



1

00:00:01,500 --> 00:00:06,680

This is Hubble Telescope's famous photograph, Hubble Ultra-Deep Field.

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00:00:06,700 --> 00:00:10,380

There are nearly 10,000 galaxies each containing as many as

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00:00:10,400 --> 00:00:13,810

100 billion planets in this image alone.

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00:00:13,830 --> 00:00:17,510

But the question has always been, out of those billions of planets,

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00:00:17,530 --> 00:00:19,730

how many could have life?

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00:00:19,750 --> 00:00:24,000

Observing Earth's global biology on a massive, planetary scale

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00:00:24,020 --> 00:00:28,010

has given scientists the tools to answer important questions -

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00:00:28,030 --> 00:00:34,580

like how can we use models of our own planet to detect signs of life on other worlds?

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00:00:34,600 --> 00:00:39,930

In short - the first thing we're going to do is figure out how we'd find ourselves.

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00:00:46,000 --> 00:00:47,680

When I talk to people about this,

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00:00:47,700 --> 00:00:52,070

about the search for life on all these planets we've found around all these other stars,

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00:00:52,090 --> 00:00:55,900

a very common response I get is this line from Contact

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00:00:55,920 --> 00:00:59,630

– well, if there isn't anything out there, it would be a horrible waste of space –

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00:00:59,650 --> 00:01:04,340

which is a wonderful line, and especially was a wonderful line 20 years ago.

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00:01:04,360 --> 00:01:05,640

But now we're beyond that.

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00:01:05,660 --> 00:01:08,410

That's Dr. Shawn Domagal-Goldman.

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00:01:08,430 --> 00:01:11,570

He's one of NASA's many scientists heading up the search for life.

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00:01:11,590 --> 00:01:16,220

I'm a research space scientist and astrobiologist at NASA Goddard Space Flight Center.

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00:01:16,240 --> 00:01:21,660

What I do at NASA is I look for ways to look for life on other planets.

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00:01:21,680 --> 00:01:24,710

Ten years ago, conversations about life in the universe

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00:01:24,730 --> 00:01:28,350

were mainly limited to bar talk and philosophical conversations.

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00:01:28,370 --> 00:01:30,410

But that's all changed.

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00:01:30,430 --> 00:01:34,890

We can now apply the scientific method to the question, are we alone?

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00:01:34,910 --> 00:01:38,140

We, based on our understanding of how life operates on Earth,

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00:01:38,160 --> 00:01:41,650

are starting to derive principles of the signals that life creates

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00:01:41,670 --> 00:01:45,140

that we could then look for on these planets around other stars.

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00:01:45,160 --> 00:01:47,890

But with a universe as vast as ours,

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00:01:47,910 --> 00:01:51,720

where do you even begin looking for these Earth-like planets?

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00:01:54,110 --> 00:01:58,090

NASA scientists must take an extremely calculated approach

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00:01:58,110 --> 00:02:01,070

when it comes to combing the universe for signs of life.

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00:02:01,090 --> 00:02:03,920

By studying Earth's climate over its long history,

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00:02:03,940 --> 00:02:08,760

we have a pretty good understanding of how climate operates on other rocky planets.

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00:02:08,780 --> 00:02:12,580

And that gives us some helpful clues on the distance from a star and the size of planet

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00:02:12,600 --> 00:02:17,090

that could harbor a global biosphere like the one we have here on Earth.

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00:02:17,110 --> 00:02:19,920

It all comes down to knowing where to look.

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00:02:19,940 --> 00:02:21,120

We have a concept for this:

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00:02:21,140 --> 00:02:23,500

its called the habitable zone or the Goldilocks zone

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00:02:23,520 --> 00:02:28,630

and the basic idea is, you can't be too hot, because otherwise you'll lose your oceans

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00:02:28,650 --> 00:02:32,080

– they'll basically boil and steam away, you can't be too cold,

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00:02:32,100 --> 00:02:33,750

because then your oceans will freeze over.

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00:02:33,770 --> 00:02:36,300

You want that that big sort of ocean reservoir

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00:02:36,320 --> 00:02:39,460

at the surface which happens when you're kind of in the middle and just right.

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00:02:39,480 --> 00:02:43,010

In our solar system, the Goldilocks zone is bound by Venus

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00:02:43,030 --> 00:02:46,300

which is too hot and steamy with no oceans at the surface and Mars

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00:02:46,320 --> 00:02:48,330

which is too cold and too small.

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00:02:48,350 --> 00:02:50,600

And size matters too.

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00:02:50,620 --> 00:02:54,330

To give an example, the moon is technically in just right place.

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00:02:54,350 --> 00:02:57,370

It's in the middle of the Goldilocks zone just like Earth is,

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00:02:57,390 --> 00:03:00,660

and it gets the right amount of energy from the sun.

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00:03:00,680 --> 00:03:04,540

But it's too small to hold on to an atmosphere.

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00:03:04,560 --> 00:03:06,700  
And the same thing goes for planets that are too big,

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00:03:06,720 --> 00:03:10,550  
like gas giants where there's too much pressure bearing down on liquid water.

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00:03:10,570 --> 00:03:13,480  
We're on the Goldilocks planet, and what's really neat is

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00:03:13,500 --> 00:03:17,540  
we found a lot of other so-called Goldilocks planets in the last few years

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00:03:17,560 --> 00:03:21,520  
that we could then think about looking for signs of life on in the future.

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00:03:21,540 --> 00:03:26,200  
The studies Shawn is talking about have been coming out pretty consistently since the early 2000s.

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00:03:26,220 --> 00:03:31,480  
The recent uptick in exoplanet discoveries over the past seven years or so

58  
00:03:31,500 --> 00:03:33,660  
is due in large part to the Kepler Space Telescope

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00:03:33,680 --> 00:03:38,000  
which found over thousands of exoplanets orbiting other stars.

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00:03:38,020 --> 00:03:41,590  
One cluster of planets after another, astrophysicists have discovered

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00:03:41,610 --> 00:03:45,380  
a mind-blowing number of worlds that are the right size and distance from their star

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00:03:45,400 --> 00:03:48,480  
to have potentially have conditions for life similar to Earth.

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00:03:48,500 --> 00:03:50,780

The most amazing thing that Earth has taught us

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00:03:50,800 --> 00:03:54,090

is that life can really exist in very dramatic environments

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00:03:54,110 --> 00:03:57,030

from really hot environments in the middle of a desert

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00:03:57,050 --> 00:04:01,170

to really cold environments with little light at the very bottom of the ocean.

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00:04:01,190 --> 00:04:05,930

Based on what we know about Earth, the fundamental cocktail looks like this:

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00:04:05,950 --> 00:04:07,240

You need liquid water,

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00:04:07,260 --> 00:04:09,160

the right atmospheric gases

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00:04:09,180 --> 00:04:13,880

- and if you're lucky – specific global signals of life.

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00:04:15,000 --> 00:04:18,290

Everywhere we look, whether it's a desert or Antarctica

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00:04:18,310 --> 00:04:23,000

or the deep ocean or the deepest parts of Earth's crust that we've explored,

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00:04:23,020 --> 00:04:27,670

as long as there's a little tiny speck of liquid water, there's life.

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00:04:27,690 --> 00:04:33,370

And because of that, it's been central to NASA's search for habitable environments elsewhere.

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00:04:33,390 --> 00:04:36,420

It's why scientists get excited about the water spewing up

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00:04:36,440 --> 00:04:40,200

from the icy moons of Europa and Enceladus in our outer solar system.

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00:04:40,220 --> 00:04:47,660

Not only could they have water, they could have global oceans like we have here on Earth.

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00:04:47,680 --> 00:04:51,090

After liquid water, we'd look for atmospheric gases

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00:04:51,110 --> 00:04:54,170

– actually the gas we're breathing now, oxygen.

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00:04:54,190 --> 00:04:57,320

Find oxygen and methane together in the same atmosphere

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00:04:57,340 --> 00:04:58,890

and you've got something special.

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00:04:58,910 --> 00:05:03,080

There are ways to build up oxygen or methane in a planetary atmosphere,

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00:05:03,100 --> 00:05:06,600

but the only way you get them both in the same atmosphere at the same time

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00:05:06,620 --> 00:05:10,120

is if you produce them both super rapidly.

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00:05:10,140 --> 00:05:14,450

And the only way we know how to do that is through life.

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00:05:16,280 --> 00:05:19,280

The next thing scientists could look for is pigment

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00:05:19,300 --> 00:05:23,140

- the colors of life, like the chlorophyll found in plants on land

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00:05:23,160 --> 00:05:26,300

and algae and phytoplankton in the ocean.

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00:05:26,320 --> 00:05:30,250

Although there aren't currently any outer space missions in progress to retrieve this data,

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00:05:30,270 --> 00:05:36,310

we could— in theory— be able to detect similar colors on a planet around another star in the future.

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00:05:38,510 --> 00:05:44,530

But maybe one of the coolest things about this whole enterprise is how quickly we're learning.

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00:05:44,550 --> 00:05:49,800

I firmly believe that one of two things is going to happen in the course of my scientific career.

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00:05:49,820 --> 00:05:53,330

Either we're going to find evidence that we're not alone in the universe

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00:05:53,350 --> 00:05:57,510

or we'll have so exhaustively searched for it and not found anything