CHAPTER III

FROM GEMINI TO LEO AND ROUND ABOUT

"If thou wouldst gaze on starry Charioteer,
And hast heard legends of the wondrous Goat,
Vast looming shalt thou find on the Twins' left,
His form bowed forward."--POSTE'S ARATUS.

The zodiacal constellations of Gemini, Cancer, and Leo, together with their neighbors Auriga, the Lynx, Hydra, Sextans, and Coma Berenices, will furnish an abundance of occupation for our second night at the telescope. We shall begin, using our three-inch glass, with alpha, the chief star of Gemini (map No. 4). This is ordinarily known as Castor. Even an inexperienced eye perceives at once that it is not as bright as its neighbor Pollux, beta. Whether this fact is to be regarded as indicating that Castor was brighter than Pollux in 1603, when Bayer attached their Greek letters, is still an unsettled question. Castor may or may not be a variable, but it is, at any rate, one of the most beautiful double stars in the heavens. A power of one hundred is amply sufficient to separate its components, whose magnitudes are about two and three, the distance between them being 6", p. 226°. A slight yet distinct tinge of green, recalling that of the Orion nebula, gives a peculiar appearance to this couple. Green is one of the rarest colors among the stars. Castor belongs to the same general spectroscopic type in which Sirius is found, but its lines of hydrogen are broader than those seen in the spectrum of the Dog Star. There is reason for thinking that it may be surrounded with a more extensive atmosphere of that gaseous metal called hydrogen than any other bright star possesses. There seems to be no doubt that the components of Castor are in revolution around their common center of gravity, although the period is uncertain, varying in different estimates all the way from two hundred and fifty to one thousand years; the longer estimate is probably not far from the truth. There is a tenth-magnitude star, distance 73", p. 164°, which may belong to the same system.

From Castor let us turn to Pollux, at the same time exchanging our three-inch telescope for the four-inch, or, still better, the five-inch. Pollux has five faint companions, of which we may expect to see three, as follows: Tenth magnitude, distance 175", p. 70°; nine and a half magnitude, distance 206", p. 90°, and ninth magnitude, distance 229", p. 75°. Burnham has seen a star of thirteen and a half magnitude, distance 43", p. 275°, and has divided the tenth-magnitude star into two components, only 1.4" apart, the smaller being of the thirteenth magnitude, and situated at the angle 128°. A calculation based on Dr. Elkin's parallax of 0.068" for Pollux shows that that star may be a hundredfold more luminous than the sun, while its nearest companion may be a body smaller than our planet Jupiter, but shining, of course, by its own light. Its distance from Pollux, however, exceeds that of Jupiter from the sun in the ratio of about one hundred and thirty to one.

In the double star pi we shall find a good light test for our three-inch aperture, the magnitudes being six and eleven, distance 22", p. 212°. The four-inch will show that kappa is a double, magnitudes four and ten, distance 6", p. 232°. The smaller star is of a delicate blue color, and it has been suspected of variability. That it may be variable is rendered the more probable by the fact that in the immediate neighborhood of kappa there are three undoubted variables, S, T, and U, and there appears to be some mysterious law of association which causes such stars to group themselves in certain regions. None of the variables just named ever become visible to the naked eye, although they all undergo great changes of brightness, sinking from the eighth or ninth magnitude down to the thirteenth or even lower. The variable R, which lies considerably farther west, is well worth attention because of the remarkable change of color which it sometimes exhibits. It has been seen blue, red, and yellow in succession. It varies from between the sixth and seventh magnitudes to less than the thirteenth in a period of about two hundred and forty-two days.

Not far away we find a still more curious variable zeta; this is also an interesting triple star, its principal component being a little under the third magnitude, while one of the companions is of the seventh magnitude, distance 90", p. 355°, and the other is of the eleventh magnitude or less, distance 65", p. 85°. We should hardly expect to see the fainter companion with the three-inch. The principal star varies from magnitude three and seven tenths down to magnitude four and a half in a period of a little more than ten days.

With the four-or five-inch we get a very pretty sight in delta, which appears split into a yellow and a purple star, magnitudes three and eight, distance 7", p. 206°.

Near delta, toward the east, lies one of the strangest of all the nebulæ. (See the figures 1532 on the map.) Our telescopes will show it to us only as a minute star surrounded with a nebulous atmosphere, but its appearance with instruments of the first magnitude is so astonishing and at the same time so beautiful that I can not refrain from giving a brief description of it as I saw it in 1893 with the great Lick telescope. In the center glittered the star, and spread evenly around it was a circular nebulous disk, pale yet sparkling and conspicuous. This disk was sharply bordered by a narrow black ring, and outside the ring the luminous haze of the nebula again appeared, gradually fading toward the edge to invisibility. The accompanying cut, which exaggerates the brightness of the nebula as compared with the star, gives but a faint idea of this most singular object. If its peculiarities were within the reach of ordinary telescopes, there are few scenes in the heavens that would be deemed equally admirable.

In the star eta we have another long-period variable, which is also a double star; unfortunately the companion, being of only the tenth magnitude and distant less than 1" from its third-magnitude primary, is beyond the reach of our telescopes. But eta points the way to one of the finest star clusters in the sky, marked 1360 on the map. The naked eye perceives that there is something remarkable in that place, and the opera glass faintly reveals its distant splendors, but the telescope fairly carries us into its presence. Its stars are innumerable, varying from the ninth magnitude downward to the last limit of visibility, and presenting a wonderful array of curves which are highly interesting from the point of view of the nebular origin of such clusters. Looking backward in time, with that theory to guide us, we can see spiral lines of nebulous mist occupying the space that now glitters with interlacing rows of stars. It is certainly difficult to understand how such lines of nebula could become knotted with the nuclei of future stars, and then gradually be absorbed into those stars; and yet, if such a process does not occur, what is the meaning of that narrow nebulous streak in the Pleiades along which five or six stars are strung like beads on a string? The surroundings of this cluster, 1360, as one sweeps over them with the telescope gradually drawing toward the nucleus, have often reminded me of the approaches to such a city as London. Thicker and closer the twinkling points become, until at last, as the observers eye follows the gorgeous lines of stars trending inward, he seems to be entering the streets of a brilliantly lighted metropolis.

Other objects in Gemini that we can ill miss are: , double, magnitudes three and eleven, distance 73", p. 76°, colors yellow and blue; 15, double, magnitudes six and eight, distance 33", p. 205°; gamma, remarkable for array of small stars near it; 38, double, magnitudes six and eight, distance 6.5", p. 162°, colors yellow and blue (very pretty);

lambda, double, magnitudes four and eleven, distance 10", p. 30°, color of larger star blue--try with the five-inch; epsilon, double, magnitudes three and nine, distance 110", p. 94°.

From Gemini we pass to Cancer. This constellation has no large stars, but its great cluster Præsepe (1681 on map No. 4) is easily seen as a starry cloud with the naked eye. With the telescope it presents the most brilliant appearance with a very low power. It was one of the first objects that Galileo turned to when he had completed his telescope, and he wonderingly counted its stars, of which he enumerated thirty-six, and made a diagram showing their positions.

The most interesting star in Cancer is zeta, a celebrated triple. The magnitudes of its components are six, seven, and seven and a half; distances 1.14", p. 6°, and 5.7", p. 114°. We must use our five-inch glass in order satisfactorily to separate the two nearest stars. The gravitational relationship of the three stars is very peculiar. The nearest pair revolve around their common center in about fifty-eight years, while the third star revolves with the other two, around a center common to all three, in a period of six or seven hundred years. But the movements of the third star are erratic, and inexplicable except upon the hypothesis advanced by Seeliger, that there is an invisible, or dark, star near it by whose attraction its motion is perturbed.

In endeavoring to picture the condition of things in zeta Cancri we might imagine our sun to have a companion sun, a half or a third as large as itself, and situated within what may be called planetary distance, circling with it around their center of gravity; while a third sun, smaller than the second and several times as far away, and accompanied by a black or non-luminous orb, swings with the first two around another center of motion. There you would have an entertaining complication for the inhabitants of a system of planets!

Other objects in Cancer are: Sigma 1223, double star, magnitudes six and six and a half, distance 5", p. 214°; Sigma 1291, double, magnitudes both six, distance 1.3", p. 328°--four-inch should split it; iota, double, magnitudes four and a half and six and a half, distance 30", p. 308°; 66, double magnitudes six and nine, distance 4.8", p. 136°; Sigma 1311, double, magnitudes both about the seventh, distance 7", p. 200°; 1712, star cluster, very beautiful with the five-inch glass.

The constellation of Auriga may next command our attention (map No. 5). The calm beauty of its leading star Capella awakens an admiration that is not diminished by the rivalry of Orion's brilliants glittering to the south of it. Although Capella must be an enormously greater sun than ours, its spectrum bears so much resemblance to the solar spectrum that a further likeness of condition is suggested. No close telescopic companion to Capella has been discovered. A ninth-magnitude companion, distant 159", p. 146°, and two others, one of twelfth magnitude at 78", p. 317°, the other of thirteenth magnitude at 126", p. 183°, may be distant satellites of the great star, but not planets in the ordinary sense, since it is evident that they are self-luminous. It is a significant fact that most of the first-magnitude stars have faint companions which are not so distant as altogether to preclude the idea of physical relationship.

But while Capella has no visible companion, Campbell, of the Lick Observatory, has lately discovered that it is a conspicuous example of a peculiar class of binary stars only detected within the closing decade of the nineteenth century. The nature of these stars, called spectroscopic binaries, may perhaps best be described while we turn our attention from Capella to the second star in Auriga beta (Menkalina), which not only belongs to the same class, but was the first to be discovered. Neither our telescopes, nor any telescope in existence, can directly reveal the duplicity of beta Aurigæ to the eye--i. e., we can not see the two stars composing it, because they are so close that their light remains inextricably mingled after the highest practicable magnifying power has been applied in the effort to separate them. But the spectroscope shows that the star is double and that its components are in rapid revolution around one another, completing their orbital swing in the astonishingly short period of four days! The combined mass of the two stars is estimated to be two and a half times the mass of the sun, and the distance between them, from center to center, is about eight million miles.

The manner in which the spectroscope revealed the existence of two stars in beta Aurigæ is a beautiful illustration of the unexpected and, so to speak, automatic application of an old principle in the discovery of new facts not looked for. It was noticed at the Harvard Observatory that the lines in the photographed spectrum of beta Aurigæ (and of a few other stars to be mentioned later) appeared single in some of the photographs and double in others. Investigation proved that the lines were doubled at regular intervals of about two days, and that they appeared single in the interim. The explanation was not far to seek. It is known that all stars which are approaching us have their spectral lines shifted, by virtue of their motion of approach, toward the violet end of the spectrum, and that, for a similar reason, all stars which are receding have their lines shifted toward the red end of the spectrum. Now, suppose two stars to be revolving around one another in a plane horizontal, or nearly so, to the line of sight. When they are at their greatest angular distance apart as seen from the earth one of them will evidently be approaching at the same moment that the other is receding. The spectral lines of the first will therefore be shifted toward the violet, and those of the second will be shifted toward the red. Then if the stars, when at their greatest distance apart, are still so close that the telescope can not separate them, their light will be combined in the spectrum; but the spectral lines, being simultaneously shifted in opposite directions, will necessarily appear to be doubled. As the revolution of the stars continues, however, it is clear that their motion will soon cease to be performed in the line of sight, and will become more and more athwart that line, and as this occurs the spectral lines will gradually assume their normal position and appear single. This is the sequence of phenomena in beta Aurigæ. And the same sequence is found in Capella and in several other more or less conspicuous stars in various parts of the heavens.

Such facts, like those connecting rows and groups of stars with masses and spiral lines of nebula are obscure signboards, indicating the opening of a way which, starting in an unexpected direction, leads deep into the mysteries of the universe.

Southward from beta we find the star theta, which is a beautiful quadruple. We shall do best with our five-inch here, although in a fine condition of the atmosphere the four-inch might suffice. The primary is of the third magnitude; the first companion is of magnitude seven and a half, distance 2", p. 5°; the second, of the tenth magnitude, distance 45", p. 292°; and the third, of the tenth magnitude, distance 125", p. 350°.

We should look at the double Sigma 616 with one of our larger apertures in order to determine for ourselves what the colors of the components are. There is considerable diversity of opinion on this point. Some say the larger star is pale red and the smaller light blue; others consider the color of the larger star to be greenish, and some have even called it white. The magnitudes are five and nine, distance 6", p. 350°.

Auriga contains several noteworthy clusters which will be found on the map. The most beautiful of these is 1295, in which about five hundred stars have been counted.

The position of the new star of 1892, known as Nova Aurigæ, is also indicated on the map. While this never made a brilliant appearance, it gave rise to a greater variety of speculative theories than any previous phenomenon of the kind. Although not recognized until January 24, 1892, this star, as photographic records prove, was in existence on December 9, 1891. At its brightest it barely exceeded magnitude four and a half, and its maximum occurred within ten days after its first recognition. When discovered it was of the fifth magnitude. It was last seen in its original form with the Lick telescope on April 26th, when it had sunk to the lowest limit of visibility. To everybody's astonishment it reappeared in the following August, and on the 17th of that month was seen shining with the light of a tenth-magnitude star, but presenting the spectrum of a nebula! Its visual appearance in the great telescope was now also that of a planetary nebula. Its spectrum during the first period of its visibility had been carefully studied, so that the means existed for making a spectroscopic comparison of the phenomenon in its two phases. During the first period, when only a stellar spectrum was noticed, remarkable shiftings of the spectral lines occurred, indicating that two and perhaps three bodies were concerned in the production of the light of the new star, one of which was approaching the earth, while the other or the others receded with velocities of several hundred miles per second! On the revival in the form of a planetary nebula, while the character of the spectrum had entirely changed, evidences of rapid motion in the line of sight remained.

But what was the meaning of all this? Evidently a catastrophe of some kind had occurred out there in space. The idea of a collision involving the transformation of the energy of motion into that of light and heat suggests itself at once. But what were the circumstances of the collision? Did an extinguished sun, flying blindly through space, plunge into a vast cloud of meteoric particles, and, under the lashing impact of so many myriads of missiles, break into superficial incandescence, while the cosmical wrack through which it had driven remained glowing with nebulous luminosity? Such an explanation has been offered by Seeliger. Or was Vogel right when he suggested that Nova Aurigæ could be accounted for by supposing that a wandering dark body had run into collision with a system of planets surrounding a decrepit sun (and therefore it is to be hoped uninhabited), and that those planets had been reduced to vapor and sent spinning by the encounter, the second outburst of light being caused by an outlying planet of the system falling a prey to the vagabond destroyer? Or some may prefer the explanation, based on a theory of Wilsing's, that two great bodies, partially or wholly opaque and non-luminous at their surfaces, but liquid hot within, approached one another so closely that the tremendous strain of their tidal attraction burst their shells asunder so that their bowels of fire gushed briefly visible, amid a blaze of spouting vapors. And yet Lockyer thinks that there was no solid or semisolid mass concerned in the phenomenon at all, but that what occurred was simply the clash of two immense swarms of meteors that had crossed one another's track.

Well, where nobody positively knows, everybody has free choice. In the meantime, look at the spot in the sky where that little star made its appearance and underwent its marvelous transformation, for, even if you can see no remains of it there, you will feel your interest in the

problem it has presented, and in the whole subject of astronomy, greatly heightened and vivified, as the visitor to the field of Waterloo becomes a lover of history on the spot.

The remaining objects of special interest in Auriga may be briefly mentioned: 26, triple star, magnitudes five, eight, and eleven, distances 12", p. 268°, and 26", p. 113°; 14, triple star, magnitudes five, seven and a half, and eleven, distances 14", p. 224°, and 12.6", p. 342°, the last difficult for moderate apertures; lambda, double, magnitudes five and nine, distance 121", p. 13°; epsilon, variable, generally of third magnitude, but has been seen of only four and a half magnitude; 41, double, magnitudes five and six, distance 8", p. 354°; 996, 1067, 1119, and 1166, clusters all well worth inspection, 1119 being especially beautiful.

The inconspicuous Lynx furnishes some fine telescopic objects, all grouped near the northwestern corner of the constellation. Without a six-inch telescope it would be a waste of time to attack the double star 4, whose components are of sixth and eighth magnitudes, distance 0.8", p. 103°; but its neighbor, 5, a fine triple, is within our reach, the magnitudes being six, ten, and eight, distances 30", p. 139°, and 96", p. 272°. In 12 Lyncis we find one of the most attractive of triple stars, which in good seeing weather is not beyond the powers of a three-inch glass, although we shall have a far more satisfactory view of it with the four-inch. The components are of the sixth, seventh, and eighth magnitudes, distances 1.4", p. 117°, and 8.7", p. 304°. A magnifying power which just suffices clearly to separate the disks of the two nearer stars makes this a fine sight. A beautiful contrast of colors belongs to the double star 14, but unfortunately the star is at present very close, the distance between its sixth and seventh magnitude components not exceeding 0.8", position angle 64°. Sigma 958 is a pretty double, both stars being of the sixth magnitude, distance 5", p. 257°. Still finer is Sigma 1009, a double, whose stars are both a little above the seventh magnitude and nearly equal, distance 3", p. 156°. A low power suffices to show the three stars in 19, their magnitudes being six and a half, seven and a half, and eight, distances 15", p. 312°, and 215", p. 358°. Webb describes the two smaller stars as plum-colored. Plum-colored suns!

At the opposite end of the constellation are two fine doubles, Sigma 1333, magnitudes six and a half and seven, distance 1.4", p. 39°; and 38, magnitudes four and seven, distance 2.9", p. 235°.

Under the guidance of map No. 6 we turn to Leo, which contains one of the leading gems among the double stars, gamma, whose components, of the second and fourth magnitudes, are respectively yellow and green, the green star, according to some observers, having a peculiar tinge of red. Their distance apart is 3.7", p. 118°, and they are undoubtedly in revolution about a common center, the probable period being about four hundred years. The three-inch glass should separate them easily when the air is steady, and a pleasing sight they are.

The star iota is a closer double, and also very pretty, magnitudes four and eight, colors lemon and light blue, distance 2.17", p. 53°. Other doubles are tau, magnitudes five and seven, distance 95", p. 170°; 88, magnitudes seven and nine, distance 15", p. 320°; 90, triple, magnitudes six, seven and a half, and ten, distance, 3.5", p. 209°, and 59", p. 234°; 54, magnitudes four and a half and seven, distance 6.2", p. 102°; and 49, magnitudes six and nine, distance 2.4", p. 158°.

Leo contains a remarkable variable star, R, deep red in color, and varying in a space of a hundred and forty-four days from the fifth to the tenth magnitude. It has also several nebulæ, of which only one needs special mention, No. 1861. This is spindle-shaped, and large telescopes show that it consists of three nebulæ. The observer with ordinary instruments finds little to see and little to interest him in these small, faint nebulæ.

We may just glance at two double stars in the small constellation of Sextans, situated under Leo. These are: 9, magnitudes seven and eight, distance 53", p. 292°; and 35, magnitudes six and seven, distance 6.9", p. 240°.

Coma Berenices (map No. 6) includes several interesting objects. Let us begin with the star 2, a double, of magnitudes six and seven and a half, distance 3.6", p. 240°. The color of the smaller star is lilac. This hue, although not extremely uncommon among double stars elsewhere, recurs again and again, with singular persistence, in this little constellation. For instance, in the very next star that we look at, 12, we find a double whose smaller component is lilac. The magnitudes in 12 are five and eight, distance 66", p. 168°. So also the wide double 17, magnitudes five and a half and six, distance 145", exhibits a tinge of lilac in the smaller component; the triple 35, magnitudes five, eight, and nine, distances 1", p. 77°, and 28.7", p. 124°, has four colors yellow, lilac, and blue, and the double 24, magnitudes five and six, distance 20", p. 270°, combines an orange with a lilac star, a very striking and beautiful contrast. We should make a mistake if we regarded this wonderful distribution of color among the double stars as accidental. It is manifestly expressive of their physical condition, although we can not yet decipher its exact meaning.

The binary 42 Comæ Berenicis is too close for ordinary telescopes, but it is highly interesting as an intermediate between those pairs which the telescope is able to separate and those--like beta Aurigæ--which no magnifying power can divide, but which reveal the fact that they are double by the periodical splitting of their spectral lines. The orbit in 42 Comæ Berenicis is a very small one, so that even when the components are at their greatest distance apart they can not be separated by a five-or six-inch glass. Burnham, using the Lick telescope, in 1890 made the distance 0.7"; Hall, using the Washington telescope, in 1891 made it a trifle more than 0.5". He had measured it in 1886 as only 0.27". The period of revolution is believed to be about twenty-five years.

In Coma Berenices there is an outlying field of the marvelous nebulous region of Virgo, which we may explore on some future evening. But the nebulæ in Coma are very faint, and, for an amateur, hardly worth the trouble required to pick them up. The two clusters included in the map, 2752 and 3453, are bright enough to repay inspection with our largest aperture.

Although Hydra is the largest constellation in the heavens, extending about seven hours, or 105°, in right ascension, it contains comparatively few objects of interest, and most of these are in the head or western end of the constellation, which we examined during our first night at the telescope. In the central portion of Hydra, represented on map No. 7, we find its leading star alpha, sometimes called Alphard, or Cor Hydræ, a bright second-magnitude star that has been suspected of variability. It has a decided orange tint, and is accompanied, at a distance of 281", p. 153°, by a greenish tenth-magnitude star. Bu. 339 is a fine double, magnitudes eight and nine and a half, distance 1.3", p. 216°. The planetary nebula 2102 is about 1' in diameter, pale blue in color, and worth looking at, because it is brighter than most objects of its class. Tempel and Secchi have given wonderful descriptions of it, both finding multitudes of stars intermingled with nebulous matter.

For a last glimpse at celestial splendors for the night, let us turn to the rich cluster 1630, in Argo, just above the place where the stream of the Milky Way--here bright in mid-channel and shallowing toward the shores--separates into two or three currents before disappearing behind the horizon. It is by no means as brilliant as some of the star clusters we have seen, but it gains in beauty and impressiveness from the presence of one bright star that seems to captain a host of inferior luminaries.