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# Unorthodoxies and Controversies in Planetary and Space Science

I feel very honored to have been invited to speak at the fifth annual meeting of the Working Group on Extraterrestrial Resources. It is not only a great privilege but also a very difficult task to select a suitable topic for this audience of experts in the fields of geology, selenology, and planetology. I have decided to talk about theories which are not in accord with the present generally accepted ones, but which should not be ignored because they might, after all, be correct. I shall discuss some freely selected examples of unorthodoxies and controversies with special reference to the space-life sciences.

I would like to begin with a theory proposed in 1937 by Prof. P. A. M. Dirac of London, a Nobel Prize winner in physics (ref. 1). He suggested that Newton's constant of gravitation is actually not a constant but has decreased slightly during the lifetime of the solar system and continues to decrease in correlation with the expanding universe. This idea was not accepted in physical science, and 2 years ago, when I had the opportunity to talk with Prof. Dirac about his theory, he emphasized that most physicists are hostile to it. But 5 years ago Prof. R. H. Dicke, physicist at Cornell University, came to the same conclusion (ref. 2), and, at about the same time, Pascual Jordan, physicist at the University of Hamburg, published several papers in favor of Dirac's theory (ref. 3).

An acceptance of Dirac's theory leads to interesting conclusions. Generally, it is assumed that the Earth is contracting like a "shrinking apple." This probably was the case during the time when the protoearth cooled off from a much higher temperature. But after it had reached a temperature equilibrium, about 1 billion years ago, the decrease of the gravitational constant might have become the dominant factor in shaping the volume and surface of the Earth by causing the opposite of shrinking; namely, expansion. It has been calculated that the radius of our globe during the past half billion years has increased by 37 meters, and its circumference, by 600 kilometers. This tendency to expand has led, and still leads, to tension cracks in its crust. This explains why the primordial supercontinents, Gondwanaland and Laurasia, were split into a number of secondary continents, which then drifted apart (continental drift). Formerly, the African Continent was connected with the South American Continent, and the North American Continent, Greenland, and Iceland were part of the Eurasian Continent. The islands off the east and west coasts of the United States and Canada have been split off from the continent by tension cracks, and there are numerous faults on the continents; for example, the San Andreas Fault in California.

Recently, explorers working in oceanography have discovered fissures of several thousand kilometers in length at the bottoms of the Atlantic and Pacific Oceans. These, too, have been interpreted as expansion tension cracks. Thus the Earth can no longer be compared with a shrinking apple; rather, it seems to be an expanding planetary body. Its tendency to expand may be a factor in making earthquakes produced by volcanic activities more destructive.

The phenomenon of gravitational decrease is not restricted to our planet; it includes the whole universe. However, I would like to confine myself to our local universe, the solar system, and specifically to Mars. (See ref. 4.)

In contrast with the surface of Earth, the surface of Mars is a stony solid with no open waters. The generally accepted theory is that Mars formerly had oceans, but, because of its lower gravity, most of the water molecules have escaped into space. However, around 1910, Baumann of Zurich (ref. 5) suggested that parts of the Martian ancient oceans are now frozen and covered with dust which has become solidified in the course of millions of years. In Urey's book (ref. 6), H. E. Suess, at that time at the University of Chicago, is quoted as stating that "substantial quantities of water may be buried under dust and never become volatile at the low temperature of parts of the planet." As you know, the average temperature on Mars is about 15° C lower than that on Earth. This somewhat forgotten, unorthodox, frozen-ocean theory has been recently revived and developed in more detail in references 7 and 8 by V. D. Davydov, an astronomer at the Sternberg Astronomical Institute in Moscow. He theorizes that there may be a subsurface ice layer 500 meters thick in the equatorial regions now covered by a 100-meter-thick layer of solidified dust. He even expressed the opinion that beneath this frozen conglomerate, or "cryosphere," as he called it, water might be found in the liquid state because of an increase of temperature in the interior of Mars.

If we combine this unorthodox hypothesis of the existence of a hydrocryosphere below the surface of Mars with Dirac's unorthodox theory of the gravitational constant, we get an interesting picture. The gravitational decrease would cause on Mars, too, a volume expansion and tension cracks. Their appearance might be triggered by the impact of meteorites and asteroids which should produce fissures of tremendous length in a crust of nonuniform composition. This threefold environmental combination—planetary volume expansion, subsurface ice layer, and meteoroid impacts—might well be the mechanism producing the dark spots called oases and the dark linear markings, or canali, which generally originate in the dark spots and radiate over tremendous distances.

The existence of a subsurface ice and water table on Mars would increase the humidity in and around the meteoritic impact craters and along the fissures, and make them more suitable ecologically for the growth of vegetation. Actually, it might be the soil's humidity and vegetation that make these surface features visible to Earth-based optical astronomy.

The theory of the existence of a subsurface hydrocryosphere on Mars is unorthodox, but there are some astronomical arguments and indications that speak for it. For instance, according to Barabashov (ref. 9), without such a subsurface ice table all the water molecules might have disappeared into space in the course of millions of years. Furthermore, when cracks caused by Mars quakes occur in this kind of crust, water may reach the surface and produce localized giant clouds and white streaks of fog; such clouds, visible for days, have been described by Lowell (ref. 10) and Slipher (ref. 11). White spots glittering like ice have been observed in the equatorial regions by Saheki of Tokyo (ref. 12).

How does this combination of theories look in the light of the Mariner IV pictures? Their initial interpretation was that the visible Martian surface is extremely old and that neither a dense atmosphere nor oceans have been present on the planet since the cratered surface was formed. But later evaluations of Mariner IV photographs led to the consideration that the surface of Mars was only 300 to 500 million years old and to the statement that: "The crater density on Mars no longer precludes the possibility that liquid water and a denser atmosphere were present on Mars during the first 3.5 billion years of its existence." (See ref. 13.) Thus, the ancient ocean theory might be correct after all. It might be that some 300 million years ago, after Mars had lost most of its water into space, it entered a permanent ice age; the remaining frozen water in the course of millions of years became covered with a deep layer of dust that became solidified and was bombarded by numerous asteroidal meteoroids, starting some 300 million years ago with the disruption of Planet X, the matrix planet of the asteroids. This might indeed be the history of the features on the red planet as we see it today.

Now, I would like to go into a little more detail about some controversies concerning life on Mars. The dark areas, according to most observers, show seasonal color changes from dark to bluish-green, to yellow-gold, to brown, and back to dark, which is interpreted as an indication of green vegetation on Mars. But to some observers these regions always appear to be dark gray. These observations can be accepted only from persons with normal color vision, as confirmed by an ophthalmologist (ref. 14). As you know, 7 percent of human males are color defective.

The bluish-green color is also interpreted as a visual contrast phenomenon against the ocher-reddish surroundings. Visual contrast effects certainly occur, especially if the areas are small, but the bluish-green coloration of large areas, such as Syrtis Major, which is about the size and shape of Texas, is in all probability real. This is also supported by the observation of Tombaugh (ref. 15), according to whom certain areas occasionally look dark when others look green, despite the fact that both are surrounded by reddish areas. The final answer in this color dispute might come from color photographs made by future flyby probes. But, of course, the green color is not decisive of the existence of life on Mars.

Fifty years ago, Arrhenius (ref. 16) advanced the theory that the dark areas are salt beds of dried-out oceans and concluded that "Mars is indubitably a dead world." But on Earth the Dead Sea, in Palestine, which is an extremely salty medium, was for thousands of years considered to be without life, whence its name. Recently, however, numerous species of micro-organisms, bacteria, and algae have been detected therein. The Dead Sea, therefore, is not so dead as was believed, and the red planet, Mars, might not be so dead either.

Recent spectroscopic studies indicate that carbon dioxide pressure in the Martian air might amount to 3 millibars; that is, 10 times as high as that on Earth. The opinion has been expressed that this would exclude life; but, actually, it would even be an advantage for the growth of green vegetation, because carbon dioxide in this pressure range increases photosynthesis; although beyond 22 mm Hg it has an inhibiting effect on this process.

It has been argued that the low density of a 10-millibar-pressure atmosphere, as revealed by Mariner IV, might not provide effective protection from harmful solar ultraviolet and X-rays. But, first of all, the intensity of solar irradiation at Mars' distance from the Sun is less than one-half of that at the Earth's solar distance. Furthermore, a certain amount of these rays is certainly absorbed within the atmosphere. It is, of course, well known that ultraviolet rays, particularly in the range from 2500 to 2800 Å, are indeed very destructive to most terrestrial micro-organisms. For this reason they are used for sterilization of food and of lunar and planetary probes to prevent interplanetary contamination. But there are various degrees of resistance to ultraviolet rays and X-rays. Moreover, certain micro-organisms are even stimulated in growth when exposed to low-intensity ultraviolet rays and X-rays, as was found in bacteriological experiments around 1930.

The temperature on the Martian surface during the night is always and everywhere below the freezing point of water. This is considered to be particularly prohibitive for life; but experiments in Mars environmental simulators have shown that many organisms survive the freeze-thaw cycle for some time. If there is a Mars biology, during the night it is always a cryobiology; that is, a low-temperature biology.

All in all, the question of life on the Martian surface is still more a matter of probability than possibility. If there is life on the Martian surface, a precondition for it would have been the existence of open waters for its origin and development. Furthermore, if there is a water table below the ice layer, as mentioned earlier, this water table could be a second habitat for life based on chemosynthesis. This, of course, sounds ultraunorthodox; but on Earth the water of the geysers contain micro-organisms, and there are microbes even in oilwells and jet-fuel containers. This has led to the establishment of a new branch of bacteriology called petroleum bacteriology.

Finally, I would like to touch upon some controversial points concerning human physiology in space flight. In all space medical discussions the duration of the flight plays an important role. What might be the time limit in this respect? A flight to the Moon is no problem because this takes only about 3 days, but a flight to Mars, based on a minimum energy trajectory, lasts more than 8 months. This is, of course, the simplest and most economic method for unmanned automated planetary probes, such as Mariner IV.

But is such a long duration also acceptable for a manned planetary mission? To get a realistic judgment in this respect, we must consider the whole complexity of life of the mission crew, a team of perhaps six or more, living in a cramped, closed ecological world with its own economy and autonomy. The activities of this "capsule society," as Sells calls it (ref. 17), include power control, navigation, exploration, telecommunication, control of the life-support system, hygiene, housekeeping, and so forth. Weightlessness complicates some of these activities and facilitates others.

The astronauts, after some 20 hours of flight, should be in a state of "relatively stable adaptation to weightlessness," as has been concluded from the medical observations taken in orbital flight. Anthropometric comfort, appropriate exercise, and a well-regulated sleep-duty regime might enable them to endure space flight lasting for months. Artificial gravity might not be required. Be that as it may, it seems to me advisable, if not even a requirement, to base a flight plan to Mars on a high-energy trajectory so that the duration of the minimum-energy trajectory of about 8 months can be shortened to 20 to 30 percent of this time. This can be achieved by novel methods of propulsion.

In addition to the man-machine-intracabin environment complex, the external space environment also must be taken into account. A shorter time reduces the possibility of meteoritic incidents and the radiation hazards after solar flares.

In brief, a minimum in time and an optimum in comfort is the prescription for achieving a maximum of success of any manned planetary landing mission (ref. 18). Of course, astronauts with week-long experiences in orbital flight and the space medical practitioners who have controlled these flights will have a decisive voice in this respect.

In the case of long-range manned space operations, as, for instance, a flight to Mars, preflight prophylactic surgical measures in addition to preventive dentistry must be considered. Appendectomy and even cholecystectomy would certainly be advisable; the latter may be necessary only if there is some doubt that the astronaut is completely free of positive and negative gall-bladder stones. This much, according to my opinion, makes sense. But the suggestion to transform astronauts into cyborgs, that is, persons with artificial organs, which hit the headlines of the press some 10 years ago and might be revived since the successful transplantation of organs, will probably remain a matter of wild imagination; for it is not the task of space bioengineering to adapt the human body artificially to the extraterrestrial environment. Rather, it is our aim to make the extraterrestrial environment artificially as physiologically suitable as possible. This is the challenging task of the Working Group on Extraterrestrial Resources.

The present main object of your working group is the Moon. I would like to conclude this discussion with a brief remark about the controversial question: How should selenonauts, the Moon explorers, walk on the Moon? At the 1966 meeting of the Lunar International Laboratory Committee in Madrid, Margaria of Milano suggested that the selenonauts should take advantage of the Moon's low gravity by jumping some 5 meters, like grasshoppers (ref. 19). This might be acceptable if the surface is smooth, but if the "moonhoppers" should lose their balance and hit the ground on a rough surface, they might risk a leak in their pressure suits. In contrast, at the same meeting, I suggested that the selenonauts should increase their weight by carrying, in addition to the life-support equipment, some 30 kilopounds of material, maybe moonpebbles, in pockets around their waist or shoulders (ref. 20). This would increase stimulation of the peripheral mechanoreceptors in the skin and muscles of the legs and would help them to keep their balance. It would make the stimulation of these mechanoreceptors more Earth-gravity equivalent, but it will not, of course, affect the otolith apparatus.

In conclusion, there are many more controversies in space medicine, lunar and Martian medicine, and Martian biology that will be a stimulus for further theorization and experimentation. The technological and scientific achievements in man's advance on the space frontier have so far been spectacular and will be even more fantastic in the years to come. Nevertheless, despite the possibility of some of the unorthodox theories I have presented, in the area of space medicine we must be realistic and sensible, particularly in our extrapolations for long-range, manned missions such as a flight to Mars.

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