THE RED SPOT ON JUPITER, AND ITS SUSPECTED IDENTITY WITH PREVIOUS MARKINGS.

THE outlines of the red spot are still faintly distinguishable on a night of good definition. With a 10-inch reflector and power of 312, I have obtained the following estimated transits :—

Date 1898	Spot on central meridian h. m.	Longitude °
March 22 ...	10 43 ...	23·6
April 15 ...	10 26 ...	22·6
,, 17 ...	12 6 ...	23·6
,, 18 ...	8 0 ...	25·2
,, 22 ...	11 16 ...	24·9
May 14 ...	9 25 ...	24·1
June 7 ...	9 20 ..	25·9

At the present time the spot follows the zero meridian (System II.) of Mr. Crommelin's ephemerides in *Monthly Notices* by 26 degrees, which is equivalent to 43 minutes.

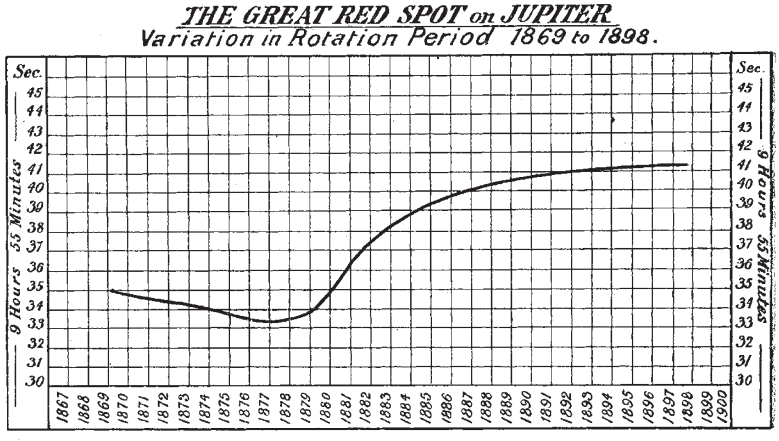
During recent observations the spot has not appeared to be quite centrally placed within the concavity in the great southern belt. Its position is slightly on the following side.

Now that this singular marking has been watched for a period of twenty years, the time may be opportune for referring to the question whether it can be physically identified with the large spot seen at intervals by Cassini, Hooke and Maraldi about two centuries ago, and with more modern observations of somewhat similar formations by Key in June 1843, by Dawes in 1857, by Lassell and Huggins in 1858 and 1859, by Gledhill and Mayer in 1869, 1870 and 1871, by Rosse and Copeland in 1873, and by Russell and Bredichin in 1876. In some instances the features alluded to exhibited a very suggestive resemblance to the red spot, and were, moreover, situated in, or nearly in, the same latitude.

This question of identity, when the details come to be considered, presents so many difficulties that, though the affirmative view has much in its support, it scarcely admits of definitive settlement in respect to the more ancient observations. For our knowledge of the older spots we have to depend upon drawings of the planet; and it is notorious that delineations by different observers are rarely consistent as to the form of an object, or accurate as to its position on the disc. Before the apparition of the red spot in 1878, the great utility of taking the times when the markings passed the central meridian of Jupiter had not been sufficiently recognised, and such observations had been rarely attempted.

Apart from the approximate character of former materials, the extremely variable motion of the Jovian features presents a serious impediment when we attempt to demonstrate the absolute identity of any of them. Were the observed velocities equable, and the spots permanent markings on the real surface, like those discerned on Mars, the matter would be simplified, and we should possess a well-assured base for investigation. It would be easy to determine whether a modern spot occupied the same longitude as one of its prototypes visible at a distant period. Thus, the Kaiser Sea, as we see it to-day on Mars, can be unmistakably identified as one of the principal lineaments drawn by Huygens in 1659 and subsequent years. But the visible markings on Jupiter appear to be quite of another character. They are atmospheric details which display vagaries inducing great changes of appearance and displacements in longitude, so that we can only speak with confidence of individual markings which have been retained continually under telescopic scrutiny. It is true that a break of a few months in such observations need not, in particular cases, be fatal to the identification of markings. There must necessarily occur such breaks during the interval when Jupiter is near conjunction with the sun; but notwithstanding this, there has been no difficulty whatever in recognising the red spot at every reappearance of the planet since 1878. When, however, there occur breaks of two or three years in observations of a supposed identical feature, doubts are at once introduced by the lack of connecting links to bridge over the intervals. This is the case affecting the various features which are suspected to have been early representations of the modern red spot; there are many links wanting in the chain of evidence necessary to prove their identity.

I have been carefully comparing the various observations of apparently analogous markings in the southern hemisphere of Jupiter since 1857, with the view of associating them if possible and discovering what rates and changes of motion influenced them. The result of the examination has tended to strengthen the idea that Gledhill's ellipse of 1869–70, Lord Rosse's and Dr. Copeland's red spot of 1873, and Russell's and Bredichin's oval spot of 1876 were really one and the same object. I believe that all these observations are to be satisfactorily accounted for on the theory of identity. Certainly there are some small differences due to the approximate character of the materials available for discussion. The times of passage of the objects across the central meridian have in most cases to be estimated from their positions as drawn either west or east of it. But it must happen that, in getting transits from such rough data, our resulting values will be sometimes erroneous to the extent of 15 or 20 minutes, and occasionally perhaps it will amount to 30 minutes. Even the latter quantity is not, however, always a very serious item, for when the rotation of a spot has to be derived from, say, observations extending over two years, it only introduces an error of 1 second in the resulting period.



There is little doubt that the red spot before its remarkable intensification of colour, and prior to freeing itself from the obscuring material which apparently veiled it in 1877, had been increasing its velocity of rotation. We know that after 1878 it gradually slackened. When Gledhill first observed the spot in the autumn of 1869, its period of rotation appears to have been about 9h. 55m. 35s. Slightly increasing in velocity, the rate up to the close of 1872, when Lord Rosse and Dr. Copeland redetected the spot by means of the six-foot reflector, was 9h. 55m. 34·5s. It had been seen in the interim by several others. Mr. Gledhill saw the ellipse resting on, and actually in contact with, the great southern equatorial belt on December 1, 1871, and on January 5, 6 and 11–12 it was seen by Messrs. E. B. Knobel, H. Pratt and J. Birmingham respectively (*Astronomical Register*, January and February 1872, and *English Mechanic*, September 13, 1872). Several others, including Dr. F. Terby, appear to have recognised it at about this period. During the interval from Rosse and Copeland's observations in the winter and spring of 1873, to Russell and Bredichin's in the summer of 1876, the mean period of the spot was 9h. 55m. 34s., and between June 1876 and Dennett's observation of July 27, 1878, it had further decreased to about 9h. 55m. 33·5s. Subsequently to this the motion of the spot has slackened until, now, twenty years after Dennett's observation, its period is 9h. 55m. 41·5s., or 9 seconds more. The variation of motion since 1869 can perhaps be graphically represented by a diagram.

The slackening of its motion is still evident, but it is very slight as compared with that which took place in the years from 1879 to 1884.

Taking the whole period from Gledhill's first observation on November 14, 1869, when the spot was central at about 10h. 50m., to one obtained at Bristol on June 7 last, at 9h. 20m., we shall find the interval covered 10,431 days 22 hours and 30 minutes, and that 25,218 rotations were performed with a mean period of 9h. 55m. 37·7s.

In addition to the variation exhibited in the diagram, there have been some minor changes in the motion of the spot. These could, however, only be satisfactorily worked out from the most accurate observations and by determining the rotation periods for short intervals.

As to the question whether the red spot is identical with markings seen in 1857, 1858 and 1859, the matter is open to doubt, for there seems to be a great lack of corroborative observations between 1860 and 1869. The objects delineated by several skilled observers about forty years ago were somewhat similar in position and form to the red spot of recent years, and afford strong presumptive evidence of identity. We have had the spot continuously before us for twenty years, and there can be no doubt that its existence can be traced back to 1869. We ought to be able to go back another ten years and affiliate it with the elliptical markings which were drawn by Dawes, Huggins and others in the region immediately south of the great equatorial belt in 1857, 1858 and 1859, but there is an absence of suitable observations along the interval, and though it is easy to infer that the various objects were identical the fact cannot be demonstrated.

Had observations been more numerous, we should perhaps be able to put our hands on a complete series of records of the red spot extending back for a very long period. It must be remembered that some years ago the planet was so much neglected that a conspicuous feature might easily escape notice during the whole of a favourable apparition. Thus the ellipse of 1869–70 was only seen by Gledhill and Mayer, though Jupiter was a splendid object at about that period. The fact that an object was not seen is, therefore, far from being conclusive evidence of its non-existence.

Though there is reasonable proof that the marking drawn by Russell and Bredichin in 1876 was the same as that which attracted so much notice two years later, it is curious what became of it in 1877. Bredichin gives fifteen drawings of the planet's appearance in the summer of the latter year (see *Annales de l'Observatoire de Moscou*, vol. iv., 1878), but there is no sign of the red spot. The object, if it existed during that opposition, may have been temporarily obscured by more highly reflective material lying above it. It seems to have been much involved with the belts in the southern hemisphere before 1878. Mr. H. C. Russell remarks that he first saw it separated from the belts on July 8, 1878, and was not long in recognising it as an old friend which he had frequently seen in 1876.

Many of the markings on Jupiter are probably formed by materials evolved from the actual surface of the planet, which afterwards become floating masses in the outer region of the atmosphere. Their longitudes do not probably long coincide with that of the original seat of disturbance, for they will fail to keep pace with the exceedingly rapid motion of the sphere, and must exhibit a retardation similar to that so well pronounced in the case of the red spot. The latter has proved itself a very special object with a durableness which does not seem to have characterised other markings. There were "new red spots" in 1886 and 1891, but they did not last long. The majority of the Jovian markings appear to be somewhat transient and irregular in their apparitions, and certain zones of the planet would seem favourable to the production of markings having an individuality of aspect.

The true rotation period of the actual sphere of Jupiter still awaits accurate determination. An occasion might, however, present itself for this element to receive satisfactory investigation. If the spots are really due to eruptions from the planet, and if these should be sustained over periods sufficiently long for the purpose intended, then a string of spots might be formed along a zone, and the time taken to complete the circumference might give data for ascertaining the true rotation period if the retardation of the markings on arriving in the outer atmosphere were allowed for. Thus, in 1880–81 I watched the formation of a complete girdle of spots in about ninety days; and had the distension taken place always on the preceding side, the materials would have been obtained for finding the correct period, for the observed rotation of the spots was 9h. 48m. But the objects appeared to extend themselves both east and west, though the spreading out on the following side may have been due to an increase in the slackening motion, rather than to the formation of new spots. Phenomena of this character obviously offer important features for discussion. Whenever an outbreak of spots takes place, it becomes necessary to learn the direction and rate of its longitudinal distension; for such inquiries may usefully increase our knowledge of the physical condition of Jupiter, and supply us with a more precise value for the rotation period. Our previous acquaintance with this element depends upon atmospheric phenomena, and must be to some extent in error, for the markings display proper motions differing among themselves to the extent of nearly eight minutes, and in nearly every case the rate of velocity appears to vary in an irregular manner but generally lengthening with the time

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THE GERMINATION OF HORDEUM VULGARE.[1]

THE work described in this paper is a continuation of a previous research by Mr. Horace T. Brown and Dr. G. H. Morris published in 1890 (*Jour. Chem. Soc.*, vol. lvii. p. 458), dealing with the respective influences of embryo and endosperm in the alteration of the reserve-starch and cellulose for the requirements of the young plant during germination of seeds of the *Gramineæ*. The seeds of various species were examined, but the main results were obtained with *Hordeum vulgare*; the observations made in this later work are also almost entirely confined to this species, and there can be but little doubt that the results will be found applicable to the *Gramineæ* generally.

It was shown in the earlier paper that the first changes in the endosperm during incipient germination are disintegration and ultimate dissolution of the membranes of the amyliferous cells, this being followed by erosion of the contained starch-granules. These phenomena suggested that the action is due to the influence of the embryo, and not to any autonomous action of the endospermous cells themselves.

While investigating this point, it was found that a carefully excised embryo can exist independently of the seed, if supplied with suitable artificial nutriment in the form of certain carbohydrates, its own proteids yielding sufficient nitrogen for the production of plantlets of considerable size. It was also found that the embryo can be transferred from the endosperm of one seed to that of another, and that healthy plantlets are produced under these artificial conditions.

In this manner it was shown that an excised embryo can induce in starch-granules an action alike in kind and degree to that produced by an embryo growing *in situ* on its natural endosperm, as in normal germination. It was found that the columnar epithele of the scutellum can secrete a very active amylohydrolytic enzyme, and project this into the endosperm or any artificial nutriment in intimate contact with itself. This embryonic activity was, however, recognised not to exclude the possibility that the endospermous cells might participate in the dissolution of their own reserve-materials. To ascertain how far such co-operation might exist, degermed seeds were studied when placed in conditions allowing rapid removal of any products of change. The same end was also obtained by grafting a living embryo from one grain on to the endosperm of another, that had been so treated, so as to destroy presumably all potential vitality of the endospermous cells. Since living embryos induced in these supposititiously dead endosperms all normal changes of depletion, and since no autonomonous changes were observed in the degermed endosperms not attributable at that time to adventitious micro-organisms, the idea of residual vitality in the endosperm as a condition of its depletion seemed superfluous.

Since 1890, Grüss, Hansteen, and others, have confirmed the conclusions formed in 1890, that the embryo can secrete enzymes, but Pfeffer, Hansteen, Grüss, and Puriewitsch have strongly contested the view that the endosperm has no autonomous power of self-depletion. These latter observers state that the amyliferous cells of the endosperm have distinct power of digesting their own reserves, this function being quite independent of any induced action of the embryo, and due to residual vitality.

The present work is the result of a re-examination of the

[1] "On the Depletion of the Endosperm of *Hordeum vulgare* during Germination." By Horace T. Brown, F.R.S., and F. Escombe. (Read before the Royal Society on March 3.)