results. A spare column should of course be kept for abnormal details, etc.

Mrs. Voigt, one of our members, has already volunteered to take up this enquiry and the work is well suited to lady members. I hope others will also come forward and a start will be made. If so, it would help matters probably to divide up the classification or to collaborate. I have a certain number of photographs on which a start can be made; there are also some in the library as well as maps of the Moon and others would very easily be obtained.

Habitability of the Planets.

BY U. L. BANERJEE.

Mars.

Now let us consider how far Mars is fit for habitation. This planet travels round the Sun in 687 days and its average distance is 141½ million miles against 92,900,000 miles of the Earth. Its orbit is of considerable eccentricity ; the centre of its orbit being not less than 13,000,000 miles from the Sun. At favourable oppositions it comes within about 35½ million miles from us, and it then shines as a red star of more than twice the brightness of Sirius. The globe of Mars has a mean diameter of 4,230 miles and rotates in a period of 24 h. 37 m. 23 s. on an axis inclined 24° 50′ (according to some 23° 56′) to the plane of its orbit. The substance of Mars has an average density rather less than ¾ of the Earth, or very nearly 4 times that of water. Thus its force of gravity is much less than the gravity on the Earth, inasmuch as that a pound weight on the Earth's surface would weigh only 6 ozs. 3 dwts. on the surface of Mars. Its surface is less than that of the Earth in the proportion of about 25 : 64, or, in other words, the Earth's surface is about 2½ times that of Mars. When Mars is at its mean distance from the Sun, it receives light and heat about 2¼ times less than ours.

The inclination of its axis like our Earth gives it seasons not much different in character than that on the Earth except that the length of each season is nearly double of ours. The Martial axis is situated such that it summers in the northern hemisphere when its distance from the Sun is the greatest. The same thing occurs on the Earth and the Sun is 1,500,000 miles nearer to us in winter than in summer. In the case of Mars the effects are very striking, as it gets half as much light and heat again in perihelion as in aphelion. Thus summer in its northern hemisphere is much cooler, and its winter much warmer, and the contrast between these two seasons is not so striking as on the Earth.

The general surface is reddish in colour, but $\frac{3}{8}$ of it is covered by vivid green tracts, in the main permanent, though subject to minor variations by seasonal changes. These tracts were regarded as seas and oceans. The reddish tracts are regarded as great deserts. They are traversed by long narrow lines. They are thought to be canals, which take their origin from these oceans and could be traced across the continents for considerable distances. They form as it were a kind of net-work connecting different seas and sometimes reaching thousands of miles. They sometimes run in parallel doubled lines for considerable distances, a remarkable feature, nothing like which can be seen on the Earth. There are two white caps at the Poles, which increase until they reach a diameter of 45° to 50°. As summer advances these white tracts shrink in size and assume an area 4° to 5° in diameter and are surrounded by greenish tracts resembling the other greenish tracts and trees on its surface. These polar caps are regarded as snowy polar regions like our Earth which diminish in size by the melting of snow as the summer advances. The simultaneous development of straight greenish lines, connecting their green patches with other green tracts on its surface, led astronomers like Schiaparelli and Lowell to believe that these greenish lines are nothing but water-courses drawing the water from the Poles towards equatorial regions and on both sides of which vegetation abounds.

Besides these canals and the polar caps there are many other parts of the surface of Mars which alter their outlines from time to time. Change of colour, sometimes green, blue, sometimes brown and violet, are often observed on parts of the planet with the change of seasons, from which it is concluded that this is due to growth of vegetation around the watery regions.

The atmosphere of Mars is usually very transparent, although clouds or mists occasionally appear and cause obstructions to our view of the surface. The spectroscopic observations show that the atmosphere is very thin. The mass of Mars is so much smaller than that of the Earth that the force of gravity at the surface of the planet is too weak to retain an atmosphere of anything like the density of our own.

The above are the principal broad facts regarding the physical conditions of the planet. Now let us consider whether it is possible for life like ours to be existing under these conditions. Presence of water, atmosphere and seasonable solar heat, with solid crust of the globe consisting of elements of the Earth, are the chief factors for the existence of such life. Although dark patches on the surface are regarded to be seas or oceans, it is generally believed by astronomers that the body of water on its surface is not so plentiful as on the Earth. In summer seasons the dark patches abound, showing that at other seasons either the water dries up or its volume diminishes to such an extent that it is scarcely visible to the telescopic observer. If it is to be believed that waters completely dry up before the summer, it becomes a perplexing problem, how the water from the Polar regions travel to the equatorial regions by the numerous canals. Force of gravity is out of the question, as there are no high mountains on the Polar regions to allow the water to gravitate downwards towards the Equator.

It can perhaps be conceived that shallow water always exists in the canals and seas setting up a perpetual current between Polar and Equatorial seas (owing to differences of temperature in Equatorial and Tropical regions)—currents like those which exist in the Atlantic and Pacific Oceans of our globe. As either one or the other hemisphere always enjoys the summer season, the current flows with more or less regularity without making any part of the globe completely waterless.

Atmosphere there is although too attenuated to support a being possessing a respiratory organ like ours. But when upon the Earth there are animals who can live on the summits of highest mountains breathing the "thin atmosphere," the attenuated atmosphere does not seem to be a stumbling-block to the existence of life.

Next question is temperature. Astronomers like Professor Lowell and Poynting have calculated the average temperature between 36° to 48° F. As there are several places on our own globe having average temperature much lower, where myriads of animals of different types abound, it can hardly be believed that our ruddy globe with an average atmosphere of Southern England will be devoid of beings; but what these beings are like, what their physical constitution is, whether they are superior or inferior in the order of creation, there are no means at our disposal to know. The questions are left to posterity to solve, if they could ever be solved at all.

Jupiter.

Let us next pass to the giant Planet Jupiter, which is the noblest of all planets wending its majestic course with 4 large and 4 small satellites in an elliptic orbit around the Sun at a mean distance of 483,000,000 miles, which is 5·2 times the distance of the Earth from the Sun. Its greatest distance from the Sun is 5·45, while the least distance is 4·95 times the Earth's distance. Its mean diameter is 87,000 miles, *i.e.*, about 11 times that of the Earth the equatorial diameter being 89,600 miles, while the polar one is 84,400 miles. Its mass is 316, its volume about 1,300 times that of the Earth. Gravity on its surface is about $2\frac{1}{2}$ times as great as on our Earth. The light and heat which it receives from the Sun is about $\frac{1}{25}$ of our supply. Its density is only $\frac{1}{4}$ that of the Earth, *i.e.*, a little greater than that of water. It rotates round its axis in rather less than 9 h. 55 m., so that the length of the Jupiter day is much less than the terrestrial day. The axis is almost perpendicular to the plane of its orbit, the deviation being only 3°, so that there are no appreciable seasonal changes as on our Earth. The period of its revolution round the Sun is about 12 of our year or $4,332\frac{1}{2}$ of our days. Its surface is marked by belts of red and purple and white moving almost parallel to its equator. They form a sort of concentric belts dividing the surface in so many zones. The planet has got 4 large and 4 small satellites, the 5 inner ones revolving round it in about $\frac{1}{2}$, 2, 4, 7 and 17 days, at a distance of 112,500, 261,000, 415,000, 664,000 and 1,167,000 miles from it.

Its habitability depends upon the presence of normal average temperature, atmosphere and water. The intensity of the Sun's heat on the planet is only a mere fraction, less than 25th part of what we receive on the Earth, but as the inclination of the axis is only 3° the Sun passes every day almost perpendicularly overhead at the equator. The maximum heat is thus poured on the equatorial region. As the time of rotation is only 9 h. 55 m. the heat which its surface absorbs in the day time may not completely radiate at night as the atmosphere envelopes store the radiated heat for some time, and the heat may gradually accumulate making the average temperature much higher than it would otherwise have been the case. At the poles the Sun seems to glide along the horizon rising in the east, passing towards the south and then setting in the west. In intermediate latitudes the Sun passes to a southernly elevation, greater or less according as the region is nearer or further from the equator. Thus the temperature varies from its maximum at the equator to its minimum at the poles, giving all shades of climatic conditions to intermediate regions.

Next let us see what evidence there is of the existence of an atmospheric envelope to protect these dark rays radiating into the space. Careful observations of the markings on its surface show that belts running parallel to the equator dividing the surface in so many zones, continually change in shape and size. Their continuity is disturbed by formations like circular spots which completely fill up after a time. Their appearance is like that of so many vortices formed under the influence of storms in our terrestrial atmosphere. Those atmospheric storms of the Earth are the effects of the solar heat. The heat rays striking on the surface warm the air in contact therewith. The heated air becomes lighter and rises, while air from a colder region rushes in to fill up the gap causing thereby a breeze or a wind. Under exceptional circumstances these develop in cyclones and hurricanes. The way in which the surface markings change their shape shows that the air in the equatorial regions is replaced by colder air of the polar regions by a sort of wind corresponding to the trade wind on our Earth, and it is not unreasonable to believe that this change of shapes of the markings is partly due to the disturbance in the atmosphere on the globe. The changes in the surface markings are, however, of exceptionally gigantic nature, so the astronomers do not solely attribute them to atmospheric disturbances. They are of opinion that the planet still retains a portion of its primitive internal heat, and as the Sun is disturbed by violent tempests consequent on its intense internal heat, so in a lesser degree the same phenomenon appear on Jupiter. But what the necessity of that heat is and whether it is apt to make the globe uninhabitable there is not much evidence. Absence of self-luminosity of the globe as proved by the completely dark shadows of satellites thrown on its surface while passing between the Sun and the planet, and complete disappearance of the satellites when they pass through the planet's shadow during the eclipse periods, shows that the internal heat is not like that of the Sun making it unsuitable for habitation.

Astronomers also believe in the existence of aqueous vapour in its atmosphere, and they think that the dark belts are nothing but cloud belts. Their existence could not have been discovered on the edge of the planet's disc by some irregularity in the level—as the cloud must have projected slightly beyond the real outline of the planet. It might be that the atmosphere depth is not large enough to be susceptible of measurement at such long distances and the low height at which the clouds ordinarily suspend on the atmosphere escape detection by telescopes entirely. But whether these clouds condense into water and whether there is sufficient water on its surface, we have no direct evidence as on Mars.

Taking all these facts into consideration one is led to think that the planet is not a barren globe like our Moon. If it is not inhabited at present, it has, in the distant future, the prospect of a glorious career, as the residence of organic life.

Extracts from Publications.

Dr. Stromgren, of Copenhagen, according to the *Athenæum*, has computed an orbit for the minor planet Hector, taking account of the perturbations produced by Jupiter and Saturn. There are, of course, several hundreds of these small bodies whose orbits are known; but Hector is one of four which are distinguished for a particular reason. Most of the orbits lie between those of Mars and Jupiter, but in 1898, a planet, since named Eros, was found whose orbit interlaced that of Mars, and in 1906 another was discovered whose peculiarity lay in the opposite direction for it went at times well outside the orbit of Jupiter. Since then others of the same type have been discovered; so there are now four minor planets, called respectively by the names of Homeric heroes—Achilles, Hector, Patroclus and Nestor.

[*English Mechanic.*

Here is an interesting experiment and an absolute proof of the Moon's rotation. Obtain a light spherical object, such as a boy's football, and paint half of it white. In the centre of the painted hemisphere fix a string about 4 feet long. Raise the arm above the head and swing the ball around at the 4 feet radius at a fairly good speed. The ball now assumes the conditions of the Moon's revolution; it continually presents the painted side towards the hand. Now without a sudden jerk, release the string, the ball will then fly off at a tangent, and will be observed rotating on its own axis, as it rushes through the air. If it was not rotating when revolving, whence did it get this new motion from? This simple experiment could be elaborated with ease and a little skill, and would quite crush the opposite theory.—R. W. GREEN.

[*English Mechanic.*