West of England Medical Journal

Formerly Bristol Medico-Chirurgical Journal

The e-journal of the
Bristol Medico-Chirurgical Society

WEMJ Volume 112 No 4 Article Number 4 December 2013

The Medical Implications of the New Space Race and the Proposed Conquest of Mars.*

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Figure 1
Bronze statue: Giordano Bruno by Ettore Ferrari (1845-1929), Campo de' Fiori, Rome (1)

INTRODUCTION

In the sixteenth century Giordano Bruno, philosopher, was burnt at the stake for suggesting that the sun was a star and that planets, like those of our own solar system, orbited the stars.
He surmised that intelligent life would be common throughout the Universe. The discovery, in the last decade, of more than a thousand extra solar planets has re-stimulated such a belief and added to the growing body of evidence for the cosmic theory of life which has been accumulated by Fred Hoyle (2), Chandra Wickramasinghe (2), Milton Wainwright (3) and Chris McKay (4).

THE SPACE RACE

In 1969 , when men first walked on the moon, many people thought that a conquest of Mars would soon follow. But it was not to be. Forty five years later President Bush stated that the USA would send astronauts back to the moon by 2020 and thence to Mars and this pronouncement can be considered as the start of the new space race.

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Based on a paper to be read to the Bristol Medico Chirurgical Society 8.1.2014

Mars, the Roman God of War, is the name of the 4th planet out from the sun. Seventh largest in the solar system it orbits the sun at a mean distance of 227,940,000 km or 1.52 AU. It is thus 50% further out than the Earth. The diameter of Mars is 6,794 km compared with Earth's 12,742 km and the mass of Mars has been calculated to be 0.107 Earth Mass.
In the Nineteenth Century speculation that there might be intelligent life on Mars was fuelled by the reports of canals on Mars. These came from astronomers Giovanni Virginio Schiaparelli (1835-1910) and Percival Lawrence Lowell (1855 –1916). Further telescopic examination of the red planet showed that the canals did not exist but by then the imagination of the public and of writers such as H.G. Wells had been stimulated, leading to science fiction about the supposed inhabitants of Mars that has continued to the present day. The possibility that microbial life may be sequestered on Mars is still a major draw for the space race. If alien life is discovered on the 4th planet it will mean that we are not alone in the universe.... a profoundly important discovery with many implications for science, philosophy and the arts.

But this time the space race will not be a two horse affair. Joining the old participants, USA (NASA) and Russia, are a host of new protagonists. Europe, China, Japan, India, Iran, Israel and North Korea are already involved. In addition there are a host of commercial concerns... the space race is becoming privatised. Non-State organisations involved in Space travel are tabulated below:

Table 1 Private Space Companies

Virgin Galactic (Richard Branson)
SpaceX (Elon Musk CEO of Tesla) (have docked with ISS)
Stratolaunch (Paul Allen of Microsoft)
Blue Origin (Jeff Bezos of Amazon)
Mars One
Orbital Sciences (have docked with ISS)
Moon Express.

New Scientist reported the 'Private space race comes of age' (5) when referring to the competition Orbital Sciences are now providing to the darling of private spaceflight, SpaceX. Certainly the new companies are a force to be reckoned with and, just as there were medical implications of state-controlled space travel, so there are of a private space race. Who will police the newer participants and make sure that they keep to agreed standards? How do the laws of health and safety apply to space travel? Perhaps the most interesting and also the most disturbing, is the ambition of Mars One. Their intention is to send a one-way manned expedition to Mars by 2023..... and they already have 200,000 applicants. This expedition is to be partly funded by reality TV. For such a trip any medical participant would need to be multi-talented, encompassing the entirety of medicine from radiation protection to childbirth

HAZARDS TO HEALTH ON A MANNED TRIP TO MARS

The hazards of manned space travel the distance of Mars are considerable and have been listed in table 2.

***Table 2 Hazards of prolonged manned space fligh*t**

Radiation
Accident: Trauma, Burns, Poisoning, Suffocation, Starvation
Weightlessness and lack of exercise
General health problems (myriad!)
Psychological problems due to confinement

Radiation

A one-way trip to Mars would take about six months. Some of the hazards of such prolonged space flight have already been encountered by astronauts such as those on space stations. A doctor of medicine, cosmonaut Valeri Vladimirovich Polyakov, is the holder of the record for the longest single spaceflight in human history, staying aboard the Mir space station for more than 14 months (437 days) during one trip.

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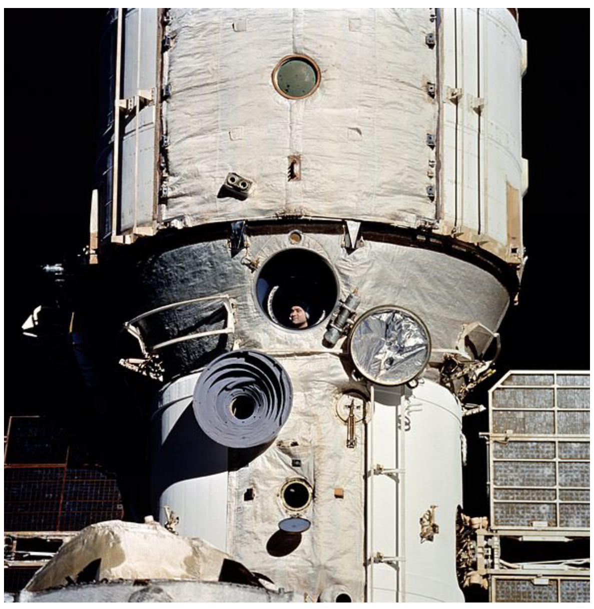
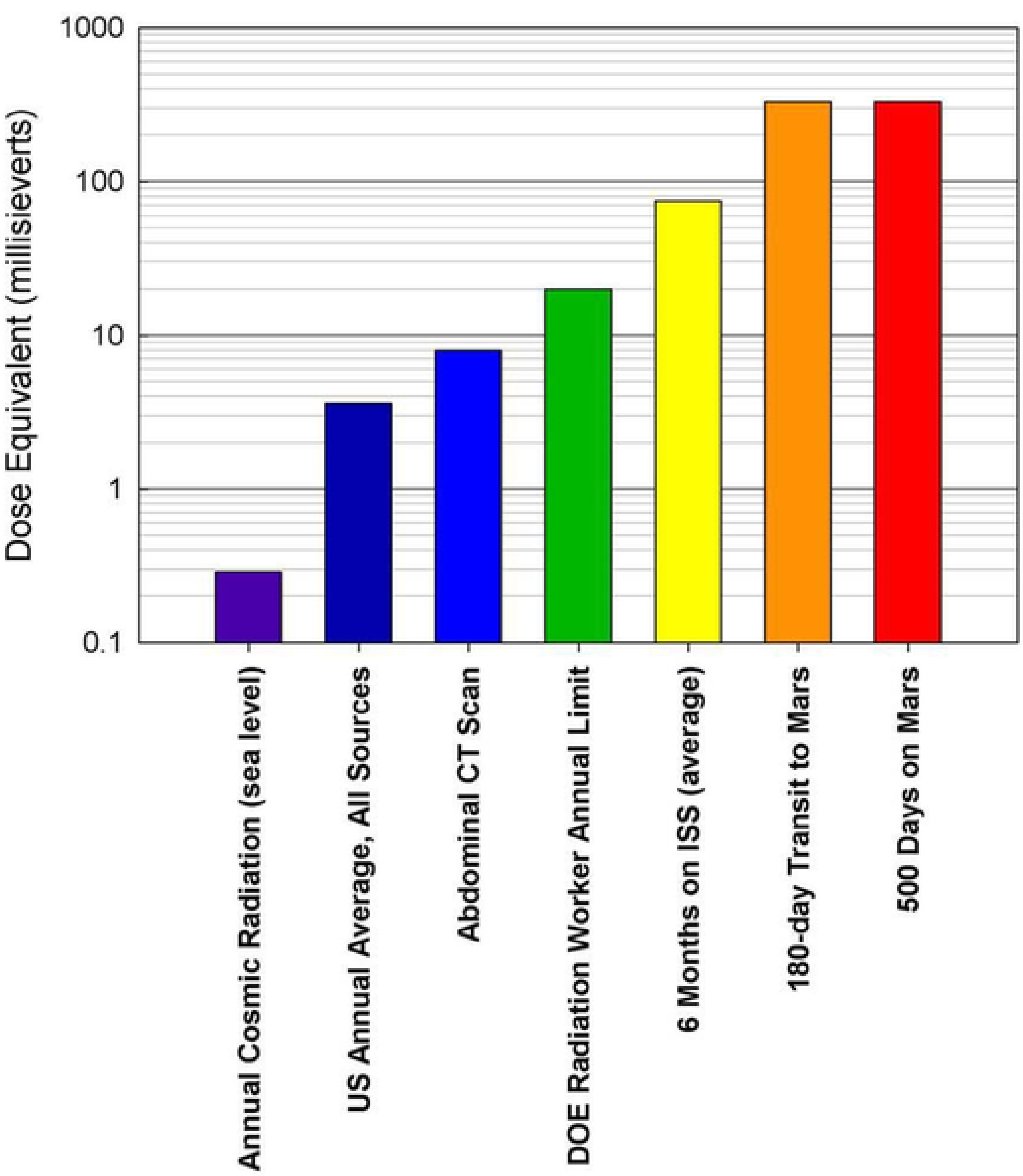


Figure 2 (above) Cosmonaut Polyakov watches Discovery's Rendezvous with Mir

Table 3 (below) Radiation Study from the Mars Rover Curiosity* [6]*. From Wikipedia. Source NASA



Whilst such trips allow for many of the tabulated health problems to be studied they do not include the radiation burden that would be experienced on a trip to Mars. The space stations are within the Earth's magnetosphere and this protects against much of the cosmic radiation that otherwise bathes the solar system.

The radiation detector on the Mars Rover Curiosity showed levels of radiation that are lower than those considered likely by the more pessimistic pundits but are still a significant consideration. Careful examination of table 3 reveals the logarithmic nature of the axis and that the six months trip to Mars results in about five times the radiation burden of the same time on a space station and about forty times that from an abdominal CT scan. Table 4 shows that this is well below the lethal radiation (LD50 30 days) for human beings and that there are organisms that can tolerate radiation doses many orders of magnitude greater.

Table 4 Lethal radiation dose (Gray) (LD50 30 days) [7]

dog 3.5 Gy
human 4.5 Gy
tortoise 15 Gy
goldfish 20 Gy
german cockroach 64 Gy
shellfish 200 Gy
fruit fly 640 Gy
amoebae 1000 Gy
braconidae wasps 1800 Gy
thermococcus gammatolerans 30,000 Gy

It is likely that the radiation burden would stochastically shorten the life of astronauts who travel to Mars but that this would not be an immediate life threatening risk unless there was a major fluctuation in the radiation hitting the space craft. The usual radiation protection measures may also be considered. These can be summarised under the headings of time, distance and barriers. Keeping the space travel as short as possible would be advantageous thus minimising the time spent exposed to cosmic rays. Keeping a distance from the cosmic ray source would not be possible due to the all pervasive nature of the extra-solar cosmic rays. Staying away from the sun would reduce somewhat the effect of solar wind but this is fairly easy to protect from using barriers. High energy cosmic radiation requires different thinking from the lower energy gamma and x-rays used on Earth. Lead would be counter-productive leading to slower, more biologically effective, and hence dangerous, radiation. Low atomic number barriers may help and storing the necessary water for the trip in a sheath around the cabin may be a method of reducing the radiation. An artificially-induced magnetosphere is a possibility that the author has suggested but its feasibility has not yet been studied.

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In 1994 the author travelled to the Ukraine (see figures 3a and 3b) to medically head-up a mission to provide medical services to the 43rd rocket army in the process of breaking up rockets and nuclear warheads.

Figures 3a and 3b
Visiting the 43rd rocket army, Ukraine 1994

The greatest health hazard was not radiation but accident, in particular trauma, burns and poisoning, followed by the general health problems encountered by the public. Similarly accident has been the major problem for astronauts so far with about one in twenty-two US astronauts dying from accident. Only about 50 % of Mars probes have been successful although the last few have had much greater success. So the hazard could be somewhere between 1 in 2 to about 1in 22 that death will occur due to accident. This is approximately the same as attempting to climb Mount Everest, which presently has a 1 in 10 death rate.

Weightlessness

Table 5
Reported Hazards from weightlessness

muscle atrophy
deterioration of skeleton
slowing of cardiovascular system
decreased production of RBC
balance disorders leading to vomiting and disorientation.
weakening of the immune system
fluid redistribution (+ visual problems)
sleep disturbance
nasal congestion
excess flatulence

Some of the hazards of weightlessness can be countered by exercise but the best method would be artificially-induced gravity by spinning the space-craft. This is presently beyond the capability of the engineers and the size of craft required is too great for the payload of present-day rockets. On the positive side Zoledronate can be given to reduce bone loss and scopolamine and dexedrine administered for low-gravity vomiting.

General health problems and Psychological problems due to confinement

The crew of spacecraft are well-vetted by the present-day state-run systems but this may change with a privatised space race. For example astronauts are chosen for their calm nature in face of adversity, psychological stability, their resistance to travel sickness, general good health and other abilities such as technical wizardry and skill at flying aircraft. Reality TV stars are chosen by their appeal to the judges and the viewing public.

Anybody can suffer from health problems but careful vettingof astronauts has reduced the incidence of such medical and surgical emergencies. This is an important consideration. Unhealthy candidates should not be selected just because they make good television!

Health hazards related to a landing on Mars

There are health hazards specifically due to a landing on Mars. Firstly.... the descent is difficult. The gravity on the surface is just under half that on Earth but this is sufficient to accelerate any landing craft to considerable velocity. The atmosphere is slight due to the low gravity and parachute systems therefore have to be very large and complex. The danger of trauma on landing must not be under-estimated....and the surface is very cold.
Once on the surface the radiation burden may be decreased compared with spaceflight but Mars does not have an internal dynamo so the magnetosphere is much less extensive than on Earth and therefore less protective (see Table 3).

The atmospheric pressure on the surface is half of a percent of that at Earth's surface, equivalent to being well up in the stratosphere on Earth. The composition of the Mars atmosphere is shown in table 6.

Table 6 The Martian Atmosphere

Pressure: half of one percent
Gases:
Carbon Dioxide 95%
Argon 3 %
Nitrogen 1.5 %
Oxygen 0.15 %

Surface temperature:
max 20^0C min -153^0C

Clearly it will be a complex task to obtain sufficient air to sustain human life. In addition the surface is very cold and dusty. The dust is highly reactive and presents a hazard in itself. Dust-storms are common and it would be difficult to keep the dust out of the environment of landing craft. Exposure to the dust could cause skin damage and respiratory problems such as asthma and, in the longer term, silicosis.
One reason for going to Mars is to look for alien life-forms. Simple alien life-forms, such as the archaea and bacteria found on Earth, may be sequestered in rock. It is unlikely such life-forms could represent a hazard to health but it must be considered. Moreover we have already contaminated the red planet with organisms from Earth [4, 8].

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Food and water will have to be carried to Mars from Earth. There would not be sufficient capacity to feed a colony and the technology and science is not yet at a high enough state of development for the heating, food, water and air to be sourced locally on the planet. This would need considerable research before the Mars One, one-way trip is undertaken or the 'colonists' would die very quickly from suffocation, thirst, starvation or hypothermia. A colony would also require a major energy source as the sunlight is only about half that on Earth. The surface temperature of Mars is very low ranging from a high of 20^{0}C to a low of - 153^{0}C. The modal temperature is around -55^{0}C and a range of 100^{0}C in one day is not unusual.

It is likely that a nuclear power source of some kind would have to be used. The Soviet Union launched 31 low power fission reactors utilizing thermoelectric converters between 1967 and 1988. Shortly after, the Soviet Union developed TOPAZ II reactors, which utilize UO2 thermionic converters instead. There were five failures involving Soviet or Russian spacecraft carrying nuclear reactors between 1973 and 1993. This presents a hazard to life on Earth as well as to the Mars crew.

If the 'colonists' wished to return to Earth all the health hazards of the outward bound trip would be met again plus the added problem of a rocket launch from the surface of Mars without the major back-up that is present on Earth.

WHAT IS THE LIKELIHOOD THAT ALIEN MICROBES WILL BE FOUND ON THE PLANET?

One of the major reasons for going to Mars would be to look for alien life forms. The possibility of succeeding in this mission has increased since the discovery of extremophiles on Earth. It was previously thought that Space was too harsh for microbes to survive and that the reactive nature of the surface of Mars made life impossible there also. Recently, however, microbes have been found in the most hostile of environments on Earth raising the possibility that microbes, particularly archaea, may survive in other places in the solar system.

The idea that life originated elsewhere in the Universe and has seeded throughout space was postulated in Ancient Greece and has been called panspermia.

This idea was given a scientific basis by Arrhenius (9) who suggested that microbes could be moved through space by the radiation pressure from stars. Fred Hoyle and Chandra Wickramasinghe (2) working on this theory showed that the spectrum of interstellar dust has a remarkable resemblance to that of desiccated bacteria. Many bacterial spores can survive in space if protected from the radiation. Embedded within rock extremophiles such as archaea could also survive space. Recent disputed evidence has suggested that fossils of bacteria are present in meteorites (2). Undisputed is the evidence that meteorites contain much organic material including many amino acids not normally found on Earth.

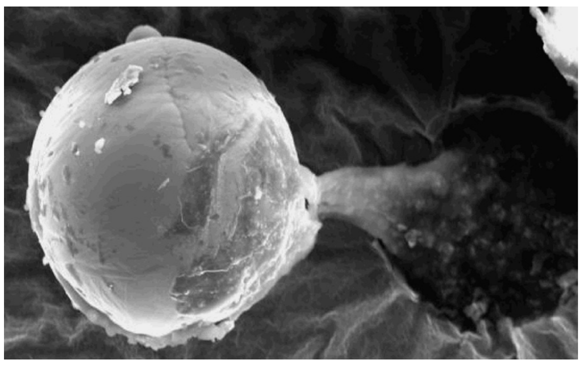

Figure 4
Stratospheric Titanium sphere containing organic material

Wainwright (3) has recently detected organic material within a tiny titanium sphere 37 km up in the stratosphere and his team from Sheffield postulate that this could be of extra-terrestrial origin (figure 4). Certainly the sphere impacted with some considerable velocity on the collecting device making an extra-terrestrial source likely.

ROBOTIC SURVEYS OF SPACE.

Already robots have been successfully deployed on the Moon and on Mars and unmanned spacecraft have explored the solar system and even beyond. Viking I and II, launched in 1975, provided amazing images and analysis that simultaneously both supported and refuted life on Mars. Opportunity and Spirit, 2004 and Curiosity (2012) have all been very successful. The Chinese presently have a rover on the moon. Robots are better suited to work in the hostile environment of Space. So the question may be put: why not just send robots?

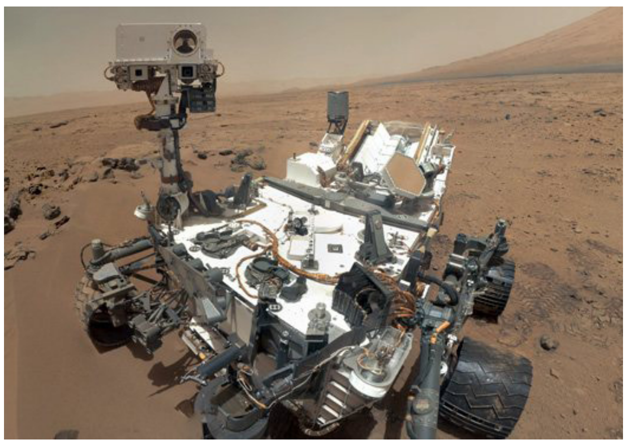

Figure 5
Curiosity takes a selfie on Mars.
Picture: NASA/JPL-Caltech/Malin Space Science Systems Source: NASA

The answer may be philosophical rather than scientific. Certainly government agencies can be berated for posturing by sending rockets into space when they have too little money to feed their own people but they have an ulterior motive of showing their rivals the capability of their State. Private organisations have no such motivation and are now utilising the over-excessive wealth of their founders for the Space Race. This could be considered as a more useful endeavour than the usual expenditure on a failing local football club.

Some people believe that humankind must eventually escape the clutches of the third rock from the sun and thereby increase the chance of survival of homo sapiens.

But the real reason for a desire to send manned flight may simply be the same as that for climbing mountains...'Because it is there.'

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