VEDIC ASTRONOMY

(Vedaanga Jyotisha)

(A Prehistoric Puzzle)

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यथा शिखा मयूराणां नागानां मणयो यथा।
तद्वद्वेदाङ्गशास्त्राणां ज्योतिषं मूर्धनि स्थितम्।।

Like the comb on the head of a peacock or a jewel on the head of a snake, this scientific composition of Jyotisha (Vedic astronomy) occupies the position at the top of all (six) annexures of Vedas.

– Lagadha Mahaamuni

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Author :
Prabhakar Vyankatesh Holay
Advocate,
Dhantoli, Nagpur-440 012 (India)

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FOREWORD

Shri Babasaheb Apte Smarak Samiti has so far published a few books which are based on research carried out with the objective of investigating our true history. We have now the pleasure in publishing this book which is a part of the same series. The Samiti was founded in 1973 to prepetuate the cause to which the late Babasaheb devoted a major portion of his life viz. investigating and writing the true history of Bharat. History which is at present taught in educational institutions is either written by English scholars or by persons under their supervision or influence.

Late Umakant Keshav Apte in whose memory the Samiti has been formed, was called maananeeya Babasaheb by his friends and wellwishers. It is worthy to give here his brief life-sketch. He was born in 1903 and lost his father in 1919.

"Oh, God, this child suffering from illness is yours! I am offering it at your feet; you may save or kill it." Reminding his mother of her utterance when he was seriously ill, young Babasaheb expressed his determination of living a bachelor's life by saying, "As I am already offered to God, you should not expect from me anything for the family. I have to devote myself to the noble cause of serving the motherland." This dialogue took place between him and his mother, when his mother asked him to get married, after he had passed matriculation in 1920.

Shri Babasaheb Apte served as a school teacher from 1920 to 1924, but resigned his job, when he was not allowed to tell stories of patriots to his students. In 1926, he came in contact with Dr. K.B. Hedgewar, the founder of Rashtriya Swayamsevak Sangh, who inspired him to dedicate his entire life to R.S.S. work. He became a pracharak (full time organiser) in 1931 and worked as such till the end of his life in 1972.

Shri Apte's life was the best example of ceaseless activity and an untiring acquisition of knowledge that can be compared only to that of our ancient seers. Bharat was his venerable God and he inspired lakhs of R.S.S. Swayamsevakas to follow his example. Every year he toured the entire country and awakened partiotism in the hearts of the people by his nectarous speeches. He was a firstrate ıtor, having vast information and an extra-ordinary command over

Hindi, Marathi, Bengali and English. Though he began to learn Sanskrit in his middle age, his studious efforts not only helped him to gain a command over that language, but also enthused and inspired others to follow suit. It was with his inspiration that two Sanskrit periodicals, Bhaaratee from Jaipur and Bhavitavyam from Nagpur were started and are being continuously published.

Shri Apte was himself a prolific writer and contributed innumerable articles on social, historical and cultural topics. In 1928, he wrote and published the biography of Punjab Kesari Lala Lajapat Rai and in 1930 that of Shilpakalaanidhi K.N. Vaze. His book entitled 'Hamare Raastrajeevana Kee Paramparaa' published in 1950, highlights the stories of Dashaavataaras (regarding the incarnations of Lord Vishnu) with his sincerest attempt to present the well-knit picture of ideal and continuous development of our national life. This work is a crystal clear testimony to his aptitude for research.

Shri Bhanupratap Shukla, a renowned Hindi writer, collected and published in Hindi in 1980 the various articles of Shri Babasaheb in a book entitled 'Mrtyunjaya Bhaarata' (Immortal India). The very title of the book gives a glimpse of the thinking of Shri Apte. For the last 2,000 years, our country is facing foreign invasions of all types. We have many examples in the world history which show that many mighty empires and civilizations were completely destroyed by such invasions. But Bharat has survived them all. The reason of this longevity and tenacity, according to Shri Babasaheb, lies in our long past glorious history, not only political but allsided one, dealing with every facet of our national life. Every nation is naturally proud of its history and culture and it is no wonder that Bharat with its hoary past and with perhaps the longest unbroken cultural tradition in the world, would be justly proud of its heritage.

Late Babasaheb Apte was not only proud of our history but was also an ardent scholar who always stressed that a proper study of our glorious past would tremendously help us in building a bright future. Rather unpleasingly, he often pointed out the non-presentation of our entire national history embracing simultaneously all spheres of our national life and all parts of the country in a very small compass. He put in the best of his efforts to inspire many to get rid of this historiographical drawback, but unfortunately could not remove it during his lifetime.

The need for compiling the history of Bharat, which would embody all facets of our national life, is now being felt more and more. Collection of necessary data preceding any such compilation is itself a stupendous task. In order to offer a befitting homage to the revered soul, the Shri Babasaheb Apte Smarak Samiti therefore resolved to continue all efforts of compilation of our entire history since the commencement of Kali yuga. The Samiti feels that this gigantic and indispensable national task can be fulfilled only by establishing district-wise centres under the able guidance of scholars in history. The Samiti has already commenced its efforts from the last eight years with the active and amalgamated co-operation from many scholars, and has been able to give some elementary shape to the scheme. The present book is one more step in this direction.

Shri Babasaheb Apte Smarak Samiti aims at compiling an all-sided history of India since the beginning of Kali yuga. Kali yuga is the era followed in the Hindu almanacs all over the world. It may be pointed out that the year 1988 A.D. is 5089-5090 year of Kali era. Hence the project undertaken by the Samiti amounts to the compilation of Indian history for the last over 5100 years.

A thorough knowledge of various calendars in our history is essential to students of history to enable them to accurately determine dates and time of several epoach-making events. Without such a knowledge, they cannot write our history in the proper chronological order. In 1986 Shri P.V. alias Balasaheb Holay wrote a book in Marathi "Vedaanga Jyotisha" dealing with Indian astronomy and calendar. In all probability Vedaanga Jyotisha, astronomical calendar, was used in Bharat from immediately after the great mahaabhaarata war upto the advent of Greek invaders. The text is precise, almost like a mathematical formula. Later, however, because of centuries of non-use, it became incomprehensible. After years of painstaking research and penetrating analysis of its archaic Sanskrit text, Shri Holay has succeeded in unravelling its secrets. It will be a powerful key to resolve many perplexing riddles of chronology. That is why we prevailed upon him to translate his book into English to further the course of probing Indian history. We hope his work will inspire all present and future workers in this vast field.

Nagpur **MOROPANT PINGLEY**
Date : 14 Jan. 1989 Working President,
Ugabda 5080 Shri Babasaheb Apte Smarak Samiti, Nagpur.

PREFACE

The pages of the history of ancient astronomy begin with designing of the instruments to measure time and speed, recording the speeds of motions of the Sun, the Moon and the planets, preparing a proper calendar to measure the exact length of the day, the month, and the year, and fixing of their ratios. One of the earliest books, or perhaps the first such book in antiquity, is 'VEDAANGA-JYOTISHA' commonly called as "Vedaanga" written by an unknown author to describe the most accurate luni-solar calendar designed by the great sage Lagādha. Various civilisations made such an effort. They failed. The modern calendar which we use is only a solar calendar, which rectifies the defect in earlier efforts. VEDAANGA-JYOTISHA was used as a hand-book by Vedic priests to know the positions of the Sun and the Moon on a particular future day. It consists of some formulae. Its antiquity is so remote that it had become unintelligible in the past.

An astronomical problem of 'dropping a lunation (Kshaya maasa) and inserting a compensatory intercalary month came up before Hindu almanographers in 1983 . On that occasion the author of this book wrote an article in the 'Maharashtra Times' suggesting a luni-solar calendar based on the 19-year luni-solar cycle. Comparative tables of lunar year and tropical year were required to be prepared on the said occasion (Please see appendix 1 A & B). The author was aware that the interpretation of Vedaanga was an unsolved problem. Accidentally it came to his mind that the R@k text of the 'Vedaanga' is based on the 19-year luni-solar cycle. It was found correct. He therefore wrote a book in Marathi which was appreciated by the authorities of Birla Planetarium of Hyderabad, who invited him as a guest speaker in a seminar on Ancient Indian Astronomy held in January 1987. The participants at the Seminar expressed their desire to have a book in Hindi and English.

Honourable Morpant Pingley, President of Babasahed Apte Smarak Samiti, took keen interest in publishing the book. But for his help, this book could not have been placed before the readers.

The author of this book has worked out the antiquity of Vedaanga to 2976 B.C. i.e., about 4964 years from to-day. Late Lokamanya

Tilak had expressed that some of the important verses in the text are conundrums. They are puzzles which could not be solved for the last 2000 years. To say that they are solved by me is a bold statement; but to the author's mind they *are* solved. Let us see how the readers appreciate the book.

The author expresses his deep feeling of gratitude towards Maananeeya Moropant Pingley, Shri Prabhakarrao Faizpurkar, Shri N. G. Baitule, Dr. S. M. Ayachit and other members of Babasaheb Apte Smarak Samiti.

Nagpur
Dt-20th Oct. 1988
Aashvina Shuddha 10

P. V. HOLAY
West Park Road,
Dhantoli, Nagpur.

PRONUNCIATION

Sanskrit	English	Instance
अ	a	As in infant
आ	aa	As in far
इ (अि)	i (short)	As in pin
ई (अी)	ee (long)	As in deep
उ (अु)	u (short)	As in put
ऊ (अू)	oo (long)	As in moon
ऋ	r@	As in triune & ruin, Sanskrit Mr@ga (between riu and rui)
ए (अे)	e	As in pen
ऐ (अै)	ai	As in dine
ओ	o	As in bone
औ	au	As in house, mountain
अं (-)	am or an	depending upon the consonant that follows. *
अः	ah	visarjaneeya (in-take of breath)

Consonants

Velar	क	ख	ग	घ	*(ङ)
	K	Kh	g	gh	n
Palatals	च	छ	ज	झ	*(ञ)
	Ch	Chh	J	Jh	
Cerebrals	ट	ठ	ड	ढ	ण
	<u>t</u>	<u>th</u>	<u>d</u>	<u>dh</u>	<u>n</u>
Dentals	त	थ	द	ध	न
	t	th	d	dh	n
Labials	प	फ	ब	भ	म
	p	ph	b	bh	m

Semi Vowels

	य	र	ल	व	
	y	r	l	v or w	
श	ष	स	ह	ळ	ज्ञ
sh	<u>sh</u>	s	h	<u>l</u>	jn

* **Note :** Letter n is used for anusvaara. No separate pronuciation mark is used for ङ् & ञ् because these nasals are rarely followed by vowels. The consonants that follow them govern their pronunciation (as Velars or palatals) e.g. Vedaanga वेदांग or वेदाङ्ग, Pancha पंच or पञ्च This rule itself is sufficient as guide for their pronuciation. If the consonant that follows is labial, anusvaara is pronounced as m.

CONTENTS

PART - II

CHAPTER - 1

History of Ancient Astronomy and Calendars

European world knows the story of Robinson Crusoe. He was forced to land on an unknown island and live like a civilian. For remembering days and dates he prepared a calendar by marking the stump of a tree. He named his tribal servant as Friday. In India there was a time when people, unlike Robinson Crusoe, did not require any artificial means to remember days and dates, provided the Indian citizen could have a look at the moon in the clear sky. They used the most natural calendar. They could find out the month in a year by looking at the eastern horizon after dusk and by identifying the star or the constellation that was rising, they could tell the date by observing the phase of the moon. The day was named according to the asterism (nakshatra) or the small constellation which the moon covered on the relevant day. Had a Vedic priest been in the same situation as Crusoe, he could have told the number of years, months and days after he left his house, if he could see the sky, and the moon, and if he could fix the longest day by looking at the shadows at mid-noon. This could be done by the Indian priests because of the work of the great Indian astronomer sage Lagadha, whose work is a subjectmatter of this book. At initial stages most of the civilizations of the world made efforts to follow natural calendars. The history of ancient calendars is relevant to our subject. C.V. Vaidya has narrated the history in the following words :

'Lunar months can be noticed from two consecutive full moons. A year can be noticed from the cycle of the seasons. On a rough scale twelve lunar months constituted a year, but their proper relation could not be found out by earlier civilizations. This created confusion and difficulties. To come over this confusion, the Arabs ignored the solar cycle and followed a year consisting of twelve lunations. At present Muslims regard this interval as a year. Their year revolves through all seasons and (after 32½ years) gets back to the original position.

The Romans used to count ten months from the month of March, thereafter left some days uncounted, and began with a fresh year with full moon in the spring season. Several years thereafter, king Numa introduced the custom of inserting 23 days at the interval of two years.

There were disputes between the religious heads on the point of time for introducing these 23 days. To avoid a confusion, Julius Caesar discarded the lunar cycle and introduced a solar year comprising of $365^1/_4$ days. He divided the year in twelve parts of roughly equal duration, and called them solar months. Greeks also tried to design a lunar calendar consistent with solar days. They completed the year in 354 days with twelve lunar months, alternatively consisting of 30 days and 29 days. But they missed the seasons. King Solan therefore tried to introduce an intercalary month to harmonise the lunar year with seasons, but he was unsuccessful. Egyptians knew that the year comprises of 365 days. They divided the year in twelve months consisting of 30 days each, and added 5 days at the end of the year. Yet the seasons rotated in a cycle of 1460 years due to a mistake of about 1/4 day in a year, Because $365 \times 4 = 1460$. Modern astronomers call the period of 1460 years as Sothic cycle. Parsis also added 5 days after an interval of 360 days to constitute a year of 365 days.

Jews at present use a luni-solar calendar based on the 19-year cycle. This cycle was introduced in the 4th century of the Christian era. It provides for addition of intercalary months at the intervals of 3, 6, 8, 11, 14, 17 and 19 years. The intercalation is made in the months of Adar (Feb-March). The British Encyclopaedia states that the present knowledge of the pre-exile Jewish calendar is limited and uncertain. Both the testaments of the Bible, the old and the New, refer to calendar matters sparingly.

In China, Shang civilisation could find out a solar year of $365^1/_4$ days and the lunation of $29^1/_2$ days by about 14th Century. They added a 13th month in the lunar year intermittantly. They could know about the 19-year luni-solar cycle consisting of 235 lunations about a century before Meton could find it out. They divided the ecliptic path of the Sun, the Moon, and the planets in 24 divisions. The Sun was presumed to travel each division in $15^1/_4$ days. For the purpose of naming these divisions, 24 stars were selected. They called this luni-solar calendar as Yin-Yang-li. Their method of intercalation was the same as the one introduced by Varaahamihira in the present Hindu Calendar. Thus though the

Chinese knew the 19-year astronomical cycle, they did not use it in Calendars.

Encyclopaedia Britannica gives an interesting history of calendars. It states that "in Babylonia it was necessary for the lunar year of about 354 days to be brought into line with solar year of approximately 365 days which determines the growth of vegetation. This was accompanied by the use of intercalated month. Thus in the 21st cen. B.C. a special name for the intercalated month *'iti diring'* appears in sources. The intercalation was operated haphazardly according to real or imagined needs and each Sumerian city intercalated months at its will. In 380 B.C. Babylonian calendar calculaters succeeded in computing an almost perfect equivalence in a luni-solar cycle of 19 years and 235 months with intercalations in the years 3, 6, 8, 11, 14, 17 and 19 of the cycle." (See page 605 Enc. Br. on Calendars.)

"The main use of cycles was to try to find some commensurate basis for lunar and solar calendars and the most famous of all the attempts was that usually attributed to Leostratus (500 B.C.) and Endoxus of Cnidus (390 - 340 B.C.) often known as the *Octacteris*. The cycle covered 8 years as its name implies and since the 6th cen. B.C. the year was accepted to be 365 days in length, the *octacteris* amounted to 365 $\times$ 8 i.e. 2920 days. This comes close to the total 99 lunations 99 $\times$ 29.5 = 2920.5 days" (see page 597 Enc. Br.)

About the Greek calendar, it says that "Astronomers such as Meton who in 432 B.C. calculated a 19-year luni-solar cycle were not heeded by the politicians, who clung to their calendar-making power". (page 606-606 Enc. Br.).

Other nations have used arbitrary time cycles for preparing calendars, as e.g. a 15-year cycle in view of a custom of making accounts of collected tax, or a week of seven days which has no relevance with the speed of astronomical bodies.

It is worth-while to give here a brief history of the development of calendars in India, excluding detailed evidence. In India, the lunar and the solar cycles had a specific importance in cultural and spiritual development of the Vedic people. They worshipped god *Indra* for a successful harvest. They depended on the monsoon cycle of rains for cultivation. *Indra* was their deity. They presumed the place of *Indra* near the rising star on the eastern horizon, which they saw immediately after dusk (i.e. practically 180^0 away from the Sun). For them the Moon was a pot carrying Soma juice which gets filled every day. After getting completely filled, it touched the lips of *Indra* and his friend, one of the six *Aadityas* (i.e. the deities of the seasons) on the full-moon day (see Tait. Sam. 2-4-14)

यमादित्या अंशुमाप्याययन्ति
यमक्षितमक्षितयः पिबन्ति

and also R@k Sam. X. 85-5

यत्त्वा देव प्रपिबन्ति तत आप्यायसे पुनः ।
वायुः सोमस्य रक्षिता समानां मास आकृतिः ।।

They thought, whatever Soma juice they offered as oblation to the fire god, gets accumulated in the Moon-pot on a giant wheel, which takes it to gods for a drink. If they were to continue their sacrifices with this concept, it was necessary for them to find out a proper relation between the solar cycle of six monsoon seasons and the lunar cycle.

Their early method of harmonising the two cycles was introduced by an astronomer *Shunahshepa*. It was visual, similar to that of Imams, who declare Eed for muslims. The path of the Sun, the Moon, and the planets on the background of the stars is known as the ecliptic path. Vedic citizens named a fixed star on the ecliptic as *Varuna*. They counted the number of full moons which appeared at various points, one after another throughout the year from the eastern side of the star of *Varuna*. They found that the full moon usually appeared at various twelve places before completing the cycle. It was found that sometimes there were 13 points in the sky, where the full moon appeared at successive intervals before completing the *Varuna* cycle. They therefore counted 13 months in that year. The 25th hymn of the first *mandala* of the R@gVeda is composed by *Shunhshepa* in praise of the deity *Varuna*.The 8th verse of this hymn is translated by H.H. Wilson thus -

"He, who accepting the rites (dedicated to him), knows the twelve months and their productions, and that which is supplimentarily engendered."

From R@k X. 147 *Yama antyeshti* hymn, the place of *Varuna* can be located as a star on the cross-lines of the milky way and the ecliptic near two dogs *Canis Major* and *Canis Minor,* most probably at Alhena. An intercalary month can be found out by a most easy visual method without involving any calculations. I have explained the same with the help of a figure at Appendix-II.

Students of astronomy call the star's year cycle like that in the

Varuna cycle as sidereal year. The cycle of seasons i.e. the tropical year receeds by one day in a period of 72 years with respect to the sidereal year. The difference is so small that it could not be noticed in those days.

The Vedic priests started their sacrifices on a full moon day immediately after a rainy season i.e. in autumn (or some times eight days prior to such a day). Summer rains have a duration of 2, 3 or 4 months, depending on the location of the place in India. The sacrifices therefore continued for 9 to 10 months. The priests who performed the sacrifices were consequently called *Navagva* and *Dashagva Angirasa*s.

The rotation of the seasons with respect to the stars was very slow. It could not be noticed in the beginning, but when the difference increased after about 2000 years, the predictions of the priests about the time for the commencement of rains were found wrong.

Ashvini brothers, who were also called *Naasatya*s, found out by an ingenious method the time of commencement of the summer rains. They observed the image of the Sun in a well of drinking water at mid-noon in summer. They found that the Sun which started climbing the sky from the south in the winter season reached zenith. If I were to give corresponding dates in modern European calendar, I would say that the Sun reached the zenith on the 18th of June, went towards the north, and returned back to the zenith again on the 26th of June. *Ashvini*s could therefore fix the date of the return journey of the Sun towards south, which we now call the longest day or a day or Summer Solstics (i.e. 22nd June). The probable date of the commencement of summer rains could be fixed with respect to this day, depending upon the location of the relevant place. From the interval of 9 days journey of the sun as observed by the *Ashvini*s, we can locate the place of their experiment. It was about 10 kilometers towards south of the tropic of cancer.

Other Vedic astronomers, known as *R@bhu* brothers, took advantage of *Ashvini's* experiment and counted the number of days in a solar year. They divided the year in four parts. *Aitareya Braahmana* gives the calendar, which is practically the same as the one designed by *R@bhus*. Their calendar consisted of 12 solar months of 30 days each. They allotted 2 days for Summer Solstice (i.e. 22nd of June) and called them a *Rathantara Saaman*. At winter solstice, 3 days were allotted for *Br@hat-Saaman* (i.e. big Saaman). The word *Rathantara* means changing a chariot. The Sun was presumed to change his chariot for return journey towards the south. Vedic astronomers used to observe the image of the Sun in a well during these days and adjust the duration of the *Rathantara Saaman*. Usually it was 2 days and probably 3 days between the interval of four years. The custom of observing the image of the Sun during Summer Solstice is given in *Asya-Vaameeya Sookta* i.e. R@g 1-164-25. The solar calendar is described as *Aadityaa naama ayanam* in the *Aitareya Braahmana*. According to this solar year, sacrifices were to commence on a day of autumnal equinox i.e. the 91st day from Summer Solstice. This day was called *Aarambhaneeya* day. The author of the *Aitareya* compares *Rathantara* with the change of a ship at the shore for return journey. He gives a warning not to miss it or combine with the *Br@hat Saaman,* otherwise the sacrifices would begin at any time i.e. in any season (Ait Br 17.7.4). Here the relevant fact for our subject is that the Vedic astronomers could find out the day of the Summer Solstice very correctly. It is worthy of note that the image of the Sun in water in a well is more sharp than the shadow of sticks which were usually used for fixing the dates of summer and winter solstices. These shadows were always accompanied by *pen-umbra*. Another relevant fact to be brought to the notice of the readers is that the Vedic priests knew the importance of dividing the tropical year at 4 proper points, the knowledge of which is a condition precedent to deriving the *Vedaanga cycle* and preparing a calendar.

The search for an accurate tropical solar year also could not solve the problem before the Vedic priests, because it had no relevance with the phase of the moon. For some of those priests, worship of *Indra* was obligatory, because their concept of the moon as a pot filled with Soma juice for offering to the *Aadityas* could not be removed easily. Moreover, it would have been found difficult to have experimental observations to fix the date of the Summer Solstice throughout India. It was, therefore, necessary to search some method to predict the Summer Solstice and the Winter Solstice. The best method was to fix their positions in a lunar calendar with respect to a lunar month and a lunar date. They therefore started to find out a time-cycle, which would create harmony between the solar and the lunar cycles. Sidereal positions of the sun and the moon were therefore observed for thousands of years and ultimately the Vedic sage *Lagadha* discovered the cycle from such records. He also gave rules to prepare a good natural calendar. The rules are given in the form of verses attached to the *R@gVeda* as one of the six appendices.

A Vedic priest has to learn by heart the text of the Vedas which is called *Samhitaa*. He is also required to learn by heart and reproduce six appendices to the *Samhitaa*. These are called *Shadangas*, which consist of six different subjects, the knowledge of which is necessary for conducting sacrifices, and *Jyotisha* i.e. astronomy is one of them.

The Vedaanga calendar presumes the point of Summer Solstice near the star *Regulus*. The gradual precession of Summer Solstice was not known to earlier civilisations. Various luni-solar calendars were therefore designed and discarded before and after the composition of the present text. Some different cycles were also tried, and as a result, the religious Vedaanga calendar differed from other official calendars. In the 5th cen. A.D. an eminent Hindu astronomer *Varaahamihira* introduced a meteorological cycle with 12 points located at equal distance in the sky called *Sankraantis* with corresponding days when the Sun covers those points. The lunation was named according to the *Sankraanti* day that occurs in the lunation. Occasionally we have a lunation in which there is no *Sankraanti* day; that lunation is called *adhika maasa,* an intercalary month. *Varaahamihira* used Greek names for the 12 divisions of the ecliptic path.

As a result, the religious calendar *Vedaanga Jyotisha* went out of use, though it was preserved for reciting as a religious procedure.

If I do not mention here the name of the Vedic astronomer "Archan Hiranyastoop", this book on Vedic Astronomy would remain incomplete. Lokmanya Tilak has assessed Vedic antiquity to be more than 6000 years. This is a most moderate assessment. Archan Hiranyastoop who lived in such a remote antiquity could imagine solar gravitational fetters holding the earth operating through the indestructible medium ether. We get it in the tenth Mandala of the R@gveda. Following is the translation of R@k. verse X. 149.1 by H.H. Wilson –

> "Savitr@ (Sun) has fixed the earth with fetters. Savitr@ (Sun) has made the heaven firm in place where there was no support. Savitr@ has made the cow of the firmament bound to the indestructible (ether) like trembling horse."

Greek astronomer Aristorchus also thought of a heliocentric model of the Universe. The theories of Archan-Hiranyastoop or of Aristorchus were not based on any firm mathematical foundation. Recent astronomers Copernicus and Newton have advanced their theories in a more convincing form with mathematical details. We do not expect astronomers of remote antiquity to be so exact. Yet the history of astronomy has to begin with their names. However, this book deals with the work of Sage Lagadha who found out the 19-year luni-solar cycle and designed a calendar.

CHAPTER - 2

Modern Probe

Lokmanya Tilak has used the word 'Vedaanga' for our text. Let us use the same. Vedaanga is the oldest text on astronomy. This text is a hand-book used by Vedic priests. It therefore presumes that its readers have some knowldge about the then existing practices, e.g. (i) it refers to only 2 names of lunar-months i.e. *Maagha* and *Shraavana* and expects from its readers knowledge of other names. (ii) just as in chemistry we denote an element by a symbol (e.g. H for hydrogen), Vedaanga gives symbols for 27 asterisms (*nakshatras*) on the ecliptic path. Some symbols are derived from names of asterisms and others from names of deities concerned. (iii) it narrates some formulae using some numbers, but does not give what the numbers are about i.e. years, months or days and expects from its readers knowledge of the Vedic practices for their calculations (e.g. verse 4). With all these deficiencies, the text is preserved for thousands of years because of its religious and sentimental importance. It had become unitelligible.

There are six appendices to the Vedas. Vedaanga is one of them. All the six appendices of the Vedas are treated as sacred as the Vedas themselves. They were reproduced or recited for religious purposes even without understanding their meaning. S.B. Dixit says that if any effort to suggest an amendment or correction is made, it is opposed by Vedic Brahmins. Yet in all parts of India, the text is meticulously reproduced in the same manner with all its supposed defects.

Lokmanya Tilak says that "the tract appears in two forms, one belonging to the R@gVeda and the other to the Yajur Veda. Of these,' the first was published by Captain Jarvis at the end of his "Indian Meteorology" as far back as 1834, and late Prof Weber brought out in 1872 a critical edition of both the recensions with various readings collected from manuscripts then available to him. He further adds: "Dr. Thibaut, in his essay on the Vedaanga, which appeared in the Journal of the Asiatic Society of Bengal, 1877, was the first to decipher a few difficult verses, and among others who followed him the name of Shankar Balkrishna Dixit deserves to be equally mentioned".

A commentary on the *Yaajusha* text of the Vedaanga is composed by Somaakara. S.B. Dixit says that Dr. Thibaut could decipher six more verses than Somaakara and adds that in 1881 he had translated all such verses in Marathi, the meaning of which was then known to him. Krishnashastri Godbole also tried to decipher the Vedaanga, but he could not explain more verses than were already explained by Dr. Thibaut. In 1885 J.B. Modak printed a Marathi translation of both the texts of the Vedaanga. He explained 2 or 3 verses more than what Dr. Thibaut did.

There are in all 36 verses in R@k text and 43 verses in Yujus text. 36 verses are practically common to both, and therefore there are in all 36 + 13 = 49 verses. Dixit has given a table of comparative numbers in his Marathi book on the History of Indian Astronomy. Dixit stated that he had deciphered 9 more verses. There is also a third text known as *Atharva Jyotisha,* but it deals mainly with astrology than Astronomy. As such it is not a subject matter of this book.

Lokamanya Tilak says : "The French astronomer Bailey in his treatise on Indian Astronomy published in 1786 had assigned a very high antiquity to the Indian Science; and it was to refute this view that Bentley published his Historical View of Indian Astronomy in 1823. Bentley thinks that in times of Akbar the Great, in order to impose upon the Emperor, many of the ancient theories were in reality composed or fabricated." Sir William Jones and Colebrooke, who held opposite view, gave a sharp reply to Bentley. However, Bentley's view was subsequently rejected by all scholars. Lokamanya Tilak has mentioned that Prof. Whitney, who edited and published the translation with notes under the auspices of the American Oriental Society in 1860, has not a word to say in favour of the Indian astronomers, whom he considers incapable of originating any scientific theory or making even tolerably accurate observations. He has, therefore, come to the conclusion that the Indians were whole-sale borrowers in this respect."

Lokamanya Tilak, while writing "Criticisms and Suggestions" on the Vedaanga has taken into consideration the works of Lala Chhotelal (*nom de plume* Baarhaspatya) and Mm. Sudhakar Dvivedi (Sudhaakara *bhaashya,* 1903) and explained R@g verses 10, 11, 12, 13, 19 & 21 along with other verses in the Yajus recension. He presumed that the yuga or the luni-solar astronomical cycle in Vedaanga was of 5 years, and therefore could not decipher the R@k verses properly. He also presumed wrong interpretations given by earlier workers in respect of verses 1, 4 and 8 to be correct. Accordingly, to me the astronomical cycle in Vedaanga is of 19 years, which was discovered by the Vedic astronomer Lagadha. This cycle was also subsequently discovered by the Chinese in the 6th cen. B.C. and a Greek astronomer Meton in 432 B.C. Meton's cycle was known to Vedic astronomer *Lagadha Maharshi* at least 2500 years before Meton knew it. *Maharshi Lagadha* did not stop at discovering the cycle, he made rules for an ideal calendar. His calendar can be read by an illiterate person by looking at the moon and the stars in the sky. He mentioned in verse R@k 30 of Vedaanga that his calendar accords with the reading of the heaven (लोक) by the people (लोक)

सोमसूर्यस्त्रिचरितो लोकाँल्लोके च संमितं।
सोमसूर्यस्त्रिचरितो विद्वान्वेदविदश्नुते।। ३० ।।

"The Sun and the Moon have three motions in the heaven known to the people. The Sun and the Moon have three motions known to the learned (priests) who knew the Vedas (i.e. Vedic Sacrifices)."

I have gone through a cyclostyled copy of a booklet on *Vedaanga Jotisha* by Kaavyateertha Vaachaspati Dr. Himmatram M. Yajnik of Ahmedabad. In the introduction to his book he mentions the names of earlier scholars like Lokamanya Tilak, and further adds that Dr.M.M. Pandit, R. Sharanashastri and Shyaama Shastri have written on the subject. Even after reading these interpretations, he comes to the conclusion that "Yajus *Jyotisha* is mostly an enlarged and corrected version and more or less a supplement to the R@k *Jyotisha*". He then explains the Vedaanga *Jyotisha,* treating its R@k and Yajus recensions to be based on a 5-year cycle. In March 1979

Prof. T.S. Kuppanna Sastry of Madras, on the occasion of a workshop on Ancient Indian Astronomy organised by Bharatiya Vidya Bhavan, set out his exposition of *Vedaanga Jyotisha,* which was subsequently edited in August 1984 by Dr. K.V. Sarma of the Kuppannaswami Sastri Research Institute of Madras. This work was then published in the same year in a journal of Indian National Science Academy.

In Prof Kuppanna Sastri's book, he has made an effort to explain the yuga in both R@k and Yajus texts of the Vedaanga to be based on a 5-year luni-solar cycle. He has further published an amended edition of both these recensions. In 36 verses of the R@k recension he has suggested 39 emendations out of which 8 emendations are suggested in the verses touching the subject of yuga (Viz. verses No. 8, 9, 19, 20).

The important purpose of this work is to demonstrate how the number of synodical months i.e. lunations were systimatically arranged in a luni-solar cycle by Vedic astronomers. We rely more on the unamended text of the Vedaanga. I am obliged to Dr. K.V. Sarma who has edited Prof. Kuppanna Sastri's book. He has given in his foot-notes the difference in different critical versions of the Vedaanga in all manuscripts. The R@k recension printed by Nirnaya Sagar Press, Bombay, fully corroborates the original recension. Lok. Tilak has also given in his book the original text first and then the amendment suggested by him. We thus ultimately rely more on texts which were commonly used by Vedic priests throughout India.

PART - II

वेदांगज्योतिषम्

(ऋक्पाठः)

श्रीगणेशाय नमः। हरिः ॐ।।

पञ्चसंवत्सरमयं युगाध्यक्षं प्रजापतिम्।
दिनर्त्वयनमासाङ्गं प्रणम्य शिरसा शुचिः।।१।।
प्रणम्य शिरसा कालमभिवाद्य सरस्वतीम्।
कालज्ञानं प्रवक्ष्यामि लगधस्य महात्मनः।।२।।
ज्योतिषामयनं कृत्स्नं प्रवक्ष्यामनुपूर्वशः।
विप्राणां संमतं लोके यज्ञकालार्थसिद्धये।।३।।
निरेकं द्वादशार्धाब्दं द्विगुणं गतसंज्ञिकम्।
षष्ट्या षष्ट्या युतं द्वाभ्यां पर्वणां राशिरुच्यते।।४।।

स्वरार्कमेके सोमार्कौ यदा साकं सवासवौ।
स्यात्तदादियुगं माघस्तपःशुक्लो दिनंत्यजः।।५।।
प्रपद्येते श्रविष्ठादौ सूर्याचान्द्रमसावुदक्।
सार्पार्धे दक्षिणार्कस्तु माघश्रावणयोः सदा।।६।।
धर्मवृद्धिरपां प्रस्थः क्षपाऱ्हास उदग्गतौ।
दक्षिणे तौ विपर्यस्तौ षण्मुहूर्त्ययनेन तु।।७।।
द्विगुणं सप्तमं चाहुरयनाद्यं त्रयोदश।
चतुर्थं दशमं चैव द्विर्युग्माद्यं बहुलेप्यृतौ।।८।।

वसुस्त्वष्टा भगोजश्च मित्रः सर्पाश्विनौ जलम्।
धाता कश्चायनाद्याश्चार्धपञ्च नभस्त्वृतुः।।९।।
भांशाः स्युरष्टकाः कार्याः पक्षा द्वादश चोद्गताः।
एकादशगुणस्योनः शुक्लेर्धं चैन्दवा यदि।।१०।।
कार्या भांशाष्टकास्थाने कला एकान्नविंशतिः।
ऊनस्थाने द्विसप्ततीरुद्वपेदूनसंमिताः।।११।।

त्र्यहंशीभशेषो दिवसांशभागश्चतुर्दशस्याप्युपनीतभिन्नम्।
भार्धेधिके चाधिगते परेंशे द्वावुत्तमैकं नवकैरवेद्यम्।।१२।।

पक्षात्पञ्चदशाच्चोर्ध्वं तद् भुक्तमिति निर्दिशेत्।
नवभिस्तूद्गतोंशः स्यादूनांशद्व्यधिकेन तु।।१३।।

जौद्राघः खेश्वे हीरोषाचिन्मूषण्यः सोमाधानः।
रेमृघ्राश्वा ओजस्तृष्णो हर्येष्टा इत्यृक्षालिङ्गैः।।१४।।
जावाद्यंशैः समं विद्यात्पूर्वार्धे पार्वसूत्तरे।
भादानांशाच्चतुर्दशी काष्ठानांदेविनाकलाः।।१५।।
कला दश च विंशा स्याद् द्विमुहूर्तस्तु नाडिके।
द्वित्रिंशस्तत्कलानां तु षट्शती त्र्यधिकं भवेत्।।१६।।

नाडिके द्वे मुहूर्तस्तु पञ्चाशत्पलमाषकम्।
माषकात्कुम्भको द्रोणः कुटपैर्वर्धते त्रिभिः।।१७।।
ससप्तकुंभयुक्स्योनः सूर्याद्योनि त्रयोदश।
नवमानि च पञ्चाह्नः काष्ठा पञ्चाक्षराः स्मृताः।।१८।।
श्रविष्ठाभ्यां गुणाभ्यस्तान् प्राग्विलग्नान्विनिर्दिशेत्।
सूर्यान्मासान्षळभ्यस्तान् विद्याच्चान्द्रमसान् ऋतून्।।१९।।
अतीतपर्वभागेषु शोधयेद् द्विगुणां तिथिम्।
तेषु मण्डलभागेषु तिथिनिष्ठां गतो रविः।।२०।।

याः पर्वभादानकलास्तासु सप्तगुणां तिथिम्।
प्रक्षिपेत्कलासमूहस्तु विद्यादादानकीः कलाः।।२१।।
यदुत्तरस्यायनतोयनं स्याच्छेषं तु यद्दक्षिणतोयनस्य।
तदेव षष्ट्या द्विगुणं द्विभक्तं स द्वादशं स्याद्दिवसप्रमाणम्।।२२।।
तदर्धं दिनभागानां सदा पर्वणि पर्वणि।
ऋतुशेषं तु तद्विद्यात्संख्याय सहपर्वणाम्।।२३।।
इत्युपायसमुद्देशो भूयोप्येनं प्रकल्पयेत्।
ज्ञेयराशिं गताभ्यस्तान् विभजेज्ज्ञानराशिषु।।२४।।

अग्निः प्रजापतिः सोमो रुद्रोदितिर्बृहस्पतिः।
सर्पाश्च पितरश्चैव भगश्चैवार्यमापि च।।२५।।
सविता त्वष्टाथ वायुश्चेन्द्राग्नी मित्र एव च।
इन्द्रो निर्ऋतिरापो वै विश्वेदेवास्तथैव च।।२६।।

विष्णुर्वसवो वरुणोज एकपात्तथैव च।
अहिर्बुध्न्यस्तथा पूषाश्विनौ यम एव च।।२७।।
नक्षत्रदेवता एता एताभिर्यज्ञकर्मणि।
यजमानस्य शास्त्रज्ञैर्नामनक्षत्रजं स्मृतम्।।२८।।

इत्येतन् मासवर्षाणां मुहूर्तोदयपर्वणाम्।
दिनर्त्वयनमासांगं व्याख्यातं लगधोऽब्रवीत्।।२९।।
सोमसूर्यस्त्रिचरितो लोकाँल्लोके च संमितम्।
सोमसूर्यस्त्रिचरितो विद्वान् वेदविदश्नुते।।३०।।
विषुवं तद्गुणं द्वाभ्यां रूपहीनं तु षड्गुणम्।
यल्लब्धं तानि पर्वाणि तथोर्ध्वं सा तिथिर्भवेत्।।३१।।
माघशुक्लप्रवृत्तस्तु पौषकृष्णसमापिनः।
युगस्य पञ्चवर्षाणि कालज्ञानं प्रचक्षते।।३२।।

तृतीयां नवमीं चैव पौर्णमासीं त्रयोदशीम्।
षष्ठीं च विषुवां प्रोक्तो द्वादश्यां च समं भवेत्।।३३।।
चतुर्दशीमुपवसथस्तथा भवेद्यथोदितो दिनमुपैति चंद्रमाः।
माघशुक्लाह्निको युंक्ते श्रविष्ठायां च वार्षिकीम्।।३४।।
यथा शिखा मयूराणां नागानां मणयो यथा।
तद्वद् वेदाङ्गशास्त्राणां ज्योतिषं मूर्धनि स्थितम्।।३५।।
वेदा हि यज्ञार्थमभिप्रवृत्ताः कालानुपूर्वा विहिताश्च यज्ञाः।
तस्मादिदं कालविधानशास्त्रं यो ज्योतिषं वेद स वेद यज्ञान्
यो ज्योतिषं वेद स वेद यज्ञानिति।।३६।।

पञ्च संवत्सरं प्रपद्येते कार्याः कला दश च याः पर्वसंविता
विषुवं सप्त।। इति वेदांगज्योतिषं समाप्तम्।।

CHAPTER - 3

What is a Yuga

A cycle of events in astronomy was called by Indian astronomers a 'YUGA' i.e. a cycle in which all planets Viz. Venus, Mars, Jupiter, Saturn etc assembled at one *nakshatra* (asterism on the ecliptic). The cycle of these yugas was considered quite big i.e. of about 4320 thousand years. Comparatively 'Lagadha Yuga' is very small. We should know the beginning of the tropical year and the lunar month before we know the duration of this yuga.

Initially the Vedic sacrifices began on the day of autumnal equinox. The corresponding date on the European calendar for this would be the 21st of September. Ashvinis and R@bhus had provided a method to find out the day for the beginning of such an year. It is called a tropical year. Another year is called a sidereal year or the year of the stars. The day of beginning of the year of the stars was fixed according to a star that rose on the eastern horizon immediately after dusk. There was a time when the year began with the rising of Maghaa (Regulus). Rising of full moon with Regulus was therefore treated auspicious and some priests began their sacrifices on this day.

Astronomers know that the year of the stars gradually starts with a late beginning. In this particular case, Regulus started rising in a season corresponding to October, then in November and subsequently in December. There is a difference of opinion among scholars about the day of rising of Regulus in the Vedaanga period. Majority of scholars including Tilak, Dixit, Kuppanna Sastri and Yajnik, presume that Regulus used to rise on or about the 22nd of December in the Vedaanga period, while Srinivas Raghavan and G. Sampat Ayyangar presume that it used to rise on a day corresponding to the 21st of September (Autumnal equinox). I avoid discussion on this point and presume for explaining the subject that the Maghaas used to rise in Vedaanga period on the day of winter solstice i.e. a day corresponding to the 22nd of December.

In Vedaanga a lunar month begins with the new-moon. The Vedaanga Yuga began when the beginning of the year coincided with the beginning of the month, it ended when the end of the year coincided with the end of a month. In other words Lagadha yuga began on a day when a day of amaavasyaa coincided with *Uttaraayana* (winter solstice). The cycle takes 19 years to complete.

Vedic Astronomical Terms

A day and a night together is called a *dina* in Sanskrit. The same word is used in Vedaanga with the same connotation. A lunation or a lunar month has a length of about 29.530588 days i.e. roughly 29.5 days. Lagadha divided the month in subdivisions with round figures and called them 30 *tithi*s. For a layman a tithi was practically a day. But it was shorter than a day by about 23 minutes. Hindus still use this unit of time for their calendar. We have thus two sets of units of time, solar and lunar units.

Solar year	=	365.25 days.
Lunar year	=	12 lunations (about 354 days)
Solar month	=	1/12 year (about 30.44 days)
Lunar month	=	1 lunation
Solar day	=	24 hours
Lunar day	=	tithi = 63/64 day (in 19-year yuga)
		61/62 day (in 5-year yuga)

Zero tithi or the astronomical new-moon event being common to all parts on the globe is universal, unlike a day which is local, dependant on the time of Sun-rise and the mid-noon. As the path of the Moon around the earth is not perfectly circular, nor the path of the earth around the Sun, they are elliptical, all tithis and lunar months in the year are not equal as to the length of time.

In Vedaanga these units of time are of mean average length. Broadly speaking, the moon moves 12^0 away from the Sun in a tithi, so that in 30 tithis it covers 360^0 and returns to its original i.e. new-moon position. For a layman a full-moon day is the 15th tithi. The lunar month is further divided in two halves. The first half, during which its phase grows, is called *Shukla paksha* i.e. the bright wing with full moon on its last tithi. The latter half of the month is called *Kr@shna paksha* i.e. the dark wing. These wings are also called *Shuddha* and *Vadya Pakshas* respecively. The tithis in these pakshas are numbered from 1 to 15 each e.g. bright 1st tithi, dark 8th tithi and so on. For a layman the moon looks in a semi-circular shape on the 8th tithi of each of these pakshas. Thus by practice even an illiterate person can tell the tithi of a day simply by looking at the phase of the moon. In Vedaanga period the length of the tithi was fixed by dividing the time taken by 12 lunations by 360. This time is fairly constant.

NAKSHATRAS

The apparent path by which the planets, the Moon and the Sun move in the sky on the background of the stars is called a 'Royal Path' in the Aitareya braahmana. It is called the Zodiac in Greek astronomy, because they imagined 12 pictures of animals on this path. Thus there are 12 constellations on the Zodiac of equal length i.e. 30^0 each. The central line of this Zodiac is called 'the ecliptic'. The centre of the Sun's disc is supposed to move on the ecliptic in its journey. In the prehistoric period man had no means to mark the path of the Sun on the background of the stars. Hindus ingeniously treated the path of Jupiter as the ecliptic. In the Taittireeya Samhitaa the author addresses the moon as carrier of 'Soma Juice' and tells that Jupiter would guide her. (Tait Sam 1-2-3). It is worthy to note that the path of Jupiter has minimum deviation form the ecliptic. It is 1.305^0.

Hindus divided this path into 27 divisions called *nakshatras*. The distance travelled by the moon in the sky from one place of the full-moon to the next is more than a complete circle. It is about two *nakshatras* in excess. The moon was expected to travel one *nakshatra* in a day. It therefore travelled 29 and 30 *nakshatras* in alternate months. Hindus therefore presumed the existence of an additional or ancillary *nakshatra* called Abhijit. .The number of *Nakshatras* were therefore 27 (i.e. 29-2) and 28 (i.e. 30-2). The sage Lagadha subsequently fixed the number as 27 for mathematical purposes. The reasons for this change are given at a later stage. Following is the list of *nakshatras*. For identification, English names of important stars in each *nakshatra* are given against their names.

1. **Ashvinee** *(group)*
   Alpha Aritis
   'Hamal' (Jau)जौ
2. **Bharanee**
   41 Aritis
   (Nya)ण्य
3. **Kr@ttikaa** (group)
   Eta Tauri
   'Alcyone' (Tr@)तृ
4. **Rohinee**
   Alpha Tauri
   'Aldeberon' (Ro)रो
5. **Mr@gasheersha**
   Lamda Orinis (group)
   (Mr@)मृ
6. **Aardraa**
   Gama Geminorium
   "Alhena" (Draa)द्रा
7. **Punarvasu**
   Bita Geminorium
   (Polax) (Soo)सू
8. **Pushya** (group)
   Delta Cancri
   (Shya)ष्यं
9. **Aashleshaa**
   Zita Hydree
   (Shaa)षा

10. Maghaa (Ghaa)
Alpha Leonis
"Regulus" घा

11. Poorvaa Phaalgunee
Thita Leonis
(Gah) गः

12. Uttaraa Phaalgunee
Beta Leonis
'Denobola' (Maa) मा

13. Hasta (group)
Delta Curri
(Ha) ह

14. Chitraa
Alpha Verginis
'Spica' (Chit) चित्

15. Swaatee
Alpha Bootes
'Arcutus' (Swaa) स्वा

16. Vishaakhaa
Libra (Khe) खे

17. Anuraadhaa (group)
Bita Scorphi
'Graffias' (Dhaa) धा
'Dschubba'

18. Jyeshthaa
Alpha Scorpi
'Antares' (Ry) र्ये

19. Moola
Lamda Scorphi
"Shaula" (Moo) मू

20. Poorvaashaadha
Epsilon Sagattari
Kans (O) Astralis ओ

21. Uttaraashaadhaa
Pai Sagattari
(Shave) श्वे

22. Shraavana
Alpha Aquilii
"Altair" (Nah) नः

23. Shravisthaa Alpha
Delfhini (Group)
(Sthaa) ष्ठा

24. Shatabhishaj
Lamda Aquarii
(group)(Shak) षक्

25. Poorvaa Bhaadrapadaa
Alpha Pegasi
'Markab' (Ajah) जः

26. Uttaraa Bhaadrapadaa
Gama Pegasi
"Algenib" (Hi) हि

27. Revatee Zita
Pesium
(Re) रे

SUPPLEMENTARY :- Abhijit (Alpha Lyrae) is traditionally inserted after the 21st *Nakshatra* Uttaraashadhaa, where there is no space for insertion. There is a gap of one *nakshatra* between the 23rd nakshatra Dhanisthaa and the 24th nakshatra Shatabhishaj.

— A —
R@tuShesha (ऋतुशेष)

*R@*TU - **SHESHA** (**ऋतुशेष**). If the length of the month and the year are measured in tithis, the lunar year has a duration of $30 \times 12 = 360$ tithis, and the solar year consists of approximately 371.05 tithis. The difference is of about 11.05 tithis. It is fairly constant. It is called *r@tushesha* in Vedaanga. At the end of every solar year, this R@tushesha gets added and ultimately when the total of tithis exceeds 30, they constitute an additional month. Astronomers tell us that in 19 years there are seven such additional lunations. Readers will appreciate the following results of multiplications.

$30 \times 7 = 210$ *tithis*
$11 \times 19 = 209$ *tithis* (i.e. $210 - 1$) *tithis*

Perhaps these results inspired sage Lagadha to frame a yuga of 19 years with one leap year in each yuga. In Lagadha yuga there are 18 years with 371 lunar-days and one year with 372 lunar days.

Astronomical bodies move under astronomical forces and complete their cycles. We cannot therefore get ratios of various speeds of their cycles or revolutions in round figures. A leap or cut mechanism is therefore required to express the ratios of their speeds. Sage Lagadha was required to express the number of months, a year in tithis. Similarly a tithi, a day and a lunar nakshatra in *kalaas*. At every place he has used such type of leap or cut mechanism. Hindus call such tithis as *Vr@ddhi* (वृद्धि) and *Kshaya* (क्षय) tithis. Modern students of Vedaanga are aware of this leap mechanism, but miss to find out the places where it was used. For internal divisions of a year of 372 tithis is a suitable figure, because it is divisible by 12, it could be divided in six seasons, but in reality the solar year consisted 371 tithis. Therefore the r@tushesha as given in Vedaanga is 11 tithis (371-360) and not 12 tithis. (372-360). If we presume r@tushesha as 12 tithis for constructing a yuga, we get a 5-year cycle. If we multiply 12 tithis by 5, we get $12 \times 5 = 60$ additional tithis, which means we have to add two intercalary months in a 5-year cycle. A yuga of five years in that case would consist of $60 + 2 = 62$ months. This is the conclusion from Vedaanga so far drawn by scholars, including Lokamanya Tilak. We will see in this part of the book that R@g Jyotisha is based on yearly r@tushesha of 11 tithis and not 12 tithis. In this book S.B. Dixit's and Lokmanya Tilak's commentaries are presumed as representing scholars who inferred that the Vedaanga is based on a 5-year cycle. Some scholars have interpreted the words Uttaraayana and Dakshinaayana as autumnal and vernal equinoxes, while some have treated them as winter and summer solstices. For the convenience of narration, they are presumed as solstices. Yajus recension is definitely based on a 5-year cycle. This part of the book is confined to the explanation of R@k recension. Yajus recension is used only for comparison.

CHAPTER - 4
Arrangement Of Years In Yuga

निरेकं द्वादशार्धाब्दं द्विगुणं गतसंज्ञिकम्।
षष्ट्या षष्ट्या युतं द्वाभ्यां पर्वणां राशिरुच्यते।।RVJ 4

The period of 15 tithis from new moon to full-moon and vice-versa is called a '*paksha*' (wing). The angular distance travelled by the Sun on the ecliptic during this period is called a *parvan*. But at times the words parvan and paksha are used interchangeably, one for the other (like the words hour-angle minutes, or seconds). We gather the meaning from the context. The literal translation of words in the aforementioned verse is as follows :–

Nirekam- Subtract one, *Dvaadasha*- Twelve,
Ardhaabdam- half year, *Dviguna*- double,
Gata-samjnikam- Presume previous. *Shashtyaa-60*
Yutam- added together. *Dvaabhyaam*- by twos
Parvanaam- of parvans. *Raashi*- Adhika maasa (or total)
Uchyate- are called.

It is from such texts that scholars gather the meaning.In Yajus text the word अर्धाब्दं is substituted by अभ्यस्तं (multiples).

The text resembles to some extent the algebraic expressions where we have to substitute the variables a, b, c by some known quantities to get the value of an unknown quantity X. But we must know what a, b, c represent. In the aforementioned verse, we must know what nirekam or dvaadashaardhaabdam mean? Whether a month, a year or a day?

S.B. Dixit with his concept of a 5-year yuga has interpreted dvaadasha as twelve months. He treats 60 parvans as 30 months and asks us to add a double parvan i.e. an intercalary month, per interval of 30 months to make the total 31 months. This is how almost all scholars, even after reading all commentaries of pandits of Siddhaanta age, have explained the verse so far.

According to me, this 4th verse is meant for calculating, R@tushesha and intercalary months at the end of solstices. Before we proceed further I would give the meaning of the technical words used in this verse.

All present Hindu astronomers use the word Raashi for Greek constellation on the Zodiac. The word raashi is used at two places in Vedaanga. Its meaning here and in verse 24 is the same. It is the sum of R@tushesha tithis or intercalary months as calculated at summer and winter solstices. In Hindu astronomy a half tithi is called *Karana*. To avoid fractions and to make it possible to separate an intercalary month at summer solscice, *Lagadha* has used in this verse *Karana* as unit of time. A half year terminating at a solstice is called an *ayanam*. I interpret the verse as follows :-

"Subtract one (Karana) from twelve (Karanas) per half year (ayanam). Assume two (Karanas) for previous (yuga). Group of two parvans consisting of sixty karanas, each clubbed together are called Raashis i.e. Inter-calary months (adhika maasa) Table No. 1 is prepared by using the aforementioned rule.

TABLE NO. 1

Sr. No.	First Ayanam	Summer Solstice	Balance Karanas	Second Ayanam	Winter Solstice	Balance Karanas
1	2	3	4	5	6	7
0	(0 × 11 + 2)		2			2
1	(1×11+2) =	11+2 = 13	13	(2×11+2) =	22+2 = 24	24
2	(3×11+2) =	33+2 = 35	35	(4×11+2) =	44+2 = 46	46
3	(5×11+2) =	55+2 = 57	57	(6×11+2) =	66+2 = **68**	68
4	(7×11+2) =	77+2 = 79	19	(9×11+2) =	88+2 = 90	30
5	(9×11+2) =	99+2 = 101	41	(10×11+2) =	110+2 = 112	52
6	(11×11+2) =	121+2 = **123**	3	(12×11+2) =	132+2 = 134	14
7	(13×11+2) =	143+2 = 145	25	(14×11+2) =	154+2 = 156	36
8	(15×11+2) =	165+2 = 167	47	(16×11+2) =	176+2 = 178	58
9	(17×11+2) =	187+2 = **189**	9	(18×11+2) =	198+2 = 200	20
10	(19×11+2) =	209+2 = 211	31	(20×11+2) =	220+2 = 222	42
11	(21×11+2) =	231+2 = 233	53	(22×11+2) =	242+2 = **244**	4
12	(23×11+2) =	253+2 = 255	15	(24×11×2) =	264+2 = 266	26
13	(25×11+2) =	275+2 = 277	37	(26×11+2) =	286+2 = 288	48
14	(27×11+2) =	297+2 = 299	59	(28×11+2) =	308+2 = **310**	10
15	(29×11+2) =	319+2 = 321	21	(30×11+2) =	330+2 = 332	32
16	(31×11+2) =	341+2 = 343	43	(32×11+2) =	552+2 = 354	54
17	(33×11+2) =	363+2 = **365**	5	(34×11+2) =	374+2 = 376	16
18	(35×11+2) =	385+2 = 387	27	(36×11+2) =	396+2 = 398	38
19	(37×11+2) =	407+2 = 409	49	(38×11+2) =	418+2 = **420**	

Column Nos. 3 and 6 in table No. 1 give us total r@tushesha in number of karanas at summer and winter solstices respectively. The 1st year of the yuga was presumed to be a leap year. Hence the yuga begins with a balance of two karanas. A r@tushesha of 11 karanas is added for every ayana and the total is calculated at every solstice, which is noted in columns 3 and 6. When the total exceeds a multiple of 60, the excess is noted in columns 4 and 7. If we divide by two the entries in Columns 4 and 7 (which indicates the number of karanas), we get the tithi with which the next ayana begins.

Prof. Kupanna Sastri has used abbreviations RVJ and YVJ for quoting a verse in R@k text and Yajus text of Vedaanga Joytisha respectively. I have used the same.

CHAPTER - 5
Classes Of Years

द्विगुणं सप्तमं चाहुरयनाद्यं त्रयोदश ।
चतुर्थं दशमं चैव द्विर्युग्माद्यं बहुलेप्यृतौ ।। RVJ 8

During the Vedaanga age, lunar years were classified into five types (i) Samvatsara (ii) Anuvatsara (iii) Parivatsara (iv) Idvatsara and (v) Idaavatsara.

These names have connotations somewhat similar to those used for motor car engines. They may therefore be called (i) tuned year (ii) advanced year (iii) converse year (iv) extra-retarde year (v) retarded year.

We have seen that r@tushesha in a 5-year yuga system would come to 12 tithis per year, and 6 tithis per ayana. The year used to begin in the month of Maagha which was named after the asterism Regulus (maghaa) in the constallation Leo. During the Vedaanga age summer solstice used to occur in the month of Shraavana (i.e. the month in which full moon appeared near Aquila). If we begin with the lunar year and the yuga on the first day of the month 'Maagha' with winter solstice on the said date, the lunar year is expected to lag behind by 12 tithis after a year and a lunar semistar would lag behind by 6 tithis. As a result, in the second semester of the year we would get the Vedic date as 7th on the summer solstice, 13th on the next winter solstice, and so on. In Yajus Jyotiṣha, this verse corresponds to RVJ 8. it is as under :-

प्रथमं सप्तमं चाहुरयनाद्यं त्रयोदश।
चतुर्थं दशमं चैव द्विर्युग्माद्यं बहुलेप्यृतौ।। YVJ 9

Most of the scholars have treated this recension to be correct and the R@k recension as destorted. S. B. Dixit is one of them. From contemporary literature we get five names of years. Dixit has treated the figures in this verse as tithis on winter and summer solstice, and classified the years according to such tithis (Please see chart I.)

CHART - I

Sr. No.	Name of the year	Winter Solstice	Summer Solstice
1.	Samvatsara	Maagha Shu 1	Shraavana Shu. 7
2.	Parivatsara	Maagha Shu. 13	Shraavana Vad. 4
3.	Idaavatsara	MaaghaVad 10	Shraavana Shu. 1
4.	Anuvatsara	Maagha Shu 7	Shraavana Shu. 13
5.	Idvatsara	Maagha Vad. 4	Shraavana Vad. 10

When the Vedic date of a month exceeds 15, it is counted as Vadya 1st for 16th, Vadya 2nd for 17th, and so on.

The speeds of revolutions of the Sun and the Moon cannot be very rigid, so that these five types of years would begin at particular fixed dates. Let us therefore interpret these dates as the limits of dates for the beginnings of the luni-solar year. They should be as follows :-

CHART 2

Sr. No.	Name of the Year	Dates of winter solstice
1.	**Samvatsara**	1st Shuddha Maagha to 6th Shuddha Maagha.
2.	Anuvatsara	7th Shuddha Maagha to 12th Shuddha Maagha.

3.	Parivatsara	13th Shuddha Maagha to 3rd Vadya Maagha.
4.	**Idvatsara**	4th Vadya Maagha to 9th Vadya Maagha
5.	Idaavatsara	10th Vadya Maagha to Amaavaasyaa.

TABLE NO. 2

Sr. No.	Name of the year	Winter Solstice	Mid year	Summer Solstice	Year end
1.	**Samvatsara**	Shu. 1		Shu. 7	
2.	Anuvatsara	Shu. 12		Vad. 3	
3.	Idvatsara	Vad. 8		Vad. 14	+m
4.	**Samvatsara**	Shu. 4		Shu. 10	
5.	Parivatsara	Paurnimaa		Vad. 6	
6.	Idaavatsara	Vad. 11	+m	Shu. 2	
7.	**Samvatsara**	Shu. 7		Shu. 13	
8.	Parivatsara	Vad. 3		Vad. 9	
9.	Idaavatsara	Vad. 14	+m	Shu. 5	
10.	Anuvatsara	Shu. 10		Vad. 1	
11.	Idvatsara	Vad. 6		Vad. 12	+m
12.	**Samvatsara**	Shu. 2		Shu. 8	
13.	Parivatsara	Shu. 13		Vad. 4	
14.	Idvatsara	Vad. 9		Amaavasyaa	+m
15.	**Samvatsara**	Shu. 5		Shu. 11	
16.	Parivatsara	Vad. 1		Vad. 7	
17.	Idaavatsara	Vad. 12	+m	Shu. 3	
18.	Anuvatsara	Shu. 8		Shu. 14	
19.	Idvatsara	Vad. 4		Vad. 10	+m
20.	New Yuga begins	Amaavasyya			

+m Shows Adhikamaasa

The dates of the beginning of a luni-solar year should be taken from table No. 1 column 7. This column gives r@tushesha in a number of karanas. It has to be divided by two to convert it into tithis. The R@g Jyotisha verse 8 begins with the word dvigunam 'doublet' in stead of the word *prathamam* first. This indicates that the numbers given in the verse are ordinarily tithis, but for computing r@tushesha in karanas they have to be doubled. The following figure will express in a better way the limits which are given in table No. 1.

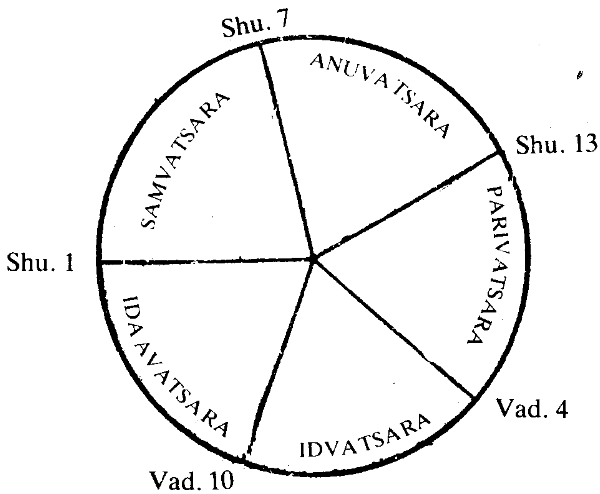


FIGURE -1

The words *bahule'pyr@tau* occurring at the end of the 8th verse support our interpretation. They indicate that the dates given in the said verse are only to indicate the lower limits of five zones. In different years, there exists some additional r@tushesha. The r@tushesha given in column 7 of table No. 2 gives the dates of the winter solstices at the beginning of the next year. Table No. 2 is thus prepared by reading Table No. 1 and figure No. 1 together.

Dr. D.K. Abhyankar of Usmania University (Hyderabad) has pointed out to me two rules followed by Sage Lagadha in giving names to the years (i) Intercalary months occur only in Idvatsara and Idaavatsara (ii) If it is Idvatsara, it comes at the end of the solar year, and if it is Idaavatsara it comes before the summer solstice i.e. in the middle of the year. He drew this inference after reading my book in Marathi. The rule is correct, and useful.

THE SHALAHAS

They observed a week of six days called *'Shalaha'* (i.e. a hexad.) A lunar month also used to be divided in five tithi-shalahas. The solar year was named according to serial numbers of shalaha in the lunar month Maagha, in which the winter solstice i.e. i.e. the New Year day of the solar year occured. Thus if the winter solstice occured in the first shalaha, it was called samvatsara, and if it occured in the second shalaha, it was called anuvatsara, and so on. This is an easier way of interpreting RVJ 8.

The year classified as Samvatsara has occurred five times in a yuga of 19 years in Table No. 2. Lagadha has therefore started with the words pancha-samvatsara-mayam which were misunderstood and misinterpreted by the commentators as a yuga of five years. He simply meant that his yuga covers five samvatsaras along with other years. There is a difference between the words Pancha-samvatsara yuga and Pancha-samvatsara-maya yuga. Table No. 3 gives tithis on winter solstice from 1957 to 1984. If we compare table No. 2 (which is theoretical) with Table No. 3 (which is practical) we realise the extent of accurancy of the Vedaanga.

TABLE NO. 3

Yuga Year	Date winter Solstice	Tithi	Yuga year Sr.No.	Date winter Solstice	Tithi
1.	21 Dec. 1957	Mag. Vd. 30	15	22 Dec. 1971	Pus.Sh. 5
2.	22 Dec. 1958	Mrg. Sh. 12	16	21 Dec. 1972	Mrg. 1
3.	22 Dec. 1959	Mrg. Vd. 7	17	21 Dec. 1973	Mrg. Vd. 12
4.	21 Dec. 1960	Pus. Sk. 4	18	22 Dec. 1974	Mrg. Vd. 8
5.	21 Dec. 1961	Mrg. Sh. 15	19	22 Dec. 1975	Mrg. Vd. 4
6.	22 Dec. 1962	Mrg. Vd. 11	1	21 Dec. 1976	Mrg. Vd. 30
7.	22 Dec. 1963	Pus. Sk. 6	2	21 Dec. 1977	Mrg. Sh. 11
8.	21 Dec. 1964	Mrg. Vd. 3	3	22 Dec. 1978	Mrg. Vd. 7
9.	21 Dec. 1965	Mrg. Vd. 14	4	22 Dec. 1979	Pus. Sh. 4
10.	22 Dec. 1966	Mrg. Sh. 10	5	21 Dec. 1980	Mrg. Sh. 15
11.	22 Dec. 1967	Mrg. Vd. 6	6	21 Dec. 1981	Mrg. Vd. 11
12.	21 Dec. 1968	Pus. Sh. 2	7	22 Dec. 1982	Mrg. Sh. 7
13.	21 Dec. 1969	Mrg. Sh. 13	8	22 Dec. 1983	Mrg. Vd. 3
14.	22 Dec. 1970	Mrg. Vd. 9	9	21 Dec. 1984	Mrg. Vd. 14

NOTE : If we call a European leap year as the 1st year, in a group of 4 years we have winter solstice on 21st in the 1st and the 2nd years, and it is on the 22nd in the 3rd and the 4th years.

CHAPTER - 6

Nakshatra & Yuga

Before Lagadha, people presumed 28 nakshatras. They counted 27 and 28 nakshatras in alternate months. The ancillary nakshatra *abhijit* was dropped for mathematical calculations, and 27 names were retained. As nakshatras were 27 small constellations on the ecliptic, they were used for denoting positions of the planets in the sky. A tithi gives a *phase* of the moon while a nakshatra gives the *location* of the moon in the sky or the celestial sphere. A lunar month begins at various different places in the sky. Hence we cannot assign a particular nakshatra for a particular tithi. The names of nakshatras were used for naming a day according to the position of the moon. we shall now see how nakshatras were arranged in a 19-year yuga. While making room for nakshatras in a yuga, sage Lagadha took advantage of the following products -

$$19 \times 10 = 190$$
$$27 \times 7 = 189 \text{ i.e. } (190 - 1)$$

Where the number 7 indicates 7 intercalary months in a yuga.

We have seen that there is r@tushesha of 11 tithis per year. It is 10 when counted in terms of nakshatras. A separate arrangement for the nakshatras was therefore necessary. We have 7 intercalary sidereal months in 19 years i.e. $27 \times 7 = 189$. One surplus nakshatra is required in 19 lunar years for equating them with 19 solar years. If we presume the 19th year as leap year, the total becomes 190 nakshatras. We have thus a r@tushesha of 10 nakshatras per year in 19-years cycle. For every ayana or semester, it is five nakshatras. For easy computation Lagadha made a list of nakshatras at intervals of 5 serial numbers.

Lagadha used symbols for the nakshatras with letters either from the names of the nakshatras or the deities presiding over the nakshatras; RVJ 14 gives the list.

जौद्राघःखेश्वेहीरोषाचिन्मूषण्यःसोमाधानः ।
रेमृघ्राश्वाओजस्तृष्वोहर्येष्टा इत्यृक्षालिङ्गैः ।। RVJ 14

Lokmanya Tilak called this list as Javaadi list. i.e. a list beginning with Jau. Let us use the same name. The nakshatras in this verse are in the following order.

Sr. No.	Symbol	Name	Serial No from Shravishthaa
1.	Jau	Aashvayujah (Ashvini)	Sr. No. 6
2.	Draa	Aardraa	Sr. No. 11
3.	Gha	Bhagah (Poorvaaphaalgunee)	Sr. No. 16
4.	Khe	Vishakhaa	Sr. No. 21
5.	Shve	Vishve (Uttaraashaadhaa)	Sr. No. 26
6.	Hee	Ahirbudhnyah (Uttaraabhaa-drapadaa).	Sr. No. 4
7.	Ro	Rohinee	Sr. No. 9
8.	Shaa	Aashleshaa	Sr. No. 14
9.	Chit	Chitraa	Sr. No. 19
10.	Moo	Moola	Sr. No. 24
11.	Sha	Shatabhishaj	Sr. No. 29
			and so on

S. B. Dixit was the first to decipher the symbols and give the aforementioned list. He tried to give reasons for giving the list of nakshatras in such a peculiar order.

Dixit tried to give a ratio between the lengths of parvans and solar nakshatras. He presumed that the Vedic yuga consisted of five years. The total number of nakshatras in a yuga would therefore be $27 \times 5 = 135$. The total number of parvans in a yuga would be $62 \times 2 = 124$. It was therefore convenient to divide a yuga in $135 \times 124 = 16740$ subdivisions. He called them Bha-amshas. Let us denote this unit of angle by 1 Bh°. Thus a parvan consisted 135 Bh°. Dixit thereafter prepared a table showing the positions of the Sun in Solar nakshatras at the end of various parvans. (please see Annexure 3A, B, C, D, E). He pointed out that the difference between Bha-amshas in parvans and those in nakshatras increased by multiples of 11. From these multiples of 11 he subtracted multiples of 27, and showed that the figures 1, 2, 3, 4 appear again at every fifth nakshatra as arranged in Javaadi list RVJ 14.

He further states that he is unable to give the purpose for such an arrangement. For explaining the purpose of including Javaadi list in Vedaanga, Lokamanya Tilak and Prof. T. S. Kuppanna Sastri were required to refer to verse 20 in Yajus recension (तिथिमेकादशाभ्यस्तान्) indicating that R@k Jyotisha is an incomplete text.

According to me, the purpose for giving Javaadi list in R@k Jyotisha is altogether different yet simple. I have demonstrated in the beginning of this chapter that R@tushesha per ayana is 5 nakshatras. We need one additional nakshatra in 19 years to make the total 190 nakshatras. The first nakshatra i.e. Shravishthaa was

TABLE No. 4

Shravishthaa = Shravana + 38 divisions of 1/38 nakshatras

Sr.No. of the year.	Winter Solstice	5th Nakshatra	Summer Solstice
1.	Shravishthaa (shrvana + 38 divisions).	Revatee (+ 13 Nakshatra s)	= Hasta
2.	Mr@ga + 36 div.	Maghaa + 13 N	= Shravishthaa
3.	Swaati + 34 div.	Poor.Aash ,,	= Aardraa
4.	Poor. Bhaad + 32 div	Kr@t	= Vishaakhaa
5.	Pushya + 30 div	Hasta ,,	= Utt. Bhaadra.
6.	Jyeshthaa + 28 div	Shravishthaa ,,	= Aashleshaa
7.	Ashvini + 26 div	Aardraa ,,	= Moola
8.	Poor. Phal + 24 div.	Vishaakhaa ,,	= Bharanee
9.	Utt.Aashd + 22 div	Utt. Bhaadra ,,	= Utt. Bhaadra.
10.	Rohinee + 20 div	Aashleshaa ,,	= Shravana
11.	Chitraa + 18 div.	Moola ,,	= Mr@ga
12.	Shata + 16 div.	Bharanee ,,	= Swaatee
13.	Punarvasu + 14 div.	Utta. Phal ,,	= Poor. Bhaadra.
14.	Anuraadhaa + 12 div	Shravana ,,	= Pushya
15.	Revatee + 10 div	Mr@ga ,,	= Jyeshthaa
16.	Maghaa + 8 div	Svaatee ,,	= Ashvinee
17.	Poor. Aashd + 6 div	Poor. Bhaadr. ,,	= Poor. Phaal
18.	Kr@t + 4 div.	Pushya ,,	= Utt. Aash.
19.	Hasta + 2 div.	Jyeshthaa ,,	= Rohinee
20.	Shravishthaa	New Yuga begins.	

therefore, sub-divided in 19 × 2 = 38 divisions. Shravishthaa nakshatra = Shravana nakshatra + 38 divisions. Table 4 gives R@tushesha in nakshatras in each of the 19 years at every solstice.

The second column of Table 4 gives the position of the moon at winter solstice in various nakshatras in a chain of 19 years. In every ayana the R@tushesha increases by 4 + 37/38 nakshatra i.e. 5−1/38 nakshatra apparently indicating an increase of 5 nakshatras (in an integral part of the number). If we multiply 4 + 37/38 by 1, 2, 3, 4 etc. we get 4 + 37/38, 9 + 36/38, 14 + 35/38, 19 + 34/38 and so on. Thus the serial number of a nakshatra increases by 5 at every solstice, which is shown in the 3rd column. During one ayana the Sun advances through 180°, when it is at summer solstice. The moon therefore advances through 13 + 1/2 nakshatras more, and its position is shown in column 4. Its sidereal position thus shows a retreat of two divisions i.e. 2/38 nakshatra every year, and it receeds by one nakshatra in 19 years. We are therefore required to presume Shravishthaa as a leap nakshatra. This fact is given in verse 19.

श्रविष्ठाभ्यां गुणाभ्यस्तान् प्राग्विलग्नान्विनिर्दिशेत् ।
सूर्यान्मासान् षळभ्यस्तान्विद्याच्चांद्रमसानृतून् । ।RVJ 19

S.B. Dixit has left the first line of the verse unexplained. Scholars have given different purposes for incorporating this verse in Vedaanga, and have interpreted the words guna (गुण) and lagna (लग्न) in various ways. From Tilak's book it appears that Dvivedi has suggested to change guna (गुण) into gana (गण) and subsequently into bhagana (भगण) i.e: nakshatra to indicate the figure 27, and Lala Chhotelal has suggested to treat the meaning of the word lagna (लग्न) as number 8, with the intention to connect Shravishthaa with Kr@ttikaa which are 8 units (of nakshatras) away from them. According to him, vernal equinox was then at Kr@ttikas. Lok. Tilak interprets the word lagna as multiples of 3 counted from Shravishthaa and says that this meaning is conjectural.

According to me, the word गुणाभ्यस्त means repetition, reproduction, i.e. multiples of a number from a multiplication table. Javaadi list gives multiples of five in the serial number of nakshatras. The word गुणाभ्यस्त in verse 19 is therefore meant to reproduce verse 14 i.e. Javaadi list. The word *vilagna* suggests separation or cutting off. Hence प्राग्विलग्न means separation at the rear side. Sage Lagadha asks us to break the chain of nakshatras at 'Shravishthaa (श्रविष्ठाभ्यां) and go back one nakshatra to create a leap year of nakshatras. In the second line of verse 19 he tells us the results of such an action. He says, "At each end of a group of six solar months, (we) observe r@tushesha of lunar nakshatras. I thus explain the verse in the following words -

"If we break the (chain of) nakshatras, (a nakshatra) before Shravishthaa and repeat (Javaadi) multiplications, we observe a r@tushesha in lunar nakshatras at the intervals of six solar months."

In the second line of RVJ 19 we have the words *Sooryaan maasaan shalaabhyastaan* meaning 'at the end of six solar months'. These words did not give any intelligible meaning suited to the theory of a 5-year yuga; Dvivedi therefore amended them and substituted स्वार्क्षान् for सूर्यान् (see Tilak pp 101) 'six sidereal months'. Tilak approved the meaning and amendment. Prof. T. S. Kuppanna Sastri substituted स्तर्यान् (Star's) for सूर्यान् which also mean sidereal months. These amendments are not necessary, if we interpret the verse in the context of a 19-year yuga.

We have seen that lunar years were grouped in five classes according to the tithis at the winter solstice immediately after the commencement of the lunar year. They were also classified according to the nakshatras. Sage Lagadha provided verse 9 for that purpose.

वसुस्त्वष्टाभगोजश्चमित्रःसर्पाश्विनौजलं ।
धाताकश्चायनाद्याश्चार्धपंचनभस्त्वृतुः ।।RVJ 9

Disit has explained the verse in the following words: "Those nakshatras whose lords are *Vasu, Tvashtaa, Bhaga, Aja, Mitra, Sarpa, Ashvini, Jalam, Dhaataa* and *Brahmaa* i.e. *Dhanishthaa, Chitraa, Aardraa, Poorvaa Bhaadrapadaa, Anuraadhaa, Aasleshaa, Aashvayujaa, Poorvashaadhaa, Uttaraa Phaalgunee and Rohinee* were at the beginning of the ayanas. There are 4 1/2 nakshatras in a season.

Taking into consideration the fact that there are six seasons in India, S.B. Dixit explained the last portion of the verse thus : "There are four and a half (27/6) nakshatras in a season". But the words in the verse are quite different: अर्धपञ्चनभस्त्वृतुः which literally mean "half-five sky r@tus." The total number of presiding deities in the first part of the verse are also ten. It is clear that five zones of R@tushesha of nakshatras similar to those of tithis are assumed in the verse and sage Lagadha speaks of points dividing these zones in two halves.

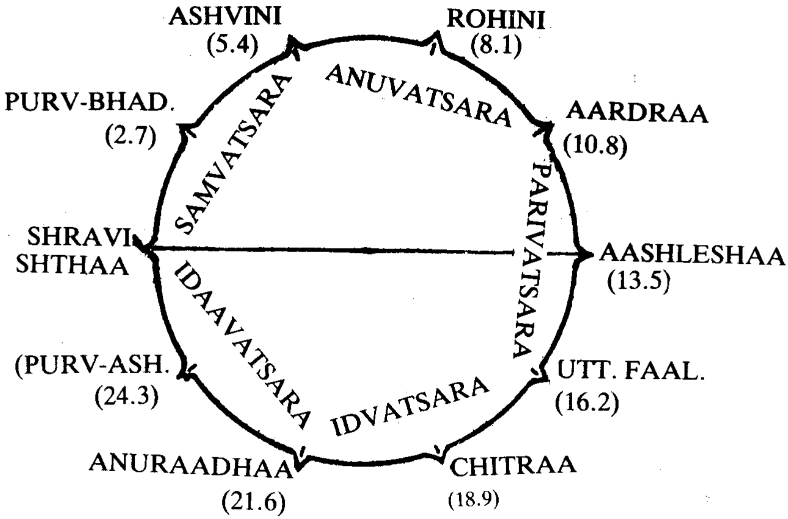


Figure No. 2 will clarify the meaning.

It is worthwhile to compare this figure with figure 1. In figure-1 we five zones for classification of the years as *Samvatsara*, etc. The criterion of classification is tithis, pratipadaa प्रतिपदा to saptamee सप्तमी etc. In figure-2 we have to divide 27 nakshatra in 5 equal zones. Each zone is of 5.4 nakshatras and one half zone is of 2.7 nakshatras. The names of the nakshatras at the junction of these half-zones are therefore given according to the serial number forming an integral portion of the sub-division 2, 5, 8 etc. The five zones are r@tushesha zones. भ or नभस् in Jyotisha means a nakshatra. The poet therefore uses the words अर्धपञ्चनभस्त्वृतुः We can identify the class of year (i.e. Samvatsara etc.) from the nakshatra position of the moon at winter solstice at the beginning of a year. We get it from table 5, which is prepared by a combined reading of table 4 and figure 2. The entry Mr@ga + 36 divisions in Table 4 at Serial No. 2 is shown as current nakshatra Aardraa in Table 5. All other nakshatras are shown in a similar manner. The last quarter of RVJ 9 therefore means : "These are the limits of the half divisions of the five zones allotted to r@tushesha expressed in nakshatras."

Now we can explain the first line of verse 15.

जावाद्यंशैः समंविद्यात्पूर्वार्धे पार्वसूत्तरे ।

"Know that Javaadi list has a balanced application : First (symbol) for the first half (of the year) and latter (symbol) for the latter half (of the year)." Thus if at winter solstice we have Jau then at summer solstic we have Aardraa (Dra) and so on. (please see table 4)

TABLE No. 5

Sr.No. of the Year		Winter Solstice	Summer Solstice
1.	**Samvatsara**	Shravishthaa	Chitraa
2.	Anuvatsara	Aardraa	Poor. Bhaa.
3.	Idvatsara	Vishaakhaa	Punarvasu
4.	**Samvatsara**	Utt. Bhaa.	Anuraadhaa
5.	Parivatsara	Aashleshaa	Revatee
6.	Idaavatsara	Moola	Maghaa
7.	**Samvatsara**	Bharanee	Poor. Aashd.
8.	Parivatsara	Utt. Phaalgunee	Kr@ttikaa
9.	Idaavatsara	Shravana	Hasta
10.	Anuvatsara	Mr@ga	Shravishthaa
11.	Idvatsara	Swaatee	Aardraa
12.	**Samvatsara**	Poor. Bhaa.	Vishaakhaa
13.	Parivatsara	Pushya	Utt. Bhaa.
14.	Idvatsara	Jyeshthaa	Aashleshaa
15.	**Samvatsara**	Ashvinee	Moola
16.	Parivatsara	Poor. Phalgunee	Bharanee
17.	Idaavatsara	Utt. Aash.	Utt. Phaalgunee
18.	Anuvatsara	Rohinee	Shravana
19.	Idvatsara	Chitraa	Mr@ga
20.	New Yuga Begins	Shravishthaa	

It was impossible to reasonably explain verse 19 (श्रविष्ठाभ्या) on the basis of five-year astronomical cycle without making drastic changes in the original text. The only way out was to explain it on the basis of 19 year-yuga. We have seen how it can be so explained by keeping harmony with RVJ 9 and RVJ 14 Lok. Tilak tried to explain verse RVJ 19 on the basis of a five-year astronomical cycle and made the following remark.

"Mr. Diksnit has not translated the first half of the verse. But in several places of his book he has thrown out certain suggestions regarding its meaning, which deserve to be noticed. He has shown that before the introduction of Raashis and along with it the twelve lagnas, the number of Lagnas was nine, each consisting of three nakshatras. If so, one may interpret the verse as meaning that "one should indicate the Lagnas by the (successive) multiples of three (counted) from Shravishtha," without straining the meaning of any word therein. But even this meaning is merely conjectural; and in the absence of any further accurate information about the number and meaning of lagnas in the pre-Raashi period of Hindu astronomy, Mr. Diksnit was right in leaving this part of the verse unexplained. The Vedaanga rules were intended for ordinary priests; and it is not reasonable to assume that they were originally expressed in any but the simplest language and the simplest manner, consistent with the nature of the subject. True that the Vedaanga has all along been a conundrum to us. But this was due partly to its present fragmentary character, partly to the corrupt state of the text and its technical nature, and partly to our ignorance of the ancient astronomical methods. Thanks to the labours of Thibaut, Diksnit, Barhaspatya and others, these difficulties have been almost overcome. But still, if a verse in the Vedaanga fails to yield any intelligible meaning, except by violating the natural construction and meaning of the words used, we may be sure to have missed its true import; and the safest course to follow in such case is simply to record our suggestions, if any, and to leave the verse to be finally deciphered by future workers in the field, rather than try to give by hook or crook, to our work a semblance of completeness it has not really attained. For in spite of the great progress already made, the last word on the Vedaanga is, in my opinion, yet to be uttered."

CHAPTER - 7

Balancing Provisions

The first solar year in a **yuga** is a leap year. It consists of 372 tithis. Number 372 is **divisible** by 12 and as such the first year is treated as the basic year **or** the elementary year. Vedaanga presumes 366 days in the basic year.

The basic solar year is divided in six monsoon seasons. Each season consists of 61 days = 62 tithis. The lunar year consists of 360 tithis. A Lunar month is shorter than a solar month.

A lunar month = 30 tithis, while a solar month = 31 tithis. Therefore a solar half-month consists of $15^1/_2$ tithis. This is expressed in RVJ 23.

तदर्धं दिनभागानां सदा पर्वणि पर्वणि ।
ऋतुशेषं तु तद्विद्यात् संख्याय सहपर्वणां । ।RVJ 23

Thus this half-tithi per parvan totals to 12 tithis in a solar year. The difference gradually increases and gets converted into an intercalary month.

Excepting the first solar year, all other solar years in a yuga consist of 371 tithis. Let us call them normal years. We have therefore to deduct the last i.e. (372nd) tithi from the 2nd solar year, and add it in the 3rd solar year, and repeat the operation at the end of every year. This procedure therefore forms a modification or proviso to the general rule. It is stated in RVJ 20.

अतीतपर्वभागेषु शोधयेद् द्विगुणां तिथिम् ।
तेषु मण्डलभागेषु तिथिनिष्ठां गतो रविः ।।२०।।

Apte's Sanskrit English dictionary gives the meaning of the word 'Nishthaa' (निष्ठा) as foundation, fixity, steadiness. Hence the words tithi-nishthaa imply : 'when the Sun reaches a day of solstice'. Verse 20 therefore means 'make correction at extending parvan-portion to (avoid) the error of doubling of tithis at the point of the circle where the Sun becomes steady (on the day of solstice). A detailed method for deducting the fraction of the day and the tithis is given in RVJ 12 and RVJ 13.

We have similar general rule for calculating the number of parvans before a day of equinox and the tithi of the day of equinox. It is given in RVJ 31. But RVJ 31 has to be read with RVJ 20.

विषुवं तद्गुणं द्वाभ्यां रूपहीनं तु षड्गुणम्।
यल्लब्धं तानि पर्वाणि तथोर्ध्वं सा तिथिर्भवेत्।। RVJ 31

Here the word *roopaheenam* means 'deduct one', *tadgunam-dvaabhyaam* means multiply by two, *shadgunam* means 'multiply by six'.

The rule can be well explained by giving an example : Suppose we have to find out the number of parvans from the beginning of the yuga till the 9th equinox (vishuvan) parvans :-

9×2	(तद्गुणं द्वाभ्यां)	=	18
$18 - 1$	(रूपहीनं)	=	17
17×6	(षड्गुणं)	=	102 number of parvans

Tithis :-

$102 \div 2$	(तथोर्ध्वं)	=	51 tithis
		=	3 parvans + 6 tithis.

We have thus the answer according to RVJ 31, (102 + 3) parvans + 6 tithis. But from the beginning of the Yuga 8 semesters have passed; hence we apply the rule in RVJ 20 and deduct 3 tithis. Our answer is therefore 'from the beginning of the Yuga 105 parvans have passed and we have Vaishaakha Shuddha 3rd (6 – 3) tithi.

PART III

CHAPTER - 8

Parvan Bha-amshas of the Basic Year

In the basic year the path of the Sun is divided in 27 nakshatras as well as into 372 tithis. One nakshatra would therefore consist of $372 \div 27 = 124/9$ tithis. To avoid fractions sage Lagadha sub-divided the angular distance travelled by the Sun in a tithi into 9 parts called *Bha-amshas* (भ-अंश). Let us denote this angular distance as 1 Bh^0.

1 tithi = 9 Bh^0

1 Nakshatra = 124 Bh^0

The angular distance travelled by the Sun in a half-lunation i.e., from syzygy to syzygy (paksha to paksha) is called parvan. Therefore –

1 parvan = 15 tithis

= 135 Bh^0

In a year we have $372 \div 15 = 24.8$ parvans. S. B. Dixit had thought that both the texts of *Vedaanga* are based on 5-year luni-solar cycle. He has therefore given 5 tables to show parvan and nakshatra positions of the Sun in five years. I have given those tables in Appendix 3. These tables are called *Amsha-Saarinees*. The Zero position of the Sun in these tables is at Winter-Solstice in Shravishthaa (Delphinus).

From amsha-saarinees we get the nakshatra positions of Sun at the end (i.e. joint) of each parvan during its journey in a number of nakshatras and Bha degrees. Tilak calls them Sun's parvan nakshatras.

As the first year of the R@k cycle of Vedaanga consists of 372 tithis, S.B. Dixit's first year table shows parvan nakshatra positions of the Sun in the basic year. With slight modifications, I have given the amsha-saarinee of the basic year of R@k cycle at Table 5-A.

भांशाः स्युरष्टकाः कार्याः पक्षा द्वादश चोद्गताः ।

एकादश गुण स्योनः शुक्लेर्धं चैन्दवा यदि ।।१०।।

We would first know the meaning by examples and then put it into words.

Example - Find out the parvan nakshatra position of the Sun at the end of the 7th parvan (Please see Table-5A Column 2, 3, 4.)

TABLE No. 5-A
Basic Solar Year (RVJ 10)

	Solar Sidereal Positions				Lunar Sidereal Positions			
Name of the Month	Sr.No.of parvan	No. of complete solar nakshatra	Solar Bh^{o}'s	Name of the solar nakshatra	No. of complete lunar nakshtra	lunar Bh^{o}'s	Total Nakshatras crozzed/27 Remainder	Name of lunar nakshatra
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Maagha	1	1	11	Shatabhishaj	14	73	14	Maghaa
Maagha	2	2	22	Poor'Bhaad.	29	22	2	Poor'Bhaad.
Phaalguna	3	3	33	Utt'Bhaad.	43	95	16	Utt'Phaal.
Phaalguna	4	4	44	Revatee	58	44	4	Revatee.
Chaitra	5	5	55	Ashvayuj	72	117	18	Chitraa.
Chaitra	6	6	66	Bharanee	87	66	6	Bharanee.
Vaishaakha	7	7	77	Kr@ttikaa	102	15	21	Anuraadhaa
Vaishaakha	8	8	88	Rohinee	116	88	8	Rohinee.
Jyeshtha	9	9	99	Mr@ga	131	37	23	Moola.
Jyeshtha	10	10	110	Aardraa	145	110	10	Aardraa.
Aashaadha	11	11	121	Punarvasu.	160	59	25	Utt'shaadhaa
Aashaadha	12	13	8	Aashleshaa	175	8	13	Ashleshaa.
Shraavana	13	14	19	Maghaa	189	81	27	Shravishthaa.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Shraavana	14	15	30	Poor'Phaalg.	204	30	15	Poor'Phaalg.
Bhaadrapada	15	16	41	Utt.'Phaalg.	218	103	2	Poor'Bhaad.
Bhaadrapada	16	17	52	Hasta	233	52	17	Hasta.
Aashvina	17	18	63	Chitraa	248	1	5	Ashvayuj.
Aashvina	18	19	74	Swaatee.	262	74	19	Swaatee.
Kaartika	19	20	85	Vishaakhaa	277	23	7	Kr@ttikaa.
Kaartika	20	21	96	Anuraadha.	291	96	21	Anuraadhaa.
Maargasheersha	21	22	107	Jyeshthaa	306	45	9	Mr@ga.
Maargasheersha	22	23	118	Moola	320	118	23	Moola.
Pausha	23	25	5	Utt'shaadhaa	335	67	11	Punarvasu
Pausha	24	26	16	Shravana	350	16	26	Shravana
R@tushesha	12 Tithis	27	+ 108		361	99	− 10	Aardraa
			= 124					

Let us denote the angular distance travelled by the Sun in a nak<u>sh</u>atra by 'N' so that 124 Bh^0 = N.

$$1 \text{ parvan} = 135 \; Bh^0$$
$$= N + 11 \; Bh^0$$
$$7 \text{ parvans} = 7\,(N + 11 \; Bh^0)$$
$$= 7\,N + 77 \; Bh^0$$

Therefore, the answer of the above question is: at the end of the 7th parvan the Sun was 77 Bh^0 inside the 7th nak<u>sh</u>atra i.e. Krittikaa. This is called the sidereal position of the Sun.

When the number of parvans increases more than 12, we have

$$12 \text{ parvans} = 12\,(\text{Nakshatras} + 11 \; Bh^0)$$
$$= 12 \text{ Nakshatras} + 132 \; Bh^0$$
$$= 13 \text{ Nakshatras} + 8 \; Bh^0$$

(Please see Table 5-A.)

Thus the first line and a half of the second line of verse 10 can be translated as :-

"In a group of 12 pak<u>sh</u>as 8 Bha-amsha arise. For the remainder (i.e. less than 12 pak<u>sh</u>as) 11 Bha-amshas (per pak<u>sh</u>a) arise" (see Table 5-A) The latter portion of the second line in R@k verse 10 is provided for calculating the sidereal position of the moon at the beginning of each parvan (शुक्लेर्ध चैन्दवा यदि) It is explained at a subsequent stage.

NORMAL YEARS

The basic year consists of 366 days, 372 tithis and 361.8 lunar nak<u>sh</u>atras. We are therefore required to deduct some part of a day as well as some part of a tithi every year, so that the average year in a yuga should consist of $365^1/_4$ days and 371 tithis. The average deduction thus required is 3/4 of a day as well as 1 tithi per year in a yuga of 19 years.

In 366 days the Sun travels an angular distance of about 360^0 45' (minutes). This surplus angular distance of 45' of arc per year, travelled in 19 years, has to be divided in 18 years. If the average deduction is calculated in Bha-amshas, it comes to 7 Bh^0 per year. The author therefore asks us in the first stage to make corrections in the path travelled by the Sun. He also wants us to make corrections in the angular distance travelled by the moon in equal time. He has provided verse 12 for this purpose.

There is a minor difference in the presumed relative angular velocity of the Sun and the moon per parvan and their actual velocities. This minor difference has to be corrected once in a year. RVJ 13 is provided for this purpose. RVJ 12 reads as under :-

त्र्यहंशीभशेषो दिवसांशभागः चतुर्दशस्याप्युपनीतभिन्नम्।
भार्धेऽधिके चाधिगते परेंशे द्वावुत्तमैकं नवकैरवेद्यं।।RVJ 12

Before we begin with an explanation, the word navaka in the second line of the verse has to be explained. In one tithi the Sun travels a distance equal to 9 Bh^0. Therefore, 9 Bh^0 of angular distance is equal to one navaka. The beginning of a navaka may not necessarily coinside with the beginning of a tithi. One tithi = 593 + 17/62 kalaas. Its 9th part would be about 66 Kalaas. Therefore for practical purposes the journey of the Sun in 66 kalaas would be 1 Bh^0. The meaning of RVJ 12 would now be :

"Destroy a portion of a day equivalent to one third of Bha-amsha (22 kalaas) adjoining (every) chaturdashee (14th tithi in a parvan). Ignore (अवेद्यं) from this process two such navakas that follow after half of the advancement (of the Sun) in nakshatras (i.e. summer solstice)."

According to this rule we have to reckon every chaturdashee of a short length i.e. by 22 kalaas (593 + 17/62 − 22 = 571 + 17/62 Kalaas). While doing so, we should not disturb two chaturdashees which follow a summer solstice. Our regular time clock also records the relevant Paurnimaa to have begun 22 kalaas earlier. The total effect of the rule is that the Sun travels in a parvan 134⅔ Bh^0 instead of 135 Bh^0. Yet we presume it to have travelled 135 Bh^0. The ratio of the angular velocities of the sun and the moon is 5:67. When we subtract 1/3 Bh^0 from the Solar journey by actual deduction of 22 Kalaas from the relevant tithi, we also reduce 67/15 Bh^0 of lunar-angular journey. Such a deduction, angular as well as temporal, is called by the author भशेषो दिवसांशभागः (Bhashesho divasaamsha bhaaga). In such an arrangement there is no change in Table 5-A, which is meant for plotting the angular distance in nakshatras per parvan travelled by the Sun. The parvan becomes smaller on diurnal scale, other things remaining undisturbed.

The author of Vedaanga asks us not to disturb the chaturdashee at the end of the 13th and the 14th parvans of the year which follow the summer solstice (See second line of RVJ 12). The end of the 15th parvan is required to be modified for the purpose given in RVJ

13. Its explanation is given at a subsequent place. We are therefore left with (24-3) = 21 parvans per year for the operation of the rule given in RVJ 12, in which we have short chaturdashees. The total deduction of time per year would therefore be $(21 \div 3)$ Bh^0 i.e. 7 Bh^0 in all the normal 18 years. In other words we would have an average year equal to 365 days, and 2 Bh^0 i.e. 365 days and 122 kalaas.

The next procedure is given in RVJ 13.

पक्षात् पञ्चदशात् चोर्ध्वं तद् भुक्तम् इति निर्दिशेत्।
नवभिस्तद् उद्गतोंशः स्यात् ऊनांशद्वयाधिकेन तु।।१३।।

In this verse the word दिवसांशभाग is absent. Its object is therefore not to adjust the length of the total days; but only to adjust the tithis and lunar nakshatras in a year. RVJ 13 can be explained as -

"On the top side of the 15th paksha when 9 bha-amshas arise, record them used (as a tithi) except two of them so added".

The last day of the 15th parvan is Paurnimaa (full moon day)

In Table 5-A the Sun is shown to occupy its celestial position at 16th nakshatra and 41 Bh^0 at the end of 15th parvan.

Now let us see what adjustment RVJ 13 asks us to make at this point. 15 parvans are equal to 225 tithis. If they are converted into days, we have $225 \times 61/62$ days, which are equal to 221 days and $220 \frac{22}{62}$ kalaas. In the basic year this would be the time from the beginning of the Solar year at the end of the 15th parvan. The rule given in RVJ 12 tells us to deduct 22 kalaas per parvan for 12 parvans upto the application of RVJ 13. The total deduction is 264 kalaas. We therefore cover in normal year 220 days and $559 \frac{22}{66}$ kalaas till the end of the 15th parvan. When we reach this point of time from the beginning of the Solar year, RVJ 13 asks us to record only 2 Bh^0 of the 15th tithi to have been used, which are equal to 132 kalaas. The rest part of the time (i.e. 7 Bh^0) of paurnimaa is yet to pass. We therefore record it to have continued for $461 \frac{17}{62}$ kalaas more $(592 \frac{17}{62} - 132 = 461 \frac{17}{62}$ kalaas). The relevant paurnimaa therefore ends at -

$(559 \frac{22}{62} + 461 \frac{17}{62} =)$ 1 day $417 \frac{39}{62}$ kalaas or roughly 418 kalaas on the 221st day of the solar year. The net result is 372 tithis which were compressed in 365 $\frac{2}{9}$ days in a year (according to RVJ 12) again get expanded, so that 371 tithis are accommodated in 365 days.

The journey of the Sun is also recorded during this time. At the end of the 15th parvan of the solar year, it moves 16 Bh°. Therefore in Table 5-A, modifications become necessary to make it suitable for a normal year. In column 4 we have to add 7 Bh° from the 15th parvan onwards.

The relevant amended portion is given as Table 5-B

Table 5-B

Name of the month	Sr. No. of Parvan.	No. of Saura nakshatra	Bh⁰
Bhaadrapada	15	16	48
Bhaadrapada	16	17	59
Aashvina	17	18	70
Aashvina	18	19	81
Kaartika	19	20	92
Kaartika	20	21	103
Maargasheersha	21	22	114
Maargasheersha	22	24	. 1
Pausha	23	25	12
Pausha	24	26	23
+ r@tu shesha			* 99
+ 99 Bh⁰	=	26	122

The last entry in this table shows the position of the Sun in the nakshatras at the end of 365th day of the Solar year. It is 26 nakshatras and 122 Bh⁰.

We have so far examined for corrections 24 points (according to RVJ 12 & 13) in the solar year at the end of 24 parvans. The last i.e. the 25th point used by the author of the Vedaanga is the day of winter solstice. After completion of 365 days journey, the Sun travels 2 Bh⁰ (in 132 kalaas) more to complete its journey of 27 nakshatras. The last tithi or a solar year has therefore 11 Bh⁰. This is implied in RVJ 20 (i.e. अतीतपर्वभागेषु) because we close all accounts of fraction-tithis (kalaas), when we reach 365 2/9 days from the beginning of the solar year. It is worthwhile to note that there are 24.8 parvans in a solar year.

Comparative Objects

There is a difference in the operation of the rules given in verses 12 and 13. The author of Vedaanga wants to compress the total journey of the Sun in a Solar year by providing verse 12. The total journey of the Sun in a solar year is equal to (24.8 × 135 =) = 3348 Bh⁰. He creates a redeeming feature in calling 134 2/3 Bh⁰ in 21 parvans as 135 Bh⁰. The total path of the Sun is thus compressed to 3341 Bh⁰ though we call it as 3348 Bh⁰. The net result is that the Sun travels 27 nakshatras in 365 2/9 days, instead of 366 days. The total number of 372 tithis also gets reduced and adjusted in 365 2/9 days. The author of Vedaanga then provides verse 13 to remove the effect of contraction of the total time in respect of tithis, which is caused by RVJ 12. He makes the tithi of the 15th syzygy longer by 461 17/62 kalaas (7 Bh⁰). We further add 132 kalaas (2 Bh⁰) to the last tithi of the solar year so that 371 tithis are adjusted in 365 2/9 days.

Zero Error at the Beginning of a Yuga

The last step given by Lagadha for harmonising the calendar with actual astronomical position of the Sun and the moon is in RVJ 34 (चतुर्दशीमुपवसथस्तथा). Here the great sage tells us to watch the position of the moon before the dawn of the last day of the last month Pausha of a 19-year yuga. It is a day of krshna chaturdashee (end of the 29th tithi). The moon is just above the rising Sun in the east when the day dawns, it moves with the Sun forming a new-moon day. All minor defects in Bha-amshas, naadikaas and Kalaas come to the zero point. This event may also occur a day earlier or a day later than the calculated day due to the difference of time accumulated at a very minute rate. It has to be corrected.

चतुर्दशीमुपवसथस्तथा भवेद् यथोदितो दिनमुपैति चंद्रमाः ।
माघशुक्लाह्निको युंक्ते श्रविष्ठायां च वार्षिकीम् ।। RVJ. 34

In the first line Lagadha describes the last day of the month of Pausha to be fixed by observation. In the second line he gives the description of the astronomical position of the Sun and the Moon on the next day i.e. the first day of the month of Maagha of the new Yuga.

"On the (Krshna) chaturdashee day when the moon is found just above the rising Sun (उपवसथ), then as the day dawns, presume that it is with (उपैति) the Sun (indicating the new-moon day). The year (thereafter) begins (on the next day) with shukla paksha, the Sun and the moon in *Shravishthaa* (nakshatra)"

The first line gives description of the Moon 12^0 behind the zero point of the month, while the second line gives the description of the Sun and the moon at the zero point.

NOTE : In the scheme of R@g Jyotisha calendar, a yuga begins after 15 tithis from the aforementioned day of astronomical observation i.e. on Maagha shukla paurnimaa. For further details please see the chapter on Antiquity.

CHAPTER - 9
Preparation of Calendars.

In Vedaanga an intecalary month is called Raashi (see RVJ 4 and 24). Winter solstice divides the first lunar month Maagha in two parts. The former part gradually grows year by year and gets converted into an intercalary month. It is therefore called *raashi vibhaaga.* A winter solstice indicates a zero position of nakshatras and Bh^0 and it is the beginning of the first solar semester. If we want to prepare 19 calendars, we need to know the zero position of tithis and the latter fraction of the month of Maagha. The latter fraction of the month of Maagha forms the base at the zero position of the next year. RVJ 24 reads as under :

इत्युपायसमुद्देशो भूयोप्येनं प्रकल्पयेत्।
ज्ञेयराशिं गताभ्यस्तान्विभजेज्ज्ञानराशिषु।।२४।।

"With these aims and means by process of repetitions derive the unknown fraction of raashi from the known portion of the raashi". When we want to make tables for parvan-nakshatra position of the Sun for a year, the latter raashi-vibhaaga is necessary. It forms a base at the zero point. When we prepare a solar calendar, we need the parvan position in tithis at the zero point of the year. When we prepare a lunar calendar we need the zero position of the Sun in nakshatras and Bh^0. RVJ 24 asks us to calculate it.

A similar mathematical operation is necessary at the summer solstice.

In the calendar of Lagadha tithis and lunar-months had more prominence than days and solar months. Each of the six seasons consisted of 62 tithis. The basic portion of the tithis at the zero point of the year would therefore indicate how much each season is advanced in the calendar of a given year. For example in the 10th year of the yuga (See Table No. 2) we have a base of 10 tithis. The spring season began in the first year of the yuga on the 3rd tithi of Chaitra, but in the 10th year it would begin on Chaitra shukla 13th. This is one of the reasons for calling the initial part of parvans at the zero point of the solar year as n@tushesha (balance of tithis for calculating the time of the beginning of seasons).

CHAPTER - 10
Kalaas and Naadikaas.

From table 5-A we get the positions of the Sun at the end of various parvans in nakshatras and Bh^0. The time of the entry of the Moon in current nakshatra may not be same as that of the Sun. The Moon moves faster than the Sun. The time of the entry of the moon in the current nakshatra is measured in days and kalaas from the beginning of the yuga. Before we do so, we should know some more time units. Let us know what are kalaas.

कला दश च विंशा स्याद् द्विमुहूर्तस्तु नाडिके।
द्वित्रिशस्तत्कलानां तु षद्शतीत्र्यधिकंभवेत् ।।१६

Meaning – Naadee = (10+1/20 kalaa)
Muhoorta = 2 naadees
1 day = 30 Muhoortas = 603 Kalaas

The following ratios of the time units are derived for recording the positions of the moon in the sky.

1 day = 603 kalaas.
1 tithi = 593 + 17/62 kalaas.

Time taken by the moon to cross one nakshatra is 610 kalaas.

Bhaadaana Kalaas.

There is a separate thumb rule provided in RVJ 21 for the purpose of calculating the time taken by the moon to cross a given number of nakshatras.

याः पर्वभादानकलास्तासु सप्तगुणां तिथिम्।
प्रक्षिपेत् कलासमूहस्तु विद्यादादानकीः कलाः।।RVJ-21

Let the number of nakshatras which the moon has to cross be R. Then the time required by the moon to cross R nakshatras.

$$= R \times 610 \text{ kalaas}$$
$$= R\ (603+7) \text{ kalaas}$$
$$= 603\ R + 7\ R = R \text{ days} + 7\ R \text{ kalaas.}$$

Table No. 6

Month	Sr.No. of the paksha	Sr.No. of last lunar nakshatra	Lunar Bh°	Bham-shaashtaka	Kalaas of a previous day	Oonasthane Udwaped	Dwisapta-teeh na Sammita
	1	2	3	4	5	6	7
Maagha	1	14	73	9 1/8		171-73	98
Maagha	2	29	22	2 6/8	603+	38-438	203
Phaalguna	3	43	95	11 7/8	603+	209-511	309
Phaalguna	4	58	44	5 4/8	603+	95-292	406
Chaitra	5	72	117	14 5/8	603+	266-365	504
Chaitra	6	87	66	8 2/8		152-146	6
Vaishaakha	7	102	15	1 7/8	603+	19-511	111
Vaishaakha	8	116	88	11		209	209
Jyeshtha	9	131	37	4 5/8	603+	76-365	314
Jyeshtha	10	145	110	13 6/8	603+	247-438	412
Aashaadha	11	160	59	7 3/8	603+	133-219	517
Aashaadha	12	175	8	1		19	19
Shraavana	13	189	81	10 1/8		190-73	117
Shraavana	14	204	30	3 6/8	603+	57-538	222
Bhaadrapada	15	218	103	12 7/8	603+	228-511	320
Bhaadrapada	16	223	52	6 4/5	603+	114-292	425
Aashvina	17	248	1	1/8	603+	−73	530
Aashvina	18	262	74	9 2/8		171-146	25
Kaartika	19	277	23	2 7/8	603+	38-511	130
Kaartika	20	291	96	12		228	228
Maarga-sheersha.	21	306	45	5 5/8	603+	95-365	333
Maarga-sheersha.	22	320	118	14 6/8	603+	266-438	431
Pausha	23	335	67	8 3/8	603+	152-219	536
Pausha	24	350	16	2		38	38
R@tushesha	12	361	99	12 3/8		228-219	9

Thus for crossing 9 nakshatras the moon would require 9 days and 63 kalaas. These surplus kalaas are called Bhaadaana kalas.

To calculate the time of the entry of the moon in the current nakshatra, Vedaanga provides the last quarter of verse 10 and 11.

The first step to make these calculations is to find out the total number of nakshatras, which the moon has crossed at the end of a particular parvan from the beginning of the yuga. Let us begin with the end of the first pervan.

शुक्लेर्धं चैन्दवा यदि

We have a full moon at the end of the first parvan. On full-moon day,the moon is diametrically opposite to the Sun i.e. 27/2 = $13^1/_2$ nakshatras (13N + 62 Bh^0) + (N + 11 Bh^0) = 14 N + 73 Bh^0 (See Table No. 5-A. column No. 7). At the end of 2 parvans, we have the moon's journey = 2 (14 N + 73 Bh^0) = 29 N + 22 Bh^0. We find here that the total exceeds 124 Bh^0. We have therefore an additional nakshatra. Thus when we compare the Sun's journey with the moon's journey only for bha-amshas (ignoring the nakshatra portions i.e. column 4 with column 7), we get additional 62 $\overline{Bh}^0$ at the end of an odd number of parvans i.e. on full-moon days. These 62^0 are equal to a segment of half nakshatra. This is what is stated in a few words in the last quarter verse 10 शुक्लेर्धं चैन्दवा यदि.

When we divide the entries in column 6 of Table 5-A by 27, we get the number of complete rounds made by the moon in stars. From the remainder number (column 8) we get the name of the nakshatra which the moon occupies at the end of each parvan.

Bhaadaana Kalaas at the End of Parvans

Now we turn to RVJ 11

कार्यभांशाष्टकास्थाने कला एकान्नविंशतिः ।
ऊनस्थाने द्विसप्ततीः उद्वपेदूनसंमिताः ।।११ ।।

Just as Vadaanga provides verse 10 for finding out the angular position of the Sun at the end of each parvan, it provides verse 11 (equal to YVJ 19) for calculating the time of the entry of the moon in the last nakshatra on the relevant day at the end of various parvans. Tilak has explained from elementary principles how to calculate these Bhaadaana Kalaas.

The Sun takes $13^5/_9$ days to traverse one nakshatra, while the moon takes 1 day and 7 kalaas to traverse a nakshatra. We know that in one paksha the moon traverses an angular distance equal to

14 N 73 Bh^0. Out of these 14 nakshatras are travelled by the moon in 14 × (days + 7 kalaas) = 14 days + 98 kalaas. We are therefore required first to calculate the number of complete nakshatras, which the moon has crossed at the end of each parvan, and then multiply the number by 7 to get the total number of kalaas. Thus at the end of the 16th parvan (see table 6), the moon (after completing various rounds of 27 nakshatras each) is noted to have crossed in total 233 nakshatras from the beginning of the yuga. That means 233 days + 233 × 7 kalaas are taken by the moon to reach the end of the 233rd nakshatra, which are equal to 235 days and 425 kalaas. Presume that the day began at mean time of Sun-rise in the morning (6 AM) then, on 236th day the moon entered the 234th nakshatra after a lapse of 425 kalaas after Sun-rise at the end of the 16th parvan.

In RVJ 11 the Vedic sage has tried to give a thumb rule to calculate the Bhaadaana kalaas at the end of a given number of parvans. To explain the thumb rule, Tilak was required to use three verses viz. 11, 12 and 13 with a number of mathematical operations, so that it can not be called a thumb rule.

Prof. T.S. Kupanna Sastri has given a consistant explanation of this verse. I am giving it in my own words. (Please see table 6 when we read the explanation).

Meaning of Verse 11

"Substitute 19 kalaas for every group of 8 Bh^0 (Bhaamshas) in a table prepared for solar position. Then subtract 72 times the remainder Bh^0 (when the remainder occurs) along with the remainder Bh^0."

The words द्विसप्तती: उद्वपेद् ऊनसंहिता: are explained by Tilak as "72 times the remainder along with the remainder" ultimately meaning "73 times the remainder". The words are interpreted by him as "at odd places", while Prof. Kuppanna Sastri interprets them as "on the negative side". The verse will now mean "Substitute 19 kalaas for every group of 8 Bh^0. Then subtract Kalaas equal to 73 times for the remainder of Bh^0". The meaning would be clear from the following examples -

Example : Calculate the time in kalaas of the moon's entry on a new moon tithi at the end of the 6th parvan.

We have 66 Bh^0 in the moon's position at the end of the 6th parvan (See table No. 6 C Col. 3). Let us convert these into octads $66 \div 8 = 8^2/_8$. We have 8 octads and 2 Bh^0 as remainder. When we apply the rule of verse 11, we have (8×19−2×73) kalaas. That is the time of day of the moon to transit from one nakshatra to the other. It is equal to (152−146) = 6 kalaas (see col. 7).

Example–2 : Calculate the time in kalaas of the moon's entry in the new-moon position at the end of the 4th parvan. We have 44^0 at the end of 4th parvan $44 \div 8 = 5^4/_8$ (5 octads and 4 Bh^0). Required kalaas are therefore $(19\times5-4\times73) = 95-292$ kalaas. The answer may turn negative. We therefore require kalaas from earlier day. Hence (603 + 95 − 292) = 406 kalaas.

In Prof. Kuppanna Sastri's method, we do not get the number of days that have lapsed from the beginning of yuga, which can be independently found by using the formula.

Number of days = 61/62 number of tithis.

PART -IV
CHAPTER - 11

A Puzzling verse

There can be an objection to the 19-year cycle theory of a Vedic yuga. Verse 32 states as under -

माघशुक्लप्रवृत्तस्तु पौषकृष्णसमापिनः ।
युगस्य पञ्चवर्षस्य कालज्ञानं प्रचक्षते ।।RVJ 32

"We have the knowledge of a 5-year (cycle of a) yuga which begins with a bright fortnight of the month **Maagha** and ends with the dark fortnight of the month of Pausha".

But S. B. Dixit states in **his book** in a paragraph in the chapter on Vedaanga that in Bhatt**otpal's** commentary the second line reads युगस्य पंचमस्येह कालज्ञानं निबोधत **which** means that there are 5 yugas, out of which the last **one, that** is the 5th (पंचमस्येह) is explained (निबोधत). We find from table 2 that there are 5 sub-yugas in a chain of 19 years. All these sub-yugas begin with a samvatsara. The 5th sub-yuga consists of five years in its proper order. This itself shows that the chain is bigger than five years. If I am given an option to suggest a correction, I would do it as युगस्य पञ्चकस्येह which would mean a "Pentad of yugas". This needs no addition of a word not mentioned in the original text, like वर्ष, a year, which is subsequently included in पञ्चवर्षस्य.

Here we end with our 19-year cycle theory in respect of the R@g Jyotisha.

The Distinguishing Features

Western Orientalists of the 19th century tried to collect an authentic version of both the texts of Vedaanga-Jyotisha i.e. the R@k text as well as the yajus text with the help of Indian Brahmins. The Yajus text was available in Somaakara's commentary dating back to the 8th Century A.D. Indian Brahmins were reciting the R@k text meticulously as a part of their religious discipline. S. B. Dixit says that there was uniformity in the pronunciation of the text throughout India. Any effort to suggest a change was opposed by the Brahmins.

Scholars were trying to interpret both the texts on the basis of a 5-year astronomical cycle. They were doing so till 1985. The Yajus text is definitely based on a 5-year luni-solar cycle. As a consequence a number of modifications were suggested in the R@k text. Moreover, when such an interpretation could not explain the actual astronomical positions and speed of the Sun and the moon, they said that the text is distorted due to passage of thousands of years from its composition and some verses from the original text might be missing.

Now when we examine the distinguishing features between the R@k text and the Yajus text, we find that the R@k text is based on a 19-year astronomical cycle. Following are the important features of the R@k cycle.

(a) In RVJ 4 the words ardha-abdam (अर्धाब्दं) need not be changed as abhyastam (अभ्यस्तं) and the word samjnikam (संज्ञिकं) need not be read as samyutam (संयुतं).

(b) In RVJ 8 all scholars have suggested to read the first word as prathaman (प्रथमं) in place of the word (द्विगुणं) i.e. to read "one" in place of "two", which is a drastic change. Such a change need not be made, if we look to the R@k text from an angle of a 19-year cycle and treat the numbers representing kara<u>n</u>as i.e. (half-tithis).

(c) The word *r@tau* occurs at the end of RVJ 8 and RVJ 9 and RVJ 19. It can be consistantly explained as r@tushe<u>sh</u>a.

(d) The words *bahulepyr@tau* at the end of RVJ 8 have not been properly explained so far. They mean "additional r@tushe<u>sh</u>a (after these tithis)". This compels us to treat the tithis as limits defining the five types of years. Once we treat them as limits, the astronomical cycle must necessarily consist of 19 years. It is worth while to mention here that if we treat the r@tushe<u>sh</u>a as 12 tithis per year, we have a 5-year cycle, and when we treat it as 11 tithis per year, we have a 19-year cycle. This line of mathematical distinction is very narrow.

Our concept of the tithis given in RVJ 8 as limiting tithis of the beginnings of the semesters in stead of fixed tithi changes the r@tushe<u>sh</u>a from 12 tithis to 11 tithis.

(e) If we consider the object of providing some verses in the R@k text, the arrangement appears to be parallel with respect to the tithis and nak<u>sh</u>atras. The arrangement is as follows :-

S.No.	Object	Tithis	Nakshatras
1.	Specifying limits of beginning of semesters.	RVJ 8	RVJ 9
2.	Specifying r@tushesha	RVJ 4 (11 tithis)	RVJ 19 & 14 (10 nakshatras)
3.	Comparison of parvan with tithis and nakshatras	RVJ 23 (half tithi)	RVJ 10 (11 Bh^0)
4.	Converting hypothetical year of 366 days into an actual year of $365^{1}/_{4}$ days; Corrections are in tithis a nakshatras.	RVJ 13 & 20	RVJ 12

Such a comparison reveals us the object of RVJ 13 (पक्षात्पञ्चदशाच्चोर्ध्वं) and RVJ 19 (श्रविष्ठाभ्यां गुणाभ्यस्तान्). These verses are not found in Yajus text. R@g Jyotisham being based on the 19-year cycle, their incorporation is necessary in it.

(f) No proper explanation can be given for including RVJ 14 (commonly called Javaadi series) in the R@k text. Tilak and Prof. T.S.K. Sastri explain it with the help of YVJ 20 (तिथिमेकादश) but the *R@k paatha* does not provide any verse equivalent to YVJ 20. The purpose of RVJ 14 becomes clear when we read it with RVJ 19 (श्रविष्ठाभ्यां) in the context of 19 year cycle.

(g) Scholars have suggested a change in the 2nd line of RVJ 19. They suggest to read the words सूर्यान् मासान् as स्वार्क्षान्मासान् or स्तर्यान् मासान्. Such a change is not necessary, when we explain the verse on the basis of a 19-year cycle. These words in RVJ 19 are similar to the words अर्धाब्दं in the first line of RVJ 4. The purpose of these verses being similar, the meaning becomes clear when we note the purpose.

(h) Lok Tilak proceeds to explain RVJ 12 (त्र्यंशीभशेषो) saying that its purpose is to give an easier thumb rule to calculate the kalaas at the entry of the moon in various nakshatras from the sunrise on the relevant day, which we get from table 6. Prof. T.S.K. Sastri has pointed out that the object given by Tilak is superfluous. RVJ 11 is a complete and precise rule for that purpose. Prof. T.S.K. Sastri himself uses the rule to find out the sidereal positions of the

Sun, but even for that purpose RVJ 10 (भांशाः स्युरष्टकाः) is sufficient. We have seen that by the use of RVJ 12 a year consisting of 366 days is reduced to that of 365¼ days. This indicates that the astronomical cycle in the R@k text is of 19-years.

These are the glaring and important points among others, which lead us to conclude that the basis of R@g Jyotisha is a 19-year luni-solar cycle.

CHAPTER - 12

Utility And Accuracy

Modern civilisation has based the time units on two astronomical motions (excluding atomic watches). They are the rotation of the earth around its axis (i.e. a day) and its revolution around the Sun (i.e. an year). Hindus use other astronomical motions, including the precession of equinox to reckon historical time. A 19-year luni-solar cycle can also be an aid to fix historical time.

It is mentioned in the Mahaabhaarata that Bheeshmachaarya expired on a day of winter solstice. The author has also mentioned the tithi and the relevant paksha (see Anushaasana parva 167-27, 28). All scholars, excepting Prof. G.V. Kaveeshvar, on interpreting these verses say that Bheeshma died on Maagha Sh 8 on a Rohinee day (i.e. Aldeberon day). From tables 2 and 5, we find that it is the first day in the 18th year in the Yuga. The year is called Anuvatsara. A simile of a telescope is best suited for explaining the Hindu method of finding our historical time. We first use a finder telescope to locate an astronomical object, and then we use the main telescope to get the details of the object. In searching an historical event, we have (i) the sidereal position of the winter solstice and (ii) the sidereal position of the planets as the first and broad means. For finer details we have a 19-year luni-solar cycle in Vedaanga as our means. In the given example, once the year (in a 19-year Cycle) and the tithi of expiry of Bheeshma is fixed, we can verify the validity of other tithis or dates given in the Mahaabhaarata.

Prof. G. V. Kaveeshvar interprests the relevant verses and says that Bheeshma died on Maagha Sh 15th (Paurnimaa) on a day of winter solstice. If his version is correct, the relavant date is the first day of the 5th year in the cycle i.e. a parivatsara (please see tables 2 and 5). In such a case, the position of intercalary months would be different. Facts can be verified from other tithis given in the Mahaabhaarata.

Thus the luni-solar calendar with sidereal base has one more advantage. The months and the seasons revolve along with the precession cycle of 26000 years. It is therefore useful for finding out the time of historical events. We have used such method in the latter part of this book to find out the antiquities of Vedaanga.

From tables 2 and 3, we find a remarkable accuracy in finding out the tithis on the day of winter-solstice. The tithis in table 1 are taken from the Government of India calendar issued by the Positional Astronomy Centre. In 19 solar years there are 235 lunar months. This cycle of lunar months lags behind by 4 Hrs. 23 Mts. 1.82 sec. in 19 solar years. In RVJ 34 sage Lagadha has provided a visual method to correct the accumulated difference when it amounts to one tithi after a few cycles.

We thus fix the antiquity of historical events in two stages : (i) to fix a broad span by the method of precession and (ii) to find out accurate day within a period of 19 years by Vedaanga method, Prof. Srinivas Raghavan, Sampat Ayyengar and the author of this book are of opinion that during the Mahaabhaarata period people used to reckon an intercalary month just before vernal and autumnal equinox days while we find in the text which we are studying, the intercalary months are reckoned before winter and summer solstices. In the former case we would require to revise our table for fixing the antiquity of the Mahaabharata. The author of this book also thinks that the tithi and nakshtra system was different and much simpler during the Mahaabhaarata period. It is not our main subject of explanation. It is mentioned here for explaining the utility of the Vedaanga.

CHAPTER - 13

Translation Of The R@k Text

One of the objects of writing this book is to prove that the basis of R@k text of Vedaanga Jyotisha is 19-year luni-solar cycle. It is therefore necessary to give translation of the complete text to demonstrate that there is nothing repugnant to our theory in the verses which are not so far explained. Most of the verses in the text are in the nature of mathematical formulii. In Sanskrit there is a peculiar style of writing mathematical formulae. A literal translation of such verse in English would be meaningless. Insertion of some supplimentary words in the translation of the verse and some explanatory notes are necessary. I have given explanatory notes for the verses which are not so far explained. It is worthy to mention here that Lok. Tilak, S.B. Dixit and Prof. T.S. Kuppanna Sastri have also inserted such supplimentary words in their translations wherever they thought it necessary.

RVJ. – 1

Oh, *Prajapati*, thou art the lord of cycles *yuga* consisting of five *samvatsaras.* Your organs are days, seasons, semesters and months. I bow before thee with bent head and pure mind.

RVJ. – 2

Having saluted time, I bow with bent head before samvatsara. I explain the knowledge of time as narrated by the great sage *Lagadha.*

RVJ. – 3

I explain the movements of the luminaries of the heaven (the Sun and the moon) as they are known to the people from the past and (mathematically) known to the priests ready for performing sacrifices.

RVJ. – 4

Subtract one (kara<u>na</u>) from twelve (kara<u>na</u>s) per half year (*ardhaabdam*). Assume two (kara<u>na</u>s) for previous (yuga). Make the total. Group of two parvans consisting of sixty *karanas* each clubbed together are called RAASHIS i.e. inter-calary months (*adhika maasa*).

RVJ. – 5

When the Sun and the moon are on both sides (with the Sun) at *Vaasava nakshatra* in the heaven, the cycle begins with full moon day in Maagha month in Winter season.

RVJ. – 6

The (astronomical events that the) Sun arising at the beginning of *Shravishthaa* and the Sun reaching at the mid-point of *Aashleshaa* in the south indicate the rising (beginnings) of the months of (चान्द्रमसावुदक्) *Maagha* and *Shraavana* respectively.

RVJ. - 7

When the Sun moves up (Northward), sweat increases and also increases the length of the day by *kshapaa* measure of water. During southward course, there is reverse action. The difference in the length of the extreme days is six *muhoortas.*

RVJ. - 8

Years can be deivided into five classes according to the beginnings of *ayanas* (semesters of solar years). Such beginnings of the ayanas fall in *shalahas* which begin with (i) 1st tithi (ii) 7th tithi (iii) 13th tithi of bright fortnight and (iv) 4th tithi (v) 10th tithi of the dark fortnight.

RVJ. - 9

"Those *nakshatras* whose lords are *Vasu, Tvashtaa, Bhaga, Aja, Mitra, Sarpa, Ashvini, Jala, Dhaataa and Brahmaa* (i.e. Dhanisthaa– Chitraa, Aardraa, Poorvaa Bhaadrapadaa, Anuraadhaa, Aashleshaa, Aashvayujaa, Poorvaashaadhaa, Uttaraa-Phalgunee and Rohinee), were at the beginnings of the segments of the ecliptic as lunar nakshatras which classify the ayanas (solar semesters). They form a half-part of the five divisions of *r@tushesha* in terms of nakshatras.

RVJ. - 10

In a group of 12 *pakshas* 8 *bha-amshas* arise. For the remainder (i.e. less than 12 pakshas) 11 bha-amshas (per paksha) arise. When you calculate lunar bha-amshas for a parvan ending in a full moon day, add bhaamshas equal to a half-nakshatra i.e. 62 Bh^0.

RVJ. - 11

Substitute 19 kalaas for every group of 8 Bh^0 (bha-amshas) in a table prepared for solar-positions. Then subtract 72 times the remainder Bh^0 (when the remainder occurs) along with the remainder Bh^0.

RVJ. - 12

Destroy a portion of a day equivalent to one third of bha-amsha (22 Kalaas) adjoining (every) 14th tithi in a parvan. Ignore (अवेद्य) from this process two such *avakas* that follow half of the advancement (of the Sun) in nakshatras (i.e. Summer-solstice).

RVJ. – 13

On the top side of the 15th paksha (in the solar clock of an year) when nine bha-amshas arise, record them used (as a tithi) except two of them so added.

RVJ. – 14

Note : If we rearrange the list of nakshtras by skipping over five nakshtras every time and indicate them by symbols we get verse 14, जौद्राघः खेश्वे हीरोषाचिन्मुषण्यः

RVJ. – 15

"Know that Javaadi list (RVJ 14 जौद्राघः) is balanced. Former (letter) is for the lunar nakshatra at the beginning of the first half-year; the latter is for the latter half. Bha-amshas and bhaadaana kalaas are to be adjusted at the ends of 14th tithis (for computing the exact number of days in solar years).

Note :- The last quarter of this verse is काष्ठानांदेविनाकलाः The text is thousands of years old. This portion of the text is in the then current Sanskrit language. We can only guess and tell the meaning of this portion. It may be "the last bha-amsha of the solar year (measured in kaashthaas) leaves no fraction which can be measured in *kalaas.*

RVJ. – 16

(The time measure) *naadikaa* is equal to ten plus one-twentieth *kalaas* (10 +1/20). Two *naadikaas* make one *muhoorta.* Thirty *muhoortas* or twice the number (30×2 i.e. sixty) *naadikaas* make a day which is equal to 603 *kalaas.*

RVJ. – 17

A *muhoorta* is equal to two *naadikaas.* An *aadhaka,* a measure of volume, is equal to 50 *palas.* A *drona* is equal to 4 *aadhakas.* A *drona* exceeds one *naadikaa* by three *kutapas.*

Note : The words माषकात् कुम्भको द्रोणः do not give any proper meaning, but on the contrary have a missing link. S. B. Dixit quotes Bhattotpala चतुर्भिः आढकैः द्रोणः and Bhaaskaraachaarya has also said that 4 aadhakaas are equal to one drona. S. B. Dixit has further found from YUJ 24 that when 3 kutapas of water is removed from drona and the remainder is allowed to pass through a water clock, it takes time equal to one naadikaa.

RVJ. - 18

When the moon moves through one nak<u>sh</u>atra, it takes seven (kalaas) more than a day and when the Sun moves through a nak<u>sh</u>atra it takes 13⁵/₉ days.

The last quarter of this verse is काष्ठा पञ्चाक्षराः स्मृताः. The two units of time kaashthaa and akshara are not now known. they cannot be explained by a comparison with a known unit of time.

RVJ. - 19

If we break the (chain of) the nak<u>sh</u>tras, (a nak<u>sh</u>atra) before Shravi<u>sh</u><u>th</u>aa and repeat (Javaadi) multiplications, we observe a r@tushe<u>sh</u>a in lunar nak<u>sh</u>atra at the intervals of six solar months.

RVJ. - 20

Make correction for extending the parvan-portion to (avoid) the error of doubling tithis at the point of the circle where the Sun becomes steady (on the day of solstice).

RVJ. - 21

Multiply the total number of nak<u>sh</u>atras travelled by the moon in a given number of parvans by seven; you get the difference of time in kalaas between the total number of nakshatras and the number of days that have passed. Know that these kalaas obtained by transformation are called Bhaadaana Kalaas.

RVJ. - 22

The length of a given day (excluding night) is equal to the number of days that have lapsed from the beginning of the northward course of the Sun, or the number of days which are required to complete the southward course, multiplied by 2 and devided by 61 plus 12 (muhoortaas).

Explanation : A day consists of 30 muhoortaas. The night in Vedaanga was 18 muhoortaas on the day of winter solstice; the day was 12 muhoortaas long. (See verse 7). The year roughly consists of 366 days; therefore after a lapse of a half-year i.e. 183 days, the lengths of days and night are in reverse position. The average rate of change of the length of the day was therefore 6/186 = 2/61 muhoortas per day. The minimum length of the day was 12 muhoortas.

Example : Find out the length of the 13th day after winter-solstice.

Length of the day = $13 \times 2/61 + 12$
= $12 + 26/61$ muhoortas

RVJ. – 23

A solar half month is greater than a parvan by a half-tithi; it consists of $15^1/_2$ tithis. Make a total of half-tithis per parvan. Know that the sum stands in the account of r@tushesha.

Note : The rule given in this verse has to be read with rule in RVJ 4, and RVJ 20, because we deduct half-tithis per dozen of parvans from the total r@tushesha.

RVJ. – 24

With these aims and means, by process of repetitions derive the unknown fraction of raashi (adhika maasa) from the known portion of the raashi. (for preparing a calandar of a given year.)

RVJ. – 25

Deities : The presiding deities of the 27 nakshatras in serial order are–

Agni, Prajaapati, Soma, Rudra, Aditi, Br@haspati, Sarpa, Pitr@s, Bhaga, Aryamaa,

RVJ. – 26

Savitaa, Tvashtaa, Vayu, Indraagnee, Mitra, Indra, Nirr@ti, Aapa, Vishvedevas,

RVJ. – 27

Vishnu, Vasu, Varuna, Ajaikapaat, Ahirbudhnya, Pooshaa, Ashvini and Yama.

RVJ. – 28

These are the deities of the nakshatras. Remember the name of the deity which presides over the birth-nakshatra of the person on whose behalf a sacrifice (or a religious rite) is to be performed, while making a sankalpa (or resolution) to begin a religious ceremony.

Note : A birth-nakshatra means the nakshatra position of the moon at the time of the birth of a person.

RVJ. – 29

This is what sage Lagadha spoke about the lunar months, years, muhoortas, the risings, the parvans (syzygies), the days, the seasons, the ayanas (i.e. both the courses of the Sun) consisting of solar months.

RVJ. - 30

There are three types of motions of the Sun and the moon in the heaven (लोक) known to the common people (लोक). There are three types of motions of the Sun and the Moon (mathematically) analysed by the learned people.

RVJ. - 31

Note : The rule enunciated in this verse is meant for calculating the number of parvans that have passed from the beginning of the yuga if a serial number of a vishuvan is known. It also gives the tithi of the vishuvan.

"Double the serial number of the vishuvan or subtract one from the product. Multiply by six the number so obtained. We get the number of parvans passed over. Divide the number of parvans so obtained by two, we get the tithis. (Saparate complete number of parvans from the tithis so obtained, the residue is meant for the tithi of the vishuvan. We have to modify the number, so obtained by using RVJ 20 and RVJ 4).

RVJ. - 32

We have knowledge of a 5-year cycle yuga which begins with a bright fortnight of the month Maagha and ends with the dark fortnight of Pausha.

Note : In Bhattotpala's commentary we find the words पञ्चमस्येह for the word पञ्च वर्षाणि in the present text. These words make a difference in the nature of the cycle (see commentary).

RVJ. - 33

Years can be divided in five classes according to the shalaha in which the vishuvan (equinox) occurs. The first tithi of such shalahas are (i) tr@teeyaa (3rd of bright fortnight), (ii) Paurnimaa (full moon-day), (iv) shashthee (6th of dark fortnight) and (v) dvaadashee (12th of dark fortnight).

Note : This verse is similar to RVJ 8.

RVJ. - 34

On the (kr@shna) chaturdashee day (i.e. 29th tithi of a lunation) when the moon is found just above the rising Sun (उपैति), then as the day dawns, presume that it is with (उपवसथ) the Sun (indicating a new-moon day). The year (thereafter) begins (on the next day) with shukla paksha, with the Sun and the moon in Shravishthaa (nakshatra).

Note : At this point of time, solar bhaamshas and lunar kalaas are presumed to be zero. There is an implied mandate in the verse to observe the moon on kr@shna chaturdashee just before the next day dawns for next cycle of 19-year yuga to begin. This assures the removal of one day's difference, which may occur at the end of 76 years (i.e. four 19-year cycles). The yuga in R@g Jyotisha begins 15 tithis hereafter on a full-moon day. The Sun used to be at winter-solstice on such Pournimaa (see chapter on antiquity).

RVJ. - 35

Like the comb of the head of a peacock or a jewel on the hood of a snake, this scientific composition of Jyotisha (Vedic astronomy) occupies the position at the top of all (six) annexures of *Vedas.*

RVJ. - 36

The Vedas are revealed (to the sages) for the purpose of performing sacrifices. They are to be performed according to a predetermined time-table. It is the knowledge of these scientific rules of time which a sacrificer must possess.

PART - V

याजुषज्योतिषम् (YUJ)

अथ ,याजुषज्योतिषं प्रारभ्यते।
पञ्चसंवत्सरमयं युगाध्यक्षं प्रजापतिम्।
दिनर्त्वयनमासाङ्गं प्रणम्य शिरसा शुचिः।।१
ज्योतिषामयनं पुण्यं प्रवक्ष्याम्यनुपूर्वशः।
संमतं ब्राह्मणेन्द्राणां यज्ञकालार्थसिद्धये।।२
वेदा हि यज्ञार्थमभिप्रवृत्ताः
कालानुपूर्व्या विहिताश्च यज्ञाः।
तस्मादिदं कालविधानशास्त्रं
यो ज्योतिषं वेद स वेद यज्ञम्।।३
यथा शिखा मयूराणां नागानां मणयो यथा।
तद्वद् वेदाङ्गशास्त्राणां गणितं मूर्धनि स्थितम्।।४
[ये बृहस्पतिना भुक्ता मीनान्प्रभृति राशयः।
त्रिवृताः पञ्चभिर्भ्रृता यः शेषः स परिग्रहः।।४-०]
माघशुक्लप्रपन्नस्य पौषकृष्णसमापिनः।
युगस्य पञ्चवर्षस्य कालज्ञानं प्रचक्षते।।५

स्वराक्रमेते सोमार्कौ यदा साकं सवासवौ।
स्यात् तदादि युगं माघस्तपः शुक्लोऽयनं ह्युदक्।।६
प्रपद्येते श्रविष्ठादौ सूर्याचन्द्रमसावुदक्।
सार्पार्धे दक्षिणार्कस्तु माघश्रावणयोः सदा।।७
धर्मवृद्धिरपां प्रस्थः क्षपाह्रास उदग्गतौ।
दक्षिणे तौ विपर्यस्तौ षण्मुहूर्त्ययनेन तु।।८
प्रथमं सप्तमं चाहुरयनाद्यं त्रयोदशम्।
चतुर्थं दशमं चैव द्विर्युग्माद्यं बहुलेऽप्यृतौ।।९
वसुस्त्वष्टा भवोऽजश्च मित्रः सर्पोऽश्विनौ जलम्।
धाता कश्चायनाद्याः स्युरर्धपञ्चमभस्त्वृतुः।।१०

एकान्तरेऽह्नि मासे च पूर्वान् कृत्वादिरुत्तरः।
अर्धयोः पञ्चपर्वाणां मृदू पञ्चदशाष्टमौ।।११

दुहेयं पर्व चेत् पादे पादस्त्रिंशत्तु सैकिका।
भागात्मनापवृज्यांशां निर्दिशेंशोऽधिको यदि।।१२
निरेकं द्वादशाभ्यस्तं द्विगुणं गतसंयुतम्।
षष्ट्या षष्ट्या युतं द्वाभ्यां पर्वणां राशिरुच्यते।।१३
स्युः पदोऽर्धं त्रिपाद्या या त्रिदव्यैकेऽह्नः कृते स्थितिम्।
साम्येनेन्दोः स्तृणोऽन्येषु पर्वकाः पञ्चसंमिताः।।१४
भांशाः स्युरष्टकाः कार्याः पक्षा द्वादशकोद्गताः।
एकादशगुणश्चोनः शुक्लेऽर्धं चैन्दवा यदि।।१५

नवकैरुद्गतोंऽशः स्यादूनः सप्तगुणो भवेत्।
आवापस्त्वयुजेऽर्धं स्यात्पौलस्त्येऽस्तंगतेऽपरम्।।१६
जावाद्यंशैः समं विद्यात् पूर्वार्धे पर्वसूत्तराः।
भादानं स्याच्चतुर्दश्यां द्विभागेभ्योऽधिको यदि।।१७
जौ द्रा गः खे श्वेऽही रो शा
चि(न्) मूषण्यः सू मा धा नः।
रे मृ घा स्वा ऽपो ऽजः कृ
ष्य ह ज्ये ष्ठा इत्यृक्षा लिङ्गैः।।१८
कार्या भांशाष्टकस्थाने कला एकान्नविंशतिः।
ऊनस्थाने द्विसप्ततिमुद्वपेद् युक्तसंभवे।।१९
तिथिमेकादशाभ्यस्तां पर्वभांशसमन्विताम्।
विभज्य भसमूहेन तिथिनक्षत्रमादिशेत्।।२०

याः पर्वभादानकलास्तासु सप्तगुणां तिथिम्।
उक्तास्तासां विजानीयात् तिथिभादानिकाः कलाः।।२१
अतीतपर्वभागेभ्यः शोधयेद् द्विगुणां तिथिम्।
तेषु मण्डलभागेषु तिथिनिष्ठां गतो रविः।।२२
विषुवन्तं द्विरभ्यस्तं रूपोनं षड्गुणीकृतम्।
पक्षा यदर्धं पक्षाणां तिथिः स विषुवान् स्मृतः।।२३

पलानि पञ्चाशदपां धृतानि
तदाढकं द्रोणमतः प्रमेयम्।
त्रिभिर्विहीनं कुडवैस्तु कार्यं
तन्नाडिकायास्तु भवेत्प्रमाणम्।।२४
एकादशभिरभ्यस्य पर्वाणि नवभिस्तिथिम्।
युगलब्धं सपर्व स्याद् वर्तमानार्कभक्रमात्।।२५

सूर्यर्क्षभागान्निवभिर्विभज्य
शेषं द्विरभ्यस्य दिनोपभुक्तिः।
तिथियुक्ता भुक्तिदिनेषु कालो
योगं दिनैकादशकेन तद् भम्।।२६
त्रियंशो भशेषो दिवसांशभागश्
चतुर्दशश्चाप्यनीयभिन्नम्।
भार्धेऽधिके चापि गते परोंऽशो
द्वावुत्तमे तन्नवकैरवेद्यम्।।२७
त्रिंशत्यह्नां सषट्षष्टिरब्दः षट् चर्तवोऽयने।
मासा द्वादश सूर्याः स्युरेतत् पञ्चगुणं युगम्।।२८
उदया वासवस्य स्युर्दिनराशिः स्वपञ्चकः।
ऋषेर्द्विषष्टिहीनं स्याद्विंशत्या चैकया स्तृणाम्।।२९
पञ्चत्रिंशं शतं पौष्णमेकोनमयनान्यृषेः।
पर्वणां स्याच्चतुष्पादी काष्ठानां चैव ताः कलाः।।३०

सावनेन्दुस्त्रिमासानां षष्टिश्चैका द्विसप्तिका।
द्वित्रिंशतम् सावनस्यार्धः सूर्यः स्तृणां स पर्ययः।।३१
अग्निः प्रजापतिः सोमो रुद्रोऽदितिर्बृहस्पतिः।
सर्पाश्च पितरश्चैव भगश्चैवाऽर्यमाऽपि च।।३२
सविता त्वष्टाऽथ वायुश्चेन्द्राग्नी मित्र एव च।
इन्द्रो निर्ऋतिरापो वै विश्वेदेवास्तथैव च।।३३
विष्णुर्वसवो वरुणोऽज एकपात् तथैव च।
अहिर्बुध्न्यस्तथा पूषा अश्विनौ यम एव च।।३४
नक्षत्रदेवता ह्येता एताभिर्यज्ञकर्मणि।
यजमानस्य शास्त्रज्ञैर्नाम नक्षत्रजं स्मृतम्।।३५

उग्राण्यार्द्रा च चित्रा च विशाखा श्रवणाऽश्वयुक्।
क्रूराणि तु मघा स्वातिर्ज्येष्ठा मूलं यमस्य यत्।।३६
द्व्यूनं द्विषष्टिभागेन हेयं सौर्यात् सपार्वणम्।
यत्कृतावुपयुज्येते मध्येऽन्तं चाधिमासकौ।।३७
कला दश सविंशा स्याद् द्वे मुहूर्तस्य नाडिके।
द्वित्रिंशत् तत्कलानां तु षट्छती त्र्यधिका भवेत्।।३८
ससप्तकं भयुक् सोमः सूर्यो द्यूनि त्रयोदश।
उत्तमानि तु पञ्चाह्नः काष्ठा पञ्चाक्षरा भवेत्।।३९

यदुत्तरस्यायनतो गतं स्याच्
छेषं तथा दक्षिणतोऽयनस्य।
तदेव षष्ट्या द्विगुणं द्विभक्तं
सद्वादशं स्याद् दिवसप्रमाणम्।।४०

यदर्धं दिनभागानां सदा पर्वणि पर्वणि।
ऋतुशेषं तु तद् विद्यात् संख्याय सह पर्वणाम्।।४१
इत्युपायसमुद्देशो भूयोऽप्यह्नः प्रकल्पयेत्।
ज्ञेयराशिगतान् व्यस्तान् विभजेज्ज्ञानराशिना।।४२
[इत्येवं मासवर्षाणां मुहूर्तोदयपर्वणाम्।
दिनर्त्वयनमासाङ्गं व्याख्यानं लगतोऽब्रवीत्।।४२-०]
सोमसूर्यस्त्रिचरितं विद्वान् वेदविदश्नुते।
सोयसूर्यस्त्रिचरितं लोकं लोके च संततिं
लोकं लोके च संततिम्।।४३

इति याजुषज्योतिषं समाप्तम्।।

CHAPTER - 14

Yajus - Jyotisham

We shall now turn to the Yajus recension of Vedaanga Jyotisha. Verses 28, 29, 30 and 31 inform us that the author of Yujus Jyotisha had in his mind elements of a 5-year yuga when he wrote these verses. Verse 31 reads as under :

> सावनेन्दुस्तृमासानां षष्टिः सैका द्विसप्तिका।
> द्युत्रिंशत् सावनः सार्धः सूर्यः स्तृणां सपर्ययः।।YVJ 31

"(In a Yuga) there are 61 Saavana months, 62 lunations and 67 sidereal months i.e. naakshatra maasas; 30 days make one Saavana-month and $30^1/_2$ days make one solar month. One revolution (of the moon) in stars (स्तृणां) is called a *naakashatra maasa.* This verse along with verse 4, tells us that after $2^1/_2$ solar years we have one adhika maasa and in a yuga of five years we have two adhika maasas. It shall not therefore be possible for us to find out any internal evidence in the Yajus text to show that the Yajus cycle was reasonably accurate, so that it could have been used as it is, at least for a century.

On this subject scholars have said that there might be some practice or custom observed by the Vedic priests to retune or readjust the luni-Solar cycle. Krishna Shastri Godbole thought that probably one adhika maasa was dropped at the end of 40 years. S. B. Dixit observed that there should have been a practice to count 35 adhika massas in 95 years instead of 38 adhika maasas. Prof. Kuppanna Sastri guessed that there must have been a practice to drop one intercalary month at the end of 6 yugas and subsequently one at the end of 7 yugas. This means two intercalary months might have been dropped in 65 years. When we think of any such practice, which is not included in the text itself, we have to investigate (i) some other literature which is of about the same age, which may help us to draw a proper conclusion. External aid is one of the acknowledged modes of interpretation. (ii) It is also necessary that the conclusion which we draw about any such custom or practice must be reasonable. (iii) If we try to implement such a practice along with the Yujus text, it should not show much deviation from the actual position of the Sun and the moon in the sky. If we follow these cannons of interpretation, we actually get at the solution.

Readers should imagine that we start with one such Yajus yuga on a winter-solstice, commencing from the 22nd of December with the first day of a lunation i.e. bright 1st day (Shukla Pratipadaa). We have now before us verse 9 (= RVJ 8) which gives us the tithis (lunar dates) of subsequent winter solstice days in a serial order. They are bright 7th, bright 13th, dark 4th and dark 10th. We also know that the actual solar year consists of 371 tithis, while the Yajus-year consists of 372 tithis. There is a difference of 1 tithi. A tithi being practically equal to a day, within 16 years, there will be a difference of 16 days. According to our calculations, a winter solstice would appear on 6th January, while it had actually occured on 22nd December. The Sun moves one nakshatra in 13+7/9 tithis. We will therefore wrongly presume that on 6th January the Sun is in its original place of nakshatra, where it was at the beginning of the yuga. It would be found to have advanced by one nakshatra. At the end of 28 years, the difference would be about 2 nakshatras. Thus in 30 years the calculated positions of the moon will also differ very much from the actual. Under these circumstances, what must have been the practice followed by the Vedic priests?

Dr. Daftari in his lectures delivered in Nagpur University in 1940 (and subsequently published in 1942) pointed out a verse from the Mahaabhaarata which would help us in finding out the practice in correcting the calendar occasionally.

क्षयं संवत्सराणां च मासानां च क्षयं तथा। शान्तिपर्व, ch. 301/46

'(By way of leap) drop years as well as months.'

Though Dr Daftari referred to this verse, he came to the same conclusion that there was a practice of dropping one intercalary month each at the end of the 6th and the 7th yugas alternately.

In this connection there are very important verses in the *Vaajasaneyi Samhitaa* and the *Taittireeya Braahmana*. They are cited by S. B. Dixit in his History of Ancient Indian Astronomy at its first chapter. In one such verse cited from Tait Bra 3-10-4, we have six names of lunar years.

संवत्सरोसि परिवत्सरोसि।
इदावत्सरोसि इदुवत्सरोसि इद्वत्सरोसि वत्सरोसि। तै. ब्रा.३-१०-४

(i) Samvatsara (ii) Parivatsara (iii) Idaavatsara (iv) Iduvatsara (v) Idvatsara (vi) Vatsara. Dixit further adds that Maadhavaacharya

TABLE No. 7

Sr. No.	Name of the year. 1	Total days 2	Total Tithis 3	Speciality 4	Solar day at the beginning of the Semester 5	Tithi at the beginning of the Semester 6	Nakshatra at the beginning of the Semester 7
1.	Samvatsara	366	372		Uttaraayana	Maagha Shukla 1	Shravishthaa
2.	Parivatsara	366	372		2nd day	--"-- 13	Punarvasu
3.	Idaavatsara	366	372	Additional month ($2^1/_2$)	3rd day	Maagha vadya 10	Jyeshthaa
4.	Anuvatsara	366	372		4th day	--"-- 7	Bharanee
5.	Idvatsara	366	372	Additional month ($2^1/_2$)	5th day	Maa. vad. 4	Hasta
6.	Sammidaa (संमिदा)	360	366	Saavana year	6th day	Maa. shu. 1	Shatataarakaa
7.	Anuvatsara	366	372		Uttaraayana	Maa. shu. 7	Bharanee
8.	Idvatsara	366	372	Additional month (3)	2nd day	Maa. vad. 4	Hasta
9.	Samvatsara	366	372		3rd day	Maa. shu. 1	Shatataarakaa
10.	Parivatsara	366	372		4th day	Maa. shu. 13	Pushya
11.	Idaavatsara	366	372	Additional month ($2^1/_2$)	5th day	Maa. vad. 10	Moola
12.	Anusama (अनुसम)	360	366	Saavana year	6th day	Maa. shu. 7	Krttikaa
13.	Parivatsara	366	372		Uttaraayana	Maa. shu. 13	Pushya
14.	Idaavatsara	366	372	Additional month (3)	2nd day	Maa vad. 10	Moola

1	2	3	4	5	6	7
15. Anuvatsara	366	372		3rd day	Maa. shu. 7	Krttikaa
16. Idvatsara	366	372	Additional month ($2^1/_2$)	4th day	Maa. vad. 4	Chitraa
17. Samvatsara	366	372		5th day	Maa. shu. 1	Poo' Bhaa
18. Paryanu (पर्यनु)	360	366	Saavana year	6th day	Maa. shu. 13	Aashleshaa
19. Idvatsara	366	372	Additional month (3)	Uttaraayana	Maa. vad. 4	Chitraa
20. New Yuga			Samvatsar	--"--	Maa. shu. 1	Shravishthaa

interprets the words Iduvatsara in this series as Anuvatsara. But we must know the meaning of the word *vatsara,* which is the sixth type of year? We get the answer, when we try to interpret Yajus cycle. With the aid of these two verses (i.e. the verses in the Mahaabhaarata and the Taittireeya Brahmaṉa), I think we can now explain the Yajus cycle.

Let us again start with our astronomical cycle on winter solstice on the Shukla Pratipadaa. At the end of five years, our calculated winter solstice will advance five tithis more than the real. Why not have the sixth year shorter than the usual year? If in the sixth year of the yuga, we reckon only 360 days (366 tithis) the cycle would be reajusted. The total number of tithis in a group of such six years would be (372×5+366=) 2226. The average would again be 371 tithis per year. It is well known that in ancient Indian astronomy, a year consisting of 360 days was called a Saavana year. In the 31st verse (cited supra) a Saavana month is defined. It consists of 30 days. In the R@k recension we do not find any reference of Saavana month or Saavana year. The reason is obvious that such a year was not necessary in the R@k calendar. Let us verify the results by treating a Saavana year as *vatsara* as part of the cycle as enlisted in Tait Bar 3-10-4. I have prepared table-7 by inserting Saavana year as the sixth year. Readers should note that there is a difference between R@g ayana (R@k Semester) and Yajus ayana (Yajus semester). Yajus ayanas are longer than R@g ayanas by a half-tithi. They begin on different tithis. Let us call a Yajus ayana which begins near winter solstice as vernal ayana (वसन्त अयन) and the one that begins near summer solstice as autumn ayana (शरद् अयनम्) of the year.

From table 7 we find that there is an addition of one tithi in the beginning of the subsequent year with respect to the position of the winter solstice. (see column 5) The date of the beginning of the Yajus solar year advances by 12 tithis per year (See column 6). Thus in place of Shukla 1st tithi in the subsequent year, we get Shukla 13th tithi. But in the 6th year we have only 366 tithis. The year therefore advances only by 6 tithis. As a result, the 7th year begins with shukla 7th. The name of the year is given according to the tithi at its beginning (see chart I). The seventh year is therefore called anuvatsara. It is worth while to note that the 6th year has a beginning like samvatsara (shukla 1st) and it ends like Idaavatsara on shukla 6th. For facility of narration I have named the year as Sammidaa. (संमिदा).

The effect of inserting a saavana year as the 6th year is th we have dropped parivatsara and idaavatsara after the 6th yea which would have been the 7th and the 8th year in the norm course. The name idaavatsara indicates that there should be a adhika maasa in the middle of the year i.e. before summer solstice When we say that we have dropped idaavatsara, we also say th we have dropped an adhika maasa. In this sense we have droppe 2 years and 1 month between the 6th and the 7th years in the serie It is in this context that the words क्षयं संवत्सराणां च मासाणां च क्षयं तथ are used in the Shaanti parvan of the Mahaabhaarata.

We have three Saavana years in the Series of years given i table 7. They are at serial No. 6, 12 and 18 Sammidaa (संमिदा Anusama (अनुसम) and Paryanu (पर्यनु). If we presume that we hav dropped 2 years, each time following these three saavana years, th total number of years which we have dropped would amount to si Let us now imagine a series of 25 years (five batches of 5 yea each) and then subtract 6 years as stated hereinbefore. We are le with a yuga of 19 years.

CHAPTER - 15

Concurrent Adhika Maasa

It will be interesting to compare the intervals at which adhik maasas appear in Yajus cycle with those in the R@k cycle. Tabl 7 gives Yajus cycle, while table 2 gives a R@k cycle. In Yajus cycl the Adhika maasas appear at the intervals of $2\frac{1}{2}$, $2\frac{1}{2}$, 3, $2\frac{1}{2}$, 3 $2\frac{1}{2}$, 3 years while they appear at the intervals of 3, $2\frac{1}{2}$, 3, $2\frac{1}{2}$, 3 $2\frac{1}{2}$, $2\frac{1}{2}$ years in the R@k cycle.

We have prepared Table 7 in search and flow of a cogent an logical explanation of the internal and external evidence of the Yaju cycle. It can be rearranged without violating the rules, so that th adhika maasas take concurrent place in both the types of yuga Table 8 shows readjusted Yajus yuga. We have not disturbed th cyclic order of years while preparing table 8. We have only give 1st place to 6th year in 7th Table while preparing the 8th table.

The first year in table 8 is Saavana year which is a short yea and therefore the next year begins with a tithi which comes earlie

TABLE No. 8

Sr. No.	Name of the year	Total days	Total Tithis	Speciality	Solar day at the beginning of the Semester	Tithi at the beginning of the Semester	Nakshatra at the beginning of the Semester
1.	Sammidaa (संमिदा)	360	366	Saavana year	Uttaraayana	Maagha Shukla 1	Dhanishthaa
2.	Anuvatsara	366	372		−5 days	--"-- 7	Ashvini
3.	Idvatsara				−4 days	Maagha vadya 4	Utt' Phalgunee
4.	Samvatsara				−3 days	Maa Sh. 1	Dhanishthaa
5.	Parivatsara				−2 days	Maa. Sh. 13	Aardraa
6.	Idaavatsara				−1 day	Maa. Vad. 10	Anuraadhaa
7.	Anusama (अनुसम)	360	366		Uttaraayana	Maa. Sh. 7	Ashvini
08.	Parivatsara				−5 days	Maa. Sh. 13	Aardraa
09.	Idaavatsara				−4 days	Maa. Vad. 10	Anuradhaa
10.	Anuvatsara				−3 days	Maa. Sh. 7	Ashvini
11.	Idvatsara				−2 days	Maa. Vad. 4	Utt' Phal.
12.	Samvatsara				−1 day	Maa. Sh. 1	Dhanishthaa
13.	Paryanu (पर्यनु)	360	366		Uttaraayana	Maa. Sh. 13	Aardraa
14.	Idvatsara				−5 days	Maa. Vad. 4	Utt' Phaal.
15.	Samvatsara				− 4 days	Maa. Sh. 1	Dhanishthaa
16.	Parivatsara				−3 days	Maa. Sh. 13	Aardraa
17.	Idaavatsara				−2 days	Maa. Vad. 10	Anuraadha
18.	Anuvatsara				−1 day	Maa. Sh. 7	ashvinee
19.	Idvatsara				Uttaraayana	Maa. Vad. 4	Utt' Phaal.
20.	New Yuga				Uttaraayana	Maa. Sh. 1	Dhanishthaa.

before the winter solstice. All the years in the Yajus cycle must therefore begin on or before the winter solstice. Their beginnings are therefore indicated by (–) sign in column 5 of table 8.

New meaning in the context of the Yajus cycle

Two verses R@k 20 and 24 are also included in Yajus Jyotisha. They are Yajus verses 22 and 42.

अतीतपर्वभागेषु शोधयेद् द्विगुणां तिथिम्।
तेषु मण्डलभागेषु तिथिनिष्ठां गतो रविः ।।YVJ 22
इत्युपायसमुद्देशो भूयोप्येनं प्रकल्पयेत्।
ज्ञेयराशिं गताभ्यस्तान् विभजेद् ज्ञानराशिषु ।।YVJ 42

In the new context, Yajus verse 22 can be explained by the following figure.

7th W.S. 13th

We have taken for example the 10th year from Table 7. We have Maagha Shukla 7th tithi before winter solstice and Maagha Shukla 13th tithi after winter solstice. Verse 9 which begins with प्रथमं सप्तमं चाहुरयनाद्यं (First, seventh, thirteenth are the beginnings of ayanas) gives us a fixed set of tithis from which we have to choose one proper tithi near winter solstice (तिथिनिष्ठां गतः). We therefore exclude the portion from the 7th tithi onwards from the previous year. The author of Vedaanga calls this portion 'excess portion of the parvan'. When we approach the end of the 7th year in Table 8, we find 366th tithi of the year is Shukla 12th, the next tithi Shukla 13th is on the day of winter solstice. A normal year consists of 372 tithis. Therefore in the normal course the next year should have started on Vadya 4th. When we start with the 8th year, we have to make a choice between Shukla 15th and Vadya 4th. Verse 22 asks us to sever अतीतपर्वभाग i.e. the excess portion of the parvan beyond winter solstice. We therefore choose Shukla 13th as the beginning of the 8th year even at the cost of making the 7th year small by 6 tithis. Seventh year thus becomes a saavana year.

42nd verse – The interval of time between the end of a lunar year and the winter solstice was called *raashi-vibhaaga* (i.e. fraction of an adhika maasa), because this portion gradually increases in succeeding years and gets converted into an adhika maasa. In verse 42 we get a general direction to repeat the aforementioned process about dividing the r@tushesha to determine the ends and beginnings of ayanas.

Aforementioned modification in Yajus cycle can be enunciated in the following rule–

"In Yajus cycle of Vedaanga the two semesters in a year used to begin on the first day of the shalahas in which the winter solstice and the summer solstice occurred".

CHAPTER - 16

Nakshatra of the Yaajusha ayanaas

Knowledge of the beginnings of lunar nakshatras at the beginning of each Yajus ayana was also important for the Yajus priest. There is no verse in the Yajus text equivalent to RVJ 19 which begins with श्रविष्ठाभ्यां गुणाभ्यस्तान्; because, for a Yajus priest his verse 10 वसुस्त्वष्टा was sufficient to find out the lunar nakshatras at the beginning of Yajus ayanas.

S. B. Dixit has reproduced in his history of Indian astronomy Somaakara's 16 verses on this point. He has prepared a small chart from Somaakara's description, which is given in chart III. Most of the scholars so far relied on this chart for finding out the tithis and the nakshatras of winter and summer solstices in a system of 5 year

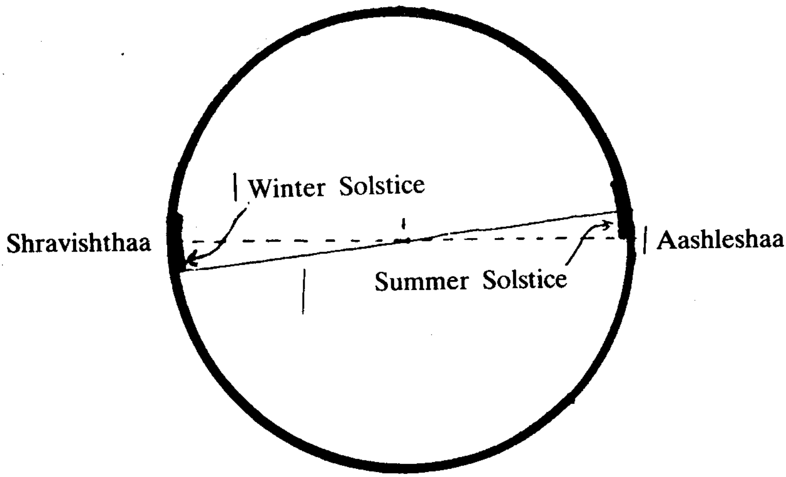
CHART NO. III

Sr. No.	Name of the year.	Winter Solstice Tithi	Winter Solstice Lunar Nakshatra	Summer Solstice Tithi	Summer Solstice Lunar Nakshatra
1.	Samvatsara	Maagha Sh. I	Dhanishthaa	Shraavana Sh. 13	Chitraa
2.	Parivatsara	-"- Sh. 7	Aardraa	-"- Vad. 4	Poorvaa Bhaad
3.	Idaavatsara	-"- Vad. 10	Anuraadha	-"- Sh. 1	Aashleshaa
4.	Anuvatsara	-"- Sh. 7	Ashvinee	-"- Sh. 13	Poorvaa-shaadhaa
5.	Idvatsara	-"- Vad. 4	Uttaraa Phaalgunee	-"- Vad. 10	Rohinee

yugas. According to me, though the tithis and the nakshatras given in the chart do not show the actual position of winter and summer solstices, they indicate the beginnings of Yajus ayanas in the years, whose names are given in the chart. The basis of this chart is Yajus verses 9 and 10 i.e. प्रथमं सप्तमं चाहुः and वसुस्त्वष्टा. Only the names of the lunar years samvatsara, parivatsara etc are provided by Somaakara. In this respect he has himself quoted Garga.

Let us take an example of Idaavatsara. From chart III, we know that its vernal ayana (वसन्तायनम्) must begin on the 10th of Vadya when the moon is in anuraadhaa nakshatra. Let us now turn to table 8. In this table 6th, 9th and 17th years are Idaavatsaras. they respectively begin on 1, 4, and 2 days before the winter solstice. Thus a Solar Shalaha (six days) in which winter solstices is the last day, prescribes the limit of the beginnings of the ayana. Let us call this Shalaha as basic Shalaha. It is a mathematical requirement that the Sun must have remained in the first half of Shravishthaa during its journey in the basic shalaha (see figure 3). When the Yajus civilisation witnessed the tithis and nakshatras given in cnart III, the moon was required to be in a particular range of angular distance from Shravishthaa corresponding to the name of the year given in chart III.

Figure 3



The Autumnal Ayana

The summer solstice is at a distance of $13^1/_2$ nakshatras from winter solstice. With similar reasoning as in the preceding paragraph, we find that the point of summer solstice was at the eastern end of aashleshaa.

When we consider the positions of the beginnings of both the Yajus ayanas, we have to conclude that the point of Winter Solstice was at the centre of Shravishthaa during the Yajus Jyotisha period. Autumn Ayana therefore began when the Sun was in the latter half portion of Aashleshaa.

The Saavana years

Saavana years consist of 366 tithis. We do not have separate rules to fix the beginnings of their ayanas. Chart III with Yajus verses 9, 10, 22 and 42 are our rules to fix the beginnings of the ayanas. For example let us take the 1st year in table 8. In being a samvatsara, its vernal semester should begin on Maaghaa Shukla 1st and autumn semester should begin on Maaghah Shukla 7th. Eventually the vernal semester would consist of 186 tithis, while the autumn semester would consist of 180 tithis. Thus for practical purposes the 1st year in table 1 is Samvatsara, 7th year is anuvatsara and 13th year is parivatsara. The only difference is from total 372 tithis. Their last Shalaha is removed. We have thus five samvatsaras in the Yajus cycle also. Yajus text therefore begins with the words *Pancha-samvatsara-mayam yugaadhyaksham.*

Advantages : No doubt there is a little loss of accuracy in the Yajus cycle, because its basic position has widened into a Shalaha from a point in Shravishthaa; but the particulars of the beginnings (tithis & nakshtras) of its ayanas have become easier to remember. Verses 9 and 10 give all the particulars. It is usual experience in the practical applications of science, that a thumb rule is always easier to remember, but in the majoirity of cases, thumb rules are applied with the calculated loss of accuracy. Yet the loss of accuracy is much less than was conceived by the scholars so far.

Let us view the Yajus cycle from a different angle. From table 8 we find that the years at Sr. Nos. 1, 7, 13 and 19 form cross lines dividing the chain in three sections. Out of these four years, the first three are Saavana years, and the 19th year idvatsara is the last year. We can therefore call them as cross lines. In between these cross lines, we have three groups of five solar years. In every such group we have 2 adhika maasas. Verse 31 सावनेन्दु is applicable to all such batches of five years. For the solar positions at the end of each parvan, Dixit's tables at Annexure 3 can be used according to their names.

"Two intercalary months arise in batches of five years". From table 8 we find that all these batches of five years do not begin with samvatsara; yet their cyclic order is maintained.

CHAPTER - 17

ANTIQUITY

Various scholars have made efforts to fix the antiquity of Vedaanga Jyotisha by astronomical calculations, basing their calculations on RVJ 5 & 6 and YVJ. 6 & 7. The names of a few important persons with their respective conclusions are as follows –

Name	Year of Vedaanga.	
1.	Weber	500 B.C.
2.	Swami Kannu Pallai	850 B.C.
3.	William Jones	1181 B.C.
4.	Lokamanya Tilak	1181-1269 B.C.
5.	C. V. Vaidya	1200 B.C.
6.	Colebrooke	1381 B.C.
7.	Prof. T.S. Kuppanna Sastri	1370 B.C.
8.	S. B. Dixit	1400 B.C.
9.	Daftari	1197 B.C.

All these scholars presume that when Vedaanga verses were composed on the day of the beginning of the yuga, the point of winter solstice was at the beginning of the segment of Shravishthaa on the day of the beginning of the yuga i.e. the solstice. Sampath Ayyangar has presumed that the yuga used to begin at autumnal equinox, and therefore he takes the antiquity 6500 years still more in the past. I do not want to enter into this debate about the season of the beginning of the yuga, viz. whether it was winter solstice or autumnal equinox. Scholars have missed to note from relevant verses. For the sake of convenience let us assume the majority view vig. The yoga used to begin at winter solstice.

(i) There is a difference between the wording and meaning of

RVJ 5 (स्वरार्कमेके) and RVJ 6 (प्रपद्येते) which were so far supposed to be equivalent. (ii) There is also a difference in the purpose of giving RVJ 5 and 6. It was so far thought that both of these verses speak about the beginning of the yuga, but it is not so. RVJ 5 reads as under -

स्वरार्कमेके सोमार्कौ यदा साकं सवासवौ ।
स्यात्तदादि युगं माघस्तपः शुक्लो दिनंत्यजः ।।५

Last two words in the second line are obviously (शुक्लो दिनंत्यजः) which mean the end of the bright wing i.e. full-moon day. The first word in the first line स्वरार्कमेके includes the word एके which indicates a dual nominative case. The meaning of the verse should therefore be -

"When the Sun and the moon are on both sides (with the Sun) at a Vaasava nakshatra in the heaven, the yuga begins with a full-moon day in the month of Maagha in the winter season."

There is a difference between this verse and the next verse i.e. RVJ 6. It simply tells us as to when the months Maagha and Shraavana used to begin in those days.

प्रपद्येते श्रविष्ठादौ सूर्याचान्द्रमसावुदक् ।
सार्पार्धे दक्षिणार्कस्तु माघश्रावणयोः सदा ।।६

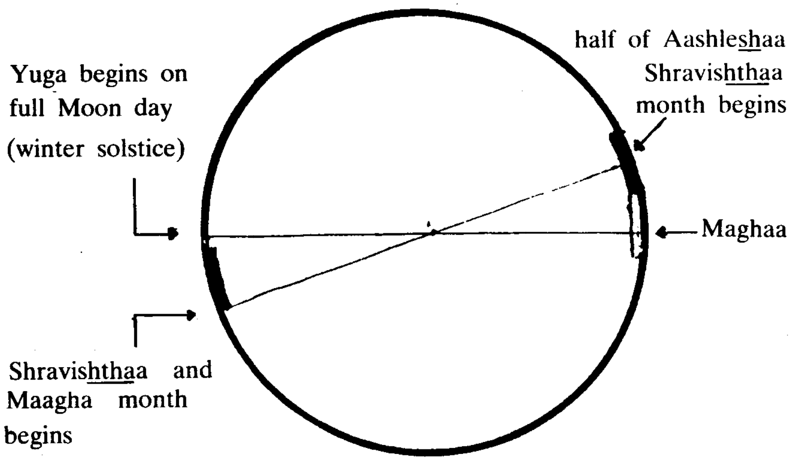
"The (astronomical events that) the Sun arriving at the beginning of Shravishthaa and the Sun reaching at the mid-point of Aashleshaa in the south indicate the rising (beginning) of the months of (चान्द्रमसावुदक्) Maagha and Shraavana".

Thus during the R@g Jyotisha period, the beginning of the yuga was at different times than the beginning of Maagha. The yuga began at winter solstice with the full-moon, but the month of Maagha began with the new-Moon about 15 days earlier.

The Sun advances 14^0 33' in 15 tithis i.e. a paksha. The nakshatra segment has a breadth of 13^0 20'. The Sun would therefore cross the whole of Shravishthaa and enter Shatataarakaa 1^0 13' on the relevant full-Moon day. As a result, in all our calculations we must take back the date 14^0 33' × 72 years i.e. 1047 years past. The points of winter and summer solstice would also have to be located 14^0 33' towards the east. From the points mentioned in RVJ 6, let us call the relevant points as full-moon points at winter solstice and full-moon point at summer solstice.

We do not expect that in the early days of astronomy people

Figure 4



would be using instruments like a sextant or any structure even like a stone-heng to mark the angular distance travelled by the Sun and the moon in the sky. The astronomical observers presumed that (i) the Sun or the moon traversed equal angular distances in equal time (ii) the Sun occupies a diametrically opposite point in the sky on the full moon day. (iii) they fixed some bright star on the ecliptic and visually observed the position of the full moon near it, and then by calculations fixed the position of the Sun opposite to it. From historical evidence, we can say that Vishaakhaa (Libri), Chitraa (Spica) and Maghaå (Regulus) served the purpose of such marking stars. It is obvious that Maghaa (regulus) was the marking star in the R@g Jyotisha period.

From RVJ 6 we find that the month of Maagha began when the Sun was in mid-Aashleshaa. Therefore the full moon point at the time of winter solstice must Be 1^{0} 13’ towards the east of mid-Maghaa i.e. about 8^{0} on the eastern side of Regulus. (Such a full moon point is also a point of summer solstice at the relevant point of time). The latitude of Regulus in 1987 A.D. is 150^{0} 56’. The angular distance between the present point of Summer solstice and Regulus is therefore 60^{0} 56’. It has therefore moved from the time of composition of Vedaanga (60^{0} 56’ + 8^{0}) = 68^{0} 56’ due to precession. The total time required for the precession of the point of summer solstice is (68^0 56' × 72) years 4963.2 years. The antiquity of Vedaanga is therefore (4963.2 − 1987) years B.C. = 2976 B.C.

Mark of deeper remoteness

The author of the R@k text says in verse 3 that he is narrating the astromony or the calendar as it is known from earlier times and as known to the priests who were well-versed in conducting sacrifices.

ज्योतिषामयनं कृत्स्नं प्रवक्ष्याम्यनुपूर्वशः ।
विप्राणां संमतं लोके यज्ञकालार्थसिद्धये ।।३

The author also says in verse 2 that he is narrating the lore of time as described by the great Sage Lagadha. We thus gather two things from these verses that (i) the author of the text is some one else than sage Lagadha and (ii) the knowledge of the science in the text was age old on the date of the composition of the verses.

In RVJ 8 also we have some obscure evidence of the antiquity of the text. It says -

द्विगुणं सप्तमं चाहुरयनाद्यं त्रयोदश ।
चतुर्थं दशमं चैव द्विर्युग्माद्यं बहुलेप्यृतौ ।।RVJ 8

The words *Dvir yugmaadya* mean the beginning at two pairs. The words are interprened so far to indicate that the tithis given in the verse are repeated twice at the beginning of two ayanas. But in that sense the words would have been (द्विर्युगाद्यं) . I would therefore interpret that two pairs of stars were the marks of the beginning of the yuga. The Poorvaa Phaalgunee is a pair, Uttaraa Phaalgunee (Denibola) is also a separate pair. Some authors of the R@k text must have changed the versions in RVJ 5 and 6 to suit the astronomical position suitable to their time; but fortunately for us, he has not made any consequent change in RVJ 8. Lok Tilak has also proved in his Orion that there was a time when the Vedic sacrifices began with full moon at Phaalgunee on winter solstice.

Readers would note that in RVJ 5 the deity presiding over Shatataarakaa is marked as Vasu in the Taittireeya Samhitaa, while the present R@k text shows it as of Shravishthaa (सवासवौ). All this evidence creates serious doubt in our mind that the origin of 19-year cycle in Vedaanga must be very much prior to 2976 B.C.

Antiquity of Yajus Jyotisha

The verse प्रपद्येते श्रविष्ठादौ is also found in Yajus Jyotisha (RVJ 7).

We have seen that the verse gives description of the points of beginning of Maagha and Shraavana. Their earliest limit was about 6 days prior to the days of winter and summer solstice (see Figure 3) with a similar reasoning as for the date of R@g Jyotisha, We find that the date of Yajus Jyotisha should be 2352 B.C. i.e. 624 years subsequent to the date of R@g Jyotisha.

CHAPTER - 18

Concluding View

Europeans divide the Solar year in twelve approximately equal parts and call them months. The word month is derived from the word moon. In European calendar, which is gradually being adopted by other civilisations of the world, the unit of time known as month does not keep any nexus or relation with the phases of the moon. The 15th day of the month does not necessarily coincide with the full-moon day. The Arabs and the muslims call a group of 12 lunations an year. In their calendar the word year is a misnomer. In this sense those civilisations have accepted their defeat in designing calendars. They could not design a calendar in which a proper co-ordination of the positions of the Sun and the moon in heaven is depicted.

In the Vedic civilisation, a month was named after a rising star, which was seen in the east immediately after dusk, a month of Orion, a month of Spica etc. Dates were reckoned according to the size i.e. the phase of the moon. A semi-circular moon indicated the 8th tithi or the day of the month. The star on the back-ground of the moon indicated the day. The observer would tell the day e.g. "on Aldeberon day on the 8th of Regulus (रोहिणी दिन, माघ शुद्ध ८) This is just describing the nature i.e. the position of the Sun as well as the moon. The history of astronomy and calendars reveals to us that civilisations in the past tried to achieve this object but failed.

The work of the sage Lagadha is described in two lines in his verse RVJ 30.

सोमसूर्यःस्त्रिचरितो लोकान् लोके च संमिता।
सोमसूर्यःस्त्रिचरितो विद्वान् वेदविदश्नुते।।RVJ 30

An illiterate agriculturist might not be able to tell the ratios of the speeds of the journies of the Sun and the moon, but his method of naming a day and a date was definite and yet most naturally befitting the process of evolution of civilisations. It was for the learned people to analyse and form mathematical rules to foretell the sequence of the positions of the Sun and the moon in the sky in the form of a calendar.

The perfect astronomical method of intercalation is the one which is used by a Hindu astronomer Varaahamihira, which is the same as that used by the Chinese as Yin-Yang-Li. But the path of the moon around the earth is not circular; it is abnormal due to the effect of gravitation of the Sun. The place of intercalation in the calendar is therefore abnormal. Jews intercalate an addtional month only at one place in the year. i.e. in the month of Adar (March). As a result, the intercalation may be at times either late or early by six months with astronomical standards. Sage Lagadha has divided the cycle in 38 semesters for the purpose of intercalation. The intercalation has therefore, a rhythm and fair accuracy according to astronomical standards. An easy method to remember it is to count $2^1/_2$, 3, $2^1/_2$, 3, $2^1/_2$, 3, $2^1/_2$ year-groups on inverted base fist of the left hand as we do it for counting the days in the month of a Gregorian calendar. The first group begins on the summer solstice of the 17th year in the cycle.

An illiterate person needs to know such a rhythm. If we divide the solar year in more than two parts, we again lose such a rhythm. In the method of intercalation used by the Jews, we do not have such a good rhythm. They intercalate a month at the end of 3, 6, 8, 11, 14, 17 and 19 years, The groups have a sequence of 3, 3, 2, 3, 3, 3, 2 years.

Sage Lagadha asks us to observe the sky at the end of a 19-year yuga, and tells us the method to correct the time lag, if it is found in the positions of the Sun and the moon.

We now accurately know that there is a difference of 4 hours and 23 minutes in the 19-year Lagadha cycle of 235 lunar months and 19 sidereal years. The difference totals to about 1.48 tithi in 152 years i.e. in 8 chains of a 19-year cycle. If we add last 8 years in the yuga consisting three links of 3, $2^1/_2$, $2^1/_2$ years, the difference reduces to only 23 minutes 8.69 seconds in the total number of 160 years. The cycle then proves useful for 9920 years which is a very long period. We thus have a bigger cycle of 160 years. We therefore do not need to observe the positions of the moon and the Sun in the sky for the purpose given in RVJ 34.

However, all the lunations in a year are not equal in length of time. The lengths of pakshas or fortnights and months have to be taken from positional astronomy centre, so that a mistake of even the time of beginnings of various tithis should not be left out. Still the place of intercalation given by the Vedaanga is worthy to follow for easy computation by an agriculturist and industrial labourer.

At the end, I would express that one gets amazed at the work done by the great sages at such a remote antiquity.

The meaning of same verses especially R.V.J. 11, 12 and 13 appear so technically deeper and detailed that one is inclined to search still simpler meaning. I have therefore the same feeling as expressed by Lokmanya Tilak that the last word on Vedaanga is yet to be ultered.

Appendix No. 1-A
(Tropical years)

Name of the year	No.of year	Solar months	Total days	Lunar months	Total days	Difference
1	2	3	4	5	67	8
Samvatsara	1	12	365.242199	12	354.367056-	10.875143
Anuvatsara	2	24	730.484398	24	708.734112-	21.750286
Idvatsara	3	36	1095.726597	37	1092.631756-	3.094841
Samvatsara	4	48	1460.968796	49	1446.998812-	13.96994
Parivatsara	5	60	1826.210995	61	1801.365868-	24.845127
Idvatsara	6	72	2191.453194	74	2185.263512-	6.188074
Samvatsara	7	84	2556.695393	86	2539.630568-	17.064825
Parivatsara	8	96	2021.937592	98	2893.997624-	27.939968
Idaavatsara	9	108	3287.179791	111	2177.895268-	9.284523
Anuvatsara	10	120	3652.42199	123	3632.262324-	20.159666
Idvatsara	11	132	4017.664189	136	4016.159968-	1.504221
Samvatsara	12	144	4382.906388	148	4370.527024-	12.379364
Anuvatsara	13	156	4748.148587	160	4724.89408-	23.254507
Idvatsara	14	168	5113.39086	173	5108.791724-	4.599062
Samvatsara	15	180	5478.632985	185	5463.15878-	15.474205
Parivatsara	16	192	5843.875184	197	5817.52583-	26.52582
Idaavatsara	17	204	6209.117383	210	6201.42348-	7.693903
Anuvatsara	18	216	6573.359582	222	6555.79053-	18.569052
Parivatsara	19	228	6939.601781	235	6939.68818+	0.86399
Samvatsara	20		New cycle begins.		=	2 Hrs. 4 mit. 24.8736 Secd.

NOTE : The name of the year in the first column is derived from the difference in days of the previous year given in the last column.

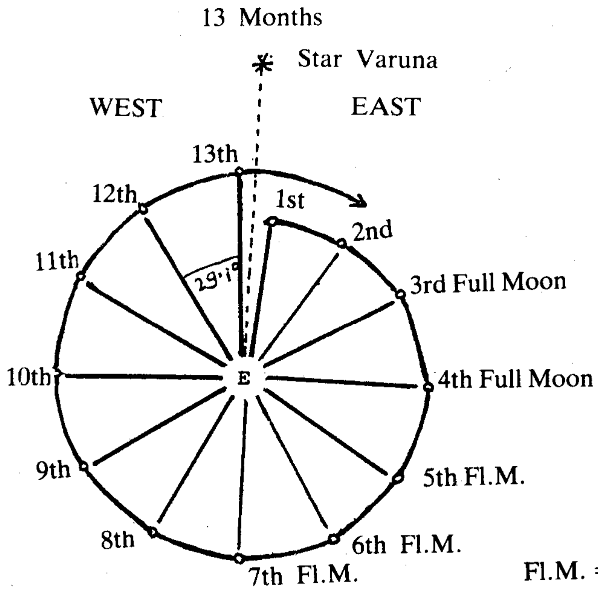
Appendix No. 1-B
(Sidereal years)

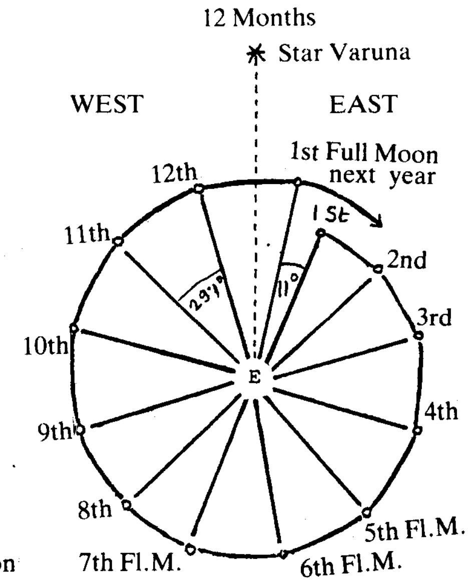
Name of the year	No.of year	Solar months	Total days	Lunar months	Total days	Difference
1	2	3	4	5	67	8
Samvatsara	1	12	365.25636	12	354.367056-	10.8893
Anuvatsara	2	24	730.51272	24	708.734112-	21.778608
Idvatsara	3	36	1095.76908	37	1092.631756-	3.137324
Samvatsara	4	48	1461.02544	49	1446.998812-	14.026628
Parivatsara	5	60	1826.2418	61	1801.365867-	24.915932
Idvatsara	6	72	2191.538118	74	2185.263512-	6.274688
Samvatsara	7	84	2556.79542	86	2539.630568-	17.163952
Parivatsara	8	96	2922.05088	98	2893.997624-	28.053256
Idaavatsara	9	108	3287.30724	111	3277.895268-	9.411972
Anuvatsara	10	120	3652.5636	123	3632.262324-	20.301276
Idvatsara	11	132	4017.81996	136	4016.159968-	1.659992
Samvatsara	12	144	4383.07632	148	4370.527024-	12.549296
Anuvatsara	13	156	4748.33268	160	4724.89408-	23.4386
Idvatsara	14	168	5113.58904	173	5108.791724-	4.797316
Samvatsara	15	180	5478.8454	185	5463.15878-	15.68662
Parivatsara	16	192	5844.10176	197	5817.52583-	26.57593
Idaavatsara	17	204	6209.35781	210	6201.42348-	7.93433
Anuvatsara	18	216	6574.6144	222	6555.79053-	18.82387
Parivatsara	19	228	6939.87084	235	6939.68818+	00.18266
Samvatsara	20		New cycle begins.		=	4 Hrs. 23 mit. 1.72 Secd.

NOTE : The name of the year in the first column is derived from the difference in days of the previous year given in the last column.

Appendix-2

Shunahshepa-method of detecting inter calary month (अधिक मास) Star Varuna is on the ecliptic. Observe at point E marks full moon to follow Varuna's minimum distance in the year on the East; counts it as firs full-moon and first month. After 12 months full-moon is on the western side of Varuna. If 13th full-moo does not cross Varuna, count it as of an Inter-calary month; if it crosses Varuna, it is the 1st month of the next year.





Fl.M. = Full Moon

Appendix 3-A

Position of the Sun at the parvan-end in a 5 year cycle.

संवत्सर

मास	पर्वक्रम	गतनक्षत्र	वर्तमान नक्षत्र अंश	वर्तमान नक्षत्र नाम	२७ भशेष	मास	पर्वक्रम	गतनक्षत्र	वर्तमान नक्षत्र अंश	वर्तमान नक्षत्र नाम	२७ भशेष
माघ	1	1	11	शतभिषक्	11	श्रावण	13	14	19	मघा	19
-"-	2	2	22	पूर्वा भाद्रपदा	22	-"-	14	15	30	पूर्वा फाल्गुनी	3
फाल्गुन	3	3	33	उत्तरा भाद्रपदा	6	भाद्रपद	15	16	41	उत्तरा फाल्गुनी	14
-"-	4	4	44	रेवती	17	-"-	16	17	52	हस्त	25
चैत्र	5	5	55	अश्वयुज्	1	आश्विन	17	18	63	चित्रा	9
-"-	6	6	66	भरणी	12	-"-	18	19	74	स्वाती	20
वैशाख	7	7	77	कृत्तिका	23	कार्तिक	19	20	85	विशाखा	4
-"-	8	8	88	रोहिणी	7	-"-	20	21	96	अनुराधा	15
ज्येष्ठ	9	9	99	मृग	18	मार्गशीर्ष	21	22	107	ज्येष्ठा	26
-"-	10	10	110	आर्द्रा	2	-"-	22	23	118	मूल	10
आषाढ	11	11	121	पुनर्वसू	13	पौष	23	25	५	उत्तराषाढा	5
-"-	12	13	8	आश्लेषा	8	-"-	24	26	16	श्रवण	16

Appendix 3-B

परिवत्सर

मास	पर्व-क्रम	गत-नक्षत्र	अंश	वर्तमान नक्षत्र नाम	27 भ शेष
माघ	25	27	27	श्रविष्ठा	27
-"-	26	1	38	शतभिषज्	11
फाल्गुन	27	2	49	पूर्वा भाद्रपदा	22
-"-	28	3	60	उत्तरा भाद्रपदा	6
चैत्र	29	4	71	रेवती	17
-"-	30	5	82	अश्वयुज	1
वैशाख	31	6	93	भरणी	12
-"-	32	7	104	कृत्तिका	23
ज्येष्ठ	33	8	115	रोहिणी	7
-"-	34	10	2	आर्द्रा	2
आषाढ	35	11	13	पुनर्वसु	13
-"-	36	12	24	पुष्य	24
श्रावण	37	13	35	आश्लेषा	8
-"-	38	14	46	मघा	19
भाद्रपद	39	15	57	पूर्वाफाल्गुनी	3
-"-	40	16	68	उत्तरा फाल्गुनी	14
आश्विन	41	17	79	हस्त	25
-"-	42	18	90	चित्रा	9
कार्तिक	43	19	101	स्वाती	20
-"-	44	20	112	विशाखा	4
मार्गशीर्ष	45	21	123	अनुराधा	15
-"-	46	23	10	मूल	10
माघ पौष	47	24	21	पूर्वाषाढा	21
-"-	48	25	32	उत्तराषाढा	5

Appendix 3-C

इदावत्सर

मास	पर्वक्रम	गतनक्षत्र	अंश	वर्तमान नक्षत्र नाम	२७ भशेष	मास	पर्वक्रम	गतनक्षत्र	वर्तमान नक्षत्र अंश	नाम	२७ भशेष
माघ	49	26	43	श्रवण	16						
-"-	50	०	54	श्रविष्ठा	27	श्रावण	63	14	73	मघा	19
फाल्गुन	51	1	65	शतभिषज्	11	-"-	64	15	84	पूर्वा फाल्गुनी	3
-"-	52	2	76	पूर्वा भाद्रपदा	22	भाद्रपद	65	16	95	उत्तरा फाल्गुनी	14
चैत्र	53३	3	87	उत्तरा भाद्रपदा	6	-"-	66	17	106	हस्त	25
-"-	54	4	98	रेवती	17	आश्विन	67	18	117	चित्रा	9
वैशाख	55	5	109	अश्वयुज्	1	-"-	68	20	4	विशाखा	4
-"-	56	6	120	भरणी	12	कार्तिक	69	21	15	अनुराधा	15
ज्येष्ठ	57	8	7	रोहिणी	7	-"-	70	22	26	ज्येष्ठा	26
-"-	58	9	18	मृग	18	मार्गशीर्ष	71	23	37	मूल	10
आषाढ	59	10	29	आर्द्रा	2	-"-	72	24	48	पूर्वाषाढा	21
-"-	60	11	40	पुनर्वसू	13	पौष	73	25	59	उत्तराषाढा	5
अधिक श्रावण	61	12	51	पुष्य	24	-"-	74	26	70	श्रवण	16
-"-	62	13	62	आश्लेषा	8						

Appendix 3-D

अनुवत्सर

मास	पर्व-क्रम	गत-नक्षत्र	अंश	वर्तमान नक्षत्र नाम	27 भ शेष
माघ	75	0	81	श्रविष्ठा	27
-''-	76	1	92	शतभिषज्	11
फाल्गुन	77	2	103	पूर्वा भाद्रपदा	22
-''-	78	3	114	उत्तरा भाद्रपदा	6
चैत्र	79	5	1	अश्वयुज्	1
-''-	80	6	12	भरणी	12
वैशाख	81	7	23	कृत्तिका	23
-''-	82	8	34	रोहिणी	7
ज्येष्ठ	83	9	45	मृग	18
-''-	84	10	56	आर्द्रा	2
आषाढ	85	11	67	पुनर्वसू	13
-''-	86	12	78	पुष्य	24
श्रावण	87	13	89	आश्लेषा	8
-''-	88	14	100	मघा	19
भाद्रपद	89	15	111	पूर्वा फाल्गुनी	3
-''-	90	16	112	उत्तरा फाल्गुनी	14
आश्विन	91	18	9	चित्रा	9
-''-	९२	१९	२०	स्वाती	२०
कार्तिक	93	20	31	विशाखा	4
-''-	94	21	42	अनुराधा	15
मार्गशीर्ष	95	22	53	ज्येष्ठा	26
-''-	96	23	64	मूल	10
पौष	97	24	75	पूर्वाषाढा	21
-''-	98	25	86	उत्तराषाढा	5

इद्वत्सर

मासनाम	पर्व-क्रम	गत-नक्षत्र	अंश	वर्तमान नक्षत्र नाम	27 भा शेष
माघ	99	26	97	श्रवण	16
-"-	100	0	108	श्रविष्ठा	27
फाल्गुन	101	1	119	शतभिषक्	11
-"-	102	3	6	उत्तरा भाद्रपदा	6
चैत्र	103	4	17	रेवती	17
-"-	104	5	28	अश्वयु	1
वैशाख	105	6	39	भरणी	12
-"-	106	7	50	कृत्तिका	23
ज्येष्ठ	107	8	61	रोहिणी	7
-"-	108	9	72	मृग	18
आषाढ	109	10	83	आर्द्रा	2
-"-	110	11	94	पुनर्वसु	13
श्रावण	111	12	105	पुष्य	24
-"-	112	13	116	आश्लेषा	8
भाद्रपद	113	15	3	पूर्वा फाल्गुनी	3
-"-	114	16	14	उत्तरा फाल्गुनी	14
आश्विन	115	17	25	हस्त	25
-"-	116	18	36	चित्रा	9
कार्तिक	117	19	47	स्वाती	20
-"-	118	20	58	विशाखा	4
मार्गशीर्ष	119	21	69	अनुराधा	15
-"-	120	22	80	ज्येष्ठा	26
पौष	121	23	91	मूल	10
-"-	122	24	102	पूर्वाषाढा	21
अधिक माघ	123	25	113	उत्तराषाढा	5
-"-	124	26	124	श्रवण	16

Supplement

Interpretation of the verses in "Vedaanga," that could stand the test of reasoning, involves much research. Lokmanya Tilak has called the rules therein enigmatical. The research would. therefore, continue till the meaning of the verses becomes clear. After writing the book on the subject, the author considers some clarifications and modifications in the theory necessary and hence this supplement.

About the leap Year

In the 19 year cycle, every year consists of $(371 + \frac{1}{19})$ tithis or $361 - \frac{1}{19})$ nakṣhathatras. The leap year calculated for tithis consists of one additional tithi (372 tithis), while the leap year calculated for nakṣhatras is devoid of a nakṣhatra (360 nakṣhatras). A problem, therefore, was to find out the exact year that was treated by sage Lagadha as the leap year, the first or the 19th ? The author, therefore, relied on RVJ 4 to fix the leap year "निरेकं द्वादशार्धाब्दं द्विगुणं गतसंज्ञीकं." The words "गत संज्ञीकं" led him to call the first year in the 19-year chain as the leap year consisting 372 tithis. Let us reason:

When we number a year, a month or a day, the last of them is incomplete e. g. when we say "in the 10 th month" we mean that nine months are complete and some days have passed thereafter. The words "द्विगुणं गतसंज्ञीकं" occuring in the 4 th verse make us presume that 2 karanas or 1 tithi of the previous yuga should be added for numbering the first tithi of the first year and not for treating the first year as a leap year. The 19 th year beginning with Vd. 4th (19th tithi of the month) ends with Amaavasya (30th tithi). (Please see table No. 1 and 2). Both the tithis are included in the year. The last year in the chain is, therefore, the leap year. A relevant correction has to be made in the book, wherever the point occurs, especially in part III chapter 8 (page 37). The basic year is the 19th year, not the first year in the chain. This change does not disturb the arrangement of the 19 year yuga as given in the book.

Segments according to nakshatras

If we look at figure 2 on page 32 of the book, we find that the names of the nakshatras used in the figure are derived from the integral part of the number i. e. the complete nakṣhatra crossed by the Moon. These names are used in RVJ 9 (वसुस्त्वष्टाभगोजश्च) by sage Lagadha for the classification of the segments. We should, therefore, use the names of the complete nakṣhatras in column No. 2 in table No. 4 (page 29) for the classification of the years as Samvatsara etc., and should not use the names of the current nakṣhatras given in column No. 3 in table No. 5 (page 33). The names of the classes of years according to the nakṣhatras are given in column 2 of table No. 5 (at page 33).

Segments according to tithis

When we have to classify a year according to a tithi, the number of the tithi completed by the Moon should be used for reasoning given in the preceding paragraph. However, the tithis given in column 3 of table No. 2 at page 24 are current tithis. We should, therefore, get the number of the complete tithi by deducting one tithi. For example, in the 9th year we have Winter-solstice on Vd. 14th. The complete tithi on the day is vd. 13th. From figure 1 we find that Vd. 13th is in Idaavatsara segment. Ninth year is, therefore, classified as Idaavatsara. Similarly, the 7th year is Samvatsara. This is how we have to interpret with consistency RVJ 8 and RVJ 9. (Please also see the classification of years made in Appendix 1 A and 1B at pages 85 and 86 of the book).

It is useful to mention here that the first line of RVJ 8 reads "द्विगुणं सप्तमं चाहुरयनाद्यंत्रयोदश" The first word "द्विगुणं" asks us to multiply the number of tithis by two to convert them into "Karnas." It does not indicate "where the segment of Samvatsara begins." What is then the point of distinction between Idaavatsara-segment and Samvatsara-segment ? The Shalaha-segment theory for naming the classes of years, therefore, needs modification. By consistent reading of RVJ 8 and RVJ 9, we find that the first segment of "Samvatsara" begins with Amaavasya and ends with 6th tithi. Both of which thus should be chosen as complete tithis for classification. One more reason for doing so is that the 19th Year of the Yuga consists of 372 tithis. Samvatsara-segment in R@k-text is, therefore, bigger than other segments.

Shorter Yugas

A question often asked is : "Why should we not choose 11 solar-year-cycle with 4 lunations for a Yuga ?" What prompts the question is because $11 \times 11 = 121$, the R@tushesh of 11 tithis per year would total to 121 tithis in 11 years. We can, therefore, have 4 intercalary months of 30 tithis each, in a yuga of 11 years with one leap year. A yuga of 11 years is not possible because not only do we calculate total number of surplus tithis in a yuga but we also calculate surplus number of nakṣhatras. We have $11 \times 10 = 110$ surplus nakṣhatras in 11 years. In 4 sidereal months we get $27 \times 4 = 108$ nakṣhatras. There is a difference of 2 nakṣhatras in these totals. A yuga of 11 solar years is, therefore, not possible. Similarly if we consider only nakṣhatras factor of lunations, we feel that there can be a yuga of 8 solar years (because $27 \times 3 = 81$ and $10 \times 8 = 80$). When we make calculations for surplus tithis we find that a yuga of 8 years is not possible ($8 \times 11 = 88$ and $3 \times 30 = 90$). With these calculations we find that with Vedaanga methods we have only 19 years astronomical cycle which can be called as yuga of luni-solar years.

Additional texts for reference and studies :

1. "Bharatiya Jyotish Sastra" by Shankar Balkrishna Dixit (English) Part I Published by Positional Astronomy Centre, India Meteorological Department, New Alipore, Calcutta, 700053.

2. "The Astronomical Method and its application to the chronology of Ancient India" a lecture delivered by Dr. Daftari in 1940 and subsequently published by Nagpur University in 1942 (State of Maharashtra, India).

3. "The Astronomy of Vedaanga Jyotisha" a lecture delivered by Dr. Gorakh Prasad on 21st March 1947 and published in the Journal, Vol. IV Part 1-4 (1946-47) of Ganganath Jha Research Institute Allahabad (U. P., India)

CORRIGENDUM

Page	Line	Incorrect	Correction
Forewords last Page	Last line	Ugabda 5080	Ugabda 5090
3	3rd para last line	Page 606-606	Pages 605-606
5	14th line from bottom	Summer solstics	Summer solstice
6	17th line from top	worthy of note	worthy to note
9	3rd para 2nd line	36 verses are	33 verses are
21	6th line from top	Solscice	solstice
21	Table No. 1.3rd line 7th column	68	8
21	Table No. 1.4th line 5th column	$(9 \times 11 + 2)$	$(8 \times 11 + 2)$
22	7th line from bottom	Constallation	Constellation
26	4th line from top	i. e. i. e.	i. e.
32	2nd line below the figure	five zones	have five zones
34	1st & 20th line	Diksnit	Dikshit
44	9th line from top	redeeming	deeming
47	Table 7-6 last line	$12\frac{3}{8}$, 228-219, 9	Delete all these figures
49	3rd line from bottom	Table No. 6 C	Table No. 6
66	3rd line from bottom	सोयसूर्य	सोमसूर्य
80	4th line from bottom	the latitude	the longitude

Reference Books

1. Bharatiya Jotisha by Shankar Baalkrishana Dixit (Hindi translation by Shivnaath Zaarkhandi 1975 Edn.) Govt. of Uttar Pradesh "Hindi Bhavan" Mahatma Gandhi Road, Lucknow.

2. Vedic Chronology and Vedaanga Jyotisha (1925 Edn.) by Lokmanya Tilak Publisher Tilak bros. Gwaliar Wada, Poona.

3. Sampurna Mahaabharat (1984) Vol. VIII Publisher "Varadaa Books" Senaapati Bapat Marg, Poona.

4. Encyclopaedia britanica (XV Edn.) Vol. 3 on Calandars.

5. Vedaanga Jyotisha of Lagadha by Prof. T.S. Kuppanna Sastri (1985) Publisher Indian National Science Academy, New Delhi.

6. Mythology to History through Indian Astronomy (Seminar Papers 1980 Edn.) N.I.A. Publications Pollachi, Tamil Nadu. Pin-642 003.

Correction

The author has received Indian Ephemeries 1989 in which Longitude of the mean position of Regulus is given as 149°41'. On page 81 of this book Antiquity of Rik-text is calculated after presuming that it is 150°56'. The figure should therefore be reduced from 2976 B.C. to 2884 B.C. Similarly on page 82 the antiquity of Yajus text has to be calculated as 2260 B.C. instead of 2352 B.C.

SUPPLEMENT (II)*

The author has written two books on the present subject. The Marathi book was published in July 1986 and the English book was published in January 1989. After December 1987 he was called to read his paper and deliver lectures on the srbject at three All India seminars arranged by (i) Birla Planetarium Hyderabad (ii) Indian Astrnomical Society C/o. Department of Applied Mathematics, Calcutta University, Calcutta, (iii) Ved Vidya Pratisthan established by the Ministry of Human Resource Development, Government of India. The author was required to deliver speeches on the subject at places other than such seminars. The participants or the audience had read the books before hearing the speeches and the proposition that " the base of Rik-text of Vedaanga is a 19-Year cycle " surprised them when they read it. Several questions were, therefore, asked by the audience. The author has also received letters asking a few questions. This supplement is being published to answer such questions and to make small amendments in the explanations of the verses of R@k-text wherever it is needed.

1. **Question 1 : What is the meaning of the word "राशि:" occuring in Verse No. 4 ? Do they mean the 12 Zodiacal constellations, or the total number of Karanas or the total number of parvans ?**

Ans. :—Shri V. S. Apte's Sanskrit Dictionary gives the meaning of the word राशि: as :

(i) A heap, mass, collection, quantity, multitude, धनराशि: तोयराशि: यशोराशि: etc. and,

* The first supplement is enclosed in the book.

(ii) The numbers of figures put down for any arithmetical operation such as adding, multiplying etc.

2. It is worthy to mention here that the verse ends by the word राशिरुच्यते. This means the author wants to define the word for its use elsewhere in the text. It also means that the author wants to give a ceiling limit to the heap, pile or the number to create a unit.

3. Those scholars who wanted to suggest that there is a five year cycle interpreted that the meaning of the word राशि: as comprising 62 पर्वन् [पक्ष] i. e. 31 mouths. But for that purpose they were forced to suggest changes in the first line of the verse. They suggested to change the words निरेकं द्वादशार्धाब्दं to be read as निरेकं द्वादशाभ्यस्तं and द्विगुणं गतसंज्ञिकं as द्विगुणं गतसंयुतं.

4. The settled rule of interpretation is that the text should be read as it is. It is only in rare cases that when the meaning is totally unintelligible, and when there is a doubt that some scribe has made a mistake in writing, then for having a meaningful construction some words may be suitably changed. RVJ. 4 can be well explained without any change in the text by presuming that the cycle which forms the basis of R@k-paatha is of 19 solar years. I have translated the last line of RVJ. 4 as " the group of two parvans consisting of 60 karanas (½ tithi) each club together are called " Raashis " [अधिकमास]

5. There is another way of explaining RVJ. 4 and RVJ. 23. I have presumed that RVJ. 4 gives calculations in terms of " Karanas " to find out the place of insertion of ' Adhikmaasa ' in a Yuga. Let us presume for a while that RVJ. 4 is provided for making calculations in terms of " Parvans " instead of making them in terms of " Karanas ". Please see table No. 1 on page 21 of my book. In this table we have converted lunar semesters (i. e. 12 parvans) into solar-semesters. Column 3 and 6 give the calculations of R@tushesha in terms of Karanas at the end of each semester. Let these figures indicate the number of Parvans. Let us call these Parvans as " useful Parvans " (उपयुक्त पर्वन्), because we have ignored one Parvan out of a group of 12 Parvans in each semester. In such calculations we get Raashis of Parvans (पर्वणां राशि:) instead of having Karana-

Raashis. After making these calculations we have to apply the rule given in RVJ. 23 (तदर्धं दिनभागानां). For each Parvan from the parvan-Rashi we count a R@tushesha of ½ tithi. A group of 60 parvans gives us an Adhikamaasa of 30 tithis. The two additional Parvans give us the current tithi.

The revised meaning of RVJ. 4 would therefore be as follows—

'Subtract one (parvan) from 12 (parvans) per semester. Assume two (parvans) for previous yuga. When these two parvans are added to groups of 60 (parvans obtained as balance from each semester) the number of parvans are called Raashis.'

Raashis are therefore equal to, (62), (122), (182), (242), (362) and (420) useful parvans. However from RVJ. 19, RVJ. 20 and RVJ. 24 we get that intercalation was made at the end of the semester in which Raashi had accumulated. A tithi of the day of the solstice was then computed according to RVJ. 23.

Those scholars who support the 5-year-cycle theory suitably change the text of RVJ. 4 and define the term 'Raashi' as groups of 62 parvans each, The cycle is completed by two groups of such type, i. e. in 124 parvans.

6. Yajus-Paatha reads "यदर्धं दिनभागानां" instead of "तदर्धं दिनभागानां" in RVJ. 23 (see YVJ. 41). RVJ. 23 starts with the word तदर्धं because the verse indicated that it has to be read in the context of some earlier verse, which the author of Yajus-text could not point out. In my opinion such an earlier verse is RVJ. 4 (i. e. YVJ. 13). The author of R@k-text therefore uses the words तदर्धं दिनभागानां. Normally definitions are given in a earlier part of a text and they are used at some suitable place in its latter part. This is the reason why RVJ. 23 and RVJ-24 are so much separated from RVJ. 4.

7. Those scholars, who base their explanation of R@k-paatha on five year Luni-Solar cycle, presume that the word "Year" must be read along with the word "निरेकं" in RVJ. 4, though it is not expressly mentioned there. I have explained RVJ. 4 after presuming that the numbers mentioned in the said verse indicate the number of Karanas, though the word "Karana" is not expressly included in the verse. According to

the new explanation of RVJ. 4, we calculate the R@tushesha from a given number of Parvans. The word "Parvan" is expressly mentioned (पर्वणां राशिः) in the seeond line of RVJ. 4. We thus avoid the error of calling the verse as ambiguous. This explanation indicates that the R@k-paatha of Vedaanga is based on 19 year Luni-Solar cycle. RVJ. 23 should not, therefore, be read independently.

8. The latter explanation of RVJ. 4 answers questions on the Sanskrit language and grammar of RVJ. 4 There is no. basic difference in the two methods of mathematical calculations. There are two stages of calculations : (i) to seperate the useful-parvans from the total number of parvans, and (ii) to divide the number so obtained by two. The sequence may be arranged in any manner. I have, therefore, given proper explanation of RVJ. 4 in my book. The explanation has been much easier with the help of the unit Karana. It is easier for a layman to understand. But it appears that the time unit Karana (½ tithi) was not used by the sages during Vedaanga period; otherwise the author of Vedaanga would have directly used the word " Karana " in RVJ. 23 instead of using the word half tithi (अर्धं दिनभागानां). This also shows that RVJ. 23 had no independent useful purpose devoid of RVJ. 4.

9. Those who interprete the text favouring a five year cycle do not use the word " राशिः " in the same sense elsewhere. The word " राशिः " occurs only twice in the text i. e. in RVJ. 4 where it is defined and in RVJ. 24 where the definition is used. RVJ. 24 is interpreted by such scholars as a simple rule of three. In fact it means that when the process given in RVJ. 4 is repeated for the seperation of अधिकमास at various stages, we get some complete numbers of अधिकमास and the remainder in the form of R@tushesha. This can be called as " Raashi-Vibhaaga " preceeding before relevant उत्तरायण or दक्षिणायन. The remaining fraction of the " अधिकमास " forms the first part of the next semester. This is the meaning conveyed by RVJ. 24.

10. RVJ. 24 is also applicable to the calculations of अधिकमास according to naxatra R@tushesha.

This meaning creates a consistent reading of the two verses i. e. RVJ. 4 and RVJ. 24. The interpretation, " R@k-paatha having a base of 19 year luni-solar cycle" must, therefore, be accepted.

11. Interpretation without the error of repetition.

There is a presumption that a technical document like "Vedaanga Jyotisha" is precise and reasonably brief. Scholars on "Vedaanga" explain verses Nos. 4 and 23 for the same purpose i. e. for calculating a R@tushesha of one adhikamaasa for 30 lunations. Their interpretation of one of these verses has to be rejected for having a vice of being superfluous.

12. Question 2 : What is the difference between the meanings of RVJ. 31 and YVJ. 23 ?

Ans. : The object of RVJ. 31 and YVJ. 23 is to find out the tithis on various days of equinox in a yuga. Most of the scholars have so far treated RVJ. 31as pari-materia with YVJ. 23 and have explained only YVJ. 23. S. B. Dixit has, however, explained both the verses, though he has treated them pari-materia with each other with a base of 5-year cycle. Following paragraphs would reveal the difference in the meanings of the two verses.

विषुवं तद्गुणं द्वाभ्यां रूपहीनं तु षड्गुणम् ।
यल्लब्धं तानि पर्वाणि तथोर्ध्वं सा तिथिर्भवेत् ॥ ३१ ॥

Note : In the first line रूपहीनं means subtract one.

S. B. Dixit translated the verse after giving following example. (See Page 82 Vol. I of BJS.)[1]

EXAMPLE – To find when the 10th equinox would fall.
Method–

$10 - 1 = 9$ $\qquad 9 \times 2 \times 6 = 108$ Parvans.
$\qquad\qquad\qquad 9 \times 1 \times 6 = 54$ tithis.

108 Parvans + 54 tithis = 111 Parvans + 9 tithis ... (a)

Adding to this, the period elapsed for first equinox from the beginning of yuga i. e. 6 Parvans + 3 tithis

We get : 117 Parvans + 12 tithis.........(b).

1. BJS. = Bharatiya Jyotisha Shastra by S. B. Dixit English Edn. published by Govt. of India Meteorological Dept., Calcutta.

(10th equinox therefore falls on the 12th tithi of dark half in 118th Parvan from the beginning of the yuga)

In this method of calculations, there are two deviations from the proper meaning of the text, they are :

(i) Dixit subtracts one directly from the serial number of the Vishuvan i. e. ten. This is not according to the sequence of mathematical operations given in the verse.

(ii) Dixit also separately multiplies (10 - 1) by 6 to obtain the number of tithis, which step is not given in the verse. It appears that he does so for giving effect to the implied meaning in the word " तथोर्ध्वं ". We will discuss it at a later stage.

In fact, the first step of the calculations according to the sequence given in the verse for obtaining the number of parvans elapsed up to the TENTH Vishuvan should be.

$10 \times 2 = 20$ (विषुवं तद्गुणं द्वाभ्यां)
$20 - 1 = 19$ (रूपहीनं)
$19 \times 6 = 114$ (षड्गुणं)
i. e. 114 Parvans ... ...(c)

(See page 36 of my book " Vedic Astronomy ")

Thses parvans are in fact solar parvans elapsed from the beginning of the yuga.

The portion marked above by me as (b) in Dixit's calculations appears to be inserted by him, assuming that it is obvious to add it. It does not find any place in the verse. Its insertion is objectively oriented.

Let us now turn to the explanation of the last quarter of RVJ. 31.

" तथोर्ध्वं सा तिथिर्भवेत् "

Apte 's dictionary gives one of the meanings of the word ऊर्ध्वं as " afterwards or subsequent to ". Perhaps keeping this meaning in his mind, Dixit inserted an additional and subsequent step in his calculations [see portion (a) of the above calculations].

$9 \times 1 \times 6 = 54$ tithis

But the text of RVJ. 31 does not give such a subsequent step for calculating tithis. The word तथा means " in that manner." The literal meaning of this line of RVJ. 31 is ;—

" in that manner subsequently it would become a tithi."

A question would thereafter arise : " by what method tithis should be derived from the parvans obtained by the method given in 1st line of RVJ. 31 ?" Obviously, they should be obtained by a general method by using the verse RVJ. 4 (निरेकं) and RVJ. 23.(तद्‌र्धं) together, We proceedfrom the portion marked (c) above with the following steps—

114 parvans have elapsed from the beginning of the yuga, according to 1st line of RVJ. 31. Now according to RVJ. 4 we have to calculate the number of semesters (half years) that have elapsed since the begining of the yuga.

114 parvans/ 12 = 9 semestars + 6 parvans.

According to RVJ. 4, we have to deduct one parvan per semester from the number of parvans at step (c) in the calculations given above.

(114 – 9) parvans = 105 parvans (निरेकं द्वादशार्धाब्दं)
(105 + 2) parvans = 107 parvans (द्विगुणं गतसंज्ञिकं)
Thereafter we have to apply the rule in RVJ. 23.
107/2 = 53½ tithis.........(तदर्धं दिनभागानां)
= 3 parvans + 8½ tithis.........(r@tushesha)

∴ total number of lunar parvans and tithis elapsed from the beginig of the yuga are :

114 parvans (according to 1st line of RVJ. 31)
+ 3 parvans + 8½ tithis.........(r@tushesha)

117 parvans + 8½ tithis ....(d)

This is the answer according to a the concept of 19 year yuga.

It is worthy to compare the last quarter of RVJ. 31 with second line of YVJ. 23, i. e.

पक्षा यदर्धपक्षाणां तिथिः स विषुवान् स्मृतः ।। २३ ।।

The word " अर्धं " which appears here is conspicuously absent in the corresponding R@k–Verse RVJ. 31.

Following calculations would explain the above cited line of YVJ. 23 after step (c) in the calculations given above.

114/2 = 57 tithis (पक्षा यदर्धं पक्षाणां तिथिः)
= 3 parvans + 12 tithis ....(e)

We add step (e) to step (c) to get total number of parvans and tithis.

114 parvans	......from (c)
+ 3 parvans + 12 tithis	......from (e)
117 parvans + 12 tithis	...... (f)

This is the answer according to a 5-year yuga of the Yajus-text. It differs from the answer calculated according to to the R@k text, which is at step (d) above.

13. Q. 3— **Another question which is usually asked is that "wether a 19-Year cycle was otherwise used in any other text of ancient Vedic astronomy ?"**

Ans.— In fact this question should not arise, when there is an inbuilt evidence of a 19-Year luni-solar cycle in the text itself. Yet the following evidence may be considered.

(i) In original Romak Siddhaanta (मूल रोमक सिद्धांत) it is said "Romaka's yuga consisted of 2850 years. During this period the number of intercalary month was treated as 1050 and that of pralaya's or "Suppressed tithis" (क्षय तिथि) as 16574 (Please see page 10 Vol. II of BJS.). The concept of क्षय तिथि is not known to foreigners. The सिद्धांत is therefore purely Indian. 10500 intercalary months in 2850 years are equivalent to 7 intercalary months in 19 years.

14. Romans were not aware of Metonic cycle; they therefore followed the Egyptian Calendar. Original Romak Siddhaanta was known to the Hindus before ptolemy (Please see page 1 2 ibid). Its antiquity is not known. We can therefore presume that the original Romaka Siddhaanta was taken by its author from R@k.-text of Vedaanga, and subsequently modified.

(ii) In (R@g-Veda III-9-9) the sage says :

"Three thousand, three hundred and thirty-nine divinities have worshipped AGNI: they have sprinkled him with butter, they have spread for him the sacred grass: and have seated it as their ministrant priest." (Wilson's Trns.)

15. Let us read this verse in the context of the naxatras, their subdivisions, the divisions of the tithis in bhaamshas and the vedic deities. We know that the naxatras are the of houses

the vedic deities (देवगृहा वै नक्षत्राणि, तै. ब्रा. १ .५. २) and there are 27 such deities. Eaeh naxatra is divided in **124** bhaamshas (Bh^{o}s) $27 \times 124 = 3348$. The Sun travels 9 Bhaamshas in a tithi. We have, therefore, **3348/9 = 372** tithis in a year, according to these calculations. 372 tithis per year indicate a reckoning of five-year yugas, but the figure 3339 which occurs in R@k. III-9 indicates something different. Let us presume that the Vedic sage thought of a seperate deity for each Bh^{o} in a year, just as we have a separate deity for a naxatra. The number of tithis in a year must have been reckoned as $3339/9 = 371$. In a 19-year luni-solar cycle we have years consisting of 371 tithis. This means the Vedic sages knew the19 year luni-solar cycle.

16. This R@k-verse III-9-9 also gives us the reason why in RVJ. 10 and RVJ. 11 the author of vedaanga Jyotisha divided the ecliptic in 3348 divisions of Bhaamshas (Bh^{o}) and subsequently reduced the number to 3339 Bh^{o} by dropping the number by 9 Bh^{o}. The figure 3339 can only be arrived at by stages. The ecliptic or the year is required to be divided in 27 naxatras or SIX seasons. The figure 3348 is divisible by both of these numbers. Bhaamshas are required to be reduced from 3348 to make the length of the ecliptic suitable for actually observed 19-year luni-solar cycle. This is done by the author in RVJ. 12 and RVJ. 13 where he reduces the figure by 9 Bh^{o} = 1 tithi.

17. **Q. 4— Why the 19-Year calendar was given up when it was so accurate and sufficient for priests' needs ?**

Ans.— Vedic priests had two objects before them while composing the Vedaanga Jyotisha : (i) To prepare a fairly accurate calendar for having in advance the knowledge of the tithi and lunar naxatra of the first day of the next solar-semester for the beginning of sacrifices. (ii) To know the exact mean periods of sidreal revolutions of the Sun and the Moon, in pursuit of the knowledge about the nature. R@k-calendar was given up for following reasons.

(i) The charts of astronomical particulars prepared according to the Rik-text of "Vedaanga" had 19 entries. The Yajus-text supplied a thumb-rule and reduced the number of entries to five, at a loss of some accuracy within reasonable limits. A small number of verses learnt by heart could therefore serve the purpose of easy calculations for a calendar.

(ii) The difference between the tropical-year and the sidereal-year was not known to earlier civilisations, so also to the Vedic sages. It is possible that due to precession of eqinoxes, after about 1200 to 1500 years the then generation might have found that theoretical calculations based on 'Vedaanga' did not accord with their actual observations and the seasons. They might have thereafter discontinued its use for practical purpose and retained it only for religious purpose.

(iii) Vedic astronomers recorded the sidereal periods of the Sun and the Moon for a few million years by the instruments which were then available with them. As the time passed they could arrive at more accurate conclusions. In the original Surya-Siddhanta, (composed a few hundred years before chirst) it is written that in 180000 sidereal revolutions of the Sun we have 66389 intercalary months. (Ses page 21 of Vol. II of BJS.) The following chart will reveal the nature of accuracy—

Method of calculations	Period of a lunation	Intercalary months in 180000 Years
1. Modern instruments	29.530588 days	66374.425 months
2. R@k-text of Vedaanga or Metonic cycle	29.531365 days	66315.79 months
3. Original Surya Siddhaanta	29.5303902 days	66389 months
4. 160 sidereal Year cycle	29.5305803 days	66375 months

(iv) From about 500 A. D., like the Chinese, the Hindus started following the meterological or 'Sankranta Method' of intercalation. It is described on page 7 of the book. Since the time of introduction of 'Sankranta-Method' of intercalation both the text of Vedaanga Jyotisha went out of use. It became difficult to make out their meaning. It appears that semester-sacrifices were rarely performed in this period.

18. Q. 5— **Did 5 Year-luni-solar cycle ever exist ?**

Ans.— Those, who think that the bais of Vedanga Jyotisha is a 5-Year Luni-Solar cycle, ~~agree~~ that when Vedaa- argue nga Jyotisha was composed, the angular velocities of the Sun and the Moon with respect to the earth might be such that the Vedic sages on practical verification found a 5-Year-luni-solar cycle. This is also not possible, because we find that the lenght of the day is decreasing at the rate of 0.00000002 seeonds per day as measured by modern instruments. We have to go back 2 crores of years in antiquity to reach a probable cycle of 5 years.

Some scholars including Dr. K. D. Abhyankar from Usmania University, Hydrabad (Andhra Pradesh) think that " A knowledge of the 19 Year luni-solar cycle is not necessary to have a good working luni-solar calender. Vedaanga Jyotisha is only a rule book for preparing a five year calendar which must necessarily have been modified from time to time by actual observations " (Please see his Review on the book in Science Today, Feb. 1990 issue.) Had Mahaamuni Lagadha not used 27 naxatras to plot the mean sidereal positions of the Sun and the Moon, I would have accepted this proposition. Vedaanga specifies the day of the begining of the Yuga as (i) Winter solstice with (ii) the Sun in Shravistha naxatra and (iii) the last day of a Paxa (पक्ष) i. e. a specific phase of the Moon. These particulars of the positions of the Sun and the Moon can be observed in the sky only once in 19-years. According to 5-year luni-solar cycle theory we are expected to observe identical positions on the 'New-Year's days of 1st, 6th, 11th, and 16th year of the cycle which is not possible. The 2nd column of Table No. 5 in my book (at page 33) gives the names of naxatras indicating the positions of the Moon on the first day of each of the 19 Years, which were expected to be observed in the sky in Vedaanga period. Let us compare these entries with those in Column No. 4 in Chart III (at page 75) in my book. The chart gives particulars of the 5-Year cycle. The naxatra positions of the Moon in these two tables do not tally. They differ very much. Suppose we have to select a set of 5 years from the set of 19 years from table no. 5 and we also allow a reasonable error in selecting the first year (e. g. 9th year) then in the last year

(Idvatsara) we have a vast difference in the naxatra position of the Moon. (Please compare Moon's positions in the 13th year in Table No. 5 with the last year in Chart No. III) The difference in the theoritical calculations and actual observations would be 4 naxatras i. e. about 53°. There was therefore no scope for modifications at the time of actual use of the so called 5-year cycle as contemplated in the R@k-paath of Vedaanga. I do not mean to say that 5-year cycle could not or was not used by Hindus at any time. It might have been used without the complex system of tithis as well naxatras with solstices as included in the R@k-text of Vedaanga Jyotisha.

19. Q. 6 : **Whether the Hindus borrowed the theory of the 19-year luni-solar cycle from Babylonia or china?**

Ans. : Those who ask questions on Vedic astronomy go to the extreme end in asking their questions. They challenge the extent of accuracy of the R@k-text of the Vedaanga Jyotisha. When it is shown that the base of the text is a 19-year luni-solar cycle, they express that the knowledge about this astronomical cycle must have been borrowed by the Hindus from Babylonia and China. They forget that the basic researches in natural sciences can be made independently by different civilisations, which can come to the same conclusion. The following points show the distinctive nature of the system in the R@k-cycle.

(i) In the R@k-cycle, we have to divide the period of 19 years in 38 semesters. The first line of the RVJ-4 & RVJ. 19 RVJ-20 directs us to make calculations of surplus tithis at the end of each semester. As a result, the periods for intercalations are at the intervals of 3, 5½, 8½, 11, 14, 16½ and 19 years, while in the Babylonian cycle, the intervals for intercalations are at the end of 3, 6, 8, 11, 14, 17 and 19 years. (See page 605 of En. Cl. Br. XV Edn, vol. 3 on calendars and p. 3 of this book.)

(ii) Sage Lagadha uses smaller unit i. e. the tithi for calculations of intercalary months, while it is the solar days in other systems.

(iii) Vedaanga Jyotisha is a text which not only gives a method for preparing a calendar for the solar year with lunar months in terms of tithis, as well as naxatras, i. e. sidereal months, but it also gives a method of separation of sidereal intercalary months, at proper parvans. In this respect it is a peculiarity of the R@k-Joytisha.

(iv) Modern astronomers divide the ecliptic in 360°, and use the ecliptic with such division as an axis for marking the positions of the celestial bodies, i. e. the Sun, the Moon, & planets, comets, and stars etc. They call such a measurement a 'longitude.' Sage Lagadhgha divided the ecliptic in 3339 Bh° for marking the positions of the Sun and the Moon. In this sense, the R@k-text of the Vedaanga Jyotisha is the first book on 'Positional Astronomy' in the history of the world.

20. Q. 7 : **What was the social or cultural background which compelled the Vedic sages to make astronomical observations and to design an accurate luni-solar calendar ?**

Ans. : The Hindus named the days according to the name of the naxatra i. e. the small asterism, with which the Moon was in conjunction on that day. (e. g. in the Mahabharata, Shalyaparvan verse 34 /6 : Balarama remarks. 'I have proceeded (for journey) on Pushya-day and returned on Sharavana-day. There are in all 28 naxatras. One of these was ancillary, (for reasons please see page 17 of the book).

21. A host who performed the sacrifices was required to solemnly affirm in advance the day and date of the beginning of the sacrifice (RVJ-36). Such an affirmation was called a sankalpa. Sacrifices began either on the day of the solstice or on an equinox. (RVJ-31). Vedic sages could therefore keep record of their astronomical osbervations and find out the relation between the mean sidereal period of the Sun and the synodical period of the Moon.

22. Q. 8 : **What is the archaeological evidence to show that Man had made progress in the proposed antiquity of Vedaanga Jyotisha to make the detailed calculation as shown in the present book.**

Ans. : In the Indian subcontinent, archeologists have excavated the Indus civilisation dating back to 9½ thousand years from now at Mehergadh near Quetta in Baluchistan.

Heaps of thatched rice in Uttar Pradesh were found dating back to 8000 years. The antiquity of both the excavations is fixed with the carbon dating method. There is, therefore, no wonder if we find Sage Lagadha composing the Vedaanga Jyotisha in the 3rd millenium before Christ.

23. Q. 9 : **What is the place of the composition of the Vedaanga Jyotisha ?**

Ans. : S. B. Dixit calculated the latititude of the place of composition of the Vedaanga Jyotisha from verse no. 7 and 22 of the R@k-test as 34°45'.8 N. or 34°54' N. Scholars therefore guess the place as either Shrinagar or Taxasheela. It is worthy to note that Taxashcelaa (Taxila) was once upon a time a University (an *Aashrama*) of Vedic learning.

I hope that the above mentioned clarification will leave no doubt that Mahamuni Lagadha knew the 19-year luni-soarl cycle and that is the base of the R@k-text of Vedaanga Jyotisha.

7th June 1990
Vata-Paurnima

Comments by Arun Kumar Upadhyay, Cuttack-753001
(M) 09437034172, Email <arunupadhyay30@yahoo.in>

1. **Meanings of Samvatsara**-(1) Samvatsara = Sam+vat + sarati = moves in rune with that. Shaka =cumulative count of days from a particular epoch, from which positions of planets are calculated. That gives mathematical year. Samvatsara is civil year followed by society which is almost similar to Shaka. Fastings and festivals are mostly as per Samvatsara which is decided by phases of moon. For ease in calculation, Shaka is solar year. Following of Samvatsara is called Samavasarana (anniversary) in Jain tradition. Mathematically, Samvatsara is alunar year which is equated in long period with solar year by adding extra lunar months.

(2) Orbit of earth in which earth is continuously changing its direction (curved motion). This is from rot verb tsara = oblique motion (Panini Dhatupatha 1/373).

(3) Collection of seasons-'*Samvasanti ṛtavah yasmin*'= in which *ṛtu* (seasons) reside. This has two meanings. In the space of solar system there are 6 zones of varying energy-

Zone number	**location**	***Ahargaṇa* No.**(radius of nth zone = earth radius x 2^{n-3})
0	Earth surface	3 (2 layers within earth as image of solar system, galaxy)
1	2^6 times earth	9 (sphere enclosing moon orbit)
2	2^{12} times earth	15 (sphere extending up to 60% of venus orbit)
3	2^{18} times earth	21sphere around sun, radius of 1000 sun diameter)
4	2^{24} times earth	27 (*maitreya* or *sāvitrī maṇḍala*, 1 lakh sun diameter)
5	2^{30} times earth	33 (*dyu* or sky of solar system, 1 crore diameter)

On earth surface, there are 6 seasons due to apparent north-south motion of sun. In this sense, Samvatsara means tropical year.

(4) Jupiter years by mean motion of Jupiter in a zodiac sign which almost matches with solar year.
(5) One of 5 years named by 5 prefixes –sam, pari, ida, anu, id -to the root word 'Vatsara'. Even vatsara is a civil year of 12 x 30 = 360 days which is mathematically convenient. All other years are by slight adjustment to that.
(6) Longer periods of rotation like (a) saptarshi-vatsara (or samvatsara) of 3030 manusha years (12 rotations of moon in 324 days) or 2700 divya or solar years, (b) Dhruva or Kraunch vatsara of 9090 manush years, (c) Divya samvatsara of 360 solar years, (d) Guru vatsara in 60 years cycle (e) Ayanabda = 24000 years cycle slightly shorter than Ayana-cycle of 26000 years, but matching with glacial cycle-so Bija correction is in this cycle as per Agama, quoted by Brahma-gupta and Bhaskara-2.

त्रीणि वर्ष सहस्राणि मानुषेण प्रमाणतः ।

त्रिंशदधिकानि तु मे मतः सप्तर्षि वत्सरः ।।

(ब्रह्माण्ड पुराण, १/२/२९/१६, वायुपुराण, ५७/१७)

सप्तविंशति पर्यन्ते कृत्स्ने नक्षत्र मण्डले ।

सप्तर्षयस्तु तिष्ठन्ते पर्यायेण शतं शतम् ।। (वायु पुराण, ९९/४१९)नव यानि

सहस्राणि वर्षाणि मानुषानि तु। अन्यानि नवतिश्चैव ध्रुवः सम्वत्सरः स्मृतः॥

(ब्रह्माण्ड पुराण १/२/२९/१८, वायु पुराण ५७/१८-क्रौञ्च सम्वत्सर)

Here , 2700 Divya years = 2700 x 365.25 days, 3030 *Mānuṣa* years = 3030 x 327 days. Both are equal.

2. Yuga of 5 Samvatsaras-

पञ्च संवत्सरमयं युगाध्यक्षं प्रजापतिं (ऋक् ज्योतिष १, याजुष ज्योतिष १)

पञ्च संवत्सरं प्रपद्येते कार्याः कला दश च याः पर्वसंविता विषुवं सप्त (ऋक् ज्योतिष, उपसंहार)

Here, yuga of 5 Samvatsaras has 3 meanings-
(1) Yuga is of 5 years.

(2) Yuga has 19 years in Rk jyotish, out of which 5 years are of samvatsara type and other 14 years are of remaining 4 types

(3) Yuga is determined by 5 types of samvatsaras-(a) Guru, (b) Divya, (c) Saptarshi, (d) Krauncha (e) Ayana.

3. Saptarshi vatsara– It is of 2700 years in which Saptarshis make complete rotation of 27 nakshatrs @ 100 years each. Vishnu purana tells that the line joining 2 eastern stars meets zodiac (Kranti-vritta) at a point which is called nakshatra of Saptarshis. That point moves in reverse direction and remains in a nakshatra for 100 years.

सप्तर्षीणां तु यौ पूर्वौ दृश्येते ह्युदितो दिवि।

तयोऽस्तु मध्ये नक्षत्रं दृश्यते तत्समं निशि॥१०५॥

तेन सप्तर्षयो युक्तस्तिष्ठन्त्यब्द शतं नृणाम्। (विष्णु पुराण ४/२४/१०५)

There can be another interpretation of Saptarshi era. In each century, there are 5 yugas of 19 years each of Rk type (or 5 x 5 years of Yajush jyotish with 6 kshaya year-page 68) and additional 5 years of 1 Yajush yuga. In that yajusha yuga, there is one nakshatra extra (Table 7 at page 69). Beginning of yuga is from Shravishtha, but beginning of 6th years (Sammida) is from next star Shatataarakaa. To adjust that, we may mark the century by a nakshatra in backward manner. That could be only a convention and not real motion of saptarshis.

4. Antiquity of Vedanga jyotish– By assuming start of year from winter solstice, its period has been determined to be 2976 BC (page 81) and Yajush jyotish 2352 BC after 624 years. However, since time of Vivasvan, Surya-siddhanta was in use which starts year with Chaitra month. His son Vaivasvata-Manu was in 13,902 BC. After him, Satya, Trta and Dvapara of 4800 + 3600 +2400 years ended in 3102 BC when Bhagvan Krishna passed away. This was revised by Maya Asura when 121 (alpa) years were remaining in Satya-yuga, i.e. in 9223 BC. Prior to that, Brahma started year with Rohini nakshatra, then with Abhijit star. When Abhijit star fell, i.e. direction of north pole shifted away from that, then the year started with Dhanishtha which has been described in Vedanga -jyotish. Mahabharata quotation is given below-

अभिजित् स्पर्धमाना तु रोहिण्या अनुजा स्वसा।

इच्छन्ती ज्येष्ठतां देवी तपस्तप्युं वनं गता॥८॥

तत्र मूढोऽस्मि भद्रं ते नक्षत्रं गगनाच्युतम्।

कालं त्विमं परं स्कन्द ब्रह्मणा सह चिन्तय॥९॥

धनिष्ठादिस्तदा कालो ब्रह्मणा परिकल्पितः।

रोहिणी ह्यभवत् पूर्वमेवं संख्या समाभवत्॥१०॥

(महाभारत, वनपर्व, २३०/८-१०)

Fall of Abhijit started in 16000 BC. Then Dhanishtha was start of rains, i.e. rains started when sun entered Dhanishtha in about 15,800 BC-about 13000 years before estimate of Sri Holay. That is the reason why year is called Varsh as Varsha means rains. Till Karttikeya, Asuras were supreme, hence Surya-siddhanta calls this as Asura year (southward motion of sun is day of Asuras, north motion is day of Devas).

This also supported by the fact that Karttikeya was before Vaivasvata Manu. That was Deva-yuga prior to Satya-yuga

आदिकाले हि अदितिसुतसमौजसोऽति विमल विमल विपुल प्रभावाः प्रत्यक्ष देव-देवर्षि धर्म यज्ञ विधि विधानाः (चरक संहिता, विमान स्थान ३१/३)

पुरा देवयुगे ब्रह्मन् प्रजापति सुते युगे।

आस्तां भगिन्यौ रूपेण समुपेतेऽद्भुतेऽनघे॥

ते भार्ये कश्यप्स्यास्तां कद्रूश्च विनता च ह। (महाभारत, आदि पर्व १४/५)

पुरा देवयुगे राजन्नादित्यो भगवान् दिवः। (सभा पर्व ११/१)

पुरा देवयुगे चैव सृष्टं सर्वं मया विभो। (वन पर्व ९२/७)

पुरा देवयुगे राजन् चार्वाको नाम राक्षसः। शान्ति पर्व (३८/३)

Karttikeya had defeated Krauncha dvipa (north America in shape of flying bird. Prior to that, it was supremacy of Asuras centered in Krauncha. Dhruva year started after demise of King Dhruva as per Bhagavata purana. After one cycle of 8100 years, it was Kraunch supremacy-then it was Kraunch samvatsara.

त्रैलोक्यादधिके स्थाने सर्वताराग्रहाश्रयः।

भविष्यन्ति न सन्देहो मत्प्रसादाद्भवान् ध्रुव ॥९०॥

सूर्यात्सोमात्तथाभौमात्सोमपुत्राद् बृहसतेः।

सितार्कतनयादीनां सर्वर्क्षाणां तथा ध्रुव ॥९१॥

सप्तर्षीणामशेषाणां ये च वैमानिकाः सुराः।

सर्वेषामुपरि स्थानं तव दत्तं मया ध्रुव ॥९२॥

(विष्णु पुराण १/१२/९०-९२)

When 2 more cycles were completed after 16200 years, again Saptarshi cycle started in kali 25 (3076 BC) when Yudhishthira expired. Thus, Krauncha-samvatsara was in 19276 BC. Asura supremacy was for 10 yugas = 3600 years, after which Karttikeya started calendar from Shravishtha (Dhanishtha) nakshatra in about 15800 BC.