THE HUMAN VALUE OF SCIENTIFIC INVESTIGATIONS OF THE ORIGIN AND EVOLUTION OF THE SOLAR SYSTEM

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We are in a period when the focus is on reevaluating our priorities with the objectives of redirecting our resources and activities toward solving human problems, rather than problems of a nonhuman and purely materialistic nature. We question the value of space programs to mankind in terms of using both financial and human resources when we are burdened with so many earthbound problems, such as poverty, hunger, overpopulation, pollution, disease, and urban blight. We ask if a space program is relevant to human needs?

The HATS Space Congress has addressed this and other questions, and established the relevance of space programs to human needs on all fronts by revealing an incredibly large spectrum of technological benefits which are directly related to social, political, and economic problems. These technological benefits, however, provide primarily material benefits, but we should note that there are also intellectual benefits for scientists and other scholars, in addition to the less obvious psychological and even spiritual benefits for all men. These benefits are related to the age-old human questions such as "Where do we come from?" "Will mankind endure?" "What is man's future?" "What is our place in the universe?"

These human questions, however, typically arise from man's fears and curiosities. They have remained for all times in midst of social, political, and economic issues that change, not only on a daily-to-yearly basis but every decade and every century.

The significance of such questions were, no doubt, manifested by the Apollo VIII crew when they responded to man's first awe-inspiring views of earth from deep space with phrases such as "The Good Green Earth" and their Christmas message from the moon with reading of the Genesis. At a time when the world was ready to pull itself apart, it spiritually united when Apollo VIII arrived at the moon, and reunited again when Apollo IX landed on the moon. The meaning of the historic words of Neil Armstrong, as he descended onto the lunar surface, "That's one small step for a man, one giant step for mankind" is that man can finally accomplish near impossible tasks through collective efforts of many - not only materially, but also intellectually, psychologically, and spiritually.

Human Questions and Man's Fears

Most of the life on the earth exists in a biosphere; i.e., shell of life, about 2 miles thick. It extends from the continental shelves, onto the land, and into the lower regions of the atmosphere. Manmade wastes of all sorts have and are still contaminating the biosphere to such a level that all life on earth is endangered. The realization of imminent catastrophe has precipitated some men's fears to a point of near panic. We ask "Can the world be saved?" The answer is probably yes, with the aid of modern technology, and particularly that of space technology; e.g., the development of nonpolluting power systems, waste management control systems, recycling waste materials, etc. This capability can and should be applied to the eradication of manmade biosphere contamination. It, in fact, is probably the most effective means of quickly eliminating contamination or pollution without impairing (if not destroying) civilization, itself, because of an overemphasis of technology reduction.

On the other hand, man is not the only threat to life on earth. Nature occasionally assumes that role as well, bestowing a variety of catastrophes over many regions of the earth, such as tornadoes, hurricanes, earthquakes, volcanoes, tidal waves, not to mention an ice age or two, and more. These have resulted in both animal and human disasters throughout recorded and unrecorded history and have precipitated man's fears of nature's wrath.

In view of the current concerns with manmade pollution, natural pollution catastrophes should be recognized as being relevant to the manmade pollution issue. In terms of the overall ecological question, one should also recognize our uncertainties as to the causes of the extinction of the mighty dinosaurs and the ice-age mammals, in addition to the extinction of their ecological systems. What caused their extinctions? Is the earth evolving such that living species, along with their ecological systems, will eventually be discarded by nature and perhaps replaced by new species and new ecological systems?

A significant example of the destructive powers of nature is the volcanic disaster at Krakatau, when on August 27, 1883, a catastrophic explosion propelled ash 50 miles high, over 300 000 square miles, and generated 120-ft tidal waves which took the lives of 36 000 people in the neighboring coastal towns of Java and Sumatra. The explosion could be heard within a radius of 3000 miles and the resulting pressure waves were recorded around the world. The air became so polluted with expelled ash that the surrounding region (50-mile radius) was in total darkness for 2.5 days, and the entire world experienced spectacular red sunsets for over a year, because of the fine dust which rose high in the stratosphere and circled the globe several times. Similarly, the eruption of Vesuvius in A.D. 79 destroyed the ancient cities of Herculaneum, Stabie, and Pompeii. It is interesting to note, however, that the inhabitants of Pompeii were killed not with molten lava but with natural air pollutants: poisonous gas and ash which buried Pompeii under a layer 12 ft or more in depth.

Consider even further the recent near-encounter with the asteroid, Icarus, which passed some 4 million miles from the earth. This raises additional questions concerning potential hazards that the solar system may impose on mankind in the course of time. One can certainly raise the question "Have catastrophic events occurred on earth or other planets as a natural result of solar system evolution?" In addition, comets, historically, have been considered as signs of disaster and catastrophe, announcing the death of kings, the destruction of kingdoms, pestilence, and famine. Are such fears based on mere superstition or have comets been responsible for an unidentified human catastrophe somewhere in the recesses of man's unrecorded past? One can certainly ask the question as to whether or not nature's wrath will one day unload a new unexpected catastrophe on the earth and eradicate our ecology (if not the earth itself), in spite of man, rather than because of man: probably not, but who can actually say? Our knowledge of the solar system, including an understanding of earth evolution, is too incomplete at this point in time to predict our future with any real certainty.

If man wishes to protect himself from the adversities of nature, no matter what the cause, he must understand her. In order to understand her, he must understand her laws, he must complete his understanding of the solar system evolution and be able to predict not only solar eclipses, magnetic storms, and the weather, but any phenomena good or bad, known and unknown, which affects the evolution of earth.

Human Questions and Man's Curiosity

In addition to man's basic fears, his insatiable curiosity has precipitated ancient and medieval intellectuals to provide rational philosophical and religious answers to these human questions. Moreover, renaissance to modern time philosophers and scientists have provided some empirical or scientific answers to these questions that have resulted in additional benefits of quasi-accurate disaster predictions, which in turn, provide man with some control over his destiny. In other words, man's curiosity has driven him to explore nature both rationally and empirically, providing him with some means of self-preservation and subsequently, some psychological benefits, with corresponding intellectual benefits.

All is not solved, however, and these same human questions remain; but they can be translated into a more manageable set of scientific questions which, by their very nature, are capable of being answered. Such questions are:

How is the earth evolving?
How is the solar system evolving?
How is the universe evolving?
How is the life evolving?
What is the origin of the earth, the solar system, the universe, life?

We ask "Why investigate apparent esoteric scientific questions concerning the origin and evolution of the earth and the solar system as a whole?" The answer to this question is not only to satisfy man's insatiable curiosity concerning his origin and evolution, but also to mitigate his fears by addressing related questions of the age-old human question of his destiny, identity and purpose, as well as the contemporary question, such as "Can the earth be saved?"

Attempts to Answer Human Questions

Since the 17th century, many theories have been formulated in attempts to address questions of the origin of the solar system, with a minimum emphasis as to its evolution. Figure 1 [1], for example, lists some of the originators of these theories. These theories, each in their own way, have attempted to account for the existence of the solar system by using data from astronomical observations available at that time in terms of known laws of nature.

In recent times, contemporary theoretical scientists have suggested that some objects of the solar system may provide more information as to solar system origin and evolution than others. The oceans and atmosphere of the earth, for example, have washed away much of the earth's past history, but the moon may have undergone relatively minor changes in the past few million years and, therefore, possesses permanent records of the sun's activity; i.e., sun evolution, and the solar environment to which the earth, as well as the moon, was exposed; i.e., earth and moon evolution. The asteroids are regarded by Alfvin [2] as being structured with preplanet material; i.e., primordial. He has also suggested that an exploration of the brick-shaped asteroid, Eros (which will pass close to earth in 1975), may provide a key to the origin of the solar system. On the other hand, others have speculated that the existing asteroids are reminiscent of an exploded planet. The resolution of these questions is vital in determining asteroid origin and evolution. The giant planet, Jupiter, has been referred to by Rasool [3] as "the Rosetta Stone" of the solar system and may be inhabited with the most primitive forms of living material. This belief is supported by many in the scientific community.

Nature of the Origin of Evolution Problem

Thus far, all theories of the origin and evolution of the solar systems have taken us only from total darkness to the shadows of dawn. Each theory is, in one way or another, incomplete and considerable observational data are required before we will understand each one.

Any theory of the origin of the solar system as well as its evolution must be capable of explaining both the regularities and irregularities of the solar system in order to establish a high level of scientific creditability; e.g., the fact that all planets of the solar system are in nearly the same plane excepting Pluto. Moreover, all solar system models must take into account the fact that the solar system models consist of entirely different kinds of objects, ranging from atoms of gas and microscopic dust grains to the sun (a star), which is a massive nuclear inferno. Table 1 lists the class of objects which make up the solar system.

Figure 2 pictorially relates the sizes and distances of the major solar system bodies. Figure 3 relates some of the larger minor bodies with some of the smaller major bodies. Jupiter's Red Spot (Fig. 3) is about 3 times the size of the Earth; Mercury and Mars are seen to be comparable in size to the larger satellites of Jupiter and Saturn; and finally the larger asteroids, Ceres and Vesta, are seen to be comparable in size to some of the smaller satellites of Jupiter and Saturn. It is the origin and evolution of these bodies, to which we refer when we speak of the origin and evolution of the solar system.

An examination of the various origins and evolution theories (e.g., those in Figure 1) clearly indicate, however, that there is no single object to be explored and no critical tests that can be applied to assert or deny any one theory or model. Each theory has sufficient freedom to permit the incorporation of almost any new observable data. Advances can be made, however, by attempting to understand the fundamental elements which structure these theories. These elements are the physical processes which have operated and are still operating to produce the present state of evolution of the solar system from its initial state or time of origin. The physical processes by which solar nebula became fractioned, for example, to produce the small but dense terrestrial planets and the giant gassy outer planets is a common element in all theories. It must be understood in great detail if an enhanced understanding of the origin and evolution of the solar system is to be made. It is only through a thorough understanding of all relevant physical processes that will enable mankind to understand the actual evolutionary procedures that occur in solar system formation and evolution. All theories combine many of these processes, most of which are only partially understood, and all are incomplete in one way or another. This situation would be considerably improved, however, by relating theories with measurements to acquire new observational data. Figure 4 [4] shows this relationship, which, in essence, says that theories are structured from our understanding of the physical processes: the better we understand them, the better the theory. But in order to understand these processes, we must collect certain kinds of information which is limited by the kinds of observations that can be made and is, itself, limited to the measurement techniques available. There is no doubt that if we can observe the solar system from various observation points, such as space missions provide, and utilize available measurement techniques, we can obtain the much-needed information required to understand the physical processes governing the evolution and origin of the solar system.

The Benefits of the Space Age in Addressing Science Questions

The Space Age has opened new investigative horizons for modern science by providing the capability of placing instruments at new on-site observation points (i.e., in situ observations) to see the solar system as it actually is and allowing scientific investigators to collect otherwise unobtainable observational data of the solar system. The use of space exploration may, in fact, be the only viable means of addressing questions of the origin and evolution of the solar system and ultimately answering the related human questions discussed above.

The National Academy of Sciences and Presidential Scientific Advisory Committees, in recognizing the investigative capabilities provided by the space age, has recommended that future space efforts be directed toward questions of the origin and evolution of not only the solar system, but also of the large scale universe, of life itself along with the discovery of extraterrestrial life, and with particular emphasis on exploring the near-earth terrestrial environment. They further recommend that these space efforts be regarded as national goals [5, 6].

These recommendations are certainly in line with previous space activities, such as the International Geophysical Year (IGY), conducted in 1958, the exploration of near-earth space, the discovery of the Van Allen belts, and the retrieval of lunar rock and soil samples with the Apollo program.

The Human Value of Scientific Investigation

To clarify and answer the questions "What good are lunar rocks?" and "Who can profit from Moon rocks beside scientists?," one should recognize that stellar observations have revealed that there are many unstable stars in the universe which periodically flare up expelling mass in its near-environment that would have catastrophic effects on nearby and associated planetary systems. We may certainly ask the questions "Will the sun suddenly erupt and destroy life on the earth? Is the sun stable enough to support life over extended time periods? Is there any sign that fluctuations in the sun could affect ecological systems on earth?" Prior to the space program scientists typically held the opinion that the middle-aged sun was a stable body having a stable lifetime perhaps 10 to 11 billion years. The lunar rock samples have certainly confirmed these opinions to some extent by showing that today's sun and the sun of a million years ago have not undergone any appreciable change. The answers to additional questions concerning the earth's evolution as a result of the sun's evolution will no doubt provide greater visibility in course time, as we play back the records of time with further lunar exploration, including lunar rock and soil analysis.

Designing future space missions which meet these science goals will no doubt generate new questions and new mission requirements (Fig. 5).

In addition to further explorations of the Moon and our nearest planetary neighbors, Mars, Venus, and Mercury, the grand tours of the late seventies to the giant outer planets, along with future asteroid and comet missions, will provide a wealth of new information on the basic processes involved in the operation of our solar systems (Figs. 6-10). This information will further provide man with the greatest visibility he ever had since the beginning of time as to his origin and evolution. While it is obvious that such missions will be of direct benefit to the natural sciences, we ask "What is the human value of scientific investigations of the origin and evolution of the solar system?" The answer is that science can help man to answer his age-old human questions by examining the bridge between our human questions and science questions and recognizing that both sets of questions are, in a human sense, the same questions.

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TABLE 1. SOLAR SYSTEM OBJECTS

• SUN (A STAR)	• ASTEROIDS (30,000)
• TERRESTRIAL PLANETS (5)	• COMETS (580)
• GIANT PLANETS (4)	• METEORITES
• SATELLITES (32)	• DUST & PLASMA

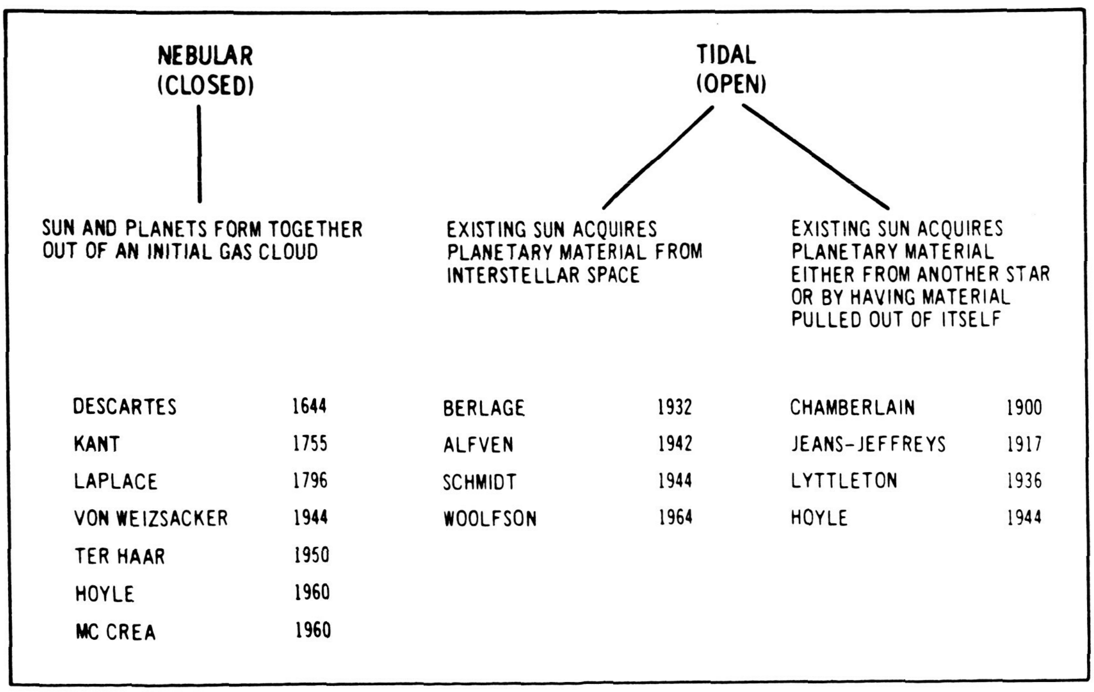

Figure 1. Solar system cosmologies.

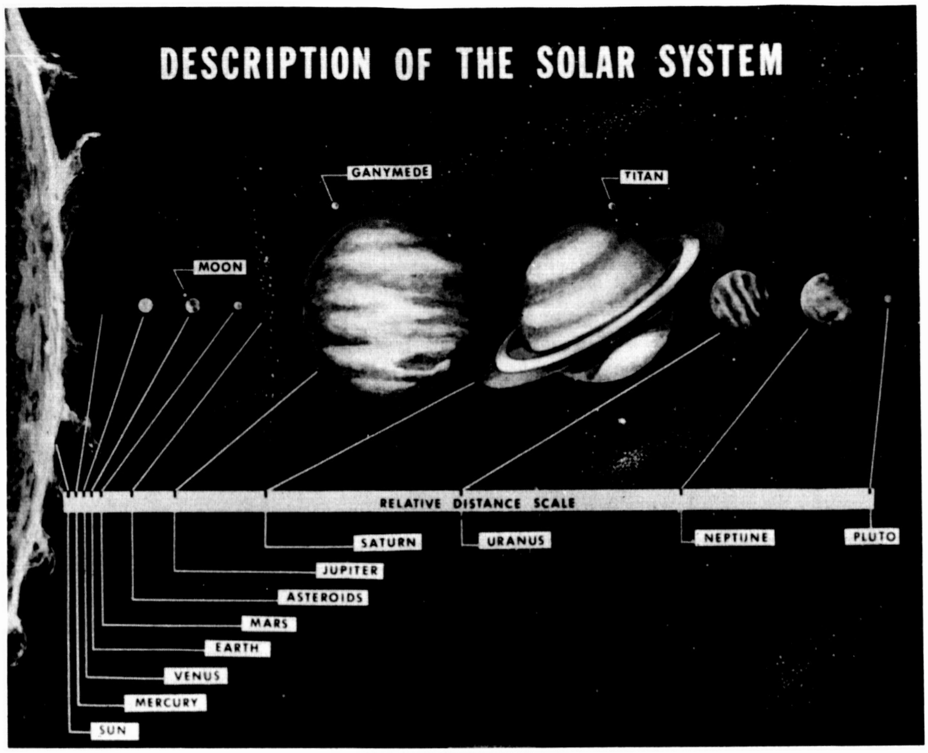

Figure 2. Description of the solar system.

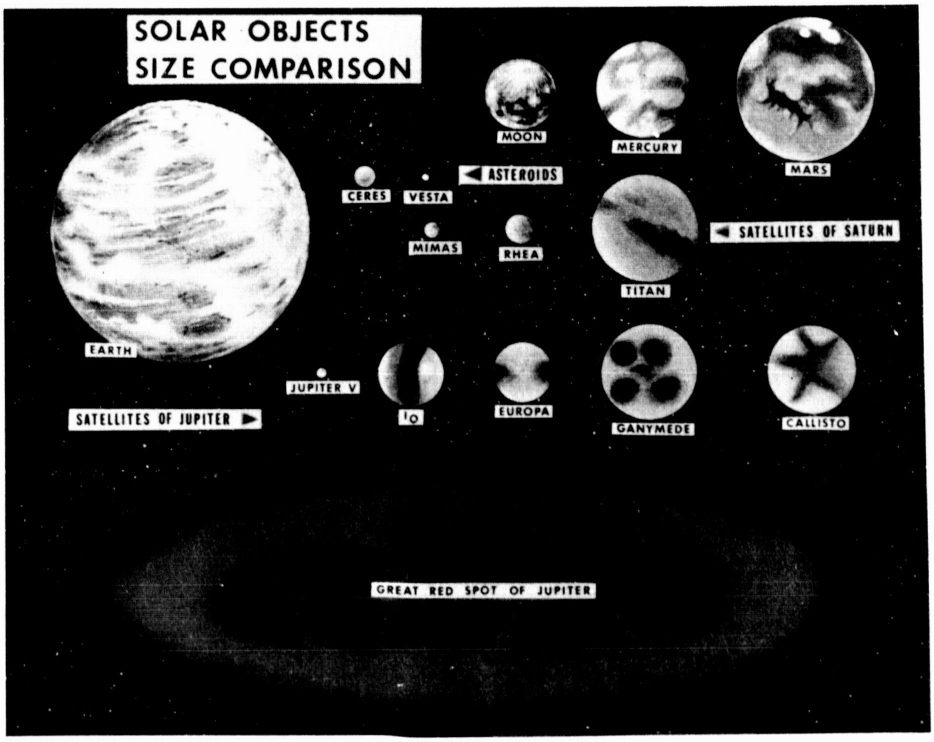

Figure 3. Solar objects size comparison.

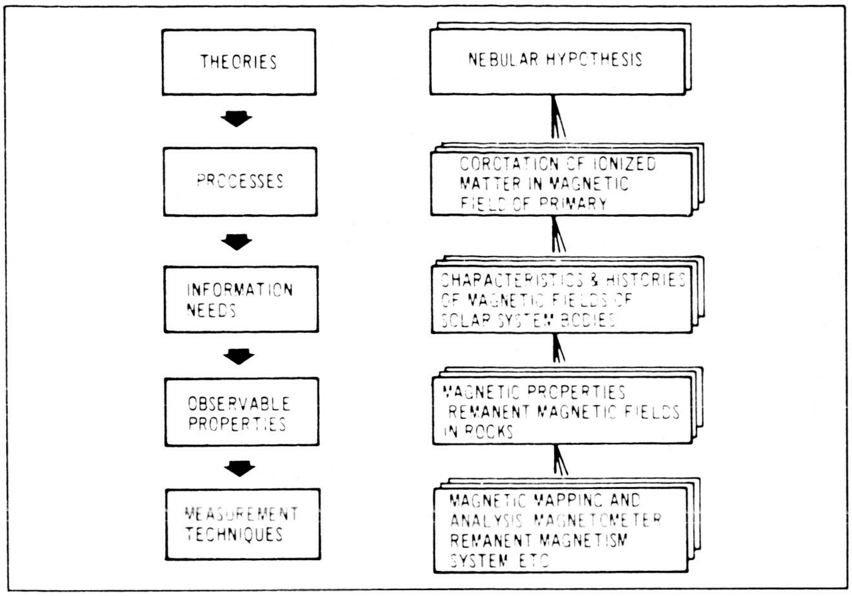

Figure 4. Space exploration rationale development.

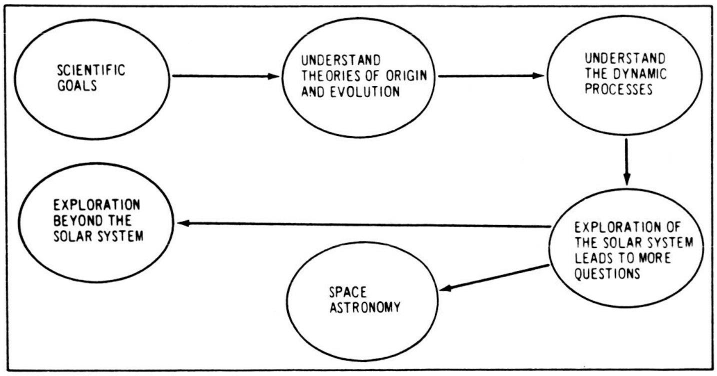

Figure 5. Relationship of scientific goals to space astronomy [7].

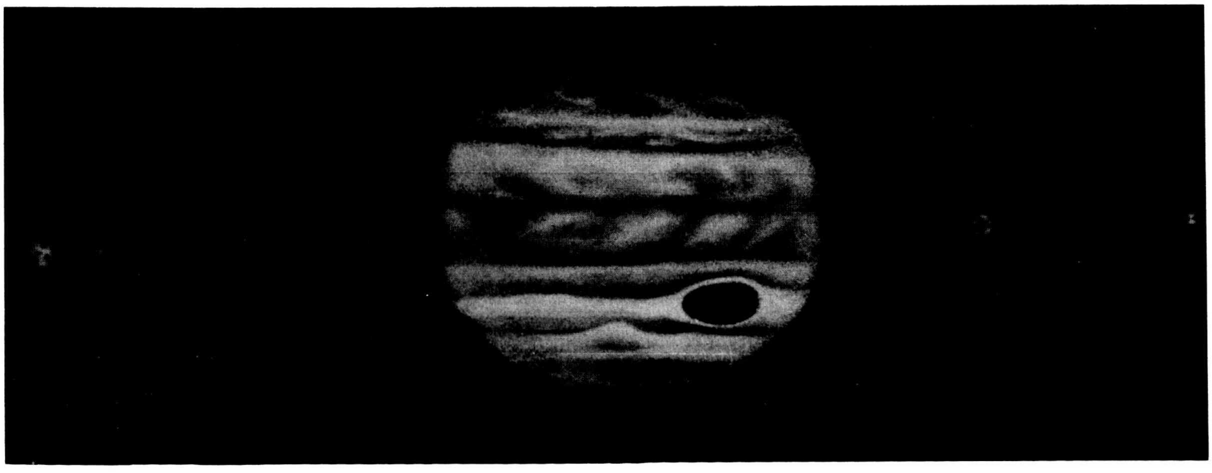

Figure 6. Planet Jupiter with its four moons.

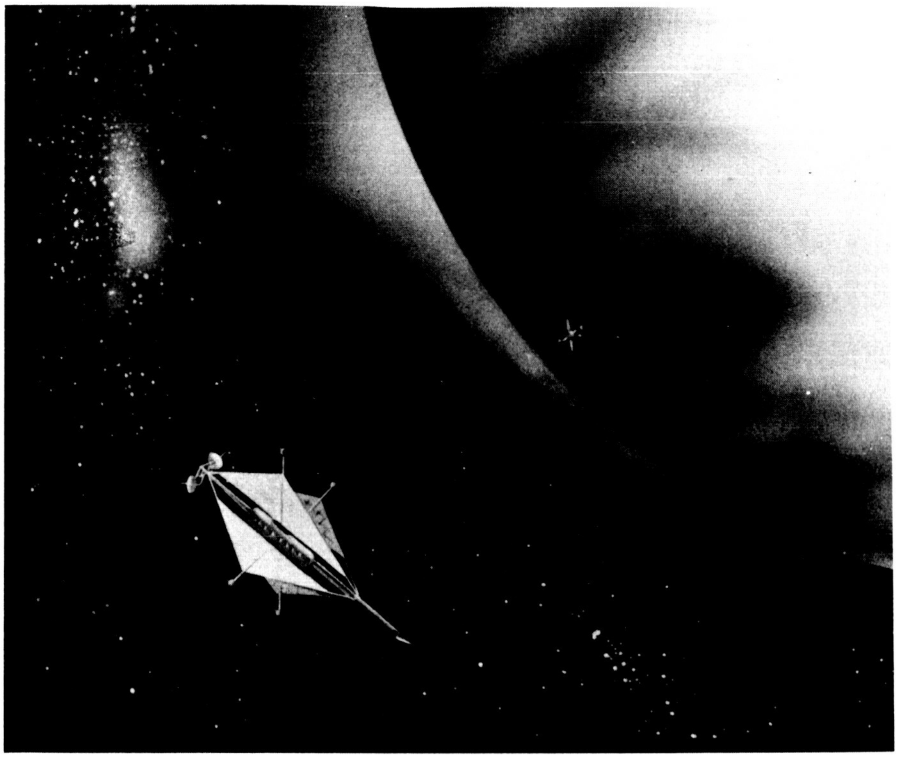

Figure 7. Exploration of Jupiter.

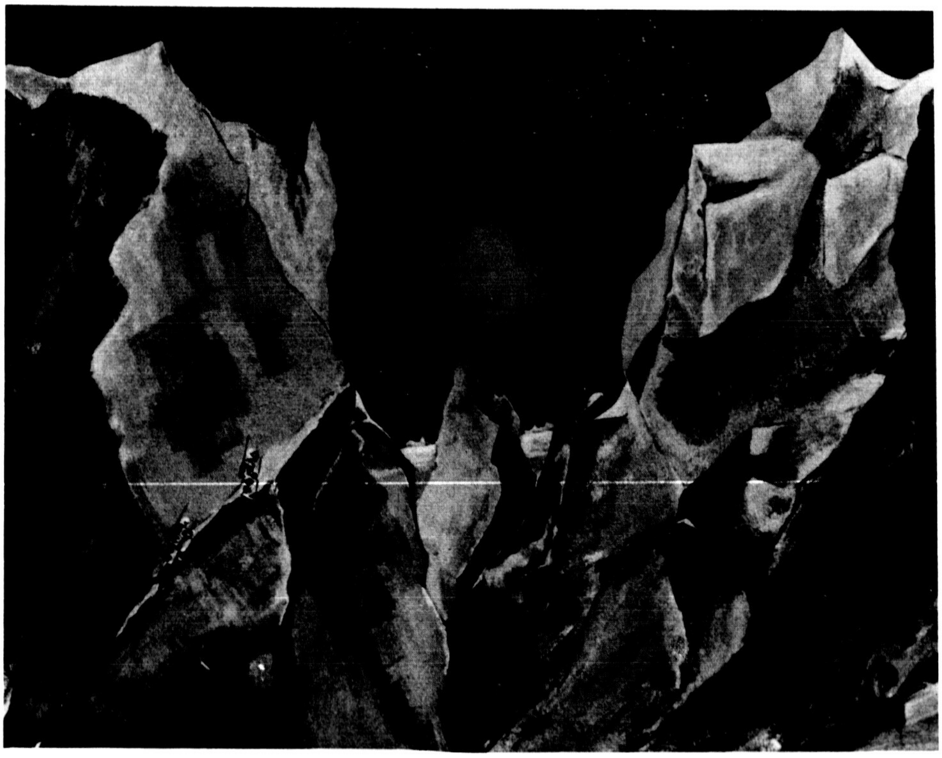

Figure 8. Manned exploration of Jupiter's moon, Ganymede.

Figure 9. Exploration of the rings of Saturn.

Figure 10. Manned exploration of Saturn's moon, Titan.