The Greek is *ἀστήp,* and the Sanskrit *tara,* for *stara.* The ultimate root is unknown, but may be connected with that meaning “ to strew,” and the word would thus mean the points of light scattered over the heavens. The study of the stars is coeval with the birth of astronomy (see Astronomy: *History);* and among the earliest civilizations bene­ficent or malevolent influences were as­signed to them (see Astrology). With the development of observational astro­nomy the sidereal universe was arbitrarily divided into areas characterized by special

assemblages of stars; these assemblages were named asterisms or constellations, and each received a name suggested by mythological or other figures. The heavenly bodies fall into two classes: (1) the fixed stars, or stars proper, which retain the same relative position with respect to one another; and (2) the planets, which have motions of a distinctly individual character, and appear to wander among the stars proper.

Numerous counts of the number of stars, visible to the naked eye have been made; it is doubtful whether more than 2000 can be seen at one time from any position on the earth. When a telescope is employed this number is enormously in­creased, and still more so with the introduction of photographic methods; with modern appliances more than a hundred million of these objects may be rendered perceptible.

The recognition of stars is primarily dependent on their brightness or “ magnitude and it is clear that stars admit of classification on this basis. This was attempted by Ptolemy, who termed the brightest stars “of the first magnitude,” and the progressively fainter stars of progressively greater magnitude. Ptolemy’s classification has been adopted as the basis of the more exactly quantitative modern system. In this system one star is defined to be unit magnitude higher than another if its light is less in the ratio 1:2·512. This ratio is adopted so that a difference of five magnitudes may correspond to a light-ratio of 1 : 100. This subject is treated in the article Photometry, Celestial. The faintest stars visible to the naked eye on clear nights are of about the sixth magnitude; exceptionally keen, well-trained eyes and clear moonless nights are necessary for the perception of stars of the seventh magnitude. According to E. Heis the numbers and magnitudes of stars between the north pole and a circle 35° south of the equator are:—

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1st mag. | 2nd mag. | 3rd mag. | 4th mag. | 5th mag. | 6th mag. |
| 14 | 48 | 152 | 313 | 854 | 2010 |

From the value of the light-ratio we can construct a table showing the number of stars of each magnitude which would together give as much light as a first magnitude star, viz.:—

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1st mag. | 2nd mag. | 3rd mag. | 4th mag. | 5th mag. | 6th mag. |
| **1** | 21/2 | 6 | 16 | 40 | 100 |

Comparing these figures with the numbers of stars of each magnitude we notice that the total light emitted by all the stars of a given magnitude is fairly constant.

*Variable Stars.—*Although the majority of the stars are unchanging in magnitude, there are many exceptions. Stars whose brightness fluctuates are called *variable stars.* The number of known objects of this class is being added to rapidly, and now amounts to over 4000. The systematic search made at Harvard Observatory is responsible for a large proportion of the recent discoveries. Many of these stars seem to vary quite irregularly; the changes of magnitude do not recur in any orderly way. Others, however, are periodic, that is to say, the sequence of changes is repeated at regular intervals, and it is thus possible to predict when the maximum and minimum brightness will occur. Of the periodic variable stars, the lengths of the periods range from 3 hours 12 minutes, which is the shortest yet determined, to 610 days, the longest. When statistics of the lengths of the periods are collected, it is at once

noticed that they fall into two fairly well-marked classes. The following table, based on S. C. Chandler’s “ Third Catalogue ” *(Astronomical Journal,* vol. xvi.), supplemented by A. W. Roberts’s list of southern variables (ibid. vol. xxi.), classifies the lengths of the periods of 330 stars.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Period in days | 0 to 50 | 50to  100 | 100 to  150 | 150to  200 | 200 to  250 | 250 to  300 | 300 to  350 | 350 to  400 | 400 to  450 | 450to  500 | 500 to  550 | 550 to  600 | 600 to  650 |
| Stars | 73 | 8 | 12 | 22 | 41 | 45 | 49 | 50 | 20 | 6 | **1** | 2 | **1** |

It will be noticed that there arc very few periods between 50 and 150 days, that a considerable number are less than 50 days (actually a large majority of these are less than 10 days), and that from 150 days upwards the number of periods increases to a maximum at about 350 days and then diminishes. We thus recognize two classes of variables, of which (1) the *long-period variables* have periods ranging in general from 150 to 450 days, though a few are outside these limits, and (2) the *short-period variables* have periods less than 50 days (in the majority of cases less than 10 days). There is some over-lapping of these two classes as regards length of period, and it is doubtful in which class some stars, whose periods are between 10 days and 150 days, should be placed; but the two classes are quite distinct physically, and the variability depends on entirely different causes.

*Long-period Variables.—*the best known and typical star of this class is Mira or *o* Ceti. This was the first variable star to be discovered, having been noticed in 1596 by David Fabricius, who thought it was a new star (a *Nova).* The varying brightness, ranging from the ninth to the second magnitude, was recognized in 1639 by John Phocylides Holwarda, and in 1667 Ismael Boulliau (1605-1694) established a periodicity of 333 days. Although the periodic outbursts of light have taken place without intermission during the two and a half centuries that the star has been under observation, they are somewhat irregular. The different maxima differ considerably in brightness; thus in 1906 (the brightest maxi­mum since 1779) the second magnitude was reached, but in other years (as in 1868) it has failed to reach the fifth magnitude. The minima likewise are variable, but only slightly so. Also, the period varies somewhat; the maxima occur sometimes early and sometimes late as compared with the mean period, but the difference is never more than forty days. No general law has been discovered govern­ing these irregularities. The change of magnitude takes place gradually, but the rise to maximum brilliance is rather more rapid than the decline. Spectroscopic observation shows that the in­creased light accompanies an actual physical change or conflagration in the star. The spectrum is of the third type with bright hydrogen emission lines (see below, *Spectra of Stars).* Stars having this type of spectrum are always variable, and a large proportion of the more recently discovered long-period variables have been detected through their characteristic spectrum.

*χ* Cygni is another star of this class, remarkable for its range of magnitude. In its period of 406 days it fluctuates between the thirteenth and the fourth magnitudes; thus at maximum it emits 4000 times as much light as at minimum. The mean range of 75 long-period variables, observed at Harvard *(Harvard Annals,* vol. lvii.) was five, magnitudes. Another variable, R Normae@@1 is of interest as having a pronounced double maximum in each period.

It is natural to compare the periodic outbursts occurring in these stars with the outbursts of activity on the sun, which have a period of about eleven years. In both cases no extraneous cause can be assigned; the period seems to be. inherent in the star itself and not to be determined by the revolution of a satellite (no variability of the line-of-sight motion of Mira has been found, so that it is probably not accompanied by any large companion). In both cases the rise to a maximum is more rapid than the decline to a minimum, and in fact some of the minor peculiarities of the sunspot curve are closely imitated by the light-curves of variable stars. H. H. Turner has analysed harmonically the light-curves of a number of long-period variables, and has shown that when they are arranged in a natural series the sun. takes its place in the series near, but not actually at, one end. It is necessary to suppose, if the analogy is to hold, that the sun is brightest when sunspots and faculae are most numerous; this is by no means unlikely. On the other hand, the variations in the light of the sun must be very small compared with the enormous fluctuations in the light of variable stars. Moreover, the solar period (11 years) is far outside the limits of the periods of

@@@1 Variable stars (except those sufficiently bright to have received special names) are denoted by the capital letters R to Z followed by the name of the constellation. The first nine variables recognized in each constellation are denoted by single letters, after which combinations RR, RS, &c., are used.