The calculation of the elements of the eclipse is thus completed. For the purpose, however, of illustrating the rules of the text (iv. 18-21) for determining, in the case of a solar eclipse, the amount of obscuration at any given moment during the continuance of the eclipse, we add also the following process:

XVI. To find the amount of obscuration of the sun, 2\textsuperscript{n} 38\textsuperscript{v} after first contact.

We make choice of this time, which is equivalent to 27\textsuperscript{n} 13\textsuperscript{v} after sunrise, because the data for finding the parallax in latitude at the moment have already been calculated (see above, XI). By iv. 18, from the

True former half-duration (\textit{upshta upsavasthitvityardha}), 3\textsuperscript{n} 22\textsuperscript{v}
deduct the given interval, 38\textsuperscript{v}.

Interval to apparent conjunction (\textit{madhyagragha}), 44\textsuperscript{v}.

To reduce this interval in time to distance in longitude of the centres, we say (iv. 18)

\[ 60^a : 60^b : 7^c :: 44^d : 8^e : 7^f \]

This, then, would be the interval in longitude between the two centres at the given moment, if there were no change of the moon’s parallax in longitude during the eclipse, or if the moon actually gained in 2\textsuperscript{n} 20\textsuperscript{v}, instead of in 3\textsuperscript{n} 22\textsuperscript{v}, the distance intervening between her centre and the sun’s at the moment of first contact. That, however, being not the case, we must reduce the result thus found in the ratio of 3\textsuperscript{n} 22\textsuperscript{v} to 2\textsuperscript{n} 20\textsuperscript{v}, or of the true to the mean half-duration. That is to say (iv. 19),

3\textsuperscript{n} 22\textsuperscript{v} : 2\textsuperscript{n} 20\textsuperscript{v} : 8^c : 7^d : 5^e : 5^f

and this result, 5’ 50\textsuperscript{"}, is the true distance of the two centres in longitude, 27\textsuperscript{n} 13\textsuperscript{v} after sunrise.

A briefer and more obvious method of obtaining the quantity in question would have been to make a proportion as follows: if, at the time of the eclipse, the moon gains upon the sun 27’ 29’’ in 3\textsuperscript{n} 22\textsuperscript{v}, what will she gain during 44\textsuperscript{v} / or

3\textsuperscript{n} 22\textsuperscript{v} : 27’ 29’’ :: 44\textsuperscript{v} : 5’ 50\textsuperscript{"}

Upon computation, we find the

Moon’s parallax in latitude, 27\textsuperscript{n} 13\textsuperscript{v} after sunrise, \(16° 51’’\) S.
Moon’s true latitude, \(5° 25’’\) N.

Moon’s apparent latitude,
Its square, \(11° 26’’\)
Square of distance in longitude (8° 59’’), \(35° 59’’\)

Their sum (iv. 20), \(16° 34’’\)
Actual distance of centres, \(12° 54’’\)
deduct from sum of semi-diameters, \(3° 6’’\)

Amount of obscuration at given time, \(17° 12’’\)

If it were desired to project the eclipse, we should now have to calculate (by iv. 24-25) the deflection (\textit{valana}) for the moments of contact, conjunction, and separation, and likewise (by iv. 26) the scale of projection. As we do not, however, intend to present here a projection, and as
the subject of the deflection has been sufficiently illustrated already, in the notes upon the text and in the calculation of the lunar eclipse, we regard it as unnecessary to go through with the labor required for making the computations in question. Finally, we annex, as in the case of the lunar eclipse formerly calculated, a summary comparison of the principal results of the Hindu processes with the elements of the eclipse in question as determined by Prof. Cuffin, in his work referred to above. It must be borne in mind, however, that, owing to the faulty manner in which many of the computations of the native astronomer have been made, the comparison is not entirely trustworthy; a more careful adherence to the methods of the Siddhānta would have given somewhat different results; in the case of the daily motions of the sun and moon, the true calculations, as performed by us (see p. 308), give more correct values; in other instances, the contrary might perhaps have been the case.

<table>
<thead>
<tr>
<th>Sūrya-Siddhānta</th>
<th>Prof. Cuffin</th>
<th>Hindu error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of true conjunction in longitude,</td>
<td>2h 30m</td>
<td>3h 50m</td>
</tr>
<tr>
<td>Sun’s and moon’s longitude,</td>
<td>63° 50′ 37″</td>
<td>65° 12′ 37″</td>
</tr>
<tr>
<td>Moon’s distance from node,</td>
<td>43° 6′</td>
<td>4° 12′ 22″</td>
</tr>
<tr>
<td>Sun’s daily motion in longitude,</td>
<td>56° 52′</td>
<td>57° 45′</td>
</tr>
<tr>
<td>Moon’s do. do.</td>
<td>12° 5′ 59″</td>
<td>12° 7′ 13″</td>
</tr>
<tr>
<td>Sun’s apparent diameter,</td>
<td>31° 10′</td>
<td>31° 3′</td>
</tr>
<tr>
<td>Moon’s do. do.</td>
<td>29° 2′</td>
<td>29° 45′</td>
</tr>
<tr>
<td>Time of apparent conjunction,</td>
<td>3h 40m</td>
<td>5h 30m</td>
</tr>
<tr>
<td>Parallax in longitude, in time,</td>
<td>1h 10m</td>
<td>1h 36m</td>
</tr>
<tr>
<td>Amount of greatest obscuration,</td>
<td>1°</td>
<td>3° 59′</td>
</tr>
<tr>
<td>Time of first contact,</td>
<td>2h 21m</td>
<td>4h 15m</td>
</tr>
<tr>
<td>Time of separation,</td>
<td>4h 50m</td>
<td>6h 38m</td>
</tr>
<tr>
<td>Duration of eclipse,</td>
<td>2h 33m</td>
<td>2h 23m</td>
</tr>
</tbody>
</table>

26. pp. 183–200. Prof. Weber, of Berlin, has favored us in a private communication with a number of additional synonyms of the names of the asterisms, derived from the literature of the Brahmaṇa period.

Mravāra, the fifth of the series, is also styled andaḥkā, "the blind," apparently from its dimness; āryikā, "honorable, worthy;" indrākā, of doubtful meaning: this latter epithet is also found in some manuscripts of the Amaraśāstra, as various readings for āvata, which is there expressly declared (I. i. 2. 25) to designate the stars in the head of the antelope.

Ādara, the sixth asterism, is called bālu, "arm." Taking this name in connection with that of the preceding group, it seems probable that the Hindus figured to themselves the conspicuous constellation Orion as a running antelope, of which α, γ, β, and ζ mark the feet: α, then, is the left fore-foot, or arm. Perhaps the name Mraviyāda, "antelope-hunter," given to the neighboring Sirius (viii. 10), is connected with the same fancy.

The Maghas are called in a hymn of the last book of the Rig-Veda (x. 85. 13) apikā: the word means literally "evil, base, sinful," and its application to one of the asterisms is so strange that, if not found elsewhere, we should be inclined to conjecture a corrupted reading.
Phalguna, or the Phalguns, forming the eleventh and twelfth groups, are styled also arjuna, "bright, shining."

Cravana, the twenty-third asterism, receives the name aputtha, which is properly that of a tree, the Ficus religiosa; the reason of the appellation is altogether obscure.

Bhadrapada, the last double asterism, is called pratiṣṭhāna, "stand, support," in evident allusion to the disposition of the four bright stars which compose it, like the four feet of a stand, table, bedstead, or the like.

27. p. 200. We offer herewith the stellar chart to which reference was made in the note on p. 205, and which is intended to illustrate the positions and mutual relations of the Hindu nakṣatras, the Arab mundžil al-kamar, and the Chinese sieu. We add a brief explanation of the manner in which it has been constructed, and the form in which it is presented.

The form of the map is that of a plane projection, having the ecliptic as its central line. It would have better illustrated the Hindu method of defining the positions of the junction-stars, and the errors of the positions as defined by them, if the equator of A.D. 500, instead of the ecliptic, had been made the central line of the projection. This, however, would have involved the necessity of calculating the right ascension and declination of every star laid down, a labor which we were not willing to undertake. Moreover, the ecliptic is, in fact, the proper central line along which the groups of the Hindu and Arab systems, at least, are arranged, and the form given to the chart also facilitates the laying down of the equator of B.C. 2350, which we desired to add, for the purpose of enabling our readers to judge in a more enlightened manner of the plausibility of M. Biot's views respecting the origin of the Chinese system: it is drawn with a broken line, while the equator of A.D. 500 is also represented, by an entire line. As the zone of the heavens represented is, in the main, that bordering the ecliptic, the distances and the configuration of the stars are altered and distorted by the plane projection to only a very slight degree, not enough to be of any account in a merely illustrative chart, such as this is. As a general rule, we have laid down all the stars of the first four magnitudes which are situated near the ecliptic, or in that part of the heavens through which the line of the asterisms passes; stars of the fourth to fifth magnitude are also in many cases added; smaller ones are noted only when they enter into the groups of the several systems, or when there were other special reasons for introducing them. The positions are in all cases taken from Flamsteed's Catalogue, and the magnitudes are also for the most part from the same authority: in many individual cases, however, we have followed other authorities. We have endeavored so to mark the members of the three different series that these may readily be traced across the map; but, to assure and facilitate the comparison, we also place upon the page opposite it a conspectus of the nomenclature, constitution, and correspondence of the three systems, referring to pages 183–200 for a fuller discussion of these matters, and an exposition of what is certain, and what more or less hypothetical, or exposed to doubt, with regard to them.
1. Ācyantī.
2. Bhārata.
4. Rohini.
5. Megāciras.
6. Ārdrī.
7. Punarvasu.
8. Pushya.
9. Āclesha.
10. Māγdā.
11. Pūrva-Phalgunī.
12. Uttar-Phalgunī.
15. Svātī.
17. Amṛādhā.
19. Mūla.
20. Pūrva-Aṣādhā.
22. Abhijit.
23. Črāvana.
24. Čravīshṭhā.
25. Čataḥ bhāṣā...
27. Uttar-Bhādrapadā.

Arab. manusīt.
1. ash-Shāraṭān.
2. al-Būtān.
3. ath-Thurāyā.
4. ad-Dabarān.
5. al-Hakāh.
6. al-Hanīh.
7. adh-Dhīrī.
8. an-Nathrah.
9. al-Tarf.
10. aj-Jubah.
11. az-Zubrah.
12. an-Nafṣīh.
13. al-Auwāʾ.
14. an-Simāk.
15. al-Qhaffār.
16. an-Qaṣāmān.
17. al-Iklīl.
18. al-Kalīb.
19. ash-Shaunah.
20. an-Naʿāim.
21. al-Baldah.
22. Saʿl adh-Dhiḥiḥ.
23. Saʿl Bulaʾ.
24. Saʿl as-Suʿūd.
25. Saʿl ad-Alkhābiyāh.
27. al-Farḥ al-Mukhir.

Chinese. aitīt.
27. Lēu.
28. Cēi.
1. Māo.
2. Pi.
3. Taò.
4. Tām.
5. Tīng.
7. Līu.
8. Sing.
10. Y.
11. Chiń.
14. Ti.
15. Fang.
16. Sin.
17. Wei.
18. Ki.
22. Hīū.
23. Gōi.
24. Che.
25. Pi.

β and γ Arietis.
35, 39, and 41 Arietis.
γ Tauri, etc. (Plolades).
γ Tauri, etc. (Plolades).
γ Tauri, etc. (Plolades).
n Tauri, etc. (Plolades).
α Orionis.
α Orionis.
η, ω, γ, δ, ε Tauri.
φ, ω Orionis.
η, μ, ν, γ, δ Geminorum.
η, η Tauri, etc. (Plolades).
γ, δ Tauri, etc. (Plolades).
ζ Cancri.
γ, δ Cancri, and Praesepe.
γ Cancri, λ Leonis.
α Virginis.
δ, ζ Librae.
β, δ Scorpionis.
α, δ Scorpionis.
λ, μ, ν, δ, ζ, ε Scorp.
β, δ Librae.
β, δ, ε Scorpionis.
α Scorpionis.
λ, ν Scorpionis.
ρ, δ, ε, ζ Sagittarii.
ρ Sagittarii.
β Capricorni.
ε Aquarii.
ε Aquarii.
ε Aquarii.
ε Aquarii.
β Aquarii.
α Aquarii.
γ Aquarii.
γ Aquarii.
ε Pegasi, and Andromeda.
ε Andromedae, etc.
28. p. 207: We have perhaps expressed ourselves in a manner liable to misconstruction as to the want of reason or authority for giving to the asterisms the name of "lunar mansions," "houses of the moon," and the like. We would by no means be understood as denying that in the Hindu science, especially its older forms, and in the Hindu mythology, they are brought into particular and conspicuous relations with the moon. Indeed, whether they were originally selected and established with reference to the moon's daily progress along the ecliptic, as has been, until lately, the universal opinion, or whether we are to believe with M. Biot that they had in the first instance nothing to do with the moon, and only came by chance to coincide in number with the days of her sidereal revolution—it is at any rate altogether probable that to the Hindu apprehension this coincidence formed the basis of the system. We may even conclude, from the fact that the asterisms are so frequently spoken of in the early literature of the Brāhmaṇa period, while nevertheless there is no distinct mention of the planets until later (Weber, Ind. Lit., p. 222), that for a long time the Hindus must have confined their attention and observations to the sun and moon, paying no heed to the lesser planets: and yet we cannot regard it as in any degree probable—hardly as possible, even—that any nation or people could establish a system of zodiacal asterisms without discovering and taking note of the planets; or that such a system could have been communicated to, and applied by, the Hindus, without a recognition of their part of those conspicuous and ever-moving stars. It may fairly be claimed, then, that the asterisms, as a Hindu institution, are an originally lunar division of the zodiac; but we object none the less to their being styled "lunar mansions," or called by any equivalent name; because, in the first place, the Hindus themselves have given them no name denoting a special relation to the moon, and no name signifying "house, mansion, station," or anything of the kind; and because, in the second place, as soon and as far as the Hindu-astronomy extended itself beyond its limitation to observations of the moon, just so far and so soon did it employ the system of asterisms as a general method of division of the ecliptic; so that finally, as pointed out by us above, the asterisms have come to be divested, in the properly astronomical literature of India, of all special connection with the moon. With almost the same propriety might we call the Hindu signs "luni-solar mansions"—since they are, by origin, the parts of the ecliptic occupied by the sun during each successive synodical revolution of the moon—as denominate the nakṣatras of the Siddhāntas "lunar mansions."

29. p. 209. We should have mentioned further, that an additional inducement—and one, probably, of no small weight—to the reduction of the number of asterisms from twenty-eight to twenty-seven, is to be recognized in the fact that the time of the moon's sidereal revolution in days, though intermediate between the two numbers, is yet decidedly nearer to twenty-seven, exceeding it by less than a third. M. Biot might even claim with some reason that the choice of the number twenty-eight tended to prove the whole system not a lunar one by origin: yet it might be replied that, the time of revolution being distinctly more than twenty-seven days, the larger number was fully admis-
sible, and that it was also in some respects preferable, as being one that could be halved and quartered.

30. p. 273. In bringing this work to a close, we deem it advisable to present, in a summary manner, but more distinctly and connectedly than could properly be done in the notes upon the text, our conclusions as to certain points in the history of the Sûrya-Siddhânta, and of the astronomical science which it represents.

In the first place, Bentley's determination of the age of the treatise we conceive to be altogether set aside by the considerations which we have adduced against it (note to i. 29–34); there is no reasonable ground for questioning that the Sûrya-Siddhânta is, as the Hindus have long believed it to be, one of the most ancient and original of the works which present their modern astronomical science. How far the text of which the translation has been given above is identical in substance and extent with that of the original Sûrya-Siddhânta, is another question, and one not easy to solve. That it is not precisely the same is evident enough. Even the modern manuscripts differ from one another in single readings, in details of arrangement, in added or omitted verses. A comparison of the texts adopted and established by the different commentators would be highly interesting, as carrying the history of the treatise a step further back; but to us only one commentary is accessible, nor do we find anywhere any notices respecting the versions given by the others: in the absence of such, we may conclude that all present substantially the same text, and so are alike posterior to the modelling of the work into its present form and with its present contents. But the indications of addition and interpolation, which we have noted in so many cases to point out in our notes, are sometimes too telling to be misinterpreted. Farther than this we may not at present go: any detailed discussion of the subject must remain unsatisfactory, until a fuller acquaintance with other of the ancient treatises, and a more careful comparison of them with one another, shall throw upon it new light. A point of special interest connected with it is, whether the elements of mean motions of the planets do actually date from about the time pointed out by Bentley's calculations. With regard to this we are far from being confident; but we do not regard it as impossible, or even as very improbable, that those elements, as presented by our text, have been the same from the beginning, never having undergone correction until the application of the bija, about A.D. 1500 (p. 10 etc.). And the date of that correction is calculated at least to suggest the suggestion that Muslim science may have had something to do with it. That observation, and the improvement of their system by deductions from observation, were ever matters of such serious earnest with the Hindus that they should have been led to make such amendments independently, is yet to be proved. The most important alteration of which anything like direct proof is furnished is that which concerns the precession of the equinoxes (note to iii. 9–12); and even here we would not undertake to say confidently what is the conclusion to be drawn. All such inquiries must remain conjectural, mere gropings in the twilight, until the position of the Sûrya-Siddhânta in the Siddhânta literature shall be better understood. What has given it so much greater
prominence and popularity than are enjoyed by the other works of its
class, or from what period its precedence dates, is unknown. There
are treatises, like the Čahāra-Śāhita (add. note 1), which agree with
it in all essential features; there are yet others, like the Soma and Va-
sishtha Śulbhāntas, which are said (add. note 6) to vary little from it:
whether any one among them all is original—and if any, which—
whether in each case the relation is one of co-ordination or of subordi-
nation—we must be content for the time to be ignorant.

One thing, however, is certain: underneath whatever variety may
characterize the separate treatises, there exists a fundamental unity;
their differences are of secondary importance as compared with their
resemblances; they all represent essentially a single system. And this
by no means in the same sense in which all modern astronomical works
may be said to represent a single system. For the Hindu system is not
one of nature; it is not even a peculiar method of viewing and inter-
preting nature, from which, after it had once been devised by some con-
trolling intellect, others had not the force and originality to deviate: it
is a thoroughly artificial structure, full of arbitrary assumptions, of abs-
surdities even, which have no foundation in nature, and could be in-
vvented by one as well as another. We need only to refer, as instances,
to the framework of monstrous chronological periods (i. 14–23)—to
the common epoch of the commencement of the Iron Age (note to i.
29–31), with its exact or nearly exact (add. note 6) conjunction of all
the planets—to the form of statement of the mean motions, yielding
recurring conjunctions, at longer or shorter intervals—to the assump-
tion of a starting-point for the planets from at or near ζ Scopium (note
to i. 27)—to the revolutions of the aspects and nodes of the planets
(i. 41–14)—to the double system of epicycles (ii. 34–38)—to the deter-
mination of the planetary orbits (xii. 80–90), etc., etc. These are plain
indications that the Hindu science emanated from one centre; that it
was the elaboration of a period and of a school, if not of a single mas-
ter, who had power enough to impose his idiosyncracy upon the science
of a whole nation. The question, then, of the comparative antiquity of single treatises is lost in the higher interest of the inquiry—when,
where, and under what influence originated the system which they all
agree in representing?

What our opinions are upon these points will not be a matter of
doubt with any one who may have carefully looked through the preced-
ing pages, although they have nowhere been explicitly stated. We re-
gard the Hindu science as an offshoot from the Greek, planted not far
from the commencement of the Christian era, and attaining its fully de-
volved form in the course of the fifth and sixth centuries. The grounds
of this opinion we will proceed briefly to state.

In considering such a question; it is fair to take first into account the
general probabilities of the case. And there can be no question that,
from what we know in other respects of the character and tendencies
of the Hindu mind, we should not at all look to find the Hindus in pos-
session of an astronomical science containing so much of truth. They
have been from the beginning distinguished by a remarkable capacity
and disinclination to observe, to collect facts, to record, to make indus-
tive investigations. The old belief under the influence of which Bailly
could form his strange theories—the belief in the immense antiquity of
the Indian people, and its immemorial possession of a highly developed
civilization—the belief that India was the cradle of language, myth-
ology, arts, sciences, and religions—has long since been proved an error.
It is now well known that Hindu culture cannot pretend to a remoter
origin than 2000 B.C., and that, though marked by striking and mi-
ment traits of intellect and character, the Hindus have ever been weak
in positive science; metaphysics and grammar—with, perhaps, algebra
and arithmetic, to them the mechanical part of mathematical science—
being the only branches of knowledge in which they have independently
won honorable distinction. That astronomy would come to constitute
an exception to the general rule in this respect, there is no antecedent
ground for supposing. The infrequency of references to the stars in
the early Sanskrit literature, the late date of the earliest mention of the
planets, prove that there was no special impulse leading the nation to
devote itself to studying the movements of the heavenly bodies. All
evidence goes to show that the Hindus, even after they had derived
from abroad (p. 204) a systematic division of the ecliptic, limited their
attention to the two chief luminaries, the sun and moon, and contented
themselves with establishing a method of maintaining the concordance
of the solar year with the order of the lunar months. If, then, at a later
period, we find them in possession of a full astronomy of the solar sys-
tem, our first impulse is to inquire, whence did they obtain it? A
closer inspection does not tend to inspire us with confidence in its Hindu origin. We find it, to be sure, thoroughly Hindu in its external
form, wearing many strange and fantastic features which are to be at
once recognized as of native Indian growth; but we find it also to con-
tain much true science, which could only be derived from a profound
and long-continued study of nature. The whole system, in short, may
be divided into two portions, whereof the one contains truth so success-
fully deduced that only the Greeks, among all other ancient nations, can
show anything worthy to be compared with it; the other, the frame-
work in which that truth is set, composed of arbitrary assumptions and
absurd imaginings, which betray a close connection with the fictitious,
cosmogonies and geographies of the philosophical and Puranic literature
of India. The question presses itself, then, strongly upon us, whether
these two portions can possibly have the same origin: whether the sci-
entific habit of mind which could lead to the discovery of the one is
compatible with those traits which would permit its admixture with the
other. But most especially, could a system founded—as this, if original,
must have been—upon sagacious, accurate, and protracted observa-
tion of the heavenly bodies, so entirely ignore the ground-work upon
which it rested, and refuse and deny all possibility of future improve-
ment by like means, as does this Hindu system, in whose text-books
appears no record of an observation, and no confessed deduction from
observations; in which the astronomer is remanded to his text-book as
the sole and sufficient source of knowledge, nor ever taught or coun-
selled to study the heavens except for the purpose of determining his
longitude, his latitude, and the local time? Surely, we have a right to
say that the system, in its form as laid before us, must come from another people or another generation than that which laid its scientific foundation; that it must be the work of a race which either had never known, or had had time to forget, the observing habits and the inductive methods of those who gave it origin. But the hypothesis that an earlier generation in India itself performed the labors of which the later system-makers reaped the fruit, is well-nigh excluded by the absence, already referred to, of all evidence in the more ancient literature of deep astronomical investigation: the other alternative, of derivation from a foreign source, remains, if not the only possible, at least the only probable one. We come, then, next to consider the direct evidences of a Greek origin.

First in importance among these is the system of epicycles for representing the movement, and calculating the positions, of the planets. This, the cardinal feature in both systems, is (ii. 34-45) essentially alike and the same in both. Now, notwithstanding the fact that such secondary circles do in fact represent, to a certain degree, true quantities in nature, there is yet too much that is strange and arbitrary in them to leave any probability to the supposition that two nations could have devised them independently. But there are sufficient grounds for believing the Greeks to have actually created their own system, bringing it by successive steps of elaboration to the form in which Ptolemy finally presents it. In the history of the science among the Greeks, everything is clear and open; they tell us what they owed to the Egyptians, what to the Chaldeans: we trace the conceptions which were the germ of their scheme of epicycles, the observations on which it was based, the inductive and deductive methods by which it was worked out and established. In the Hindu astronomy, on the other hand, all is groundless assumption and absurd pretense: we find, as basis for the system, neither the conceptions—for these are directly or implicitly denied or ignored—nor the observations—for not a mention of an actual observation is anywhere to be discovered—nor the methods: the whole is gravely put forth as a complete and perfect fabric, of divine origin and immemorial antiquity. On the agreement of the two sciences in point of numerical data we will not lay any stress, since it might well enough be supposed that two nations, if once set upon the same track toward the discovery of truth, would arrive independently at so near an accordance with nature and with one another. We will look for other evidences, of a less ambiguous character, to sustain our main argument. The division of the circle, into signs, degrees, minutes, and seconds, is the same in both systems, and, being the foundation on which all numerical measurements and calculations are made, is an essential and integral part of both. Now the names of the first subdivisions, the signs, are the same in Greece and in India (see note to i. 58); but with the Greeks they belong to certain fixed arcs of the ecliptic, being derived from the constellations occupying those arcs; with the Hindus they are applied to successive arcs of 30°, counted from any point that may be chosen: this is an unambiguous indication that the latter have borrowed them, and forgotten or neglected their original significance. But farther, the ordinary Hindu name of that division of the circle which is in most frequent use, the
minute, is no Sanskrit word, but taken directly from the Greek, being 

\textit{leptē}, which is \textit{kentrōn}. Again, the planets are ordinarily named in the Siddhāntas in the order in which they succeed one another as regents of the days of the week; and not only has it been shown above that the week is no original Hindu institution, but it has even appeared that, on tracing it to its very foundation, we find there another Greek word, 

\textit{gnōs}, represented by \textit{ārdh}. Once more, in the cardinal operation of finding by means of the system of epicycles the true place of a planet, we see that one of the most important data, the mean anomaly, is called by another name of Greek origin, namely \textit{kendra}, which is \textit{xērōn}. These three words, occurring where they do, not upon the outskirts of the Hindu science, but in its very centre and citadel, amount of themselves almost to full proof of its Greek origin: taken in connection with the other concurrent evidences, they form an argument which can neither be set aside nor refuted. Of those other evidences, we will only mention farther here that Hindu treatises and commentaries of an early date often refer to the \textit{yāmanas}, “Greeks” or “wrestlers,” and to \textit{yavanēcārīs}, “the Greek (or western) teachers,” as authorities on astronomical subjects—that astronomical treatises are found bearing names which come more or less distinctly from the West (note to i. 4—6)—and that floating traditions are met with, to the effect that some of the Siddhāntas were revealed to their human promulgators in Romaka-city, that is to say, at Rome. Farther witness to the same truth, deducible from other coincidences of the two systems, we pass unnoticed here, since it is not our object to discuss the question exhaustively, but only to bring forward the main grounds of our opinions.

The question next arises, when, and in what manner the knowledge of astronomy was communicated from Greece to India. In reply to this, only probabilities offer themselves, yet in some points the indications are pretty distinct. It is, in our own view, altogether likely that the science came in connection with the lively commerce which, during the first centuries of our era, was carried on by sea between Alexandria, as the port and mart of Rome, and the western coast of India. Two considerations especially favor this supposition: first, that the chief site of the Hindu science is found to be the city which lay nearest to the route of that commerce (note to i. 62); secondly, that Rome is the only western city or country which is distinctly mentioned in the astronomical geography (xii. 39), and the one with which, as above noticed, the astronomical traditions connect themselves. Had the Hindus derived their knowledge overland, through the Syrian, Persian, and Bactrian kingdoms which stood under Greek government, or in which Greek influence was predominant, and Greek culture known and prized, the name of Rome would have been vastly less likely to stand forth with such prominence, and the capitals of Hindustan proper would more probably have been the cradles of the new science. The absence from the Hindu system of any of the improvements introduced by Ptolemy into that of the Greeks (note to ii. 43—45) tends strongly to prove that the transmission of the principal groundwork of the former took place before his time: nor can we think it likely that the numerical elements adopted by the Hindus would vary so much as in many cases they are found to
do from those of the Syntaxis, if the latter had been already in existence, and acknowledged as the principal and most authoritative exponent of Greek astronomy. Whether the information was transmitted through the medium of Hindus who visited the Mediterranean, or of learned Greeks who made the voyage to India, or by the translation of Greek treatises, or by what other methods, we would not at present even offer a conjecture; and the point is one of only subordinate consequence.

Whatever may have been the date of the first communication of the elements out of which the Hindu system was elaborated, there is good reason to suppose that its final reduction to its present form did not take place until some time during the fifth and sixth centuries. That period is distinctly pointed out by the choice of the equinox of A.D. 570 as the initial and principal point of the fixed sphere (note to i. 27), by the definition of position of the junction-stars of the asterisms (p. 211), and by the Hindu traditions which refer to that time the names of greatest prominence and authority in the early history of the science. It is evident that the elaboration of the system must have been a work of time, probably of many generations: what were the forms which it wore in the interval we do not know; here, as in many other departments of the Hindu literature, all record of the steps of development appears to be lost, only the final and fully formed product being preserved and transmitted to us: yet more light upon this point may still be hoped for, from the careful examination of all documents now accessible, or of such as may hereafter be discovered. The process of assimilation and adaptation to Hindu conceptions and Hindu methods was thoroughly and completely performed. Among the changes of method introduced, the most useful and important was the substitution of sines for chords (p. 60); the general substitution of an arithmetical for a geometrical form also deserves particular notice. That no great amount of geometrical science is implied in any part of the system, is very evident: it is distinguished by the constant and dexterous application of a few simple principles: the equality of the square of the hypothenuse to the sum of the squares of the base and perpendicular—the comparison of similar right-angled triangles—the formation and combination of proportions, the rule of three—are the characteristic features of the early Hindu mathematical knowledge, as displayed in the Sūrya-Siddhānta. Of other treatises, of an earlier or later period, as those of Brahmagupta and Bhāskara, which (see Colebrooke's Hindu Algebra) give evidence of knowledge more profound in arithmetic and algebra, we cannot at present speak; but we hope at some future time to be able to revert to the subject of the Hindu astronomy, in connection with these or other of the text-books by which it is represented.

Rev. Mr. Burgess, having placed his translation and notes in the hands of the Committee of Publication for further elaboration, has very liberally allowed them entire freedom in their work, even where their deductions, and the views they expressed, did not accord with his own opinions. The most important point at issue between us is that discussed in the next preceding pages, or the originality of the Hindu astronomy; upon this, then, he is desirous of expressing independently his dissenting views, as in the following note.
Concluding Note by the Translator.

It may not be improper for me to state, in a closing note, that I had prepared a somewhat extended and elaborate essay on the history of astronomy among the Hindus, to be published in connection with the preceding translation. But the length of this essay is such—the subject matter of it not being material to the illustration of the Siddhānta, and the translation and notes having already occupied so much space—that it was not thought advisable to insert it here.

Yet as my investigations have led me to adopt opinions on some points differing from those advanced by Prof. Whitney in his very valuable additions to the notes upon the translation, truth and consistency seem to require me to present at least a brief summary of the results at which I arrived in that essay in reference to the points in question. By so doing, I free myself from any embarrassment under which I should labor, if hereafter—as I now intend—I shall wish to express the grounds for my opinions on these points, in this Journal or elsewhere.

The points to which I allude bear upon the claims of the Hindus to the honor of original invention and discovery in astronomical science—especially, their claims to such an honor in comparison with the Greeks.

Prof. Whitney seems to hold the opinion, that the Hindus derived their astronomy and astrology almost bodily from the Greeks—and that what they did not borrow from the Greeks, they derived from other people, as the Arabians, Chaldeans and Chinese (see pp. 34, 201, 206, et al.). I think he does not give the Hindus the credit due to them, and awards to the Greeks more credit than they are justly entitled to. In advancing this opinion, however, I admit that the Greeks, at a later period, were the more successful cultivators of astronomical science. There is nothing among the Hindu treatises that can compare with the great Syntaxis of Ptolemy. And yet, from the light I now have, I must think the Hindus original in regard to most of the elementary facts and principles of astronomy as found in their systems, and for the most part also in their cultivation of the science; and that the Greeks borrowed from them, or from an intermediate secondary source, to which these facts and principles had come from India. I might perhaps so far modify this statement as to admit the supposition that neither Greeks nor Hindus borrowed the one from the other, but both from a common source. But with my present knowledge, I cannot concur in the opinion that the Hindus are, to any great extent, indebted to the Greeks for their astronomy, or that the latter have any well-grounded claims to the honor of originality in regard to those elementary facts and principles of astronomical science which are common to their own and other ancient systems, and which are of such a nature as indicates for them a single origin, and a transmission from one system to another. For the sake of clearness, it is well that I should state more specifically a few of the more important facts and principles that come under the class above referred to. They are as follows:

1. The lunar division of the zodiac into twenty-seven or twenty-eight asterisms (see transl., ch. viii). This division is common, with slight modifications, to the Hindu, Arabian, and Chinese systems.
2. The solar division of the zodiac into twelve signs, with the names of the latter. These names are, in their import, precisely the same in the Hindu and Greek systems. The coincidence is such that the theory of the division and the names of the parts having proceeded from one original source is unquestionably the correct one.

3. The theory of epicycles in accounting for the motions of the planets, and in calculating their true places. This is common to the Hindu and Greek astronomies. At least, there is such a coincidence in the two systems in reference to the epicycles as almost to preclude the idea of independent origin or invention.

4. Coincidences, and even a sameness in some parts, between the systems of astrology received among the Hindus, Greeks, and Arabsians, strongly indicate for those systems, in their primitive and essential elements, a common origin.

5. The names of the five planets known to the ancients, and the application of these names to the days of the week (see notes, i. 52).

In regard to these specifications I remark in general:

First, in reference to no one of them do the claims of any people to the honor of having been the original inventors or discoverers appear to be better founded than those of the Hindus.

Secondly, in reference to most of them, the evidence of originality I regard as clearly in favor of the Hindus; and in regard to some, and those the more important, this evidence appears to me nearly or quite conclusive.

I have not space for detail, nor is it the design of this note to enter into the details of argument on any point whatever. A brief remark, however, for the sake of clearness, seems called for in reference to each of the above five specifications of facts and principles common to some or all of the ancient systems of astronomy and astrology.

1. As to the lunar division of the zodiac into twenty-seven or twenty-eight asterisms. The undoubted antiquity of this division, even in its elaborated form, among the Hindus, in connection with the absence or paucity of such evidence among any other people, incline me decidedly to the opinion that the division is of a purely-Hindu origin. This is still my opinion, notwithstanding the views advanced by M. Biot and others in favor of another origin.

2. As to the solar division of the zodiac into twelve parts, and the names of those parts. The use of this division, and the present names of the signs, can be proved to have existed in India at as early a period as in any other country; and there is evidence less clear and satisfactory, it is true, yet of such a character as to create a high degree of probability, that this division was known to the Hindus centuries before any traces can be found in existence among any other people.

As corroborative of this position in part, or at least as strongly favoring the idea of an eastern origin of the division of the ecliptic in question, I may be allowed to adduce the opinions of Ideler and Lepsius, as quoted by Humboldt (Cosmos, Harper’s ed., iii. 120, note): “Ideler is inclined to believe that the Orientals had names, but not constellations, for the Dodecatomera, and Lepsius regards it as a natural assumption that the Greeks, at the period when their sphere was for the most part
unfilled, should have added to their own the Chaldean constellations from which the twelve divisions were named." Whether Ideler meant by "Oriental" the Chaldeans, or some other eastern people, the application of the term in this connection to the Hindus exactly suits the supposition of the Indian origin of the division in question, since in Indian astronomy the names of the signs are merely names of the twelfth parts of the ecliptic, and are never applied to constellations. Humboldt's opinion is, that the solar divisions of the ecliptic, with the names of the signs, came to the Greeks from Chaldea. I think the evidence preponderates in favor of a more eastern, if not a Hindu, origin.

3. The theory of epicycles. The difference in the development of this theory in the Greek and Hindu systems of astronomy precludes the idea that one of these people derived more than a hint respecting it from the other. And so far as this point alone is concerned, we have as much reason to suppose the Greeks to have been the borrowers as the contrary; but other considerations seem to favor the supposition that the Hindus were the original inventors of this theory.

4. As regards astrology, there is not much honor, in any estimation, connected with its invention and culture. The coincidences that exist between the Hindu and Greek systems are too remarkable to admit of the supposition of an independent origin for them. But the honor of original invention, such as it is, lies, I think, between the Hindus and the Chaldeans. The evidence of priority of invention and culture seems, on the whole, to be in favor of the former; the existence of three or four Arabic and Greek terms in the Hindu system being accounted for on the supposition that they were introduced at a comparatively recent period. In reference, however, to the word ḫurā, Greek ἔκα (see notes to i. 52; xii. 78-79), it may not be inappropriate to introduce the testimony of Herodotus (B. II, ch. 109): "The sun-dial and the gnomon, with the division of the day into twelve parts, were received by the Greeks from the Babylonians." There is abundant testimony to the fact that the division of the day into twenty-four hours existed in the East, if not actually in India, before it did in Greece. In reference, farther, to the so-called Greek words found in Hindu astronomical treatises, I would remark that we may with entire propriety refer them to that numerous class of words common to the Greek and Sanskrit languages, which either came to both from a common source, or passed from the Sanskrit to the Greek at a period of high antiquity; for no one maintains, so far as I am aware, that the Greek is the parent of the Sanskrit, to the extent indicated by this numerous class of words, and by the similarity of grammatical inflections in the two languages.

5. As to the names of the planets, I remark that the identity of all of them in the Hindu and Greek systems is not to my mind clearly made out. However this may be, I think the present names of the planets in Greek astronomy originated at least as far east as Chaldea. Herodotus says (B. II, ch. 52): "the names of the gods came into Greece from Egypt." The names of the planets are names of gods. Herodotus's opinion indicates the belief of the Greeks in reference to the origin of these names. Other considerations show for them, almost beyond a question, an origin as far east, to say the least, as Chaldea.
As to the application of the names of the planets to the days of the week, it is impossible to determine definitely where it originated. Respecting this matter, Prof. H. W. Wilson expresses his opinion—in which I concur—in the following language: “The origin of this arrangement is not very precisely ascertained, as it was unknown to the Greeks, and not adopted by the Romans until a late period. It is commonly ascribed to the Egyptians and Babylonians, but upon no very sufficient authority, and the Hindus appear to have at least as good a title to the invention as any other people” (Jour. Roy. As. Soc., ix. 84).

One word on the claims of the Arabians to the honor of original invention in astronomical science. And first, they themselves claim no such honor. They confess to having received their astronomy from India and Greece. They had at an early period some two or three of the first Hindu treatises of astronomy. “In the reign of the second Abbasside Khalif Almansur... (A.D. 779), as is related in the preface to the astronomical tables of Ben-Al-Adami, published... A.D. 920, an Indian astronomer, well versed in the science which he professed, visited the court of the Khalif, bringing with him tables of the equations of planets according to the mean motions, with observations relative to both solar and lunar eclipses, and the ascension of the signs; taken, as he affirmed, from tables compiled by an Indian prince, whose name, as the Arabic author writes it, was PurnaTN” (Colebrooke’s Hindu Algebra, p. lixiv). That the Arabians were thoroughly imbued with a knowledge of the Hindu astronomy before they became acquainted with that of the Greeks, is evident from their translation of Ptolemy’s Syntaxis. It is known that this great work of the Greek astronomer first became known in Europe through the Arabic version. In the Latin translation of this version, the ascending node (Greek ανωθελός πόρος) is called nodus capitis, “node of the head,” and the descending node (Greek καταθελός πόρος), nodus caudae, “node of the tail”—which are pure Hindu appellations (see Latin Translation of Almagest, B. iv, ch. 4; B. vi, ch. 7, et al.). This fact, with other evidence, clearly shows the influence of Hindu astronomy on that of the Arabians. In fact, this latter people seem to have done little more in this science than work over the materials derived from their eastern and western neighbors.

Another fact showing the belief of the Arabians themselves respecting their indebtedness, in matters of science, to the Hindus, should be mentioned here. They ascribe the invention of the numerals, the nine digits (the credit of whose invention is quite generally awarded to the Arabians), to the Hindus. “All the Arabic and Persian books of arithmetic ascribe the invention to the Indians” (Strachey, on the Early History of Algebra, As. Res., xii. 184; see likewise Colebrooke’s Hindu Algebra, pp. lii-liii, where the same is shown from a different authority. Strachey’s article was published subsequently to the work of Colebrooke).

The above facts and considerations, showing the indebtedness of the Arabians to the Hindus in regard to mathematical and astronomical science, clearly have an important bearing on the question of priority of invention in regard to the lunar division of the zodiac into twenty-eight asterisms, at least so far as the Arabians are concerned. Taking
all the facts into account, the supposition that this people were the
inventors is altogether untenable.

I close this note—already longer than I intended—with a quotation
from that distinguished orientalist, H. T. Colebrooke. In a very valu-
able essay entitled "On the Notions of the Hindu Astronomers con-
erning the Precession of the Equinoxes and Motions of the Planets," hav-
ing stated with some detail some of the more striking peculiarities of the
Hindu systems, and likewise coincidences existing between them and that
of the Greeks, with the evidence of communication from one people to
the other, he says: "If these circumstances, joined to a resemblance
hardly to be supposed casual, which the Hindu astronomy, with its ap-
paratus of eccentrics and epicycles, bears in many respects to that of
the Greeks, be thought to authorize a belief, that the Hindus received
from the Greeks that knowledge which enabled them to correct and im-
prove their own imperfect astronomy, I shall not be inclined to dissent
from the opinion" (As. Res., xii. 245-6; Essays, ii. 411).

This is all that so learned and cautious a writer could say in favor of
the opinion that the Hindus derived astronomical knowledge from the
Greeks. More than this I certainly could not say. After the solar
division of the zodiac, with the names of its parts, it is evident, I think,
that only hints could have passed from one people to the other, and that
at an early period; for on the supposition that the Hindus borrowed
from the Greeks at a later period, we find it difficult to see precisely
what it was that they borrowed; since in no case do numerical data and
results in the systems of the two peoples exactly correspond. And in
regard to the more important of such data and results—as for instance,
the amount of the annual precession of the equinoxes, the relative size
of the sun and moon as compared with the earth, the greatest equation
of the centre for the sun—the Hindus are more nearly correct than the
Greeks, and in regard to the times of the revolutions of the planets
they are very nearly as correct: it appearing from a comparative view
of the sidereal revolutions of the planets (p. 24), that the Hindus are
most nearly correct in four items, and Ptolemy in six. There has evi-
dently been very little astronomical borrowing between the Hindus and
the Greeks. And in relation to points that prove a communication from
one people to the other, with my present knowledge on the subject, I
am inclined to think that the course of derivation was the opposite to
that supposed by Colebrooke—from east to west rather than from west
to east; and I would express my opinion in relation to astronomy, in
the language which this eminent scholar uses in relation to some coin-
cidences in speculative philosophy and religious dogmas, especially the
doctrine of metempsychosis, found in the Greek and Hindu systems,
which indicate a communication from one people to the other: "I
should be disposed to conclude that the Indians were in this instance
teachers rather than learners" (Transactions of the Roy. As. Soc., i. 579):
This opinion is expressed in the last essay on oriental philosophy that
came from the pen of Colebrooke.

E. B.

Boston, May, 1860.