MACARTHUR ASTRONOMICAL SOCIETY Inc.

Journal

PRIME FOCUS

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President's Report

It Happens Tonight

Welcome to all members and guests. Tonight it gives me great pleasure to introduce to you Ben Pawlutschenko. Ben is the observations officer for the NSW Astronomical Society and is an experienced solar observer. He also has built is own observatory complete with a 16" telescope - all this resides in his back yard.

For the talk tonight Ben will share his knowledge about that big glowing ball in the sky, our friend Sol. Ben's talk will include topics such as the nature of sunspots, characteristics of the Sun and coronal mass ejections. He is also keen to engage us on why it is important to observe the Sun and the scientific purpose behind such observations. I am sure that everyone will make Ben feel most welcome.

Last month

I cannot recall a time previously when we showed a video at a meeting, well except for my brief encounter with fame. John Rombi said that the documentary he saw on the research and construction of the Martian rovers was fascinating, and I agree.

It was very interesting and amazing to think that these two golf kart sized rovers are currently doing the rounds on the red planet.

The Gremlins

A spanner in the works, disregard the forest date of 27/03/04 as mentioned in last months Prime Focus. No night is planned at the forest for that night, however some of us may go to The Oaks. See John Rombi.

The Correct Dates

20/03/04	The Forest
27/03/04	The Oaks (maybe)
17/04/04	The Forest (unconfirmed)
19/04/04	Annual General Meeting
24/04/04	The Oaks
15/05/04	The Forest (unconfirmed)

Phone 0410 445 041 my number or contact John to make sure the above nights are on, as poor weather may decide if we venture out or not

We have to wait on our insurance to come through before confirming the forest nights. The renewal forms have already be sent to the Community Underwriting Agency.

Just Quickly

Fees are due so if you could please pay tonight or next month at the very latest. After that you risk becoming become unfinancial. Also nominations for committee positions must be in the hands of the Secretary by 5th April - you will find nomination forms near the sign-on book.

Both myself and John Rombi have now touched base with Dr Ragbir Bhathal. University commitments out at the Nepean campus on Monday nights make it difficult for Ragbir to join us for a meeting. However during discussions we have been informed that the observatory functions will now be handled by a newly formed committee titled "Friends of the Observatory".

We have scant detail at the moment but will keep the membership informed of developments when they come to hand. John has agreed to act as my liaison with the uni at the moment as I am working on a rather exciting project for the Society, which I have called "the Nimbus 2004"

Please enjoy your stargazing. At time of writing things have been a tad bit wet but we really need the rain

Regards
Noel Sharpe (President) ■

Book Review by Ian Cook

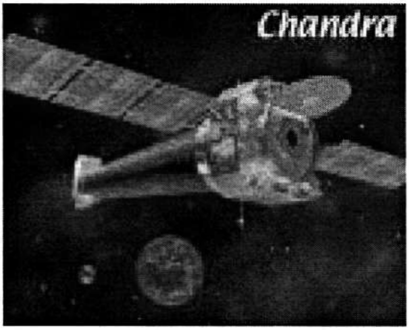
"The Restless Universe Understanding X-Ray Astronomy in the age of Chandra and Newton"
by Eric Schlegel

I started this book not knowing a thing about X-ray astronomy and found the terminology and ideas a real challenge to understand. However the author really knows his subject, and teaches what you need to know simply and thoroughly. By the end I was reading eagerly to discover the next stage, and the pages turned at an easy rate.

This is an informative survey of the history and development of X-Ray space missions from 1980 to 2002. Schlegel worked on the Chandra project for seven years during the building and launch phases.

He begins by introducing three X-ray satellite observatories, two of which are flying and one that was destroyed during an expensive launch failure. Readers learn about the kind of locations or objects where X-rays may be found and why things such as brightness, luminosity and arrival times are so important in X-ray observations.

One of the most fascinating parts of the book was about detecting x-rays by grazing mirrors in the Chandra and Newton observatories. Matters like spatial resolution, pixel size and the use of spectroscopy and what it tells us about atomic structure are thoroughly covered. There is an explanation of what future research needs to be done and a consideration of the costs and resources which may be needed.



The last chapter looks ten years down the track to describe what future satellites are needed to produce finer detail and let us see broader structure to unlock the secrets of active galaxies, black holes and neutron stars. Some are already on the drawing board and Schlegel says which ones will probably get launched and why.

I must confess that when I took it from the library I was prepared to read maybe the first three chapters before being overwhelmed by detail and lack of interest. However, I was pleasantly surprised at how much I learned and got excited about, and how readable the book turned out to be.

For a brief but readable introduction to X-ray objects and their detection, I recommend –

"The Restless Universe"
Oxford University Press 2002 163 pages
Extensive notes to the text, good bibliography.
Campbelltown Library – 522.6863

Chandrasekhar – the Man

Subrahmanyan Chandrasekhar was born in India on 19th October 1910 and received his B.A. at Madras University. At the University of Cambridge he earned his Ph.D. and developed the theory of white dwarf stars, showing that quantum mechanical degeneracy pressure cannot stabilize a massive star. He worked at the University of Chicago and its Yerkes Observatory from 1937-1995.

He won the **Nobel prize for Physics** in 1983.

He investigated and wrote important books on stellar structure and evolution, dynamical properties of star clusters and galaxies, radiative transfer of energy, hydrodynamic and hydromagnetic stability, the stability of ellipsoidal figures of equilibrium, and the mathematical theory of black holes. He also worked in relativistic astrophysics, and his last book was *Newton's Principia for the Common Reader.* He edited the *Astrophysical Journal* for nearly twenty years. He was known for his love of mathematical beauty and precision. He died on 21st August 1995.

RB

The following article by John is an excellent (but unplanned) segue from Ian's article above. It's amazing how these things just happen. (Ed)

The Sun as an X-Ray Source

J Casey 17/1/04

In 1901, the first major demonstration of wireless transmission took place. This was by the Italian born inventor Guglielmo Marconi. He transmitted a wireless message over a distance of 2700 km, transmitting from Cornwell, England, to Newfoundland, Canada. No one could explain, at the time, how the radio waves managed to reach their destination, well below the horizon,[and well out of line of sight, due to the curvature of the Earth].

Then, independently, the Englishman Oliver Heaviside, and an American, Arthur Kennelly, suggested that the radio waves bounced off a reflective layer in the Earth's upper atmosphere. However, for this to happen, the atoms in the upper atmosphere would have to be ionized - stripped of some of their electrons.

The source of the radiation that would be needed to do this was not known - but it was most likely to be the Sun - but no one was aware of sufficiently energetic radiation that could cause this effect. Radio communications developed in spite of the lack of understanding of the mechanisms involved in long range communications. US naval ships needed long range radio communications, so in 1923 the Naval Research Laboratory was set up in Washington DC. In 1938, Edward Hulburt, after research at this establishment, proposed that X-rays from the Sun were responsible for the Earth's ionosphere. Further work showed that the Sun **was** a source of X-rays, but that it was a weak emitter, and if it was typical of other stars, then there would be no possibility of measuring the X-rays from other stars from Earth due to the huge distances involved, and the diminishing signal strength, which varied as the inverse square law.

The solar corona also defied exact interpretation - until 1942, at which time it was realised that beneath the Sun's visible surface, [with a temperature of 6000°K], nuclear reactions were taking place at temperatures of over a million degrees. At these temperatures X-rays would certainly be emitted. However, in spite of the high temperatures and the X-ray fluxes present at the core, the total X-ray intensity at the surface of the sun was still low. This was confirmed in 1962, when the first rocket born X-ray detector payload was launched. It was then thought that X-ray astronomy would have little promise, and no other X-ray sources besides the Sun would be found, as other stars are too far away.

John Casey ■

What IC this Month
March 15 – April 18, 2004

Overhead at 8.30 pm
Constellations: Orion, Gemini, Monoceros, Canis Minor, Cancer, Hydra and Leo in the north. Looking south: Centaurus, Crux, Carina, Vela, Canis Major, Eridanus and Lepus.
The Earth is at Autumn equinox on 20/3

The Moon Diary
22/3 New Moon
29/3 First Quarter
05/4 Full Moon
12/4 Last Quarter
19/4 New Moon

Evening Sky Planets:

Mercury rises in Pisces 19° from the Sun and will set ¾ hour after sunset. This is the highest in the evening sky it will get. After a close encounter with the crescent moon on 22/3 it will plunge to the horizon again to pass in front of the Sun on 17/4 and return to the late April morning sky.

Venus will set between 8.30 and 8.00 pm over this next month. It rises in Taurus where it will stay all through April. On 24/3 a thin crescent Moon will pass nearby before Venus reaches its highest point in the sky on the 30/3 where it will be exactly 90° from the Sun and look like a ¼ Moon in a telescope. A red orange filter helps the view. On 3rd-4th April Venus parades past the Seven Sisters (the Pleiades M45).

Mars leads Venus to the Pleiades in Taurus on the 20/3 and will stay in this vicinity all April. During this month Mars will set between 9.15 – 8.30 pm and will have close encounter with crescent moon on 25/3.

Saturn remains in Gemini midway between Castor and Betelgeuse. It sets between midnight in March and 10 pm in April with a quarter moon passing below on 28/3.

Jupiter is past opposition on 4th March but remains large and bright dominating the mid evening sky. Some good view can be had of the cloud bands and dance of the moons.

A rare triple shadow event will occur on the 28/3 when at sunset Io, Ganymede and Callisto will cast shadows on the planet at the same time. The Callisto shadow will leave the planet disk very soon after sunset and we will not see it. However the moon Ganymede itself will leave the face at 7.05pm and the shadow at 7.47. Io will leave the face at 7.14pm and its shadow at 9.23. There will not be another triple shadow event till 2045.

On 2nd-3rd April a full moon will be close up to Jupiter.

Morning Sky:
Neptune rises in Capricornus about midnight to 2am with **Uranus** following about 1 hour 45 mins behind in Aquarius.

Comets:
Expectations are high that **C/2001 Q4** in Tucana will brighten to 6th magnitude or even 3rd during April as it moves through Pictor and Puppis.

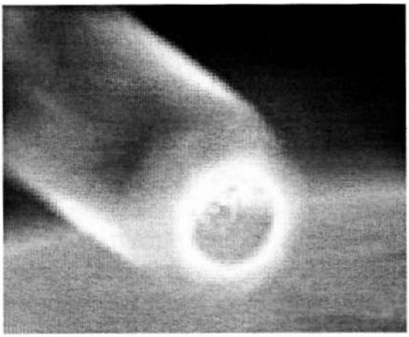
C/2002 T7 should rise from the pre-dawn horizon in Pisces around mid April. It also is expected to brighten to 5th or 4th magnitude, which would make it naked eye. It might be worth getting up early to give it a try. On 17-18 April a crescent moon will be within 10°.

There are no bright **Meteor showers** till late April.

Good seeing IC

How Did Navigators Hit Their Precise Landing Target on Mars?

Anyone who's been blindfolded and spun around knows how hard it is to "pin the tail on the donkey," even though players are pointed in the right direction when they last look at their target. To land in a precise location on Mars after travelling over 480 million km, navigators at the Jet Propulsion Laboratory (JPL) had to overcome the head-spinning challenges of calculating the exact speeds of a rotating Earth, a rotating Mars, and a rotating spacecraft, while they all simultaneously are spinning in their own radical orbits around the Sun.



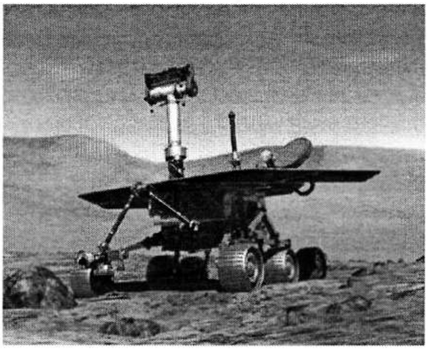
All the hard work paid off January 3 when navigators hit their target at the top of the Martian atmosphere to within about 200 meters, setting a new standard for navigation accuracy for all future interplanetary missions. "The trajectory was so perfect that not only was it within 200 meters, we also didn't need to adjust course in the final eight days of cruise," said Dr. Michael Watkins, navigation and mission design manager at JPL.

Navigators cancelled two trajectory correction manoeuvres that were scheduled to correct the flight path by firing a series of small engine thrusters. The navigation team researched the exact performance of the engine thrusters to a tiny fraction of a millimetre per second to ensure flawless aiming for the four previous manoeuvres. "The Mars Exploration Rover spacecraft design team helped our ability to navigate precisely in the sense that they created a dynamically quiet spacecraft. Spirit didn't thrust much during prior trajectory manoeuvres because the spacecraft was spinning for stability, and when it did thrust, it did so in a way that was easy for navigators to predict movement," said Watkins. Spacecraft thruster firings are a significant effect navigators have to deal with, but even the seemingly insignificant solar radiation pressure and thermal radiation forces acting on the spacecraft to a level equal to less than a billionth of the acceleration of gravity one feels on the Earth need to be taken into account. Without knowing the acceleration error to that degree, the spacecraft would have moved off course by 3.7 km over 10 days.

"We had to know everything from how the iron molten lava in the centre of the Earth was churning to how plate tectonic movements were affecting the wobble of the Earth to how the plasma in the atmosphere delayed the radio signals to and from the Deep Space Network stations," explained Dr. Louis D'Amario, Mars Exploration Rover navigation team chief. "We assembled the best navigation team in the world with experts in orbit determination, propulsive manoeuvre design, and entry, descent, and landing trajectory analysis," said D'Amario. The navigation team has been working extremely hard on this mission for three years - they even sacrificed their holidays this December and New Year's Eve, and they have essentially worked around the clock for the last two weeks.

Navigators use radio signals sent and received by the Deep Space Network (DSN) antennas on Earth to compute spacecraft position and velocity. Three DSN sites are roughly equally spread around Earth's globe at 120-degree intervals, so that antennas are pointed toward Mars at any given time as the Earth turns. If the exact location of any of these antennas is incorrect by just 5 centimetres on the surface of Earth, that maths error builds over the 150 million kilometres distance between Earth and Mars, creating a 460 metre location error at Mars. So hitting a precise landing site target that is scientifically interesting on Mars is impossible unless the calculations of how fast Earth is rotating on its own axis is known to the timing of 0.2 milliseconds. At the other end of the journey, navigators must also know the location of Mars to the level of accuracy of several hundred metres. Using recent measurements with Mars Global Surveyor and Mars Odyssey, navigators know the location of Mars relative to the Earth to 800 metres or less.

The navigation team's intense attention to detail was focused on ensuring that this mission would be the most accurately navigated in history. Navigators ran up to 1,000 different location accuracy solutions several times every day to cover the full range of possible answers. The navigation team also used a tongue-tying tracking technique called spacecraft-quasar delta differential one-way range or DDOR (pronounced "Delta Door"), which utilized their knowledge of locations of quasars to a few billionths of a degree to help locate the spacecraft's motion in the "up or down" direction in the sky. "Even though it was seemingly impossible to reach the small science-rich landing site inside Gusev Crater, the dedicated navigation team hit the bulls-eye tonight to put us in position for a winning science mission," Watkins said. ■



More Life Out There
John Casey 17/1/2004

In the previous article on "Life Out There", the basic requirements for life on Earth was discussed. This article goes one step further, to speculate on what life on another planet in another solar system might look like, and how it might develop there. These speculations are not without scientific basis, however. Observations of the development of early life on the blue planet- Earth show by example from millions of species which characteristics endure and which fade away. So our journey to life out there begins at the beginning of life on Earth for the lessons it teaches.

Genesis Of Life On Earth

Life on Earth began about 3.2 billion years ago, about 1.5 billion years after the major rock components of Earth solidified. This Proterozoic era [**protero-**"very first", **-zoic**,""life"] covers nearly half of the total history of the Earth, and extends from the earliest appearance of cells through to the development of animal phyla at the beginning of the Paleozoic era. The very first cellular organisms were prokaryotic heterotrophs which had similar form and function as modern bacteria. They reproduced by simple division into identical cells, and the variations that took place were the result of mutations, most probably caused by cosmic rays or radioactive decay. Their energy source was the "organic soup" of carbon containing molecules that had accumulated in the oceans from natural, non-life chemical processes that occurred over millions of years. The seas contained only one third the salinity of today.

The early Earth atmosphere contained hydrogen, methane, ammonia, nitrogen, water vapour, a large amount of carbon dioxide, and many hydrogen rich compounds- but no free oxygen. Without oxygen in the atmosphere there could be no ozone in the upper atmosphere to absorb the strong UV from incoming sunlight. Life could not exist in the atmosphere, or on the land surfaces exposed to such disruptive radiation so it is no coincidence that life would develop in the seas that filtered out this harmful UV light. The seas accumulated the chemical cocktail brewed in the atmosphere, as well as on land - [carried to the seas via the deluge rains that would have resulted from high ambient temperatures of the time.]

Man Made Synthesis of Life Precursors

The first definitive experiments to demonstrate the feasibility of prebiotic organic synthesis was performed by Stanley Miller in 1952. He passed spark discharges through an atmosphere of hydrogen, methane, ammonia and water vapour to simulate lightning strikes, and after one week the water within the glass vessel he used was found to have a variety of amino acids and other organic compounds. The reducing atmosphere made these chemicals stable, and encouraged further polymerisation reactions that would indeed form a rich "organic soup" for life to utilise as food. Some later experiments even showed that the chemical adenosine triphosphate could be formed this way.

The Energy Source Powering Life on Earth

Adenosine Triphosphate [ATP] is an essential chemical used universally by life on Earth as the energy source of choice for synthesis of cells. It is a high energy phosphate that releases a large amount of energy to the cell when it hydrolyses in water. This process is utilised in cells to power all their energy requiring reactions, such as the building of protein, or the contraction of a muscle fibre. ATP is also used in the reverse reactions, where sugars that plants synthesised with ATP and sunlight are broken down again in a respiration cycle that produces ATP once again.

Drawing Energy from the Sun

A major development for life on Earth was the photosynthesis of ATP directly from sunlight. This first occurred about 2 billion years ago as some bacteria began to use light energy to break down hydrogen sulphide into sulphur, then utilised the hydrogen to form new chemical compounds. The big breakthrough occurred when some of these bacteria, through mutations, altered the chemistry used and began to break down water instead. These bacteria used the hydrogen, but discarded the poisonous oxygen gas also formed.

These bacteria were somewhat like blue-green algae of today, and their efforts gradually, over millions of years, overcame the reducing atmosphere of Earth from the oxygen they produced. This opened new opportunities for life to evolve and allowed some life forms to change to much more efficient mechanisms for extracting energy from organic molecules.

Oxygen in the Atmosphere

About 4.7 billion years ago there was a super-continent now called Pangaea, which had a small coastline compared with the continents of today. The oceans were very warm [over 38°C], and the atmosphere contained about 0.002% v/v oxygen. There was no life, but extensive volcanism was present. The high CO_2 levels from the volcanism caused very strong green house effects, and the strong UV light caused dissociation of water in the upper atmosphere into hydrogen and oxygen. Some of this hydrogen bled off into space, and small amounts of oxygen remained in this primaeval reducing atmosphere.

By the time that the first living cells had come into existence, at 4 billion years ago, the oxygen level had risen to 0.008 % v/v. As early as 3.5 billion years ago, some types of autotroph bacteria [self-feeders] in the ocean began to produce small amounts of oxygen as a waste product, and this began to oxidize soluble ferrous iron in the oceans, and precipitate ferric hydroxide, to build up massive layers of this on the ocean bottom that would be the iron ore deposits of the future. This process ceased about 2.5 billion years ago, when all the soluble ferrous iron in sea water had been precipitated. The oxygen content of the atmosphere continued to rise at a slowly accelerating rate.

At about 3 billion years ago, some bacteria began a form of photosynthesis, using sunlight to assist in breaking down hydrogen sulphide into hydrogen, which they used in cell formation, and precipitating sulphur, and thus building the great sulphur deposits throughout the world that are still present today. The atmospheric oxygen level by that time had reached 0.03 %v/v. But even the supply of sulphides was not inexhaustible, so the development of bacteria similar to blue-green algae that used light to break down water instead of hydrogen sulphide gave an opportunity for an explosion of life in the oceans. This life caused a quickening in the build up of oxygen in the atmosphere, and at about 2 billion years ago, the atmospheric oxygen level reached about 0.2 % v/v. At this concentration some life began a respiration cycle. These were single celled, but had a nucleus. By using available oxygen, these cells were able to "burn" sugar molecules all the way to CO_2, instead of just to the organic acids that anaerobic cells made, and could thereby extract about 10 times the energy that these anaerobic cells could.

In fact, the thermodynamic efficiency of conversion of energy from light by aerobic bacteria is about 70%,- about twice what a modern automobile can achieve in burning petrol to cause motion!

The reactions of photosynthesis can be summarised by the equation-
$6CO_2 + 6H_2O$ + light -> $C_6H_{12}O_6$ (glucose)
The reactions of glycolysis plus respiration can be summarised as-
$C_6H_{12}O_6$ (glucose) -> $6CO_2 + 6H_2O$ + energy as ATP

To achieve this efficiency, the cells extract the energy in small steps. There are over 10 different chemical steps, some repeated, to give 30 steps in all [that are neither spontaneous, nor random events] required for a cell to convert the sugar glucose into CO_2 and water. Each reaction requires a specialist catalyst-[an enzyme], to perform these steps, and carried the energy away as Adenosine Triphosphate [ATP].

It can be seen by the above, which is one of the simplest steps in the growth of a cell, that the process certainly is NOT simple, and it is hard to see how the assembling together of these steps could have occurred by simple chance encounters. Life did no "happen" easily.

These single celled organisms with a nucleus [Eukaryote] were sophisticated AND efficient, and were much more efficient not only in respiration, but also in the photosynthesis cycle as well. As a result, the rate of production of oxygen accelerated, so at 1 billion years ago, when the first multi celled organisms developed, the oxygen level had risen to 2%, and ozone was now being formed in sufficient quantities in the upper atmosphere to filter out the harmful UV light in sunlight, so life could begin to move onto the land. This coincided with the beginning of the Cambrian age.

It has been suggested that the 300 million year long Precambrian ice age was caused by the activity of the Eukaryotes in depleting the atmosphere of the greenhouse effects of the higher levels of CO_2 present then,-by removing a large proportion of CO_2 from the atmosphere by their explosive growth. This effect would be the reverse of the global warming worried about today. At present, about 45 % of the CO_2 removed from the atmosphere is taken up by marine phytoplankton, releasing an equivalent quantity of oxygen back into the atmosphere.

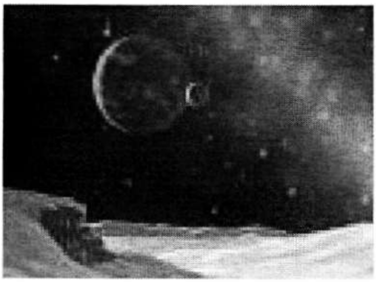
Global Warming

The average surface temperature on Earth {combining annual land, surface air, and sea surface temperatures} have risen 0.5°C in the last 100 years, but there are fluctuations [or random noise levels] of about 0.2°C each year. These may not be truly random, however, as 0.2°C dips occurred for a couple of years after large volcanic events [eg Krakatoa 1883, Agung 1963, El Chichon 1983, Pinatubo 1991]. There is indirect evidence that some of the 0.5°C rise in average temperature is due to the "Green House" effect of rising CO_2 levels since the industrial revolution.

The mean global surface air temperature is 14°C. If the Earth was in thermal equilibrium with its environment, so it consistently radiated away to space energy equivalent to that which it received from the Sun, then it should have a black body temperature of –18°C. The discrepancy, warming by 32°C, is due to the green house effect. The Earth's surface and thick cloud cover still closely approximates the radiation of a black body, but the atmospheric gases do not do so. The lower energy infrared radiation being radiated back into space is selectively absorbed by water vapour, CO_2, methane, nitrogen oxides, ozone and other trace gases. Also, the clouds are more opaque to this lower energy radiation than to the incoming sunlight, and when reradiated by the clouds, the emissions are from a black body at the colder cloud temperatures, not of the warmer surface temperatures. Most of the effects of the green house gases are due to the water vapour - but this effect remains fairly constant, so it is CO_2 and other man-made trace green house gases that are of concern, because these in principle are variable, but controllable by man.

The concern about green house gases is that the record of past ice ages have shown that 2°C warmer average surface temperatures were associated with dramatic flip/flop changes in sea bottom temperatures that were associated with positive feedback mechanisms that brought on ice ages very dramatically.

Life on Other Worlds



If we make the assumption that there is indeed life on Other Worlds in different star systems, then it becomes interesting to consider what are the requirements and constraints that these worlds must meet in order to support this life, especially if the life is to progress beyond the single cell form.

The Star

About 50% of the observable stars in the sky have been found to be binaries - two stars that orbit around each other. There are even some systems with 3 stars orbiting. Planets would have very unstable orbits around a triple star system, so life is very unlikely to be found here, as even the planets would have short life times. Planets can have stable orbits around a binary star system, but the planets would need to orbit far out so as not to be perturbed from their orbits. This would suggest that ice planets, further out, might be found here, but not rocky terrestrial inner planets that might support life.

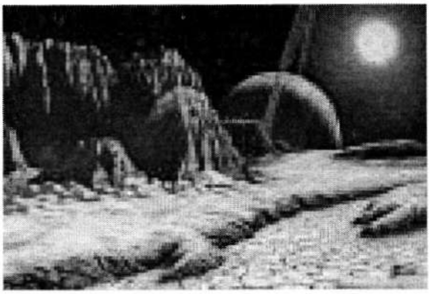
Stars with masses much greater than the Sun would not be good candidates either, as they have progressively shorter star life with increasing mass, and their solar winds would be much greater- blowing away any atmosphere on the inner planets, and subjecting them to more energetic radiation. The Sun has a life time of 10 billion years, a star with 5 times the mass has a life time of 68 million years, and a star of 30 times the mass of the Sun has a lifetime of only 5 million years [certainly not enough time for higher life to develop]. Thus the most likely stars to support planets with suitable conditions for life would be similar in mass to the Sun. They would also have to be in the prime of their star life, not near old age, as well, otherwise they would distend and swell to become red giants that would continue to expand and consume the rocky planets nearer to the star. A new star, freshly igniting it's nuclear furnaces would also be an unlikely candidate, as the planets would still be cooling and the solar winds would tend to strip away any atmospheres that they had been developing. So the star should be Sun like in mass and less than middle aged as well.

The Planet

The prime requirement for life is liquid water. The planet must be rocky [not a gas or ice planet] to support a liquid sea or ocean. For life to develop there must be the minerals to provide nutrients and a suitable atmosphere. To hold onto the atmosphere for a prolonged period, the planet must be of sufficient mass to prevent leakage of a substantial amount of the atmosphere, and water vapour into space. Mars is at the lower mass planet size, and has lost most of the hydrogen and other light gases. When the planet is more than twice the mass of Earth, it can build up an atmosphere that will thicken and deepen over time, and begin to cut back on the sunlight reaching the surface. The atmosphere will tend to trap the sunlight and raise the surface temperature by greenhouse effects to vaporise the seas.

The planet will need to still be thermally active from residual primaeval heat and heat from radioactive decay and tidal effects, so that volcanic and plate tectonic effects can recycle and redistribute the minerals from within the planet. Without such forces, erosion will remove the mountains, and restrict the supply of fresh water and nutrients. A nearby moon would be a definite advantage both in triggering volcanic and tectonic events, and in providing tides to mix the seas and provide a rich area of sea / land interaction.

A magnetic field, caused by a liquid iron core, would deflect the solar winds and protect the life from some of the high energy radiation from the star.



Thus life would not easily happen by chance, and once the spark of life is ignited, it could easily be killed off by far off events which give sudden large changes in climate, run away green house effects etc. So life is precious and rare. How rare is the question.

But even if primitive cellular life does exist in multiple other worlds, the chances of life evolving to the point of being capable of communicating with us would be extremely remote. Even then, the probability that we would hear or see the signal being sent would be slight, as such life would have to be close by for us to pick out the signal from amongst the random noise of the universe. So the sad fact is, that even if there is a lot of life out there, it is extremely unlikely that we will ever know about it!

John Casey ■