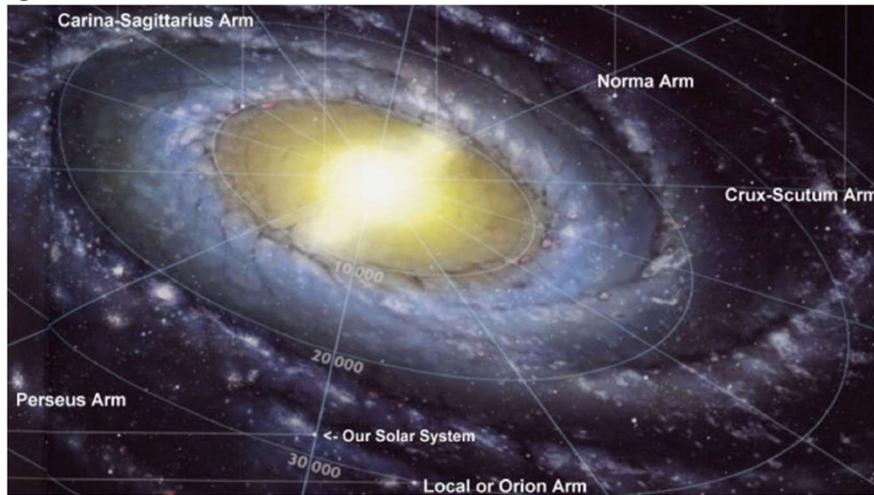


## Main Event – The Search for Life in the Universe by Professor Charles Cockell

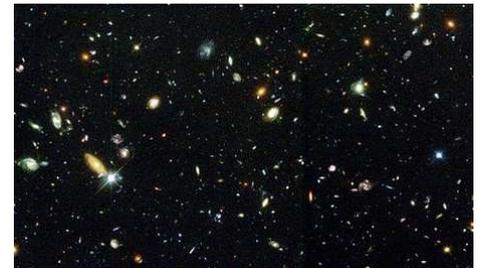
Charles Cockell is Professor of Astrobiology at the University of Edinburgh and director of the UK Centre for Astrobiology, which he established in 2011.. He has worked at NASA and the British Antarctic Survey. He has published over 300 scientific papers as well as numerous books.

Charles asked the society members, what he feels is, one of the most interesting questions in astronomy: “Are we alone in the universe?” It is felt that we are now close to having an answer to this fundamental question. It doesn't matter what the answer is, it is terrifying either way. If we are not alone, what kind of life is out there? Simple bacterial life or intelligent life? If the later, would we ever be able to communicate with it. If we are alone, many other questions need to be asked such as, “Why have we spent the last 40,000 years building a civilisation if there is no one to communicate with?” Living in a lonely universe makes us think about what we are going to do with our own civilisation and our long-term purpose in the universe. This question forces us to confront some of the most fundamental aspects of our society and our place in the cosmos. To discover whether life exists elsewhere is through space missions and science.



Our Milky Way (artist's impression left contains perhaps 150 billion stars; we are just one situated in the Orion Arm of our spiral Galaxy about two thirds of the way from the galactic centre. (Bottom of image).

We know our universe contains very many galaxies (below)– every single bright dot is a galaxy in the Hubble Deep Field view and each galaxy contains about 150 billion to 200 billion stars. Our universe is

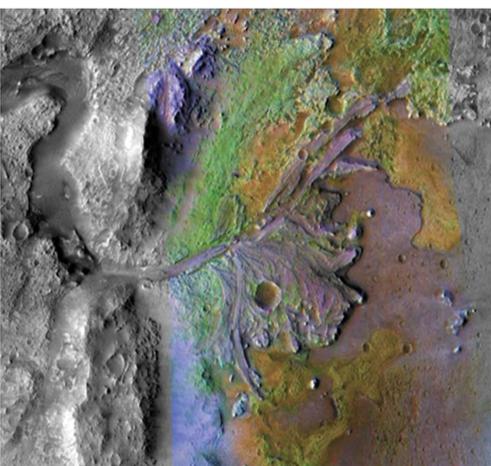


thought to have about 200 billion galaxies, each containing one – two billion stars so it seems reasonable to assume we are not the only planet with life.

This question has occurred many times over the centuries. Metrodorus of Chios was an ancient Greek who said “It would be strange if a single ear of corn grew in a large plain, or there were only one habitable world in the

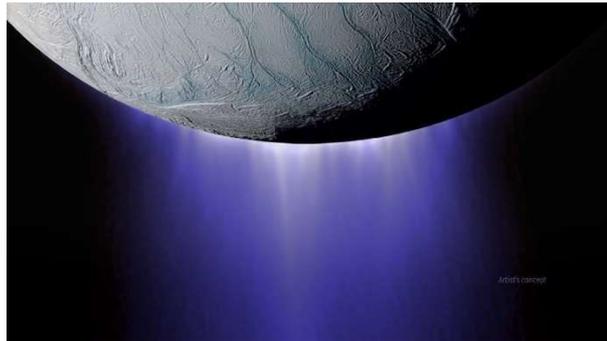
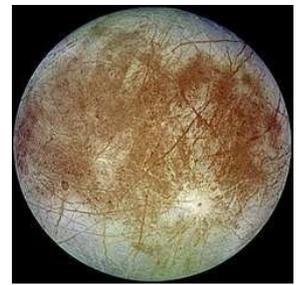
infinite”. Using the same argument; if Earth has life surely there must be lots of other planets with life around. Metrodorus shows that people had grasped our place in the universe 2 ½ thousand years ago.

The most likely life in the universe is bacterial, and bacteria makes up most of the life on Earth with many living in extreme environments, e.g. Prismatic Lake (right) in Yellowstone Park is a hot (90°C) volcanic pool, surrounded by life in the form of different coloured microbial mats eating the minerals formed from the volcanic hot springs. They have been doing this for 3 ½ to 4 billion years.



It was long thought there would be life on Mars but we have since discovered that it is a desert world with no water and is bombarded with radiation. However, there is a lot of evidence to suggest that 4 billion years ago, Mars was more similar to Earth with seas and rivers. If the amount of water that Mars was thought to have was poured over the red planet it can be seen there was a northern basin and many of the craters contained water. There are many images showing what appears to be rivers crossing Mars and we know water flowed in them because this has been confirmed by orbiters like Mars Express that have identified minerals associated with water. Jezero crater (left) shows a river that ends in a delta. The blue and green show volcanic rock but the brown colours indicate clay which can only have been laid down in water suggesting water remained here for millions of years.

20 years ago, we would never have considered looking for life on icy moons in the solar system but what we have since found leads us to suspect life could exist in these frigid places. One of Jupiter's moons, Europa (right), is about the size of our Moon, has very few craters (which indicates a young surface) and has a covering of ice through which salt and organic materials have been squeezed through cracks to lie on the surface as brown streaks. There are iceberg features that suggest the surface has broken up and moved around. It is now known that Europa has a salty ocean that has about twice the amount of water that is contained in all the oceans on Earth. The question is, "does Europa's ocean contain life?" Prof Cockell is currently involved in a mission to land on the surface of Europa in 2034.

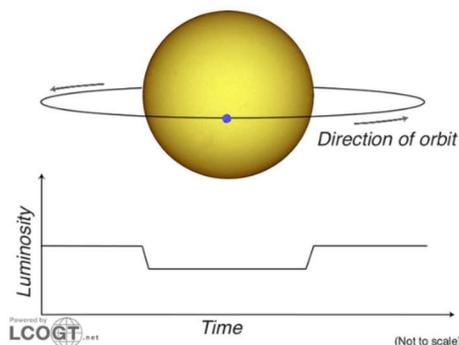


The Cassini spacecraft exploring the Saturnian system discovered that a tiny moon called Enceladus (less than the size of Britain) has water vapour erupting from the 'tiger stripes' (fractures) at its south pole. Heated rock deep within Enceladus melts the ice forming an internal ocean which is pressurised and then escapes as water vapour. The spectrometer on Cassini found organic carbon in the water which is exciting for astrobiologists as these are the ingredients for life. NASA is considering a mission to fly through the plumes, collect the water vapour and molecules and return it to Earth.

Not only do we have Mars and the icy moons as places where life may have occurred but we can now look at extrasolar planets. With a Galaxy of 150 billion or so stars, there must be other planets so the question is, are there any Earth-like worlds? The hunt for a second Earth, where water is present and conditions are suitable for life, is now on. Again, 20 years ago, the idea that we could look for life on extrasolar planets would have seemed astonishing but in the next five to ten years we should have an answer to whether life exists elsewhere in our Galaxy.

We find exoplanets by the transit method (left) or the radial velocity method (doppler shift due to stellar wobble – right) and we have even found habitable worlds orbiting multiple star systems where the inhabitants would

## Exoplanet Transit

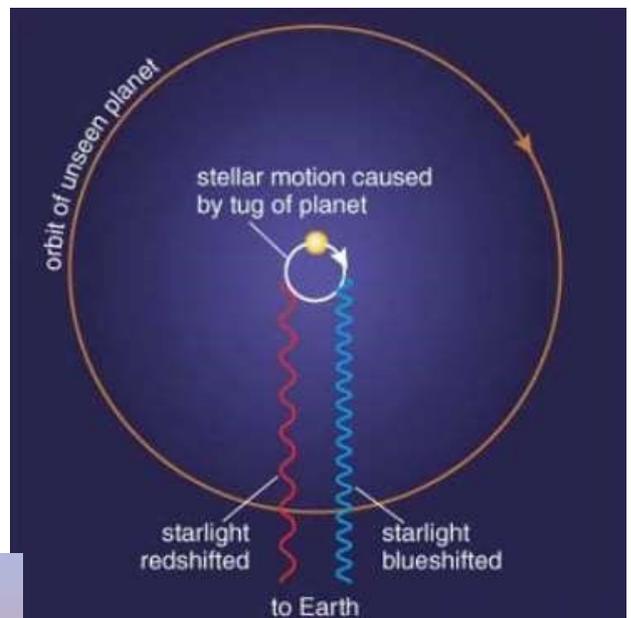


multiple star systems where the inhabitants would

see two or three sunsets. Yet, long before these discoveries were made, writers of Star Wars had already imagined a planet with a moon called Tatooine where two sunsets could be seen; at the time this was considered radical science fiction. It seems that Earth is quite mundane with just one



Kepler has found lots of exoplanets we are interested in those found in the habitable zone (Goldilocks zone) where liquid water can be stable on the surface of a planet. Too close to the star and it will be too hot like Venus, too far from the star and it will be too cold like Mars.

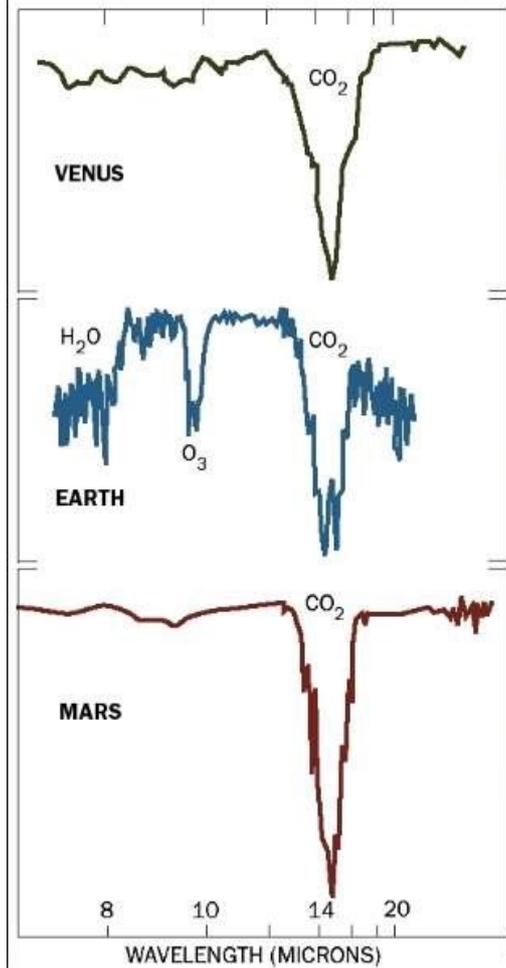


the Sun! but



Many rocky exoplanets have now been found in the habitable zone around their stars since the first confirmed one, Kepler 20 2b, which was discovered 6 or 7 years ago. We are now concentrating on whether these exoplanets might

have any biology. The number of habitable planets in our Milky Way is vast and one estimation alone is 8.8 billion but do any have life or is Earth the only one?



How do we look for life on exoplanets? One way, is to look at the atmospheric gases using spectroscopy. This diagram (left) shows Venus, Earth and Mars. Both Venus and Mars have noticeable carbon dioxide indicating atmospheres predominantly of this gas. Earth also has carbon dioxide but also present is water, which suggests it either has a lot of water clouds or a lot of water is present on its surface. In addition, there is ozone (O<sub>3</sub>) which indicates there must be a lot of oxygen in the atmosphere and this implies there must be photosynthesis. There is no known way of making a lot of oxygen other than life. A lack of an oxygen spectrum doesn't mean no life as it could just be in a low abundance.

In the next five to ten years, telescopes will allow us to look at the spectrum of an atmosphere of an exoplanet which means the answer to the question of life in our Galaxy is very close. Over the coming decades we will expand the search to look for life in other galaxies.

Prof Cockell finished with the iconic picture of Saturn where Earth can be seen as a tiny blue dot (arrow) and he pointed out we were all in the picture.

Returning the question of whether we are alone in the universe, it is likely we will be able to answer it within the next 20 years. Hopefully it will help to advance the state of our own society and perhaps even use it as an instrument of social reform.

