THE HEAVENS IN AUGUST.

BY HENRY NORRIS RUSSELL, PH.D.

THAT the hot weather of midsummer should be an astronomical phenomenon hardly seems possible to any one who is not an astronomer. Still, everyone can determine by direct observation that the heat comes from the sun, and should be greatest when it rises highest in the sky, and shines on us for the longest time; and it is easy to see how the stored-up heat of early summer is carried on, so that the maximum temperature falls, not in June, but in July or August.

But when we ask, How hot must the sun itself be, in order to send us so much heat, at its enormous distance? the astronomer and the physicist must join in long and careful studies before the question can be answered. In the first place, the sun's temperature does not really depend on its distance at all. If it was twice as far off, and twice as big, it would look just the same, and send us just as much heat. What we receive depends on how big the sun *looks* in the heavens, and how bright it *really is per square mile* or square foot. We can therefore compare it with substances in our laboratories, which, though enormously smaller than the sun, are also enormously nearer, so that the two things balance.

Now, in the laboratory we find that all substances radiate heat to a greater or less degree, even at the lowest temperatures we can produce. Complete absence of radiation would only occur for a body at the "absolute zero" (i. e., one for which the motions of its molecules had all ceased) which can never be obtained in practice. As the body grows hotter, the radiation of heat from it rapidly increases. However, at the same temperature, some substances (such as polished metal) send out much less heat per square inch than others (such as a surface covered with lampblack).

For reasons which we have not space to detail, the blackest substances (which at a given temperature send out most heat) are taken as a standard. It is found that the amount of heat sent out per square inch by such a "black body" depends, not on the particular substance, but only on its temperature, and that as the temperature rises, the heat radiated increases as the fourth power of the temperature measured from the absolute zero. Doubling the temperature increases the radiation sixteen times, and so on. We can find by actual experiment how much heat a black body, apparently as large as the sun, sends us at different temperatures, and verify this law (which bears the name of its discoverer, Stefan). The sun itself sends us very much more heat than a body of the same apparent size, heated as hot as we can get it; but by applying Stefan's law (which there is good theoretical reason to trust) we can estimate how hot we would have to heat our experimental body (if it could stand it) to imitate the sun's condition.

The problem then reduces to the exact measurement of the heat we get from the sun. This is difficult, because our atmosphere absorbs a good deal of it, and it is hard to calculate how much. By working on a high mountain (so as to have less air above one) and measuring the heat which we receive from the sun at different altitudes (that is, through layers of air of different thickness) the problem can be solved with a good deal of accuracy.

A very careful determination, using delicate electrical apparatus to measure the heat received, has been made by Dr. Scheiner of the Potsdam University, who set up his apparatus on a mountain in Switzerland, at an altitude of 10,000 feet.

Translating his results into the units most familiar in our ordinary life, it appears that the heat which we receive from the sun (if directly overhead) per square foot would raise the temperature of a pound of water 8½ deg. F. per minute.

Only about half this heat reaches the earth's surface (at sea level) directly. The rest is absorbed in our atmosphere, and helps to warm it. Even so, a man lying on the ground in the sun's rays, and presenting six square feet of surface to them, will receive more heat in an hour than is needed to raise a gallon of water to the boiling point. So it is no wonder he is warm!

Working out the sun's temperature from his data, Dr. Scheiner finds it to be 5,950 deg. C., or 10,740 deg. F., with an uncertainty of about 50 deg.

This is, however, the temperature which would give us the observed radiation if the sun was a "perfect radiator," and had no absorbing atmosphere. As a matter of fact, all known substances have to be heated somewhat hotter than this theoretical temperature before they give out the same amount of heat. Also, if the sun's atmosphere stops some of his heat, the radiation from, and the temperature of, his actual surface must be greater than the *minimum* value here determined. How much allowance must be made is a matter of judgment. Dr. Scheiner estimates the actual temperature of the surface (if a good radiator) at 6,800 deg. C., or about 12,250 deg. F.

The highest temperatures attainable by artificial means (in the electric arc and furnace) are about 4,000 deg. C., or 7,000 deg. F.

The sun's surface temperature, though higher than we can produce experimentally, is hardly of a different order of magnitude. What the internal temperature may be we can hardly even conjecture, for we know too little of the properties of matter under conditions so far removed from our experience.

THE HEAVENS.

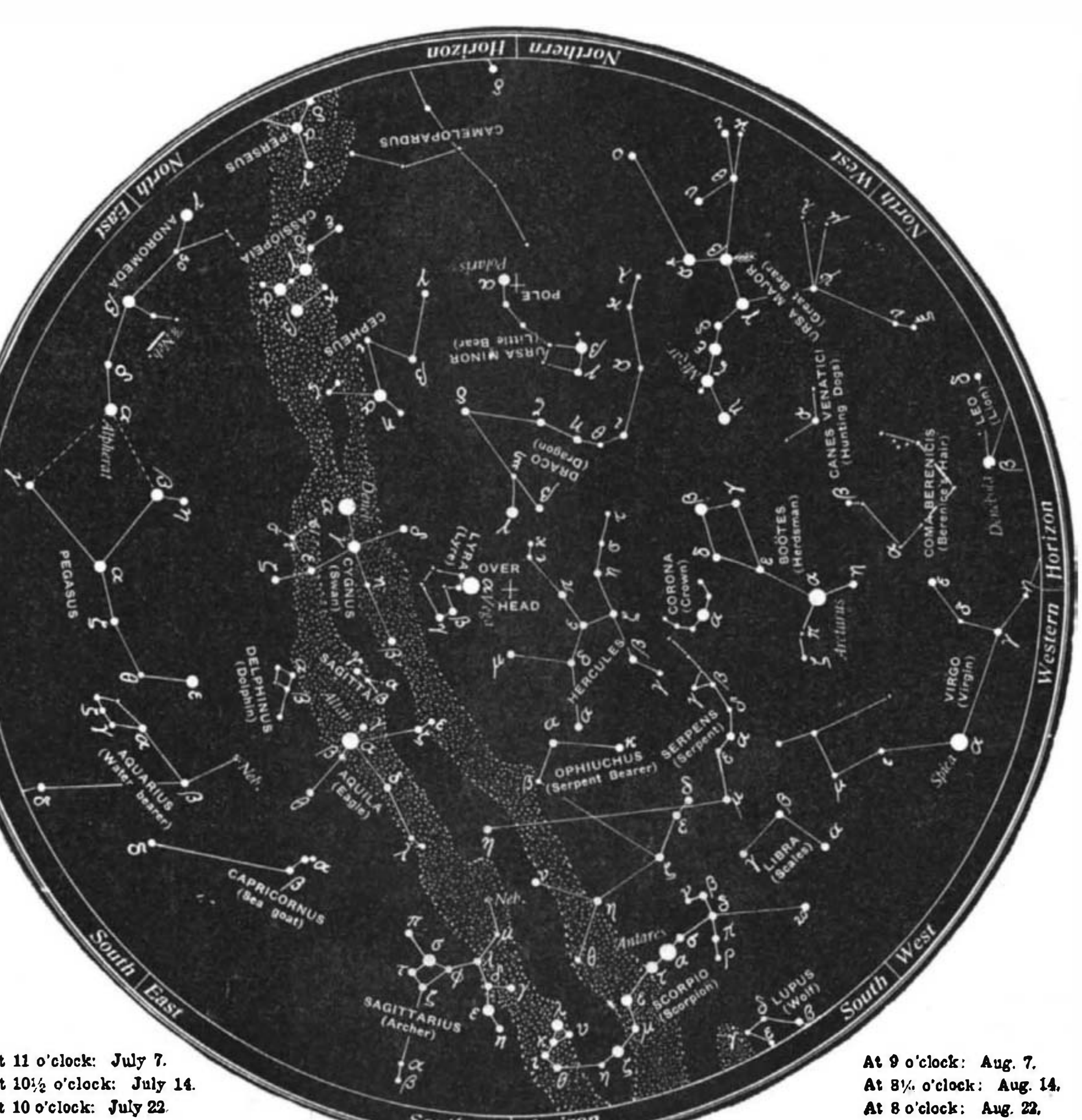
The most characteristic of the summer constellations is perhaps Scorpio, which can now be well seen on the southern horizon. It is the finest of the twelve zodiacal constellations, but we never fully realize its brilliancy, for a great part of it rises but a few degrees above our horizon. As our initial letter shows, the resemblance of the constellation to the creature for which it is named is remarkably good.

The great red star Antares is at the Scorpion's heart, its head and claws extend to the conspicuous vertical line of stars β, δ, π (in fact, they once occupied a large part of what is now attributable to Libra) and the long, recurved tail sweeps down to the horizon and ends with the bright star λ, which might be called the Scorpion's sting.

Several individual stars are noteworthy. β and μ are fine doubles, which are resolved into multiple systems by powerful telescopes. Antares itself has a close companion, less than 1/100 as bright as its primary, and very green. This is one of the finest pairs in the heavens, but is too difficult for small telescopes, unless the air is exceptionally steady. μ is a naked-eye double, though hard to separate except on a very clear night, and one of the components is a spectroscopic binary, remarkable for the great mass and orbital velocity of the two bright stars which compose it.

To the left of Scorpio we see Sagittarius, with the familiar "Milk Dipper" (composed of the stars λ, φ, σ, τ, ζ). The magnificent star clouds in the Milky Way, which lie in this region, can now be seen at their best.

Capricornus, with the naked-eye double α, is in the southeast, and Aquarius is rising on the left. The great square of Pegasus is almost due east, and Andromeda is in the northeastern horizon. Cassiopeia is higher up, then Cepheus, then Cygnus, nearly overhead. South of this are the small groups of Sagitta and Delphinus, then Aquila, with the bright star Altair. Vega is almost exactly overhead, a splendid mark for the zenith. Due west is Hercules, then Corona, then Boötes, with the ruddy Arcturus. Ophiuchus and Serpens occupy the upper part of the southwestern sky, and Libra and Virgo the lower. Ursa Major is in the northwest, and Draco and Ursa Minor in the north, above the Pole.



At 11 o'clock: July 7.
At 10½ o'clock: July 14.
At 10 o'clock: July 22.

At 9 o'clock: Aug. 7.
At 8½ o'clock: Aug. 14.
At 8 o'clock: Aug. 22.

At 9½ o'clock: July 30.

NIGHT SKY: JULY AND AUGUST

THE PLANETS.

Mercury is in conjunction with the sun on the 4th, and is invisible during the first half of August. Toward its end he can be seen just after sunset, but not as well as next month. On the 25th he is very near Jupiter, about 1 min. south of him, and should be easy to pick up.

Venus is likewise evening star, setting about 8 P. M. On the afternoon of the 12th she is in conjunction with Jupiter. At 2 P. M. they are but 12 min. of arc apart, in the same telescopic field. By nightfall in America they will have separated a little, but their distance will still be less than the moon's apparent diameter. This close approach of the two brightest planets is well worth watching.

Mars is in Pisces, rising about 9:45 P. M. on the 1st, and 8 P. M. on the 31st. He is very conspicuous, and will be an object of assiduous telescopic study, though his nearest approach to us does not occur till next month.

Jupiter is evening star in Leo, setting about 8 P. M. in the middle of the month.

Saturn is in Pisces, about an hour east of Mars, and rises about 9:30 P. M. on the 15th.

Uranus, which passed opposition last month, is in Sagittarius, well placed for observation. On the 15th he is in R. A. 19 h. 17 m. 30 s., dec. 22 deg. 44 min. south, and is moving 8 s. westward and 15 s. southward per day.

Neptune is in Gemini, observable, if at all, only in the early morning.

THE MOON.

Full moon occurs at 4 P. M. on the 1st, last quarter at 8 A. M. on the 8th, new moon at 7 P. M. on the 15th, first quarter at 11 P. M. on the 23d, and full moon once more at midnight on the 30th.

The moon is nearest us on the 3d, and farthest off on the 19th. She is in conjunction with Mars on the 5th, Saturn on the 6th, Neptune on the 12th, Mercury on the 16th, Jupiter on the 17th, Venus on the 18th, and Uranus on the 27th.

A faint comet was discovered by Mr. David at the Princeton University Observatory about the middle of June. Details of its orbit are not yet accessible to the writer.