire career has been curiosity driven. Like I just wanted to understand how things around me were working.

00:34:42:23 - 00:35:19:08

Lucia Strader

And then, you know, I majored in agronomy as an undergraduate, which is the study of farming. And when I did that, it really illustrated to me how little we know about how plants are actually growing. And so that motivated me to continue my career to really interrogate that very deeply while still having this agricultural background, which gives me a touchstone for what are the real world problems that farmers are facing so that our foundational research is always aligned with what the problems are. So that's, that might not be the fancy answer, but that's the truthful answer of how I got here.

00:35:19:08 - 00:35:25:27

Michelle Chamberlain

I love that. And when you're at Salk, Lucia, how are you deciding what questions you want to pursue exploring?

00:35:25:27 - 00:36:44:11

Lucia Strader

Yeah. So, you know, it's a lot of chance to, I mean, I hate to say it, but a lot of chance discoveries, even this nitrate responsive anchor root formation, we were interested in nitrate, but we, um, we didn't realize that that what was driving the effects of this, except that we changed water sources and our original water source had high levels of nitrate in it like as a background level because our purification system wasn't removing it and when we moved that nitrate went away and so the phenotypes of the plants completely shifted and it took us a while I mean it was an important crop trait but it took us a while to understand like what was this chance discovery like what was the source of it and now we understand that nitrate is the driver and we can now like apply that to crop plants. So some of what we're pursuing is like chance discoveries and observations that are leading us down new roads. Some of it is very intentional and like trying to understand environmental cues and how oxen is involved. And then a lot of it is also driven by chance conversations by with other scientists who might not even be plant biologists and borrowing tools from their systems to understand how our system works.

00:36:44:11 - 00:36:59:00

Michelle Chamberlain

And I will say, Lucia, because I truly believe this, what you're referring to in your mind as chance, very often I see as an intellectual curiosity that's just insatiable amongst our scientists.

00:36:59:00 - 00:37:01:16

Lucia Strader

Right. I don't like things I don't understand.

00:37:01:16 - 00:37:03:22

Michelle Chamberlain

I know that. I know that.

00:37:03:22 - 00:37:06:06

Lucia Strader

Why does this look different with different waters?

00:37:06:06 - 00:37:19:22

Michelle Chamberlain

The world is benefiting from that. There's a great question about the cohabitants of soil. So whether we're talking about bacteria, fungi, how do they harmoniously or destructively work with the plant roots in extracting nutrients?

00:37:19:22 - 00:38:26:15

Lucia Strader

Yeah, that's a really, really great question. So one of my colleagues, Lena Mueller, is a young faculty here at Salk that was recruited only a few years ago. And her research studies, these are vascular mycorrhizates. So these are specialized fungi that form a relationship with a plant host to help them actually acquire nitrogen, most specifically. And so the plant host benefits from getting a boost of nitrogen from this relationship and the fungi benefits because the plants are capturing sunlight and fixing those into sugars. And so they're giving a little sugar to the fungi. So they have this like relationship where it's like, I'll trade you some nitrogen if you trade me some sugar. So that's definitely happening in many plants and uh you know you can imagine it's a very complex soil is a very complex, very crowded environment with lots of microbes, lots of interactions happening, lots of deals being made between the plants and the microbes like we'll trade i'll trade you this if you give me that so i think it's a really exciting place to think about.

00:38:26:15 - 00:38:31:26

Michelle Chamberlain

Excellent, excellent. Well, there are just so many great questions here, but there is a question that I love that the author said that he hopes that this isn't a mean question to ask. But in terms of your example about the sunflowers, when a sunflower, when you said that a sunflower was changing its position proactively to capture the rays of the sun, if you turned that pot 180 degrees, would the plant still know to do that? how would it respond? And again, I don't think there was an experiment being planned here because the author of the question really did want to make sure that it was known it was coming out of their interests, not at a point.

00:39:14:12 - 00:39:39:20

Lucia Strader

Yeah, absolutely. So I think what would happen is that very first morning, the plant would be turned in the wrong direction. But plants are sensing the direction of light all the time. And so it would correct it in the next day. So like the first day I'd be confused, like, you know, the sun is pretty reliably coming from the same, you know, traveling the same art every day. So it would take like a, probably a day or so for it to like realize that that angle had changed.

00:39:39:20 - 00:39:49:01

Michelle Chamberlain

Okay. And is that tied in, Lucia, to some of when you referred to all the circadian rhythm that we covered in the last webinar?

00:39:49:01 - 00:40:52:00

Lucia Strader

Yes. So actually there's a study that came out about 10 years ago that showed that all of this circadian rhythm driven differential daily growth such as in the sunflower example is a circadian clock differently turning on oxen so that you're getting so in the sunflower example what's actually happening is like the different parts of the plant are growing at different rates at different times of day and that's what's causing the movement it's not actually like there's no muscles in the plant so it's not like moving its leaves it's actually moving because it's growing more quickly on one side and that's like shifting the final form of the plant and then it slowly grows faster on the other side to shift it in the other direction that's just happening on a daily basis for this to keep going and if you're really interested in sunflowers you might notice that when they get very old and then they're no longer actively growing they no longer track the sun because they don't have this growth that's happening to continue that to to be driven Right.

00:40:52:00 - 00:41:34:11

Michelle Chamberlain

A lot of questions on roots. So maybe we'll address a couple of them right now. I think we have some guests that are familiar with the Harnessing Plants Initiative at the Salk Institute. Fun fact, everyone, a multimillion dollar gift has been received for all of that incredible work that we'll be announcing soon. so keep your eye on it. But a question about subarin and in terms of how, what other benefits to the plant and the soil subarin presents beyond carbon sequestration. And also a question about absorbing the nutrients and is that happening all along the root branch or just at the bottom?

00:41:34:11 - 00:43:13:00

Lucia Strader

Yeah, those are both excellent questions. I'll address the subarin question first. So probably many people in the audience have never heard of subarin. Subarin is the form of carbon that's frequently found, for example, in the bark of cork trees. That's the main component of cork. It is highly resistant to breakdown by microbes, which is why it's used as a cork in wine bottles. But it's also forming a specialized layer in the root that prevents free diffusion of of molecules in and out of the root. So you can have specialized transporters that are taking up these nutrients and getting it past this diffusion barrier. So one of the goals of Harnessing Plants has been to increase the levels of subrin in those roots and to make those roots grow very deeply in an attempt to create plants that are putting carbon into a form that's not easily reclaimed back into CO2 in the air, and also stored deeply in the soil so that it's going to be a carbon reserve for a long time in the soil. That not only increases carbon drawdown by crops, but also increases the health of the soil to have a carbon source deep in the soil, because that actually keeps water in the soil for a longer period of time as well. So there's some long-term net benefits for this Salk-idealized plant with the deeper roots and the more suberin. So that's definitely already being deployed in the field by Salk scientists. And I've already forgotten the second question, Michelle.

00:43:13:00 - 00:43:22:00

Michelle Chamberlain

No, it was my fault for asking a compound question, Lucia. The second question was about nutrient absorption and if that's happening along the whole root branch or at the stem.

00:43:22:00 - 00:43:40:00

Lucia Strader

Yeah, so all parts of the root can absorb nutrients, but it's really mostly focused towards the tips. So, you know, the, the, the rate of nutrient, um, acquisition is more at the tips of the roots and you can have many lateral roots with like tips along the entirety of that root system, but it's everywhere can, it's just more efficient at those tips.

00:43:40:00 - 00:44:15:00

Michelle Chamberlain

Excellent. Excellent. Like I said, there are just so many fantastic questions in here. When we're looking at what you're studying in your model plant, there's a question, there's a couple of questions that allude to how our confidence level that that those findings will apply overall to crops or others in their native environment.

00:44:15:00 - 00:44:55:15

Lucia Strader

Right. That's an excellent question, too. There's recently been an assessment by the Arabidopsis community to look at all of the foundational work that was discovered in Arabidopsis and how well that is translated to crop plants. And pretty much all of the basic biology we've uncovered is conserved across all into crops. So those discoveries, particularly those involving the plant hormones, like the ones that I study, are easily translatable. There are, of course, some specialized cases that don't translate as well, but those foundational core discoveries havereally been instrumental for driving crop productivity.

00:44:55:15 - 00:45:53:00

Lucia Strader

So I'll give you a quick example from my PhD work. So in my PhD, I studied a different plant hormone, GA. So GA regulates how long a stem grows. and there were mutants in GA signaling that were found many decades ago now that resulted in much shorter stalks and this was completely just changing the response to this one hormone and those shorter stalks resulted in what's called the green revolution this using these mutations and all the grass crops, all the grains resulted in a doubling of crop productivity, right? And that was just changing the response to one hormone that had this dramatic effect to doubling yields of wheat and rice and maize. And so, you know, foundational discoveries in Arabidopsis have really immense effects on real world problems.

00:45:53:00 - 00:47:00:10

Michelle Chamberlain

Fantastic. There is one question here, and as the Vice President of Advancement, I'm not going to ignore it, about how private donations can help accelerate discoveries. And so I will certainly start off by just saying Salk Science has always been supported by a combination of federal money and private philanthropy. And especially with some of the uncertainties we've been seeing recently, the private philanthropy is incredibly important. But I'll also mention that some of the more novel questions that our scientists are asking and some of the more what we would consider risk-taking research that they're conducting is best aligned to private philanthropy. And we have hundreds of examples of where an early investment by someone who was very interested in the work or really believed in the curiosity and the efforts of a researcher has allowed research to move forward far enough that it then qualifies for some of the longer-term federal funding. So that partnership is very important to us. Lucia, I don't know if there's anything you want to add. I took it upon myself to answer that question first.

00:47:00:10 - 00:47:06:20

Lucia Strader

Yeah, I mean, I think in general, plant biology is less well-funded than other areas of biology in the U.S. And because of that, any funding is going to go to an important question, right? Whether that's coming from a federal source or from a private source, there are no small questions for us to be asking. There's only big questions. And so private funding can really drive some really large fundamental discoveries in plant science, particularly at Salk, where some of the top people in the world are here. And we're all asking really big questions. Like we don't want to ask the small fill in the blank questions, but like the big, like we don't even understand how this works types of questions.

00:47:48:14 - 00:48:06:09

Michelle Chamberlain

Great. Thank you. Two questions related to soil health. One is about what's the best balance of the different elements that spurs root growth and another is you know any ideas on that balance and what can the term used was turbo charge so turbo charge.

00:48:06:09 - 00:48:47:10

Lucia Strader

Yeah, so if you were interested in improving the soil in your home garden or if you're a farmer and you want to improve the soil and understand you can actually every state has a facility that will test the soil on your behalf so you can take a sample of your soil you can send it to that facility I'm I'm guessing in California that facility is going to be housed at UC Davis and they will test the soil for you and tell you which nutrients are abundant and which are lacking so that you can put the right type of fertilizer on your soil to make it the right environment for your plant of interest. And that's going to vary by your plant.

00:48:47:10 - 00:49:10:17

Lucia Strader

Like some plants like acidic soils, some plants like alkaline soils. Some need a lot of nitrate. Some don't need that much because there's other nutrients that are going to be limiting for their growth. So that's what I encourage people to do is like test your soil and don't assume that you just need nitrogen because that's what is in Miracle-Gro and that's what you get from the garden store.

00:49:10:17 - 00:49:36:05

Michelle Chamberlain

Excellent. This is a question about overall the plant adaptation. So through fossil roots or other sources, have scientists been able to understand how plants have adapted to past warming and cooling events on the planet and any of those applicable to be repeated potentially in the coming years or decades?

00:49:36:05 - 00:50:41:24

Lucia Strader

Actually, decades or centuries. I accelerated that question. Sorry to the author. Yeah, so that is a really big and very important question. So there's some ways we can get at that as scientists. One is an Arabidopsis. We have natural variations of plants of the Arabidopsis species that are growing in very different environmental conditions, and we can look to see what genes have changed over centuries and thousands of years to make that plant adapted to that one environment. So that's one tool that we use. And then the other tool that we use is we try to understand how different plants that grow in very different environments are doing that properly. But it's really hard to study the thing that doesn't exist anymore. So we can't study the plant that was here 500 million years ago, but we can study what was shared by that plant and all of the plants that exist today to understand what must have been driving some of the activity that long ago.

00:50:41:24 - 00:50:48:25

Michelle Chamberlain

Great. And speaking of research, Lucia, we have a question on what's next for your lab. What are you turning your attention to?

00:50:48:25 - 00:51:50:26

Lucia Strader

Yeah, so many exciting things since we've moved to Salk. One of the key discoveries we've made that I didn't talk about today because it's very much getting into the weeds of molecular biology is we have discoveries that allow us to tune gene expression in a very fine way so we can really dictate when genes are turned on so for example there's a key transcription factor called DREB2A that is the thing that allows plants to be resilient to heat and drought stress And we now have data in hand that tell us exactly how to change how strongly that transcription factor acts when a drought comes. So we can like have plants that are more drought resilient by making these small changes. So a lot of my work is really, you know, fundamental, like transcription is a fundamental process, but like trying to understand how that can be translated into a real problem.

00:51:51:11 - 00:52:08:12

Michelle Chamberlain

Excellent. Lucia, this is a fun question. one of our audience members says, given your decades of studying plants, what has been one of the most surprising things that a plant can sense or respond to that the average person might not even realize?

00:52:08:12 - 00:53:15:15

Lucia Strader

Yeah. So there's this really great study by a colleague of mine some time ago where she was studying the effects of another hormone on, um, on plant growth and development, except she didn't do the controls so like she had some plants where she was spraying the hormone on and she had the control plants that she wasn't spraying the hormone on and they were really different and then later when she repeated it she did the controls where she sprayed the treatment plants with the hormone and the control plants with water and it turns out they look the same those plants were actually responding to like the sensation of the water droplets hitting the plants so what she thought was the hormone turned out to just be the effect of like the droplets hitting the plants and they looked vastly different from each other so I think it was really surprising to me and the entire community when like it turned out plants were sensing touch and then changing their growth and response to something as simple as water droplets hitting them so you know plants are doing amazing things all the time and we just have to discover what they are.

00:53:15:15 - 00:53:32:20

Michelle Chamberlain

All right. I'm going to, I'm going to leave us on the cutting edge with this last question, but based on what you just said, we have an audience member that's interested in any sentient behavior that plants might demonstrate. Provocative question for sure.

00:53:32:20 - 00:54:29:07

Lucia Strader

Provocative. So plants, plants are always sensing their environment and plants can also communicate some of those environmental cues to one another so for example when there is an insect chewing on one plant that plant will release volatile hormones so airborne hormones that are put out into the air around it and they're sensed by neighboring plants and that volatile hormone is telling the neighboring plants hey i'm being chewed on you might be next and those other plants will start making compounds that decrease the nutrition value that they have for those chewing insects so they can't grow as fast if they're chewed on so plants can literally communicate those types of things to one another and I think that is the closest thing to sentient behavior I think we can we have evidence for.

00:54:29:07 - 00:54:43:03

Michelle Chamberlain

That's a fascinating response. Lucia thank you all right well thank you very much for your time. We're going to wrap up now. I want to make sure that we thank each and every one of you, but especially the Del Mar Foundation.

00:54:43:03 - 00:55:12:27

Michelle Chamberlain

Again, we have a fantastic match in place. It can double your impact on the research at the Salk Institute, research like Lucia's incredible work. I hope you will use the QR code or go to the salk.edu website and help support this incredible work that's happening. Like we say at Salk, this is really the foundation. This is where we're creating knowledge and providing it to the world to translate.

00:55:12:27 - 00:55:35:28

Michelle Chamberlain

Finally, I want to make sure that I mention that we have one more incredible webinar in this series. It will be on May 13th with Dr. Dan Hollern, discussing how we can turn the immune system against breast cancer. Certainly something that's very relevant in my life and the life of my family.

00:55:35:28 - 00:55:51:09

Michelle Chamberlain

I want to thank all of our Discovery Society members and our partners in research who have prioritized Salk Science and have joined us today. And until next time, thank you for your consideration of supporting Salk Science. Thank you to Dr. Lucia Strader, and we will see you soon.