WEBVTT - https://subtitletools.com

00:00:00.492 --> 00:00:03.492 (students chatting)

00:00:04.640 --> 00:00:07.070 - [Kai] Yeah, I think we can start now.

00:00:07.910 --> 00:00:11.230 And so welcome everyone to today's seminar,

00:00:11.230 --> 00:00:14.230 hosted by the Yale Center on Climate Change and Health.

00:00:14.230 --> 00:00:17.550 So, I'm Dr. Kai Chan,

00:00:17.550 --> 00:00:20.090 Assistant Professor of the EHS Department.

00:00:20.090 --> 00:00:23.120 I'm also the Director of Research for the center.

00:00:23.120 --> 00:00:24.960 So today, we are very honored and prepared

00:00:24.960 --> 00:00:29.960 to have Dr. Lewis Ziska come to give us today's lecture.

00:00:30.690 --> 00:00:34.550 So Dr. Ziska is a professor at the Mailman School

00:00:34.550 --> 00:00:36.560 of Public Health at Columbia University.

00:00:36.560 --> 00:00:41.331 So before joining Columbia, he was a senior scientist

00:00:41.331 --> 00:00:45.450 at the US Department of Agriculture for nearly 25 years.

00:00:45.450 --> 00:00:48.620 So he's one of the most leading experts

00:00:48.620 --> 00:00:53.060 on the effects of climate change on plants and agriculture.

00:00:53.060 --> 00:00:56.317 So, without further ado, let's welcome Dr. Ziska.

00:00:56.317 --> 00:00:59.470 (students applauding)

00:00:59.470 --> 00:01:00.370 - [Lewis] Thank you, Professor Chan,

00:01:00.370 --> 00:01:02.423 I appreciate the opportunity to be here.

00:01:04.070 --> 00:01:06.099 The good news is you've got free food.

00:01:06.099 --> 00:01:07.070 (students laughing)

00:01:07.070 --> 00:01:09.870 The bad news is you've got to listen to me lecture so...

00:01:13.062 --> 00:01:16.580 I wanted to look at the nexus between climate change,

00:01:16.580 --> 00:01:19.430 rise in carbon dioxide and public health

00:01:19.430 --> 00:01:22.570 and just sort of give you a sense of the range

00:01:22.570 --> 00:01:25.720 of different consequences associated with it.

00:01:25.720 --> 00:01:30.697 So we have the good, we have the bad, and we have the OMG.

00:01:31.890 --> 00:01:34.670 So, I want to go through and talk about some of the work

00:01:34.670 --> 00:01:38.200 that we've been doing on all of these different aspects.

00:01:38.200 --> 00:01:40.260 Before I do that, however, I wanna make sure

00:01:40.260 --> 00:01:42.980 that we're all on the same page when it comes

00:01:42.980 --> 00:01:47.290 to defining what we mean by climate change.

00:01:47.290 --> 00:01:51.530 So, we know that carbon dioxide is going up.

00:01:51.530 --> 00:01:55.890 This is a recent Keeling Curve, where you can see

00:01:55.890 --> 00:01:59.513 that we're getting close to about 410 parts per million.

00:02:00.690 --> 00:02:03.660 In my lifetime, the amount of carbon dioxide is increased

00:02:03.660 --> 00:02:07.850 by about 30% and the reason why is not difficult.

00:02:07.850 --> 00:02:10.860 It turns out that if you take a carbon source,

00:02:10.860 --> 00:02:13.763 fossil fuel source, and you oxidize it, you burn it,

00:02:14.760 --> 00:02:18.107 carbon-oxygen, yeah carbon dioxide, who knew?

00:02:19.105 --> 00:02:21.480 So, if you look at, this is a little bit out of date,

00:02:21.480 --> 00:02:24.360 but if you look at where the carbon dioxide comes from,

00:02:24.360 --> 00:02:28.070 again, oxidation of fossil fuels and cement production

00:02:28.070 --> 00:02:30.820 in calcium carbonate, one of the offshoots

00:02:30.820 --> 00:02:33.600 of calcium carbonate is carbon dioxide.

00:02:33.600 --> 00:02:35.630 Land use change, where does it go?

00:02:35.630 --> 00:02:39.270 About 50% of it stays in the atmosphere, about 25% of it

00:02:39.270 --> 00:02:41.880 goes back in the land through photosynthesis,

00:02:41.880 --> 00:02:44.640 and about 25% of it is dissolved into the oceans

00:02:44.640 --> 00:02:46.090 where carbon dioxide and water

00:02:46.090 --> 00:02:47.913 is formed (mumbling) acid.

00:02:48.850 --> 00:02:51.690 Okay, so...

00:02:51.690 --> 00:02:54.510 here are as we know,

00:02:54.510 --> 00:02:58.400 this particular change is recent.

00:02:58.400 --> 00:03:01.000 This is the highest carbon dioxide that we've experienced,

00:03:01.000 --> 00:03:03.470 at least in the last million years.

00:03:03.470 --> 00:03:05.860 We know where it comes from, where is it gonna go?

00:03:05.860 --> 00:03:08.927 Well, depends on which model you happen to believe in.

00:03:08.927 --> 00:03:11.020 And I won't go through all the different models.

00:03:11.020 --> 00:03:12.520 We'll look at the green one down here.

00:03:12.520 --> 00:03:15.880 We'll call this everyone drive a Prius and Hans model,

00:03:15.880 --> 00:03:18.820 and that so far is not working out.

00:03:18.820 --> 00:03:21.460 We have the business as usual model here,

00:03:21.460 --> 00:03:25.240 and that may not be working out because that's depending on

00:03:25.240 --> 00:03:28.720 a certain amount of coal usage, and that's been going down,

00:03:28.720 --> 00:03:31.830 but there's still a bit of uncertainty about the fact,

00:03:32.937 --> 00:03:34.610 particularly in regards to methane,

00:03:34.610 --> 00:03:36.460 but there's no question that it's going up.

00:03:36.460 --> 00:03:38.027 If we just do the rule of thumb, it's going up

00:03:38.027 --> 00:03:40.190 two to three parts per million per year.

00:03:40.190 --> 00:03:43.410 We have about 80 years left, so it can range anywhere

00:03:43.410 --> 00:03:47.313 from 160 to 240 parts per million higher than it is today.

00:03:49.190 --> 00:03:52.450 Okay, so why should you give a flying fig

00:03:52.450 --> 00:03:55.620 whether carbon dioxide is 300 or 400 or 500,

00:03:55.620 --> 00:03:58.180 what difference does it make, right?

00:03:58.180 --> 00:03:59.177 Well, it makes two differences.

00:03:59.177 --> 00:04:02.920 The first one has to do with the physical aspects

00:04:02.920 --> 00:04:06.116 of increasing these particular gases.

00:04:06.116 --> 00:04:09.600 We know that the atmosphere consists of certain gases.

00:04:09.600 --> 00:04:13.150 Most of those we are familiar with, but there are two

00:04:13.150 --> 00:04:16.063 that we consider to be global warming gases.

00:04:17.500 --> 00:04:19.290 What does that mean exactly?

00:04:19.290 --> 00:04:21.790 What makes it a global warming gas?

00:04:21.790 --> 00:04:23.940 Well, to answer that question,

00:04:23.940 --> 00:04:25.843 I will, of course, turn to music.

00:04:26.900 --> 00:04:30.060 How many of you have ever played a string instrument?

00:04:30.060 --> 00:04:32.363 Excellent, so I'm gonna turn this over to you.

00:04:34.200 --> 00:04:36.250 Suppose for the sake of argument

00:04:36.250 --> 00:04:40.830 that I tune two strings to the same frequency, okay?

00:04:40.830 --> 00:04:42.950 Let's say A 440 Hertz, all right?

00:04:42.950 --> 00:04:43.820 So you have two strings

00:04:43.820 --> 00:04:45.960 that are tuned to the same frequency,

00:04:45.960 --> 00:04:49.273 and I pluck one string, what will the string next to it do?

00:04:51.833 --> 00:04:53.010 - [Female Voice] Suddenly vibrate?

00:04:53.010 --> 00:04:54.690 - [Lewis] It'll vibrate, it'll resonate, it'll absorb

00:04:54.690 --> 00:04:57.110 some of the energy from the first string.

00:04:57.110 --> 00:04:59.543 What if I'm a Methodist, will that still work?

00:05:00.870 --> 00:05:01.703 - [Student] Yes.

00:05:02.570 --> 00:05:04.479 - [Lewis] What if I'm a republican?

00:05:04.479 --> 00:05:05.630 (student laughing)

00:05:05.630 --> 00:05:06.463 - [Student] Yes.

00:05:06.463 --> 00:05:07.900 - [Lewis] Are you telling me that the laws of physics

00:05:07.900 --> 00:05:09.750 are independent of religious denomination

00:05:09.750 --> 00:05:10.840 and political affiliation?

00:05:10.840 --> 00:05:12.816 Oh my god, you have no idea.

00:05:12.816 --> 00:05:13.649 (students laughing)

00:05:13.649 --> 00:05:15.930 Oh wait, no, that isn't how it works, is it?

00:05:15.930 --> 00:05:17.730 Sorry, I've been in DC for too long.

00:05:18.910 --> 00:05:20.160 Yeah, no it's absolutely true.

00:05:20.160 --> 00:05:21.510 So, what does this have to do

00:05:21.510 --> 00:05:22.760 with being a global warming gas?

00:05:22.760 --> 00:05:27.760 Well, it turns out that in addition to music,

00:05:28.440 --> 00:05:30.800 molecules also resonate.

00:05:30.800 --> 00:05:33.910 They don't resonate in the key of A,

00:05:33.910 --> 00:05:37.490 but they resonate in the key of infrared, or heat.

00:05:37.490 --> 00:05:40.800 So whenever heat is experienced by one of these molecules,

00:05:40.800 --> 00:05:43.360 it resonates, it absorbs some of that energy

00:05:43.360 --> 00:05:48.030 that would otherwise be lost, does that make sense?

00:05:48.030 --> 00:05:50.110 Good, this has taken an entire semester

00:05:50.110 --> 00:05:51.343 of physics and atmospheric chemistry

00:05:51.343 --> 00:05:53.443 into five minutes so please forgive me.

00:05:55.040 --> 00:05:57.100 - [Lewis] So the two major greenhouse gases

00:05:57.100 --> 00:06:00.470 are carbon dioxide and water vapor, humidity, if you will.

00:06:00.470 --> 00:06:01.660 All right?

00:06:01.660 --> 00:06:05.180 So as this change in carbon dioxide occurs,

00:06:05.180 --> 00:06:07.590 that's not a bad thing because

00:06:07.590 --> 00:06:10.140 there's a natural greenhouse effect.

00:06:10.140 --> 00:06:13.990 If there were no carbon dioxide, the average temperature

00:06:13.990 --> 00:06:17.560 on the earth would be about minus 80 degrees Celsius.

00:06:17.560 --> 00:06:20.903 So, by having carbon dioxide, by having water vapor,

00:06:22.010 --> 00:06:23.943 you have a livable environment.

00:06:24.820 --> 00:06:25.657 But I think you can see that

00:06:25.657 --> 00:06:29.490 this sort of a Goldilocks principle that occurs here, right?

00:06:29.490 --> 00:06:31.243 Too little, too much.

00:06:32.700 --> 00:06:35.603 So, we're seeing the earth warm up,

00:06:36.660 --> 00:06:39.580 but it's not warming up the same everywhere, is it?

00:06:39.580 --> 00:06:42.650 Some areas are warming up faster than others.

00:06:42.650 --> 00:06:44.120 Why?

00:06:44.120 --> 00:06:46.170 Well, if it was the sun, then the equator

00:06:46.170 --> 00:06:49.140 would be warming up very fast.

00:06:49.140 --> 00:06:51.383 It's not, what's warming up the fastest?

00:06:53.000 --> 00:06:55.090 What area of the world is warming up quickly?

00:06:55.090 --> 00:06:57.790 - [Male Student] The poles. - [Lewis] The poles.

00:06:57.790 --> 00:06:59.290 They get the least amount of sun,

00:06:59.290 --> 00:07:01.203 how come they're warming up so quickly?

00:07:03.270 --> 00:07:06.256 Wait a minute, I said there were two, there were two

00:07:06.256 --> 00:07:09.214 greenhouse gases, weren't there?

00:07:09.214 --> 00:07:12.350 And, water vapor's one of the greenhouse gases,

00:07:12.350 --> 00:07:16.350 so where on the globe is water vapor dominant,

00:07:16.350 --> 00:07:17.873 the dominant greenhouse gas?

00:07:21.560 --> 00:07:23.490 Where's the air warming unit?

00:07:23.490 --> 00:07:25.709 I'm not trying to trick you.

00:07:25.709 --> 00:07:28.290 - [Female Student] Equator? - [Lewis] At the equator.

00:07:28.290 --> 00:07:32.700 So at the equatorial regions, where it's warm and wet,

00:07:32.700 --> 00:07:33.940 you already have water vapor,

00:07:33.940 --> 00:07:35.990 it's the dominant greenhouse gas.

00:07:35.990 --> 00:07:39.090 Adding more CO2, yeah, it's gonna get warmer and wetter.

00:07:39.090 --> 00:07:40.720 Is it gonna rise very quickly?

00:07:40.720 --> 00:07:43.450 No, it takes a lot more energy to move something

00:07:43.450 --> 00:07:45.190 that has a lot of water in it, right?

00:07:45.190 --> 00:07:46.540 Because water absorbs heat.

00:07:48.560 --> 00:07:51.763 Okay, so we got a big change in the tropics.

00:07:52.750 --> 00:07:54.710 Where is the air dry

00:07:56.150 --> 00:07:58.530 and therefore adding more carbon dioxide would be

00:07:58.530 --> 00:08:01.623 the primary driver, in terms of surface temperatures?

00:08:03.220 --> 00:08:04.520 You already mentioned one.

00:08:08.910 --> 00:08:09.743 The Poles.

00:08:12.890 --> 00:08:16.290 When the air is cold, is does not pull a lot of water vapor

00:08:16.290 --> 00:08:18.580 and therefore adding more carbon dioxide is going to have

00:08:18.580 --> 00:08:21.700 a major effect in terms of surface temperatures.

00:08:21.700 --> 00:08:23.723 Where else is the air dry?

00:08:28.613 --> 00:08:29.446 - [Student] The surface. - [Lewis] I'm really not

00:08:29.446 --> 00:08:33.088 trying to trick you, this is just basic high school biology.

00:08:33.088 --> 00:08:34.140 - [Student] The desert.

00:08:34.140 --> 00:08:34.973 - [Lewis] Pardon?

00:08:34.973 --> 00:08:35.880 - [Student] Someone said desert.

00:08:35.880 --> 00:08:37.820 - [Lewis] Deserts, excellent.

00:08:37.820 --> 00:08:38.653 Deserts.

00:08:39.512 --> 00:08:41.490 So what do we expect to see with more carbon dioxide?

00:08:41.490 --> 00:08:43.410 Increased desertification, right?

00:08:43.410 --> 00:08:44.860 Deserts are gonna get bigger.

00:08:45.720 --> 00:08:47.560 Makes sense so far?

00:08:47.560 --> 00:08:49.877 Okay, gonna add a little bit more to this.

00:08:49.877 --> 00:08:53.160 If you go up in elevation and altitude,

00:08:53.160 --> 00:08:55.430 as you move up in altitude the air becomes dryer,

00:08:55.430 --> 00:08:56.980 therefore there is gonna be a major shift

00:08:56.980 --> 00:08:58.570 in terms of temperature.

00:08:58.570 --> 00:09:01.360 Seasonally, which season, summer or winter,

00:09:01.360 --> 00:09:02.610 has the highest humidity?

00:09:04.520 --> 00:09:05.830 - [Student] Summer.

00:09:05.830 --> 00:09:07.910 - [Lewis] Connecticut, is it hotter and wetter

00:09:07.910 --> 00:09:09.403 in July or in December?

00:09:12.662 --> 00:09:14.520 - [Student One] December. - [Student Two] July.

00:09:14.520 --> 00:09:15.943 - [Lewis] Again, I'm not trying to trick you, okay?

00:09:15.943 --> 00:09:17.610 All right, it's July.

00:09:17.610 --> 00:09:20.083 The summer is warmer and wetter, so the fact is

00:09:20.083 --> 00:09:23.050 that temperature is gonna happen more in the winter

00:09:23.050 --> 00:09:27.200 than it is in the summer, and that's what we're seeing okay?

00:09:27.200 --> 00:09:29.940 So, here's the technical message.

00:09:29.940 --> 00:09:34.000 If water vapor is high, it's the dominant warming gas,

00:09:34.000 --> 00:09:36.670 and there's less effect of CO2.

00:09:36.670 --> 00:09:40.100 If the water vapor is low, adding more CO2

00:09:40.100 --> 00:09:43.040 will have a differential higher effect

00:09:43.040 --> 00:09:44.890 with respect to surface temperatures.

00:09:46.040 --> 00:09:48.720 Again, I've taken an entire semester and given five minutes,

00:09:48.720 --> 00:09:51.570 but you can hopefully adjust to this, there's more to it.

00:09:52.770 --> 00:09:55.660 So, let's look at it from the plant biology point of view.

00:09:55.660 --> 00:09:57.893 Okay, warmer temperatures, well,

00:09:59.020 --> 00:10:01.380 we know that greater temperature increase

00:10:01.380 --> 00:10:04.370 with latitude or altitude, based on what I've talked about,

00:10:04.370 --> 00:10:07.160 increased desertification, increased drought,

00:10:07.160 --> 00:10:10.150 rise in sea levels from increased polar and glacial melt.

00:10:10.150 --> 00:10:11.410 Okay?

00:10:11.410 --> 00:10:13.260 So, what's warm is gonna get warmer,

00:10:13.260 --> 00:10:15.000 what's wet is gonna get wetter,

00:10:15.000 --> 00:10:17.580 and we see these changes going on, right?

00:10:17.580 --> 00:10:21.083 That's the indirect effect of rise in carbon dioxide.

00:10:22.100 --> 00:10:25.010 Now, let me tell you the other direct effect,

00:10:25.010 --> 00:10:26.380 or the only direct effect,

00:10:26.380 --> 00:10:28.290 and that is plants are essential to life.

00:10:28.290 --> 00:10:30.170 What do plants need in order to grow?

00:10:32.830 --> 00:10:33.663 - [Student One] Sunlight.

00:10:33.663 --> 00:10:35.570 - [Lewis] Sunlight, excellent, thank you so much

00:10:35.570 --> 00:10:37.020 for sitting in the front row.

00:10:37.900 --> 00:10:40.680 Water, light, nutrients, right?

00:10:40.680 --> 00:10:43.060 They need all kinds of nutrients;

00:10:43.060 --> 00:10:45.950 your nitrogen, your phosphorous, your potassium.

00:10:45.950 --> 00:10:47.483 What's the fourth thing they need?

00:10:48.452 --> 00:10:49.820 - [Students] CO2.

00:10:49.820 --> 00:10:51.373 - Carbon dioxide, right?

00:10:53.760 --> 00:10:56.703 Okay, let's do this as a thought experiment.

00:10:57.630 --> 00:11:02.160 Suppose for the sake of argument that phosphorous, okay,

00:11:02.160 --> 00:11:03.840 that the amount of phosphorous had gone up

00:11:03.840 --> 00:11:07.340 in every soil around the world by 30%.

00:11:07.340 --> 00:11:09.603 By 30% in your lifetime.

00:11:10.960 --> 00:11:13.110 Would that have an effect on plant biology?

00:11:15.300 --> 00:11:16.610 Yeah, of course.

00:11:16.610 --> 00:11:19.770 There are over 400, 000 different species of plants.

00:11:19.770 --> 00:11:22.905 Would all plants respond the same way to that effect?

00:11:22.905 --> 00:11:24.155 - [Student] No.

00:11:25.130 --> 00:11:27.550 - [Lewis] And as plants are the foundation or the basis

00:11:27.550 --> 00:11:29.940 for life on the planet, for they're

00:11:29.940 --> 00:11:31.770 the bottom of the food chain,

00:11:31.770 --> 00:11:34.260 are there gonna be ramifications of that?

00:11:34.260 --> 00:11:35.093 Oh, hell yes!

00:11:38.930 --> 00:11:43.043 Here's one of them, I got this from the ExxonMobil website.

00:11:43.970 --> 00:11:45.270 Now that provides strength

00:11:46.140 --> 00:11:47.887 but this is lovely fine.

00:11:47.887 --> 00:11:50.187 And you can see lovely fine you can (mumbles).

00:11:52.153 --> 00:11:55.250 Well look at that, that is so cool.

00:11:55.250 --> 00:11:56.400 I've only find Rosemary

00:11:57.350 --> 00:11:59.200 when you give it more carbon dioxide.

00:12:00.580 --> 00:12:03.010 If you're a forester you understand that the faster

00:12:03.010 --> 00:12:04.880 the tree grows the weaker the wood.

00:12:04.880 --> 00:12:07.830 But you told me that aside from that wasn't on the website.

00:12:10.080 --> 00:12:11.333 Oh, hey,

00:12:12.490 --> 00:12:14.490 this is Kazoo.

00:12:14.490 --> 00:12:16.150 Anybody from the southern US?

00:12:16.150 --> 00:12:17.710 Anybody experienced Kazoo firsthand?

00:12:17.710 --> 00:12:19.490 Yeah, I know.

00:12:19.490 --> 00:12:22.043 We did not in the front doorstep or in the morning.

00:12:23.130 --> 00:12:24.660 This is an invasive vine

00:12:24.660 --> 00:12:27.060 and it also responds to carbon dioxide.

00:12:27.060 --> 00:12:29.807 Wow, this is one of the worst weeds in the United,

00:12:29.807 --> 00:12:32.270 am sorry, I keep saying weeds,

00:12:32.270 --> 00:12:35.660 the current administration term is alternative crop.

00:12:35.660 --> 00:12:38.170 So I don't wanna confuse anybody, okay?

00:12:38.170 --> 00:12:41.843 All right, so this also responds to carbon dioxide.

00:12:43.660 --> 00:12:44.960 Well what are the consequences

00:12:44.960 --> 00:12:47.540 of this direct effect of rising CO2?

00:12:47.540 --> 00:12:49.647 Well, it's a fundamental resource for plant growth

00:12:49.647 --> 00:12:53.010 and all plants are gonna be beneficial to human society.

00:12:53.010 --> 00:12:55.030 Not all plants respond the same way

00:12:55.030 --> 00:12:56.270 and rising CO2 alters

00:12:56.270 --> 00:12:58.253 the qualitative components of plants.

00:13:00.560 --> 00:13:03.360 Nobody talks about this because CO2

00:13:03.360 --> 00:13:05.780 is plant food and everything is wonderful and good,

00:13:05.780 --> 00:13:07.690 and everything's gonna be great.

00:13:07.690 --> 00:13:08.790 Doesn't work that way.

00:13:09.920 --> 00:13:11.510 So let's look at the good.

00:13:11.510 --> 00:13:13.610 Let's take the good part first, all right?

00:13:14.490 --> 00:13:16.340 All of you are familiar with malaria.

00:13:17.430 --> 00:13:20.110 About 400, 000 deaths primarily in

00:13:20.110 --> 00:13:23.783 Sub-Saharan, Saharan regions.

00:13:23.783 --> 00:13:28.260 It's a tremendous and awful storage disease.

00:13:30.400 --> 00:13:34.720 So, one of the ways in which it is dealt with

00:13:36.400 --> 00:13:41.400 is through this particular plant.

00:13:41.720 --> 00:13:45.273 This is Artemisia annua or sweet Annie, okay?

00:13:46.145 --> 00:13:49.800 It has been used in Chinese medicine for hundreds of years

00:13:49.800 --> 00:13:52.333 as a means to combat malaria.

00:13:53.520 --> 00:13:55.700 It produces this compound artemisinin

00:13:57.000 --> 00:13:59.740 which has this wonderful peroxide bridge

00:13:59.740 --> 00:14:02.743 which is important in terms of killing Plasmodium,

00:14:04.260 --> 00:14:05.953 the carrier for malaria.

00:14:07.680 --> 00:14:10.100 So, it is part of what are considered

00:14:10.100 --> 00:14:12.140 to be artemisinin combination therapies

00:14:12.140 --> 00:14:13.700 which is still the primary means

00:14:13.700 --> 00:14:16.040 to respond to malaria globally.

00:14:16.040 --> 00:14:17.630 And what they do in this is

00:14:17.630 --> 00:14:19.530 they take artemisinin compounds,

00:14:19.530 --> 00:14:22.380 they add different one or two longer acting drugs,

00:14:22.380 --> 00:14:24.700 usually from the quinine family, they add it

00:14:24.700 --> 00:14:27.590 to the artemisinin and that's a means to prevent or

00:14:27.590 --> 00:14:29.750 to help you get over the malaria.

00:14:29.750 --> 00:14:34.750 And just from a sort of anatomical point of view,

00:14:35.110 --> 00:14:38.176 the glandular secretion, the trichomes in artemisia

00:14:38.176 --> 00:14:40.260 when you have a little closer look, that's where

00:14:40.260 --> 00:14:42.320 your artemisinin is being produced.

00:14:42.320 --> 00:14:43.460 Okay.

00:14:43.460 --> 00:14:46.490 So obviously, the question I gotta ask is,

00:14:46.490 --> 00:14:49.800 if CO2 stimulates plant growth,

00:14:49.800 --> 00:14:51.950 what does it do for artemisinin production?

00:14:52.990 --> 00:14:57.220 And we worked with a group at Nanjing University

00:14:57.220 --> 00:15:00.600 at the National Academy, the Chinese Academy of Sciences.

00:15:00.600 --> 00:15:03.893 And they have a FACE of free CO2 enrichment system.

00:15:04.840 --> 00:15:06.980 We were looking at the artemisinin content

00:15:06.980 --> 00:15:09.650 as a function of carbon dioxide

00:15:09.650 --> 00:15:11.710 and function of the carbon:nitrogen ratio.

00:15:11.710 --> 00:15:13.810 So you could use this elemental analysis

00:15:13.810 --> 00:15:15.470 of carbon and nitrogen as a means

00:15:15.470 --> 00:15:17.650 to predict how much our artemisinin

00:15:17.650 --> 00:15:20.083 was being produced by give a plant.

00:15:21.140 --> 00:15:26.140 And then Chan Jiu who was my colleague there,

00:15:26.210 --> 00:15:29.280 went to different herbarium around China

00:15:29.280 --> 00:15:31.780 to look at artemisinin, to collect it

00:15:31.780 --> 00:15:34.100 and to do this C:M ratio.

00:15:34.100 --> 00:15:37.389 So we have collections that vary from

00:15:37.389 --> 00:15:41.560 1900 to 2005, 2006.

00:15:41.560 --> 00:15:45.523 And during this time period, carbon dioxide has risen,

00:15:46.739 --> 00:15:48.160 in sort of a logarithmic fashion,

00:15:48.160 --> 00:15:49.860 slow at first and then increasing.

00:15:50.950 --> 00:15:52.720 Is there a connection between this rise

00:15:52.720 --> 00:15:54.990 in carbon dioxide and the change in

00:15:56.010 --> 00:15:59.160 the estimated artemisinin concentration produced?

00:15:59.160 --> 00:16:01.100 And we think there is.

00:16:01.100 --> 00:16:04.430 Here's the carbon dioxide levels here in the curve,

00:16:04.430 --> 00:16:07.200 and here is the estimated artemisinin concentration

00:16:07.200 --> 00:16:10.070 that we're seeing for this as a function of decade,

00:16:10.070 --> 00:16:11.670 as a function of carbon dioxide.

00:16:12.800 --> 00:16:14.670 In fact, what they're doing now is that

00:16:14.670 --> 00:16:19.550 the are forwarding greenhouses where our AC is growing,

00:16:19.550 --> 00:16:21.650 adding more carbon dioxide as a means

00:16:21.650 --> 00:16:24.950 to increase artemisinin production now.

00:16:24.950 --> 00:16:26.600 So this is a good thing.

00:16:26.600 --> 00:16:29.190 It's a way of increasing a chemical compound produced

00:16:29.190 --> 00:16:33.180 by leaves that we know has a positive effect with respect

00:16:33.180 --> 00:16:34.340 to malarial

00:16:36.565 --> 00:16:38.300 concentrations,

00:16:38.300 --> 00:16:40.993 trying to cure your malarial symptoms.

00:16:42.200 --> 00:16:45.770 So from the good point of view, Artemisia annua by the way,

00:16:45.770 --> 00:16:49.460 is a common weed in North America, is a central

00:16:49.460 --> 00:16:51.570 pharmacological resource to treat malaria in Africa

00:16:51.570 --> 00:16:54.238 Recent increases in atmospheric CO2 are associated with

00:16:54.238 --> 00:16:56.104 the increase of a known anti-malarial drug

00:16:56.104 --> 00:16:57.880 derived from this plant.

00:16:57.880 --> 00:17:00.080 What other plant-based drugs are responding?

00:17:03.200 --> 00:17:04.033 Don't know?

00:17:05.130 --> 00:17:06.033 You need find out.

00:17:09.200 --> 00:17:10.700 Let me give you the bad, okay?

00:17:12.018 --> 00:17:13.410 This is something I've been working on for

00:17:13.410 --> 00:17:15.030 a number of years and has to do with pollen.

00:17:15.030 --> 00:17:17.730 How many of you suffer from seasonal pollen allergies?

00:17:18.640 --> 00:17:20.100 Raise your hand, excellent.

00:17:20.100 --> 00:17:22.650 Okay, so basically the plants that are

00:17:22.650 --> 00:17:25.290 associated with seasonal pollen allergies sort of fall

00:17:25.290 --> 00:17:28.250 into three major taxa; you have trees in the spring,

00:17:28.250 --> 00:17:30.060 weeds and grasses in the summertime

00:17:30.060 --> 00:17:32.147 and Ragweed in the fall (mumbles).

00:17:34.190 --> 00:17:37.130 So we went through and looked at how again,

00:17:37.130 --> 00:17:40.020 how is carbon dioxide affecting pollen production

00:17:40.020 --> 00:17:43.240 from ragweed during sampling of catkins.

00:17:43.240 --> 00:17:44.863 Here are some of the early work that we did,

00:17:44.863 --> 00:17:47.470 this is great chamber work where we were lowering

00:17:47.470 --> 00:17:50.510 the carbon dioxide values to pre-industrial levels

00:17:50.510 --> 00:17:52.701 and all the time back in the 90s

00:17:52.701 --> 00:17:54.240 and then projecting to 600

00:17:54.240 --> 00:17:57.580 which will almost certainly occur in the century.

00:17:57.580 --> 00:18:01.000 And this is the overall plant biomass for ragweed

00:18:01.000 --> 00:18:03.670 of the branch per plant basis.

00:18:03.670 --> 00:18:05.780 Here's the pollen production going for

00:18:05.780 --> 00:18:08.770 280 to 370 double pollen production,

00:18:08.770 --> 00:18:11.350 going from 370 to 600 double as you can.

00:18:11.350 --> 00:18:14.488 And hey, not only was an increase in growth

00:18:14.488 --> 00:18:16.330 but only increasing in terms of pollen production,

00:18:16.330 --> 00:18:19.179 but also in terms of the antigen Amb a1

00:18:19.179 --> 00:18:22.350 based on the ELISA test where going as an increase

00:18:22.350 --> 00:18:24.500 as carbon dioxide went up as well.

00:18:24.500 --> 00:18:27.070 We haven't been able to replicate this, by the way.

00:18:27.070 --> 00:18:29.680 So that's another challenge for you young researchers

00:18:29.680 --> 00:18:31.320 that are out there.

00:18:31.320 --> 00:18:34.410 But, there's pretty good indication

00:18:34.410 --> 00:18:36.773 that ragweed has this kind of respond.

00:18:37.810 --> 00:18:39.940 Yeah, yeah, all the interesting doctors

00:18:39.940 --> 00:18:41.060 has good interesting stuff,

00:18:41.060 --> 00:18:42.973 but it's a chamber study.

00:18:43.980 --> 00:18:44.970 It's a chamber study,

00:18:44.970 --> 00:18:48.120 doesn't add any relevance in the real world.

00:18:48.120 --> 00:18:49.560 What's wrong with you?

00:18:49.560 --> 00:18:52.110 Okay, how do we get from the lab to the real world?

00:18:53.040 --> 00:18:55.980 Okay, well, there's, I showed you

00:18:57.020 --> 00:19:00.520 was talking about FACE, FACE free air CO2 enrichment.

00:19:00.520 --> 00:19:03.240 This is the Duke University FACE which was funded

00:19:03.240 --> 00:19:05.270 by the Department of Energy as we refer to it

00:19:05.270 --> 00:19:08.270 in federal circles, the department that everything,

00:19:08.270 --> 00:19:09.870 they had lots and lots of money.

00:19:11.730 --> 00:19:14.420 So this is the rain.

00:19:14.420 --> 00:19:17.470 This is pushing in carbon dioxide

00:19:17.470 --> 00:19:21.330 to the low valley pine forest showed you the effect

00:19:21.330 --> 00:19:23.910 of CO2 on low valley earlier.

00:19:23.910 --> 00:19:26.020 This is an afterward, it turns out that

00:19:27.090 --> 00:19:28.920 plants do respond differently, you know the plant that

00:19:28.920 --> 00:19:31.240 responded the most with this change?

00:19:31.240 --> 00:19:32.690 Within the forest understudy?

00:19:34.072 --> 00:19:36.197 Of course you don't.

00:19:36.197 --> 00:19:38.620 I'm sorry (mumbles)

00:19:40.550 --> 00:19:41.407 There's a problem here.

00:19:41.407 --> 00:19:44.543 The problem for me was this cost $5 million a year.

00:19:45.430 --> 00:19:48.663 My entire discretionary budget at the time was $2, 000.

00:19:50.030 --> 00:19:52.470 I could hire it for maybe five minutes,

00:19:52.470 --> 00:19:54.120 but that's not really gonna work.

00:19:55.090 --> 00:19:58.061 So, I kind of like,

00:19:58.061 --> 00:19:59.393 how do I take it from the lab,

00:20:01.098 --> 00:20:03.650 to the real world, how do I do that?

00:20:03.650 --> 00:20:05.067 How do I do that?

00:20:07.890 --> 00:20:08.853 Hang on a second.

00:20:10.120 --> 00:20:11.870 Let's go back to the Keeling curve.

00:20:13.450 --> 00:20:15.250 Why did they measure this in Hawaii?

00:20:17.150 --> 00:20:19.780 I mean, I like Hawaii.

00:20:19.780 --> 00:20:21.043 It's got great factories.

00:20:22.140 --> 00:20:25.263 Why would you measure carbon dioxide background in Hawaii?

00:20:27.160 --> 00:20:28.289 - [student] High elevation

00:20:28.289 --> 00:20:29.380 and well background carbon dioxide?

00:20:29.380 --> 00:20:30.870 - [Lewis] Exactly.

00:20:30.870 --> 00:20:31.890 Exactly.

00:20:31.890 --> 00:20:34.030 So you're measuring the background carbon dioxide,

00:20:34.030 --> 00:20:36.750 you're not measuring the carbon dioxide in the room here,

00:20:36.750 --> 00:20:39.130 which I chose over the camp 11.

00:20:39.130 --> 00:20:41.960 Or if I go out in the street and measure carbon dioxide.

00:20:41.960 --> 00:20:43.433 So that gave me an idea.

00:20:45.940 --> 00:20:49.000 Yeah, so most geological, geographically isolated spot

00:20:49.000 --> 00:20:50.330 on Americans have high emissions,

00:20:50.330 --> 00:20:51.163 but

00:20:52.500 --> 00:20:57.500 maybe we could use an urban-rural transect as a means

00:20:57.910 --> 00:21:02.040 to simulate what future environment would be like.

00:21:02.040 --> 00:21:05.780 If I move the temperature and a carbon dioxide transect

00:21:05.780 --> 00:21:10.030 along this line from an organic farm in Western Maryland

00:21:10.030 --> 00:21:13.620 to downtown Baltimore, we dug the plots and moved the soil,

00:21:13.620 --> 00:21:16.332 we made the soil uniform at the same seabed

00:21:16.332 --> 00:21:18.000 and so the seed was the same.

00:21:18.000 --> 00:21:20.703 We monitor all this fairly carefully.

00:21:21.570 --> 00:21:23.180 And I'm sorry, as an academic,

00:21:23.180 --> 00:21:24.540 I gotta show you at least one slide

00:21:24.540 --> 00:21:25.970 that nobody in the back row can read.

00:21:25.970 --> 00:21:28.680 So this is my contribution to that.

00:21:28.680 --> 00:21:30.880 And so try to go through it.

00:21:30.880 --> 00:21:34.550 This is daytime CO2, early 2000s.

00:21:34.550 --> 00:21:38.180 It does go up with going from rural to sub-urban.

00:21:38.180 --> 00:21:39.560 Night-time temperatures go up,

00:21:39.560 --> 00:21:42.750 season light goes up the number of forestry days.

00:21:42.750 --> 00:21:44.730 Now there are some day time temperature,

00:21:44.730 --> 00:21:46.690 now there's some concerns here.

00:21:46.690 --> 00:21:48.720 One of them is ozone.

00:21:48.720 --> 00:21:51.200 Well, it turns out that when you had an ozone,

00:21:51.200 --> 00:21:53.560 day in downtown Baltimore, within four hours,

00:21:53.560 --> 00:21:56.293 you got the same ozone occurring at the rural site.

00:21:57.210 --> 00:21:59.533 So we didn't think that was too much of an issue.

00:22:00.400 --> 00:22:03.220 Yeah, we did get more hydrogen deposited and rainfall

00:22:03.220 --> 00:22:05.690 for the urban side relative to the rural side.

00:22:05.690 --> 00:22:09.370 But the soil that we took out to each location

00:22:09.370 --> 00:22:11.150 already had a great deal of nitrogen in it,

00:22:11.150 --> 00:22:13.660 it was firm, so from the same source.

00:22:13.660 --> 00:22:16.380 So we don't think that was too much of a problem.

00:22:16.380 --> 00:22:18.860 So maybe we could use this.

00:22:18.860 --> 00:22:21.583 Since there we are, two meters by two meters,

00:22:22.620 --> 00:22:24.560 digging down into the soil, if you look closely,

00:22:24.560 --> 00:22:26.137 you'll see Jenny Hopper (mumbles).

00:22:27.540 --> 00:22:28.693 Okay, so we did that.

00:22:30.290 --> 00:22:34.010 And we packed the soil, the seed bank down,

00:22:34.010 --> 00:22:36.830 we took out our railroad samplers here

00:22:36.830 --> 00:22:39.880 to monitor falling around each of the sites.

00:22:39.880 --> 00:22:43.075 And hey, cool.

00:22:43.075 --> 00:22:46.940 We got in the farm site, the rural site years

00:22:46.940 --> 00:22:49.330 here's when the ragweed first showed up, the pollen first

00:22:50.239 --> 00:22:54.377 showed up around day of year to sometime in September,

00:22:54.377 --> 00:22:56.340 peaked and then went down.

00:22:56.340 --> 00:23:00.840 Okay, now, these two lines here, these two arrows,

00:23:00.840 --> 00:23:04.820 are the start of the maximum pollen based on the farm side,

00:23:04.820 --> 00:23:06.570 sort of out of control.

00:23:06.570 --> 00:23:08.290 And you can see it if I go to the

00:23:08.290 --> 00:23:12.450 to the semi rural, the sub-urban areas starting earlier

00:23:12.450 --> 00:23:15.850 and maximizing the warmer when we get to the cities.

00:23:15.850 --> 00:23:17.567 Holy cow!

00:23:17.567 --> 00:23:20.270 The individual ragweed plant in the city

00:23:20.270 --> 00:23:22.580 with more CO2 with more temperature

00:23:22.580 --> 00:23:25.040 and a longer growing seasons producing on average

00:23:25.040 --> 00:23:28.963 10 times more pollen than the one out in the country.

00:23:30.820 --> 00:23:33.053 Wow, okay.

00:23:33.053 --> 00:23:34.990 That was a cheap way of getting a featured climate

00:23:34.990 --> 00:23:36.913 to see what ragweed might do.

00:23:37.770 --> 00:23:40.040 Yeah, okay, that's interesting,

00:23:40.040 --> 00:23:42.500 but it's a global problem here.

00:23:42.500 --> 00:23:44.727 Yeah, it's a global climate change.

00:23:44.727 --> 00:23:47.163 How do we scale up from this?

00:23:48.070 --> 00:23:51.960 Well, I use a very sophisticated instrument

00:23:51.960 --> 00:23:54.223 on my desk called telephone.

00:23:55.300 --> 00:23:57.630 And I called up different allergists and medical doctors

00:23:57.630 --> 00:23:58.677 and said, "Hi, you don't know me,

00:23:58.677 --> 00:23:59.857 "but I'm a plant physiologist

00:23:59.857 --> 00:24:02.680 "from USK Oh, no, don't hang up, don't hang up.

00:24:02.680 --> 00:24:04.067 "Hi, am a plant physio you don't know me,

00:24:04.067 --> 00:24:05.427 "but would you be interested?

00:24:05.427 --> 00:24:07.807 "Oh, you would, okay, great, hang on."

00:24:08.760 --> 00:24:12.730 So what we did is we got allergists

00:24:12.730 --> 00:24:15.380 and other pollen counters across the central part of

00:24:15.380 --> 00:24:20.010 the United States to look and see whether there had been

00:24:20.010 --> 00:24:23.470 a change in temperature that could be associated

00:24:23.470 --> 00:24:25.930 with the change of pollen season for ragweed.

00:24:25.930 --> 00:24:28.020 Now, we didn't look at ragweed numbers per se

00:24:28.020 --> 00:24:30.420 in terms of the amount of pollen just whether or not

00:24:30.420 --> 00:24:31.920 the season have been affected.

00:24:32.880 --> 00:24:37.330 And so what we found was beginning in the 1990s.

00:24:37.330 --> 00:24:39.341 And if you start down here remember

00:24:39.341 --> 00:24:43.250 remember that humidity CO2 paradigm?

00:24:43.250 --> 00:24:45.030 Right here, it's warm and wet.

00:24:45.030 --> 00:24:46.510 We're not expecting a big change

00:24:46.510 --> 00:24:48.970 in recent decades in terms of temperature,

00:24:48.970 --> 00:24:51.640 but it shouldn't expand as you move northward.

00:24:51.640 --> 00:24:53.493 And that's kind of what we saw.

00:24:54.780 --> 00:24:58.450 That now going up into the northern part of the US

00:24:58.450 --> 00:25:02.580 that from 95 to 2013 there's hardly has been a significant

00:25:02.580 --> 00:25:04.793 increase in the ragweed pollen season.

00:25:06.520 --> 00:25:09.870 Okay, well, we've gone from the lab, we've gone to the city,

00:25:09.870 --> 00:25:14.050 we've gone to the country, lets do the world.

00:25:14.050 --> 00:25:15.147 Now when I called up they said,

00:25:15.147 --> 00:25:18.720 "Oh, I have a paper and PNAS, please listen to me."

00:25:18.720 --> 00:25:19.797 And they would listen.

00:25:19.797 --> 00:25:22.163 "So yeah soil paper that's really interesting.

00:25:22.163 --> 00:25:23.407 "We wanna help you.

00:25:23.407 --> 00:25:24.760 "Great."

00:25:24.760 --> 00:25:28.830 Okay, so started getting data this is from Turku, Finland.

00:25:28.830 --> 00:25:31.273 One of the longest pollen seasons that we had.

00:25:31.273 --> 00:25:33.260 This is total seasonal pollen,

00:25:33.260 --> 00:25:36.653 in terms of grains per cubic meter over time.

00:25:38.290 --> 00:25:42.023 Reykjavik, Iceland, grains per cubic meter over time.

00:25:44.670 --> 00:25:47.290 Kansas City, Missouri, we've since found out

00:25:47.290 --> 00:25:50.240 this probably not correct because it's a long story,

00:25:50.240 --> 00:25:51.500 but they got a new pollen counter,

00:25:51.500 --> 00:25:53.900 it was much better in counting pollen (mumbles).

00:25:55.990 --> 00:25:57.220 Geneva Switzerland.

00:25:57.220 --> 00:25:58.500 Okay, you're seeing, if you're seeing,

00:25:58.500 --> 00:26:03.230 I think it's fair to say a trend here, a global trend.

00:26:03.230 --> 00:26:04.340 Right?

00:26:04.340 --> 00:26:06.730 So basically, we went out on a lab

00:26:06.730 --> 00:26:08.840 and looked at the change in pollen load,

00:26:08.840 --> 00:26:10.720 the amount of pollen over the end of the season

00:26:10.720 --> 00:26:13.050 as a function of different temperatures.

00:26:13.050 --> 00:26:16.430 And where there was some good significant correlations here

00:26:16.430 --> 00:26:20.340 in terms of, based on locations around the world.

00:26:20.340 --> 00:26:23.480 But all of these locations are in the northern hemisphere.

00:26:23.480 --> 00:26:26.130 So our next goal is to go to the southern hemisphere.

00:26:27.280 --> 00:26:30.023 And we're working on that now, so stay tuned.

00:26:31.340 --> 00:26:32.740 Alright,

00:26:32.740 --> 00:26:36.100 so that rising CO2 temperatures

00:26:36.100 --> 00:26:38.323 can influence pollen season falling amounts.

00:26:39.360 --> 00:26:41.680 Pollen allergenicity, we're still not sure,

00:26:41.680 --> 00:26:44.150 we have one laboratory data.

00:26:44.150 --> 00:26:47.133 Maybe, maybe not, we need to do more work on that, right?

00:26:48.184 --> 00:26:49.017 Okay.

00:26:51.311 --> 00:26:53.400 Let's go to the OMG part.

00:26:53.400 --> 00:26:54.630 Right, this is...

00:26:55.610 --> 00:26:57.490 What's the role of carbon dioxide

00:26:57.490 --> 00:26:59.860 if the trees are growing bigger and there's more water

00:26:59.860 --> 00:27:02.110 available, does that affect fire frequencies?

00:27:03.120 --> 00:27:03.953 I don't know.

00:27:04.880 --> 00:27:06.260 Is it possible it's affecting

00:27:06.260 --> 00:27:09.330 the qualitative component of the woods such as burning

00:27:09.330 --> 00:27:12.690 the higher climate change or more CO2?

00:27:12.690 --> 00:27:15.380 Is it affecting the air pollution pollen?

00:27:15.380 --> 00:27:18.133 I don't know, nobody's said a word.

00:27:20.913 --> 00:27:23.073 We talked about Kazoo earlier, well Kazoo when you give it

00:27:23.073 --> 00:27:25.030 more carbon dioxide, generates

00:27:25.030 --> 00:27:27.280 more volatile organic compounds.

00:27:27.280 --> 00:27:30.033 Has that shifted in the last 20 years of more CO2?

00:27:31.090 --> 00:27:31.923 I don't know.

00:27:33.260 --> 00:27:35.220 Well, what about contact dermatitis

00:27:35.220 --> 00:27:36.490 from something like poison ivy?

00:27:36.490 --> 00:27:38.610 We actually know this one, I mentioned that this was

00:27:38.610 --> 00:27:40.460 the one that was growing more

00:27:40.460 --> 00:27:42.890 in the FACE system in the deep forest.

00:27:42.890 --> 00:27:45.710 It actually produces a more virulent form of urishiol.

00:27:45.710 --> 00:27:47.891 You get contact dermatitis faster

00:27:47.891 --> 00:27:50.900 when you come in contact with it.

00:27:50.900 --> 00:27:52.023 What about narcotics?

00:27:53.030 --> 00:27:54.400 We spend billions of dollars a year

00:27:54.400 --> 00:27:56.073 trying to eradicate narcotics.

00:27:57.430 --> 00:27:59.530 How is CO2, how is climate affecting

00:27:59.530 --> 00:28:02.034 where these narcotics are growing?

00:28:02.034 --> 00:28:03.117 I don't know.

00:28:04.390 --> 00:28:06.520 What about food allergies?

00:28:06.520 --> 00:28:08.890 If I'm changing the quality of the composition of the food

00:28:08.890 --> 00:28:11.506 is it affecting the number of food allergies?

00:28:11.506 --> 00:28:13.050 I don't know.

00:28:14.490 --> 00:28:16.250 Food safety, hey,

00:28:16.250 --> 00:28:18.700 everybody gets sick from eating food occasionally.

00:28:18.700 --> 00:28:19.850 Turns out warmer temperatures

00:28:19.850 --> 00:28:22.230 can promote pathogen infestation.

00:28:22.230 --> 00:28:24.290 Oh no, who knew?

00:28:24.290 --> 00:28:26.480 Is climate change or rise in carbon dioxide

00:28:26.480 --> 00:28:28.263 affecting food safety?

00:28:29.330 --> 00:28:30.470 I don't know.

00:28:32.250 --> 00:28:34.490 Funding for all of these things from the federal government

00:28:34.490 --> 00:28:37.650 is, yeah.

00:28:37.650 --> 00:28:39.643 Nobody's doing anything worse.

00:28:41.640 --> 00:28:43.120 Here's some work we did do.

00:28:43.120 --> 00:28:46.490 This is kind of thistle highly invasive species.

00:28:46.490 --> 00:28:48.890 This is being sprayed with glyphosate,

00:28:48.890 --> 00:28:52.320 the recommended rates under ambient CO2 that's being sprayed

00:28:52.320 --> 00:28:55.557 with glyphosate under 650 parts per million CO2.

00:28:55.557 --> 00:28:57.373 And added absolutely no control.

00:28:59.230 --> 00:29:01.362 The reason why, is that

00:29:01.362 --> 00:29:02.330 when you give them more carbon dioxide,

00:29:02.330 --> 00:29:04.620 there was a difference between how much would accumulate

00:29:04.620 --> 00:29:07.260 on the top and how much accumulated in the roots.

00:29:07.260 --> 00:29:10.190 It did not, one of the things that glyphosate does is

00:29:10.190 --> 00:29:13.030 it travels, it's systemic, it goes everywhere in the plant.

00:29:13.030 --> 00:29:17.520 But if I have more roots, it was diluted out

00:29:17.520 --> 00:29:20.700 and roots can generate new shoots, et cetera.

00:29:20.700 --> 00:29:22.310 So what's the effect of carbon dioxide

00:29:22.310 --> 00:29:25.040 and climate change on pesticide usage?

00:29:25.040 --> 00:29:26.373 Pesticide ethicacy?

00:29:27.580 --> 00:29:28.780 We know about this much.

00:29:32.080 --> 00:29:35.970 If there is a green revolution, if there is a green new deal

00:29:37.480 --> 00:29:39.780 these are the things that we need to focus on.

00:29:42.480 --> 00:29:44.780 Let's work on one of these issues.

00:29:44.780 --> 00:29:46.762 There's not enough time to go into all of them.

00:29:46.762 --> 00:29:48.726 Let's look at nutrition.

00:29:48.726 --> 00:29:49.876 And let's look at rice.

00:29:51.890 --> 00:29:55.050 Rice is consumed on a daily basis by

00:29:55.050 --> 00:29:56.300 about two billion people.

00:29:58.000 --> 00:30:01.080 About 600 million people get more than 50%

00:30:01.080 --> 00:30:03.053 of their daily food intake from rice.

00:30:05.690 --> 00:30:08.920 Rice, wheat, corn, they're what we call the big three

00:30:08.920 --> 00:30:10.890 that account half of the calories that you consume

00:30:10.890 --> 00:30:13.330 and I would be willing to bet all my life savings

00:30:13.330 --> 00:30:16.230 that you're consuming at least one of them for this lunch.

00:30:17.560 --> 00:30:19.480 There's pretty good evidence that projected

00:30:19.480 --> 00:30:22.003 increases in CO2 reduce proteins.

00:30:23.152 --> 00:30:24.240 Some of the first work that I did back

00:30:24.240 --> 00:30:26.543 at the International Rice Research Institute,

00:30:27.570 --> 00:30:31.330 doing open top chamber work with different temperatures.

00:30:31.330 --> 00:30:34.600 For the 94 wet season, our percent protein was about

00:30:34.600 --> 00:30:38.420 10% of ambient CO2, we had a CO2 it dropped

00:30:38.420 --> 00:30:42.100 9.3%, the dry season similar response

00:30:42.100 --> 00:30:47.100 in terms of temperature per se, reduced protein levels,

00:30:47.440 --> 00:30:50.570 but it did not interact with carbon dioxide to,

00:30:50.570 --> 00:30:53.920 in any kind of synergistic to reduce levels even more so

00:30:53.920 --> 00:30:55.257 it was a separate effect.

00:30:56.170 --> 00:30:58.520 The change in protein is ongoing.

00:30:58.520 --> 00:31:00.060 We looked at future changes.

00:31:00.060 --> 00:31:04.500 This is recent changes from 300 to 400 parts per million

00:31:04.500 --> 00:31:07.360 for about eight different rice lines.

00:31:07.360 --> 00:31:09.110 And here I think eight of the nine

00:31:09.110 --> 00:31:12.230 showed a decline or significant decline

00:31:12.230 --> 00:31:14.463 in protein concentration for the rice.

00:31:15.300 --> 00:31:18.680 And we had to stop this because our funding got hold

00:31:18.680 --> 00:31:20.313 when new administration came in.

00:31:22.230 --> 00:31:25.440 It's ubiquitous, here's some work by Taub.

00:31:25.440 --> 00:31:27.517 Here was in Texas and this is looking at

00:31:27.517 --> 00:31:31.710 annual crop staples; barley, rice, wheat, soybean, potato.

00:31:31.710 --> 00:31:34.040 This is the number of studies,

00:31:34.040 --> 00:31:36.480 average and standard deviation.

00:31:36.480 --> 00:31:38.930 This is the percent change in protein concentration

00:31:38.930 --> 00:31:43.143 under elevated CO2 which range from about 600 to 700.

00:31:44.440 --> 00:31:46.930 All of them declined with the exception of soybean.

00:31:46.930 --> 00:31:48.720 Soybean is a legume, that's to say

00:31:48.720 --> 00:31:50.620 it fixes its own nitrogen.

00:31:50.620 --> 00:31:53.540 So when you add more CO2, it's not affected.

00:31:53.540 --> 00:31:57.350 So soybean, peanut, other leguminous plants do not show

00:31:57.350 --> 00:32:00.553 that change in terms of proteins with more carbon dioxide.

00:32:03.520 --> 00:32:06.810 This is some work by a colleague Irakli Loladze,

00:32:06.810 --> 00:32:09.010 he went through and looked at the Sweden country

00:32:09.010 --> 00:32:12.930 of all the different elements in the context of rising CO2,

00:32:12.930 --> 00:32:15.470 the average of about 690.

00:32:15.470 --> 00:32:18.780 And what we see is that this very rapid rise

00:32:18.780 --> 00:32:23.780 in carbon dioxide is causing plants to be carbon rich,

00:32:24.330 --> 00:32:27.113 but nutrient poor across the board.

00:32:28.180 --> 00:32:30.430 And we think there are ramifications of that.

00:32:31.730 --> 00:32:34.373 So it's not just crops.

00:32:35.280 --> 00:32:38.467 We're looking at at personal work that is done by me,

00:32:38.467 --> 00:32:40.550 or that is done by Augustine and all,

00:32:40.550 --> 00:32:42.367 came out recently looking at pasture grass

00:32:42.367 --> 00:32:45.630 that have been grown under elevated CO2.

00:32:45.630 --> 00:32:48.290 And what effect this had in terms of

00:32:48.290 --> 00:32:51.110 weight being put on by the cattle.

00:32:51.110 --> 00:32:53.430 And this is a seven year average,

00:32:53.430 --> 00:32:56.660 we're looking at ambient CO2, ambient temperature;

00:32:56.660 --> 00:32:58.980 ambient CO2, elevated temperature

00:32:58.980 --> 00:33:00.510 and then the two bars on the right

00:33:00.510 --> 00:33:04.272 are elevated carbon dioxide to different temperatures.

00:33:04.272 --> 00:33:08.080 20% nitrogen which is a proxy for percent protein

00:33:08.080 --> 00:33:11.570 declined significantly with more carbon dioxide.

00:33:11.570 --> 00:33:14.810 The animals put on weight, took them longer to put on

00:33:14.810 --> 00:33:17.550 the same amount of weight, they were slower growing.

00:33:17.550 --> 00:33:20.510 So there's pretty good evidence across the board

00:33:20.510 --> 00:33:24.040 that plants are responding by reducing protein levels.

00:33:24.040 --> 00:33:25.390 That's going to have ramifications

00:33:25.390 --> 00:33:27.640 in terms of human nutrition, direct consumption,

00:33:27.640 --> 00:33:29.190 but also in terms of livestock.

00:33:30.740 --> 00:33:32.860 Hey, but it's just people food, right?

00:33:32.860 --> 00:33:35.513 Well, no, not necessarily.

00:33:37.240 --> 00:33:39.170 We decided to look at bees.

00:33:39.170 --> 00:33:40.840 And turns out that, you know,

00:33:40.840 --> 00:33:42.250 bees also have nutritional requirements

00:33:42.250 --> 00:33:45.850 that are important in the context of agriculture.

00:33:45.850 --> 00:33:48.798 So they get their carbs from nectar.

00:33:48.798 --> 00:33:51.190 Understandable, so then they do this,

00:33:51.190 --> 00:33:52.712 they're really good at it.

00:33:52.712 --> 00:33:53.820 They do the little waggle dance.

00:33:53.820 --> 00:33:55.800 You know, the little waggle dance

00:33:55.800 --> 00:33:56.907 the bee says to the other bee,

00:33:56.907 --> 00:33:59.077 "Hey, you know if you go right behind this building,

00:33:59.077 --> 00:34:01.937 "there's a sunflower there, 20 feet to the left

00:34:01.937 --> 00:34:04.190 "of the dumpster and you'll find all the carbs you want."

00:34:04.190 --> 00:34:05.810 They're really good at that.

00:34:05.810 --> 00:34:08.770 They're not so good in terms of pollen yet pollen

00:34:08.770 --> 00:34:10.430 is their main source of protein,

00:34:10.430 --> 00:34:12.000 they get 10 essential amino acids

00:34:12.000 --> 00:34:14.440 from the pollen that they consume.

00:34:14.440 --> 00:34:17.330 So again, we wanted to see okay well carbon dioxide

00:34:17.330 --> 00:34:18.480 is affecting protein,

00:34:18.480 --> 00:34:20.913 is this in fact affecting bee nutrition?

00:34:22.870 --> 00:34:24.130 And let's do it from a point of view

00:34:24.130 --> 00:34:26.690 of the recent changes that occur.

00:34:26.690 --> 00:34:28.650 That's a tough one to get to.

00:34:28.650 --> 00:34:32.660 How did we, we chose Goldenrod because Goldenrod

00:34:32.660 --> 00:34:35.250 is one of the last sources of pollen that bees see

00:34:35.250 --> 00:34:37.000 in the fall before they overwinter.

00:34:38.040 --> 00:34:39.910 I won't go through all the machinations we did

00:34:39.910 --> 00:34:42.760 to come up with that, but it is.

00:34:42.760 --> 00:34:45.960 And so it's important for bees before they overwinter

00:34:45.960 --> 00:34:49.017 to have a good source of protein, and one of those good

00:34:49.017 --> 00:34:50.730 source is Goldenrod so we considered it

00:34:50.730 --> 00:34:52.780 to be a key for the species.

00:34:52.780 --> 00:34:54.280 So what I'm trying to do is sort of two

00:34:54.280 --> 00:34:56.020 lines of evidence here and I wanna give you

00:34:56.020 --> 00:34:58.280 the historical evidence first.

00:34:58.280 --> 00:34:59.370 And they got this through,

00:34:59.370 --> 00:35:01.630 this Smithsonian Natural History Museum.

00:35:01.630 --> 00:35:04.250 Now, I don't know if you've ever been to DC but it's a great

00:35:04.250 --> 00:35:06.170 place to go to, you got your dinosaurs,

00:35:06.170 --> 00:35:08.637 you got your elephants, you got your little diamonds,

00:35:08.637 --> 00:35:10.730 it's a great place to go, right?

00:35:10.730 --> 00:35:15.730 Okay, but here's the thing, way in the back in the basement,

00:35:16.750 --> 00:35:18.560 right next to the Ark of the Covenant,

00:35:18.560 --> 00:35:21.960 you'll find all these, okay (mumbles)

00:35:22.970 --> 00:35:26.490 You'll find all these plants samples, right?

00:35:26.490 --> 00:35:30.183 They go back to pre industrial times in the 1850s, 1860s.

00:35:31.400 --> 00:35:33.263 And those samples included Goldenrod.

00:35:34.290 --> 00:35:38.655 So we're able to actually take the pollen,

00:35:38.655 --> 00:35:41.640 the stigmas, the reproductive parts,

00:35:41.640 --> 00:35:46.640 and to look at the carbon, hydrogen, nitrogen ratios.

00:35:47.050 --> 00:35:48.950 Nitrogen as a proxy again for protein.

00:35:50.000 --> 00:35:52.080 Now, I wanna give you a second line here.

00:35:52.080 --> 00:35:52.983 This is the experimental evidence.

00:35:52.983 --> 00:35:55.820 This is some work that was done by my colleague,

00:35:55.820 --> 00:35:58.040 a scientist down in the Temple, Texas.

00:35:58.040 --> 00:36:02.420 He's since retired but this is a really cool study,

00:36:02.420 --> 00:36:03.793 waiting kind of for guy.

00:36:05.040 --> 00:36:07.253 Kind of circle wagons that you see here.

00:36:08.140 --> 00:36:10.520 What Wayne did is, he added carbon dioxide

00:36:10.520 --> 00:36:12.260 at one end of the wagon.

00:36:12.260 --> 00:36:14.550 And because of photo-sensors and because it's Texas

00:36:14.550 --> 00:36:17.135 where the sun's shining all the time,

00:36:17.135 --> 00:36:19.330 by the time you got to the bottom wagon,

00:36:19.330 --> 00:36:21.450 all that carbon dioxide have been taken out.

00:36:21.450 --> 00:36:23.720 So they were looking at carbon dioxide levels

00:36:23.720 --> 00:36:27.624 pre-industrial, right 283 hundred.

00:36:27.624 --> 00:36:30.850 And we were very fortunate to have just enough goldenrod

00:36:30.850 --> 00:36:32.280 growing along that trans sector

00:36:32.280 --> 00:36:35.110 that we could actually look at the numbers.

00:36:35.110 --> 00:36:37.200 So here are the data.

00:36:37.200 --> 00:36:39.730 This is historical data from the Smithsonian.

00:36:39.730 --> 00:36:42.760 This is the estimated protein based on

00:36:42.760 --> 00:36:44.870 using nitrogen as a proxy.

00:36:44.870 --> 00:36:49.270 And going from the pre-industrial time to the current time,

00:36:49.270 --> 00:36:51.580 which is the beginning of the 21st century.

00:36:51.580 --> 00:36:56.200 We see about a 30% drop in the nitrogen protein content

00:36:57.650 --> 00:36:59.643 and an increase, corresponding increase in carbon

00:36:59.643 --> 00:37:02.450 and the nitrogen of that pollen.

00:37:02.450 --> 00:37:05.090 And for the experimental evidence,

00:37:05.090 --> 00:37:07.487 numbers are slightly different.

00:37:07.487 --> 00:37:09.940 There's a lot of the sampling so the larger the bigger,

00:37:09.940 --> 00:37:12.870 but basically the same sort of response;

00:37:12.870 --> 00:37:14.840 that as you increase the carbon dioxide,

00:37:14.840 --> 00:37:18.790 you're decreasing the amount of protein in the pollen.

00:37:18.790 --> 00:37:22.923 That has effects in terms of the health.

00:37:23.880 --> 00:37:25.950 And these are already under environmental,

00:37:25.950 --> 00:37:28.120 number of environmental stressors.

00:37:28.120 --> 00:37:29.600 How's it affecting that?

00:37:29.600 --> 00:37:31.290 We don't know.

00:37:31.290 --> 00:37:33.650 We're not able to get funding to continue this work.

00:37:33.650 --> 00:37:35.970 But we think it's a toe in the water stage

00:37:35.970 --> 00:37:37.280 where we think it's really interesting

00:37:37.280 --> 00:37:38.730 we want to do more if we can.

00:37:39.810 --> 00:37:42.580 Let's go back to people food for a moment.

00:37:42.580 --> 00:37:45.060 And let's look a little more deeper into rice.

00:37:45.060 --> 00:37:48.740 This is work that was done two different FACE of free air

00:37:48.740 --> 00:37:50.537 C02 reference systems,

00:37:50.537 --> 00:37:53.210 one in Scuba Japan, which is shown here,

00:37:53.210 --> 00:37:56.330 another one in near Nanjing, China.

00:37:56.330 --> 00:37:58.450 And again, you're going your rice, you're

00:37:58.450 --> 00:38:01.313 ejecting carbon dioxide into a field situation.

00:38:02.400 --> 00:38:05.330 They did this, we did this under different cultivars,

00:38:05.330 --> 00:38:08.010 rice cultivars, eight different cultivars in Japan,

00:38:08.010 --> 00:38:11.550 most of the Japonica lines, some of the (mumbles) lines

00:38:11.550 --> 00:38:14.480 and then also in China which had a wider range

00:38:14.480 --> 00:38:17.750 in terms of indica, hybrids and so forth.

00:38:17.750 --> 00:38:19.830 So the 18 different lines altogether

00:38:19.830 --> 00:38:21.940 was the percent protein.

00:38:21.940 --> 00:38:24.240 Again, this is, the differences now,

00:38:24.240 --> 00:38:26.582 were about 550 parts per million, which is the elevated 400,

00:38:26.582 --> 00:38:31.083 which is the ambient for all the lines.

00:38:31.920 --> 00:38:35.420 Percent change relative to ambient CO2, again trying

00:38:35.420 --> 00:38:38.825 to decline in protein for the rice.

00:38:38.825 --> 00:38:40.780 You look at iron and zinc,

00:38:40.780 --> 00:38:44.260 a little more scattered, but again many of the lines,

00:38:44.260 --> 00:38:45.870 showing a significant

00:38:45.870 --> 00:38:48.270 and rice overall showing a significant decrease.

00:38:49.230 --> 00:38:51.530 Now, we wanted to delve a little bit deeper and look at it

00:38:51.530 --> 00:38:54.763 in terms of the vitamin content.

00:38:55.740 --> 00:38:58.250 And we didn't have this for all the different samples but

00:38:58.250 --> 00:38:59.770 for the Chinese ones.

00:38:59.770 --> 00:39:03.153 So B1 vitamin, B1, B2, B5 and B9.

00:39:04.160 --> 00:39:06.230 And I haven't had time to go through all

00:39:06.230 --> 00:39:08.430 the stats on, there's a whole,

00:39:08.430 --> 00:39:09.670 there were significant effects

00:39:09.670 --> 00:39:12.720 in terms of all these declining

00:39:12.720 --> 00:39:15.580 as you increase the carbon dioxide, okay?

00:39:15.580 --> 00:39:19.910 And then we got this out of the blue, the response,

00:39:19.910 --> 00:39:22.900 it went up for alpha tocopherol, okay?

00:39:22.900 --> 00:39:26.383 Vitamin E went up with more CO2.

00:39:28.950 --> 00:39:30.930 So I was scratching my various body parts

00:39:30.930 --> 00:39:34.150 trying to figure out what the hell is this about?

00:39:34.150 --> 00:39:35.623 What's going on, okay?

00:39:37.430 --> 00:39:40.120 Well, we have a working hypothesis

00:39:40.120 --> 00:39:43.260 for a possibility is definitely needed, all right?

00:39:43.260 --> 00:39:44.980 And here it is.

00:39:44.980 --> 00:39:47.875 If you look at all the different compounds,

00:39:47.875 --> 00:39:51.263 and if the compound has a lot of nitrogen in it,

00:39:52.910 --> 00:39:56.830 it seems to be selected against, whereas tocopherol

00:39:56.830 --> 00:40:00.670 which has no nitrogen actually showed a slight increase

00:40:00.670 --> 00:40:02.500 as carbon dioxide went up.

00:40:02.500 --> 00:40:04.823 The more nitrogen the compound had,

00:40:04.823 --> 00:40:07.590 and this is just a ratio of the molecular weight,

00:40:07.590 --> 00:40:11.130 So vitamin B9 has, 20% of the provided

00:40:11.130 --> 00:40:12.483 vitamin B9 is nitrogen.

00:40:13.490 --> 00:40:15.803 So it follows along pretty good curve.

00:40:16.780 --> 00:40:19.873 So perking back to artemisinin.

00:40:21.110 --> 00:40:22.900 Artemisinin have no nitrogen in it,

00:40:22.900 --> 00:40:25.683 it went up with more carbon dioxide.

00:40:26.570 --> 00:40:30.230 So now we have eight points or nine points.

00:40:30.230 --> 00:40:31.200 We're still trying to figure out.

00:40:31.200 --> 00:40:32.710 Is this real or not?

00:40:32.710 --> 00:40:35.240 We have some recent information

00:40:35.240 --> 00:40:37.490 for coffee, more coffee produces caffeine.

00:40:37.490 --> 00:40:39.090 Caffeine is a bicyclic alkaloid

00:40:39.090 --> 00:40:41.310 with a lot of nitrogen, right?

00:40:41.310 --> 00:40:44.640 So we have some initial information suggesting

00:40:44.640 --> 00:40:47.200 that caffeine is going down.

00:40:47.200 --> 00:40:49.100 I know that's disappointing, right?

00:40:49.100 --> 00:40:50.830 Trust me when I tell you I was very disappointed,

00:40:50.830 --> 00:40:53.290 I couldn't have gone through grad school without it.

00:40:53.290 --> 00:40:55.880 But it's something to keep in mind.

00:40:55.880 --> 00:40:58.280 And but having said that, there was also variation

00:40:58.280 --> 00:41:01.373 among the different arabica lines that we looked at.

00:41:02.790 --> 00:41:07.520 All right, we tried to take all this information and say,

00:41:07.520 --> 00:41:09.970 how does it affect different countries?

00:41:09.970 --> 00:41:13.950 And we looked at it from the point of view of,

00:41:13.950 --> 00:41:15.840 depending on the economics of the country,

00:41:15.840 --> 00:41:19.700 if I'm a very poor country, I tend to consume a lot of rice.

00:41:19.700 --> 00:41:23.970 For example, as China has become, as the economic status

00:41:23.970 --> 00:41:26.040 of the Chinese has increased,

00:41:26.040 --> 00:41:27.647 then the less rice is being consumed

00:41:27.647 --> 00:41:30.060 and a more diverse diet is happening.

00:41:30.060 --> 00:41:32.420 So there are usually out of the Chinese I think,

00:41:32.420 --> 00:41:33.427 are the green lines here.

00:41:33.427 --> 00:41:36.030 But we looked at a number of different countries.

00:41:36.030 --> 00:41:39.703 And basically, the poorer the country,

00:41:40.820 --> 00:41:42.870 the greater the deficit for the different

00:41:43.950 --> 00:41:47.920 actually trying not to confuse myself anymore.

00:41:47.920 --> 00:41:50.240 But basically, the poorer the country,

00:41:50.240 --> 00:41:54.510 the greater the effect in terms of CO2 impacting nutritional

00:41:54.510 --> 00:41:56.510 value of the rice that's being consumed.

00:41:57.700 --> 00:41:59.290 And then we're trying to look at

00:41:59.290 --> 00:42:01.810 the 10 poorest countries in the world.

00:42:01.810 --> 00:42:03.460 They're mostly agrarian.

00:42:03.460 --> 00:42:06.080 This was the food production in metric tons,

00:42:06.080 --> 00:42:07.373 million metric tons.

00:42:08.320 --> 00:42:11.090 This is the population here.

00:42:11.090 --> 00:42:13.100 And then you can see food production relative

00:42:13.100 --> 00:42:14.873 to population is declining.

00:42:17.090 --> 00:42:19.523 This is the kilograms per person per year.

00:42:20.880 --> 00:42:22.850 And we're trying to also look at

00:42:22.850 --> 00:42:25.460 the elevated CO2 effect on protein.

00:42:25.460 --> 00:42:27.720 This is some work I'm doing with the broccoli,

00:42:27.720 --> 00:42:30.800 where he spent a sort of a an estimate

00:42:30.800 --> 00:42:34.390 on the effect in terms of protein for these other staples,

00:42:34.390 --> 00:42:37.610 some of the staples are, that are dominant in these

00:42:37.610 --> 00:42:40.120 countries to solve the maize, potatoes, rice, sorghum

00:42:40.120 --> 00:42:42.020 or sweet potatoes, but again...

00:42:43.300 --> 00:42:46.750 First, sorghum used to try much but there's a lot of

00:42:46.750 --> 00:42:48.860 decline in terms of protein concentration

00:42:48.860 --> 00:42:50.423 for these products.

00:42:52.610 --> 00:42:54.800 What else could be changing what's happening to the item,

00:42:54.800 --> 00:42:57.300 of course countries we don't really know for sure.

00:42:58.300 --> 00:43:00.380 Alright, so I didn't really get a chance to go into

00:43:00.380 --> 00:43:02.960 all of the things in part because there's just not,

00:43:02.960 --> 00:43:05.780 a lot of information out there to go into.

00:43:05.780 --> 00:43:08.610 But just looking at one, the nutritional aspect,

00:43:08.610 --> 00:43:11.700 you get a sense like Oh, of just how fundamental

00:43:11.700 --> 00:43:15.900 an aspect this is and how important it can be.

00:43:15.900 --> 00:43:18.577 So plants interact by multiple means in

00:43:18.577 --> 00:43:21.750 the health of our quality, the medicine and nutrition,

00:43:21.750 --> 00:43:24.450 and maybe more than just people plants with this life.

00:43:25.295 --> 00:43:26.490 How is it going to affect in terms

00:43:26.490 --> 00:43:27.790 of having a global impact?

00:43:29.579 --> 00:43:31.590 A lot of questions to be addressed.

00:43:31.590 --> 00:43:33.863 But here's the thing to keep in mind.

00:43:35.090 --> 00:43:36.600 If you look at it from the point

00:43:36.600 --> 00:43:38.860 of view of animals and plants,

00:43:38.860 --> 00:43:41.240 and you weigh all the animals weigh all the plants

00:43:41.240 --> 00:43:42.673 in terms of their biomass.

00:43:43.830 --> 00:43:46.563 All animals are shown here.

00:43:47.700 --> 00:43:49.293 They weigh about two gigatons.

00:43:50.605 --> 00:43:53.033 Plants constitute about two gigatons of carbon.

00:43:56.420 --> 00:43:58.360 All the rest is plants and

00:43:58.360 --> 00:44:01.173 they constitute 450 gigatons of carbon.

00:44:02.210 --> 00:44:05.700 If I affect plants, I'm going to affect

00:44:05.700 --> 00:44:07.890 every living thing on earth.

00:44:07.890 --> 00:44:12.220 And yet the CO2 as plant food mean dominates our thinking.

00:44:12.220 --> 00:44:13.867 It's much more than that.

00:44:16.000 --> 00:44:17.300 What are the consequences?

00:44:21.600 --> 00:44:22.850 Where do we go from here?

00:44:24.020 --> 00:44:27.710 Well, we acknowledge that there's interaction,

00:44:27.710 --> 00:44:30.940 that carbon dioxide also needs to be looked at.

00:44:30.940 --> 00:44:33.010 We acknowledge that the potential research

00:44:33.010 --> 00:44:36.050 in the context of public health is enormous.

00:44:36.050 --> 00:44:38.700 There's so much more that we can be doing with this.

00:44:38.700 --> 00:44:41.773 What can we do to work together?

00:44:45.285 --> 00:44:47.700 What can we do, what can we do as a means

00:44:47.700 --> 00:44:51.744 to find new opportunities,

00:44:51.744 --> 00:44:56.360 new ways that we can come together to try

00:44:56.360 --> 00:45:00.370 and find new research to do on this area

00:45:00.370 --> 00:45:03.117 that we haven't been able to find yet.

00:45:03.117 --> 00:45:08.117 And I'm hoping that at some point, this will come to pass.

00:45:08.527 --> 00:45:10.068 So thank you all very much for your time.

00:45:10.068 --> 00:45:13.068 (students clapping)

00:45:15.081 --> 00:45:17.215 - [Kai] So now is the question time and

00:45:17.215 --> 00:45:21.548 if you have a question, just raise your hand ask it.

00:45:22.787 --> 00:45:25.287 - [Lewis] I know it's a lot of information people.

00:45:26.250 --> 00:45:27.428 Yes.

00:45:27.428 --> 00:45:28.817 - [Student] I just wondered if any...

00:45:28.817 --> 00:45:32.280 You know, you said that tocopherol might not go down

00:45:32.280 --> 00:45:35.550 because it's not, in a way, it doesn't contain nitrogen.

00:45:35.550 --> 00:45:39.840 So how's that experiment you've done when on (mumbles)

00:45:39.840 --> 00:45:41.363 available - [Lewis] Yeah this is one of

00:45:41.363 --> 00:45:43.633 the things that occurred to us initially was that

00:45:43.633 --> 00:45:46.130 what we're seeing is because of stimulation of growth,

00:45:46.130 --> 00:45:48.920 and there's a position (mumbles) of nitrogen.

00:45:48.920 --> 00:45:51.737 So to counter that we made sure that

00:45:52.815 --> 00:45:55.500 we had the chamber experiment where we could really vary

00:45:55.500 --> 00:45:58.215 the amount of nitrogen but also ensure

00:45:58.215 --> 00:45:59.520 that we're getting super amounts of nitrogen

00:45:59.520 --> 00:46:01.607 something like and is one of (mumbles).

00:46:06.746 --> 00:46:07.640 - [Student] Great work - [Lewis] Yes.

00:46:07.640 --> 00:46:09.090 I'm sorry.

00:46:09.090 --> 00:46:11.147 - [Student] No, that's great work.

00:46:11.147 --> 00:46:11.980 - [Male Student] Have people looked at

00:46:11.980 --> 00:46:14.100 sea grasses and aquatic plants?

00:46:14.100 --> 00:46:16.460 - [Lewis] No, not to my knowledge.

00:46:16.460 --> 00:46:18.127 Not to my knowledge.

00:46:19.750 --> 00:46:21.378 Yes.

00:46:21.378 --> 00:46:25.431 - [Student] So, as you mentioned in your view,

00:46:25.431 --> 00:46:30.098 the cost is highly variable costs probably 10 hours ago.

00:46:31.147 --> 00:46:33.003 They are paid by the common practices,

00:46:33.003 --> 00:46:37.130 so, I guess that by, to what extent or stage

00:46:37.130 --> 00:46:41.460 is impact of climate change will have observance of

00:46:42.657 --> 00:46:45.280 human health outcome and also

00:46:47.370 --> 00:46:51.573 using all this technology of reading,

00:46:52.570 --> 00:46:56.610 nutritious varieties and also different farming practices

00:46:56.610 --> 00:46:58.370 and also intensification to

00:47:01.060 --> 00:47:03.340 increase productivity as a

00:47:06.253 --> 00:47:10.384 to what, kind of, what can you say all these tests

00:47:10.384 --> 00:47:13.250 can help us to (murmurs) and damage to the plants?

00:47:13.250 --> 00:47:15.220 - [Lewis] There's a lot in there.

00:47:15.220 --> 00:47:17.287 So let me try and actually to address

00:47:17.287 --> 00:47:20.000 that particular number entire somehow.

00:47:20.000 --> 00:47:22.700 But let me try and address it quickly.

00:47:22.700 --> 00:47:24.905 One of the things that we're currently doing and nutrition

00:47:24.905 --> 00:47:26.160 is currently doing justification,

00:47:26.160 --> 00:47:28.720 we're using what are called monocultures.

00:47:28.720 --> 00:47:32.050 The genetics of the crop that you're growing all the same.

00:47:32.050 --> 00:47:35.360 So as you get rid of small landowners,

00:47:35.360 --> 00:47:38.180 which have more diverse genetics, and you go

00:47:38.180 --> 00:47:39.743 to bigger and bigger fields,

00:47:40.760 --> 00:47:42.143 there are different reasons for it

00:47:42.143 --> 00:47:45.500 that it becomes more and more uniform, has to be.

00:47:45.500 --> 00:47:48.020 The problem with becoming more uniform, you don't have

00:47:48.020 --> 00:47:53.020 a diversity necessary in order to find the lines

00:47:53.570 --> 00:47:56.870 that are you could say different to their effects

00:47:56.870 --> 00:47:58.670 and CO2 and with respect to protein.

00:48:00.398 --> 00:48:02.490 That's part of our job or it was part of our job

00:48:02.490 --> 00:48:04.990 when I was with USDA is to begin to look at these

00:48:04.990 --> 00:48:08.483 different lines and to look at how they might respond.

00:48:09.710 --> 00:48:12.250 Part of it is management and began there are different

00:48:12.250 --> 00:48:15.570 aspects of that as well, because of rising water

00:48:15.570 --> 00:48:18.270 product prices and water consumption.

00:48:18.270 --> 00:48:21.113 Flooded rice is not as grown as much as it used to be.

00:48:22.030 --> 00:48:24.310 And it has a whole nother suite of consequences that

00:48:24.310 --> 00:48:26.280 I unfortunately don't have time to, we could talk more

00:48:26.280 --> 00:48:29.270 about it after class if you wanna know more.

00:48:29.270 --> 00:48:32.000 What we are currently doing in terms of breeding

00:48:32.000 --> 00:48:37.000 is we we're seeing two dissimilar breeding attempts.

00:48:37.710 --> 00:48:40.610 We have farmers and breeders who are breeding for yield

00:48:40.610 --> 00:48:44.600 and breeding for taste and breeding for insect resistance.

00:48:44.600 --> 00:48:47.920 And as CO2 is going up in nature, we think that in

00:48:47.920 --> 00:48:50.230 itself is having a selection effect.

00:48:50.230 --> 00:48:54.470 So for example, we see wild rice, weeded rice,

00:48:54.470 --> 00:48:57.010 is showing a much stronger response to the change,

00:48:57.010 --> 00:49:00.540 recent changes in CO2 and cultivated absence.

00:49:00.540 --> 00:49:02.860 And they're actually putting more of that additional

00:49:02.860 --> 00:49:06.590 carbon dioxide into seedling for the weeded rice.

00:49:06.590 --> 00:49:11.100 So we think that there's an opportunity here as well.

00:49:11.100 --> 00:49:14.070 And that is to look at the weeded rice as a means to begin

00:49:14.070 --> 00:49:17.990 to adapt to, for the cultivated rice to adapt,

00:49:17.990 --> 00:49:21.700 and to look at the both technology and genetics

00:49:21.700 --> 00:49:26.300 of the weeded rice as a means to begin to bring or

00:49:26.300 --> 00:49:29.680 to adapt cultivated rice, so that it can not only respond

00:49:29.680 --> 00:49:32.563 to warm climate, but actually might benefit by it.

00:49:33.450 --> 00:49:35.723 Okay, anybody have a cell phone?

00:49:37.570 --> 00:49:40.150 Would you google something for me?

00:49:40.150 --> 00:49:42.393 This isn't about... is that okay?

00:49:43.430 --> 00:49:44.263 Okay.

00:49:45.601 --> 00:49:48.813 Would you google to something for me?

00:49:48.813 --> 00:49:52.010 Would you, and this is not about rice, but just for fun,

00:49:52.010 --> 00:49:55.450 would you google carbon dioxide and marijuana

00:49:57.800 --> 00:50:01.557 and tell me what the first sentence that you get.

00:50:13.682 --> 00:50:15.099 What does it say?

00:50:16.469 --> 00:50:18.836 - [Student] How do you use CO2 increase you

00:50:18.836 --> 00:50:19.700 - [Lewis] Can you say that louder?

00:50:19.700 --> 00:50:20.837 - [Student] Sure, how do you use CO2 to

00:50:20.837 --> 00:50:22.990 increase yields in your marijuana.

00:50:22.990 --> 00:50:24.640 - [Lewis] How do you do CO2 to increase yields

00:50:24.640 --> 00:50:25.790 in your marijuana crop?

00:50:27.900 --> 00:50:32.900 So I'm guessing here that if they can do that

00:50:33.593 --> 00:50:35.620 and literally they have indoor chambers and they're doing

00:50:35.620 --> 00:50:37.560 it you know that way.

00:50:37.560 --> 00:50:40.180 But remember the CO2 has already gone up by 30%.

00:50:40.180 --> 00:50:44.050 Are we missing out on an opportunity by not taking

00:50:44.050 --> 00:50:46.410 the increase that's already occurred and begin

00:50:46.410 --> 00:50:49.015 to find the best suited genotypes that can take

00:50:49.015 --> 00:50:52.450 that increase and divert them into seeds.

00:50:52.450 --> 00:50:55.260 I can go online, I can do this in more depth,

00:50:55.260 --> 00:50:57.870 I can find out from the marijuana industry,

00:50:57.870 --> 00:51:00.670 when to give the CO2, how much to give the CO2,

00:51:00.670 --> 00:51:02.460 what the temperature is to give the CO2,

00:51:02.460 --> 00:51:05.743 what the hormone THC I can get from the CO2 will be.

00:51:07.130 --> 00:51:08.630 Why can't we do that for food?

00:51:10.170 --> 00:51:13.022 I would argue there's an opportunity there.

00:51:13.022 --> 00:51:13.855 Anyway

00:51:15.740 --> 00:51:17.310 So...

00:51:17.310 --> 00:51:18.260 Yes.

00:51:18.260 --> 00:51:19.790 - [Student] How's it that when kind of follow the

00:51:19.790 --> 00:51:23.520 mass cyber, there isn't any much of a research into

00:51:24.480 --> 00:51:27.740 trying to (mumbles) the decrease in vitamins

00:51:27.740 --> 00:51:29.100 and minerals in the plants and

00:51:29.100 --> 00:51:31.190 to actual public health in the past?

00:51:31.190 --> 00:51:32.570 - [Lewis] No, and that's a good point.

00:51:32.570 --> 00:51:36.083 We haven't done that yet but,

00:51:36.083 --> 00:51:39.790 that's one of the things we'd like to work on.

00:51:39.790 --> 00:51:43.740 We put in a convergence

00:51:43.740 --> 00:51:46.707 RFP for NSF to do that.

00:51:46.707 --> 00:51:47.860 And they turned us down.

00:51:47.860 --> 00:51:49.663 So we, I know,

00:51:52.240 --> 00:51:53.290 we're still on track.

00:51:54.239 --> 00:51:55.360 I think it's important.

00:51:55.360 --> 00:51:56.193 Yes.

00:51:56.193 --> 00:51:57.450 - [Student] Yeah, on that note, I mean,

00:51:57.450 --> 00:52:01.480 I couldn't help but wonder in your, during your presentation

00:52:01.480 --> 00:52:06.480 if the increase or if the alarming increase in

00:52:09.610 --> 00:52:14.433 malnourished, obese folks might have, you know, if

00:52:16.427 --> 00:52:19.170 I'm sorry, can't talk to the, I just gave up coffee

00:52:19.170 --> 00:52:20.110 - [Lewis] Oh, am sorry.

00:52:20.110 --> 00:52:22.360 (laughing)

00:52:24.134 --> 00:52:28.650 - [Student] You spoke about plants being carbon rich

00:52:28.650 --> 00:52:31.050 and vitamin poor, now right?

00:52:31.050 --> 00:52:34.320 And so I can't help but wonder if

00:52:34.320 --> 00:52:38.450 that could potentially be some contributing factor

00:52:38.450 --> 00:52:41.640 to this concurrent prevalence

00:52:41.640 --> 00:52:44.823 of obesity alongside malnutrition.

00:52:44.823 --> 00:52:46.893 - [Lewis] We don't know, we think it could be,

00:52:46.893 --> 00:52:50.274 certainly logically interpreted there's...

00:52:50.274 --> 00:52:52.000 it could be, but we'd like to be able to get

00:52:52.000 --> 00:52:53.380 the numbers just to show it.

00:52:53.380 --> 00:52:54.230 - [Student] Sure.

00:52:55.150 --> 00:52:57.535 - [Lewis] So unfortunately, that at the moment,

00:52:57.535 --> 00:53:02.493 it's the Chinese folks, we just have to ignore it.

00:53:02.493 --> 00:53:05.090 - [Student] I also had another thought and maybe it's

00:53:05.090 --> 00:53:06.420 for everyone in the room,

00:53:06.420 --> 00:53:08.760 just from a public health stand-point,

00:53:08.760 --> 00:53:09.800 you know, are there...

00:53:09.800 --> 00:53:13.830 do we know of any large ongoing sources of data

00:53:13.830 --> 00:53:18.830 that actually, that ask about allergy, food allergy

00:53:19.390 --> 00:53:21.000 or environmental allergy?

00:53:21.000 --> 00:53:23.760 But this isn't my area of research,

00:53:23.760 --> 00:53:25.327 but does anyone know of any?

00:53:27.000 --> 00:53:30.060 - I don't imagine that there are databases

00:53:30.060 --> 00:53:33.837 for food allergies that are available.

00:53:33.837 --> 00:53:35.537 I don't know how far back they go.

00:53:37.885 --> 00:53:40.920 And it would be difficult thing given the other issue

00:53:40.920 --> 00:53:45.240 in epidemiology is early exposure, and other aspects

00:53:45.240 --> 00:53:47.420 that make it difficult to try and assess with

00:53:47.420 --> 00:53:49.863 a separate role of climate of carbon dioxide.

00:53:51.170 --> 00:53:52.220 But it's a good idea.

00:53:53.290 --> 00:53:56.603 We did, I didn't mention this, but we did a study on peanut,

00:53:58.300 --> 00:54:00.570 we have two different varieties of peanut

00:54:00.570 --> 00:54:03.331 which we grew at different carbon dioxide concentrations,

00:54:03.331 --> 00:54:07.880 and over a two year period, and one of the varieties

00:54:07.880 --> 00:54:11.105 for both years showed an increase in Arachis stage one.

00:54:11.105 --> 00:54:14.277 Arachis is peanut genus that's also the name

00:54:14.277 --> 00:54:17.450 of the primary allergen that peanuts produce.

00:54:17.450 --> 00:54:18.427 It's about a 10% increase in the allergen,

00:54:18.427 --> 00:54:20.973 but the other one didn't do anything.

00:54:21.940 --> 00:54:23.719 So it needs more work.

00:54:23.719 --> 00:54:27.273 We need to find out why is this line responding

00:54:27.273 --> 00:54:28.898 the other line not responding.

00:54:28.898 --> 00:54:30.723 What's going on?

00:54:30.723 --> 00:54:31.793 We just don't know.

00:54:34.360 --> 00:54:35.200 Yes.

00:54:35.200 --> 00:54:36.878 - [Student] I have kind an answer to your question.

00:54:36.878 --> 00:54:39.950 I mean, those collect technology

00:54:40.920 --> 00:54:44.340 so they have some (mumbles) from 2007, 2010.

00:54:47.478 --> 00:54:51.162 Probably just some recorded geology.

00:54:51.162 --> 00:54:53.781 And it looks like they have problem (mumbling)

00:54:53.781 --> 00:54:54.840 the categories so...

00:54:54.840 --> 00:54:56.940 - [Female Student] Oh, awesome, thank you.

00:54:58.948 --> 00:55:01.408 - [Lewis] Okay, yes, last question.

00:55:01.408 --> 00:55:04.797 - [Male Student] That is (mumbling) though is that

00:55:07.399 --> 00:55:11.611 the total climate change mitigation challenges

00:55:11.611 --> 00:55:13.887 that mattered, is there any one focusing on

00:55:13.887 --> 00:55:17.600 the technology challenges (mumbles)?

00:55:17.600 --> 00:55:20.380 - [Lewis] There are a number of things, for means better

00:55:20.380 --> 00:55:25.380 at the management level, but also at the genetics level

00:55:25.690 --> 00:55:27.620 and at the consumer level and we think,

00:55:27.620 --> 00:55:31.920 within the food system are ways to reduce

00:55:31.920 --> 00:55:33.670 greenhouse gas emissions.

00:55:33.670 --> 00:55:38.670 So for example, one of the things that USDA was working on

00:55:38.930 --> 00:55:40.350 before I left was

00:55:41.310 --> 00:55:42.143 was called

00:55:44.270 --> 00:55:47.210 water deficit irrigation with rice.

00:55:47.210 --> 00:55:50.370 Typically, rice is flooded because

00:55:50.370 --> 00:55:52.083 it's a way of keeping weeds down.

00:55:53.140 --> 00:55:57.310 And, but flooding rice also produces a lot of methane.

00:55:57.310 --> 00:55:59.560 And so if you change the management, you can reduce

00:55:59.560 --> 00:56:01.350 the amount of methane that's being produced.

00:56:01.350 --> 00:56:03.950 But farmers are worried and of course,

00:56:03.950 --> 00:56:05.360 they do that, that's going to reduce

00:56:05.360 --> 00:56:07.540 the bottom line of production.

00:56:07.540 --> 00:56:10.270 So USDA was doing studies trying to look

00:56:10.270 --> 00:56:14.090 at alternative drawing and say that they did management plan

00:56:14.940 --> 00:56:17.420 as a means to see if it would reduce methane.

00:56:17.420 --> 00:56:19.760 Because you can't wag your finger at a farmer

00:56:19.760 --> 00:56:21.940 and say you're producing too much methane.

00:56:21.940 --> 00:56:23.277 But you can go up to them and say, "Hey, you know

00:56:23.277 --> 00:56:25.757 "I've go this great idea that's gonna increase your yields,

00:56:25.757 --> 00:56:27.887 "but also reduce your cost for water,

00:56:27.887 --> 00:56:28.993 "oh by the way, it's gonna reduce the methane,

00:56:28.993 --> 00:56:30.043 "but you don't care."

00:56:31.540 --> 00:56:33.690 And just go, go with that.

00:56:33.690 --> 00:56:35.190 There's lots of opportunities.

00:56:36.800 --> 00:56:40.250 What if you were a pure consumer, and you're at the market,

00:56:40.250 --> 00:56:42.863 and you're looking at buying a package of beef,

00:56:43.800 --> 00:56:45.830 what if the information was there,

00:56:45.830 --> 00:56:48.560 it says how much of my greenhouse gas feature

00:56:48.560 --> 00:56:51.160 for buying this kind of be for us?

00:56:51.160 --> 00:56:53.820 Yeah, you know, I could compare it to different brands

00:56:53.820 --> 00:56:56.043 to see, okay, well, I've got three different brands

00:56:56.043 --> 00:56:58.750 of beef here, but hey, this one's producing much less

00:56:58.750 --> 00:57:01.050 greenhouse gas, maybe I should buy this brand.

00:57:02.330 --> 00:57:06.300 So yeah, there's lots of really cool, interesting,

00:57:06.300 --> 00:57:07.940 fun things to look at.

00:57:07.940 --> 00:57:10.260 I mean, it's just, it's a question

00:57:10.260 --> 00:57:11.910 of having the resources to do it.

00:57:14.550 --> 00:57:17.033 - [Kai] Okay, thank you for this kind,

00:57:17.960 --> 00:57:21.050 I think it was an excellent lecture.

00:57:21.050 --> 00:57:26.030 Although we have a few, many but all of us have an interest.