VENUS AS THE ABODE OF LIFE.*

THE MYSTERY OF A CLOUD-VEILED PLANET.

BY F. W. HENKEL.

Of all the heavenly bodies, the sun and moon only excepted, there is probably none of more interest to us than this planet. Approaching at times to a distance less than that of any other star, the great variations in its distance from us cause corresponding variations in luster. Though many speculations as to the possible inhabitants of Mars and their supposed engineering works (the so-called "canals," etc.) have been mooted with more or less ingenuity, in our opinion the probabilities in favor of the habitability of Venus are vastly greater. This planet, says Prof. Young, is "the

FIG. 1.—PHASES OF VENUS.

1 and 5, near inferior conjunction; 2, at greatest elongation; 3, at gibbous phase; 4, superior conjunction.

earth's twin sister in magnitude, density, and general constitution." Though its distance from the sun is less than three-quarters that of our own earth (about 67,000,000 miles), varying only very slightly (its path being the most nearly circular of any known planet), and consequently any given area of its surface must receive about twice as much heat as we receive on an equal area, yet this is probably mitigated by the presence of a more extensive atmosphere laden with water vapor. From time to time different observers have deduced differing periods for the length of its day, but the most probable period seems to be about 23½ hours, or rather less than our own day. Its year (owing, of course, to its greater nearness to the sun and its swifter motion) is only about 225 days, its speed in its path round the sun being 23 miles per second. Its diameter is 7,700 miles, while that of the earth is about 7,900 miles, so that the planet is slightly smaller, its mass (or quantity of matter) is rather over three-quarters that of the earth, and consequently the average density of the materials composing it is 86 per cent of the terrestrial density. A body dropped from a point near its surface would acquire a velocity of 27 feet per second at the end of one second, instead of 32 feet per second as here, and would move over 13½ feet during the first second of its motion. Surface markings have been seen from time to time upon the planet, more distinctly observed in Italy and other more favored latitudes than our own. On account of its general proximity to the region of the sky in which the sun is found, and its great brilliancy in the telescope, Venus is by no means an easy object to scrutinize with satisfactory results.

However, its phases or changes of appearance, like the moon, are easily perceived with very small optical aid, and were among the first fruits of the invention of the telescope, exactly three centuries ago. Galileo, who first discovered that the planet exhibited the crescent phase and the other appearances presented by the

FIG. 2.

S, Sun; V, Venus; E, Earth; V₁, Inferior conjunction; V₂, V₄, Greatest elongations; V₃, Superior conjunction.

moon, announced his discovery in a curious anagram, which being interpreted read (in Latin) "The Mother of Loves (Venus) imitates the phases of Cynthia (the moon)." The explanation of these phases is precisely similar to those of the moon, and their appearance was a strong confirmation of the truth of the Copernican theory. Venus being an opaque body is visible only by the light which she receives from the sun and reflects. The hemisphere turned toward the sun is, of course, illuminated, the other side in darkness; more or less of the illuminated hemisphere being turned toward the earth at different times. When the planet lies beyond the sun, turning toward the earth

the whole of its illuminated hemisphere, it is seen (if not too close to the sun's place in the sky) as a small round disk. Fig. 1 (4). When at its greatest elongation east or west of the sun, about half the illuminated side is turned toward us and the planet is seen like the moon half full, but owing to its greater proximity appears half of a considerably larger disk than before. Fig. 1 (2). Near inferior conjunction, i. e., where the planet is between earth and sun and on the same side of it, the planet is seen as a very thin crescent of large size, as it is then at its nearest to us. Fig. 1 (5).

The planet is brightest (to us) about 36 days before and after inferior conjunction.

From Fig. 2 we may see the great variations in distance of this planet from the earth—least at V₁ and greatest at V₃. Also, since at greatest elongation the angle EV₂S is a right angle, by observing the angle of elongation SEV₂ we may find the proportion SV₂ bears to SE, or the ratio of Venus's distance from the sun

to the earth's distance, for $\frac{SV_2}{SE} = \sin SEV_2$, and the

angle of elongation SEV₂ is 47° ∴ SV₂ = SE sin 47° = 0.73 (SE being taken as unity) or, as we have already stated, Venus's distance is rather less than three-quarters that of the earth from the sun.

From certain irregularities observed upon the terminator, or boundary of the limb, and the blunted appearance of one of the cusps of the crescent, various observers have concluded that there exist high mountains upon the planet's surface. Sometimes when the planet is in the crescent phase intensely bright spots have been seen near the polar regions, which may per-

FIG. 3.—BIANCHINI'S MAP.

haps be ice-caps like those seen on Mars. Darkish markings, indicating continents and seas "dimly visible," are also at times seen, and a rough map of Venus was made by Bianchini long ago. His observations were confirmed by thousands of observations made by De Vico and his assistants, so may be considered to represent real features of the surface.

We have already stated that there is evidence of the existence of an atmosphere, and from observations of the transit of the planet across the sun's disk in 1874 it was concluded that the atmosphere is about 1½ times to twice as extensive as our own. The existence of water vapor has been shown by the spectroscope.

At times the dark portion of the planet, unilluminated by the sun's light, has been faintly visible, from which it has been considered probable that phenomena of the nature of the auroræ take place from time to time upon Venus. So far as known, the planet has no satellite or moon attendant upon it, but to a great extent the want of a moon is made up for, to the possible inhabitants, by the earth. When Venus and the earth are nearest, as we have already said, they are on the same side of the sun, and the planet, turning its dark side toward us, is invisible, like the moon when new. On the other hand the earth has the whole of its illuminated side turned toward the planet, is on the opposite part of the sky to the sun, and is consequently visible as a brilliant object ("full earth") in the night sky of the planet. We know from the phenomenon of earth-shine that the earth reflects a considerable quantity of light to the moon, part of which is again reflected back to us, and if we suppose the intrinsic reflecting power of the earth's surface to be equal to that of Venus (it may be, indeed, and probably is, considerably less) it must give much greater light to the planet and be a much more brilliant object in its sky than Venus ever appears to us, owing to the following circumstances. When brightest only a small part of the planet's illuminated surface is turned toward us, but even so it appears more conspicuous than any other star or planet in our sky, and is often visible in daylight. On the other hand the whole of the earth's illuminated hemisphere is turned toward Venus when they are at their nearest together, and the earth

is then on the meridian at the planet's midnight, being in "opposition" to the sun. Thus as a night luminary the earth to some extent plays toward Venus the part the moon does for us.

Occasionally Venus passes directly between the earth and the sun at inferior conjunction, and is seen projected as a black dot on the sun's surface crossing it from east to west, sufficiently large to be visible to the unaided eye. Ordinarily, owing to the fact that the plane of its path is inclined at a small angle (3½ deg.)

FIG. 4.

EF, Earth; V, Venus; S, Sun; a f c, Planet's path seen from F; d e g, Planet's path from E.

to the plane of the ecliptic (earth's path), it passes a little to the north or a little to the south of the sun's place. These transits across the sun's surface have a special interest for astronomers, owing to their affording an opportunity for determining the sun's distance from the earth with great accuracy. Accordingly expeditions have been made to distant parts of the earth to observe these transits when they occurred. The transit of 1769 was observed by Capt. Cook at Otaheite, he having been sent by the government of that date to the South Seas at the request of the Royal Society. The transit of 1882 was visible in this country, and was also observed in various other parts of the world. When Venus passes between the earth and sun she is at her nearest to us—between three and four times nearer than is the sun. Consequently, as seen from different parts of the earth, Venus will be seen to cross different portions of the sun's disk, and by exactly determining the planet's path as seen at the different stations whose distance from one another is known, it is possible to determine both the planet's and the earth's distance from the sun. In Halley's method two stations at which the transit is visible are chosen, the stations being one as far north and the other as far south as possible. The duration of transit (i. e., the time occupied by the planet in crossing the sun's disk) is observed at each station, and knowing the planet's velocity in its path, the length of the chords a f c, d e g is known, the displacement f e being the measure of FE at the sun (while from the similar triangles EVF, e V f we shall also get EF : e f :: VF : V f, etc.). (Fig. 4.) Knowing the ratio of VF to V f, and the distance EF, all the other distances may be thus easily found (in miles, etc.).

There are, however, practical difficulties in the way of determining the exact instant the planet enters and leaves the sun's disk, different observers having obtained differences of about ten to fifteen seconds of time, though observing side by side. The atmosphere of Venus causes its edge to be more diffuse than would otherwise be the case, and the phenomenon of the black drop, at internal contact, also complicates mat-

FIG. 5.

ters. Instead of touching sharply, a kind of ligament or "black drop" extends from the planet to the sun (Fig. 5), a similar effect to that which is observed when we bring two fingers in contact and then hold them up to the light and separate them; as they separate a "black ligament" will appear to connect them for a short space. By means of photography, it was attempted to render the results more certain; but so far the photographic methods give no better satisfaction than the others. It is now generally considered that the transit of Venus method, though admirable in theory, has proved of less value than was expected, in practice, and by the time the next transit comes round (there are no more till 2004 A. D., nearly a century hence) other methods are likely to have given better results.

We have seen that there is evidence of the existence of continents and seas, air, and water vapor upon the planet. The amount of sunlight it receives, though greater than our share, is not excessively so, for there

* Knowledge and Scientific News.

appears reason to believe that polar snow-caps exist, and in other respects, for conditions favorable to the existence of beings organized not very much unlike

those with which we are familiar on this earth, we have as much evidence as we can reasonably expect. We may thus conclude that the planet is in most re-

spects not dissimilar to the earth, and is the abode of life, at least in the regions north and south of the equator, if not on the "torrid zone" itself.

INTERNATIONAL OCEAN RESEARCH.*

A PHYSICAL AND BIOLOGICAL SURVEY OF THE NORTH SEA.

BY A. E. SHIPLEY, M.A.

AS AN example of international co-operation in scientific research I may take the investigations which have been going on for the last seven years in the Baltic Sea, in the North Sea, and in that great Norwegian Sea which stretches from the western coast of Norway north to Spitzbergen and westward beyond Iceland and the Faroes. In this inquiry no less than ten nations—in fact, all those whose shores touch these seas—have had a share—England, Scotland, Norway, Sweden, Finland, Russia, Germany, Denmark, Holland, and Belgium; and since most of these countries have a special steamer equipped for research and under the command of men trained in scientific methods, it has been possible to collect a mass of facts connected with the seas of northern Europe such as has never been got together before for any similar area of the ocean.

The aim of those responsible for the scheme of work was to obtain as complete a survey as possible of the physical and biological conditions of the seas in question. They wanted to know the direction of ocean currents, both superficial and along the bottom; the variations in the degree of salinity of the water in time and in space; the nature of the sea-bottom, and whether this could be correlated with the fauna, sessile or moving, found upon it, and whether this fauna reacted on the prevalence or absence of food-fishes; the influence of depth, salinity, and temperature on the fauna; the seasonal variations and fluctuations of the small floating organisms often called the plankton; the life history of our food-fishes, where and when they deposited their ova; what became of the ova; the distribution of the larval stages; the age at which the fish become mature, and their average length of life.

Then, again, it was hoped that much could be learned about the influence of man's activity on the sea. The relative depletion of the fish population caused by different modes of fishing; the intensity of trawling; how often does the trawl pass over the same ground in a given time? The question whether or no the seas are being over-fished, and, if so, what measures can be taken to lessen this evil, either by close time, limiting the size of fish captured, or by artificial fish-breeding. Many of these last-named problems concern the legislator as much as the man of science. The function of the latter is to provide facts upon which the administrator may act.

Such a vast task as was set out by the International Council in 1902 has necessitated an immense organization. Some eight or ten steamers are employed making periodic voyages, under the direction of trained men of science. Enormous numbers of temperature-readings, investigations into the speed and direction of currents, and chemical analyses of sea-water have been recorded, and thousands of samples of the bottom, of the animals and plants living thereon, of fish in all stages, millions of fish ova, have been collected and accurately determined. To work up such an amount of material has occupied the attention of a large number of naturalists. Each country has at least one large laboratory devoted to this work, and their results are co-ordinated and generalized by the central bureau. The English part of the work was intrusted by the Lords of the Treasury to the Marine Biological Association, and has been carried out under the direction of Dr. E. J. Allen and Prof. Walter Garstang at our laboratories at Plymouth and Lowestoft.

Although all the ten countries are working upon what is, broadly speaking, a common plan, each has had its own special problems. In addition to carrying out the broad outlines of an international scheme, they have specialized along lines indicated by their own needs, and have attacked problems whose solution affected their own special food supply. Thus Norway, where the old open fishing boat is being replaced by the modern, decked trawler, has especially studied the cod and the saithe, the haddock, and the herring, and has devoted much time and labor to the discovery of new fishing grounds, and has successfully done this along the Norse coast, in the Arctic circle, and on the banks between the Faroe Islands and Iceland. They have further established a trade in *Pandalus borealis*, allied to the prawns, which are taken in the deep waters off Norway, and are now to be bought in most fishmongers' shops in Great Britain.

In a similar way the Danes have tracked the eels as they leave the estuaries of the great rivers of Central Europe across the North Sea to the deep Atlantic off the west of Ireland, just beyond the 1,000 fathom line. In these depths they spawn and the resulting larval form, the *Leptocephalus*, long thought to be a separate genus, lives there for a while, until, gradually changing into an elver, it retraces by some mysterious instinct its parents' path across the ocean and regains the fresh-water rivers which those parents had left.

The English share of the investigation is limited to that part of the North Sea which lies south of the latitude of Berwick, and for the most part to the western half of the seas and to the English Channel; the latter, as we shall see, is a very important area. The work, so far as it has been specialized, deals, in the North Sea, largely with the plaice, with the food of fishes generally, and with the character of the deposits forming the sea floor, with the creatures growing thereon. In the channel the English worker is entirely responsible for the study of the hydrography of the water, which, entering the North Sea through the Straits of Dover, contributes greatly to its mass.

As a result of Prof. Garstang's investigations, an important spawning ground of the plaice has been located in the southern bight of the North Sea; the migration of both sexes has been traced to these grounds on the advent of the spawning season, and their return to their feeding grounds in the spring has been followed. During the spawning season it is usual to catch more males than females on the spawning grounds, possibly because at this time the female is inert and elusive, while the male is unusually active.

The course of the ova has been traced, chiefly by the Dutch investigators, as they drift toward the shallow fringe of coastal water, by far the greater number along the continental coast. Here the young fry grow up, and after attaining a certain size they leave the shallow coastal waters for the deeper seas off shore. Comparatively few of these, however, reach the feeding ground of the Dogger Bank, and Garstang has been able to show that by carrying the young plaice in steamers and transplanting them at the proper time on to this rich feeding ground, their rate of growth can be greatly accelerated and thus their market value largely increased, just as Dr. Petersen has done in the case of plaice on Thisted Bredning.

A few years ago there was no reliable method of determining the age of fish. Petersen's method of arranging the measurements of a large number of specimens in a scale according to size, when they resolved themselves into certain groups, which were considered to coincide with age-classes, has been superseded by the discovery of Reibisch, Heincke, and others, that many of the bones, the scales, and the otoliths of fishes show annual age-rings, like those found in the trunk of a tree or in the horns of cattle. By laboriously counting the rings on the otoliths of thousands of plaice, Dr. Wallace and others have been able to determine their rate of growth, and to show that some specimens attain the age of twenty-five and even twenty-nine years. Similar investigations have shown that the sexes have a different rate of growth. The age at maturity is found to differ in different regions, but in the majority of cases Wallace found that the males are sexually mature (four to five years) a year before the female is capable of spawning (five to six years). We can now correlate age with size and with weight.

The migrations of the plaice and of other fish and their rate of growth depend, among many other factors, upon their food supply. And the nature of the food of fishes has recently been re-investigated in the North Sea. I give some of Todd's results, which were made by the examination of some thousands of fish of thirty-one species. Of these I select three—the cod, the plaice, and the dab.

Percentages of Stomachs Containing Various Kinds of Food.

	Cod.			
Size of fish in cm...	0—15	15—30	30—60	60+
Pisces	0 p.c.	11 p.c.	52 p.c.	67 p.c.
Mollusca	0	2	16	4
Crustacea	100	95	67	63
Polychaeta	0	9	9	26

	Plaice.			
Size of fish in cm...	0—10	10—20	20—30	30+
Pisces	0 p.c.	1 p.c.	5 p.c.	5 p.c.
Mollusca	17	66	76	84
Crustacea	57	16	13	11
Polychaeta	38	37	51	42
Echinoderma	0	20	13	6

	Dabs.			
Size of fish in cm...	0—10	10—20	20—30	30+
Coelenterata	0 p.c.	18 p.c.	18 p.c.	20 p.c.
Echinoderma	0	26	25	2
Polychaeta	30	22	20	10
Crustacea	70	30	35	61
Mollusca	2	48	57	65

These tables show what, of course, was more or less known before, that as a rule the young fry live very largely, and in many cases solely, on crustacea. To a great extent the supply of suitable food dominates the movement of the young fry, for nowhere is the truth of the Frenchman's definition of life, "I eat, thou eatest, he eats," with its terrible correlative, "I am eaten, thou art eaten, he is eaten," more true than in the sea. Later in life the fishes' taste alters, and with increased size they can tackle animals whose calcareous deposits would seem to render them highly indigestible.

Very careful investigations have been made and are being made by Mr. Borley and Mr. Todd as to the distribution of the fauna of the middle and southern parts of the North Sea, and its relation to the depth of water, the varying degree of salinity, and to the texture of the bottom deposits. These results, however, have not been published, but I may go as far as to say that the inquiry shows that within the area investigated the texture of the sea floor has, on the whole, more influence on the distribution of the invertebrates of the bottom fauna than has depth, and that depth in the area in question seems to have more influence than salinity.

With regard to the character of the bottom deposits, it has been found by Mr. Borley that off shore and on the gently shelving continental coast the sea bottom is of a uniform character over wide areas, though on the western side it is more patchy; and it has proved possible to divide the samples taken into some nineteen main types, each characteristic of one or more of the areas into which the region has been split up. Only one or two details of this laborious work can be mentioned. One is that the texture or degree of coarseness of the ground in various parts of the sea is such as to suggest that the distribution of the finer grades of material, the finer sands and silts, is greatly influenced by the joint action of currents and tides. It is, for instance, known that in the southern part of the North Sea the main direction of the bottom current is to the north and then to the east; and examination of the deposits shows a regular diminution in the proportion of the coarser sands, a regular increase in the proportion of finer material, as we proceed from the Straits of Dover in a northeasterly direction. A remarkable fact in this connection is the complete absence of silt from the sandy bottom west of the mouths of the great rivers Rhine and Maas. There can be no doubt that the presence of broad and shallow stretches of sand on the continental, but not on the English, side of the North Sea is one of the factors which has determined the distribution of the small plaice, which on the continental shores are so extraordinarily abundant, and on the English shores are relatively so scarce.

By means of bottles weighted with shot, so as to have about the same specific gravity as the surrounding sea water, Mr. G. P. Bidder has been able to trace slow currents moving over the bottom of the sea. The bottles are closed, and contain a post card in many languages, offering a reward to whosoever returns the post card, recording the latitude and longitude of the place it was trawled at, to our laboratory at Lowestoft. Attached to the neck of the bottle is a copper wire 1½ feet long. This wire trails along the bottom, the bottle itself floating about 1¼ feet above the level of the ground. Slowly as the bottles are swept along, yet the distance they cover is sufficient to sharpen the free end of the wire to a needle point.

By these and by other methods it has been possible to trace the almost imperceptible but steady flow of waters along the bed of the sea. Without doubt these currents influence the distribution of the larval and

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