CHAPTER VI

FROM LYRA TO ERIDANUS

"This Orpheus struck when with his wondrous song
He charmed the woods and drew the rocks along."--MANILIUS.

We resume our celestial explorations with the little constellation Lyra, whose chief star, Vega (alpha), has a very good claim to be regarded as the most beautiful in the sky. The position of this remarkable star is indicated in map No. 17. Every eye not insensitive to delicate shades of color perceives at once that Vega is not white, but blue-white. When the telescope is turned upon the star the color brightens splendidly. Indeed, some glasses decidedly exaggerate the blueness of Vega, but the effect is so beautiful that one can easily forgive the optical imperfection which produces it. With our four-inch we look for the well-known companion of Vega, a tenth-magnitude star, also of a blue color deeper than the hue of its great neighbor. The distance is 50", p. 158°. Under the most favorable circumstances it might be glimpsed with the three-inch, but, upon the whole, I should regard it as too severe a test for so small an aperture.

Vega is one of those stars which evidently are not only enormously larger than the sun (one estimate makes the ratio in this case nine hundred to one), but whose physical condition, as far as the spectroscope reveals it, is very different from that of our ruling orb. Like Sirius, Vega displays the lines of hydrogen most conspicuously, and it is probably a much hotter as well as a much more voluminous body than the sun.

Close by, toward the east, two fourth-magnitude stars form a little triangle with Vega. Both are interesting objects for the telescope, and the northern one, epsilon, has few rivals in this respect. Let us first look at it with an opera glass. The slight magnifying power of such an instrument divides the star into two twinkling points. They are about two and a quarter minutes of arc apart, and exceptionally sharp-sighted persons are able to see them divided with the naked eye. Now take the three-inch telescope and look at them, with a moderate power. Each of the two stars revealed by the opera glass appears double, and a fifth star of the ninth magnitude is seen on one side of an imaginary line joining the two pairs. The northern-most pair is named epsilon1, the magnitudes being fifth and sixth, distance 3", p. 15°. The other pair is epsilon2, magnitudes fifth and sixth, distance 2.3", p. 133°. Each pair is apparently a binary; but the period of revolution is unknown. Some have guessed a thousand years for one pair, and two thousand for the other. Another guess gives epsilon1 a period of one thousand years, and epsilon2 a period of eight hundred years. Hall, in his double-star observations, simply says of each, "A slow motion."

Purely by guesswork a period has also been assigned to the two pairs in a supposed revolution around their common center, the time named being about a million years. It is not known, however, that such a motion exists. Manifestly it could not be ascertained within the brief period during which scientific observations of these stars have been made. The importance of the element of time in the study of stellar motions is frequently overlooked, though not, of course, by those who are engaged in such work. The sun, for instance, and many of the stars are known to be moving in what appear to be straight lines in space, but observations extending over thousands of years would probably show that these motions are in curved paths, and perhaps in closed orbits.

If now in turn we take our four-inch glass, we shall see something else in this strange family group of epsilon Lyræ. Between epsilon1 and epsilon2, and placed one on each side of the joining line, appear two exceedingly faint specks of light, which Sir John Herschel made famous under the name of the debillissima. They are of the twelfth or thirteenth magnitude, and possibly variable to a slight degree. If you can not see them at first, turn your eye toward one side of the field of view, and thus, by bringing their images upon a more sensitive part of the retina, you may glimpse them. The sight is not much, yet it will repay you, as every glance into the depths of the universe does.

The other fourth-magnitude star near Vega is zeta, a wide double, magnitudes fourth and sixth, distance 44", p. 150°. Below we find beta, another very interesting star, since it is both a multiple and an eccentric variable. It has four companions, three of which we can easily see with our three-inch; the fourth calls for the five-inch; the magnitudes are respectively four, seven or under, eight, eight and a half, and eleven; distances 45", p. 150°; 65", p. 320°; 85", p. 20°; and 46", p. 248°. The primary, beta, varies from about magnitude three and a half to magnitude four and a half, the period being twelve days, twenty-one hours, forty-six minutes, and fifty-eight seconds. Two unequal maxima and minima occur within this period. In the spectrum of this star some of the hydrogen lines and the D3 line (the latter representing helium, a constituent of the sun and of some of the stars, which, until its recent discovery in a few rare minerals was not known to exist on the earth) are bright, but they vary in visibility.

Moreover, dark lines due to hydrogen also appear in its spectrum simultaneously with the bright lines of that element. Then, too, the bright lines are sometimes seen double. Professor Pickering's explanation is that beta Lyræ probably consists of two stars, which, like the two composing beta Aurigæ, are too close to be separated with any telescope now existing, and that the body which gives the bright lines is revolving in a circle in a period of about twelve days and twenty-two hours around the body which gives the dark lines. He has also suggested that the appearances could be accounted for by supposing a body like our sun to be rotating in twelve days and twenty-two hours, and having attached to it an enormous protuberance extending over more than one hundred and eighty degrees of longitude, so that when one end of it was approaching us with the rotation of the star the other end would be receding, and a splitting of the spectral lines at certain periods would be the consequence. "The variation in light," he adds, "may be caused by the visibility of a larger or smaller portion of this protuberance."

Unfortunate star, doomed to carry its parasitical burden of hydrogen and helium, like Sindbad in the clasp of the Old Man of the Sea! Surely, the human imagination is never so wonderful as when it bears an astronomer on its wings. Yet it must be admitted that the facts in this case are well calculated to summon the genius of hypothesis. And the puzzle is hardly simplified by Bélopolsky's observation that the body in beta Lyræ giving dark hydrogen lines shows those lines also split at certain times. It has been calculated, from a study of the phenomena noted above, that the bright-line star in beta Lyræ is situated at a distance of about fifteen million miles from the center of gravity of the curiously complicated system of which it forms a part.

We have not yet exhausted the wonders of Lyra. On a line from beta to gamma, and about one third of the distance from the former to the latter, is the celebrated Ring Nebula, indicated on the map by the number 4447. We need all the light we can get to see this object well, and so, although the three-inch will show it, we shall use the five-inch. Beginning with a power of one hundred diameters, which exhibits it as a minute elliptical ring, rather misty, very soft and delicate, and yet distinct, we increase the magnification first to two hundred and finally to three hundred, in order to distinguish a little better some of the details of its shape. Upon the whole, however, we find that the lowest power that clearly brings out the ring gives the most satisfactory view. The circumference of the ring is greater than that of the planet Jupiter. Its ellipticity is conspicuous, the length of the longer axis being 78" and that of the shorter 60". Closely following the nebula as it moves through the field of view, our five-inch telescope reveals a faint star of the eleventh or twelfth magnitude, which is suspected of variability. The largest instruments, like the Washington and the Lick glasses, have shown perhaps a dozen other stars apparently connected with the nebula. A beautiful sparkling effect which the nebula presents was once thought to be an indication that it was really composed of a circle of stars, but the spectroscope shows that its constitution is gaseous. Just in the middle of the open ring is a feeble star, a mere spark in the most powerful telescope. But when the Ring Nebula is photographed--and this is seen beautifully in the photographs made with the Crossley reflector on Mount Hamilton by the late Prof. J. E. Keeler--this excessively faint star imprints its image boldly as a large bright blur, encircled by the nebulous ring, which itself appears to consist of a series of intertwisted spirals.

Not far away we find a difficult double star, 17, whose components are of magnitudes six and ten or eleven, distance 3.7", p. 325°.

From Lyra we pass to Cygnus, which, lying in one of the richest parts of the Milky Way, is a very interesting constellation for the possessor of a telescope. Its general outlines are plainly marked for the naked eye by the figure of a cross more than twenty degrees in length lying along the axis of the Milky Way. The foot of the cross is indicated by the star beta, also known as Albireo, one of the most charming of all the double stars. The three-inch amply suffices to reveal the beauty of this object, whose components present as sharp a contrast of light yellow and deep blue as it would be possible to produce artificially with the purest pigments. The magnitudes are three and seven, distance 34.6", p. 55°. No motion has been detected indicating that these stars are connected in orbital revolution, yet no one can look at them without feeling that they are intimately related to one another. It is a sight to which one returns again and again, always with undiminished pleasure. The most inexperienced observer admires its beauty, and after an hour spent with doubtful results in trying to interest a tyro in double stars it is always with a sense of assured success that one turns the telescope to beta Cygni.

Following up the beam of the imaginary cross along the current of the Milky Way, every square degree of which is here worth long gazing into, we come to a pair of stars which contend for the name-letter chi. On our map the letter is attached to the southernmost of the two, a variable of long period--four hundred and six days--whose changes of brilliance lie between magnitudes four and thirteen, but which exhibits much irregularity in its maxima. The other star, not named but easily recognized in the map, is sometimes called 17. It is an attractive double whose colors faintly reproduce those of beta. The magnitudes are five and eight, distance 26", p. 73°. Where the two arms of the cross meet is gamma, whose remarkable cortége of small stars running in curved streams should not be missed. Use the lowest magnifying power.

At the extremity of the western arm of the cross is delta, a close double, difficult for telescopes of moderate aperture on account of the difference in the magnitudes of the components. We may succeed in dividing it with the five-inch. The magnitudes are three and eight, distance 1.5", p. 310°. It is regarded as a binary of long and as yet unascertained period.

In omicron^2 we find a star of magnitude four and orange in color, having two blue companions, the first of magnitude seven and a half, distance 107", p. 174°, and the second of magnitude five and a half, distance 358", p. 324°. Farther north is psi, which presents to us the combination of a white five-and-a-half-magnitude star with a lilac star of magnitude seven and a half. The distance is 3", p. 184°. A very pretty sight.

We now pass to the extremity of the other arm of the cross, near which lies the beautiful little double 49, whose components are of magnitudes six and eight, distance 2.8", p. 50°. The colors are yellow and blue, conspicuous and finely contrasted. A neighboring double of similar hues is 52, in which the magnitudes are four and nine, distance 6", p. 60°. Sweeping a little way northward we come upon an interesting binary, lambda, which is unfortunately beyond the dividing power of our largest glass. A good seven-inch or seven-and-a-half-inch should split it under favorable circumstances. Its magnitudes are six and seven, distance 0.66", p. 74°.

The next step carries us to a very famous object, 61 Cygni, long known as the nearest star in the northern hemisphere of the heavens. It is a double which our three-inch will readily divide, the magnitudes being both six, distance 21", p. 122°. The distance of 61 Cygni, according to Hall's parallax of 0.27", is about 70,000,000,000,000 miles. There is some question whether or not it is a binary, for, while the twin stars are both moving in the same direction in space with comparative rapidity, yet conclusive evidence of orbital motion is lacking. When one has noticed the contrast in apparent size between this comparatively near-by star, which the naked eye only detects with considerable difficulty, and some of its brilliant neighbors whose distance is so great as to be immeasurable with our present means, no better proof will be needed of the fact that the faintness of a star is not necessarily an indication of remoteness.

We may prepare our eyes for a beautiful exhibition of contrasted colors once more in the star . This is really a quadruple, although only two of its components are close and conspicuous. The magnitudes are five, six, seven and a half, and twelve; distances 2.4", p. 121°; 208", p. 56°; and 35", p. 264°. The color of the largest star is white and that of its nearest companion blue; the star of magnitude seven and a half is also blue.

The star cluster 4681 is a fine sight with our largest glass. In the map we find the place marked where the new star of 1876 made its appearance. This was first noticed on November 24, 1876, when it shone with the brilliance of a star of magnitude three and a half. Its spectrum was carefully studied, especially by Vogel, and the very interesting changes that it underwent were noted. Within a year the star had faded to less than the tenth magnitude, and its spectrum had completely changed in appearance, and had come to bear a close resemblance to that of a planetary nebula. This has been quoted as a possible instance of a celestial collision through whose effects the solid colliding masses were vaporized and expanded into a nebula. At present the star is very faint and can only be seen with the most powerful telescopes. Compare with the case of Nova Aurigæ, previously discussed.

Underneath Cygnus we notice the small constellation Vulpecula. It contains a few objects worthy of attention, the first being the nebula 4532, the "dumb-bell nebula" of Lord Rosse. With the four-inch, and better with the five-inch, we are able to perceive that it consists of two close-lying tufts of misty light. Many stars surround it, and large telescopes show them scattered between the two main masses of the nebula. The Lick photographs show that its structure is spiral. The star 11 points out the place where a new star of the third magnitude appeared in 1670. Sigma 2695 is a close double, magnitudes six and eight, distance 0.96", p. 78°.

We turn to map No. 18, and, beginning at the western end of the constellation Aquarius, we find the variable T, which ranges between magnitudes seven and thirteen in a period of about two hundred and three days. Its near neighbor Sigma 2729 is a very close double, beyond the separating power of our five-inch, the magnitudes being six and seven, distance 0.6", p. 176°. Sigma 2745, also known as 12 Aquarii, is a good double for the three-inch. Its magnitudes are six and eight, distance 2.8", p. 190°. In zeta we discover a beauty. It is a slow binary of magnitudes four and four, distance 3.1", p. 321°. According to some observers both stars have a greenish tinge. The star 41 is a wider double, magnitudes six and eight, distance 5", p. 115°, colors yellow and blue. The uncommon stellar contrast of white with light garnet is exhibited by tau, magnitudes six and nine, distance 27", p. 115°. Yellow and blue occur again conspicuously in psi, magnitudes four and a half and eight and a half, distance 50", p. 310°. Rose and emerald have been recorded as the colors exhibited in Sigma 2998, whose magnitudes are five and seven, distance 1.3", p. 346°.

The variables S and R are both red. The former ranges between magnitudes eight and twelve, period two hundred and eighty days, and the latter between magnitudes six and eleven, period about three hundred and ninety days.

The nebula 4628 is Rosse's "Saturn nebula," so called because with his great telescope it presented the appearance of a nebulous model of the planet Saturn. With our five-inch we see it simply as a planetary nebula. We may also glance at another nebula, 4678, which appears circular and is pinned with a little star at the edge.

The small constellation Equuleus contains a surprisingly large number of interesting objects. Sigma 2735 is a rather close double, magnitudes six and eight, distance 1.8", p. 287°. Sigma 2737 (the first star to the left of Sigma 2735, the name having accidentally been omitted from the map) is a beautiful triple, although the two closest stars, of magnitudes six and seven, can not be separated by our instruments. Their distance in 1886 was 0.78", p. 286°, and they had then been closing rapidly since 1884, when the distance was 1.26". The third star, of magnitude eight, is distant 11", p. 75°. Sigma 2744 consists of two stars, magnitudes six and seven, distance 1.4", p. 1.67°. It is probably a binary. Sigma 2742 is wider double, magnitudes both six, distance 2.6", p. 225°. Another triple, one of whose components is beyond our reach, is gamma. Here the magnitudes are fifth, twelfth, and sixth, distances 2", p. 274° and 366". It would also be useless for us to try to separate delta, but it is interesting to remember that this is one of the closest of known double stars, the magnitudes being fourth and fifth, distance 0.4", p. 198°. These data are from Hall's measurements in 1887. The star is, no doubt, a binary. With the five-inch we may detect one and perhaps two of the companion stars in the quadruple beta. The magnitudes are five, ten, and two eleven, distances 67", p. 309°; 86", p. 276°; and 6.5", p. 15°. The close pair is comprised in the tenth-magnitude star.

Map No. 19 introduces us to the constellation Pegasus, which is comparatively barren to the naked eye, and by no means rich in telescopic phenomena. The star epsilon, of magnitude two and a half, has a blue companion of the eighth magnitude, distance 138", p. 324°; colors yellow and violet. A curious experiment that may be tried with this star is described by Webb, who ascribes the discovery of the phenomenon to Sir John Herschel. When near the meridian the small star in epsilon appears, in the telescope, underneath the large one. If now the tube of the telescope be slightly swung from side to side the small star will appear to describe a pendulumlike movement with respect to the large one. The explanation suggested is that the comparative faintness of the small star causes its light to affect the retina of the eye less quickly than does that of its brighter companion, and, in consequence, the reversal of its apparent motion with the swinging of the telescope is not perceived so soon.

The third-magnitude star eta has a companion of magnitude ten and a half, distance 90", p. 340°. The star beta, of the second magnitude, and reddish, is variable to the extent of half a magnitude in an irregular period, and gamma, of magnitude two and a half, has an eleventh-magnitude companion, distance 162", p. 285°.

Our interest is revived on turning, with the guidance of map No. 20, from the comparative poverty of Pegasus to the spacious constellation Cetus. The first double star that we meet in this constellation is 26, whose components are of magnitudes six and nine, distance 16.4", p. 252°; colors, topaz and lilac. Not far away is the closer double 42, composed of a sixth and a seventh magnitude star, distance 1.25", p. 350°. The four-inch is capable of splitting this star, but we shall do better to use the five-inch. In passing we may glance at the tenth-magnitude companion to eta, distance 225", p. 304°. Another wide pair is found in zeta, magnitudes three and nine, distance 185", p. 40°.

The next step brings us to the wonderful variable omicron, or Mira, whose changes have been watched for three centuries, the first observer of the variability of the star having been David Fabricius in 1596. Not only is the range of variability very great, but the period is remarkably irregular. In the time of Hevelius, Mira was once invisible for four years. When brightest, the star is of about the second magnitude, and when faintest, of the ninth magnitude, but at maximum it seldom exhibits the greatest brilliance that it has on a few occasions shown itself capable of attaining. Ordinarily it begins to fade after reaching the fourth or fifth magnitude. The period averages about three hundred and thirty-one days, but is irregularly variable to the extent of twenty-five days. Its color is red, and its spectrum shows bright lines, which it is believed disappear when the star sinks to a minimum. Among the various theories proposed to account for such changes as these the most probable appears to be that which ascribes them to some cause analogous to that operating in the production of sun spots. The outburst of light, however, as pointed out by Scheiner, should be regarded as corresponding to the maximum and not the minimum stage of sun-spot activity. According to this view, the star is to be regarded as possessing an extensive atmosphere of hydrogen, which, during the maximum, is upheaved into enormous prominences, and the brilliance of the light from these prominences suffices to swamp the photospheric light, so that in the spectrum the hydrogen lines appear bright instead of dark.

It is not possible to suppose that Mira can be the center of a system of habitable planets, no matter what we may think of the more constant stars in that regard, because its radiation manifestly increases more than six hundred fold, and then falls off again to an equal extent once in every ten or eleven months. I have met people who can not believe that the Almighty would make a sun and then allow its energies "to go to waste," by not supplying it with a family of worlds. But I imagine that if they had to live within the precincts of Mira Ceti they would cry out for exemption from their own law of stellar utility.

The most beautiful double star in Cetus is gamma, magnitudes three and seven, distance 3", p. 288°; hues, straw-color and blue. The leading star alpha, of magnitude two and a half, has a distant blue companion three magnitudes fainter, and between them are two minute stars, the southernmost of which is a double, magnitudes both eleven, distance 10", p. 225°.

The variable S ranges between magnitudes seven and twelve in a somewhat irregular period of about eleven months, while R ranges between the seventh and the thirteenth magnitudes in a period of one hundred and sixty-seven days.

The constellation Eridanus, represented in map No. 21, contains a few fine double stars, one of the most interesting of which is 12, a rather close binary. The magnitudes are four and eight, distance 2", p. 327°. We shall take the five-inch for this, and a steady atmosphere and sharp seeing will be necessary on account of the wide difference in the brightness of the component stars. Amateurs frequently fail to make due allowance for the effect of such difference. When the limit of separating power for a telescope of a particular aperture is set at 1" or 2", as the case may be, it is assumed that the stars composing the doubles on which the test is made shall be of nearly the same magnitude, or at least that they shall not differ by more than one or two magnitudes at the most. The stray light surrounding a comparatively bright star tends to conceal a faint companion, although the telescope may perfectly separate them so far as the stellar disks are concerned. Then, too, I have observed in my own experience that a very faint and close double is more difficult than a brighter pair not more widely separated, usually on account of the defect of light, and this is true even when the components of the faint double are of equal magnitude.

Sigma 470, otherwise known as 32 Eridani, is a superb object on account of the colors of its components, the larger star being a rich topaz and the smaller an ultramarine; while the difference in magnitude is not as great as in many of the colored doubles. The magnitudes are five and seven, distance 6.7", p. 348°. The star gamma, of magnitude two and a half, has a tenth-magnitude companion, distant 51", p. 238°. Sigma 516, also called 39 Eridani, consists of two stars of magnitudes six and nine, distance 6.4", p. 150°; colors, yellow and blue. The supposed binary character of this star has not yet been established.

In omicron^2 we come upon an interesting triple star, two of whose components at any rate we can easily see. The largest component is of the fourth magnitude. At a distance of 82", p. 105°, we find a tenth-magnitude companion. This companion is itself double, the magnitudes of its components being ten and eleven, distance 2.6", p. 98°. Hall says of these stars that they "form a remarkable system." He has also observed a fourth star of the twelfth magnitude, distant 45" from the largest star, p. 85°. This is apparently unconnected with the others, although it is only half as distant as the tenth-magnitude component is from the primary. Sigma 590 is interesting because of the similarity of its two components in size, both being of about the seventh magnitude, distance 10", p. 318°.

Finally, we turn to the nebula 826. This is planetary in form and inconspicuous, but Lassell has described it as presenting a most extraordinary appearance with his great reflector--a circular nebula lying upon another fainter and larger nebula of a similar shape, and having a star in its center. Yet it may possibly be an immensely distant star cluster instead of a nebula, since its spectrum does not appear to be gaseous.