Fantasy Worlds – Exploring the Limits of Life

We are more optimistic about finding life beyond Earth than ever before. Astronomers have found giant planets orbiting other stars and suspect that smaller worlds exist as well. Biologists have found microscopic Earth life in places they never expected, from hot springs to Arctic ice. We have dramatically expanded our criteria for a life-bearing world and increased our confidence that we can find planets suitable for life orbiting other stars.

With this new knowledge, animators have created realistic life-bearing Fantasy Worlds for us to explore.

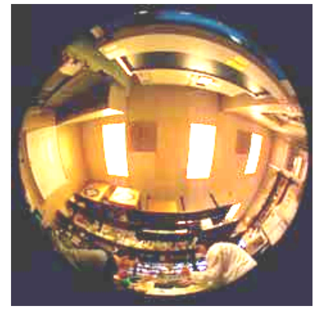
The tiny frozen Pluto is the most distant planet in our solar system.
The outermost gas giant, Neptune, is cold and lacks a solid surface like Earth's:
The same is true of its twin planet, the tilted Uranus ……
the beautiful Ringed Saturn ……and the enormous Jupiter – largest of the planets.
the red Mars is too dry for complex life.
The surface of Venus is too hot.
Mercury lies too close to the sun.
Leaving Earth, the solar system's only home for advanced life forms.

Many factors contribute to the stability of this blue watery world. Its nearby Moon causes tides, stabilizes Earth's tilt and slows its spin. The distant Jupiter traps asteroids and comets that could otherwise destroy Earth life. And the sun has been a stable energy source for billions of years. We wonder how important these factors are in the search for life-bearing worlds and if very different planets could harbor life.

In 1995 astronomers found the first planets orbiting distant stars. Now research facilities like the Lick Observatory in Northern California have identified well over a hundred alien worlds. This telescope collects the light from a likely star and sends it into a spectrograph that breaks the light into a rainbow of colors.

In the control room, astronomers look for shifted lines in the star's spectrum – a shift caused by the pull of an orbiting planet, making the star move.
Planets discovered in this manner are giants, more like Jupiter than Earth. Shifts caused by smaller Earthlike worlds are too small to detect.

These discoveries have inspired animators to create a giant alien planet, appearing from behind an orbiting moon. Like Jupiter, this giant world is probably barren, but there may be microbes hiding on its moon. With their deep and violent atmospheres, gas giants are less likely to harbor life. But a solar system with giants could have smaller rocky worlds as well.



Scientists in laboratories on Earth are also searching for life in the universe. Astrobiologists at the University of Houston culture microbes collected from the most hostile environments on Earth. This research shows that microscopic life could exist on distant planets in our solar system and on very hot or cold planets orbiting other stars. We will explore the extreme environments where these microbes live and ask animators to create alien worlds inspired by these environments and able to support the creatures we find.

Scientists discovered the first extreme-loving microbes in the geysers and hot springs of Yellowstone National Park. When we look into Yellowstone's colorful hydrothermal pools, we may be looking through a window into Earth's past -- to the beginning of life itself. The microbes thriving in these pools and their runoff channels may be heat- loving descendants of the earliest life forms on Earth.

Scientists think that during the first 3 billion years of Earth's history, microbes transformed the planet's original oxygen-free atmosphere into one that could support complex life. In these colorful mats and streamers, microbes called cyanobacteria convert carbon dioxide to oxygen in a process called photosynthesis. Gradually these bacteria created an atmosphere that would eventually support human life. Billions of heat loving microbes inhabit a tiny square of this mat -- outnumbering all the people on Earth. Microbes at the top of the mat need sunlight. Below are species that survive by combining inorganic chemicals to produce energy. Such energy sources fueled Earth's earliest life forms and support organisms living in hot springs and geysers today.

These microbes and their environments provide a living laboratory for astrobiologists exploring the limits of life on Earth and predicting where life could flourish in the universe.

When we search for planets around a much younger star than our sun, we may find worlds more like the hot springs of Yellowstone. Animators have created such a primordial world– a planet that could orbit a young star and a mirror into Earth's past.

The extreme environments of life extend from the very hot to the very cold. Each year plants and animals adapt to winter with its ice and snow. Life slows down or hibernates, waiting for the return of spring. Scientists have found creatures living inside permanent ice. Some microbes simply enclose themselves with strong walls and wait inside for warmer times. Some manufacture a kind of anti-freeze – preventing the formation of ice crystals within their cells. A few even secrete slime to melt the ice surrounding them.

Microbes thrive in Lake Hoare in Antarctica's McMurdo Dry Valley. Colonies live in mats on the lake bottom below at least four meters of ice. Here there is still enough sunlight for photosynthesis. Eventually these mats float off the lake bottom and rise to the ice above. Some of the oldest organisms yet discovered are bacteria found in Antarctic ice and Siberian permafrost, creatures that have tolerated the cold for thousands of years. Similar life forms might survive a trip through space on a frozen comet or icy asteroid.

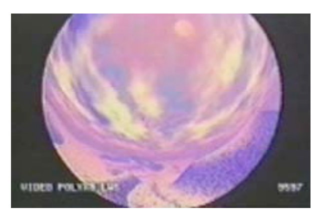
Alien worlds harboring ice-bound microbes could exist far beyond the inner planets of their solar systems. Animators have created a frozen world that might support life forms adapted to the cold and sheltered beneath the ice and snow.

On Earth all life depends on water, but the amount of water can be incredibly small. California's Death Valley is so dry and so hot that human life is threatened. Yet we find life forms adapting and surviving. Creosote and mesquite trees thrive in a sea of sand dunes. Although the sand is very dry, it allows water to percolate downward. Trees with deep roots can reach water while their leaves use sunlight to produce oxygen and food.

Death Valley is the lowest dry land in North America. This valley held a lake during the last Ice Age, but warmer weather has dried up the water and left salt pans behind. Because of freshwater springs, the valley never dries out completely and even manages to support a unique species of fish - the Death Valley pupfish, a small bluish creature that thrives in hot salty pools.

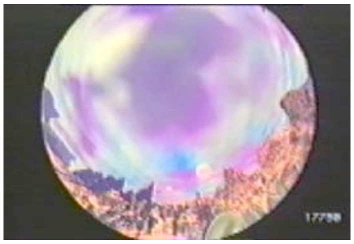
On the surface of sun-baked boulders, microbes have deposited a thin black or red coating called desert varnish. These microscopic creatures take trace amounts of manganese and iron from the air to produce this oxide coating on the rocks. These tiny rock dwellers have survived for centuries in some of the most inhospitable environments on Earth and are among the oldest living microbe colonies.

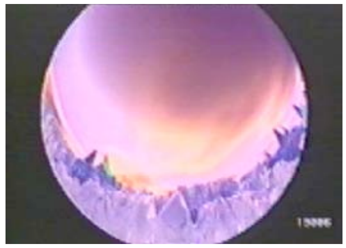
Perhaps a planet as dry as Death Valley could harbor life. Such a world, covered in sand dunes and desert varnish, might exist in solar systems throughout the universe.



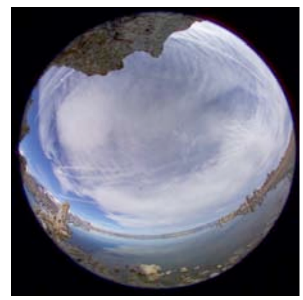
The Dead Sea is the lowest point on Earth and one of the saltiest, with a concentration 10 times that of seawater. No seaweed or plants surround the Dead Sea and no fish swim in its waters. White salt crystals encrust its shore.

But salt-loving microbes called halophiles thrive here. These are very tiny creatures. It would take more than half a million to cover the head of a pin. A single drop of Dead Sea brine may contain millions of these microbes. Their cells have a very high salt concentration and can survive only in a salty sea. Some of these microbes have stayed alive in dry salt crystals for years.





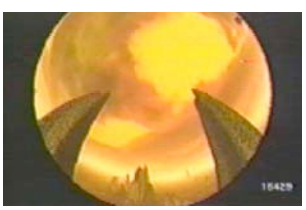
Life in this salty sea has inspired animators to create an alien world covered in crystals of salt and glass – a planet with its own roughed beauty and an environment that would kill most Earth life immediately.



Microbes also survive in the alkaline water of Mono Lake. These "venomous waters are nearly pure lye and twice as salty as seawater," complained Mark Twain. "There are no fish in Mono Lake--no frogs, no snakes, no polliwogs--nothing to make life desirable."

But Mark Twain did not look closely. There are tiny shrimp swimming in the water and scuba-diving flies in submarine air bubbles. Microscopic diatoms and cyanobacteria also thrive here.

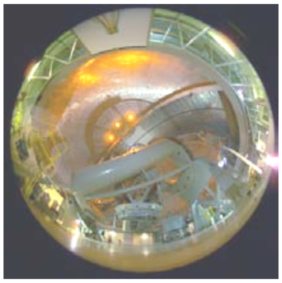
Colonies of algae cluster around springs flowing from the tops of towers. These spires form when calcium-rich spring water bubbles up through the alkaline lake. The result is tufa, a limestone rock formation. Animals help build these tufa towers. When an adult alkali fly emerges from its underwater pupa case, it leaves behind a tiny deposit of limestone.



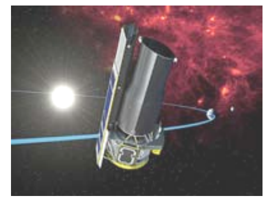
Mono Lake's tufa towers have inspired this animator to create a world of limestone structures supporting advanced alien life forms.

Sunrise over Mono Lake reminds us that Earth's atmosphere protects billions of life forms. Our air contains nitrogen, oxygen and water vapor – an unstable mixture that indicates the presence of life. Oxygen is a reactive gas that must be constantly resupplied by the Earth's green plants. Detection of oxygen, carbon dioxide and water vapor in the atmosphere of an alien planet would strongly suggest suitable conditions and the presence of life.

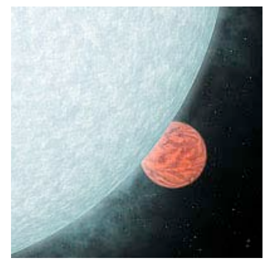
Earth's atmosphere sustains life -- leading this animator to create an alien sunset with clouds, perhaps one of millions occurring on life-bearing worlds throughout the universe each day.



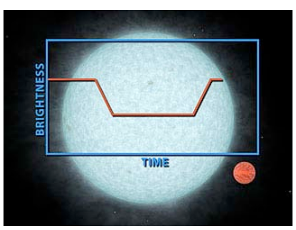
Hale Telescope on Mt. Palomar in Southern California is one of the largest optical telescopes on Earth. But it could not detect a planet orbiting another star. In visible light, stars are much brighter than any companion planet. To see planets, we must look in other wavelengths of the spectrum.



The Spitzer Space Telescope is an infrared observatory, orbiting the sun on a path following the Earth. It is designed to detect heat radiation from distant objects. Most of this radiation is absorbed by Earth's atmosphere far above the planet's surface.



This telescope has directly observed the warm infrared glows of hot Jupiter-like giant planets orbiting other stars. These gas giants lie very close to their stars and have temperatures rising to a thousand degrees. In visible light, the star far outshines its planet. But in heat radiation, the warm planet is brighter and much easier to see.



To distinguish the star's glow from the planet's, the Spitzer telescope collects infrared light from the star and planet and then from just the star as the planet dips behind it.

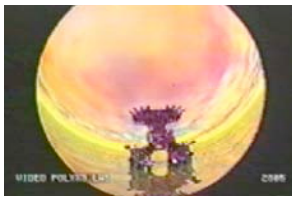
This telescope can detect infrared light from giant planets orbiting stars like our Sun at distances up to 500 light years. Future orbiting telescopes will be sensitive enough to image extrasolar planets as small and cool as Earth.

In the search for Earth-like planets, astronomers are developing another technology in a test facility at Mt. Palomar. Here several small telescopes work together to create a sharper image of a star and possible planets. The success of this test bed will lead to an armada of planet-seeking telescopes in space.

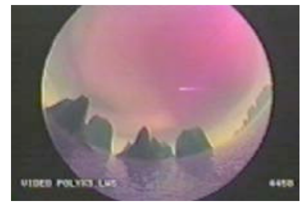
NASA's Terrestrial Planet Finder and the proposed European Space Agency's Darwin Mission will both use a cluster of sensitive telescopes above the Earth's atmosphere. By combining the light from these telescopes, astronomers will block out a star's light and look for nearby planets. The telescopes will detect the amount of carbon dioxide, water vapor, and oxygen in a planet's atmosphere and help astronomers decide if the planet could support life.

Conditions required for complex life are far more specific and demanding than those needed to support simple organisms. Animal life requires a stable environment for millions of years. Finding a planet with intelligent life is much less likely than a world where microbes survive.

A stable star, water in liquid form, an atmosphere with water vapor and oxygen – if all of these conditions are present, we may be looking at a world that can support animals and perhaps intelligent life.



An advanced alien civilization will change its world as humans have changed Earth. Here animators have created a distant watery world with the unique constructions of intelligent life.



The ultimate goal of our search is to see if the circumstances that produced human awareness and creativity occur frequently or rarely among the stars.

The answer will tell us whether we are unique or one of many intelligent civilizations in the universe

-- whether civilizations are more likely to survive or to self-destruct

– whether we are alone or no longer lonely.