

SEARCH FOR LIFE

Written by Jonathan O'Callaghan

The five most important people in the search for extraterrestrial life



■ **Dr John Mather**

Dr Mather is a senior project scientist on NASA's James Webb Space Telescope. This giant space observatory will launch in 2018 and will aid in the hunt for potentially habitable planets outside our Solar System.

Dr Jerry Ehman

Dr Ehman, now retired, is an American astronomer. He previously worked for SETI and in 1977 he discovered the famous Wow! signal, which just might have been our first contact from an intelligent alien race.

Dr John Elliott

Involved with SETI since 1999, Dr Elliott's research includes working out how we'd decipher, and respond to an alien signal. He is a Reader in Intelligence Engineering at Leeds Metropolitan University in the UK.

Dr Seth Shostak

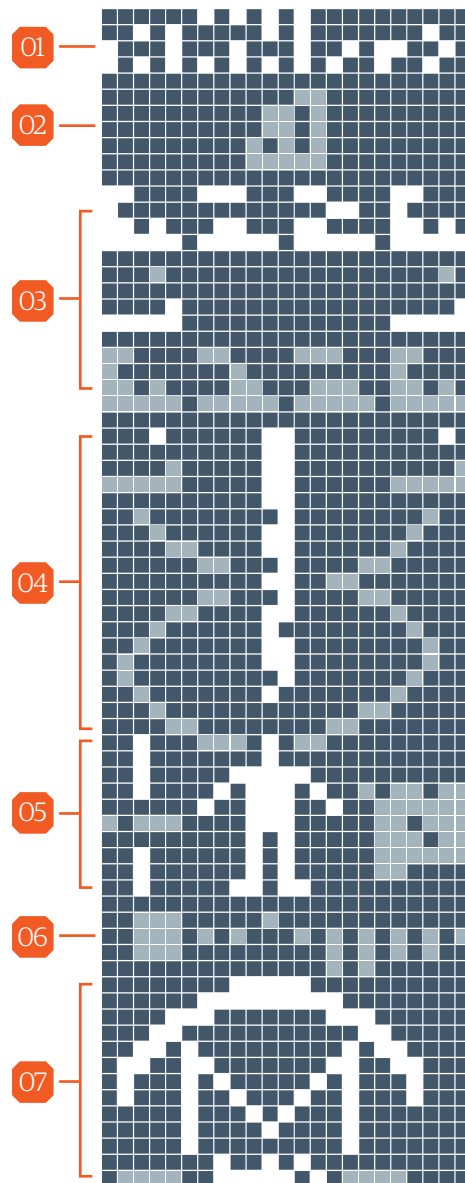
As senior astronomer at the SETI Institute in Mountain View, California, Dr Shostak is actively involved in the hunt for intelligent life. He is also a writer and hosts the *Big Picture Science* radio show.

Dr Jennifer Eigenbrode

Dr Eigenbrode is a biogeochemist at NASA who specialises in astrobiology. She's looking for signs of life in the smallest places, including looking for biosignatures in rocks and ice on Mars through the Curiosity rover.

The Arecibo message

On 16 November 1974, astronomers including Dr Frank Drake and Carl Sagan devised a message to send into the distant reaches of space. The message was intended to show the possibilities of communication with a potential intelligent race, rather than actually attempting to make contact.



1. Numbers

The numbers one to ten written in binary.

2. DNA

These represent the atomic numbers of the elements that make up DNA.

3. Formula

These are the formulas for the sugars and bases in DNA.

4. Double helix

A graphic of the double helix structure of DNA.

5. Population

A figure of a human and Earth's population.

6. Solar System

A graphic depicting the Solar System.

7. Dish

A graphic of the Arecibo dish and its dimensions.

Every month we hear of incredible new exoplanets in planetary systems seemingly like our own, and we learn more in the search for past or present microbial life as missions like Curiosity gain worldwide attention, but for some reason the notion that we might be just one intelligent race among many is yet to receive much support from the public at large.

Many people today still seem to have the same opinion that was prevalent in the mid to late 20th Century, that aliens are something that belong only to the realm of science fiction, but this is in the face of overwhelming evidence to the contrary. With every passing year, every new discovery of an exoplanet, every observation of frozen or liquid water on other bodies in the Solar System, it becomes harder and harder to argue that we are alone in our galaxy, let alone the entire universe.

In fact, it's a position that even notable astronomers are taking up. "We can't be the only instance of a race, we just can't be," said the late Sir Patrick Moore when talking to us in the fourth issue of **All About Space**, and he is joined by many others around the world who are coming around to the realisation that to think humanity is the only instance of intelligent life is implausible, ignorant and just plain naive.

For about half a century we have begun to seriously consider the possibility that we are not alone, and to prove this hypothesis scientists have focused on three areas of research, each equally capable of becoming the first to discover life outside of the confines of Earth. Throughout this feature we've spoken to the five most important people within these fields to find out what progress they're making in the search for life.

The first is the Search for Extraterrestrial Intelligence, or SETI, which is a privately funded

international endeavour to discover signals from an alien race drifting through the cosmos. Next is the search for exoplanets (worlds outside our Solar System), an area of research that has only gained credence in the last couple of decades. The field of planet hunting may be young, but it is already providing us with fascinating results that may soon help us find an exoplanet just like Earth. The final area of research is the search for microbial life, fossilised or alive, on other worlds inside our Solar System. Until now this has largely focused on Mars, but places like Europa and Titan could also prove fruitful to explore.

The oldest of the three areas of research is SETI, using antennas around the world to look for alien signals. In 1959, Giuseppe Cocconi and Philip Morrison, two physicists from Cornell University in the USA, suggested for the first time that it might be possible to communicate with another intelligent race among the stars using microwave radio. "The probability of success is difficult to estimate," they wrote in the journal *Nature*, "but if we never search, the chance of success is zero."

At around the same time a young radio astronomer named Frank Drake came to the same conclusion, and in the following year he used a 26-metre (85-foot) telescope in West Virginia, USA, to conduct the first search for alien signals outside our Solar System. He found nothing, but his research (including the Drake equation, which estimates that the chances of life elsewhere in the universe is almost a certainty) sparked an interest around the globe that remains prevalent to this day. It was in fact the Soviet Union in the Sixties that first dominated SETI, observing huge portions of the sky at once. They were sure that there would be many advanced civilisations emitting

"We can't be the only instance of a race, we just can't be" **Sir Patrick Moore**



The Arecibo Observatory in Puerto Rico



He'll be the person to know first

Dr Seth Shostak

How do you guys analyse incoming data at SETI?

The data analysis is all pretty automatic. Unless there's a signal that's looking very promising, and that only happens every couple of years, then you don't actually deal with the data processing. The algorithms in the software analyse them and do rather simple tests to try to prove if it's really ET, or if it's AT&T - interference from a telecommunications satellite or whatever.

Are there protocols in place for announcing the discovery of an alien signal?

We've been worrying about the protocols about what to do if we find a signal. We've rewritten them and they're all very nice in a nice little document, but the reality is that nobody's going to pay a whole lot of attention to protocols if we pick up a signal. And we know that because we've had false alarms, like in 1997 when for almost a day it looked like we had a signal that was the real deal. And did people stick to protocols and say, 'well, we've got to notify these people and those people?' No! None of that happened. It was completely chaotic, which it would be.

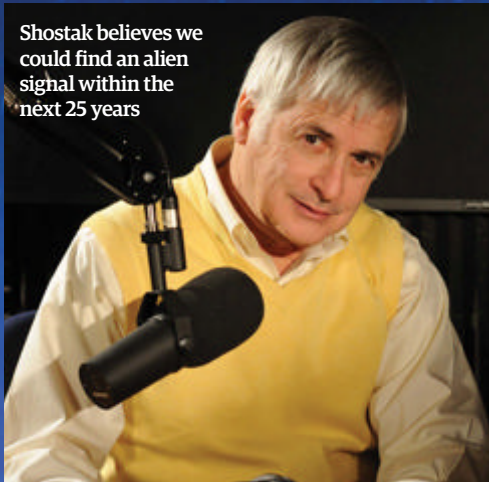
What's the next step after the discovery of a signal?

If you get a signal that looks like it might be ET on the line, the first thing you do is to spend an awful lot of effort trying to verify that, maybe several days. But in all that time while you're doing this there's no policy of secrecy, so lots of people know you've got an interesting signal. In 1997, when we had this promising signal there were no men in black, the government hadn't the slightest interest in any of it, but the media did and they started calling me up.

What happens next?

After that, every telescope in the world would be aimed in the direction of the signal to try to find out how far

Shostak believes we could find an alien signal within the next 25 years



away it is and whether there are planets there. Keep in mind that the instruments [being] used by SETI are not capable of [deciphering] messages. You're getting the bottle [signal] without the message in it, but at least you've got the bottle so you know that somebody's trying to say something.

What would become of SETI?

There would suddenly no longer be a fight to try to get enough money to keep doing the SETI experiment. There would be enough money to build much bigger instruments and go back and possibly find any message. I'm sure there would be a message there. I think that immediately SETI would be vaulted from sort of a backburner niche science experiment to something that many, many people were doing. That's exactly what happened with the discovery of planets around other stars. There were a couple of guys doing it in the world, and suddenly it became an industry. That's what would happen with SETI.

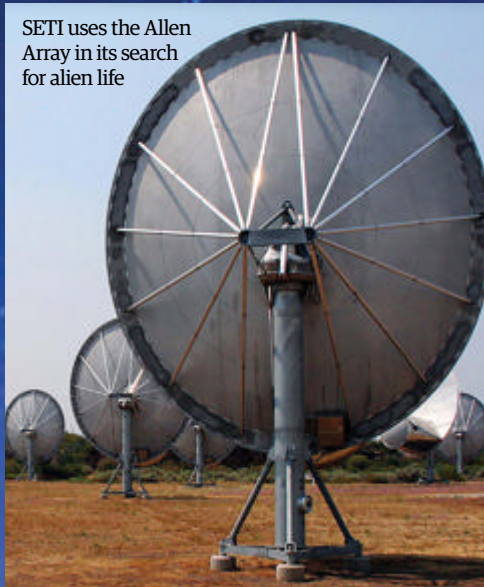
Would we understand the message?

My guess is they're likely to be hundreds of thousands of years, maybe more, beyond us. And for us to understand the information content of their transmissions is probably asking too much. But at least you'd know they were there, and that's really the idea, isn't it? You would know that what we have here on Earth is pretty nifty, but it's not a miracle.

Are you confident we'll find a signal?

I bet everyone here a cup of coffee that we'll find aliens within two dozen years.

SETI uses the Allen Array in its search for alien life



BIO

Dr Seth Shostak

Dr Shostak is the senior astronomer for the SETI Institute in Mountain View, California. He is actively involved in the hunt for alien signals. He is also a writer and hosts a weekly science radio show.

"In 1997, for almost a day it looked like we had a signal, that was the real deal"

The next great planet hunter

Dr John Mather

BIO

Dr John Mather

Dr Mather is a senior project scientist on the James Webb Space Telescope. He is also a senior astrophysicist in the Observational Cosmology Laboratory at NASA's Goddard Space Flight Center.

What's your role on the James Webb Space Telescope (JWST) project?

I'm the senior project scientist, which means that I work with the project management and engineering teams to define the mission requirements to make sure that they are correctly implemented, and with the scientific teams to make sure we have understood the scientific opportunities and their implications for what should be built to enable spectacular discoveries.

What work will you be doing in the coming years, and post launch in 2018?

I'll be continuing my role as senior project scientist to make sure our mission realises its potential. Post launch I anticipate writing observing proposals and working with colleagues to write up the results. I hope to be lucky and find something that's a great surprise.

How will JWST aid in the hunt for exoplanets?

We have two main ways. First, we look at planets directly with coronagraphs in three of the four instruments. Coronagraphs block out the direct starlight so we can look for planets orbiting nearby, which is primarily valuable for large and young planets. Second, we watch a star get fainter when a planet goes in front of or behind its star [which is known as 'transiting']. We can get amazing details about the planets and their atmospheres from this data.

The Kepler mission has given us thousands of candidate planets [using the transiting method] and they are all interesting. If we can get a really good target there is the possibility that we could find signs of water around a large

version of Earth, and then we would think such a planet could harbour life.

Could a separate star shade be flown near the James Webb Space Telescope to block out the light of distant stars and help find planets?

Yes, of course! Our team considered star shades in the very early days of conceiving the mission, but the technology was clearly not ready in 1996. Now, much work has been done by university groups and aerospace firms like Northrop Grumman and Lockheed Martin, and we know quite well how to design such a shade. In my opinion it could be done for a budget that would be worth the fabulous planet measurements that could be made. Either a star shade could be built to fly near to JWST, or a star shade could be made to work with a new telescope. Both are difficult but possible.

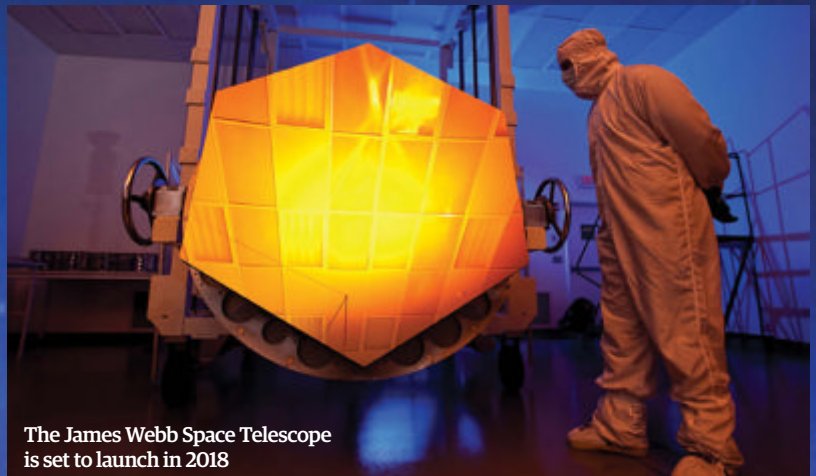
Do you think we'll find an Earth-replica before JWST launches in 2018?

Yes, I think the Kepler mission will find planets a lot like Earth, in the sense of being the right size and temperature, orbiting stars a lot like the Sun. But we probably won't know much about their properties, so we won't be able to say they are 'exactly' like Earth.

Do you think we will ever make contact with an intelligent alien race?

I don't think we will make contact with an intelligent extraterrestrial race any time soon. I think they exist but they are really hard to find and probably far away. On the other hand, I really do think it's worth trying! We already have technology that could send detectable signals across our whole galaxy, but it would only work if somebody on the other end knew how to receive them. Now our job is to guess how to eavesdrop on those other civilisations, if they exist.

"They exist but they are really hard to find and probably far away"



The James Webb Space Telescope is set to launch in 2018





Did he already make contact?

Dr Jerry Ehman

What are you working on at the moment?

I am retired. I enjoy bowling and golf and am involved in church activities. I unvolunteered from the Ohio State University Radio Observatory back in 2008, so I am no longer actively working much in SETI.

What were you doing at the time you discovered the Wow! signal?

I was a professor in Management Science at another university in Columbus, Ohio. I was also a volunteer at the Ohio State University Radio Observatory (OSURO).

What was the Wow! signal?

It was a strong narrowband signal from an unknown object. The distance to that object could not be determined.

Did you believe the Wow! signal was a sign of extraterrestrial intelligence?

Since all of the possibilities of a terrestrial origin have either been ruled out or seem improbable, and since the possibility of an extraterrestrial origin has not been able to be ruled out, I must conclude that an extraterrestrial intelligence *might* have sent the signal that we received as the Wow! source.

Where do you think it came from?

After some analysis and thought, it became quite obvious that this signal came from some object a large distance away from the Earth (well beyond the distance of the Moon).

Could we have learned more about the signal if more resources had been available?

At the time, personal computers didn't exist. If we had today's equipment, much more could have been learned. For example, it might have been possible to detect the modulation [information] components of the signal.

Do you think we'll detect a signal from an intelligent race in the coming years?

I'm certainly hopeful.

Will we ever contact alien life?

Contact is less likely than the detection of a signal, although I'm also hopeful that contact will occur some time in the next billion years or so.

Do you think life is out there?

Absolutely!



BIO

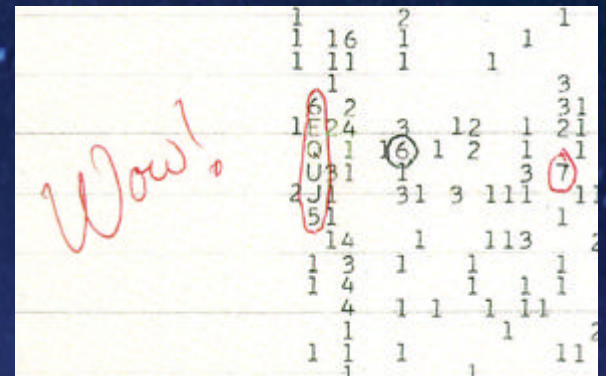
Dr Jerry Ehman

Dr Ehman, now retired, is an American astronomer. He holds a PhD in astronomy from the University of Michigan. In 1977, while working on the Big Ear radio telescope at the Ohio State University, he discovered the famous Wow! signal.



The Wow! signal

One of the most famous instances of the detection of possible alien life was a radio signal that has been dubbed the Wow! signal, owing to Jerry Ehman (above) circling the signal in excitement. Ehman discovered the signal on 15 August 1977 while working on a SETI project. The circled code, '6EQUJ5', indicated an increased intense signal that seemingly came out of nowhere.



huge amounts of power that would be easy to spot, but this was not so.

It was widely believed that SETI had a good chance of success, though, so in the Seventies NASA threw its hat into the ring. It established SETI programmes in California at its Ames Research Center in Mountain View and the Jet Propulsion Laboratory in Pasadena to look for signals around stars like our Sun or otherwise. In the mid-Nineties, however, funding was cut, and the SETI Institute was forced to go it alone.

SETI uses a number of antennas and arrays around the world, such as the Allen Telescope Array in California, to observe distant stars and discern whether they are emitting any artificial signals produced by an intelligent race. Within minutes of observing a star they have an answer, but to this day they have yet to find any conclusive evidence of extraterrestrial intelligence. Undeterred, workers at

SETI continue to search for signs of life, and they're extremely confident that they will find something.

To aid in SETI's study, the hunt for habitable exoplanets might allow us to find worlds where life could reasonably be thought to reside. Finding habitable exoplanets that SETI can study for signals is something that will prove of great importance. Of course, planet hunting itself is an area of astronomy that is not even two decades old - the first exoplanet was not discovered until 1995. But while planet hunting might still be in its infancy, the results we have obtained from just a handful of telescopes are astounding. NASA's Kepler space telescope, which launched from Cape Canaveral in March 2009, has found thousands of planet candidates in barely four years of operations, and some of these offer tantalising hints of being habitable.

But Kepler is looking at just a tiny portion of our giant Milky Way, which in turn is relatively

small in the grand scheme of the universe. Based on data from Kepler, astronomers at the Harvard-Smithsonian Center for Astrophysics estimated in January 2013 that there were at least 17 billion Earth-sized exoplanets in the Milky Way. That's not a typo; billion, not million. Consider that there are about 100 billion galaxies in the known universe, and things start to get really exciting. Is it really possible that, out of 1.7 trillion trillion potential planets in the 13.7 billion-year-old universe only one, Earth, had the necessary conditions to produce intelligent life? Many leading scientists believe this to be unlikely.

Kepler, however, can only reveal very basic data about an exoplanet, including its size, mass and orbit. Future telescopes, like NASA's James Webb Space Telescope, will allow us to study these planets in even more detail. This giant space observatory, which will launch in 2018, might be able to directly image exoplanets and even reveal the composition of



Dr Eigenbrode believes that if alien life exists beyond Earth it is most likely microbial

Looking for life in small places

Dr Jennifer Eigenbrode

What's your role at NASA?

I am a research scientist at NASA Goddard Space Flight Center. My studies focus on understanding the sources, alteration, and preservation of organic molecules in geological materials on Earth and Mars. I am a participating scientist on the Mars Science Laboratory [Curiosity] and a collaborator for the Sample Analysis at Mars [SAM] instrument suite that can detect organics in Gale Crater sediments.

Do you think we'll find evidence of past or present life on Mars?

I think Mars may have harboured life in the past. The conditions of Mars 3.5 billion years ago were probably similar to the conditions of Earth. Both were likely habitable. If past life did exist on Mars, then there should be a record of it in the sediments. If life didn't exist on Mars, we may expect to find meteoritic or geological organic matter. Hopefully, we'll find preserved organics in the surface sediments at Gale Crater where the MSL rover is exploring. Exploration by the ESA/NASA ExoMars rover [due to land in 2018] and the NASA Mars 2020 rover will be valuable in furthering our understanding of organic preservation on Mars.

Where else could we find organics in the Solar System?

Today, we find evidence of organics in interstellar gas particles, meteorites, comets and in some planetary atmospheres [such as methane on Mars and Titan]. There is every reason to suspect that organics have

been distributed all over the Solar System. What we do not understand is what has happened to these organics since their initial distribution. What processes have altered them? Has life tapped their carbon and energy to support extraterrestrial ecosystems?

Do you think the Allan Hills 84001 meteorite contained fossilised life?

It was the publication of the suspected microfossils in this Martian meteorite that energised the field of exobiology [now astrobiology]. As much as I wanted to believe 84001 contained Martian microfossils, I was never convinced.

Will we find more complex forms of life in the Solar System?

If life exists elsewhere in the Solar System, it is most likely microbial in nature. Micro-organisms and the communities that they form can be complex, but I do not think that macro-organisms or intelligent life evolved in the Solar System. Micro-organisms can harbour and manipulate small niches on planets. Larger organisms need a larger environment for support. Most environments we have observed beyond Earth do not seem conducive to supporting the physics and chemistry of macro-life forms.

What future astrobiological missions could be of most interest?

Of all the places for us to explore for possible past or present extraterrestrial life, Mars offers our best opportunity to find it. It's close and the environments are similar enough to Earth's that we can figure out how to best explore them. Exploring extremely unfamiliar environments is equally important to astrobiology. Venus, Titan, Europa and other bodies in the Solar System have conditions that are so different from Earth's that they challenge us to think outside of the box, which will also provide us with an observational baseline for exoplanet comparison.

Which do you think will be first to find signs of extraterrestrial life: robotic exploration, planet hunting or signal detection (SETI)?

I think robotic exploration poses our best chance of observing signs of extraterrestrial life since most life beyond Earth is probably microbial, if it exists.



BIO

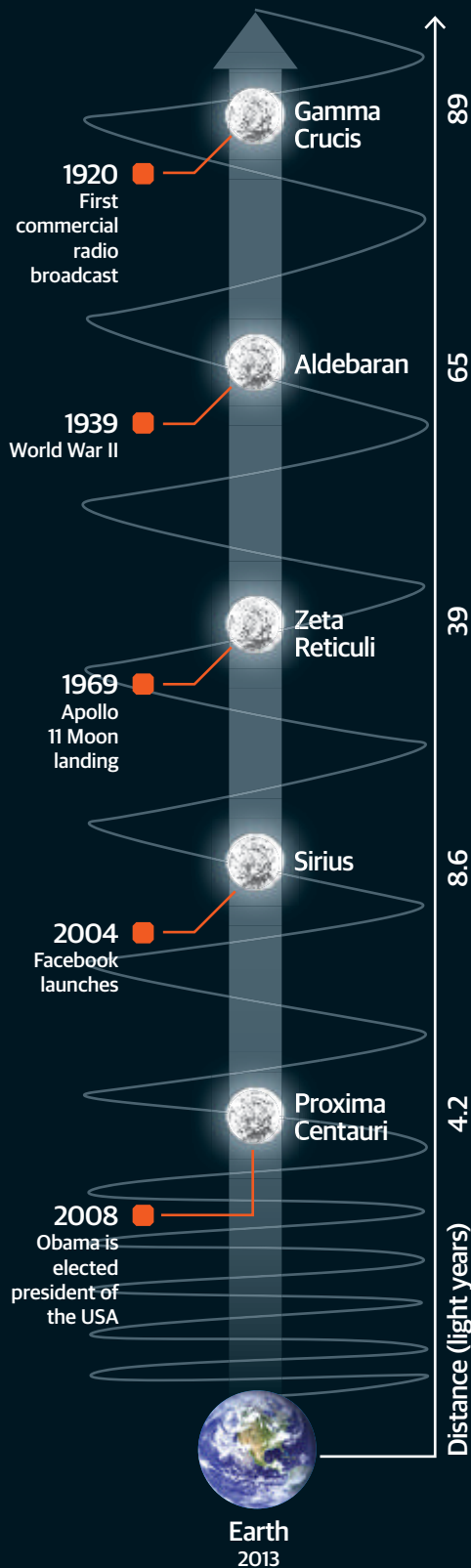
Dr Jennifer Eigenbrode

Dr Eigenbrode is a research scientist at NASA Goddard Space Flight Center, who specialises in astrobiology. She is also a participating scientist on the Mars Science Laboratory mission.

"Robotic exploration poses our best chance of observing signs of extraterrestrial life"

Interstellar broadcasts

For the past 100 years we've been broadcasting our position to the rest of the galaxy, but how far have our signals actually reached?



Search for life



Is anyone out there?
We've been sending out signals for just 100 years, so only life within a circle 200 light years in diameter around Earth would hear us.

their atmosphere, a vital clue in discerning whether they are habitable or not. Groundbreaking research into the possibility of measuring the atmospheres of exoplanets for signs of methane, oxygen and other elements, or even looking for signs of artificial lights (just as we can see the Earth at night from space) will bring us closer to finding alien civilisations.

While we're searching for alien life, however, could it be possible that other extraterrestrial races are also doing the same thing? We've been broadcasting our position, both intentionally and unintentionally, by emitting radio waves for about a century. If anyone is within 100 light years of Earth, they will be able to hear us. In fact, in 1974 we sent out something called the Arecibo message, a broadcast of radio waves that, for the first time, contained data about humanity that could be interpreted by an alien race and understood to be a call from our civilisation to theirs. It's not inconceivable to think that other races might have done the same thing; maybe there are thousands of Arecibo messages streaming through the galaxy, but we just haven't come across one yet.

With all this talk of exoplanets, habitable worlds and aliens, however, you might be forgiven for having one question burning in your mind; if there really is intelligent life out there, then where is everyone? You're not alone in thinking this. Way back in 1950, astrophysicist Enrico Fermi asked this very question, which became known as the Fermi paradox. He argued that because the galaxy isn't teeming with spacecraft, or that we've never been sent a message from aliens, then either interstellar travel must be impossible (therefore dashing our hopes of ever exploring the galaxy) or we are the only intelligent civilisation in the universe.

There are a number of explanations as to why this is so, but the most plausible relates to the history of a planet like Earth. Our planet is 4.6 billion years old, but only in the last several hundred million years has it been inhabited by sophisticated organisms. Only in the last several thousand years has intelligent and sentient life, namely humans, made its mark on the globe. And only in the past one hundred years have we seriously begun observing and exploring the cosmos, and also sending out signals of our own. Humanity won't be around forever; an extinction event, either natural or man-made, could cut short

Have we already found life?

There have been several instances where controversial evidence suggested that we may have already found life elsewhere in the universe



Allan Hills 84001

In Antarctica on 27 December 1984, a team of American scientists found a meteorite named Allan Hills 84001 (ALH 84001) that shot to fame 12 years later when it was announced that it might contain microscopic fossils of Martian bacteria. However, no conclusive evidence could prove whether this was so.



The Viking probes

In 1976, NASA landed two probes on Mars, Viking 1 and 2, which had instruments to perform biological experiments on the surface. Controversy surrounded the results; early indications suggested they'd found evidence of organic compounds, but some claimed that the nature of the experiment, which heated soil samples, would have destroyed organics, suggesting the results were erroneous.

Translating an alien language

Dr John Elliott

What work do you do for SETI?

My contributions in the academic side are in being able to understand the structures in the signal if we receive one. There's been at least one occasion where I've looked at a signal, just to see if there's any structure in there. So if they pick something up, I'll be looking at the content to see if there's anything in there that denotes intelligence, any sort of linguistic phenomena or imagery or anything with structure that's actually conveying information.

How confident are you that you could decipher the message?

It obviously all depends on the amount of content you've got. If it was just a short burst, like the Wow! signal, then you're up against it. But if it was someone on the other end broadcasting an encyclopedia, then you've got a great chance of deciphering it. And if there's a crib [key] attached to it then you've got some way to unlock it or decipher it. If it's something very simple but with enough information then you could start to pick it apart and be able to have a good guess at what they are saying like "hello", "we are here", this sort of thing.

Would you respond to their message?

The flip side of all this is message construction. Because of the nature of the deciphering side I'm sort of one of the main people that deals with the message

construction because one is relevant to the other.

Constructing a message is a big debate for SETI, it splits us down the centre. Should we send a message back? Many of us, me included, are in the camp that, yes, for God's sake, they're going to be huge distances away from us, let's just try to communicate!

What would we say to them?

The obvious thing is to copy what they've sent back to them with something of our own included. There are some people that send messages [without consent] anyway. People are sending messages purposefully out from Earth, and that's an issue. While we are debating whether to send a message, some people are already sending them. You'll end up in the hands of amateurs there if you don't watch it.

Will we ever find a signal?

Yes. There's a huge universe, at least ten to the power of 21 stars out there, and there's at least that number of planets. We've only just started searching the sky. Our ability to listen to the universe is exponentially growing. There are so many planets out there in habitable regions that, just through the power of measuring probability, life has got to be out there. I can't think of a sensible argument that would say it isn't. I wouldn't mind putting money on it, although I might not be around by the time they find it! But I think they will.



BIO

Dr John Elliott

Dr Elliott is a Reader in Intelligence Engineering at Leeds Metropolitan University in the UK. He has been involved with SETI since 1999, and his research includes the post detection decipherment of an extraterrestrial signal.



"I'll be looking at the content to see if there's anything in there that denotes intelligence"



Get involved with SETI

If you're interested in becoming an alien hunter, then there's never been a better time to get involved with the SETI Institute. Head over to the website at www.seti.org to find out more.

You can also sign up for SETI@Home, a piece of software that runs in the background on your computer and makes use of processing power that is otherwise unused.

our ambitions to continue exploring. That would mean that an intelligent civilisation has only a brief period to make a mark in the lifetime of their planet. If we're going to find one, we're going to need to continue our extensive search, as it may be that every habitable planet has only a comparatively brief window in which intelligent life thrives.

However, searching for intelligent extraterrestrial life isn't the only hunt currently on the go. As mentioned earlier, our robotic exploration of the Solar System is looking at the possibility of microbial life residing on the surface of Mars, or perhaps one of the potentially habitable moons such as Europa, Ganymede or Titan. From landers to orbiters to probes, we've barely scratched the surface of the secrets some of the other destinations in our Solar System might be hiding.

In the mid-Seventies, NASA conducted the first astrobiology experiment outside of Earth, sending its Viking 1 and 2 landers to Mars to dig into the soil and look for signs of past or present life on the Red Planet. The results proved to be inconclusive but they sparked a hunger to learn more; right now, the Curiosity rover is making its way across the

Martian surface to answer the very same question. And even here on Earth, research is proving useful. We've found life in the deepest, darkest and coldest places, whether it's at the bottom of a frozen lake or in highly acidic environments. Research like this could help us to one day look for life on frozen worlds like Europa or liquid-bearing places like Titan. In this regard, astrobiologists are hopeful of one day discovering microbial life.

Therefore, in our continued hunt to prove that Earth is just one world where life has made a mark in the universe, it will be down to the work of various people around the globe to make the vital discoveries that could indicate the presence of intelligent or basic life elsewhere. Whether it's experts at NASA working on a high-profile, next-generation planet-hunting machine such as the James Webb Space Telescope, or it's the valiant workers who are looking for signals outside of our Solar System at SETI, or even the astrobiologists searching for bacteria on another world, these dedicated people will continue to work towards finding alien life. They are convinced we are not alone in this universe and they aim to prove it, one way or another. ●