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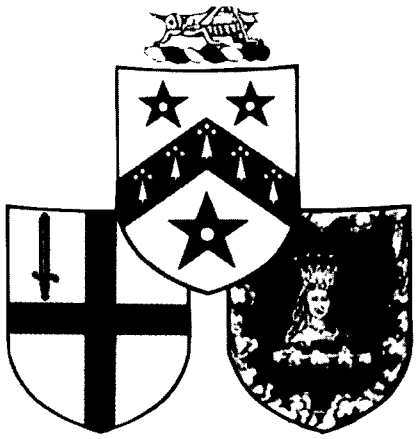

IS THERE ANYBODY OUT THERE?

A Lecture by

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GRESHAM COLLEGE

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IS THERE ANYBODY OUT THERE?

Professor Heather Couper

Some of you who've been with me all the way through my Gresham series of lectures will remember the theme: the 'top twenty' questions I'm asked about the Universe. Well, the timetabling of lectures means that I can only do 18 - but let's not haggle over figures: *this* question is undoubtedly the most profound of all. And that is why I have left it until last.

Is there anybody there?

It has to be the most tantalising unanswered question there is. Everyone seems to have a fascination with the existence (or otherwise) of life in the Universe. If we are not alone, what are the aliens like? Are they vastly more advanced than us? What would happen if we made contact? Or, if we *are* alone, what are the implications? Are we then the sole protectors of an entire Universe?

One, very visible, section of the earthling community has no problem at all in coping with ET. The media have been dishing out aliens like there's no tomorrow ever since they realised their commercial potential. Daleks, Tripods, ET himself, The Alien, CP30, R2D2... not to mention movies like 'Independence Day'. You could be forgiven for believing that aliens are just around the corner.

Take a straw poll of ordinary people and you'll find overwhelming support for the existence of extraterrestrial life - something like 75% in favour. It's almost as if we *want* to believe in aliens - or perhaps it's because we can't face up to being alone.

But where is the evidence? For the next part of the talk, I'll be presenting a series of arguments, seen through the eyes of an optimist (O), and a pessimist (P). Although the answers that come out will be at opposite extremes, it will give you an idea as to just how uncertain we are! Let's kick off with our optimist:

O: Just look at the diversity of life on Earth alone. Life here has been incredibly successful. From amoebae to elephant seals, pansies to people, dinosaurs to dachshunds, bacteria to bantam hens ... need I say more? If life has evolved into so many different forms on one small planet, this argues for even more variety when it comes to life elsewhere in the Universe.

P: Hang on. You're confusing outward appearances with real diversity. Split up a pea or a parrot into its basic constituents, and you'd get exactly the same thing. Cells. Absolutely identical cells, with identical structure. So there's no real diversity, except in the *arrangement* of cells caused by evolution. You're just looking at variations on a theme.

O: OK - let's widen the argument to another planet - Mars. Recently, there's been the fantastic news that a couple of rocks blasted out of the planet by a huge impact - and which ultimately landed on Earth - contain microfossils. This is amazing. It means that if life started off independently on two planets within one Solar System, then it could be ten-a-penny throughout the cosmos.

P: Not everyone agrees with the analysis - some of the chemistry isn't that different from what you would expect to happen in the *absence* of life. And there certainly isn't life on Mars now. Remember the Viking probes of 20 years ago? These NASA spacecraft landed on Mars' surface and actually tested soil samples for signs of life - without success. They found that Mars, which doesn't have an ozone layer, is drenched in uv radiation from the Sun. Not a pleasant place to be...

0: But I bet you life will get a hold in places like that, even if it has to go underground. After all, there are much more extreme places in our Solar System where the raw materials of life have been detected. Such as on the surfaces of the moons Europa, Titan and Triton, way out in the frozen wastes of the Solar System. And we even discovered organic - potentially life-creating - compounds on Halley's Comet, a frozen snowball that occasionally visits us from those outer limits. Some astronomers think comets like Halley even seeded the Earth with life...

P: You're using the word 'organic' very cleverly there. 'Organic' just means 'containing carbon' - it doesn't imply 'life-bearing'. Basically, you're talking chemical goo, but there's a world of difference between goo and intelligent life.

At this point, the optimist and the pessimist agree to suspend hostilities and look for another way ahead. So far, they realise, they have only contemplated whether or not there might be life in the Solar System - which is a very tiny part of the Universe. But nearly 40 years ago, a young astronomer called Frank Drake - who was very much ahead of his time - was ready to take on the Universe. He was one of a new breed of radio astronomers, using a large dish at Green Bank, West Virginia, to collect radiowaves from objects far out in space. But he also figured that he could use his dish 'in reverse' to transmit signals. That set him pondering. If *he* could transmit signals, might there be other beings out there who were doing the same?

He quickly did some back-of-the-envelope calculations. The aliens would only need a dish a little larger than Drake's to be able to transmit a powerful signal across dozens of light years. But how many of them would be transmitting? How likely was it that Drake would pick up an alien, as opposed to natural, radio signal?

This next stage needed very careful thought, and the conclusions are enshrined today in a string of terms known as 'The Drake Equation'. Drake basically needed to work out how many technologically-advanced civilisations with communication ability there are *now* in our Galaxy. I'm sorry it's a mouthful, but there are sound reasons for all these caveats. An intelligent civilisation alone isn't any good: it needs to have technology in order to broadcast across the Galaxy, and it needs to exist now to be able to give out signals. Here is the Drake Equation:

$$N = R_* f_p n_e f_l f_i f_c L$$

N is the number of communicating, technological civilisations which exist *now*

R_* is the mean annual rate of star formation

f_p is the fraction of stars with planets

n_e is the average number of planets in a system having conditions suitable for life

f_l is the fraction of planets on which life actually develops

f_i is the fraction of these on which intelligent life develops

f_c is the fraction of those planets on which the capacity for interstellar communication develops

L is the average lifetime of such a civilisation

The Drake Equation starts with a certainty - the number of stars born each year in our Galaxy - and then becomes a series of 'what ifs?'. How many of those stars will have planets? Of those with planets, how many will have one at just the right distance from its parent star for life to be possible? Even if there is a suitable planet there, on how many will life actually start? And if life *does* develop, in how many cases will it become intelligent? And even if there is intelligent life, will it necessarily be motivated to broadcast? Finally, what is the average lifetime of such a civilisation from the moment it develops broadcast technology? If civilisations last only a few years before destroying themselves through their newly-emerging technology, we won't stand much chance of detecting one.

So, each term depends on the answer you guess for the one before it. Usually, the 'fractional' terms are represented as probabilities: for instance 0.1 means there's a 1 in 10 chance, while 1 means that it will happen in all cases. By multiplying up all the terms on the right-hand side of the Drake Equation, you get N - the number of alien broadcasters who are around at this present time.

The problem with the Drake equation is that the values for most of the terms are informed guesses - and depend a lot on whether you are an optimist or a pessimist about the likelihood of life. So, let's go over again to our optimist and pessimist, and see how they argue the toss here. We'll take the right-hand side of the equation term-by-term.

R_*
Eureka! O and P are agreed, because this is a measurable quantity. The rate of star formation in our Galaxy is 10 stars per year.

f_p : O
Of course all stars have planets. They're part and parcel of starbirth - just a by-product. And you can hardly argue against me after all the discoveries in the past year. The present tally is now seven or eight planets around nearby stars - I'm only hedging my bets because some of these could be 'missing links' between planets and stars called 'brown dwarfs' - but *they're* pretty important too. My answer is 1.

f_p: P
I certainly *can* argue against you. Seven or eight planets - that's hardly overwhelming when you consider that there are 200 billion stars in our Galaxy. And the planets that have been detected (indirectly, by the pull on their parent star) are huge beasts like Jupiter, which you wouldn't expect to harbour life. But I'll be generous and give an answer of 0.1 meaning that 1 in 10 stars has planets.

n_e: O
The 'green belt' in our Solar System, where temperatures are suitable for life to exist, extends from Venus to Mars, taking in Earth on the way. So there are *three* planets in our Sun's habitable zone - and we have evidence that life got started on two of them, even though it probably later got snuffed out on Mars. What more do you want? My answer has to be 1 - meaning that there will always be a planet in any planetary system's green belt.

n_e: P
Of course, you're not admitting that Mars and Venus, stuck out at the edges of the green belt, have some rather life-threatening disadvantages. Close in to the Sun, with a massive carbon dioxide atmosphere, Venus has suffered a runaway Greenhouse Effect. If you'd like to end up as a Sunday roast, that's up to you ... And Mars, frozen on the outskirts, has a planet-wide ozone hole. Even the Earth's climate isn't stable - we've had major ice ages, and in the 17th century, a 'mini' ice-age that seems to have been triggered by the Sun's weather. I think you'd be very lucky with a 10% chance of getting a planet in the green belt - but I'll go with 0.1.

f_l : O
Once you've got a site for life, sure as the Sun rises each day, life will arise. It all started incredibly quickly on the Earth, within a billion years of our planet's formation. The raw materials of life - complex molecules buried deep in clouds of dust and gas where stars are born - are common throughout space. And a classic experiment by Stanley Miller and Harold Urey in the 1950s showed that, when you have an assemblage of 'goo' - as you've been known to call it - you can turn it into life at the drop of a hat. In a lab flask, Miller and Urey simulated the primitive constituents of the Earth's oceans, and overnight, passed electric sparks through the mixture - to simulate the young Earth's lightning discharges. Et voila! In the morning, their flask contained amino acids - the building-blocks of life. So my answer, once again, is 1.

f_l: P
You conveniently forget to mention that not many scientists support the results of the Miller-Urey experiment these days, because we now know a lot more about the chemical make-up of the early Earth. And amino acids being the building blocks of life? Fine - if you regard a grain of sand as being a major building block of a house. Really! Life is far more organized and complex than the way you present it. An amino acid is just a tiny, tiny part of the incredibly convoluted molecule DNA, which acts as life's major chemical controller. The odds of a few amino acids and a few other chemicals spontaneously coming together to form DNA are billions to one against. But I'll be generous and say that there's a 1 in 10 chance of life forming if the conditions are right.

f_i: O
Intelligent life is bound to develop! Look at the Earth: we have *two* highly intelligent species just to kick off with - the primates and the ceteceans. Oh, and I guess I ought to mention that homo sapiens is in there too. Did you know that for a significant period in the development of Man, dolphins were believed to be more intelligent. Sometimes, I wonder if they still are ... Anyway, a score of 1 all round.

f_i: P
(Shows slide of Heather pulling Patrick Moore's braces.) Call *that* intelligent? M'lud, I rest my case. 1 in 10.

For reasons that will become apparent, O and P swap their order of appearance for the next exchange of words ...

f_c: P
To someone as loquacious - sorry, eloquent - as you, it might seem amazing that some species might not want to communicate, even though they have developed intelligence. Like the Chinese, for example - a contemplative civilisation, as are many of the eastern religions. Communication *isn't* a natural consequence of intelligence - so I'll bank on the chances of it happening as being 0.1.

f_c: O
(Shows slide of rocket taking off.) Yes, it's a rocket. A *Chinese* rocket. You can't tell me the Chinese don't want to communicate - they're already doing so. In our market-driven western culture, everyone *needs* to. Communication is bound to happen in the end. So - another 1.

L: O
And I strongly believe that, with global communication, you lessen the chances of destroying yourselves with your own nuclear technology. My belief is that, if you can get over the first hundred years of a technological existence, you'll have cracked it. I would say that a technological civilisation can last for a million years, before it changes into something so utterly different that you cannot locate its roots.

L: P
We've been a communicating, technological civilisation for about 60 years now, and during that time there have been some pretty close near-misses with the finger on the red button. What was that you were saying about 100 years?

So where does that get us?

For O: N = 10x1x1x1x1x1x1,000,000 = 10 million civilisations

For P: N = 10x.1x.1x.1x.1x.1x100 = 0.01 - one hundredth of a civilisation in our Galaxy. In other words, we don't exist!

Here, we've pushed the Drake Equation to its extremes - but it demonstrates that, even with the best-informed estimates, we still don't know how common life is likely to be in the Universe. And here we'll let our optimist and pessimist shake hands and agree to differ - because they've proved the point.

Frank Drake himself was (and still is) an optimist. He'd hoped to find a signal shortly after commencing the first-ever radio search - which he called 'Project Ozma' after the princess from the mythical Land of Oz - in 1960. Signals he certainly got - but not from extraterrestrial intelligence. It was the height of the Cold War, and the airwaves were buzzing with secret signals from military intelligence. Drake had some heart-stopping moments, but no alien messages.

News of Drake's search spread to other astronomers, who began looking for themselves. A new discipline of astronomy - SETI (the Search for Extraterrestrial Intelligence) - was born. The longest-running SETI search, begun 20 years ago by Bob Dixon of Ohio State University, uses a huge rectangular radio telescope, nicknamed Big Ear, sited incongruously in the middle

of a golf course. In 1977, Dixon's team picked up the most powerful unidentified transmission ever found. It was so strong that a technician, seeing it on the chart recorder, circled it in red and scrawled 'Wow!' in the margin. Many times afterwards, Dixon scanned the sky in the position where the Wow! signal had appeared, but to no avail. And sadly, Dixon's entire project may now be coming to an end. Developers have bought the golf course, and have planning permission to demolish Big Ear and build houses on the site. So much for widening our cosmic frontiers ...

Another search which hit the headlines is being conducted by Paul Horowitz at Harvard. After the film *ET*, Horowitz had the cheek to write to its director, Steven Spielberg, to see if he'd put his money where his mouth is and help fund *his* SETI project. The approach worked, and Spielberg himself flicked the switch to open 'Project META' (for 'Million-channel Extraterrestrial Assay'). Horowitz's new search is capable of tuning into billions of 'extraterrestrial radio stations' simultaneously - hence its name BETA - which takes some of the guesswork out of anticipating which frequencies 'they' might be broadcasting on. Even so, Horowitz too has had no success. He points to the heart of his detector - stack upon stack of circuit-boards packed with microchips - and admits ruefully: "This is the biggest garbage collector in the Universe and it's getting fuller every day".

For thirty years, the SETI community battled on in their search, vastly under-funded and frequently ridiculed for their out-of-this-world vision. But a powerful subset of them lobbied hard to get NASA funding - and in 1992, they were granted $100 million for a ten-year search (compare this with the average space shuttle launch, which costs $1 billion).

NASA was well aware that to be seen to be spending money on a search for aliens was not going to be popular in some quarters - especially amongst those who might seek to make political capital out of it. Instead of calling the project the SETI program, it was code named HRMS - the High Resolution Microwave Survey.

Unfortunately, the ruse didn't work. Just a year after it started, HRMS was dead - killed off by Richard Bryan, a senator from Nevada. He complained that the search was a waste of taxpayers' money. "Not a single Martian has said 'take me to your leader', and not a single flying saucer has applied for F.A.A. approval", he claimed. An editorial in the prestigious *Boston Globe* newspaper dryly commented: "The question is not just whether there is intelligent life in space; it is whether there is intelligent life in Washington".

But the SETI researchers fought back. They created a new centre - the SETI Institute, near San Francisco - and successfully lobbied for millions of dollars'-worth of private funding. 'Project Phoenix' arose out of the ashes.

Over the past three years, Project Phoenix - in the shape of a container-box bristling with electronics - has travelled the world from Australia to the Arecibo Radio Telescope on Puerto Rico, and is just starting a more-or-less permanent residency at Green Bank, West Virginia (coincidentally where Frank Drake started out). Like Paul Horowitz's BETA system, it is capable of tuning into billions of radio channels at once, and boasts powerful pattern-recognition software to distinguish an alien message from random noise or interference. This was designed by Kent Cullers - a remarkable young astrophysicist who has been blind since birth.

Like its predecessors, though, Project Phoenix has still not come up with the goods. The SETI researchers are beginning to worry, because time is running out. Every day, radio interference on our own planet increases as more and more of us get on board the electronic revolution. Mobile phones, microwave cookers, the explosion in communications - soon our own environment will hum so loudly with radio noise that we will never hear the faint whisper from ET.

Of course, there could be another reason why we have not yet picked up an extraterrestrial message. It's just possible that most aliens don't bother to broadcast to the cosmos - after all, *we* are hardly making great efforts in that direction. However, we have made one deliberate attempt to communicate, although it was more symbolic than serious. In 1974, when the wire mesh dish of the giant 305-metre Arecibo Radio Telescope was re-surfaced, the astronomers working there - headed up by Frank Drake - decided to celebrate with a re-dedication ceremony.

They came up with an audacious plan: to use the dish in reverse to broadcast a message to the stars. The message was a stream of on-off commands which, if arranged into a rectangle, would show a picture. This revealed, among other things, our number system, the molecules that make up life, the structure of DNA, the position of the Earth in the Solar System, and even a self-portrait of the radio telescope that sent it. It was beamed towards a cluster of about a million stars 25,000 light years away - which means that if ET is in when the message comes, we can expect a return call in 50,000 years!

We have also advertised our presence on board spacecraft - the cosmic equivalent of sending a message in a bottle. The first was in the form of a plaque on the sides of the Pioneer 10 and 11 space probes, which flew past Jupiter and Saturn before heading out of the Solar System. Like the Arecibo message, the plaque contained the usual diagrams showing the location of the Earth and the structure of matter. But there was a controversial extra: outlines of a male and female human - both naked. Small-town America erupted in consternation at such nudity, and accused NASA of 'using taxpayers' money to send smut into space'. And as if that wasn't enough, feminist groups complained that the female was too submissive - only the man's hand was raised in greeting.

When NASA launched Voyagers 1 and 2, its next probes to explore the outer Solar System, it was more circumspect in the messages it sent. Both space probes carry an old-fashioned long-playing record (complete with stylus!), encoded with both sound and pictures. The tricky question of human reproduction is handled by playing the sound of a kiss, followed by a baby crying!

The odds against aliens finding any of these probes are astronomical. The messages are more a reflection on how we see ourselves fitting into the Universe, and an experiment in alien communication, than a real attempt to bring ourselves to ET's notice. Nevertheless, some people are uneasy about us drawing any attention to the Earth. They claim that, if alien life discovered the human race, it would do what many superior civilisations do to those they consider inferior - eradicate us. There are some who argue that, if the SETI researchers ever do receive a message, we should never respond, lest we draw attention to ourselves.

But for those who would argue that we should maintain silence, it is too late. If aliens exist, they almost certainly know that we are here. John Billingham, one of the pioneer SETI researchers, points out: "We have been transmitting radio - and now TV - signals from this

planet in their untold millions every day for the last 40, 50, 60 years with increasing strength. Going out from the Earth in an ever-expanding sphere are all the powerful transmissions of the 40s, 50s, 60s, 70s and 80s. Those have already passed the nearby stars - and if there are civilisations out there, they will already have discovered us".

Who knows who - or rather, what - is tuning in?

(The text for this transcript has been updated from March 1996 to incorporate the new discoveries of planets around other stars and the possibility of microfossils from Mars.)