2015 Gardens of the Galaxy: Food for the Future
Virtual Field Trip Transcript

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[Music]

[Trent Smith]: Well, good morning. And welcome to Kennedy Space Center. It's my great pleasure to welcome more than 75 sites and 2000 students here to the virtual field trip. And welcome to Kennedy, and I guess I've got Mars behind me. I'm going to talk to you a little bit about space plants and what we're doing on the international space station and what we're going to do on our journey to Mars.

My name's Trent Smith, and I am the veggie project manager. So you may have heard that NASA is working to go to Mars, and we are using the international space station as a laboratory and technology demonstration platform to do that. So we are building the technologies, learning our operations, and all of the things that we need to do in order to get there.

The international space station is a modular design. And over the course of the space shuttle program, we built it and completed in 2011. And it is almost a million pounds. It's going 17,000 miles an hour, and that is nine times faster than a bullet. We have six astronauts on orbit. We've had American astronauts and Russian cosmonauts on the space station continuously since 2000, November 1st of 2000. So it's chock full of laboratories. And so we perform a number of science experiments on the space station. One of the things that we have on the space station is veggie. And we launched veggie last year on a Falcon 9 rocket inside the Dragon capsule. And I've got a couple of photos of what a -- well, that's the exact rocket and capsule that we launched veggie in.

And just last year Steve Swanson grew our first crop of red romaine lettuce. And here he is. He's watering the plants so they'll germinate. You can see the light? Veggie utilizes red and blue LED's, because that's really all our plants need. White light, the green is -- they reflect the green. And so the green would be for you, perhaps, so you could see the plant.

Here is the space garden on space station. You can see space station is a lot of metal and plastic. And so having a little green garden can be important for astronauts.

Our first crop of lettuce after about a week, you can see the seedlings emerge from the plant pillows. Inside that plant pillow is the media, the growth media which is, I call it space dirt, so I get in trouble with the scientists, but it is a calcine clay. It has a controlled-release fertilizer. And we use that little wick to bring the water up to the seeds. And the combination of the light and the water trigger germination.

And in space there's no gravity. So the plants have to use other cues to figure out which way to grow. And so the chute grows towards the light and the roots will grow towards the darkness and the nutrient rich water in the plant pillow. And we actually put two seeds per pillow to ensure that we get good germination. And then Steve had to kind of select the ones he wanted, because we didn't want the plants competing for resources.

And here is what the little space garden looks like. So we have the bellows which help contain some of the humidity as the plants transpire. And the light and the plant pillows with the water inside. And this is after almost a month we had three good looking plants. We had watering issues. Two of our plants actually died. So, on this experiment, we actually were batting about 500. And so Steve took a lot of photos and enjoyed growing his space lettuce. And I'll let him say it.

Do we have audio? No audio, okay.

Well, so what Steve's calling down is he says he has his overalls on and he's all set. And here is Steve harvesting our first crop of red romaine lettuce. We have two astronauts. So this is pretty unique. Most of the time astronauts do not gather around the experiments. In this case we have three American astronauts. And actually off camera we have a cosmonaut. And there's Steve's red romaine lettuce. And so there's a nice photo. So, nice big robust red romaine lettuce.

And why red romaine? We chose red because it's high in antioxidants.

The red is anthocyanin which is an antioxidant. And if you're in a high radiation environment like our astronauts, having antioxidants might be a good idea.

And so that was our first crop and almost a year later we ran it again. Scott Kelly who is our one-year astronaut grew the second crop of lettuce. And he took a salad selfie the night before harvest. And this time we did much better. We had five healthy plants. And there you can see them in the garden so to speak. And this time they were allowed to eat it. We went through and we checked the food safety and microbial contamination and everything looked about as good as what you get in the grocery store.

And I'll let the video roll.

[Music]

All right. So that was our second crop of red romaine lettuce which our astronauts got to eat. And it was really important. When we send our astronauts out into space on long duration space missions, it's going to be important for them to have a fresh nutritious source of food to supplement their diets.

And why it's hard to grow space plants is because of the way water behaves in space. And so my challenge to you is to help us determine what seeds we should bring to Mars and help us figure out how we're going to grow them.

So I look forward to your questions. I'll be here. Submit your questions via text. And it is my great pleasure to turn it over to the plant pathology lab at the University of Arkansas in Fayetteville.

[Karen Ballard]: Welcome to the lab at the University of Arkansas here in Fayetteville. I'm Karen Ballard. I'm with the University of Arkansas Division of Agriculture and we're going to talk about something very important to you... eating.

I think that's important to everyone. But with all of the pressures that we encounter in our environment, whether it's pest pressure or environmental pressures, it's kind of hard to grow enough food to feed the world. And so you're going to be a part of that discussion today. It's going to be very important not just today but in your entire lifetime. So how do fewer farmers with less land feed an entire world? In fact the UN says that by 2050 we're going to have to feed 70 percent more folks on this planet. Well, the way that we're going to do that is good science. And it requires a partnership between farmers and scientists.

And right now I'm going to let you kind of be the fly on the wall to actually go behind the scenes with two wonderful scientists we have here in Fayetteville, Dr. Ken Korth and Dr. Burt Bluhm. And they're both plant pathologists. But if you're like me you might not know what that means so could you guys please explain to us what a plant pathologist does?

[Dr. Burt Bluhm]: Sure. So a plant pathologist studies diseases of plants. Plants get sick just like people do. And just like we need doctors for humans, we need plant doctors, so to speak. And so there's a wide variety of plant pathologists. There's a lot of expertise. My group studies fungal pathogens of plants.

[Dr. Ken Korth]: And my group focuses more on the host side of that equation. So plants just like animals also have natural ways to defend themselves against pathogens and deal with other kinds of stresses. So if you were on and you saw that video of the plants that were kind of dancing around to the music, you should have learned a couple things. So even though plants are stuck in the ground, they're active living organisms and they respond to their environment. So that's important to remember.

And then secondly you saw two different types of plants. And they responded very differently to their environment. And again that's important, all of that response and those differences depends on the genetic backgrounds that those plants inherited from their parents.

And so we deal here with all those sorts of stresses and again how those plants respond to them. So if you're a farmer or a gardener, you have to be concerned about those stresses. So insects for example always want to make a home for themselves in plants and want to eat plants. That has a huge impact on farmers and gardeners and on our food supply ultimately. Farmers in addition always have to be concerned about the weather, so things like wind, hail during thunderstorms, and then draught conditions, or too much water such as in this flooded field, can really cause problems for farmers.

[Dr. Burt Bluhm]: So as we mentioned earlier, you know plants get sick just like people do. As you can see on the slide sometimes the symptoms of diseases in plants look an awful like diseases of humans. So you can see chicken pox of humans on the left and then a disease on a plant on the right which also has lesions that are very similar.

[Dr. Ken Korth]: So for the rest of this virtual field trip we're going to talk a little bit about what stresses plants and how plant pathologists study those problems in the lab.

So I'm going to go down to the greenhouse. Burt's going to tell you about some of his work.

[Dr. Burt Bluhm]: Right. Come with me. I'll show you some of the fungi that we're working on and a plant disease as well.

So when you think about fungi, you might think about a mushroom. And that's a type of fungus. But a lot of the fungi that cause plant diseases are actually, take on a different morphology. And so this is an example of one of the fungi that we work with. Its scientific name is Fusarium graminearum. It causes a wide variety of diseases on many crop plants.

When you think about plant disease, you know, there's a lot of things to consider. And so you know when plants are sick, they don't perform as well. They don't yield as well. They don't produce as much food. And plant diseases can take on many shapes, whether it reduces yield or the quality of the food that's produced, or plants can die before they produce any food whatsoever.

An example here of a quality issue is purple seed stain of soybean. So you can see on the left we have healthy soybean seeds. And on the right, I hope you can see, that the seeds have a lot of purple discoloration. And this is because a fungus has entered these seeds and is producing a compound that reduces seed quality and also the viability of those seeds when they're planted in the future. So it's an example of a plant disease causing quality issues.

So you may think what do we do? You know when we think about human medicine we think about treatments and medicines, but there's a lot to human medicine as well where we're trying to prevent diseases. And one of the best remedies for plant diseases is better genetic resistance to disease. So this would be the idea of improving plants through genetics, which brings us to some of the core ideas that our research is essentially built upon.

And so you know I guess the first thing that's important to understand is that genes are the code. So that when you think of DNA which comprises the genetic architecture of all living organisms, then we have four bases, A, T, C and G. And these four bases form the language of genetics. So you can kind of think like the English alphabet where we have 26 letters and these letters form words; words form sentences; sentences, paragraphs; chapters, books, et cetera. The four bases of DNA basically encode genes; genes encode products that can form biological pathways. They can ultimately form higher levels of organization of tissues, organs, and beings.

So the genetic code is kind of similar. And what's really fascinating, to me at least about the genetic code, is that it's fundamentally conserved across life. And so a really good example of this is a green fluorescent protein of jellyfish. So you can see on the slide on the left are jellyfish. And so a lot of marine organisms deep in the sea where there's very little light produce bioluminescence. That's life produced light. And the green fluorescent protein of jellyfish for example is a protein that when excited by the right wave length of light glows fluorescently. And we can express these genes in plants. So when you see a plant that has the GFP gene from jellyfish, or fungi for that matter, it glows like a jellyfish, because that code is so conserved.

And you might ask: Well, why do this? You know why would you move a gene from a jellyfish into a plant or a fungus? And one of the reasons we do this, other than it just being fun and looking pretty cool, is that it allows us to study the biology in more detail.

And so for example, when we're trying to understand how fungi infect leaves, you can see from the picture on the slide, this is actually work that we've done here where we express GFP in a fungal pathogen. This is taken under a microscope, but we're looking at a leaf surface. So the gray in the background is the leaf surface. And the red arrow is pointing to an infection structure. This is called an appressorium. And this infection structure is what allows this fungus to basically sneak in to leaves through natural openings known as stomata. So this is very similar I guess in an analogy to if you left the door of your house open and a burglar walked in the door of your house because it was left open and went in and stole things. These fungi are basically, in some cases, using a similar mechanism to steal nutrients from their hosts.

So fungal pathogens as well as bacterial pathogens, and many other types of pathogens, are very small. They're often microscopic, but they're very sneaky. And they're very sophisticated in what they do. And so we use a wide range of molecular, genetic, and biochemical tools to try to understand disease and then with this knowledge improve genetic resistance.

So this is just kind of an overview of conceptually what we do in the lab. And we'll cut now to Ken in the greenhouse where he'll talk a bit more about what he's doing on the plant side of the equation to improve resistance.

[Dr. Ken Korth]: So I'm here in one of our research greenhouses on the University of Arkansas campus. And in here we can control the conditions for optimal plant growth. So that includes temperature certainly, but also light conditions. So plants conduct photosynthesis and all of life on earth depends on that to happen.

And on the face of it is a fairly simple equation, because all of the carbon that makes up this carrot and all of the carbon that went into this piece of wood all came from the atmosphere. Plants use energy from the sun to convert that carbon dioxide in the atmosphere into these structures you see here and into energy that the plants need but also energy as food that you and I need.

And so it's really important that we study this. A lot of you have probably seen the equation for photosynthesis. And again on the face of it, it's pretty simple. Carbon dioxide, water, again with that energy from the sun or from light is converted into glucose. So, again a sugar that's used for energy but also for structural components of the plant, and then again to also generate oxygen which obviously we depend on.

So plants of course as we've already told you have to worry about a lot more than just conducting photosynthesis. They have a lot of stresses in their environment. One of the stresses that we focus on in my lab is salt stress. So when salt is at a high level in fields, it can cause really big problems for crop production.

Here in Arkansas for example most of the soybeans that we grow here are irrigated. And most of that irrigation water comes from underground wells. Well, as that water is pumped up from underground, the minerals in that water and in the soil can accumulate on the surface. In a crop like soybean, it's fairly sensitive to salt stress or certainly it can be. And so we study mechanisms that the plants have to cope with that salt.

So here I have two different varieties of soybean. This is much as in that time lapse video. Both of these have been treated exactly the same. So for the past week or so we've been watering with some salty solutions, and so you can see this plant is very wilted. It's starting to turn yellow. In a few days this plant will be dead. This one, on the other hand, again with exactly the same treatment, looks nice and green. It's standing up right. And it's coping with that salt much better.

These two things are pretty closely related. There's only just a few differences in their genetic background. What we're trying to figure out and what we don't know and nobody knows is: What is the DNA code in this plant that makes it better than this plant? If we can figure that out, then we can work on our soybean breeders to incorporate that trait into soybean varieties that our soybean growers here in the state and really throughout the world could potentially use to grow crops under those stressful conditions.

So we use photosynthesis as a means to sort of figure out how healthy the plants are; how happy they are. We can also use other methods for that. So we have a specialized camera for example that measures infrared light. And so to the naked eye sometimes salt stressed plants can look identical. But if you look at those with infrared light, very often salt stressed plants, and other types of stresses do this as well, but those plants are hotter. They're not transpiring as much water. There's less water movement through the leaves. And so again we can visualize that with an infrared camera.

The nice deal about that is that we can now in the greenhouse look at thousands of plants at a time and pick out the ones that are more or less stressed. And again those would be the ones that we could potentially use as good parents for the next generation.

So, most of the gains that we've seen in food production over the last hundred years, and certainly since agriculture has begun, is all because of human intervention. Humans have taken advantage of natural variation in plants and selected, again, parents that would give the best offspring, the best offspring are selected, and in the next generation used again.

A great example of this is corn. If you look at the ancient ancestor of corn, Teosinte, it looks very different than modern corn. The structure of the plant is different. The grains are much smaller and very few what we would call ears on that plant. If you had to feed yourself or a population with plants like that, it would be very difficult. Corn is essentially a human created crop. It's been, again, those parents were selected and gave rise to modern corn with big ears, big grains.

Even within that crop, though, you can see tons of variations. So if you look at all of the different types of ears of corn that are out there and that have been selected over time, you see tremendous variation. Again all of that comes from the natural genetic variation that was present in that crop. And that's true for pretty much any fruit or vegetable crop or grain crop that we eat today. Humans have selected those.

So in recent years people have been able to take advantage of newer methods for introducing one or just a few genes at a time. And that gives rise to what most people call a GMO plant. So, a great example of this is GMO plants expressing a bacterial toxin called BT. So that toxin comes from a bacterium. The gene for that which encodes that protein toxin was transferred from the bacterium into crop plants. And so this had been done in a number of crop plants. So here's a photo of a cotton field that has been not treated with any chemical pesticides, but you can see on the one side, the insects have just decimated that cotton crop. On the other side you have the GMO, or BT-expressing crop, and again you see a much better yield there. If you're a cotton farmer, obviously you might want to utilize that GMO crop.

So it certainly has that advantage. Sort of the unseen advantage there is the environmental impact of using a crop like that. So again if the farmer in that case doesn't have to spray nearly as much chemical insecticide that means there's less chemicals going into the environment; they're not washing downstream, and you're not killing off a lot of the beneficial insects that are out there. So with chemical pesticides, especially insecticides, you very often kill the pest, but you also kill a lot of beneficial insects. And so if we can avoid that, that's always a desirable trait. BT is what we would call an input trait in the GMO world. So it was designed to help farmers to help grow that crop better.

More recently people in biotechnologists, plant scientists have focused a lot more on output traits. And a good example of this is golden rice. So, golden rice is a rice plant that's been engineered with just a couple genes taken from daffodil and from corn. They put it into rice to produce beta-carotene. Beta-carotene is a precursor to vitamin A that you and I need for good health and certainly for good development. And so that beta-carotene is a really important component of our diets.

In parts of the world where populations depend on rice for most of their calories, it's very common to have vitamin A deficiencies. And this is especially important in children. So if kids don't get enough vitamin A as they're developing, they get all kinds of health problems, including and especially vision problems and ultimately blindness. So the idea with golden rice is to engineer the crop, get it into a food that people are already consuming, and they're already growing in their communities. And so the hope is to get it out there and help people with that.

Other examples of this are cassava which is grown over large parts of Africa. It's a staple tuber crop that's grown there. Very high in carbohydrates, but very low in a lot of important minerals again that humans need. And so efforts are going on there.

Another example is high antioxidant tomatoes. So these tomatoes have been engineered to make, again, some of that purple die that Trent mentioned earlier, anthocyanins that can really boost the antioxidant levels of that particular plant.

So I hope that gave you a little bit of an idea of kind of some of the work we do here in the greenhouse and again in the lab. I'm going to turn it back to Burt. He's going to tell you about one of the methods that we use to get DNA into those plants.

[Dr. Burt Bluhm]: Getting DNA into plants, into their genome, it can be a little bit tricky. And there are different methods to do this, but one of the ones that's widely utilized relies on a technology called a gene gun. And when you, I don't know you might have a mental image of a gene gun looking like a shotgun or you know something that you would use for hunting. And it's not really quite like that but some of the concepts are similar.

So in this diagram that's coming up on the screen, you can see that the way the gene gun works is that instead of a cartridge propelling the DNA, there's actually a compression of gas that, helium in this case, that forces the DNA in kind of a shotgun spray into your target tissue. And you can see the picture of the gene gun here on the right. So it's not quite like a firearm, but it's interesting to note that some of the very first gene guns actually did use 22 caliber cartridges, that kind of force is required.

So we'll cut over to a video where one of my graduate students will demonstrate the gene gun in action. And so in this first step you pipette the DNA mixed with gold particles onto a rupture disk. And gold is used not just because it's expensive but because it's an inert metal that doesn't harm the cells; the DNA binds to it, but releases from it when it gets into the cells. And so he's pipetting that on this rupture disk, the orange disk that you can see in the slide.

So this step is essentially where you basically load the chamber of the gun, so to speak, just like you would chamber up a bullet. This is the step where the DNA is placed into the chamber. And it's a little bit tricky to get that. Ah, you'll get it. Give it another try there. And so that's placed into the chamber which is then tightened up and slid into the gene gun itself.

So the next thing that we'll see here is callus tissue of a plant. This is basically like human stem cells in a way in that these are undifferentiated cells that can become a plant in the future. So now what they're doing is allowing the pressure to build up and then basically pulling the trigger so to speak. And when the pressure is down to zero, the DNA has been propelled like a shotgun blast into this callus material. And so the DNA is now integrated into some of these cells in the callus. And what we do is we can select for the ones where it's integrated and we regrow little plantlets from the callus material by applying natural plant hormones. And these are examples of what you can see on the screen right now.

So I hope that gave at least an overview of the type of work that we're doing here at the University of Arkansas in the plant pathology department. And Ken has rejoined me from the greenhouse. We're sure that you may have some questions about things that we talked about and maybe questions about things we didn't have time to mention today. So we're here to answer questions and keep those questions coming in.

[Hayley Jernigan]: Okay. Awesome, great job, you guys.

Okay. First we've got tons of questions coming in. And I just want to remind all of our great question askers that we will be answering the questions that don't get answered live via text as well as via Email after this broadcast completes. First question is from Amber Johnson. How are they watering the plants on the ISS?

[Trent Smith]: All right. So the way that we're watering plants on the space station or we were when we had the experiment going on is we actually have a passive water reservoir which wicks water to the plant pillows underneath. And after a couple weeks that doesn't seem to work as well. So what we actually asked the astronauts to do is come with a syringe and a water bag and we actually do top watering. On the plant pillow there's a little white quick disk connect, and we actually connect a water bag. We use a syringe and we actually pump water into the plant pillow. So it's a labor of love for the astronauts.

[Hayley Jernigan]: Okay. Great, Trent, thanks.

Well, hey, Logan wants to know isn't the water recycled from urine and just everything that contains water?

[Trent Smith]: You bet. Today's coffee becomes tomorrow's coffee for astronauts. So yeah, but it's water. So we purify it. And they actually go to the galley. They go and get water for the plants. And we recycle on space station, about 93 percent of the water is recycled. And so what's really nice about the plants is as they transpire, we capture that water and we recycle it. And when we go to Mars we're going to need about 99 percent efficiency, because water is heavy. So yes, we absolutely recycle our water on space station.

[Hayley Jernigan]: Oh great.

Okay, next question is from Alexandra and she asks: How does gravity change how a plant grows?

[Trent Smith]: That is an excellent question. And so it depends on the plant. We have found that for the lettuce plant, it doesn't seem to change that much as far as texture and nutrient content and microbial ecology. So what that means is my ground control plants and my space plants look pretty similar. And according to the astronauts they taste pretty similar, at least how they remember red romaine lettuce, it was crunchy. But plants that grow long stems or like a sunflower, actually Don Pettit grew a sunflower, and in that case had a very wispy stalk. So in the case of maybe a tomato, it might have a little different flavor. We don't know. The answer is not in the back of the book, and we're going to go find out.

[Hayley Jernigan]: Okay. Well, Trent, Ben's asked the question we all want to know: Do you think there's going to be life on Mars?

[Trent Smith]: My personal thought is I would be surprised if we didn't find some microbial, some small simple life out in the solar system. And my hope is that, yes, we'll find it. And the announcement that we do have flowing water on Mars, just more help for my Martian gardens that we'll hopefully be doing here in the next couple decades.

[Hayley Jernigan]: Okay, great. Thanks, Trent. Okay. Well, I've got a few questions for our lab, too. First of all Priscilla wants to know: Why do we need soybean fields?

[Dr. Ken Korth]: Oh gosh, soybeans are a really important crop. Again here in Arkansas they're one of our major crops and really in the U.S. and worldwide. They're used in all sorts of applications, certainly for food in humans. They're a very high protein, high oil crop. So you may not realize it, but you're eating soybeans almost every day, pretty much most of the processed foods that you eat contain some component that probably came from soybeans. In addition to that you can generate bio-diesel fuel from soybeans. They're used in plastics. And so they have all kinds of applications and are really valuable again to our state and to the country.

[Hayley Jernigan]: Okay, great. Thanks, Dr. Korth.

Andre from Little Rock Central High wants to know: Who discovered soybeans could be used for food and so many other purposes?

[Dr. Burt Bluhm]: That's an interesting question. So soybean was domesticated a long time ago in China and has radiated out all over the world from there. So I think we have the Far East, the early farmers of the Far East to thank for the development of soybean, at least the initial domestication.

[Hayley Jernigan]: And we've got time for about two more. So the next one I have is from Jessica, and she asks: Do GMO's retain all nutritional value and their origin properties?

[Dr. Ken Korth]: Yeah, as far as we know there are no substantial differences between GMO crops and the conventional varieties, their equivalent conventional varieties. The exceptions there obviously would be things like the high anthocyanin crops or some of those output traits that we talked about. But, no, the regulations here in the U.S. certainly are that basically those crops are not substantially different from the conventional crops. And that's held up in all kinds of laboratory testing.

[Hayley Jernigan]: Great, Dr. Korth. Thank you.

And, Tal from Pottsville asked a question I want to hear from all three of you on: So where will the future of the GMO's take us?

[Dr. Burt Bluhm]: Yeah, I guess I could start. So you know I think there's -- the possibilities are boundless. So GMO's as far as traits to maximize the efficiency of nutrient utilization, disease resistance, possibly adapting crops for places where they hadn't evolved to be originally, I think the future is very bright.

[Dr. Ken Korth]: And I certainly agree with that. I think as we've tried to point out this is another tool for plant breeders and people involved in agriculture. This is a step forward. Again all of the food that we eat is only around today because humans developed new techniques and new ways to select for bigger and better plants. And again it's going to be really important, as Karen mentioned, we've got a growing population. And we've got you know shrinking amounts of land or at least finite amounts of land. And so it's going to be important to at least explore other possibilities, other possible techniques. GMO's are one of those.

[Hayley Jernigan]: And lastly, Trent, how about you? Where will this future of GMO's take us, to infinity and beyond?

[Trent Smith]: I'm saying to Mars.

[Chuckles]

I'm saying to Mars.

[Hayley Jernigan]: Awesome. Thank you so much. And that's all of the time we have for our questions, folks. But don't forget, keep submitting them and we will get your questions answered via text after our broadcast ends. Your questions will all be answered.

[Karen Ballard]: Thank you, Trent, and Burt, and Ken. There's one more discussion that we need to have before we tune off, and that's a discussion with you. Because this is not just about the work of these scientists at Kennedy Space Center and here in Fayetteville, it's about your work as a young scientist, because you are the future. And we need you to continue this process. The farmers across the state and the country need you to ask tough questions and come up with solutions.

So Blake is going to explain to you exactly how you can get involved.

[Music]

[Blake Bennett]: Hi. I'm Blake Bennett. I'm a fourth generation farmer from Pocahontas, Arkansas. I'd like to personally invite you to learn more about the improvement of soybean production for the Arkansas economy and the potential opportunity for science-based careers available in Arkansas. The Soybean Science Challenge is a program for ninth through twelfth grade students and teachers that include online education and cash awards for student research at Arkansas ISEF affiliated regional and state science groups.

We often refer to soybeans as the miracle bean because of their many uses for human food, renewable fuel, and animal feed, but there's still a lot to learn. And that's where you come in. Each year of the Soybean Science Challenge provides cash awards in student research. If you love science then, you'll want to check out the Soybean Science Challenge.

[Announcer]: Paid for by Arkansas soybean producers and their checkoff funds.

For more information about the soybean science challenge go to uaex.edu/soywhatsup.

[Karen Ballard]: I want to thank the teachers out there who have made this possible. A big round of applause in your classrooms for the ag teachers, the science teachers, the counselors all across the state and in several other states.

One of the things I want you to do is think about how you can get involved.

I hope to be seeing your faces this spring at science fairs. I've got thousands of dollars to give away to you students. So surely, surely someone can use a little extra cash. But more importantly we need your minds, your thinking, your exploration, and your ideas, because the Soybean Science Challenge is about students creating knowledge not just receiving knowledge.

Thank you for joining us today, and we look forward to seeing you in the spring.

[Music]

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