Other Solar Systems.

Towards the end of 2007, a significant announcement was made in the search for 'extrasolar planets' - those being found around stars far beyond our own solar system. It was confirmed that a system of five planets had been found, in orbit around a star not too many light years away. More importantly, the most recently discovered planet in this system is in orbit within the star's 'habitable zone', the first such discovery. Temperatures in that region would allow the presence of any surface water to be maintained, thereby bringing the possibility of favourable conditions for the development of life as we know it.

It was thought at one time that our solar system was probably a rare occurrence, that the existence of planets around other stars was very unlikely. The formation of planets, in the case of our Sun, was thought to have been caused perhaps by a passing star's gravitational effects, coming too close to the Sun and drawing out material which then formed into planets. However, because individual stars are so far apart, it now seems improbable that another star would come close enough for this to happen. Instead, the preferred theory is that our system of orbiting planets could have been produced as the Sun formed, contracting and leaving behind rings of material which then evolved into planets, and the formation of moons in many cases.

The first evidence of planets beyond our solar system came in 1992, not from a normal star but with the study of radio wave pulses from a pulsar - the small, rapidly spinning remains of a star after a supernova explosion. Variations in the pulses indicated that there were several planetary objects in orbit around the pulsar.

The announcement of the first definite evidence of a planet in orbit around a normal star came in 1995. About fifty light years away in the constellation of Pegasus, the star 51 Pegasi had been at first eliminated from the search for planets because it was classified as being of a type much older than our Sun. When it was then found that the classification was an error, and that the star was virtually identical to the Sun, astronomers working with the University of Geneva made further investigations and confirmed that the star had a slight and regular wobble effect, evidently caused by an unseen companion.

Because the stars are so far away, even the largest of present telescopes are unable to see the comparatively dim light reflected from any planet at such a distance. Valuable information can be obtained, however, by using a spectroscope to analyse light waves. The Doppler effect, more familiar to us when an approaching sound drops in pitch as it passes by, is used in astronomy when light waves are seen to be shifted towards the blue or red ends of the spectrum as an object comes closer to us or retreats. By measuring these small regular movements of a star, in the case of gravitational effects caused by a planet, astronomers can discover the mass and approximate orbit of the companion object. In the case of 51 Pegasi, analysis of the measurements indicated this first evidence of a planet orbiting another star, and that the object would have to be a large gas planet to produce the effects seen. The surprise was that the planet had a very short, close orbit of just four days. In comparison, our own gas planets are in the outer part of the solar system, with Jupiter and Saturn having orbits of many years.

By the end of 2002, the existence of more than a hundred extrasolar planets had been identified, with an increasing rate of discovery. Many stars are known to have more than one planet, identified from the more complex gravitational movements than would be caused by

just a single planet. Large gas planets are the most easily identifiable ones, until larger telescopes and better techniques are available.

There is also now the possibility of identifying planets as they transit across a parent star. This method uses CCD images, measuring small changes in light intensity, and the slight dip in star brightness during the transit. Of the stars with evidence of planets found so far, less than ten per cent of these planets have orbital planes allowing transits to be detected. In recent cases, however, the faint glow from a transiting planet has also made it possible for the first time to analyse the atmosphere from its light spectrum, and this is reported to include evidence of chemicals contributing to the building blocks of life. In December 2006, the French National Space Agency (CNES) launched its Corot space telescope to search for transiting planets, the first such telescope to be used in the hunt for extrasolar planets, or 'exoplanets' as they have also become known.

The search and success rate of significant discoveries accelerated in 2007. The first Earth-mass planet, having the lowest mass of all those so far found, was located in orbit around the star Gliese 581.
This is one of the hundred closest stars, about twenty light years away in the constellation of Libra. Measurements obtained by the European Southern Observatory in Chile indicated that the planet is slightly larger than Earth, and may have a solid surface. The planet has a short period orbit of 13 days, but this seems to be partly within the habitable zone - because the star in this case is a relatively cool red dwarf, reducing the temperature on such a nearby planet. The possibilities for the detection of life came closer in 2007, with an announcement from the USA that water vapour had been detected in an extrasolar planet's atmosphere. The NASA Spitzer space telescope identified water in the infrared signal from a planet as it passed close to the parent star.

Much of the success in identifying the existence of extrasolar planets has been achieved by a team led by Professor Geoff Marcy at the University of California, using the Lick Observatory near San Francisco. The team has been responsible for discovering evidence for most of the extrasolar planets so far known, which had reached a total of more than 250 by the end of 2007.

Another key astronomer in the search has been Dr Debra Fischer, of San Francisco State University, who was very much involved in the latest discoveries in the system of planets around the star 55 Cancri, working in collaboration with Professor Marcy, and also using the Keck telescope in Hawaii. The additional planet found in the now five planet system is the first one known to be keeping an orbit entirely within a star's habitable zone.

It has taken many years, however, to reach this point in tracking down a planetary system which is being described as a near twin to our own solar system. The first planet identified in orbit around this particular star was announced in 1996. Analysis of the measurements obtained detected another two planets in 2002, and another in 2004, before the announcement in November 2007 of yet another planet - this time in the habitable zone.

The outermost planet in the system has been identified as a gas giant, at a similar distance as Jupiter is in our own system, but several times larger. Three of the other planets are in close orbits around the star, while the habitable zone planet has an orbit of 260 days, and is located in a position similar to that of Venus in our system. The star 55 Cancri also has the importance of being Sun-like, slightly less luminous but of nearly the same age and mass, and

is at a distance of 41 light years. The constellation of Cancer is one of the less obvious ones, but is found between Gemini and Leo, and with this particular star just visible to the naked eye.

Present technology, even using the largest telescopes with adaptive optics to steady the image coming through the atmosphere, and space telescopes, still do not allow any extrasolar planets to be seen directly by astronomers, so everything depends on the precise measurement of gravitational effects and what can be learned from that. The exception at present is the possibility of observing the effects of transiting planets.

Almost all of the planets found so far are of the gas giant type, which have the more easily detectable effects on the parent star. This also applies in the case of the five planet system, where the presence of at least one other planet is also suspected. It has been pointed out that our own gas giant Jupiter has many rocky type moons around it, and there is no reason to suppose that the same does not apply in the case of the extrasolar planets. A large gas planet orbiting within a star's habitable zone could have suitable conditions for life on any of that planet's moons.

Looking more into the future, more than 200 suitable Sun-like stars have already been identified for further studies. In examining these stars, any Earth-like planets identified will also be targeted by a new radio telescope to be built by the University of California, Berkeley, in conjunction with the SETI Institute - the Search for Extraterrestrial Intelligence, which has the aim of identifying intelligent signals.

Before long there should be more visible evidence of extrasolar planets. Much larger telescopes are to be built, and it is hoped that it will then be possible to begin observing some of the larger planets, and detecting more Earth-sized planets, which must be far more common than previously realized. The European Space Agency is due to launch a group of space telescopes, working together to produce far better images than anything which can be obtained at present. This will be using infrared technology in the search for life, and is the suitably named Darwin project, at present being planned.

Two of the essential components for the evolution of life are known to be water and oxygen. Apart from the recent identification of water vapour in an extrasolar planet's atmosphere, water has also been detected elsewhere in space - notably in the Orion nebula, where protoplanetary discs have been observed, apparently in the process of formation. Oxygen is a product of plant life, and it seems that this component for life as we know it cannot be maintained in any atmosphere for an extended period of time - unless there is a source of regeneration.

When the presence of oxygen is detected in an extrasolar planet's atmosphere, it will be a good indication that life of some kind may exist there.
It will be impossible at present to consider visiting such planets at these great distances, even to the nearest stars, but it will be reassuring to know that other solar systems really do exist, and that extraterrestrial life may also be confirmed in the not too distant future.

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