Script - Distant Worlds, Alien Life? - © LWL / Dr. Björn Voss, 2012/13

The night sky: A view of infinity. Does alien life exist out there? Are such aliens perhaps traveling through space, and visiting earth?
Many people believe in UFOs: visitors from space. But such extraordinary claims demand clear evidence. Evidence for alien visitors, however, does not exist. To search for extraterrestrial life, we had better look out there: in space. Millennia ago, our ancestors were already watching the stars. Was this another world, with inhabitants of its own? Are the patterns of the stars related to this? Looking at the stars, people imagined heroes and monsters, animals and mythical creatures…
In summer, for instance, there are three stars high in the sky: the summer triangle. Part of it is the constellation of the swan. It looks like a huge cross. One can imagine this as a flying swan with its wings widely spread.
In autumn, the complete cast of a heroic saga can be seen in the sky: Cepheus the king, and Cassiopeia the queen; their daughter Andromeda; Cetos the sea monster, threatening to swallow Andromeda; and Perseus, the hero who finally saved Andromeda. Especially easy to spot is the constellation of Cassiopeia. It comprises five stars that are arranged like the letter “W”. This constellation can always be found in the northern part of the sky.
As the night progresses, the constellations of autumn are followed by those of winter. Among them is one of the most magnificent: Orion, the hunter. His belt is marked by three stars that are arranged in a straight line. Above these, two more stars show Orion’s shoulders, and another two below, his feet. To the lower left of Orion, we can see the brightest of all stars: Sirius.
But the constellations are just random patterns of stars. For the search for life in space, the planets are more interesting. In the course of weeks and months, they move compared with the stars.
Today we know that the planets are siblings of Earth, giant spheres made of rock and other materials. Like Earth, they orbit the sun.

Unmanned space probes have explored all the planets at close range.

No life was found anywhere – and especially, no intelligent aliens.

Earth is the only planet which we know to be inhabited.

Life on Earth formed more than three billion years ago. All of today's species, including man, are descendants of a single common ancestor:

A tiny single-celled organism, similar to today's bacteria. It lived on certain substances in the water, and did not require any oxygen.

From this ancestor, all other species evolved.

For a long time, all life was single-celled: even today, microbial life is still the most numerous!

Only after more than two billion years did complex beings evolve that are made of many cells, like animals and plants.

All organisms on earth, as different as they are, have much in common:

Each cell, be it a bacterium or a human cell, contains DNA molecules. They are the blueprints of all life forms.

All living cells are filled with water. It acts like a lubricant, keeping the cell alive. Without water, every being would die.

And everywhere, the same chemical elements are the most important: carbon, hydrogen, oxygen, and nitrogen. DNA, too, mainly consists of these four kinds of atoms.

These basic materials can be found in space, too. Even some "prefabricated components" of our molecules can be found in space, for example preliminary stages of parts of the DNA.

These substances are among the most frequently found in the universe. So alien life is perhaps using just the same elements as we do.

The same is true for water: Of all suitable liquids, water is the most common. Life forms based on completely different substances are likely to be rather rare.

Water can be found almost everywhere. But mostly it is only present in the form of ice, or as a very thin vapour. Life, however, requires liquid water, and that is very rare.

Where does liquid water exist?

On the moon, there is no liquid water. In the sunlight it is much too hot, and in the shadow, much too cold.

Furthermore, there is no air. Without air, or in very thin air, water would vapourise at once – even if the temperature is just right!

Thus, no life can exist here, not even micro-organisms – except … within a space suit.

Most places in space are just like the moon:

Mercury, the innermost planet, looks very much the same.

On Venus, however, there is air. But it is much too hot there; more than 500 degrees centigrade.

Mars is colder than Earth, and has only very thin air.

Even further out, at the planets Jupiter, Saturn, Uranus and Neptune, it gets increasingly chilly. These are gas planets without a solid surface. So liquid water can't accumulate here.

All this shows that a habitable planet has to be large enough, or it will not have air; and small enough, or it will not have a solid surface.

Furthermore, it has to be at the right distance from the sun, so that the temperature is just right.

Near the sun, it's too hot…

… and far away from it, too cold. Only in the transition zone – in the "green belt" – can a planet support liquid water.

Mars is situated on the outer edge of this zone.

The atmosphere on Mars is too thin for liquid water to exist here.

But this was different shortly after Mars formed, four and a half billion years ago: Back then, the atmosphere was still thick, and water did exist. Mars looked much like Earth, with rivers, lakes, and perhaps even an ocean. Could life have formed then?

But Mars lost most of its air – it is too small and its gravity is too weak. So it became cold, and the water froze. Space probes have discovered that it turned into ice and now is hidden deep below the surface.

Today, Mars is an icy desert planet.

If life ever existed here, then it probably became extinct. Instead of living creatures, it's more likely that only fossils will be found: vestiges of ancient life.

Was there life on Mars?

It's August 7th, 2012.

The space probe "Curiosity" is speeding towards Mars at 20-thousand kilometers per second.

Still moving at twice the speed of sound, a breaking parachute opens.

But the Martian air is too thin to land on a parachute.

Thus, a special trick is used…

"Curiosity" has landed. Its research work is beginning.

It searches for certain rock formations. They will provide information about early Mars.

"Curiosity" finds its way through difficult terrain, to reach the rock formations.

The rock is examined using a laser beam, and interesting spots are identified…

… a drill takes samples…

… in a miniature laboratory inside the vehicle the samples are studied in detail. Was there a life-friendly environment? Could life have formed? Answering these questions is "Curiosity's" mission.

Was Mars inhabited, or forever lifeless?

Both would be thrilling! So far, we know of only one inhabited place: Earth. A second inhabited planet in our vicinity would show that life is common everywhere in space.

But if Mars was always lifeless, this could mean that life is very rare throughout the universe.

Another place that might harbour life is found near the planet Jupiter. One of its moons, Europa, could be inhabited.

In fact it is much too cold here, and there is no air. The surface is completely made of ice which never melts. But the strong gravity of the giant Jupiter causes something special to happen: the small moon is continuously kneaded, and thus heated, from within. Deep below the surface it is warm, and there is liquid water.

An entire ocean is hidden there, with perhaps twice as much water as in all the oceans on Earth!

Especially interesting are the numerous lines that crisscross the surface. There are deep crevices here, just a few metres wide, but perhaps kilometres deep.

In the depths, there is eternal darkness.

Hot springs on the ocean's bottom provide scarce energy. Life can't thrive here; only very simple organisms might exist.

Certainly they would be very different from terrestrial life. But perhaps there are things in common. For example, all life probably requires an outer envelope – like microbes on Earth.

But who knows what really exists in Europa's ocean…

Even if life is found on Europa or Mars; intelligent beings certainly don't live there. We are alone in our solar system.

Far away, we can see the stars. Each of them is a distant sun.
Most of these suns have their own planets: There are billions of other solar systems out there.

In 1995, the first planet at another star was found. This star can be seen each night in autumn, even without a telescope. It's called "51 Pegasi", after the constellation of Pegasus, in which it is situated as seen from Earth.

This star's planet however can't be seen even with the largest telescopes: The light of the star is very bright, and completely outshines the much smaller planet.

So how do we know that the planet exists?

It was found using a sophisticated method.

If a planet is circling around a star, then the star, too, is not completely still. It wobbles back and forth in return.

The star moves very slowly. Still, this can be measured to a high degree of precision – even if the star is moving back and forth literally as slowly as a pedestrian. From the strength and rhythm of the star's motion, the mass of the planet and the size of its orbit can be calculated – without ever actually seeing the planet.

Another method used to find planets works differently. If the planet happens to move exactly in front of its star, as seen from Earth, then the star temporarily appears slightly dimmer – just by fractions of a percent. But this, too, can be measured with high precision, and allows us to determine the size and orbit of the planet.

It was discovered that the planet of "51 Pegasi" is rather strange. It is almost as large as Jupiter, but orbits so close to the star that it is heated to more than 1000 degrees.

Since 1995, more and more planets have been discovered. Today, they number more than one thousand.

Most of them are giant planets that are not suitable for life. To find smaller planets like Earth, an even higher precision is necessary. Specialized space telescopes are used to achieve this.

Starting in 2009, NASA's Kepler telescope searched for Earth-like planets. It steadily watched a certain area of the sky, towards the constellations of the Swan and Lyra. There, it monitored more than 150 thousand stars simultaneously, and looked for signs of orbiting planets. The hope was that Kepler data might discover a planet just like Earth.

But even Kepler could only determine the size and the orbit of such a "second Earth". What the planet looks like, and whether it harbours life, will remain unknown.

To find out more, the planet would have to be imaged. But so far, photographs are only possible of planets that are very far away from their stars, and thus much too cold – uninteresting for the search for life. What's more, even these photos only show the planets as tiny dots.

The Hubble Space Telescope for example took this image of a planet orbiting the star "Fomalhaut" in the constellation of the "Southern Fish". The planet orbits a hundred times

further out than Earth is from the sun – much too far out. Habitable planets have to be close to their stars – so close that no telescope today could capture an image of them.

But there are plans for new telescopes that should make this possible.

A combination of multiple space telescopes is to be deployed. In formation flight, they will combine their gathered light.

In this way, the bright star can be precisely masked out. A distant Earth will then appear as a tiny dot next to the masked-out star.

From the light of the small dot, measuring devices can now determine the temperature of the planet, and the composition of its atmosphere. This will show if it is habitable. Maybe even certain gases can be found that would indicate inhabitants on the planet – like the oxygen that is released by plants on Earth.

In this way, it would really be possible to detect life on a distant planet!

But no telescope will ever show what such lifeforms actually look like.

To unravel that mystery, one would have to travel out there – to a distant star. Will this ever be possible?

The distances to the stars are unimaginably large. A comparison shows the travel times to be expected: A flight to Mars takes six months, and to Jupiter, at least two years. At the same speed, more than a hundred thousand years would be needed to reach 51 Pegasi! For the time being, voyages to the stars are impossible.

But in our imagination, we can explore the stars! We will head for three stars with very different planets.

Our first target is located towards the constellation of the Swan.

We are approaching the “Kepler 16” stellar system. Here, two suns are circling each other: A double star – which is not unusual. In fact, most stars are not single stars, like our sun, but have a partner.

This stellar couple is orbited by a giant planet – it was discovered in 2011 and is about as large as Saturn.

This planet probably has many moons, like all giant planets in our solar system.

If one of these moons is very large, there might be liquid water on it.

If there is water, is this moon inhabited?

Two suns are shining in the sky. The rocky landscape shows no sign of life…

But a stain in the water is noticeable… caused by tiny single-celled organisms – alien microbes!

So far no one knows how life actually came about. Was it perhaps just by chance, so very improbable that it never happened a second time throughout the universe? Many scientists have a different opinion. They believe that life will arise in almost any place that provides the right ingredients.

On Earth, the first life forms already existed very soon after the planet formed. This quick appearance could mean that life is nothing out of the ordinary.

Highly developed organisms like plants and animals, however, appeared only very late on Earth. Perhaps they require special conditions to evolve, like a sufficient level of oxygen in the air. Single-celled life is much less demanding. Thus, it can exist on many planets that are not suitable for highly developed life.

Therefore, it could be that most inhabited planets only harbour very simple life forms.

“Kepler 16“ is far away from us. But another presumably habitable planet is rather close, at a distance of only 22 light years. It orbits the star “Gliese 667C” in the constellation “Scorpius”.
“Gliese 667C” is a red dwarf star – a star that is less hot than the sun and shines only very weakly. Three quarters of all stars are such Red Dwarfs.

Multiple planets orbit around “Gliese 667C”. One of them is located in the “green zone”.

It’s twice as large as Earth. So it has a stronger gravity and probably a much thicker atmosphere. That would make it warm enough for liquid water.

The planet rotates extremely slowly. Thus, the temperatures on the day and night hemispheres could be very different, and could cause strong storms.

The larger a planet is, the more water it will probably harbour. This quite large planet might therefore be entirely covered by water.

But we don’t know if this planet really is a water world. Perhaps continents also exist here, lush with plant life.
Plants probably would not be green on this planet. The green plants on Earth are adapted to our white sunlight. Here, the light is more reddish. Adaptation to this light might lead to different plant colours. The sun hardly moves in the sky and appears almost fixed in one spot. Therefore plants might evolve with a fixed orientation towards the sun. They would also have to adapt to the strong gravity and stormy winds. This might lead to sturdy stems, and to a mechanism that folds and stows the leaves during strong wind.
The true inhabitants of this planet will certainly be very different – or they don’t exist at all. Red dwarf stars are more common than stars like the sun. Planets of such stars are therefore the most numerous, and we are an exception! But there must also be planets that are virtually the spitting image of Earth. An instrument like the Kepler telescope could soon detect such a planet. Let’s travel to the area in which it might be found.
Alternative Text, since a “second earth” is found in Kepler data: But planets that are the spitting image of Earth do exist. The Kepler telescope recently found such a planet in the constellation of the Swan. Let’s travel to this planet!
A star like the sun, orbited by a planet like Earth – here the chances of finding highly developed life are best. But even this planet is not exactly like Earth – for example, there might be more oxygen in the atmosphere here than on Earth. What would this mean for life here? It would be easier to fly! There could be flying creatures much larger than anything that flies in our sky.

Giant balloon-like animals are floating high above the ground.

They are half plant, half animal. Just like plants, they absorb the sunlight and live off its energy.

For other kinds of animals, too, flying would be easy: Big, bird-like creatures could exist, larger than anything comparable on Earth.

Swarms of such creatures hunt the balloon animals, which try to escape to great heights to which the hunters can't ascend. Most succeed, but one straggler is too slow. The hunters use their weapons. They can emit very strong pulses of ultrasound, and focus them on their prey, the balloon animal. It is stunned and defenseless.

Its strong hide rips, and it loses its buoyancy. Slowly it sinks down, until it is stranded in the canopy of the forest below. Now, it is an easy prey.

Other kinds of life, too, are made possible by the abundant oxygen: Molluscs, like octopuses on Earth, could live on land. Maybe there are five-armed animals here that swing from branch to branch.

Their arms have finger-like extensions with which they can easily handle objects, just as humans can.

Some even take shreds of the hide of a stranded balloon animal, and use them like a paraglider: So they can glide from one treetop to the next. Maybe such beings will one day evolve an intelligence like ours. The essential preconditions are already there.

These creatures are pure fantasy, and certainly don't exist exactly like this. But they show that all alien life will be subject to the principles of evolution.

Each organism evolves in such a way as to make it best adapted to its environment. Thus, alien life will be as diverse as the planets it lives on.

But some adaptations will be equally advantageous on every planet: For example eyes…

… legs …

… or using sunlight for food. Such inventions of life will probably be found on many planets.

Intelligence itself is just such a result of evolution. So on some planets, there should also be intelligent aliens.

However, they're unlikely to have two arms and two legs. They will look much more… alien.

There should even be planets with technologically advanced civilisations…

So far there are no clues to any such civilization. But in the depths of space, there is certainly enough room for them…

How numerous are such advanced aliens? At what distance from Earth might the nearest civilization of this kind exist?

Viewed from 10 lightyears away, the sun appears merely as one star among others.

But it is a special star: From its third planet, radio signals are sent out into space.

This began about 80 years ago. As the signals are moving at the speed of light, the oldest have by now moved 80 lightyears out into space. This sphere shows how far they have advanced.

All stars within this sphere can receive our signals today. Is there an inhabited planet among them?

A planet like Earth is to be found at perhaps one out of a hundred stars.

We don't know how many of those are actually inhabited – maybe one in ten.

Highly developed life is even more scarce. It might exist on one out of ten inhabited planets.

Intelligent life, finally, will be most uncommon. How infrequent, we can again only guess at – maybe on one out of a thousand planets with highly developed life.

Thus, no intelligent extraterrestrials should be expected among our neighbouring stars – all those that we can see in the night sky.

But these are only the stars near to us! In fact there are many more. The Milky Way, the glowing expanse in the night sky, consists of billions of stars at much greater distances. It is our internal view of a huge flat disk of stars, of which the sun is just one. The Milky Way consists of more than two hundred billion suns.

Spread throughout the Milky Way, there could be many inhabitants: hundreds of extraterrestrial civilisations!

But the Milky Way is huge; hundreds of thousands of light years across. Thus the civilizations are probably separated by thousands of light years.

Even those that are closest to us are so far away that our signals will arrive there only after millennia.

Making contact across such a distance is almost impossible – an answer, too, would arrive only after millennia had passed.

But wouldn't it be possible instead for aliens to travel through space, and come to visit us?

In fact it is conceivable that an extremely advanced civilization might expand across the entire Milky Way. That would take an enormously long time – maybe hundreds of millions of years.

Sooner or later, such a civilization would arrive in our region of the Milky Way, too. "They" might even already be underway in our vicinity. But some scientists believe that "they" deliberately don't contact us, so that we may continue to develop undisturbed.

Such a civilization would have to be unimaginably far advanced. Its technology and intelligence would be millions of years ahead of ours – much further than we can envision.

In that case, could we even talk to "them"?

In "their" view, millions of years in advance of us, we probably wouldn't be especially intelligent; maybe just as talented as an ant is in our view. A conversation with each other would be hard to imagine.

Thus it might be that aliens deliberately don't contact us – as much as we may observe an anthill, but without trying a conversation with its inhabitants.

But who knows – maybe "they", after all, are good-natured enough to send a message to underdeveloped natives like us...

So far, such radio telescopes only collect natural radio waves from space.

Will there someday be a signal from aliens?

We would know: The signal is artificial. We are not alone in space.

This would be the greatest discovery of all time. The impact could be far-reaching. Maybe, just knowing that aliens exist might lead to big changes here on Earth.

And then? In the best case scenario, an open, amiable contact might result. We could learn a lot from such highly advanced beings.

Some people even think that the aliens would then start to solve all our problems for us – but that is very unlikely. On the other hand, hostile extraterrestrials that seek to conquer Earth would be equally unlikely.

Probably we are much too insignificant for “them” to care too much about us – in the best as well as in the worst sense.

Other people think that we first have to learn to care better for each other and for our environment. Only then, they believe, would aliens take us seriously.

But all this is a rather human way of thinking. Other intelligent beings could have very different moral values and objectives – which, we can’t know.

Probably, the future will be much more interesting than we expect.

Sooner or later we will learn that Earth is not the only inhabited planet – a revelation that will be both sobering and motivating.

Within the lifetimes of many of us, the time might come when we can look up to a certain star in the sky and say with confidence: “There is life!”

But the nearest inhabited planet is likely to be too far away for contact. And whether highly advanced aliens would even want to contact us will remain uncertain.

But who knows; maybe on this very day, somewhere out there, the first signal from Earth is being received…