The heliometer is at present engaged on a triangulation of stars near the North Pole for Prof. Pickering, but the last three months of the present year it is to be employed in the determination of the solar parallax during the extremely favourable opposition of Iris. Measures of the diameters of the sun and of Mars, measures of certain double stars, the investigation of the parallaxes of 6 B Cygni, and of 18115/22 Lalande, are amongst the other labours of the Observatory. Mr. Hall has nearly completed the reduction of his measures of Titan.

GRAVITATION IN THE STELLAR SYSTEMS.—Prof. Asaph Hall supplies an interesting paper on "The Extension of the Law of Gravitation to Stellar Systems," in *Gould's Astronomical Journal*, No. 177, to which Dr. Elkin's new value of the parallax of Arcturus might afford a most striking illustration. Prof. Hall shows that there is a theoretical difficulty in proving the law of Newton for double stars which we cannot overcome, though the probability of the existence of this law can be increased as more double star orbits, and those very differently situated, are determined. Still, even then, before the universality of the law can be inferred, there remains the difficulty of the so-called "runaway" stars, like Groombridge 1830, stars moving through space with the speed of a comet at perihelion, and yet with no visible attracting body near them. Of these Prof. Hall supplies a list. But if Dr. Elkin's value of the parallax of Arcturus be accepted, that star would outstrip any of those given in this table. For its speed in the direction at right angles to the line of sight would be 373 miles per second, a speed compared with which its speed in the line of sight, as given by Dr. Huggins, 55 miles per second, becomes small. Prof. Hall concludes, therefore, that though Newton's law is one of the greatest generalizations of science, it is better and safer "to await further knowledge before we proceed, as Kant has done, to construct the universe according to this law."

ASTRONOMICAL PHENOMENA FOR THE WEEK 1888 AUGUST 26—SEPTEMBER 1.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on August 26

Sun rises, 5h. 5m.; souths, 12h. 1m. 28·9s.; sets, 18h. 57m.: right asc. on meridian, 10h. 22·1m.; decl. 10° 11′ N. Sidereal Time at Sunset, 17h. 19m.

Moon (at Last Quarter August 29, 14h.) rises, 20h. 54m.*; souths, 3h. 22m.; sets, 10h. 2m.: right asc. on meridian, 1h. 41·6m.; decl. 5° 0′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	5 14	12 13	19 12	10 33·8	10 52 N.
Venus ...	6 14	12 51	19 28	11 11·5	6 42 N.
Mars ...	12 27	16 48	21 9	15 9·6	19 12 S.
Jupiter ...	13 2	17 23	21 44	15 44·5	19 8 S.
Saturn ...	3 6	10 43	18 20	9 3·5	17 33 N.
Uranus ...	8 59	14 35	20 11	12 56·1	5 20 S.
Neptune..	21 56*	5 43	13 30	4 2·3	18 59 N.

* Indicates that the rising is that of the preceding evening.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
R Arietis	2 9·8	24 32 N.	Aug. 26,		*M*
R Ceti	2 20·3	0 41 S.	,, 27,		*M*
λ Tauri	3 54·5	12 10 N.	,, 27,	22 41	*m*
			,, 31,	21 33	*m*
U Monocerotis	7 25·5	9 33 S.	,, 27,		*m*
R Virginis	12 32·8	7 36 N.	,, 31,		*M*
S Boötis	14 19·1	54 19 N.	,, 27,		*M*
δ Libræ	14 55·0	8 4 S.	,, 30,	22 8	*m*
W Scorpii	16 5·2	19 51 S.	,, 28,		*M*
W Ophiuchi	16 15·4	7 26 S.	,, 28,		*M*
R Draconis	16 32·4	67 0 N.	,, 30,		*M*
U Ophiuchi	17 10·9	1 20 N.	,, 30,	0 28	*m*
			,, 30,	20 36	*m*
W Sagittarii	17 57·9	29 35 S.	,, 27,	0 0	*M*
Z Sagittarii	18 14·8	18 55 S.	,, 27,	1 0	*M*
			,, 31,	0 0	*m*
U Sagittarii	18 25·3	19 12 S.	,, 26,	0 0	*M*
β Lyræ	18 46·0	33 14 N.	,, 26,	1 0	m_2
R Aquilæ	19 1·0	8 4 N.	,, 29,		*m*
X Cygni	20 39·0	35 11 N.	Sept. 1,	3 0	*m*

M signifies maximum; *m* minimum; m_2 secondary minimum.

Occultation of Star by the Moon (visible at Greenwich).

Aug.	Star.	Mag.	Disap. h. m.	Reap. h. m.	Corresponding angles from vertex to right for inverted image. ° °
26	ξ² Ceti	4	23 20	0 22†	98 238

† Occurs on the following morning.

Meteor-Showers.

	R.A.	Decl.	
	6°	11° N.	Swift.
Near β Trianguli	30	35 N.	
,, 33 Cygni	305	54 N.	Swift, bright. Sept. 1.
,, δ Cephei	336	58 N.	Swift.

GEOGRAPHICAL NOTES.

THE *Times* printed on Tuesday the substance of communications received from Mr. Joseph Thomson, dated from the city of Morocco, July 22. Mr. Thomson writes in the highest spirits, and with evident satisfaction at the results he has so far attained; for much of the country through which he has had to pass is in a state of rebellion, and the local authorities have done more to hinder than to help him. Mr. Thomson sailed from Tangier to Casablanca, and thence travelled overland to Mogador. After three weeks' preparation there he made his final start, and, as he states, soon discovered that the greatest danger to his success would not be the mountaineers nor even the opposition of the Government officials, but the half-dozen men who formed the *personnel* of his small party. Mr. Thomson's past experience in Africa enabled him to deal effectively with this difficulty. By a series of surprises and cleverly-planned excursions he has been able to enter the mountain fastnesses of Morocco and do more than any previous traveller has done. From Demnat he made two extremely interesting trips into the lower ranges, visiting some remarkable caves and equally remarkable ruins, and one of the most wonderful natural bridge-aqueducts in the world. Geologically and geographically these trips are alike important. They were followed by a dart across the main axis of the Atlas to the district of Tiluit, which lies in the basin of the Draa. Here he spent a very delightful ten days, though virtually a prisoner. As the tribes further west on the southern slope were in revolt, Mr. Thomson was compelled to return to the northern plains. Starting once more, he crossed the mountains by a pass a little south of Jebel Tizah, ascended by Hooker, and reached Gindafy safely. He was able to make a trip up a wonderful cañon, which he declares rivals those of America for depth and grandeur, and ascended a mountain, where he and his party were confined to their tents until it suited them to go back to their starting-point. Here, unfortunately, Mr. Thomson's young companion, Mr. Crichton Browne, was stung by a scorpion, and they were compelled to return, happily by a new route. Though laid up for a period, fortunately in time Mr. Crichton Browne recovered. From his previous starting-point Mr. Thomson scored another great triumph. He crossed the mountains once more, and ascended with no small danger and difficulty the highest peak of the Atlas Range north of Amsiviz, a height of 12,500 feet—the highest peak, by 1500 feet, ever attained. This he describes as the most interesting of all his trips, and he enjoyed it thoroughly, though he had to sleep on the ground and was glad to make a meal on walnuts. On his return, Mr. Thomson deemed it advisable to go into the town of Morocco to recruit and wait the arrival of further supplies from the coast. He intended to resume work in a few days after the date of his letter. He proposed first to make for the Urika River and penetrate the mountains up its course. He will then work his way round to Mogador, which he expects to reach about the end of August. There probably his work of exploration will end, though he may make one or two short trips into the interior and down to Agadir. The return route to Tangier will probably be from Mogador to the city of Morocco, thence to Mazagan on the coast, and on to Casablanca and Rabat. Then he will leave the sea again and go to Mequinez and Fez, reaching Tangier about the end of the year. The *Times* understands that his contributions to various branches of science, especially to botany, will be of the highest value.

A LETTER from Cayenne to the *Temps* states that M. Coudreau, who has recently explored Guiana, arrived there last month after having travelled for eleven months in the western range of the Tumuc-Humac Mountains, between the source of the Itany and that of the Camopy. Starting by the Maroni, M. Coudreau, after having gone up the Itany and explored the region which it waters, came down to the coast by Maronimi-Crique, which is a very large tributary of the Maroni River. M. Coudreau is the first Frenchman who has passed a consecutive winter and summer in the Tumuc-Humac Mountains, and though he did not himself suffer very much from the effects of the expedition, the same cannot be said of his companions, as the only European who accompanied him was brought near to death's door by fever, from which most of the natives also suffered. M. Coudreau escaped with nothing worse than rheumatism, and he says that the climate of the Western Tumuc-Humac is not bad. The result of 1200 observations taken by him puts the mean temperature at 70°, and the country is a magnificent one; but the difficulty of reaching it is very great owing to the uncertainty of communication with the coast. M. Coudreau and his companions, when they had exhausted their provisions, had to go and live out in the open with the Indians, leading the same kind of existence, and depending for food upon the game, fish, and fruit that they could shoot, fish, and gather. For eight months M. Coudreau lived the regular native life, and he had become so accustomed to it that he was very popular with the Rucuyennes, whose language he had learned to speak, and he induced the *pamenchi* (captain) of the tribe and four of his lieutenants to accompany him to Cayenne, where their arrival created a great sensation, as the people of the town did not believe in their existence. M. Gerville-Réache, the Governor of the colony, received them with great hospitality, and made them several presents. The most important fact brought out by M. Coudreau is the existence in Upper Guiana, which is acknowledged French territory, of sixteen new Indian tribes, forming a group of at least 20,000 persons; and these Indians are not, as was supposed, mere nomads, living upon the produce of their guns and fishing-nets, but are sedentary in their habits, and have attained a certain degree of civilization. M. Coudreau is about to start on a fresh expedition to the Appruague and the Oyapack, and does not expect to get back before next spring.

THE GASES OF THE BLOOD.[1]

II.

THE next step was the discovery of the important part performed in respiration by the colouring matter of the red blood corpuscles. Chemically, these corpuscles consist of about 30 or 40 per cent. of solid matter. These solids contain only about 1 per cent. of inorganic salts, chiefly those of potash; whilst the remainder are almost entirely organic. Analysis has shown that 100 parts of dry organic matter contain of hæmoglobin, the colouring matter, no less than 90·54 per cent.: of proteid substances, 8·67; of lecithin, 0·54; and of cholesterine, 0·25. The colouring matter, hæmoglobin, was first obtained in a crystalline state by Funke in 1853, and subsequently by Lehmann. It has been analyzed by Hoppe-Seyler and Carl Schmidt, with the result of showing that it has a perfectly constant composition. Hoppe-Seyler's analysis first appeared in 1868. It is now well known to be the most complicated of organic substances, having a formula, as deduced, from the analyses I have just referred to, by Preyer (1871), of

$$C_{600}H_{960}N_{154}FeS_3O_{179}.$$

In 1862, Hoppe-Seyler noticed the remarkable spectrum produced by the absorption of light by a very dilute solution of blood. Immediately thereafter, the subject was investigated by Prof. Stokes, of Cambridge, and communicated to the Royal Society in 1864. If white light be transmitted through a thin stratum of blood, two distinct absorption bands will be seen. One of these bands next D is narrower than the other, has more sharply defined edges, and is undoubtedly blacker. "Its centre," as described by Dr. Gamgee ("Physiological Chemistry," p. 97), "corresponds with wave-length 579,[2] and it may conveniently be distinguished as the absorption band, α, in the spectrum of oxyhæmoglobin. The second of the absorption bands—that is, the one next to E—which we shall designate β, is broader, has less sharply defined edges, and is not so dark as α. Its centre corresponds approximately to wave-length 553·8. On diluting very largely with water, nearly the whole of the spectrum appears beautifully clear, except where the two absorption bands are situated. If dilution be pursued far enough, even these disappear; before they disappear they look like faint shadows obscuring the limited part of the spectrum which they occupy. The last to disappear is the band α. The two absorption bands are seen most distinctly when a stratum of 1 cm. thick of a solution containing 1 part of hæmoglobin in 1000 is examined; they are still perceptible when the solution contains only 1 part of hæmoglobin in 10,000 of water."

Suppose, on the other hand, we begin with a solution of blood in ten times its volume of water; we then find that such a solution cuts off the more refrangible part of the spectrum, leaving nothing except the red, "or, rather, those rays having a wave-length greater than about 600 millionths of a millimetre." On diluting further, the effects, as well described by Prof. Gamgee, are as follows:—"If now the blood solution be rendered much more dilute, so as to contain 8 per cent. of hæmoglobin, on examining a spectrum 1 centimetre wide the spectrum becomes distinct up to Fraunhofer's line D (wave-length 589)—that is, the red, orange, and yellow are seen, and in addition also a portion of the green, between *b* and F. Immediately beyond D, and between it and *b*, however (between wave-lengths 595 and 518), the absorption is intense."

These facts were observed by Hoppe-Seyler. Prof. Stokes made the very important contribution of observing that the spectrum was altered by the action of reducing agents. Hoppe-Seyler had observed that the colouring matter, so far as the spectrum was concerned, was unaffected by alkaline carbonates, and caustic ammonia, but was almost immediately decomposed by acids, and also slowly by caustic fixed alkalies, the coloured product of decomposition being hæmatin, the spectrum of which was known. Prof. Stokes was led to investigate the subject from its physiological interest, as may be observed on quoting his own words in the classical research already referred to. "But it seemed to me to be a point of special interest to inquire whether we could imitate the change of colour of arterial into that of venous blood, on the supposition that it arises from reduction."

He found that—

"If to a solution of proto-sulphate of iron enough tartaric acid be added to prevent precipitation by alkalies, and a small quantity of the solution, previously rendered alkaline by either ammonia or carbonate of soda, be added to a solution of blood, the colour is almost instantly changed to a much more purple-red as seen in small thicknesses, and a much darker red than before as seen in greater thickness. The change of colour which recalls the difference between arterial and venous blood is striking enough, but the change in the absorption spectrum is far more decisive. The two highly characteristic dark bands seen before are now replaced by a single band, somewhat broader and less sharply defined at its edges than either of the former, and occupying nearly the position of the bright band separating the dark bands of the original solution. The fluid is more transparent for the blue and less so for the green than it was before. If the thickness be increased till the whole of the spectrum more refrangible than the red be on the point of disappearing, the last part to remain is green, a little beyond the fixed line *b*, in the case of the original solution, and blue some way beyond F, in the case of the modified fluid."

From these observations, Prof. Stokes was led to the important conclusion that—

"The colouring matter of blood, like indigo, is capable of existing in two states of oxidation, distinguishable by a difference of colour and a fundamental difference in the action on the spectrum. It may be made to pass from the more to the less oxidized by the action of suitable reducing agents, and recovers its oxygen by absorption from the air."

To the colouring matter of the blood Prof. Stokes gave the name of cruorine, and described it in its two states of oxidation as scarlet cruorine and purple cruorine. The name hæmoglobin, given to it by Hoppe-Seyler, is generally employed. When united with oxygen it is called oxyhæmoglobin, and when in the reduced state it is termed reduced hæmoglobin, or simply hæmoglobin.

The spectroscopic evidence is, therefore, complete. Hoppe-Seyler, Hüfner, and Preyer have shown also that pure crystallized hæmoglobin absorbs and retains in combination a quantity of oxygen equal to that contained in a volume of blood holding the same amount of hæmoglobin. Thus, 1 gramme of hæmoglobin absorbs 1·56 cubic centimetre of oxygen at 0° C. and 760 milli-

[1] Address to the British Medical Association at its annual meeting at Glasgow. Delivered on August 10 in the Natural Philosophy class-room, University of Glasgow, by John Gray McKendrick, M.D., LL.D., F.R.SS.L. and E., F.R.C.P.E., Professor of the Institutes of Medicine in the University of Glasgow. Continued from p. 382.

[2] Dr. Gamgee gives the measurements of the wave-lengths in millionths, not in ten-millionths of a millimetre.