



SILICON VALLEY

P O D C A S T

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00:00:00,440 --> 00:00:04,080

Host (Matthew Buffington): You are listening to the NASA in Silicon Valley podcast, episode

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00:00:04,080 --> 00:00:05,500

62.

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00:00:05,500 --> 00:00:07,970

Joining me for the intro is Frank Tavares.

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00:00:07,970 --> 00:00:12,639

You'll recognize his voice from a recent story he did on Pluto, so Frank, tell us a

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00:00:12,639 --> 00:00:13,639

little about that.

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00:00:13,639 --> 00:00:14,639

Frank Tavares: Hey, sure Matt!

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00:00:14,639 --> 00:00:20,790

Yeah, so during the New Horizons flyby mission in 2015, we got some great imagery of this

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00:00:20,790 --> 00:00:23,330

really strange terrain on Pluto.

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00:00:23,330 --> 00:00:29,240

We found essentially these giant ice formations that look like giant spikes or ridges coming

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00:00:29,240 --> 00:00:31,340

up in high elevations.

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00:00:31,340 --> 00:00:35,760

And the official name for it is bladed terrain, cause it kinda looks like, you know, knife

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00:00:35,760 --> 00:00:39,559

blades sticking up, you know maybe if you opened up your kitchen drawer, and the blades

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00:00:39,559 --> 00:00:41,559

were all pointed up, it would look like that.

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00:00:41,559 --> 00:00:44,780

So the big mystery was, we didn't really know how these things got there.

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00:00:44,780 --> 00:00:49,379

But recently, a science team at Ames led a research investigation that found that these

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00:00:49,379 --> 00:00:54,190

things are actually made of methane ice and found out the whole history of how these things

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00:00:54,190 --> 00:00:58,670

came to be, and it actually has taught us a lot about Pluto's own climate and geological

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00:00:58,670 --> 00:01:02,260

history, and how it came to be the object it is today.

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00:01:02,260 --> 00:01:03,260

Host: Cool!

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00:01:03,260 --> 00:01:07,790

And you can catch that story on NASA.gov, there's also a couple of videos they have

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00:01:07,790 --> 00:01:09,440

up on YouTube, Facebook, Twitter.

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00:01:09,440 --> 00:01:14,250

And obviously, there's the audio version that Frank recorded on the podcast.

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00:01:14,250 --> 00:01:18,440

But switching over to today, our guest is Ved Chirayath.

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00:01:18,440 --> 00:01:23,940

Ved is a research scientist and lead for the Laboratory for Advanced Sensing at NASA Ames.

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00:01:23,940 --> 00:01:26,670

And Frank, I believe you heard Ved speak at a couple events recently?

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00:01:26,670 --> 00:01:27,670

Frank Tavares: Yeah!

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00:01:27,670 --> 00:01:34,100

I listened to a talk he gave recently announcing the start of his new NeMO-Net project he's

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00:01:34,100 --> 00:01:38,780

a part of, and essentially this is focusing on mapping coral here on Earth.

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00:01:38,780 --> 00:01:44,320

The imagery was amazing, but what stuck out for me was when Ved said that there's only

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00:01:44,320 --> 00:01:48,180

one species on Earth that can be seen from outer space, and that's coral.

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00:01:48,180 --> 00:01:50,700

And we're killing it, at an incredibly high rate.

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00:01:50,700 --> 00:01:55,050

And that really gave me such a sense of what the stakes are for understanding coral and

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00:01:55,050 --> 00:01:56,490

what we're doing to it.

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00:01:56,490 --> 00:02:00,320

So like, if aliens were out there are doing all the same stuff we are to try and look

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00:02:00,320 --> 00:02:04,370

for life in the universe, what they would be able to see from Earth, from outer space,

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00:02:04,370 --> 00:02:06,930

would be coral, not humans.

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00:02:06,930 --> 00:02:09,520

And that's a form of life that's going extinct.

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00:02:09,520 --> 00:02:14,430

So yeah, I mean Ved's a really incredible scientist doing really important work, and

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00:02:14,430 --> 00:02:19,390

actually even recently won the Ames Early Career Research Award here at NASA's center

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00:02:19,390 --> 00:02:20,390

in Silicon Valley.

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00:02:20,390 --> 00:02:24,680

Host: Excellent, so before we jump on in, I just wanted to do a couple quick reminders,

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00:02:24,680 --> 00:02:30,590

you can call us, for folks listening, it's at (650) 604-1400.

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00:02:30,590 --> 00:02:32,910

You can leave a message or a question for

the podcast.

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00:02:32,910 --> 00:02:36,341

We're also using the #NASASiliconValley, if you prefer digital.

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00:02:36,341 --> 00:02:42,200

You can find us on iTunes, Google Play Music, SoundCloud, and through a normal RSS feed

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00:02:42,200 --> 00:02:44,250

that works with nearly all podcast apps.

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00:02:44,250 --> 00:02:48,569

And recently, we are starting to add an audio version to YouTube as well, that Frank has

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00:02:48,569 --> 00:02:50,800

actually been working on.

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00:02:50,800 --> 00:02:55,270

But you know, if you like what you hear, do us a favor and leave us a review, that really

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00:02:55,270 --> 00:02:57,209

helps others to find the podcast.

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00:02:57,209 --> 00:03:01,990

And of course, we are a NASA podcast, but we are not the only NASA podcast, so don't

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00:03:01,990 --> 00:03:06,780

forget to check out This Week at NASA, NASA Casts, and Houston, We Have A Podcast.

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00:03:06,780 --> 00:03:11,000

But for now, let's listen to our conversation with Ved Chirayath.

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00:03:11,020 --> 00:03:23,640

[Music]

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00:03:23,640 --> 00:03:25,420

Host: Tell us a little bit about yourself.

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00:03:25,420 --> 00:03:26,760

How did you end up in Silicon Valley?

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00:03:26,760 --> 00:03:28,860

How did you end up at NASA to begin with?

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00:03:28,860 --> 00:03:32,600

Ved Chirayath: This was a very concerted effort since I was about five years old.

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00:03:32,600 --> 00:03:33,600

Host: You were determined.

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00:03:33,600 --> 00:03:35,310

Five-year-old Ved was like, "I'm going to get a job there."

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00:03:35,310 --> 00:03:37,480

Ved Chirayath: I knew I wanted to work at NASA.

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00:03:37,480 --> 00:03:41,000

I saw the Mars rover landing coming in as a sojourner in '99.

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00:03:41,000 --> 00:03:45,260

We saw the images coming in live at JPL in the open house.

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00:03:45,260 --> 00:03:47,900

And I just knew then and there that's what I wanted to do.

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00:03:47,900 --> 00:03:49,360

Host: Really?

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00:03:49,360 --> 00:03:55,001

So then is that your whole -- high school, college was all centrally focused on "This

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00:03:55,001 --> 00:03:56,001

is where I'm going to be"?

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00:03:56,001 --> 00:03:57,001

Ved Chirayath: It was.

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00:03:57,001 --> 00:03:59,849

I actually created a master plan to become an astronaut.

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00:03:59,849 --> 00:04:07,800

When I was around seven, I decided to study astrophysics and particle physics and then

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00:04:07,800 --> 00:04:12,629

go to school in Russia and then try to come back to the United States to do school at

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00:04:12,629 --> 00:04:13,940

Stanford.

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00:04:13,940 --> 00:04:15,879

All those things actually worked out, fortunately.

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00:04:15,879 --> 00:04:18,880

But there were some complications along the way.

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00:04:18,880 --> 00:04:20,530

Host: This is as a seven-year-old?

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00:04:20,530 --> 00:04:24,690

Ved Chirayath: Yeah, I was a very determined seven-year-old.

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00:04:24,690 --> 00:04:25,960

I got into amateur astronomy.

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00:04:25,960 --> 00:04:29,380

I started doing a lot of backyard astronomy.

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00:04:29,380 --> 00:04:33,960

And then at around the time there were a lot of exoplanets being detected using this transit

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00:04:33,960 --> 00:04:36,830

method that actually the Kepler project uses.

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00:04:36,830 --> 00:04:41,800

I wanted to be the first kid on the block to try to find an exoplanet using that transit

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00:04:41,800 --> 00:04:45,490

method, but with amateur equipment.

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00:04:45,490 --> 00:04:50,660

I went to some telescope companies in the area of Los Angeles and I begged and pleaded

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00:04:50,660 --> 00:04:52,110

to get a larger telescope.

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00:04:52,110 --> 00:04:55,440

Host: I was going to say, I'm imagining your parents thinking like, "Really?"

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00:04:55,440 --> 00:04:56,900

We're going to buy a \$10,000 telescope?"

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00:04:56,900 --> 00:04:59,080

Ved Chirayath: Yeah, they weren't.

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00:04:59,080 --> 00:05:06,250

That's why there was a lot of science fairs
and then I got a three inch telescope that

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00:05:06,250 --> 00:05:07,290

we saved up for.

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00:05:07,290 --> 00:05:11,850

And then I tried to go these telescope companies
and say, "Hey, if we were able to make this

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00:05:11,850 --> 00:05:14,210

discovery it would be on your instruments.

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00:05:14,210 --> 00:05:18,199

So wouldn't it be a great idea if you were
to sponsor me as a high school student?"

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00:05:18,199 --> 00:05:19,430

Host: Wow, that's hilarious.

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00:05:19,430 --> 00:05:23,860

Ved Chirayath: So we got two of them in the
competition and then one of them finally gave

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00:05:23,860 --> 00:05:26,020

us a nice instrument.

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00:05:26,020 --> 00:05:30,979

I had a mentor at USC and I tried to go out
to Mount Pinos, north of LA.

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00:05:30,979 --> 00:05:34,970

I spend about a year there just taking observations.

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00:05:34,970 --> 00:05:39,460

I'd filled my own camera system and eventually
discovered a planet.

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00:05:39,460 --> 00:05:41,150

That was one of the first.

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00:05:41,150 --> 00:05:43,040

It was really large.

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00:05:43,040 --> 00:05:45,220

By today's standards, it was an easy detection.

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00:05:45,220 --> 00:05:49,250

But at the time, it was the first detection
on an amateur instrument.

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00:05:49,250 --> 00:05:50,250

Host: That was college?

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00:05:50,250 --> 00:05:52,540

Ved Chirayath: That was high school.

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00:05:52,540 --> 00:05:54,160

Host: Really?

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00:05:54,160 --> 00:05:56,050

So then where did you end up going to school?

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00:05:56,050 --> 00:05:57,169

What were you studying?

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00:05:57,169 --> 00:05:58,560

How did you do that?

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00:05:58,560 --> 00:06:01,860

Ved Chirayath: As part of that project, I
got to go to the International Science Fair

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00:06:01,860 --> 00:06:07,690

and one of the awards you get when you win

at the top places is a lunch with astronauts.

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00:06:07,690 --> 00:06:13,930

So I got to meet Pinky Nelson and gave him my master plan and said, "Hey, I've been meaning

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00:06:13,930 --> 00:06:15,419

to meet an astronaut one day.

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00:06:15,419 --> 00:06:16,980

So what do you think of this idea?

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00:06:16,980 --> 00:06:18,440

I want to be an astronaut.

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00:06:18,440 --> 00:06:23,040

I want to go to potentially study in Russia to learn Russian and learn physics."

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00:06:23,040 --> 00:06:26,330

And he said, "That's a great idea."

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00:06:26,330 --> 00:06:32,270

I went with that and I graduated from high school early and went to Moscow State University

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00:06:32,270 --> 00:06:34,570

for four and a half years.

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00:06:34,570 --> 00:06:36,750

Host: How's your Russian by now?

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00:06:36,750 --> 00:06:38,290

Did you figure it out?

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00:06:38,290 --> 00:06:42,790

Ved Chirayath: Now it's great because four and a half years of intensive education in

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00:06:42,790 --> 00:06:44,830

Russian will do that to you.

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00:06:44,830 --> 00:06:48,790

Host: That's also very smart just for the sake of NASA.

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00:06:48,790 --> 00:06:53,020

One of the cool things is we don't have to do this alone.

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00:06:53,020 --> 00:06:54,150

We have international partners.

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00:06:54,150 --> 00:06:55,310

We have private partners.

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00:06:55,310 --> 00:06:59,730

And obviously teaming up with Russia on the Space Station and things is a crucial part

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00:06:59,730 --> 00:07:00,730

of what NASA does.

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00:07:00,730 --> 00:07:05,699

Ved Chirayath: Absolutely, and I've always admired the ability for immigrants coming

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00:07:05,699 --> 00:07:09,479

into the United States to speak English fluently and almost natively.

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00:07:09,479 --> 00:07:11,280

We almost expect it of everybody.

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00:07:11,280 --> 00:07:18,070

Yet, when our astronauts speak Russian, no offense to our astronauts, the accents are

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00:07:18,070 --> 00:07:24,710

wrong, the cases are wrong and Russian is a language is so rich and exacting.

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00:07:24,710 --> 00:07:28,610

You really have to get it right to come across correctly.

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00:07:28,610 --> 00:07:34,110

Host: I always think of college is hard enough during, especially, a master's program.

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00:07:34,110 --> 00:07:42,670

It's hard enough in your own language so huge props to anybody who can go study in a different

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00:07:42,670 --> 00:07:43,670

language.

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00:07:43,670 --> 00:07:46,470

The content is already hard enough, but the language barrier -- man, that's rough.

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00:07:46,470 --> 00:07:48,750

Ved Chirayath: Yeah, I realized that the first year.

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00:07:48,750 --> 00:07:50,560

I bit off more than I could chew.

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00:07:50,560 --> 00:07:55,199

But after a couple of years of intensive training, it got better.

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00:07:55,199 --> 00:07:58,720

People do this all the time when they come to the United States from a different country

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00:07:58,720 --> 00:08:02,470

and they just have to, not only learn the language, but the academic system -- how things

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00:08:02,470 --> 00:08:05,580

get done, how research is done.

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00:08:05,580 --> 00:08:08,530

It's a mind shift for sure, but incredibly useful.

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00:08:08,530 --> 00:08:14,680

Host: It get's mentally exhausting switching between the languages.

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00:08:14,680 --> 00:08:19,160

But it's an exercise and it stretches you.

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00:08:19,160 --> 00:08:23,930

Were you studying astrophysics at that point and then did you land that into a master's

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00:08:23,930 --> 00:08:25,290

program later on back here?

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00:08:25,290 --> 00:08:26,479

Or how did that work?

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00:08:26,479 --> 00:08:31,360

Ved Chirayath: So my plan was to finish my bachelor's degree or master's degree equivalent

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00:08:31,360 --> 00:08:33,440

in Russia and then come here for graduate school.

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00:08:33,440 --> 00:08:39,630

This is also partly motivated by financial means because United States universities are

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00:08:39,630 --> 00:08:44,790

very expensive and my scholarship I got would cover one year of an Ivy League school here,

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00:08:44,790 --> 00:08:48,440

but it would cover my entire education in Russia.

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00:08:48,440 --> 00:08:49,910

I went with that option.

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00:08:49,910 --> 00:08:58,100

It saved a lot funds and then I had to actually leave Russia early due to an uptick in a lot

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00:08:58,100 --> 00:09:00,670

of violent attacks, neo-Nazi attacks.

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00:09:00,670 --> 00:09:05,631

I got attacked a few times and I just said, "It's not worth spending the last couple of

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00:09:05,631 --> 00:09:07,210

months here."

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00:09:07,210 --> 00:09:12,830

I applied to Stanford as a transfer student and said, "My goal was to apply here as a

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00:09:12,830 --> 00:09:16,230

graduate student, but I'm in this predicament."

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00:09:16,230 --> 00:09:20,850

And they actually took me as a transfer student and gave me a path to a PhD and full funding.

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00:09:20,850 --> 00:09:22,910

That was really tremendous.

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00:09:22,910 --> 00:09:29,520

I spent four and a half years in Moscow and then in 2009 transferred to Stanford to finish

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00:09:29,520 --> 00:09:33,130

my bachelor's in physics with a concentration on astrophysics.

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00:09:33,130 --> 00:09:34,720

And then I went on.

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00:09:34,720 --> 00:09:38,590

Host: You basically also grew up in LA, California.

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00:09:38,590 --> 00:09:43,360

Now you went to the northern California in the bay area.

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00:09:43,360 --> 00:09:45,080

So you basically spent most of your time over here.

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00:09:45,080 --> 00:09:47,840

Ved Chirayath: Yes, and I really like the bay area.

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00:09:47,840 --> 00:09:53,149

Host: Then coming to NASA, was it like an internship, a contractor thing?

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00:09:53,149 --> 00:09:55,620

How did you end up making that leap on over?

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00:09:55,620 --> 00:09:59,700

Ved Chirayath: I had started graduate school at Stanford after finishing my undergrad and

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00:09:59,700 --> 00:10:02,890

I'd started picking up the research that I'd started actually when I was in high school

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00:10:02,890 --> 00:10:05,190

and looking with amateur telescopes again.

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00:10:05,190 --> 00:10:08,779

I went back to the same companies and I said,
"Hey, I'm back again.

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00:10:08,779 --> 00:10:10,269

I need a larger instrument."

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00:10:10,269 --> 00:10:11,269

Host: "Remember me?"

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00:10:11,269 --> 00:10:12,519

Now I speak Russian."

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00:10:12,519 --> 00:10:17,399

Ved Chirayath: It was actually really generous
because I drove down in this very questionable

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00:10:17,399 --> 00:10:18,399

looking van.

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00:10:18,399 --> 00:10:22,950

I know I made a presentation and said I'm
interested in doing high resolution imaging

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00:10:22,950 --> 00:10:23,990

through the earth's atmosphere.

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00:10:23,990 --> 00:10:28,800

One of the issues we have looking at objects
in space is that the atmosphere blurs everything.

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00:10:28,800 --> 00:10:30,410

Stars twinkle for that reason.

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00:10:30,410 --> 00:10:34,350

So I was developing a technique at the time called atmospheric lensing that would use

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00:10:34,350 --> 00:10:36,890

the atmosphere as a lens to try to look at objects at high resolution.

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00:10:36,890 --> 00:10:42,780

But I needed big telescopes to do it and big telescope time costs a lot of money.

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00:10:42,780 --> 00:10:45,620

My graduate advisor said, "Sure, go for it."

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00:10:45,620 --> 00:10:51,279

So I went and I got -- actually I was very successful -- I came back with three 20 inch

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00:10:51,279 --> 00:10:52,279

telescopes.

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00:10:52,279 --> 00:10:56,640

We set them up on our department building and I started testing this out again.

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00:10:56,640 --> 00:11:02,430

It was an image of the sun actually that got me an invitation to Ames to give a talk to

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00:11:02,430 --> 00:11:05,410

a group interested here.

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00:11:05,410 --> 00:11:10,640

I'd finally gotten to the theoretical limit of the telescope's resolution effectively

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00:11:10,640 --> 00:11:14,440

imaging through the atmosphere's disturbances very well.

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00:11:14,440 --> 00:11:20,670

I imaged the Venus transit in 2012 and so I presented that work here.

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00:11:20,670 --> 00:11:24,560

The algorithm was still very basic at the time, so I didn't really understand why so

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00:11:24,560 --> 00:11:27,000

many things were working the way they were.

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00:11:27,000 --> 00:11:31,971

But we had essentially achieved the result of an equivalent of a space instrument, a

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00:11:31,971 --> 00:11:34,440

very small ground-based instrument.

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00:11:34,440 --> 00:11:40,150

It was at that talk that I gave that the center director at the time and a lot of other scientists

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00:11:40,150 --> 00:11:44,040

said, "Have you considered working with us?"

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00:11:44,040 --> 00:11:50,040

And then coming here as an intern, so I was brought in as an intern and now I'm a civil

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00:11:50,040 --> 00:11:50,980

servant here.

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00:11:50,980 --> 00:11:56,280

Host: Did you get pulled into -- they call it the Pathways Program or whatever its predecessor

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00:11:56,280 --> 00:11:57,340

was?

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00:11:57,340 --> 00:12:04,520

Ved Chirayath: At the time it was USRA and then it went into a Pathways fellowship in

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00:12:04,520 --> 00:12:06,600

2013, so a year after that.

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00:12:06,600 --> 00:12:07,420

Host: Cool.

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00:12:07,420 --> 00:12:08,520

Where are you sitting right now?

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00:12:08,520 --> 00:12:09,760

What kind of stuff are you working on?

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00:12:09,769 --> 00:12:12,459

Ved Chirayath: Now I got pulled over to the blue side.

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00:12:12,459 --> 00:12:17,360

I first looked at celestial objects and through the Earth's atmosphere and I started imaging

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00:12:17,360 --> 00:12:24,110

satellites and perhaps things that I should not have been imaging at high resolution.

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00:12:24,110 --> 00:12:28,250

One of my colleagues, actually the partner of one of my colleagues in marine biology,

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00:12:28,250 --> 00:12:32,000

says, "Have you looked at the ocean's surface and doing this through ocean waves?"

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00:12:32,000 --> 00:12:36,090

Because right now, we'd have no way of looking

through the refractive distortions coming

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00:12:36,090 --> 00:12:37,670
from the surface of water."

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00:12:37,670 --> 00:12:39,870
I said, "No, I haven't done that.

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00:12:39,870 --> 00:12:44,760
But actually that sound like a much easier
problem than the atmosphere because it's just

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00:12:44,760 --> 00:12:46,930
one surface that causes this distortion."

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00:12:46,930 --> 00:12:51,860
I put together a project I'd been working
a lot with UAVs at the time, small Unmanned

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00:12:51,860 --> 00:12:53,670
Aerial Vehicles or drones.

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00:12:53,670 --> 00:12:58,480
And so we deployed my technique on a coral
reef to look through the ocean's surface and

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00:12:58,480 --> 00:13:00,170
it worked remarkably well.

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00:13:00,170 --> 00:13:06,839
I got completely shifted to looking through
the air-water interface and trying to figure

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00:13:06,839 --> 00:13:08,370
out how to look through at the ocean.

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00:13:08,370 --> 00:13:12,650
I was really surprised to learn that we've
mapped more of Mars and the moon combined

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00:13:12,650 --> 00:13:17,329

than we have of our own ocean floor, which is startling because no one lives on those

232

00:13:17,329 --> 00:13:18,329

places.

233

00:13:18,329 --> 00:13:25,940

But our life is really dependent on the ocean so it became -- my mentors here at NASA Ames

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00:13:25,940 --> 00:13:29,410

really convinced me that my place was in Earth Science and to try to develop instruments

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00:13:29,410 --> 00:13:33,260

to figure out how to protect our spaceship first.

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00:13:33,260 --> 00:13:37,540

Then go off and try to do something outside of space.

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00:13:37,540 --> 00:13:39,760

That's how I got pulled over into Earth Science.

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00:13:39,760 --> 00:13:45,410

Host: Well then there's an obvious parallel to then, as we look and try to find exoplanets

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00:13:45,410 --> 00:13:49,270

or even celestial bodies in our own solar system.

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00:13:49,270 --> 00:13:54,010

Especially, we mentioned before starting, talking about Europa or Enceladus or some

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00:13:54,010 --> 00:14:01,459

of these places that have water even underneath
and a lot of ice.

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00:14:01,459 --> 00:14:06,760

There's just parallels of what we've learned
looking at our own planet can be tweaked to

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00:14:06,760 --> 00:14:07,760

look at other planets as well.

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00:14:07,760 --> 00:14:08,760

Ved Chirayath: Absolutely.

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00:14:08,760 --> 00:14:11,870

And a lot of the technologies we developed
for space science come out of Earth science

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00:14:11,870 --> 00:14:16,440

instruments and testing and validating them
on frankly the coolest planet that we know

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00:14:16,440 --> 00:14:20,410

of, the only one that has life, the only one
that has a huge diversity of life and multiple

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00:14:20,410 --> 00:14:22,350

environments.

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00:14:22,350 --> 00:14:28,100

As I looked up to do space science, I realized
I'm sitting on a gold mine already.

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00:14:28,100 --> 00:14:34,200

I found a planet that has oxygen, that has
large organisms, that has incredible diversity.

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00:14:34,200 --> 00:14:39,019

I think I could spend the rest of my life
studying planet Earth and not get bored.

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00:14:39,019 --> 00:14:44,389

Host: You were talking about the lensing and looking through liquid, is that also like

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00:14:44,389 --> 00:14:46,470

visual spectrum kind of stuff?

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00:14:46,470 --> 00:14:49,230

Because I know if you're looking through the ocean, at a certain point, the light just

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00:14:49,230 --> 00:14:50,860

doesn't get down that far.

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00:14:50,860 --> 00:14:53,560

Were you working on that stuff as well?

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00:14:53,560 --> 00:14:58,680

How do you correct that or look further than where light gets?

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00:14:58,680 --> 00:15:03,890

Ved Chirayath: The Ocean causes a lot of problems for how we view things.

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00:15:03,890 --> 00:15:07,910

Humans have been really good at exploring electromagnetic spectrum since we first discovered

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00:15:07,910 --> 00:15:11,399

it and trying to figure out all the different frequency regimes we can look at.

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00:15:11,399 --> 00:15:15,380

But when light interacts with water, you're really stuck with just a few frequencies that

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00:15:15,380 --> 00:15:16,440

transmit.

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00:15:16,440 --> 00:15:20,519

They just happen to be the optical frequencies that we naturally see.

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00:15:20,519 --> 00:15:24,700

So, blue light in clear tropical waters has a very deep penetration depth.

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00:15:24,700 --> 00:15:27,389

It's usually around a hundred meters before it's mostly attenuated.

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00:15:27,389 --> 00:15:29,089

Beneath that it's dark.

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00:15:29,089 --> 00:15:30,089

Once you get --

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00:15:30,089 --> 00:15:31,089

Host: You're not seeing anything after that.

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00:15:31,089 --> 00:15:32,089

Ved Chirayath: Right.

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00:15:32,089 --> 00:15:35,279

Even under the best circumstances in the open ocean, past a hundred meters, three hundred

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00:15:35,279 --> 00:15:39,420

meters, you're out of what we call the photic zone, which is where visible light penetrates.

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00:15:39,420 --> 00:15:40,990

And then it's just dark.

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00:15:40,990 --> 00:15:46,510

What's interesting is the ocean's average

depth is four kilometers so most of our understanding

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00:15:46,510 --> 00:15:50,160

of the ocean is this tiny little layer at the top.

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00:15:50,160 --> 00:15:53,330

That's not actually where all the life may be.

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00:15:53,330 --> 00:15:55,660

It may be in different areas.

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00:15:55,660 --> 00:15:57,610

One problem is optical absorption.

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00:15:57,610 --> 00:16:03,080

The second problem then comes from just the interface of air and water at the surface.

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00:16:03,080 --> 00:16:07,380

There's a refractive index jump between the two, which means that light going across that

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00:16:07,380 --> 00:16:08,889

boundary will get bent.

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00:16:08,889 --> 00:16:13,339

Host: And I'm sure that bubbles and air pockets and other --

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00:16:13,339 --> 00:16:17,589

Ved Chirayath: We'll call those higher order defects or floating --

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00:16:17,589 --> 00:16:18,620

Host: Too far down.

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00:16:18,620 --> 00:16:20,160

Let's go back to the basics.

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00:16:20,160 --> 00:16:23,049

Ved Chirayath: But for the large part, if you're trying to look at a target underwater

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00:16:23,049 --> 00:16:26,910

-- and you can see this at a swimming pool, and you look down at your friend underwater

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00:16:26,910 --> 00:16:30,070

-- you see the blurring effect of waves first.

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00:16:30,070 --> 00:16:33,000

And then the second effect you'll see is as he gets deeper, there's less and less color

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00:16:33,000 --> 00:16:34,310

that you see in the person.

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00:16:34,310 --> 00:16:38,360

You start just seeing one wavelength coming through and that's because of the absorption

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00:16:38,360 --> 00:16:42,889

of water molecules of certain frequencies and then a scattering of those frequencies.

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00:16:42,889 --> 00:16:45,270

The technology I had to develop had to address two issues.

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00:16:45,270 --> 00:16:47,730

One was this distortion from ocean waves.

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00:16:47,730 --> 00:16:50,600

And the second is this incredible absorption with depth.

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00:16:50,600 --> 00:16:53,790

That's a fundamental physical limit we have on how much you can see.

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00:16:53,790 --> 00:16:58,079

So, the algorithm I developed, fluobenzene, explored something called caustics.

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00:16:58,079 --> 00:17:03,740

When you look at a pool on a sunny day, you'll see at the bottom of the pool these dancing,

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00:17:03,740 --> 00:17:06,489

bright bands of light.

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00:17:06,489 --> 00:17:07,899

This really intrigued me.

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00:17:07,899 --> 00:17:12,069

I did a lot of research into how these were formed and this really formed the basis of

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00:17:12,069 --> 00:17:16,549

the algorithm that eventually we ended up using as part of this instrument.

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00:17:16,549 --> 00:17:21,140

These caustics get formed because light get essentially magnified from a wave.

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00:17:21,140 --> 00:17:27,819

Host: Almost like a magnifying glass or those glass pyramids or prisms, where it looks and

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00:17:27,819 --> 00:17:30,700

you can isolate to have a dot.

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00:17:30,700 --> 00:17:32,019

Ved Chirayath: Absolutely.

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00:17:32,019 --> 00:17:35,320

It's actually a question that has intrigued people for a long time.

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00:17:35,320 --> 00:17:39,340

Aerie in 1894, I believe, first asked this question.

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00:17:39,340 --> 00:17:42,679

What are these bright bands of light and how bright do they get?

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00:17:42,679 --> 00:17:46,419

If you figured out the properties of that band of light, you actually could figure out

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00:17:46,419 --> 00:17:51,029

a lot about what the ocean surface is doing because you know what shape it has.

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00:17:51,029 --> 00:17:54,190

Just as if you had a magnifying glass and you were to focus the light, you'd notice,

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00:17:54,190 --> 00:17:59,330

"Okay, this is a dot of high intensity, enough to fry something and it comes from this lens

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00:17:59,330 --> 00:18:00,609

shape."

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00:18:00,609 --> 00:18:02,299

I started off trying to do this experimentally.

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00:18:02,299 --> 00:18:06,049

It was very difficult because it's a complicated system and it moves.

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00:18:06,049 --> 00:18:12,159

Finally on the supercomputer at Ames, we just simulated the entire structure.

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00:18:12,159 --> 00:18:17,080

If you look at a Pixar film, or some other computer graphics generated film, you'll notice

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00:18:17,080 --> 00:18:21,630

that light gets -- they can simulate the interactions of light very accurately.

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00:18:21,630 --> 00:18:26,759

There's a lot of advanced rendering techniques we have to do that on a supercomputer.

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00:18:26,759 --> 00:18:30,409

I set up basically a swimming pool in the supercomputer and we tried to create ocean

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00:18:30,409 --> 00:18:33,260

waves and then see what the patterns of light were.

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00:18:33,260 --> 00:18:36,809

Sure enough, caustics emerged and we see these bright bands going around.

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00:18:36,809 --> 00:18:40,389

Then if you look at the intensity of those caustics, you notice that they're actually

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00:18:40,389 --> 00:18:45,080

-- this is something no one had ever figured out before -- they can be almost a hundred

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00:18:45,080 --> 00:18:50,679

times as bright as sunlight above the water.

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00:18:50,679 --> 00:18:55,700

This is a really interesting result because

it means that everything that evolved underwater,

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00:18:55,700 --> 00:19:01,059

first of all, has figured out a way to deal with bands of light hitting them that are

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00:19:01,059 --> 00:19:04,369

a hundred times the intensity of normal sunlight.

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00:19:04,369 --> 00:19:10,110

That's something that terrestrial organisms may not have to evolve with but certainly

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00:19:10,110 --> 00:19:14,730

fish with very sensitive eyes somehow manage to cope with this incredible intensity.

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00:19:14,730 --> 00:19:16,220

Host: And not go blind.

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00:19:16,220 --> 00:19:17,220

Ved Chirayath: Yes.

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00:19:17,220 --> 00:19:23,610

I have a theory that perhaps some of our suntan response underwater, I've noticed just diving

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00:19:23,610 --> 00:19:27,240

a lot you get tan very quickly even though you're not above the surface.

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00:19:27,240 --> 00:19:28,519

Host: That makes sense.

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00:19:28,519 --> 00:19:30,250

You're in a magnifying glass.

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00:19:30,250 --> 00:19:35,999

Ved Chirayath: And although the average intensity

may be much lower, the instantaneous intensity

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00:19:35,999 --> 00:19:39,850

from one of these bands hitting you can be incredibly high.

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00:19:39,850 --> 00:19:44,989

A lot of organisms respond to that using either a skin pigmentation change or some other feature.

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00:19:44,989 --> 00:19:51,429

That was the first main result is that these caustics are bright and when they form, the

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00:19:51,429 --> 00:19:55,730

traditional concept of optical absorption with depth goes away because you have now

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00:19:55,730 --> 00:20:00,450

this bright band of light that can penetrate much, much deeper than just the normal sunlight

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00:20:00,450 --> 00:20:02,899

that's coming through a diffuse surface.

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00:20:02,899 --> 00:20:05,940

So that was the first part of this puzzle.

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00:20:05,940 --> 00:20:10,700

The second was trying to figure out how to tie these bands to the surface of the ocean,

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00:20:10,700 --> 00:20:15,619

or the surface of a pool and figuring out what the lenses are essentially.

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00:20:15,619 --> 00:20:19,730

If you look down at a pool and you see this caustic band you'll also notice that wave

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00:20:19,730 --> 00:20:24,029

that's causing that band to form is acting like a magnifying glass and it magnifies whatever

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00:20:24,029 --> 00:20:26,669

object is beneath the surface.

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00:20:26,669 --> 00:20:32,190

Essentially I had to teach a computer to find those magnifying events when they went over

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00:20:32,190 --> 00:20:36,509

an object and they magnified it many, many times higher than even than natural sensor

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00:20:36,509 --> 00:20:42,049

could see, and then also tell the algorithm to track those caustics so that it wasn't

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00:20:42,049 --> 00:20:47,270

just magnifying the object, but it was lighting it up with a bright band of sunlight.

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00:20:47,270 --> 00:20:51,849

Those two together allow you to create something called a [foo] lensing algorithm, which is

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00:20:51,849 --> 00:20:56,340

what I developed to image, not only at high resolution so to use the ocean's surface as

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00:20:56,340 --> 00:21:01,389

a magnifying lens or a telescope essentially between you and whatever object is imaging

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00:21:01,389 --> 00:21:05,429

it from the surface, and then also as a scanning lighting system.

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00:21:05,429 --> 00:21:09,629

We have these bright bands going across them and they will light up the target instantaneously

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00:21:09,629 --> 00:21:14,039

so you can fix these two issues we have with ocean world sensing -- the optical absorption

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00:21:14,039 --> 00:21:19,179

of light through these caustic bands and then second is the refractive distortions actually

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00:21:19,179 --> 00:21:23,659

end up helping you because they act like little lenslets that you can magnify the target.

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00:21:23,659 --> 00:21:26,080

It only works under certain conditions.

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00:21:26,080 --> 00:21:32,080

You can't do this exactly globally, but for shallow marine systems, this has really been

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00:21:32,080 --> 00:21:33,109

a game changer.

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00:21:33,109 --> 00:21:38,519

We can now look at a coral reef from an aircraft at a resolution of a half a centimeter or

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00:21:38,519 --> 00:21:40,649

less in three dimensions.

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00:21:40,649 --> 00:21:44,090

We understand how these ecosystems look for the first time.

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00:21:44,090 --> 00:21:48,190

We're able to map huge areas of islands in the Pacific.

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00:21:48,190 --> 00:21:51,659

Host: You're not just reliant on divers going down or taking photos.

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00:21:51,659 --> 00:21:57,840

You can, whether it's a drone or an airplane, map it so much faster and understand it so

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00:21:57,840 --> 00:21:58,840

much more.

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00:21:58,840 --> 00:21:59,960

Ved Chirayath: That comes with a whole bunch of other problems.

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00:21:59,960 --> 00:22:01,049

You have these huge datasets.

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00:22:01,049 --> 00:22:05,779

But for the first time you have a map, a 3D map of what's going on under the surface.

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00:22:05,779 --> 00:22:11,019

These coral reef ecosystems have a biodiversity that's just above anything else we know on

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00:22:11,019 --> 00:22:12,119

Earth.

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00:22:12,119 --> 00:22:18,600

If you go to the Amazon rainforest, the average number of species per cubic meter is around

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00:22:18,600 --> 00:22:22,690

100 times less than the same number in a coral reef system.

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00:22:22,690 --> 00:22:26,980

These systems are not just pretty but they also support a huge amount of biodiversity

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00:22:26,980 --> 00:22:31,960

in the oceans, they shelter island systems from tsunami events and storm surge events,

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00:22:31,960 --> 00:22:38,659

they perform this natural barrier and they support a lot of humans essentially with a

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00:22:38,659 --> 00:22:43,159

food source, a very steady food source that supports fisheries.

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00:22:43,159 --> 00:22:45,009

We're just understanding now for the first time --

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00:22:45,009 --> 00:22:46,009

Host: These are the beginning stages.

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00:22:46,009 --> 00:22:49,470

Ved Chirayath: -- right, what they look like and then before we've really had to look with

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00:22:49,470 --> 00:22:53,909

diver data to understand things at the spatial scale.

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00:22:53,909 --> 00:22:58,269

Corals right now are changing drastically because the ocean is changing a lot of properties

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00:22:58,269 --> 00:22:59,269

at once.

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00:22:59,269 --> 00:23:03,499

The temperature is changing of the ocean's surface, the salinity of a lot of places is

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00:23:03,499 --> 00:23:07,269

changing, but most importantly, the acidity of the ocean is changing.

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00:23:07,269 --> 00:23:12,919

As we pump out a lot of carbon dioxide, that carbon dioxide gets absorbed, fixed by the

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00:23:12,919 --> 00:23:14,769

ocean directly.

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00:23:14,769 --> 00:23:18,759

Almost 80% of the carbon dioxide we produce goes into the ocean.

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00:23:18,759 --> 00:23:22,529

As it goes into the ocean, it's changing the acidity or the ph of the ocean.

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00:23:22,529 --> 00:23:27,970

So, if you're a coral reef and you're made of calcium carbonate skeleton, your whole

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00:23:27,970 --> 00:23:32,269

structure, your skeleton is based upon having a certain acidity and if that acidity changes,

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00:23:32,269 --> 00:23:33,679

it starts dissolving.

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00:23:33,679 --> 00:23:39,009

A lot of corals are undergoing bleaching events or they're essentially dying off and they

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00:23:39,009 --> 00:23:44,119

are losing the structure that is so crucial to supporting fisheries in those areas as

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00:23:44,119 --> 00:23:46,470

well as providing a natural barrier to storm events.

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00:23:46,470 --> 00:23:51,129

Host: What's interesting is some of the, what you talk about, especially marine life, but

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00:23:51,129 --> 00:23:57,490

as you start looking at that biodiversity, or even in some extreme situations or even

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00:23:57,490 --> 00:24:04,330

where they've evolved or figured out how to survive with this magnified light on them.

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00:24:04,330 --> 00:24:10,479

How then that can correlate to being shocked at how life can survive in some of the most

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00:24:10,479 --> 00:24:12,899

crazy extreme conditions.

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00:24:12,899 --> 00:24:17,399

And then what does that mean for us understanding these oceans, understanding how things are

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00:24:17,399 --> 00:24:20,220

surviving under these crazy conditions?

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00:24:20,220 --> 00:24:23,749

What does that mean when we're looking on Mars, when we're looking in Europa, when we're

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00:24:23,749 --> 00:24:26,370

looking outside of our solar system?

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00:24:26,370 --> 00:24:32,230

We can get a better look at some of the planets that Kepler has found, that understanding

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00:24:32,230 --> 00:24:40,590

then we know, "Hey, life has existed in this way under these circumstances here on earth.

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00:24:40,590 --> 00:24:42,320

What does that mean?"

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00:24:42,320 --> 00:24:46,380

Maybe some places that you typically rule out, you don't have to rule out, or you really

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00:24:46,380 --> 00:24:47,380

don't know.

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00:24:47,380 --> 00:24:48,380

Ved Chirayath: Absolutely.

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00:24:48,380 --> 00:24:51,210

I guess to me it's very strange because we're here at NASA.

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00:24:51,210 --> 00:24:53,590

One of our main goals is to find life.

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00:24:53,590 --> 00:24:57,440

I like to think that we're the Star Trek of all the agencies.

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00:24:57,440 --> 00:25:03,769

But really the only defining trait of humanity thus far is the mass extinction of life on

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00:25:03,769 --> 00:25:04,769

Earth.

421

00:25:04,769 --> 00:25:10,039

We're very good at killing things off, large amounts of species and it's baffling to me

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00:25:10,039 --> 00:25:16,090

that we are so interested in finding new life forms when we're sitting on a trove of them

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00:25:16,090 --> 00:25:18,849

and we're losing them at an unprecedented rate.

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00:25:18,849 --> 00:25:24,019

Host: Looking at the fluid lensing, looking at even how you apply that to looking through

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00:25:24,019 --> 00:25:26,700

the atmosphere, what do you see as the next step?

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00:25:26,700 --> 00:25:27,700

What's the next phase?

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00:25:27,700 --> 00:25:30,760

What are you looking at five years from now from all the research and stuff that you've

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00:25:30,760 --> 00:25:31,760

done?

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00:25:31,760 --> 00:25:34,779

Where do you hope that it's going or where do you see it moving?

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00:25:34,779 --> 00:25:38,830

Ved Chirayath: My job now is really just to invent new instruments and get them in the

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00:25:38,830 --> 00:25:42,889

hands of the science community to use them to understand either this coral ecosystem

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00:25:42,889 --> 00:25:44,760
or different types of ecosystems.

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00:25:44,760 --> 00:25:49,659
So my main goal right now is getting this
technology mature enough to fly on a spacecraft.

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00:25:49,659 --> 00:25:54,090
NASA's unique vantage point in space helps
us understand the planet like no one else

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00:25:54,090 --> 00:25:55,090
can.

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00:25:55,090 --> 00:25:58,610
So right now, we've been testing them on drones
and flying around different coral reef systems

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00:25:58,610 --> 00:26:02,320
producing very large data sets and really
maturing the technology to show, not only

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00:26:02,320 --> 00:26:06,179
does this produce a very high resolution result,
but it tells you something very important

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00:26:06,179 --> 00:26:07,179
about this ecosystem.

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00:26:07,179 --> 00:26:10,719
It tells you the breakdown of the different
species or the abundance of the different

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00:26:10,719 --> 00:26:12,200
types of morphologies.

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00:26:12,200 --> 00:26:15,010
That's a key science question that will motivate
a satellite instrument.

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00:26:15,010 --> 00:26:16,369

I'm looking at CubeSats.

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00:26:16,369 --> 00:26:20,059

I'd like to have a nice fleet of CubeSats that's doing this around our planet.

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00:26:20,059 --> 00:26:22,759

We still have not mapped all the corals at this resolution.

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00:26:22,759 --> 00:26:27,840

We've probably mapped one ten thousandth of the entire coral surface of the earth with

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00:26:27,840 --> 00:26:29,140

this technique.

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00:26:29,140 --> 00:26:33,679

It's a hard problem, surveying the entire planet at half a centimeter resolution on

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00:26:33,679 --> 00:26:38,249

just the coral reefs alone is a very large amount of data.

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00:26:38,249 --> 00:26:42,340

The other development we have going on right now is a lot of machine learning tools to

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00:26:42,340 --> 00:26:47,700

take in all that data and just have a human train a small portion of it to understand

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00:26:47,700 --> 00:26:48,919

how to classify all of it.

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00:26:48,919 --> 00:26:54,510

We've been very successful in using the centimeter

scaled data in particular to assess the percent

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00:26:54,510 --> 00:26:56,190

cover of the coral reef with very little error.

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00:26:56,190 --> 00:27:01,350

We're now down to about 5% error -- before it was around 30% error.

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00:27:01,350 --> 00:27:06,210

Just that metric alone will help us understand how these systems are changing with the changing

457

00:27:06,210 --> 00:27:11,600

climate, how our impacts in certain environments are affecting the ecosystem before it becomes

458

00:27:11,600 --> 00:27:12,600

too late.

459

00:27:12,600 --> 00:27:17,840

For example, if we start dredging or dumping a lot of pollutants in one area, we can see

460

00:27:17,840 --> 00:27:22,690

that change on a weekly timescale rather than our current sensors, which have very low resolution

461

00:27:22,690 --> 00:27:27,019

so they only see them after it's too late and the entire coral is bleached through the

462

00:27:27,019 --> 00:27:28,409

yearly timescale.

463

00:27:28,409 --> 00:27:33,339

Host: It's fascinating to see the entire tapestry of what NASA does.

464

00:27:33,339 --> 00:27:35,789

Of looking at the stars and have your algorithms.

465

00:27:35,789 --> 00:27:42,419

Moving into looking at the ocean and using
a supercomputer to then create new instruments

466

00:27:42,419 --> 00:27:47,880

that'll go on small sats or whether it's small
missions, large missions.

467

00:27:47,880 --> 00:27:52,429

It's everything that they do is touching it
in one way or another.

468

00:27:52,429 --> 00:27:55,649

For folks who are listening who want to learn
more about some of the cool stuff that you're

469

00:27:55,649 --> 00:28:00,849

working on and any direct questions for Ved,
we are using #NASASiliconValley, we're on

470

00:28:00,849 --> 00:28:02,029

Twitter @NASA Ames.