Review

Reviewed Work(s): The Science of the Sulba. A Study in Early Hindu Geometry by Bibhutibhusan Datta

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Le chapitre sept, Notes additionnelles, n'est pas moins intéressant que les autres, mais il suggère que le livre a été composé avec trop de hâte, car l'arrangement en est défectueux. Ce chapitre supplémentaire est presque aussi long que le reste du livre ! Ces notes se rapportent à des sujets tels que ceux ci : Répartitions des qualités des remèdes (résumé d'idées chinoises). Médecine des signatures et magies sympathiques. Coutumes et croyances. Remèdes étranges. Responsabilité médicale en Annam. « Répugnances médicinales ». Proverbes.

J'extrais de cette collection trois proverbes; les deux premiers sont purement annamites, le troisième est d'origine chinoise. Je ne les cite qu'en traduction française, mais j'ajoute des équivalents latins bien connus :

(1) « Médecin, guéris-toi toi-même» *(Medice cura te ipsum)*.

(2) « Malade, on s'inquiète de son corps; guéri, on craint pour son argent ».

Cum locus est morbis, medico promittitur orbis;
Mox fugit a mente medicus, morbo recedente. (8)

(3) « Le remède qui ne fait pas cligner les yeux du malade ne les guérit pas. *(Amaris pharmacis amara bilis proluitur)*. » Enfin un autre proverbe chinois : « Il faut avoir étudié le livre *Dich* avant de pouvoir connaître la médecine » (ce livre est un des classiques confucéens) nous fait penser à l'un des dictons hippocratiques. Il serait vain de vouloir expliquer ces ressemblances par des transmissions; il faut plutôt y voir des preuves nouvelles de l'unité de l'esprit humain.

Il nous manque des index chinois et annamite, mais peut-être ceux ci seront-ils ajoutés quand l'ouvrage sera complet. Espérons que le docteur MENAUT nous donnera bientôt une étude analogue relative au Cambodge, et MM. CREVOST et PÉTELOT, une troisième relative au Tonkin. Il sera fort intéressant de comparer leurs résultats entre eux, aussi bien qu'avec les idées chinoises.

GEORGE SARTON.

Bibhutibhusan Datta.—*The Science of the Sulba. A Study in Early Hindu Geometry.* (Readership Lectures for the year 1931). XVI+240 p. Published for the University of Calcutta, 1932.

The " śulbas " or " śulba-sūtras " are manuals for the construction of altars necessary in connection with sacrifices of the vedic Hindus. The number of those manuals may well have run into hundreds but at present we have manuscripts of only seven, namely those of

(8) Voir à ce sujet la pl. 2 dans l'article de C. D. LEAKE (*Isis*, 7, 24).

BAUDHĀYANA (1), ĀPASTAMBA (2), KĀTYĀYĀNA (3), MĀNAVA (4), MAITRĀYAṆĪYA (5), VĀRĀHA (6), and VĀDHULA. Dr. DATTA states that the available śulba-sūtras can be sharply divided into two classes, the class of prime importance including the manuals of BAUDHĀYANA, ĀPASTAMBA, and KĀTYĀYĀNA. " These give us an insight into the early state of Hindu geometry before the rise and advent of the Jaina Sect (500-300 B.C.)." "The four śulbas of the other class add practically very little to our stock of information in this respect."

What sure grounds are there for assigning any such antiquity to the documents as they have now come down to us? (7) None, so far as the reviewer can find out. KAYE gives 200 A.D., rather than 500 B.C.,

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(1) The BAUDHĀYANA śulba was published with an English translation, and critical notes by G. THIBAUT in *Paṇḍit*, a monthly journal of the Sanscrit College, Benares, v. 9-10, 1874-75 and n. s. v. 1, 1877.

(2) The ĀPASTAMBA śulba has been finely edited with German translation, notes, commentary, and introduction by A. BÜRK, *Zeitschrift der deutschen morgenländischen Gesellschaft*, v. 55, 1901, p. 543-591; v. 56, 1902, p. 327-391. He assigns this śulba to the fourth or fifth century B.C. See also G. MILHAUD, " La géométrie d'ĀPASTAMBA," *Revue générale des sciences*, v. 21, 1910, p. 512-520.

(3) The first two chapters of the so-called KĀTYĀYĀNA śulba were published with an English translation and commentary by G. THIBAUT in *Paṇḍit*, n. s., v. 4, 1882, p.

(4) No translation of the MĀNAVA śulba has been published but an account in English with details as to the contents of each of the seven sections has been given by N. K. MAZUMDAR in *University of Calcutta Journal of the Department of Letters*, v. 8, 1922, p. 327-342.

(5) The MAITRĀYAṆĪYA śulba is a different edition of the MĀNAVA. They cover almost the same ground and many passages are identical but the arrangements are different. No translation has been published.

(6) The VĀRĀHA śulbas are very closely related to the MĀNAVA and MAITRĀYAṆĪYA śulbas. No translation has been published.

(7) For further literature see : C. MÜLLER, " Die Mathematik der śulvasūtra. Eine Studie zur Geschichte indischer Mathematik," *Abhandlung aus dem mathem. Seminar der Univ. Hamburg*, v. 7, p. 173-204, 1929; N. K. MAZUMDAR, " On the different śulba sutras," *Proc. and Trans. of the Second Oriental Conference*, Calcutta, 1922, p. 561-564; G. R. KAYE, *Indian Mathematics*, Calcutta, 1915, p. 1-8; M. CANTOR, (*a*) " Über die älteste indische Mathematik," *Archiv d. Mathematik u. Physik*, s. 3, v. 8, 1905, p. 63-72, (*b*) " Gräko-indische Studien," *Zeitschrift f. Mathem. u. Physik*, v. 22, *hist.-lit. Abt.*, p. 1-23 + 1 plate, (*c*) *Vorlesungen über Geschichte der Mathem.*, v. 3, third ed., 1907, p. 635-644; G. THIBAUT, " On the Śulva-sūtras," *Journ. Asiatic Soc. Bengal*, v. 44, 1875, p. 227-275; H. G. ZEUTHEN, " Sur l'arithmétique géométrique des Grecs et des Indiens," *Bibliotheca Mathematica*, s. 3, v. 5, 1904, p. 105-108, (*d*) " Théorème de Pythagore, origine de la géométrie scientifique," *Comptes rendus du II. Congrès internat. de Philosophie à Genève,...* 1904, 1905, p. 833-854; H. VOGT, " Haben die alten Inder den Pythagoreischen Lehrsatz und das Irrationale gekannt?, " *Bibliotheca Mathematica*, s. 3, v. 7, p. 6-23, 1906.

as an upper limit. The manuscripts from which recent studies have been made are comparatively modern, and even assuming that some sort of śulba-sūtras did date from before 500 B.C., or 200 A.D., what evidence is there that most of the things of special mathematical interest were not added several centuries later? No such wholesale doubt can be associated with most Babylonian, Egyptian and Greek mathematical documents.

Dr. DATTA explains (quite differently from KAYE) that in the title śulba-sūtra the word sūtra means " an aphorism " or " a short rule," and that the science itself is called the śulba, which was the original title of the manuals. Since the śulba deals with the science of geometry, Dr. DATTA writes " we conclude that the earliest Hindu name for geometry was śulba."

Of all the śulbas, that of BAUDHĀYANA is the longest and possibly the oldest. It contains 525 sūtras; there are 223 sūtras in the śulbas of ĀPASTAMBA and 90 in the śulbas of KĀTYĀYĀNA. The sūtras are often very brief, not more than two lines; but in the printed translation of some, about a score of lines are needed. The śulbas were rules connected with the construction of sacrificial altars which were of different shapes such as a falcon shaped altar built of square bricks, or an altar of the shape of a falcon with curved wings and outspread tail; a heron-shaped altar with two feet: one of the shape of the forepart of the poles of a chariot, an equilateral triangle; another of two such triangles joined at their bases; several wheel-shaped or circular altars, tortoise shaped, etc. The area remained the same when a different shape of altar was required. Thus squares had to be found which would be equal to two or more given squares, or equal to the difference of two given squares; rectangles had to be turned into squares, and squares into rectangles, and the equivalence of area of circles and squares were sought. Such problems inspired the mathematics arising. Some examples of this may be mentioned. As a result of rules for finding the length of the diagonal of a square

$$\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3\cdot 4} - \frac{1}{3\cdot 4\cdot 34}$$

which is correct to five places of decimals. That the square on the diagonal of a square has twice the area of the square is remarked. Again, a square is *geometrically* enlarged into another square by the addition of a gnomon, two rectangles and a smaller square ($2ax + x^2$) to give another square $(a + x)^2$.

BAUDHĀYANA, ĀPASTAMBA and KĀTYĀYĀNA give the following rule: If you wish to construct a circle equal to a square " draw half its diagonal about the center towards the east-west line; then describe a circle together with one third that which lies outside the square." This to be interpreted as follows : Let O be the center of a square $ABCD$ with its side AB ($2a$) oriented east and west. With O as center and OA as radius describe a circle. AB will be a cord of this circle; draw OM perpendicular to this cord meeting the circle in E. Cut off $MP = 1/3\ EM$. Then OP is the radius (r) of the required circle, and $r = \frac{a}{3}(a + \sqrt{2})$. With regard to this discussion involving the cord and height of a segment it is of interest to recall that it was in connection with just such a figure that we have recently learned that the Babylonians of about 2000 B.C. were familiar with the Pythagorean theorem.

To transform a circle into a square BAUDHĀYANA says : " divide its diameter into eight parts; then divide one part into twenty nine parts and leave out twenty eight of these; and also the sixth part of the preceding subdivision less the eighth part of the last." If the diameter of the circle be denoted by d this rule is equivalent to

$$2a = \frac{7d}{8} + \left[\frac{d}{8} - \left\{\frac{28d}{8.29} + \left(\frac{d}{8.29.6} - \frac{d}{8.29.6.8}\right)\right\}\right]$$

or $a = r - \frac{r}{8} + \frac{r}{8.29} - \frac{r}{8.29.6} + \frac{r}{8.29.6.8}$.

Another rule given by BAUDHĀYANA, ĀPASTAMBA and KĀTYĀYANA leads to a rule equivalent to the formula

$$a = r - (2/15)\ r.$$

Such problems are not again referred to by any later Indian mathematicians. The corresponding values of π for the three rules would be 3.0883..., 3.0885..., 3.004. A better value of π is given in the MĀNAVA śulba, which states that the square of two by two cubits is equivalent to a circle of radius/cubit and 3 angulis; whence $\pi = 4(8/9)^2 = 3.16....$ the value occurring in the Rhind mathematical papyrus.

The " Pythagorean theorem " is stated quite generally and is illustrated by a number of examples some of which may be summarized as follows :

BAUDHĀYANA : $3^2 + 4^2 = 5^2$, $5^2 + 12^2 = 13^2$, $8^2 + 15^2 = 17^2$, $7^2 + 24^2 = 25^2$, $12^2 + 35^2 = 37^2$, $15^2 + 36^2 = 39^2$.

ĀPASTAMBA : $3^2 + 4^2 = 5^2$, $12^2 + 16^2 = 20^2$, $15^2 + 20^2 = 25^2$, $5^2 + 12^2 = 13^2$, $15^2 + 36^2 = 39^2$, $8^2 + 15^2 = 17^2$, $12^2 + 35^2 = 37^2$.

The Hindus thus formulated their theorem after trial in particular cases. (See T. L. HEATH, *The Thirteen Books of Euclid's Elements*, second ed. Cambridge, v. 1, 1926, p. 360-364; see also the papers of ZEUTHEN, CANTOR and VOGT listed below.) While this discovery may have been independent so far as the Greeks were concerned (HEATH) knowledge of the result may well have come to them from the Babylonians.

Dr. DATTA's work is divided into 16 chapters, the first (p. 1-9) telling of the different śulbas, the second (p. 10-19) on commentators on the śulbas from the eighth to the seventeenth centuries, the third (p. 20-40) on the " growth and development of the śulba." Dr. DATTA concludes this chapter with the statement that " we have clear proof " of the use of " (1) the theorem of the square of the diagonal, (2) the quadrature of a circle," in the time of the *Satapatha Brāhmana* (c. 2000 B.C.)." The reviewer has not found this " clear proof " convincing. Chapter IV (p. 41-51) is entitled " postulates." This chapter opens as follows : " For the geometrical operations described in the *śulba* the authors, we find, have tacitly assumed the truth of certain other results without any attempt to describe them beforehand or to indicate how they could be effected. These results we have called here postulates of the *śulba*. They might not be postulates in the Euclidean sense of the term; but they can certainly be so called in accordance with the meaning given by ARISTOTLE, namely ' whatever is assumed, though it is a matter for proof and used without being proved '." Among Dr. DATTA's twelve " postulates " the first three are : "(*a*) A given finite line can be divided into any number of equal parts "; " (*b*) A circle can be divided into any number of parts by drawing diameters "; and " (*c*) Each diagonal of a rectangle bisects it." The extent of such a system of " postulates " might be multiplied many times, but discussion of anything of the kind is surely highly misleading. We are dealing with texts containing nothing but rules, and statements concerning altars, and many of these are exceedingly difficult to interpret. There is not a single geometrical figure. There is no mathematical derivation of any rule. The reviewer has strongly felt that, for one entirely ignorant of the contents of the śulbas, it is of fundamental importance that one should have : (1) literal translations of the complete texts, so that one may read and learn exactly what the originals state; (2) interpretations, notes of commentators, conjectures, etc., clearly separated from the texts. In Dr. DATTA's work it is not possible to find to any degree of completeness, just what was in any one of the śulbas. This is partly due to his topical arrangements, " Constructions " (chapter 5, p. 52-71), " Combination of areas " (chap. 6, p. 72-82), " Transformation of areas " (chap. 7, p. 83-94), " Areas, and volumes " (chap. 8, p. 95-103), " The theorem of the square of the diagonal " (chap. 9, p. 104-122), " Rational diagonals " (chap. 10, p. 123-139), " Squaring the circle " (chap. 11, p. 140-151), " Similar figures " (chap. 12, p. 152-164), " Geometrical algebra " (chap. 13, p. 165-177), " Indeterminate problems " (chap. 14, p. 178-186), " Elem. treatment of surds " (chap. 15, p. 187-211), and " Fractions and other minor matters " (chap. 16, p. 212-220). With a fairly complete bibliography, and an index, the volume closes.

Dr. DATTA's volume is one which should be in the hands of every student of the history of mathematics. It is serious in purpose, presents arguments pro and con fairly and fully and contains many original points of view and scores of exact references to authorities and texts. So much information regarding the śulbas has not been earlier available in any readily accessible English source. Coming from a proved scholar long experienced in dealing with historical questions, it will undoubtedly inspire further research leading to more correct views of early Indian geometry and its relation to intellectual achievements of other nations.

R. C. ARCHIBALD.

H. P. J. Renaud et **Georges S. Colin**.—*Tuḥfat al-aḥbāb*. Glossaire de la matière médicale marocaine. Texte publié pour la première fois avec traduction, notes critiques et index. XXXIV+218+75 (Arabe) p. (Publications de l'Institut des hautes études marocaines, 24). Paris, GEUTHNER, 1934.

Le *Tuḥfat al-aḥbāb fī māhīyat an-nabāt wal-a'shāb* (Don précieux aux amis traitant des qualités des plantes et des simples) — traité marocain anonyme de matière médicale — n'est pas une nouveauté, mais il faut savoir gré aux auteurs de nous en avoir préparé de longue main une édition critique aussi soignée, et pourvue de notes abondantes. Une traduction française en fut publiée pour la première fois par ALPHONSE MEYER dans le *Journal de médecine et de pharmacie de l'Algérie* en 1881, et une deuxième traduction (incomplète) fut publiée vingt cinq ans plus tard dans l'ignorance certaine de la précédente par G. SALMON : Sur quelques noms de plantes en arabe et en berbère (*Archives marocaines*, vol. 8, 1906). Dans son *Dictionnaire des noms des plantes* (Le Caire, 1930; *Isis*, 20, 586), AHMED ISSA bey nous signale que ce texte fut imprimé à Alger en 1881. Comme cette indication est donnée dans le texte arabe (p. xiii) j'avais pensé d'abord qu'elle se rapportait à une édition arabe, mais sans doute s'agit-il de la traduction française portant la même date ? Je note qu'AHMED ISSA bey connaît cette traduction et en a fait usage tandis que les savants éditeurs de Rabat ne mentionnent ni son ouvrage, ni celui plus ancien de GEORG SCHWEINFURTH (1836-1925) : *Ȧrabische Pflanzennamen aus Aegypten, Algerien und Jemen* (Berlin, 1912; *Isis*, 1, 268-71).

Les deux traductions antérieures dérivaient chacune d'un seul manuscrit; leur collationnement mit en lumière des dissemblances inquiétantes. Le nouveau texte est établi sur trois manuscrits, plus la traduction de celui d'Alger.

L'auteur en est inconnu mais il était certainement un Marocain du Sud, car il dit ' *indanā* (chez nous) en parlant de Marrakech, et appelle