THE SEARCH FOR LIFE IN SPACE

A Documentary Adventure for IMAX® and Giant-Screen Theatres

While today's theatre audiences might still enjoy a *Star Wars* marathon, we no longer picture the diversity of life in space based on "Chalmun's Cantina"—the fictional bar populated by starship-hopping creatures of every imaginable shape and size. However, a lot was still left to the imagination until *The Search for Life in Space*—the new giant-screen documentary adventure from December Media, produced in association with Film Victoria and Swinburne University of Technology, and distributed by MacGillivray Freeman Films. Now, for the first time, today's audiences get a close-up look at what scientists really know about life in space, and the state-of-the-art tools they are using to peer ever deeper into the question of whether we are alone in the universe.

Narrated by acclaimed actor Malcom McDowell, *The Search for Life in Space* takes us on a fascinating journey into the relatively new science called astrobiology. This cutting-edge discipline confirms that not only do scientists know where to look for life in space, but also that the universe is teeming with thousands of newly discovered planets, some even with the potential to sustain life. By using the most current, real-life footage of what is "out there"—from landscapes of planets and moons in our own Solar System to far away stellar nurseries, captured by the world's most powerful telescopes and projected on to the world's tallest screens—*The Search for Life in Space* makes the case that we are closer than ever before to finding out whether we on Earth are alone in the greater universe.

And does this new approach work? Can we really sort through thousands of potential Earth-candidates to find the best ones? Brand new discoveries say we can. For example, by using all of the technology and science depicted in *The Search for Life in Space*, the journal *Nature* has just announced the discovery of Proxima b—a planet orbiting Proxima Centauri, the star closest to Earth, aside from the Sun. Proxima b's list of promising life-supporting characteristics is impressive, making it the "closest possible abode for life outside the Solar System," according to the European Southern Observatory.

Producer and director Stephen Amezdroz could not be happier with the timing of this awe-inspiring announcement. "Sometimes popular culture gets ahead of reality, creating unrealistic expectations and beliefs," he says. "But science is the measure as to how we understand our world and universe. For science, a new journey has begun with Proxima b, and what a ride it will be. Popular culture is going to have to work hard to beat this one."

Astronomer Lisa Kaltenegger, the founder and director of the Carl Sagan Institute at Cornell University, and star of *The Search for Life in Space,* is one of world's experts on characterizing habitable worlds. "Proxima b is the latest discovery within a fascinating diversity of other worlds out there that we are just beginning to explore," she says. Like many astronomers, she sees the big picture. The *very* big picture.

While Proxima b is our most up-to-the-second discovery covered in the story, the visual journey of *The Search for Life in Space* starts decades ago—with a reflection on humanity's first attempts at reaching out to intelligent life in the universe. It all began with astronomer Carl Sagan's golden records—"time capsules" filled with sounds of life's diversity on Earth, along with greetings in 55 different languages—which were bolted onto both Voyager spacecraft and shot into space at 40,000 miles per hour in 1977. Voyager 1 is the only human-made object that has ever left our Solar System, and it still carries our message.

Oh, how times have changed. Today's astrobiologists—who use astronomy, engineering, physics, biology, geology, chemistry, and molecular biology—do much more than "shout out" to whoever might be listening.

In an elegantly logical process, they draw on Earth's own evolution to consider the forms that life has taken on this planet, and how living plants and animals have sustained themselves in a variety of hostile environments. This information is then used to search for planets and moons most like Earth, and therefore most likely to host carbon, liquid water, and energy—the building blocks of life as we know it. (Proxima b has a temperature suitable for water to exist on its surface!)

With the newest generation of telescopes, today's scientists study the galaxy to identify possible life-supporting worlds, and they've found 21—no, make that 22—"extra-solar planets" or "exoplanets" that could be like our own Earth These exoplanets orbit suns other than our own, and are ideally sized and positioned. These 22 have been culled from thousands of candidates. More than 2,330 exoplanets have been located since 2009 by just one "planet hunter," NASA's game-changing Kepler space telescope. Once Kepler locates candidates (4,706 to date), then larger telescopes, backed up with algorithms, are employed to narrow the field.

Finding the worlds most likely to support life is what fascinates Kaltenegger. With astrobiology, she and a handful of colleagues define the features that identify the most likely planets to focus on, and what to look for in the planet's light that shows that life can exist there. For example, the first key to locating water and carbon is to find rocky planets orbiting their stars in the "habitable zone," or "Goldilocks zone"—not too close and not too far away from an essential source of heat and light. The second key is in knowing what to look for—"spectral fingerprints" that identify different characteristics of another world. For example, the chemical makeup of the air—oxygen, water, methane—all of these give off a unique "spectral signature" when light penetrates atmospheres above them. When these signatures are viewed from space, we literally see our first clue as to what that world might be made of. When combined with other data, such as the activity of the star and the age of the planet, astronomers can better choose where to pause in their visual sweep of space.

Kaltenegger calls this space-age forensic tool kit an "Alien ID Chart for life." She reflects on the differences between what her hero Carl Sagan could only imagine and the cutting-edge results of current searches. "More than twenty years ago, we didn't even have the technology to find out if there were planets around stars like ours—other than our Sun—in the galaxy," she says. "But now we do." Once the exoplanets with characteristic Earth-like ID Charts are located, science is one step closer to exploring what Kaltenegger describes as "the fascinating diversity of potential life out there."

No matter what is found on Proxima b in coming years, Kaltenegger says the planet, as our next-door neighbor, is in her "top-ten cosmic travel destinations". "These discoveries show us a completely new universe, teeming with fascinating—and still mysterious —other worlds" she says. "This science is in its infancy. We are just starting to expand our new horizon and to explore the new worlds around us."

While *The Search for Life in Space* spends a good deal of time on jaw-dropping images of our universe—from stellar nurseries to flights over icy moons and the Martian surface, all of which suggest that life might be in process elsewhere in the universe—it also takes us to the foundation that informed astrobiology. We travel to the Earth-based models of harsh environments in which tenacious life forms survive. Amezdroz invites Kaltenegger and the audience to Hawaii, where biologist Chris Johns introduces us to creative plants; we also encounter animals that withstand enormous temperature fluctuations and the bombardment of radiation. Breathtaking IMAX® footage reveals desert-like landscapes, underground lava caves, and the deepest reaches of the ocean—where real life defies our imaginations. Not only do these locations provide templates of "what to look for" somewhere else, but they also remind us that the remote worlds we see in space might be in the midst of a process that already happened—and is still happening—on Earth.

Astrobiology tells us to look for massive clouds of dust and gas that are forming stars right now, so that we can observe new stars and their planets from their very moments of origin. And this powerful science also tells us to keep an eye out for planets much older than ours, to "catch a glimpse into a possible future of Earth," as Kaltenegger puts it. That is, by discovering planets further along than Earth in their evolutionary processes, we might see the results of different influences—both good and bad, when it comes to life support. These differences could assist Earthlings in restructuring aspects of human development that could contribute to our survival. Therefore, understanding the chain of cosmic evolution is more than an exciting adventure; for humans, it is also a responsibility that passes from generation to generation.

The Search for Life in Space is the second in a trio of related, giant-screen films conceived by December Media's team of visionaries. The first—*Hidden Universe*, which Amezdroz produced—showed how technology allows us to peer into space. *The Search for Life in Space* utilizes that technology to sharpen our focus—to look for life on worlds that exhibit characteristics that are similar to Earth's. The third film in the series will be *Earth Story*, a visual journey of one planet's birth, infancy, and adolescence. The film trio will provide viewers with a detailed understanding of what happens from the genesis to the burn-out of celestial bodies—and how life has formed, and can form, here and elsewhere.

Astrobiology: The Building Blocks of Life

With *The Search for Life in Space*, film technicians have rendered never-before-seen images for the giant screen so that viewers can contemplate the most fundamental question in the universe with the best thinkers alive. We focus in on planets and moons we already know well, with astonishing, detailed views of the Martian surface, glimpses of the geysers of Saturn's icy moon Enceladus, and the veiled world of Jupiter's Moon Titan. We also look out into the universe to new planets that scientists are just now identifying. Although no ferns or dinosaurs or cockroaches or Romulans have yet been sighted on other worlds, *The Search for Life in Space* illustrates, as only the IMAX® format can, what forms life might take and how to find it.

To do this, Kaltenegger presents us with a deceptively accessible approach. Her focus on the building blocks of all Earthly life simplifies our space search—basically, we look for what we know. Everything living that humans have encountered up to now is comprised of carbon, water, and energy. Period. Might we "miss something"? When scientists look for environments where these elements exist, might they inadvertently overlook evidence of some other kind of life? Yes, they might, but the key to finding life is in knowing what to look for first. Kaltenegger knows that the longest adventure begins with the first steps, and what we know is Earth's evolution—including its geologic and cosmic origins; the diversity of Earth's most tenacious life forms, called "extremophiles"; the fossil and geologic record; atmospheric and celestial evolution; and the impacts of human activity on the planet. And every day, we learn more and more about places in our Solar System, places unlike our own, where a different kind of life might also be possible.

"What is unique about *The Search for Life in Space* is that it is not purely about astronomy," Amezdroz says. "It's about placing Earth into our idea of space as a whole. Everything that happens here on Earth could happen on another planet, or another moon—and it might be happening already."

December Media has undertaken this trilogy of giant-screen films because its principals believe that space is the cutting edge of science—and that "the big unanswered question is, 'Are we alone?'" Amezdroz says. "We seem to be ever so close to finding out." As a filmmaker, he loves experiencing the space story firsthand. "It's true that you're taking the audience places they otherwise wouldn't get to go, but for me it's pretty exciting on a personal level. I get to wake up in the morning and talk to the Mars Rover people, or scientists who are planning a mission to Jupiter, or astronomers who just found another planet. For them, looking beyond our solar system is a daily thing—and the giant screen tells the best story."

For example, the Cassini-Huygens spacecraft revealed lakes of hydrocarbons—the building blocks of amino acids, or protein—on one of Saturn's moons, Titan. Another moon, Enceladus, was long thought to be a dead ball of ice. But amazing images clearly show plumes of water vapor erupting from cracks in the ice. The scientific conclusion: this was the first liquid water to be found spewing into space, a plume a spacecraft could fly through and sample. And that water is hidden under a frozen crust. Information like this naturally causes astrobiologists to wonder what else might be hidden under that ice.

Kaltenegger's "Alien ID Chart for life," which involves watching for "spectral signature" evidence of something we recognize as signs of life, was developed after careful examination of evidence on Earth and from space. This approach is light years beyond our initial outreaches to space, in which, for example, we sent radio signals in hope that someone might be listening. "There were limitations to the earlier approaches," Kaltenegger says. "There are so many necessary conditions, such as that a civilization would have developed like ours did, and that it would lead to radio signals—and someone who wants contact with us in the first place. That approach is also married to a certain time period in our evolution. Now, technology has caught up, and we don't have to invoke a civilization. Now, we just look at planets around us to see if Earth is common or rare, whether or not anyone wants to contact us."

Astrobiology tells us to look for planets with rocky surfaces, like Earth's—which, according to images captured by the Kepler space telescope, are common. It tells us to look under the ice on Jupiter's moon Europa, as well as the geysers of Saturn's moon Enceladus. Water is a primary target for astrobiologists. "Water is a key to life on Earth," Kaltenegger says. "It abounds on our planet, and every animal, every plant, every life form we know depends on it."

For Amezdroz, learning about astrobiology shifted his perspective. "I understood the basic concepts about the Goldilocks zone, that scientists target planets where we might find life," he says. "But then, when I learned just one fact, like how there are 150 moons in our own solar system, and that these, like planets, might also offer opportunities for life—well, that was a big shift for me. I was hooked." As the story unfolded, Amezdroz found himself returning again and again to check the science—and returning particularly to Kaltenegger, who lives with one foot in space. "I kept going back to Lisa time and time again," Amezdroz said, "because as the director of the Carl Sagan Institute, she's making the rules in her science. I really needed to understand—exactly what is she *doing* out there?"

The Goldilocks Zone: Living Here on Earth

Our ideas of where and how life can survive in space are born from our understanding of how life has developed and continues to develop on Earth. A solid understanding of Earth's evolution—especially documentable environmental stressors—informs the Alien ID Chart; similarly, such an understanding can assist us in ensuring Earth's future habitability. As we look to the sky to discover new sources of life, we keep our eye on the ground to use that new knowledge to explore new ways to protect Earth from our own development.

One of the first ways to accomplish both tasks is to remind ourselves of the diversity of environments and life forms right here at home. NASA scientists have outlined how our perceptions of Earth's "habitable zone" have changed in the last 30 years. Because of penguins, desert lizards, eagles, and deep-mine worms that feed on bacteria, we used to think that life couldn't survive in environments colder than Antarctica, hotter than scalding water, higher than the clouds, or lower than a couple of miles underground. But in the last three decades, scientists have discovered microbes that live in nuclear reactors, acid, and boiling-hot water. In fact, NASA reports, deep-sea vents host entire ecosystems—where the vented water is "hot enough to melt lead."

In *The Search for Life in Space* we witness "black smokers," or chimneys formed from deposits of minerals left by hydrothermal vents. More than a mile down, these vents occur at the boundaries of tectonic plates or in association with underwater volcanoes—and while they might seem completely inhospitable, these otherwise toxic chimneys of sulfur support thriving colonies of bacteria. While scientists have not reached consensus, there is a current debate of whether the Last Universal Common Ancestor (LUCA)— the most recent single-celled organism from which all organisms now living on Earth have a common descent—can be traced to hydrothermal vents. So far, the implication is that life developed through a hot phase—even if scientists do not yet know what came before, or if life actually could have started in the vents. For Kaltenegger, however, the "fundamental question is under what conditions life started—and that question is linked to those new worlds out there. If we were find signs of life on all hot worlds, then that would tell us about what life needs to begin," she says. "But if we find them on nicely warm worlds, that tells us a different story."

Back on land, we travel to Hawaii, where Amezdroz says some landscapes are "extraordinarily similar to other planets or bodies in the universe. If we're looking at a rock planet," he explains, "we know that the planet lived through a phase where it was molten lava. And that's exactly what you find with Hawaii." Lava fields anywhere might seem to prohibit the growth of plants or animals. However, Hawaii provides a living Petri dish of what happens when nature blows and floats the seeds of life to an island of lava, and then drops rain on them. "The first life form that took hold in Hawaii's lava was the Ohia tree," Amezdroz says. "It didn't need soil; it needed only water to regenerate and grow. Then the tree created the soil for the other plants." In a miraculous moment in the film, astronomer Kaltenegger leaves her familiar sky and goes underground—into an Hawaiian cave where the roots of an Ohia tree sparkle with condensed moisture.

To get there, the film crew lugged heavy IMAX® equipment cases through caves accessed by small portals and steep ladders—so small that the cameras had to be taken apart and reassembled underground. "The crew hiked with huge crates of cameras," Kaltenegger recalls. "We went on a real adventure. The ladders were pushed onto piles of loose rocks, so we could climb deep into the lava caves. The helmets kept our heads in one piece when we got up a bit too high while exploring new paths underground in the shadows," she says. "The film crew was very adventurous, and the environment was delicate. The camera crew had to be especially careful while lugging the camera, holding on with one hand to the wooden ladder."

Amezdroz reports having less concern for the equipment's safety than for "getting the best shot." Kaltenegger confirms that the team was after the science, the best visuals, the best meaning. "Their approach embodied the excitement and the adventure of the journey of science," she says. "This is what attracted me to the project." Again, Kaltenegger had to navigate her own experience. Exploring that foreign land underground "was great fun," she says, "but I was taller than many of the people I was there with. They would stop in these lava caves—all of us with protective gear on our heads—but I had to remember not to stand up straight like everybody else. I learned that the hard way." she laughs.

As Kaltenegger sees first-hand how life adapts to this seemingly impossible environment, she connects that tenacity of life to her telescope time. Life is unexpected, tenacious, and creative here on Earth, which allows us to open our minds in space. Although the "Goldilocks zone"—the habitable zone that is "just right" for a planet, not too hot and not too cold—still allows her to target the most likely candidates for life as we know it, Hawaii shows that we have to keep an open mind. The Goldilocks zone on Earth—and in space—is larger than we used to think.

"We also look for life in extreme environments here on Earth that live in niche environments," Kaltenegger explains. While she does not specialize in any specific niche environments in her own work, she uses them to extrapolate about what to look for in space. "Imagine Yellowstone National Park, where most of the amazing colors found in the water and hot springs are really created by different biota. Now imagine a planet that is just a bit different than ours—just a bit hotter, like the water in Yellowstone, or a bit more acid, or iced over. We have already identified organisms that could survive in such scenarios." The Carl Sagan Institute staff has compiled our collective knowledge about ecosystems around the world and created the "Color Catalog of Life." This is the manual of spectral signatures for life as we know it—which tells us how another planet with similar life would look through the eye of a telescope.

The Keck Observatory: Confirming New Planets

Understanding the scope of the task of finding life in space is one thing, but this kind of exploration comes with plenty of logistical challenges here on Earth. To capture Earth-based IMAX® images, the film crew flew on helicopters, swam with sea turtles, navigated lava fields—and carried oxygen up to the 14,000-foot summit of Mauna Kea on the island of Hawaii to visit the Keck Observatory. Keck is the home of two ten-meter telescopes, currently among the largest, most innovative, and most scientifically productive astronomical telescopes in use.

Keck and other big telescopes are used to verify what NASA's Kepler space telescope—the planet-hunter—"thinks" it might be seeing. Kepler's job is to scan a section of the sky and look for exoplanets. This means that Kepler is calibrated to detect the slight dimming of the surface of a star—which can happen because an orbiting planet is passing in front of it. However, other scenarios can mimic that finding. "One of the biggest problems with seeing what appears to be the dimming of a star is that you could really be seeing two stars that are quite close together, and not realize that they are two. In these cases, you don't have enough resolution to tell them apart," Kaltenegger explains. "In addition, one of the two stars might appear to vary in brightness, which could be due either to the presence of a planet or a third companion star."

This is where a bigger telescope like Keck's comes in. It can spot individual stars even if they are very close together, or confirm if the dimming came from spots—

exoplanets—crossing its surface. Kepler starts the process by flagging certain stars in the sky, and Keck confirms or denies their status as hosts to exoplanets. Visiting the Keck observatory is always a thrill for Kaltenegger.

To get to the impressive Mauna Kea summit, the film crew became examples of the life forms they were studying. They had to be prepared for sudden drops in temperature, excessive UV radiation, winds of 150 miles per hour, and any kind of weather you can imagine—including snow or flying rocks. Two-wheel-drive vehicles are prohibited because the air is too thin to cool a vehicle's brakes during descent. Just imagine what that environment does to humans. Even after the obligatory acclimatization at 9,200 feet, the crew carefully watched out for signs of oxygen deprivation at the top. "I was so excited to see the big telescopes," Kaltenegger recalls. "I was happily jumping up and down instead of taking slow steps, which caused some crew members to wonder if I was okay." Amezdroz knew that instead of oxygen deprivation, Kaltenegger's response was just that of a typical astronomer, excited to stand close to one of the best tools to look deep into the universe. "Who cares about oxygen at that point?" Kaltenegger asks.

Making Space Images for the Giant Screen

December Media cut its 3D-CGI teeth on *Hidden Universe,* which required the development of new CGI techniques and software in order to manage the space footage. Likewise, the filmmaking team employed their proprietary processes on brand new images for *The Search for Life in Space*. They began with high-resolution 2D images from the most advanced telescopes ever built, and then enhanced them with real scientific data provided by astronomers. Amezdroz says that unlike most CGI images, this film's re-mastered, high-resolution images were not “interpretations of what we think these scenes look like. They were real,” he said. “We tiled together multiple, actual images to create scientifically accurate, cutting-edge pictures.”

The visual effects team leader, CGI Director Sam Moorfield, used super computers at the Swinburne University of Technology’s Centre for Astrophysics and Supercomputing to render the images. “It’s a different world from a normal CGI day,” he says. “You are bound to real pictures, but you still need to make each shot work artistically. You have to embrace a particular mindset, because in CGI there is always a temptation to just invent details when you encounter problems. But we can’t do that here. Instead, we focus on making sure that when you see the space images, you are truly immersed in them; they surround you and envelop you—but they are defined by reality.”

One noteworthy sequence Moorfield uses as an example is the impressive footage of the “Pillars of Creation” from the Eagle Nebula that were captured by the Spitzer Telescope. A nebula is an interstellar cloud of dust and gases that is associated with the formation and origins of stars, and the Pillars are visually arresting—more so because they are real. “The sequence we built takes you from inside the Eagle Nebula, all the way back to the Earth's view of the Milky Way,” Moorfield says. “Using real images taken with different magnification along that path allowed us to show the audience the size and position of the nebula in the sky. It really helps connect you to the universe around you.”

Amezdroz explains that these results are possible because the most advanced telescopes are shooting cleaner and more detailed images every year, which puts the pictures in *The Search for Life in Space* at a higher level than they would have been even a couple of years ago. However, “images like this are absolutely massive,” Amezdroz says. “In 8K, they are so labor intensive to render.” When he talks about 8K, he’s referring to resolution—how many pixels make up the horizontal aspect of each frame. High definition is 2K, Ultra HD is 4K—and then there’s 8K, which displays 11 times more pixels than a full 4K frame. The CGI team utilized a tremendous amount of computing power, as well as more than 500TB of storage space, to make it happen.

Moorfield explains: “Working with 8K 3D CGI was uncharted territory. You can't predict all the technical problems you might encounter, because every shot is huge, both in the resolution of the frames and the file size.” The five-person CGI team dealt with hundreds of Terabytes of rendered frames, which required massive computing power and large, fast storage systems. “Likewise, making sure each frame has the detail and information worthy of an IMAX® screen was a big challenge,” Moorfield adds. “We spent a lot of time making sure the CGI really took you into that space experience. Fortunately we had an excellent CGI team who really took the time to understand the format and they've done an incredible job.”

The Swinburne team worked with advising physicists and astronomers over a period of about 12 months to render the space images. “We have had a close working relationship with astronomers for the past 15 years,” Moorfield says. “In that time we have worked to bring many complex ideas to life through animation. With every new sequence, we take a great deal of time to understand what we are building. To turn a photograph of a nebula into a volumetric, three-dimensional object means uncovering the best research into the forces that shaped the images we see.”

Filmmakers and technicians on the entire December Media trilogy of films agree that their core visual mission is to “immerse the audience in the latest discoveries” by using real images, which Moorfield says are "always more impressive than anything we can make up. Reality is always the litmus test."

Carl Sagan's Legacy: "Extraordinary claims require extraordinary evidence."

The Search for Life in Space is both a cutting-edge presentation of the latest that science has to offer—and a love letter to Carl Sagan. Sagan has inspired and transformed how generations of burgeoning scientists and engineers have thought about space. As an astronomer, cosmologist, astrophysicist, astrobiologist, and author, Sagan first connected the dots that scientists like Lisa Kaltenegger are building on today. Because most of his career was spent at Cornell University, Kaltenegger founded the Carl Sagan Institute there in 2014. Among the elite group of interdisciplinary scientists who look at the habitability of worlds beyond Earth—only about five teams worldwide are working at this level—the Carl Sagan Institute's team stands alone. Its counterparts usually focus on one specialty area, maybe Mars, or maybe just exoplanets. The Carl Sagan Institute, however, has a wider scope that includes the Search for life both inside and outside our Solar System. "Every little piece we learn about our own Solar System helps us to understand other worlds better—and they help us to understand our place in the universe," Kaltenegger says.

She imagines what Sagan would think about the state of astrobiology today. Or the fact that just one telescope—the "planet hunter" Kepler—has found thousands of worlds beyond our solar system, while searching just two percent of the night sky. "I think this would have been one of Carl Sagan's dreams coming true," she says.

Sagan's thoughts about the search for life in space also inspired the film's director, Stephen Amezdroz. Up until this project, Amezdroz had always produced films, or stood behind the camera, but when it came to exploring the topic of life in space, he simply "couldn't stand behind and watch someone else do it." The irresistible draw of space is so palpable to him that if given the chance, he would climb aboard and soar into an uncertain future among the stars. His specialty in giant-screen films caused him to consider this particular project with the sharpest lens, the highest bar, and limitless expectations. "I could not imagine this idea in any format other than IMAX®," he says. "This project has reconfirmed my interest in film, and storytelling. It's caused me to forget about sleep all together," he says.

Meanwhile, long after *The Search for Life in Space* opens in IMAX® theatres around the world, Kaltenegger will be found exuberantly explaining the search for life beyond our Solar System to students, journalists, visitors—anyone. For her, it's an irresistible adventure we are all embarking on, to find out if we are alone in the universe. As she gently tucks our "Alien ID Charts for life" into our backpacks, we are amazed and excited, ready to hop into her world—ready to find life, *actual life*. The future seems less like science fiction and more like reality.

We all can imagine what Carl Sagan would think about *that*.

Technology: Spacecraft, Telescopes, and Space Images

Let's face it: the average moviegoer—or even the average space enthusiast—might have trouble tracking the high levels of technology and science involved in conceiving of and launching spacecraft, designing telescopes, and managing image resolution.

Astronomer Lisa Kaltenegger, ever the educator, provides an excellent overview by "grading" the tools she uses to look into space. Most of them are discussed in the film, while others are projects that are still upcoming. Grades from A+ to C are based on each project's potential assistance in searching for life in space.

Kepler Space Telescope, A+—Kepler was launched into Earth's orbit in 2009 with the assignment of peering into just one tiny fraction of the sky. It was incredibly effective, thus "changing our view of the universe forever," Kaltenegger says. "The sheer number of planets it discovered shows that the universe is teeming with planets—and especially teeming with rocky planets in the habitable zone of their stars." Thanks to Kepler, we now know that exoplanets are common, and that most stars have planetary systems. "Kepler provided the first crucial step in the journey to find other worlds like ours, and hopefully life," she says.

Messenger probe, C: Named "Messenger" both for the mythological messenger Mercury, and for the "backronym" MErcury Surface, Space ENvironment, GEochemistry, and Ranging, this robotic spacecraft orbited the planet Mercury between 2011 and 2014. Its job was to study Mercury's chemical composition, geology, and magnetic field. Messenger was successful, and found that while there is frozen water on

Mercury, there is no life as we know it there. Kaltenegger finds this news useful and interesting, but of course not too relevant for future life searches there.

13+ spacecraft going to Mars, A: Although no life has yet been found on Mars, continued forays will expand the search for life under the surface. Since Mars is the closest planet to Earth, and thus the easiest to reach and explore, Kaltenegger gives exploring Mars an “A.”

Juno spacecraft and Jupiter, C—Juno was launched in August 2011, and has just recently (July 2016) entered Jupiter’s orbit half a billion miles away. Its assignments include studying Jupiter’s composition, gravity field, magnetic field, and polar magnetosphere, as well as searching for clues about how the planet formed. We hope to learn from Juno about whether Jupiter has a rocky core, and the amount of water present within its deep atmosphere. Even so, scientists do not expect gas giants like Jupiter to support life, but any new information about this planet will be welcomed.

Rosetta spacecraft and the comet 67P/Churyumov-Gerasimenko, C—Comets have been called “dirty snowballs,” as they are comprised of ices from water, carbon dioxide, ammonia, and methane, mixed with dust. They are considered “leftovers” from the formation of stars and planets, and thus provide interesting information about the initial material from which astral bodies were made. In November 2014, Rosetta’s lander module made the first successful landing on a comet. Although the orbiting craft and the lander’s communications have been terminated due to diminishing solar power, data is still being collected from the orbiting craft. This unusual mission has returned a variety of data, including conclusions that the water vapor on the comet is different enough from Earth’s that scientists conclude that Earth did not get its water from comets. However, while the feat of landing on a comet was impressive and informational, this kind of mission is not expected to contribute much to the search for life in space.

Flying through Enceladus's plumes, A—Saturn’s moon Enceladus is very enticing to Kaltenegger and her colleagues. When this “ice ball” revealed water vapor expelled by geysers, astrobiologists started to hope for signs of life. Flying through the plume will allow samples to be collected—and scientists to probe the internal water under the ice-crust that way. Kaltenegger calls this a “very exciting approach.”

Taking a closer look at Europa, A—The European Space Agency (ESA) is building a craft called the JUpiter ICy moons Explorer. It will look closer at all of Jupiter's icy moons and see if they can detect any information on the surfaces that could indicate life.

Future projects currently in the planning or construction phases also provide excellent possibilities of assisting scientists in their search for life. Although these are not discussed in the film because they are not yet in operation, Kaltenegger grades them for future reference.

James Webb Space Telescope (JWST), A+: The upcoming JWST is a major space observatory under construction and scheduled to launch in October 2018 by NASA. It will offer unprecedented resolution and light sensitivity (detecting infrared wavelengths from 0.6 to 28 micrometers), and is a successor to the Hubble Space Telescope and the Spitzer Space Telescope. The JWST can for the first time probe the atmosphere of potential Earths for signatures of life—allowing Kaltenegger and her colleagues to study those planets in detail, and maybe even find the first signs of life. The

JWST will orbit the sun at a position 930,000 miles from Earth, nearly four times farther than the distance between the Earth and the moon.

Transiting Exoplanet Survey Satellite (TESS), A+—TESS is a planned NASA space telescope designed to look for exoplanets; it is scheduled to fly in 2017. TESS will survey the brightest stars near Earth for passing "dots," by using an array of wide-field cameras—thus allowing astronomers to find and study small planets around our closest stars. Basically, TESS will be a small Kepler, but it will look at the whole night sky. It will be planet-hunting for nearby exoplanets that the James Webb Space Telescope (JWST) can then evaluate. Note: most of the planets Kepler detected are too far away to look at, even with such a big telescope like the JWST.

Participants

Guest Scientist

Lisa Kaltenegger – Astronomer / Astrobiologist

Lisa Kaltenegger is Associate Professor at Cornell University and Director of the Carl Sagan Institute. She not only leads one of the few teams of astrobiologists worldwide who specialize in the search for life in space, but also developed some of the signature cutting-edge approaches that these scientists use today. Her research focuses on rocky planets and super-Earth atmospheres in the habitable zone, as well as the spectral fingerprint of exoplanets that can be detected with the next generation of telescopes. Kaltenegger was named one of America's Young Innovators in 2007 by *Smithsonian* magazine, was selected as one of the European Commission's Role Models for Women in Science and Research and recently received the Heinz Meier Leibnitz Prize for Physics from Germany in 2012 among several other awards.

Narrator

Malcolm McDowell

With a career that spans more than fifty years, British actor Malcolm McDowell first came to fame with his portrayal of a twisted sociopath in Stanley Kubrick's surreal satire, *A Clockwork Orange* (1971). This breakout performance led to a career of character acting, often in boisterous and sometimes villainous roles, in such films as *Caligula* (1979), *Cat People* (1982), *Star Trek: Generations* (1994), *Tank Girl* (1995), and the 2007 remake of *Halloween* and its 2009 sequel *Halloween II*. McDowell has had recurring roles on numerous television series such as HBO's *Entourage, Heroes* and *The Mentalist.* In recent years, he has become a prolific voice actor in films, television and video games. *The Search for Life in Space* is his first giant-screen film.

Filmmakers

Tony Wright – Executive Producer

Tony Wright is the founder and Executive Chairman of December Media. He is also an award-winning and highly experienced producer and executive producer of documentary, drama, and children's television. He has worked with commercial networks, the ABC and SBS in Australia, as well a range of International broadcasters. Tony brings extensive experience in factual, drama, and children's TV financing and production. His numerous credits include, among many others, the acclaimed docudrama *Captain Cook: Obsession and Discovery*, hit children's series *Li'l Horrors*, and the Emmy®-Award winning science documentary *Immortal*. Tony produced the UK coproduction *Mrs Biggs* and executive-produced five seasons of the top-rated *The Doctor Blake Mysteries*, as well as the Australian-produced 3D IMAX® movie *Hidden Universe*—and now, *The Search for Life in Space.*

Stuart Menzies – Executive Producer

Stuart is a leading media executive with extensive experience in content creation, executive producing, commissioning, programming and financing. Before joining December Media, Stuart was the Head of Content and Creative Development at the Australian Broadcasting Corporation (ABC). Previously, he was the Controller of ABC2, the network's younger skewing digital channel, which under his stewardship saw significant audience growth. Stuart has a clear understanding of audience, and combines creativity and strategic thinking to deliver bold, provocative and popular programs and digital content. His understanding of the media landscape, as both a producer and buyer, give him deep knowledge of national and international program financing and distribution models. His early experience in feature film production and producing has given him an enduring appreciation of what it takes to make great content.

Stephen Amezdroz — Producer/ Director

Stephen Amezdroz has worked in the film industry for more than 35 years, with a background in the production of feature films and high-end, international television documentaries and dramas. His latest passion involves financing, developing, producing—and now, for the first time, directing—giant-screen documentaries. In fact, Stephen's commitment to the giant screen has led to December Media's creation of Australia's first 3D giant screen films—a trilogy that explores space, and particularly how life evolves on Earth and beyond. With many specialties in the industry, particularly the international marketplace, Stephen has become a key principal at December Media since he joined it in 2003, after more than 10 years with Beyond International.

Jim Frater – Director of Photography

Jim Frater is an award-winning Director of Photography and Cinematographer specializing in documentaries, drama-documentaries, commercials, and feature films. In 25 years' behind the camera, Jim's work has been featured across all major Australian, UK, and US networks, including the ABC, the BBC, CNN, and NBC. He has received more than twenty cinematography awards, most recently two from the Australian Cinematographers Society (ACS). In 2015, he received the Golden Tripod for Cinematography in Dramatised Documentaries, and in 2014 the Silver Tripod for Cinematography in the Documentaries, Drama, and TV category. His success is augmented by his extensive experience as an aerial camera operator, drone operator, Steadicam owner/operator, and jib operator—as well as his abilities as a very capable underwater cameraman and scuba diver. Working out of Perth, Western Australia, Jim is currently the only licensed Phantom high-speed camera operator based on the country's West Coast. His work has taken him across all continents except Africa—for now….

Dale Cornelius – Composer

Dale Cornelius is an AGSC multi-award nominee and recipient of the 2013 AACTA award for Best Music & Design in a Documentary. He has composed music for internationally acclaimed feature films, documentaries, and television series by BBC, PBS, Discovery, and National Geographic, among many others. He has been described as highly inventive, a truly unique artist, and having an ability to evoke an immediate emotional connection with an audience through music. Dale's musical diversity and distinct scores have made him one of Australia's premiere film composers. He has crafted extraordinary soundtracks for two films in this series, *Hidden Universe* and *The Search for Life in Space*, both of which reflect our boundless curiosity and passion to explore worlds beyond our own.

Production Partners

December Media Pty Ltd

December Media (formerly December Films) is one of Australia's most experienced screen producers. Based in Melbourne, December Media has more than 20 years of experience in producing drama, documentary, educational, and award-winning live action and animated children's drama for the screen. December Media brings a wealth of development, financing, production and co-production experience as well as having extensive network, distribution and financing relationships across the globe.

Film Victoria Australia

Film Victoria, a state agency and strategic partner to the film industry, funds and promotes great original films made in Victoria, Australia, committing over $7.2 million to local film and television projects last year alone. The agency has secured international and out-of-state productions for Victoria, including *I Frankenstein*, the HBO mini-series *The Pacific*, *Don't Be Afraid of the Dark*, *Where the Wild Things Are*, *Ghost Rider* and *Knowing*.

Swinburne University of Technology's Centre for Astrophysics and Supercomputing

Swinburne University of Technology is dedicated to inspiring a fascination with the Universe through research and education. The Center's production division, Swinburne 3D Productions, is a leader in scientific film production and high-end space visualizations, combining scientific data with innovative, proprietary techniques in CGI animation and 3D imaging. Specializing in film, interactive content and educational packages, Swinburne has more than 10 years of experience producing stereo-3D films.

Distributor

MacGillivray Freeman Films is the world's foremost independent producer and distributor of giant-screen films for IMAX® theatres, including the Oscar-nominated films *Dolphins* and *The Living Sea*, and *Everest,* the highest grossing giant-screen film of all time. For the past forty years, the company's films have been shown in leading institutions around the world, making the company the first documentary filmmaker to reach the $1 billion box office benchmark. MacGillivray Freeman's films are known for their artistry and successful blend of education and entertainment, as well as their celebration of science and the natural world.