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THE SEARCH FOR LIFE: ARE WE ALONE?

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The New Space Show
at the Hayden Planetarium

Frederick Phineas & Sandra Priest Rose Center for Earth and Space
American Museum of Natural History

THE SEARCH FOR LIFE: ARE WE ALONE?

1a. OVERTURE: SONG OF LIFE ON EARTH. *Throughout this symphony of sound, the lights are gradually dimming. The sounds are dynamically distributed around the dome. At first, only a gentle rain is falling . . .*

> **Shhhhh . . . . Shhhhh . . . Listen . . . Listen to the sounds of our world.**

1b. *. . . gradually growing louder, then reverberating thunder (with lightning effects, as Zeiss door slides open), followed by a downpour, then waves crashing, sea gulls, howler monkeys, lions, elephants, cicadas, whales, pant-hoot of chimpanzee, dogs barking, rooster crowing, snatches of conversations in many languages, baby crying, radio broadcast, distant train whistle, traffic noises, crack of a baseball bat followed by roar of stadium crowd, subway rumble, snatch of classical music, rising crescendo of all these sounds, ending on a children's skip-rope song.*

2a. ZEISS SKY. *Cut audio to silence, just as the Zeiss sky is revealed in all its glory.*

> **The Earth is so *alive.***
>
> **Hello. I'm Harrison Ford.**

2b. *Ambient night sounds (crickets, whippoorwills).*

Beautiful night, isn't it.

**You really have to get away from the city lights to see the sky like this. That band of light crossing the sky –
that's the Milky Way.**

2c. *Music up.*

So many stars.

You know, the stars are really other suns. They're just very far away.

You can't help but wonder. Are there other worlds like ours, hidden among those stars?

Do any of *them* have life?

Is there someone out there lying awake wondering if *we* exist?

What would they be like? We have no idea. It's hard enough to imagine life on Earth.

If you had never seen one, could you imagine . . . an elephant or . . . a lobster?

On our planet, life is *everywhere* . . .

But can life exist *any*where?

We once believed that all life needed sunlight.

3. ZEISS SKY FADES TO BLACK. *Ambient clanking sounds of a submersible vehicle.*

But we were wrong.

4. BLACK SMOKERS. *Searchlight beams switch on and slowly sweep the dome to reveal a bizarre landscape of towering sulfide chimneys spewing shimmering fluids. An "unearthly" manta ray sweeps overhead.*

This place is as alien as another planet. But it's right here on Earth, at the bottom of the ocean.

When we finally got down to the deep sea floor, we found another kind of life that doesn't need sunlight. Miles below the surface, there was life where no one thought it could be.

Here, in this endless night, life feeds on scalding volcanic fluids that erupt from the molten depths of the Earth itself.

If the Sun ever stopped shining, life *here* would go on . . . sustained only by the Earth's inner heat and chemistry.

Life is tougher than we thought.

5. OCEAN SURFACE. *With a rumble of the seats, we begin a rapid ascent. Bubbles and glinting particles stream down past us, like snowflakes. With a splash we breach the surface, lit by the setting Sun. All around us, the sea is gently rocking*

If life can get along without sunlight, is there *any*thing that life just can't live without?

On Earth, all life as we know it needs liquid water.

But could there be other *kinds* of life that we don't know?

Are there creatures on other worlds who can't stand water but crave, say, ammonia?

Could be. If life teaches us anything, it's that we've got to keep an open mind.

6a. EARTH AND SOLAR SYSTEM ORBITS. *The seats rumble again and the seascape drops below our horizon. The blue Earth rises and recedes, followed by the Moon.*

So far, we know of only *one* world with life – the Earth, our own watery blue planet.

Our neighboring Moon is bone-dry and lifeless.

6b. *Trace the orbit of Earth.*

The Earth has the right kind of atmosphere for liquid water on the surface. It orbits at the right distance from the Sun. It's not too hot and not too cold.

6c. *Trace the orbits of Mercury and Venus .*

In our solar system, Mercury and Venus orbit closer to the Sun.

They don't have liquid water or life.

6d. *Trace the orbit of Mars.*

But what about Mars, the next planet out beyond Earth?

7a. GLOBAL MARS. *Zoom toward Mars, with its polar ice caps and volcanos.*

In some ways, it's a lot like home. Mars has a 24-hour day, regular seasons, polar ice caps, and dust storms.

It has the biggest volcano in the solar system – three times higher than Mt. Everest.

In the past, Mars was probably even more like Earth than it is today.

But now the surface is a barren desert. The Martian air is so thin and cold that any exposed liquid water would instantly evaporate and freeze at the same time.

So if there's any life on Mars today, it's *below* the surface.

7b. MARS FROM ORBIT. *We careen over the rift valleys, collapsed terrain and outflow channels.*

Mars has enough heat and pressure below ground to keep water liquid. For all we know, Martian waters could be flowing through an underground network of pores and cracks, full of microscopic creatures.

Let's go down to the *actual* surface of Mars. We can see it through the eyes of NASA's Pathfinder spacecraft.

8. MARTIAN SURFACE PANORAMA. *Wrap-around Martian landscape, synthesized from Mars Pathfinder lander data.*

You are now as close as anyone has ever been to walking on Mars.

If we never find a trace of life on Mars, a world so like our own, then life may be rare in the universe.

But if we find *any* kind of life native to Mars, no matter how tiny, then life must be in lots of other places.

9a. TRANSITION TO EUROPA. *Lift off Mars, turning to see it diminish in crescent phase, against the distant Sun.*

Beyond Mars are the giants of the solar system, the gas planets.

9b. *Acquire Jupiter and the orbits of its Galilean moons.*

All of them have moons made of rock and ice. Jupiter has four giant moons.

10. EUROPA. *Zoom up to Europa, showing its ice rafted surface.*

One of them, Europa, may be the best place in our solar system to look for life.

Its fractured icy crust floats on a deep ocean of water.

Volcanic hot springs may be gushing from the sunless sea floor of Europa and feeding life, just as we saw back on Earth.

If there *is* life on Mars or Europa, or anywhere else *inside* our own solar system, we may be close to finding it.

11. SOLAR SYSTEM FROM ABOVE. *Reprise the solar system, adding the outer planetary orbits.*

But what about life *outside* our solar system?

The stars are millions of times farther away than the planets of our Sun.

If you could look back at our solar system from the distance of a neighboring star . . .

12. PULLBACK FROM SOLAR SYSTEM. *The solar system orbits contract around the Sun, which dims to become another bright star, as nearby stars move past us.*

. . . from that far away, the Earth and its fellow planets would be lost in the Sun's glare. In the same way, the planets of other stars are invisible to us.

But we can still *detect* them. When a planet circles a star, its gravity causes a tiny wobble in the star's motion - telltale evidence for an unseen planet.

13a. CENSUS OF EXOPLANETS. *We continue spiralling out to about 500 light years from the Sun, looking back toward its position.*

Until a few years ago, the planets of *other* solar systems were only theory, or science fiction.

But *now* these so-called *exoplanets* are a scientific fact.

13b. *The star 51 Peg lights up with a distinctive bright color.*

We found the first one in 1995, around a faint star called 51 Pegasi.

13c. *In sequence we light up the known exoplanets in order of their discovery with the same distinctive bright color.*

Soon we found another, and then another. And now we're finding about one a month.

This is a revolutionary discovery. Planets could well outnumber the stars.

We don't know yet if any of those planets have life. But we do know they have something in common with our Earth: all those planets were formed by the same cosmic process.

14. MILKY WAY GALAXY**.** *We pull back to see the static Milky Way Galaxy from outside.*

You see, we live in a kind of factory that recycles matter and turns out planets, *lots of them*.

We call it the Milky Way Galaxy.

If we could see it from outside, our Milky Way would look like this – a vast spiral galaxy, with hundreds of billions of stars, and maybe a trillion planets. That's right, a *trillion*.

Where did all those worlds come from?

Let me tell you the story of *one* of them – our own.

15. ANCIENT MILKY WAY GALAXY. *With a rumbling of the seats we set the Galaxy in motion. A signature sound effect indicates that we are moving through time, and from observation to theory.*

It began in a galaxy long, long ago - nearly five billion years ago. That may seem impossibly remote, but there's an unbroken thread

that connects each of us – you and me and all life on Earth – to the awesome events of that distant time.

Back then, there was no Sun and no Earth.

16. SUPERNOVAS *are flashing in the spiral arms.*

Our Galaxy was flashing with the massive explosions of dying stars blowing themselves apart.

17a. INTERSTELLAR MEDIUM (1000-LIGHT-YEAR SCALE). *We zoom towards a spiral arm to highlight the structure of a cloudy region – the interstellar medium. We fly into a cloud.*

Vast clouds of gas drifted through space.

The exploding stars stirred up the clouds and enriched them with atoms of carbon, oxygen, iron and all the other elements.

17b. INTERSTELLAR MEDIUM (10-LIGHT-YEAR SCALE). *As we enter the cloud, wispy material surrounds the dome on all sides.*

Within the clouds, these atoms were forming grains of dust and ice, and organic molecules,

the building blocks of planets . . . and life.

We are *made* from this stuff . . . this star stuff. And it's everywhere.

18. IONIZATION CAVITY. *We fly in and explore the cavity.*

In the depths of the clouds, a brilliant young star illuminated a clearing trillions of miles across.

[ALTERNATE READING, DEPENDING ON VISUALS: **In the depths of the clouds, all was darkness. Then, a brilliant young star illuminated a clearing trillions of miles across.**]

Near the edge of the clearing, smaller clouds collapsed, which made them denser and hotter.

When they got hot enough, they became new stars.

19. FORMATION OF THE SUN. *Zoom into a compressed region outside the cavity, where we find a new star, surrounded by a disk and jets.*

And one of them was our Sun.

For a few million years our newborn star was surrounded by a spinning disk of gas and dust . . .

the leftover debris that made the planets.

20. PLANETESIMAL FORMATION. *We fly into the disk and see through the gas to find many asteroids and comets, which collide to form planets. Our Earth system emerges from the chaos.*

Within the orbiting disk, grains of dust and ice stuck together to form clumps.

These snowballed to form rocky asteroids and icy comets.

The largest asteroids grew by colliding with the smaller ones . . .

sweeping them up to become the inner planets of our solar system.

And one of them was Earth.

21a. ANCIENT EARTH. *First in a series of matched dissolved still images of the Earth at different epochs (reprising the signature effect of Scene 15). The first image shows a heavily cratered Earth with seas and a nearby Moon.*

Bombarded by leftover asteroids and comets, our planet had a violent youth.

21b. *Dissolve to tranquil Archaean Earth with micro-continents.*

But when the bombardment tapered off, life got started.

We don't know *how* life began on Earth. But as soon as life was possible, it was there.

21c. *Dissolve to Late Precambrian Earth with large continent.*

Once life took hold, it began to change the planet. Green plants appeared and supplied oxygen. Animals evolved that could eat the plants and breathe the air.

22. NIGHT SIDE OF MODERN EARTH. *Dissolve to modern sunlit Earth. We circle around to the dark side, revealing the coastlines outlined by city lights. Music and voice convey growing sense of elation.*

And some four billion years after life on Earth began, we humans awakened to consciousness.

We began to understand that the story of the universe is *our* story.

We looked up at the stars and we wondered.

We learned that the same process that made the Earth has made billions of other worlds in our Galaxy.

So what are the odds that our planet is the *only* one with life?

23a. VISIT TO AN EXOPLANET. *Turn away from the Earth, with stars streaming by. Approaching a close binary system, we find that one star is sunlike, and the other is smaller and redder, with sunspots.*

What would the worlds of other stars actually look like? So far, we can't see any of them close up, but we can speculate.

There could be gas giant planets lit by two suns . . .

23b. *Approaching the system, we encounter a gas giant planet. Its Earthlike moon has ice caps and a global ocean dotted with islands but without continents.*

and orbited by giant moons . . .

with oceans and islands and continents of their own . . .

23c. *We see its night side full of luminous islands.*

and who knows, maybe life.

24. LOCAL STARS. *Turn away from the exoplanetary system. A device indicates our solar system among thousands of neighboring stars.*

At this very moment, on a planet of another sun, is someone looking toward the Earth and asking: Might there be life on *that* little world?

In fact, we on Earth reveal our presence to the whole Milky Way.

25. EARTH'S EXPANDING RADIOSPHERE *Reprise graphics for exoplanet census. Spherical shell represents radio waves expanding from the vicinity of the Sun.*

Our radio, television and radar waves are spreading out into space at the speed of light.

A radio broadcast of 60 years ago . . . *[snatch of Orson Welles "War of the Worlds" radio broadcast with music]* **. . . has by now traveled out to 60 light years in all directions.**

The expanding sphere of Earth's radio waves has already washed over many of the exoplanets we've discovered . . .

and it will continue to spread out across our Galaxy.

26. THE MILKY WAY GALAXY FROM OUTSIDE. *Our expanding radiosphere spreads out into the Galaxy.*

Already, someone on another world may have picked up faint signals from a distant Earth.

And we *ourselves* are searching the stars for signs of intelligent life – so far, without success.

But we've barely scratched the surface in our quest for other planets, for other life, and for intelligence in the cosmos.

27. A GALAXY OF WORLDS. *Using the distinctive bright color that designated exoplanets in sequence, we turn on a galaxy of worlds.*

We think of our Milky Way as a galaxy of *stars*, just because the bright stars are what we can *see*. But now we know it's also a galaxy of unseen *worlds*.

28. A UNIVERSE OF GALAXIES. *Dissolve to Milky Way from outside. Pull back to reveal the sea of galaxies in the Virgo Supercluster. Nearby spiral and elliptical galaxies are recognizable.*

At this very moment, the same process that made *our* world is making new ones throughout our Milky Way. Making worlds is what galaxies *do*.

And our Galaxy is only one of billions in the known universe. So the possible number of worlds that may have life is staggering.

***Imagine* what might live on *all those worlds* . . . each with its *own* epic tale . . . *no two* of them the same.**

29a. EARTH IN SPACE. *Dissolve to digital Earth.*

Other life and other minds may dwell on countless other worlds.

But nowhere else in a hundred billion galaxies will we find another planet just like ours. All life on Earth evolved to fit the changing environment of *this* little world. It made us what we are.

29b. *Reprise laughter from end of Overture.*

If we can learn to protect our only home in the cosmos, and the life that it brought forth . . .

29c. *Dissolve to star streaming.*

just *think* of the new worlds, and ways of being alive, that we might discover.

THE END