Audio file

119077-PlutoBackfromtheDead.mp3

Transcript

00:00:08 Speaker 1

Three and a half billion miles from Earth, beyond Jupiter, Saturn, past Uranus and Neptune, hides Pluto and its five moons.

00:00:25 Speaker 1

Discovered in 1930, for decades we knew almost nothing about it.

00:00:33 Speaker 2

As a child, I learned that Pluto was a mysterious gray rock.

00:00:39 Speaker 1

So in 2006, NASA launched a rocket carrying a lightweight probe.

00:00:45 Speaker 2

All time tree is nominal.

00:00:48 Speaker 2

Copy that.

00:00:48 Speaker 2

We have a healthy spacecraft.

00:00:52 Speaker 1

The spacecraft returned the first ever close-up images of Pluto's surface.

00:00:57 Speaker 2

We've recorded data of the Pluto system.

00:01:02 Speaker 1

And sent our understanding of this icy world into disarray.

00:01:06 Speaker 3

The data returned has forced us to rethink everything about Pluto.

00:01:14 Speaker 1

This was not the lifeless rock we once thought.

00:01:19 Speaker 4

There's a heat source, which must be coming from inside, but the details of that are still very mysterious.

00:01:28 Speaker 3

This small, unassuming little world

00:01:32 Speaker 3

may actually have a liquid water ocean beneath its icy surface.

00:01:40 Speaker 1

Incredible new discoveries about Pluto are even changing our understanding of life beyond Earth.

00:01:47 Speaker 5

No one in their right mind would have thought Pluto had life, but now it's a possibility, and that in itself is kind of mind-blowing.

00:01:56 Speaker 1

This is the story of how Pluto came back from the dead.

00:02:18 Speaker 1

In 2006, a visionary group of scientists began A groundbreaking mission.

00:02:25 Speaker 1

To send the spaceship further than ever before.

00:02:31 Speaker 1

Its mission, to explore the far reaches of our solar system and take the first ever close-up image of Pluto before continuing into deep space.

00:02:46 Speaker 1

The probe was called New Horizons.

00:02:52 Speaker 1

And it would take more than nine years to make the three and a half billion mile voyage to Pluto.

00:03:04 Speaker 1

Keeping things on track was Mission Operations Manager Alice Bowman.

00:03:10 Speaker 2

This is the best picture of Pluto that we had before New Horizons arrived.

00:03:15 Speaker 2

And this was taken by the Hubble Space Telescope.

00:03:18 Speaker 2

And it was the picture that inspired us to send the spacecraft to Pluto.

00:03:29 Speaker 1

In 2015, 10 days before New Horizons' arrival, Alice's team began uploading computer commands to the probe.

00:03:39 Speaker 1

telling the spacecraft what to do when it reached Pluto.

00:03:46 Speaker 2

That was a very anxious time, because we wanted to make sure that those commands were received and accepted by the spacecraft, because if they weren't, we wouldn't have a mission.

00:03:58 Speaker 1

But as the final command was sent, Alice's worst fears were realized.

00:04:05 Speaker 2

We lost calm.

00:04:08 Speaker 2

with the spacecraft.

00:04:10 Speaker 2

Totally silent.

00:04:11 Speaker 2

And so you can imagine when you're in any kind of critical situation, the worst thing is lack of any information.

00:04:19 Speaker 2

And that's essentially what we had.

00:04:25 Speaker 1

The team had lost all contact with the probe.

00:04:31 Speaker 2

Pluto Ace, mom on New Horizons, Pluto 1.

00:04:35 Speaker 2

Could you advise why we are not locking up to telemetry?

00:04:40 Speaker 2

Non Pluto Ace.

00:04:40 Speaker 2

Stand by.

00:04:41 Speaker 2

I'll check with the station on the status of telemetry.

00:04:45 Speaker 1

New Horizons was designed to fly past Pluto, taking pictures as it went.

00:04:54 Speaker 1

If they didn't regain contact, it would fly past without recording a thing.

00:05:02 Speaker 2

Station 43, Pluto Ace.

00:05:05 Speaker 2

Mom, on New Horizons, Pluto 1, go ahead, Pluto Ace.

00:05:08 Speaker 1

After a frantic hour, the team received a weak signal from the probe.

00:05:15 Speaker 2

We found the spacecraft.

00:05:17 Speaker 2

It was responding to us.

00:05:18 Speaker 2

It was giving us information, but it was in a state that could not accomplish the encounter with Pluto.

00:05:28 Speaker 2

We determined that we had asked the processor on board the spacecraft to do too many labor-intensive things.

00:05:38 Speaker 2

And the spacecraft switched over to the redundant or backup computer.

00:05:43 Speaker 1

New Horizons was back online.

00:05:46 Speaker 1

But there was a problem.

00:05:48 Speaker 1

When it had switched to the backup computer, it had wiped every line of command needed for its encounter with Pluto.

00:05:57 Speaker 1

All non-essential systems had shut down, including the cameras.

00:06:02 Speaker 2

The question became, did we have enough time to recover the spacecraft and start that flyby encounter on time?

00:06:13 Speaker 2

So our plan was to switch back to the main computer and then resend the commands to the spacecraft.

00:06:22 Speaker 2

And it took us three days to do that.

00:06:26 Speaker 1

Around the clock.

00:06:27 Speaker 2

Around the clock, we slept in our offices.

00:06:31 Speaker 2

No one wanted to leave because we had waited all this time, and there was no way that we were going to let this opportunity slip by.

00:06:43 Speaker 1

Working through the night, the team re-uploaded the computer commands.

00:06:49 Speaker 1

Once completed, all they could do was wait.

00:06:55 Speaker 2

It was a very anxious time.

00:07:00 Speaker 1

Traveling past Pluto more than 10 times faster than a speeding bullet meant every new line of command needed to work with meticulous precision.

00:07:15 Speaker 1

There would be no second chance, no way to go back.

00:07:20 Speaker 1

And with New Horizons busy collecting data,

00:07:24 Speaker 1

it would be out of contact with Earth.

00:07:28 Speaker 1

Until the spacecraft beamed back a signal, the team would have no idea if the new commands had worked.

00:07:40 Speaker 2

Subsystems, please report your status as you get enough data.

00:07:47 Speaker 2

Okay, we're in lock with carrier.

00:07:50 Speaker 2

Stand by for telemetry.

00:07:52 Speaker 2

The atmosphere was very intense.

00:07:54 Speaker 2

We were all anxiously awaiting that first bit of telemetry to tell us that the spacecraft had survived.

00:08:01 Speaker 2

I'm on Pluto 1.

00:08:03 Speaker 2

We have a healthy spacecraft.

00:08:06 Speaker 2

We've recorded data of the Pluto system, and we're outbound from Pluto.

00:08:11 Speaker 1

The flyby was a success.

00:08:20 Speaker 1

And Pluto's surface

00:08:22 Speaker 1

came into focus for the very first time.

00:08:27 Speaker 2

It was amazing.

00:08:30 Speaker 2

It just blew our minds that something could be so beautiful.

00:08:35 Speaker 2

It's like telling us, Why the heck did you wait so long to come visit us.

00:08:42 Speaker 1

What New Horizons sent back was astonishing.

00:08:59 Speaker 1

The probe had taken thousands of photographs of Pluto's surface.

00:09:05 Speaker 1

Multiple cameras had charted the topography.

00:09:10 Speaker 1

The spectrograph detected what that surface was made from, revealing Pluto's secrets for the first time, and in spectacular detail.

00:09:26 Speaker 6

Oh, there's my friend.

00:09:28 Speaker 7

Beautiful.

00:09:30 Speaker 1

Leslie Young and Jeff Moore are two of the project's leading scientists.

00:09:36 Speaker 1

Their job?

00:09:37 Speaker 1

To decipher this mysterious alien world.

00:09:44 Speaker 7

It's amazing.

00:09:45 Speaker 7

You look at all these exotic features.

00:09:48 Speaker 7

Everything's so amazing and so diverse and so complex.

00:09:52 Speaker 6

I was in the main room.

00:09:54 Speaker 6

When I first saw this image, we were on tender hooks.

00:10:02 Speaker 7

Pluto was ready for its close-up.

00:10:04 Speaker 6

Pluto was ready for its close-up.

00:10:07 Speaker 1

When these images arrived, the team was struck by Pluto's familiar appearance.

00:10:14 Speaker 7

These mountains down here, they look an awful lot like Earth mountains.

00:10:17 Speaker 7

They're snow-capped.

00:10:18 Speaker 6

These guys are 4 kilometers tall, just like the Rocky Mountains are.

00:10:26 Speaker 1

But unlike Earth, these mountains were made from ice, not rock.

00:10:35 Speaker 1

Pluto is so far from the sun, the scientists were expecting an almost featureless frozen sphere.

00:10:44 Speaker 1

Instead, new horizons had revealed Pluto to be a world of puzzling complexity.

00:10:51 Speaker 1

There were mountains forged from ice.

00:10:55 Speaker 1

Craters of every size, gaping canyons and vast plains, covered in nitrogen frost and methane snow.

00:11:06 Speaker 1

All of it mysteriously colored from deep red to bright white.

00:11:13 Speaker 6

We knew Pluto was going to be scientifically astonishing.

00:11:16 Speaker 6

We didn't know it was going to be so beautiful.

00:11:20 Speaker 6

Nobody expected to see anything like this.

00:11:30 Speaker 1

Pluto's full glory had finally been revealed, 85 years after it was discovered by American astronomer Clyde Tombaugh.

00:11:43 Speaker 1

Its distance from Earth has meant that for much of the time that we've known about it, Pluto has remained as mysterious as the stories that inspired its name.

00:11:54 Speaker 4

Pluto is the god of the underworld in mythology.

00:11:57 Speaker 4

He lives in the realm underground, and this is the place where people go when they die.

00:12:02 Speaker 1

The first thing to know about Pluto is that it's tiny and really far away.

00:12:13 Speaker 4

We're standing on a lake bed, a frozen lake in Colorado.

00:12:16 Speaker 4

Let's pretend that this is the plane of the solar system.

00:12:20 Speaker 4

And over there, the ice resurfacing machine, we'll call that the sun.

00:12:25 Speaker 4

That's where the sun is, then we're roughly where Earth is.

00:12:28 Speaker 4

But of course, Earth is much smaller.

00:12:29 Speaker 4

If I don't break it, here is the Earth, roughly a centimeter across, something like that.

00:12:35 Speaker 4

Now, Pluto, by comparison, would be a grain of sand.

00:12:38 Speaker 4

That grain of sand would not be here, of course, in this part of the solar system.

00:12:42 Speaker 4

It's in the outer part, and it would be roughly on that mountaintop right over there.

00:12:46 Speaker 4

So about 6 kilometers away would be Pluto.

00:12:53 Speaker 1

Pluto's extreme distance from Earth meant that very little was known about it before new horizons arrived.

00:13:01 Speaker 1

Astronomers knew that it was cold enough to be made from ice.

00:13:05 Speaker 1

They knew it was small and that it had company.

00:13:11 Speaker 4

Pluto is not alone.

00:13:12 Speaker 4

In fact, it has five moons.

00:13:15 Speaker 1

Tiny Pluto isn't one body, but a whole system of icy worlds.

00:13:22 Speaker 1

all engaged in a strange and complex dance.

00:13:27 Speaker 1

And as new horizons approached Pluto, the scientists were able to see them in detail for the very first time.

00:13:37 Speaker 1

Pluto's first and largest moon is Charon.

00:13:42 Speaker 4

The name comes from Greek mythology as the name of the boatsman who would row people across the river to get them to the underworld.

00:13:51 Speaker 4

Charon is remarkably large compared to Pluto.

00:13:53 Speaker 4

It's about half the size, and they're very close.

00:13:57 Speaker 4

Sometimes we call them a binary planet because, in fact, they orbit together as if there were a rod between them and they were two ends of a lopsided dumbbell.

00:14:08 Speaker 1

Pluto's moon, Charon, doesn't orbit Pluto.

00:14:11 Speaker 1

Unusually, they orbit each other around a point in empty space.

00:14:20 Speaker 1

Beyond Charon are four smaller moons.

00:14:23 Speaker 1

There's Styx.

00:14:25 Speaker 4

Styx is the river that the boatsman Charon would take people across once they died and entered the underworld itself.

00:14:32 Speaker 4

Styx is a very small body.

00:14:33 Speaker 4

It's just kind of a lumpy, irregular object.

00:14:38 Speaker 1

There's Nyx.

00:14:41 Speaker 4

Nyx is about 50 kilometers across.

00:14:44 Speaker 4

It is rotating in a very strange way that we haven't quite figured out yet.

00:14:51 Speaker 1

Then there's Kerberos and Hydra.

00:14:57 Speaker 4

Hydra is spinning very, very fast, and we simply don't know why.

00:15:04 Speaker 4

If you were standing on Hydra, you might have to actually hold on.

00:15:10 Speaker 1

Why does a tiny dwarf planet have so many moons?

00:15:16 Speaker 1

The peculiar dance of Charon and Pluto are a clue.

00:15:21 Speaker 4

So the big question, of course, is you have to get two bodies.

00:15:24 Speaker 4

You have to get a binary planet in the middle.

00:15:26 Speaker 4

And the only way we really know to do that is there was a proto-Pluto out there very early in the history of the solar system, and something else hit it, something very, very big.

00:15:40 Speaker 4

Pluto kind of blew apart, and eventually re-coalesced.

00:15:49 Speaker 4

But all that material that was floating around, a lot of it formed into Charon.

00:15:56 Speaker 4

And the two got kind of stuck together as they evolved into this perfect circular dumbbell system.

00:16:02 Speaker 4

Maybe there was some debris left over that landed further out, and that became Hydra and Kerberos and Nix and Sticks.

00:16:13 Speaker 1

New Horizons had given the scientists a better understanding of Pluto's peculiar moons.

00:16:20 Speaker 1

But it was the pictures of Pluto's surface that contained the biggest surprises.

00:16:29 Speaker 1

A smaller impact than the one that created the moons could be responsible for one of Pluto's most mysterious features.

00:16:40 Speaker 6

We think this was a

00:16:42 Speaker 6

big impact crater just from the shape of it, really.

00:16:45 Speaker 6

This is probably an ancient crater rim of a huge impact that must have happened early on when Pluto was still very young.

00:16:54 Speaker 6

So this is about 1,000 kilometers across, probably something about 200 kilometers across came in and hit Pluto.

00:17:03 Speaker 1

New Horizons was carrying a spectrograph, an instrument capable of analyzing chemical composition.

00:17:10 Speaker 1

It revealed

00:17:11 Speaker 1

that much of Pluto's freezing surface was covered by soft nitrogen ice.

00:17:18 Speaker 1

Normally a gas on Earth, the scientists believe that vast amounts of it have flowed in to fill this enormous crater.

00:17:27 Speaker 7

We're pretty sure we understand that what makes up the plane is a vast reservoir of solid nitrogen ice, which, even though it's solid, is very soft.

00:17:42 Speaker 1

It was like a glacier, but made from nitrogen ice.

00:17:47 Speaker 1

The area was informally dubbed Pluto's Heart, after its obvious resemblance.

00:17:54 Speaker 1

But closer inspection left the scientists with a puzzle.

00:17:59 Speaker 7

It had all these weird forms and textures on the surface.

00:18:04 Speaker 7

Some stand out quite clearly, some are very subtle.

00:18:10 Speaker 1

An intricate and strangely organized pattern appeared to be scribed into the surface of the nitrogen ice.

00:18:18 Speaker 1

And there was something missing.

00:18:22 Speaker 7

The other thing that struck us was the fact there was no impact craters anywhere in this huge expanse.

00:18:31 Speaker 1

Ancient planetary surfaces are almost always covered in craters.

00:18:37 Speaker 1

a result of being battered by asteroids over billions of years.

00:18:43 Speaker 1

And much of Pluto's surface was heavily cratered.

00:18:48 Speaker 1

But here, there were none.

00:18:54 Speaker 7

Nobody imagined to be a huge region that was many hundreds of kilometers long and wide that would be completely devoid of craters.

00:19:01 Speaker 7

That was mind-blowing.

00:19:02 Speaker 7

What's forming this huge plain has to be an ongoing process.

00:19:11 Speaker 1

Jeff believed that whatever force had created these shapes must still be operating on Pluto today.

00:19:19 Speaker 7

This isn't an extinct world.

00:19:21 Speaker 7

This is an active world in which geological processes are operating today, and they're destroying any evidence for past cratering.

00:19:28 Speaker 7

And that was truly remarkable.

00:19:32 Speaker 1

It was a monumental discovery.

00:19:34 Speaker 1

This

00:19:35 Speaker 1

was not the dead world that everyone thought.

00:19:39 Speaker 1

Pluto's heart appeared to be beating.

00:19:54 Speaker 1

The scientist's job now was to find out what was driving it.

00:19:58 Speaker 1

All right, Mary, commercial break.

00:20:01 Speaker 8

We got 145 when we get to you.

00:20:02 Speaker 8

145.

00:20:04 Speaker 1

Coming out to you guys here in 5, 4, 3.

00:20:09 Speaker 9

Welcome to KPIX 5 News at Noon.

00:20:12 Speaker 1

The New Horizons planetary scientists were stumped.

00:20:18 Speaker 1

Mysterious patterns appeared to be carved into the surface of the nitrogen glacier.

00:20:24 Speaker 9

Quiet conditions, milder weather expected Wednesday, Thursday, and especially for Friday.

00:20:29 Speaker 1

Meteorologist Mary Lee was not involved in the New Horizons mission.

00:20:35 Speaker 1

But to her, the shapes are a familiar sight.

00:20:41 Speaker 9

That's going to do it for KPIX 5 News at noon.

00:20:43 Speaker 9

Have a wonderful afternoon.

00:20:45 Speaker 9

I am the morning meteorologist for the CBS station here in the Bay Area, KPIX 5.

00:20:52 Speaker 9

30 to start my day.

00:20:55 Speaker 9

When I'm putting a forecast together, I'm really looking at satellite data so we can determine the clouds that are over our region.

00:21:03 Speaker 1

Mary is paying special attention to the clouds forming over the Pacific Ocean.

00:21:09 Speaker 9

These are stratocumulus clouds.

00:21:12 Speaker 9

So really, you can see that puffy, lumpy texture of those cloud tops.

00:21:18 Speaker 9

These clouds are very common on the west coast of the Pacific Ocean.

00:21:22 Speaker 9

So here in the Bay Area, we see them all the time.

00:21:25 Speaker 9

You can actually see the boundaries of these clouds, and it kind of forms a bit of a hexagonal shape across our atmosphere.

00:21:33 Speaker 1

These repeating shapes are very similar to what scientists see in Pluto's heart.

00:21:40 Speaker 1

They're a result of a unique way that these clouds are formed.

00:21:45 Speaker 9

I love looking at these stratocumulus clouds.

00:21:48 Speaker 9

They form over the Pacific Ocean, and really what happens, you have the sun heating the surface, that warm air rises, and the liquid droplets, they condense, and so they form these clouds.

00:21:59 Speaker 9

And the top of these clouds, it's very cold air, so that cold air sinks.

00:22:04 Speaker 9

This process is called convection.

00:22:07 Speaker 9

You have this cycle of warmer rising and cold air sinking, and that's a convective cell.

00:22:15 Speaker 1

Plume of warm air rises, forms a cloud, cools, then sinks.

00:22:22 Speaker 1

And when you have many of these convective clouds, an hexagonal pattern is produced in the sky.

00:22:30 Speaker 9

So these clouds can only exist when you have heating from below.

00:22:36 Speaker 1

Convection currents can happen whenever hot meets cold.

00:22:41 Speaker 1

We see them in clouds,

00:22:45 Speaker 1

on the surface of the sun, and even in Mary's coffee.

00:22:54 Speaker 1

An understanding of how convection currents work has led the scientists to realize that the soft nitrogen ice on Pluto is slowly churning.

00:23:06 Speaker 7

We know that the convection rate at least takes place over hundreds of thousands of Earth years.

00:23:11 Speaker 7

This is a slow process in terms of human lifetime, but it's a very quick process in terms of geological time.

00:23:22 Speaker 1

The images sent back by New Horizons show that fresh material is being brought to Pluto's surface, driven by convection currents.

00:23:33 Speaker 1

But convection needs heat.

00:23:39 Speaker 1

How could that be possible on an ice world that's supposed to be frozen solid?

00:23:50 Speaker 3

The data returned from New Horizons has forced us to rethink everything about Pluto.

00:23:59 Speaker 3

The surface of Pluto has been repaved.

00:24:03 Speaker 3

The images are telling us that there's some sort of geological processing going on.

00:24:08 Speaker 3

How could that be powered?

00:24:12 Speaker 1

On Earth, the heat that powers geological activity doesn't come from the sun, but from radioactive elements deep within Earth's mantle.

00:24:23 Speaker 3

Often when we think about radioactive decay, we think about places like this, nuclear power plants.

00:24:31 Speaker 3

But there's a different kind of radioactive decay that is constantly occurring

00:24:37 Speaker 3

within heavy elements that are trapped within rocks, rocks that make up planets.

00:24:44 Speaker 1

A tiny fraction of those radioactive elements are harnessed as fuel for nuclear power stations like this.

00:24:51 Speaker 1

But there's enough of them in Earth's rocky interior to continually produce 44 trillion watts of power.

00:25:03 Speaker 1

And that power creates enormous amounts of heat.

00:25:08 Speaker 3

Radioactive decay within the Earth provides enough heat to produce all of the volcanoes that we see, the tectonic activity that leads to the uplift of mountains, the earthquakes, and all of the geology that we see here on planet Earth.

00:25:32 Speaker 1

Radioactive rock accounts for most of the Earth's internal heat.

00:25:37 Speaker 1

Heat, which powers the geological activity we see on the surface.

00:25:44 Speaker 1

But tiny Pluto, being mostly made of ice, was thought to be different.

00:25:52 Speaker 3

Prior to the arrival of New Horizons, the conventional wisdom was that it's probably too small and too low in density to have enough rock in its interior

00:26:05 Speaker 3

to drive enough radiogenic decay, enough heating.

00:26:12 Speaker 3

But once New Horizons started returning images and data about Pluto, that all changed.

00:26:21 Speaker 1

Could Pluto be heated from within, after all?

00:26:26 Speaker 1

The images sent back by New Horizons had allowed the scientists to see Pluto's surface in unprecedented detail.

00:26:35 Speaker 1

Comparing multiple pictures allowed them to work out the height of the mountains.

00:26:41 Speaker 1

And among them, Jeff spotted something that should be impossible on a frozen world.

00:26:48 Speaker 7

We're looking at a large mountain, which is about 5 kilometers high.

00:26:54 Speaker 7

It's about 150 kilometers across.

00:26:56 Speaker 7

And in the center is a large pit, and the pit goes down to about the same depth as the mountain is high.

00:27:03 Speaker 7

And when we first saw this, we were really surprised and puzzled as to what it might be.

00:27:09 Speaker 1

Nothing like this had ever been seen on another world.

00:27:14 Speaker 1

And for Jeff, there was only one explanation.

00:27:18 Speaker 1

A volcano.

00:27:20 Speaker 7

Its striking resemblance to volcano was so shocking that, in fact, I made the decision not to discuss it in our initial press conference just because making such claims are somewhat extraordinary and didn't want to say anything until we had more evidence.

00:27:34 Speaker 6

Once you see it as a volcano, you can't unsee it.

00:27:40 Speaker 1

But a volcano didn't make sense.

00:27:44 Speaker 1

There is no lava on Pluto.

00:27:47 Speaker 1

A spectrograph on board the probe

00:27:49 Speaker 1

confirmed that Pluto was made from ice.

00:27:52 Speaker 1

It.

00:27:54 Speaker 7

Has to be made of water ice.

00:27:56 Speaker 7

And water ice is the most difficult thing to mobilize on Pluto.

00:28:01 Speaker 7

So it's a real challenge to imagine how water ice could erupt under the surface the same way lava erupts up to the surface on the Earth.

00:28:10 Speaker 1

The question was, how could ice flow like lava on a world that's 230 degrees?

00:28:18 Speaker 1

below 0.

00:28:26 Speaker 1

Space volcanologist Kelsey Singer is on a mission.

00:28:31 Speaker 8

I would love to go to Pluto.

00:28:33 Speaker 8

Being able to stand on the surface and actually survey these features like a geologist would be amazing.

00:28:42 Speaker 1

She wants to find out how, on a frozen world like Pluto, enormous volcanoes can exist.

00:28:51 Speaker 8

A lot of the landforms that you see, like the mountains or the ice volcanoes, are probably mostly made of water ice.

00:29:00 Speaker 1

The volcano on Pluto looks remarkably similar to volcanoes on Earth, where thick lava flows out of a huge area to produce shallow mountain slopes.

00:29:12 Speaker 1

But Pluto is made from ice, and ice doesn't behave like lava.

00:29:19 Speaker 8

If you have a feature that you think formed from the flow of ice.

00:29:22 Speaker 8

That's very difficult to understand how that would occur on Pluto.

00:29:28 Speaker 1

Pluto's surface is far too cold for liquid water to flow over any distance.

00:29:35 Speaker 1

Instead, it would freeze in an instant.

00:29:40 Speaker 8

I am in an ice castle in Colorado.

00:29:43 Speaker 8

It's about minus 12, so it's pretty chilly.

00:29:46 Speaker 8

And how they form this is they have sprinklers embedded in the ice.

00:29:51 Speaker 8

The water comes out at night and then it freezes in these icicles.

00:29:56 Speaker 8

It's pretty cool.

00:30:00 Speaker 1

Temperatures here reach minus 20 degrees Celsius at night.

00:30:05 Speaker 1

Water from the sprinklers freezes in seconds.

00:30:10 Speaker 1

And it looks nothing like the volcano seen on Pluto.

00:30:17 Speaker 1

Hidden in New Horizons images.

00:30:20 Speaker 1

Kelsey spotted the missing ingredient.

00:30:23 Speaker 8

This fracture is called Virgil Fossa.

00:30:25 Speaker 8

It's a couple 100 kilometers long and at least 5 kilometers high.

00:30:30 Speaker 8

And it's got a unique red coloring.

00:30:33 Speaker 8

And that red coloring turned out to be associated with ammonia.

00:30:38 Speaker 1

The spectrograph on board New Horizons had detected ammonia on Pluto's surface.

00:30:45 Speaker 8

The detection of ammonia on Pluto was very important because it lowers the melting temperature of water.

00:30:54 Speaker 1

In fact, ammonia can lower the freezing point of water by up to 100 degrees Celsius.

00:31:02 Speaker 8

I'm going to try to recreate the effect of ammonia on Pluto's ice.

00:31:07 Speaker 8

But first, let's see what happens with water just by itself.

00:31:13 Speaker 8

So I'm pouring some water here.

00:31:17 Speaker 8

And then I'm going to add the liquid nitrogen.

00:31:21 Speaker 1

At around minus 200 Celsius, liquid nitrogen allows Kelsey to simulate the extremely low temperatures on Pluto's surface.

00:31:30 Speaker 8

And we can see it's starting to freeze here very quickly, turning into very cold ice.

00:31:40 Speaker 8

The ice on Pluto is about minus 230,

00:31:44 Speaker 8

degrees Celsius.

00:31:45 Speaker 8

It acts more like rock because it's so cold, sort of like the ice that we have recreated here.

00:31:53 Speaker 1

At this temperature, water ice is as hard as granite.

00:31:57 Speaker 8

This time we're going to try adding ammonia.

00:32:00 Speaker 8

So here I have water and ammonia.

00:32:03 Speaker 8

And now I'm going to add the liquid nitrogen.

00:32:11 Speaker 1

Ammonia lowers the freezing point of water by physically blocking the water molecules, stopping them from sticking together.

00:32:20 Speaker 8

Getting thicker.

00:32:25 Speaker 8

So now we have the water and ammonia mixed together, and it's forming a very thick and goopy, almost toothpaste-like fluid here.

00:32:35 Speaker 8

And we think that might be how the volcanoes on Pluto formed, coming out from the subsurface

00:32:41 Speaker 8

onto the surface and building up a volcano over time.

00:32:49 Speaker 1

Kelsey believes that this thick, freezing liquid has erupted through Pluto's crust, flowed across the surface like lava, before freezing solid to form the ice volcano that we see today.

00:33:05 Speaker 8

So if you were standing on one and watching a flow of icy lava, it would probably be actually quite slow going down the slope of the volcano.

00:33:18 Speaker 1

Pluto has turned out to be a geologically active world.

00:33:23 Speaker 1

Ice can flow like lava thanks to ammonia.

00:33:28 Speaker 1

But volcanic eruptions still need heat.

00:33:32 Speaker 1

And heat on icy Pluto

00:33:34 Speaker 1

would mean something incredible.

00:33:36 Speaker 8

The fact that we see something that could be an icy volcano that had to form from flow of material means that the interior of Pluto must be somewhat warm, and that means that we could have a subsurface liquid water ocean on Pluto.

00:33:55 Speaker 1

Liquid water has not been proven to exist anywhere beyond Earth.

00:34:01 Speaker 3

This small

00:34:03 Speaker 3

unassuming little world may actually have a liquid water ocean beneath its icy surface.

00:34:11 Speaker 3

And the evidence from the New Horizons mission makes it quite hard to explain what we're seeing without invoking an ocean as an explanation.

00:34:28 Speaker 1

The realization that this icy world could be hiding a liquid ocean

00:34:33 Speaker 1

has forced scientists to rethink everything about Pluto.

00:34:39 Speaker 1

But there was a mystery.

00:34:41 Speaker 1

Pluto's size.

00:34:44 Speaker 3

The problem with Pluto, in terms of its heat from the interior, is that it probably doesn't have enough of the raw materials.

00:34:54 Speaker 3

There's not enough radiogenic decay to keep it warm from within for a very long period of time.

00:35:01 Speaker 3

And yet the evidence is that something is driving this geological processing.

00:35:05 Speaker 3

So there must be another piece of the puzzle.

00:35:09 Speaker 3

There must be something else on or within Pluto that is helping it retain the small amount of heat that it gets from the interior from radiogenic decay.

00:35:23 Speaker 1

A small amount of radioactive rock in tiny Pluto's core may provide some heat.

00:35:30 Speaker 1

But for Pluto to hang on to it, something must be keeping it in.

00:35:33 Speaker 1

And this could be down to a special type of snow called a gas hydrate.

00:35:47 Speaker 1

Scientists at the National Oceanography Centre in Southampton make it in their lab.

00:35:56 Speaker 1

It looks like ordinary snow.

00:36:00 Speaker 1

It's freezing cold, like ordinary snow.

00:36:04 Speaker 1

But take a match to it, and it immediately bursts into flames.

00:36:13 Speaker 10

This in my hand looks like ice, but it is actually burning.

00:36:18 Speaker 10

And that flame is actually methane gas that's been coming off the ice as it melts.

00:36:24 Speaker 1

It burns because flammable gas, like methane,

00:36:30 Speaker 1

gets trapped within the crystal structure of ice.

00:36:35 Speaker 1

Gas hydrates form naturally on Earth under very particular conditions.

00:36:40 Speaker 10

It occurs in very large quantities in places like the Arctic and, in fact, in the Antarctic as well, so both polar regions where it's very cold.

00:36:50 Speaker 1

Huge amounts of gas hydrates exist in the very coldest places on Earth, especially where methane is present.

00:37:02 Speaker 1

The same conditions that produce gas hydrates on Earth also exist on Pluto.

00:37:09 Speaker 1

So it's possible that they fall on Pluto too.

00:37:13 Speaker 5

In order to explain what we see on Pluto's surface, we really do need heat.

00:37:17 Speaker 5

We see activity currently going on, which was exciting and unexpected and wonderful.

00:37:23 Speaker 5

But now it comes down to the science of explaining it.

00:37:29 Speaker 1

Dr.

00:37:29 Speaker 1

Carly Howard designed the cameras on the New Horizons probe.

00:37:35 Speaker 1

She believes that it's the hydrate's ability to trap gas that could be the answer to Pluto's heat problem.

00:37:48 Speaker 5

The water ice forms a hexagon, almost like a cage.

00:37:52 Speaker 5

And then inside is gas.

00:37:54 Speaker 5

In this case, we think it's probably methane.

00:37:58 Speaker 5

These are incredibly small.

00:37:59 Speaker 5

You'd end up with millions upon millions of very, very small cages, each holding its own little methane gas bubble.

00:38:08 Speaker 1

The gas bubbles on Pluto don't ignite, but act like a thermal insulator, trapping heat.

00:38:15 Speaker 5

This gas hydrate is very insulating, and it could be kind of forming a warm blanket that's enabling Pluto to hold its heat in, enabling Pluto to remain warm for billions of years.

00:38:28 Speaker 1

Pluto's surface temperature is a frigid 230 degrees below 0.

00:38:36 Speaker 1

And scientists now believe that a thick layer of gas hydrates snow could be insulating Pluto's warm, radioactive rock from those freezing surface temperatures, keeping in enough heat to melt the ice.

00:38:55 Speaker 5

So the heat comes from the rocky core, and it can't escape through this insulating layer.

00:39:00 Speaker 5

And maybe it's warm enough so that you end up being able to sustain liquid water, form and sustain liquid water.

00:39:06 Speaker 5

And maybe even in the form of a sort of global ocean, which is incredible.

00:39:09 Speaker 5

Pluto is a long way from the sun.

00:39:13 Speaker 5

That amount of heat is unexpected.

00:39:17 Speaker 1

The scientists had found a way that liquid water could exist on Pluto.

00:39:23 Speaker 1

Everything they thought about this icy world had been turned on its head, which has led some scientists to think the impossible.

00:39:34 Speaker 5

So if Pluto is warm enough to sustain a liquid water ocean, this has huge implications for astrobiology.

00:39:41 Speaker 5

One of the things that we know about life is it likes liquid water.

00:39:46 Speaker 8

Liquid water is one of the requirements for having life, as far as we know.

00:39:51 Speaker 8

And so if we were to find a subsurface liquid ocean on Pluto, that would give us more reason to believe that there could potentially have been in the past or even currently be some kind of life forms in the ocean on Pluto.

00:40:07 Speaker 3

If we've learned anything from our study of life on Earth, it's that where you find the liquid water, you generally find life.

00:40:14 Speaker 3

We look for liquid water as the sort of canary in the coal mine for habitability.

00:40:20 Speaker 3

If you've got liquid water, perhaps you could also harbor life.

00:40:28 Speaker 1

On Earth, almost everywhere you find liquid water, you find life.

00:40:35 Speaker 1

And the new pictures of Pluto seem to suggest that it was hiding a vast underground ocean.

00:40:44 Speaker 1

Pluto had been propelled from being an icy relic to a place where alien life could exist.

00:40:52 Speaker 1

But there was still something missing if biology was to have any hope.

00:41:00 Speaker 1

As well as heat and liquid water, life requires a complex array of chemical ingredients.

00:41:07 Speaker 1

Could they exist on tiny Pluto?

00:41:15 Speaker 1

The first clue about Pluto's chemistry came in 1988, long before New Horizons, when images like this were all that scientists had.

00:41:28 Speaker 11

So here's a picture you can take from the ground-based telescope like this.

00:41:34 Speaker 11

And there are a lot of beautiful background stars here, but there's one particular important one we are talking about today.

00:41:41 Speaker 11

It's Pluto here.

00:41:43 Speaker 11

in the middle of this picture.

00:41:45 Speaker 11

It's not much, right?

00:41:47 Speaker 11

It's only a few pixels.

00:41:50 Speaker 1

From Earth, Pluto was nothing but a tiny white dot.

00:41:55 Speaker 1

So astronomers waited for a rare event called an occultation.

00:42:00 Speaker 11

So look at those background stars here.

00:42:03 Speaker 11

They are relatively stationary, but Pluto is moving in the sky.

00:42:10 Speaker 1

As Pluto passed in front of a background star, rather than blocking the starlight abruptly, the starlight was slowly dimmed.

00:42:22 Speaker 1

This could only mean one thing.

00:42:27 Speaker 1

That Pluto had an atmosphere.

00:42:32 Speaker 11

Here are dry ice.

00:42:36 Speaker 11

Okay, look at this atmosphere we just made in the laboratory.

00:42:40 Speaker 11

And if there is a light source behind it, the light source will get dimmed because of the absorption and scattering of the atmosphere.

00:42:49 Speaker 11

And that's similar to what happens in Pluto's occupation.

00:42:56 Speaker 1

Here, dry ice vapor scatters the torchlight in the same way that Pluto scattered the starlight.

00:43:04 Speaker 1

It was proof that Pluto had an atmosphere.

00:43:09 Speaker 1

This was a complete surprise, a tantalizing clue that Pluto was much more than a frozen relic.

00:43:17 Speaker 1

But the question remained.

00:43:19 Speaker 1

What was Pluto's atmosphere made from?

00:43:23 Speaker 1

The New Horizons probe was sent to find out.

00:43:27 Speaker 1

And when it returned this picture, the scientists were able to see the atmosphere in detail for the very first time.

00:43:37 Speaker 6

This is such a beautiful image.

00:43:39 Speaker 6

You look at this and you think, Blue skies, just like Earth.

00:43:44 Speaker 6

This image says we were really there because this is the kind of image you can only get after you pass by Pluto.

00:43:53 Speaker 6

This picture was taken looking back toward the Sun and Earth, and we're seeing Pluto backlit by the Sun.

00:44:04 Speaker 1

The onboard spectrograph revealed that Pluto's atmosphere was made mostly of nitrogen gas, just like Earth.

00:44:15 Speaker 1

As new horizons continued away from Pluto, the long-range camera took one of the most important photographs of the entire mission.

00:44:25 Speaker 1

And it contained something that the scientists did not predict.

00:44:28 Speaker 7

Like everybody, I was surprised at this.

00:44:32 Speaker 7

beautiful, structured atmosphere.

00:44:34 Speaker 7

All these layers were wholly unexpected.

00:44:36 Speaker 6

There is so much going on in this picture.

00:44:40 Speaker 6

We can actually see these layers in the haze in Pluto's atmosphere.

00:44:46 Speaker 6

They're about 20 kilometers or so between each one, and we see the haze going up for 200 kilometers or more in this image.

00:44:56 Speaker 1

The layers in Pluto's atmosphere were a complete mystery.

00:45:03 Speaker 1

Invisible nitrogen gas alone couldn't explain the layers.

00:45:10 Speaker 1

Planetary scientist Zhi Zhong thinks it could be caused by sunlight.

00:45:16 Speaker 1

Because even on distant Pluto, ultraviolet rays have a profound effect on atmospheric gases.

00:45:23 Speaker 1

It happens every day on Earth and could even be seen above downtown Los Angeles.

00:45:30 Speaker 11

You can see the

00:45:32 Speaker 11

Air quality is not good.

00:45:33 Speaker 11

Smogs, hazes.

00:45:36 Speaker 11

That's because we have 3 million cars crisscross the city every day.

00:45:42 Speaker 11

And those cars emit a lot of air pollution.

00:45:48 Speaker 11

The air pollution is mostly volatile organic compounds, like hydrocarbons, soot particles.

00:45:56 Speaker 1

Large soot particles hang in the air above the city.

00:46:00 Speaker 1

They're created

00:46:01 Speaker 1

by a chemical reaction.

00:46:03 Speaker 1

Exhaust fumes from cars are baked by the sun, causing them to break down and reform into larger particles.

00:46:13 Speaker 11

Those smogs are actually pretty similar to what we see on Pluto in terms of chemical processes.

00:46:21 Speaker 1

But there are no cars on Pluto.

00:46:24 Speaker 1

So why is its atmosphere choking with smog?

00:46:28 Speaker 1

When New Horizons analyzed Pluto's atmosphere, it discovered that it wasn't just made from nitrogen.

00:46:36 Speaker 1

There were also tiny amounts of other gases like methane and carbon monoxide.

00:46:43 Speaker 11

When those air molecules hit by the UV light from the sun, the chemical bonds are broken, and those coagulate and make big particles.

00:46:53 Speaker 11

It's similar to the super particles we have here.

00:46:59 Speaker 1

Just like the exhaust fumes above Los Angeles, the invisible gas molecules in Pluto's atmosphere were being broken apart by the sun, before reforming into large soot particles and settling out into layers.

00:47:16 Speaker 11

Those haze particles are produced in the upper atmosphere of Pluto and gradually settle down due to gravity.

00:47:27 Speaker 1

The soot particles were a clue that something special was happening on Pluto.

00:47:34 Speaker 1

But exactly what chemicals were being created?

00:47:38 Speaker 11

Ready?

00:47:38 Speaker 11

High voltage down.

00:47:40 Speaker 1

The probe had told scientists what gases exist in Pluto's atmosphere.

00:47:46 Speaker 8

Yeah, the MFCs are off.

00:47:47 Speaker 1

Which allowed them to do something that had never been done before.

00:47:51 Speaker 8

Cylinders are closed.

00:47:53 Speaker 1

Recreate Pluto's atmosphere here on Earth.

00:47:58 Speaker 8

What this machine allows to do is to simulate space environment.

00:48:02 Speaker 8

In the case of Pluto, we can simulate the atmosphere of Pluto.

00:48:07 Speaker 8

Okay.

00:48:08 Speaker 8

Doing this experiment will allow us to get a better idea of the type of chemical processes that are occurring in the atmosphere.

00:48:16 Speaker 8

Pressure, 8 torr.

00:48:18 Speaker 8

Yeah, that's the base pressure.

00:48:19 Speaker 8

That's good.

00:48:19 Speaker 8

The base pressure is 8 torr is very good.

00:48:22 Speaker 1

Pluto's atmospheric gases enter this machine at minus 170 degrees centigrade, where an electrical discharge simulates the sun's rays.

00:48:37 Speaker 1

And after 10 hours in the machine, the gases are transformed into an entirely new substance.

00:48:44 Speaker 1

Tiny grains of dust.

00:48:47 Speaker 8

These are these grains that we make in the gas.

00:48:51 Speaker 8

and that get deposited onto a window and pile on top of each other until we have a thin layer of these dust grains.

00:49:00 Speaker 8

And as you can see, the color is a dark brown.

00:49:07 Speaker 1

These are the same particles that cause the layers in Pluto's atmosphere.

00:49:14 Speaker 1

Eventually, they grow so big that they fall to the surface like rain.

00:49:19 Speaker 1

painting Pluto in a broad spectrum of browns and reds.

00:49:24 Speaker 8

So we can think that this could be one of the contributions for the color on Pluto's surface.

00:49:34 Speaker 1

A chemical reaction in Pluto's atmosphere was causing particles to rain down onto the surface.

00:49:43 Speaker 6

So this is an enhanced color image, and we can see that this area is really red, and

00:49:48 Speaker 6

quite dark and much redder than the rest of Pluto's surface.

00:49:55 Speaker 1

Areas that receive more sunlight appear much redder than elsewhere.

00:50:02 Speaker 1

The next job for the scientists was to find out exactly what this red substance was.

00:50:14 Speaker 1

Dale Cruikshank studies the surface of small objects in space.

00:50:22 Speaker 1

And since New Horizons, he has turned his attention to the chemical reactions occurring on Pluto.

00:50:32 Speaker 10

Pluto has a very thin atmosphere, and we know that the basic components are nitrogen, methane, and carbon monoxide.

00:50:43 Speaker 10

Sunlight coming in the ultraviolet part of the spectrum has enough energy to break the energetic bonds that hold the atoms in the molecules together.

00:50:53 Speaker 1

These simple gases reform randomly into more complex molecules.

00:50:59 Speaker 10

Like that?

00:51:01 Speaker 1

And experiments to recreate this have produced something extraordinary.

00:51:06 Speaker 10

Eventually, these materials form what we call precursor molecules to

00:51:11 Speaker 10

molecules that are of biological interest, including what are called nucleobases.

00:51:18 Speaker 10

There are many different nucleobases, but five of them are of biological interest because these are the principal components of DNA and RNA.

00:51:31 Speaker 1

Nucleobases are the main ingredient of DNA.

00:51:36 Speaker 1

All life on Earth uses DNA.

00:51:40 Speaker 1

From these complex molecules, life is just a few steps away.

00:51:45 Speaker 1

And some scientists believe it's possible that they're being produced on Pluto.

00:51:52 Speaker 10

The New Horizons mission has given us these fantastic images from which we now deduce that the colors are, in fact, from organic material, complex organics that have fallen from the sky, literally.

00:52:06 Speaker 10

We are making precursors to the things that eventually we think on Earth resulted in the origin of life.

00:52:16 Speaker 1

And the surface isn't the only place where pre-life organic molecules could be being made.

00:52:25 Speaker 10

Complex organics are also being produced in water and have emerged onto the surface through cracks in the crust

00:52:33 Speaker 10

in a process that we call cryovolcanism.

00:52:38 Speaker 1

The red color of the ice around Virgil Fossa is evidence not only of ammonia, but also organic material erupting from an underground sea.

00:52:50 Speaker 10

There may be habitable zones on Pluto.

00:52:53 Speaker 10

For example, in the interior, if there's still a liquid and it's full of organic materials, this may be a habitat where life could exist.

00:53:03 Speaker 10

So if we were trying to survey the entire solar system for potential habitable zones, habitable regions, you'd have to include Pluto in that list, I think.

00:53:12 Speaker 10

The.

00:53:15 Speaker 1

Complexities of just how organic molecules spawn life is not yet fully understood.

00:53:22 Speaker 1

But Dale's experiments are evidence that Pluto has the raw ingredients to produce some of the molecules needed for life.

00:53:32 Speaker 3

Within Pluto, you might have liquid water mixed with ammonia, mixed with methane, and any number of different kinds of organic compounds, carbon compounds, that life could utilize.

00:53:44 Speaker 3

And so along with Pluto potentially having this liquid water environment that could be conducive for life, it might have some of the elements and energy that life as we know it needs.

00:54:03 Speaker 5

No one in their right mind would have thought Pluto had life, but now it's a possibility, and that in itself is kind of mind-blowing.

00:54:10 Speaker 3

What might life on Pluto look like?

00:54:13 Speaker 3

Who knows?

00:54:14 Speaker 3

But I would be happy with even the tiniest of single-celled microbial organisms somewhere out there in our solar system and beyond.

00:54:29 Speaker 1

And if on Pluto, the most unlikely of places, then why not elsewhere?

00:54:36 Speaker 4

We used to think that life could only exist on a planet like Earth, with ocean on the outside, an atmosphere, sunlight falling in, and so on.

00:54:45 Speaker 4

Now we look at there are liquid oceans elsewhere in the solar system.

00:54:49 Speaker 4

They are around Jupiter.

00:54:50 Speaker 4

They are inside Pluto.

00:54:52 Speaker 4

And it changes our concept of what the Goldilocks zone is, the zone in which life could potentially form.

00:54:59 Speaker 5

If places like Pluto, really small, very distant from a star, are able to have liquid water, it could mean that Pluto maybe has life.

00:55:07 Speaker 5

But also, as we move into other solar systems and we understand more about other solar systems, maybe life could be more abundant than we thought.

00:55:17 Speaker 10

My view is that the chemistry of life, insofar as we understand it, is so widespread through the solar system, through our galaxy, and elsewhere in the universe, that

00:55:29 Speaker 10

It is highly likely that self-replicating, metabolizing entities have originated.

00:55:36 Speaker 10

And if that's life, then the answer is yes, there is life elsewhere.

00:55:45 Speaker 1

Long viewed as a world of little importance, Pluto has been revealed to be a place of unimaginable complexity.

00:55:59 Speaker 1

Mountains,

00:56:00 Speaker 1

carved from ice, rival the most dramatic landscapes on Earth.

00:56:10 Speaker 1

A frozen volcano like nothing else in the solar system.

00:56:14 Speaker 1

A churning nitrogen glacier puzzles science's greatest minds.

00:56:28 Speaker 1

It's a place

00:56:29 Speaker 1

where something extraterrestrial life might exist.

00:56:38 Speaker 1

And could tell us where else in the universe we might find it.

00:56:46 Speaker 1

This great mystery, on the very edge of our solar system, has led scientists to call for another mission.

00:56:55 Speaker 5

The only way to really study the surface of Pluto in detail is to go back to Pluto.

00:56:59 Speaker 5

And that's why I'm leading a concept study to figure out how we would go about doing that.

00:57:07 Speaker 1

They plan to send another probe.

00:57:10 Speaker 8

We need another mission to go back to Pluto, and this time orbit Pluto, and we can bring different instruments that can get us different answers.

00:57:20 Speaker 1

And peer beneath Pluto's icy crust.

00:57:26 Speaker 3

If we committed ourselves to exploring these ocean worlds, it could be that within the next few decades, we might finally have an answer to that primordial, age-old question of whether or not we are alone in the universe.

00:57:45 Speaker 1

To the Romans, Pluto was the god of the afterlife.

00:57:50 Speaker 1

But this tiny dwarf planet

00:57:52 Speaker 1

may in fact be the gatekeeper to life itself.

00:58:02 Speaker 1

Pluto is well and truly back from the dead.

00:58:14 Speaker 11

New discoveries, natural wonders and strange mysteries all waiting to be discovered voyage across the solar system in Brian Cox's new series on BBC iPlayer.