What Euclid is to Europe, Panini is to India – Or Are They?

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The topic of this evening is the thesis that Euclid is to Europe what Pāṇini is to India. It is a baffling topic because it causes havoc to a widespread prejudice: the myth of the two cultures of sciences and humanities. The sciences, it is said, are exact and rigorous; the humanities seem to lack those qualities and what they offer instead is not very clear. Since Euclid was a mathematician and therefore a scientist, he belonged to a species that is highly regarded and for good reasons. Pāṇini, on the other hand, was a grammarian or linguist – according to some a more marginal occupation. So must we accept the myth and draw the conclusion, that Europe addressed basic and substantial issues but India dabbled in trivialities?

I hasten to add that I am not attributing any belief in that outlandish myth of the two cultures to academic
institutions such as the National Institute of Advanced Studies that has honoured me with an invitation. Modern academia includes numerous recent disciplines that transcend such boundaries – I mention only the cognitive sciences and many that deal with information and communication. All the same, popular imagination adheres to the picture and if you want money, especially in the United States, you better claim that what you are doing is science. I am therefore especially grateful and pleased that I am allowed to address the Associates of a National Institute of Advanced Studies and not just Sciences. Perhaps in the final resort, those studies are just sciences since it is, at least in part, a matter of words and definitions.

I am very happy also that I am in a position to visit Bangalore. It is not for the same reason as the prime minister of China, who preceded me in entering India at your cool and leafy city, spurning a red-carpet arrival in New Delhi in order to delve into the heart of India’s information technology and globalizing economy. Mr. Wen Jiabao did not come to announce my impending visit and I shall not follow him and proceed to New Delhi, but return to Thailand.

I spent much time in South India but do not know Bangalore well. I missed a rare chance to spend some years here and if I had been able to do it, my Sanskrit would be better. As a graduate student of Advaita Vedanta at the University of Madras, I visited the Shringeri Matha where I was introduced to the then Sankaracarya, Jagadguru Swami

Abhinava Vidya Tirtha. He was quite young himself and was studying a difficult late Advaita text, Vidyārānya’s Vivaranaprameysaṃgraha, under the tutelage of Panditataraja V.S. Ramachandra Sastri of the Sankara Matha of your beautiful city. Among the other luminaries, all University Professors, Ramachandra Sastri was the only traditional Pandit member of the first Sanskrit Commission of the Government of India. He did not speak to me but the Jagadguru addressed me in Sanskrit and must have noticed that I did not always get it. Having heard me stutter, His Holiness graciously suggested that I spend some years studying myself with that same great Pandit. But when I went back to the University of Madras, my Professor did not like the idea since I was a Government of India scholar. The Government might not approve such a transition, or approve it soon enough. And so I missed those golden opportunities to learn Sanskrit well and spend some years in Bangalore for which I now must make up fast.

But you came to hear about Euclid and Pāṇini – so where were we? I was holding forth on the difference between the sciences and humanities, arguing that we should not make that distinction. I must now explain briefly how anyone could have come up with such a preposterous idea. It was the pet theory of a nineteenth century German philosopher, Wilhelm Dilthey. Dilthey was basically a historian and did not know much about what he called the natural sciences. His more famous colleague Edmund Husserl, the founder of phenomenology, considered him
chiefly as a man of genius for intuition, not of rigorous science and theory. Dilthey himself preferred to call the sciences of culture *Geisteswissenschaften* or “sciences of the spirit,” even though no one knew or agreed on what a *Geist* or Spirit was. Whatever it is, or precisely because of that aura of mystery, the idea about the distinction between sciences of nature and sciences of culture caught on as if with a vengeance.

Then, a century later, Dilthey’s ideas were rather unexpectedly supported by the British author and physicist C. P. Snow. It is he who introduced the phrase of “the two cultures”. Snow wrote several novels about scientists but that does not mean that he knew anything about the science of literature, let alone the sciences of language, just as an elephant, himself an animal, does not know anything about zoology, let alone the life sciences in general. And so we are left with a distinction between two things, A and B, based upon the ideas of two people, one who knew A but not B, the other B but not A. A shaky foundation.

My conclusion is that we should not make sharp distinctions between large groups of scientific disciplines. Yes, there are many, like pebbles on the beach, but they are not only painted in two colors, red and blue. If you want a substantial foundation on which to base this negative conclusion, you need only glance at the history of science. During the European middle ages, the distinction did not exist. Music, for example, was regarded as a science. If you look at China, India, or the Arab world, there is no trace of

that distinction either. I conclude that we can only study the subject of this evening dispassionately if we accept a very flexible notion of the concept of science. I have found it fruitful to regard as science all forms of systematic knowledge of ourselves and the universe in which we live.

So let us try to turn to Euclid with an open mind. It is not known where he was born, but he was probably taught geometry at Athens by pupils of Plato, and taught and founded a school at Alexandria. His famous *Elements*, which were written around 300 BC, are a systematic treatise on geometry. He may not have been a great mathematician, like some other ancient Greeks, and has been called an excellent schoolmaster. He did indeed write a textbook that incorporated many theorems that others had discovered before him. But I believe that he was more than a schoolmaster because his axiomatic method was new and has so far lasted for almost two and a half millennia. Of course, few things are totally “new.” Euclid’s text starts with what he calls “common notions”, a concept that comes from Aristotle, Plato’s star pupil. Common notions are what we now call axioms. Let us take a look at an example: *Things which are equal to the same thing are also equal to each other*. It means that if 3 + 2 equals 5, and 7 - 2 also equals 5, then it follows that 3 + 2 and 7 - 2 are equal to each other. But Euclid was not, or not primarily, thinking of numbers. He was thinking of lines or line segments. His work is first and foremost about geometry though it includes some chapters on numbers. In both areas, his innovation and great contribution was to prove or
demonstrate mathematical propositions by deriving them from axioms.

Let us look briefly at one of his propositions. It is not formulated as a statement, as you might expect, but as a construction and says: "To draw a straight line at right angles to a given straight line from a given point on it." The demonstration starts with the sentence: "Let $AB$ be the given straight line, and $C$ the given point on it." This is accompanied by a figure, which depicts a triangle that stands on the line. In the printed editions of translations of the Elements, these points are marked A, B, C, D, etc. In the medieval manuscripts they are indicated by the letters of the Greek alphabet, alpha, beta, gamma, etc. The proof ends with Q.E.D. or rather the Greek equivalent of the Latin Quod est demonstrandum, "which is what had to be demonstrated."

You must not rush to the conclusion that all propositions are constructions. Following Aristotle, Euclid distinguished not only propositions from common notions or axioms. He also introduced other concepts such as hypotheses, postulates and other terms or ideas that he did not always use clearly or even consistently and that specialists continue to discuss. I therefore propose to leave it at that but you need to know one more thing: Euclid paid much attention to definitions. They are actually nicer to quote. The first is: "a point is that which has no part." The second: "A line is breadthless length." And so on it goes.

What were Euclid's shortcomings? There is, of course, a celebrated one: the fifth postulate. The formulation of that postulate by Euclid is quite complex so I shall replace it by a simple approximation. Euclid wrote something like: "Through a point outside a line you can draw only one line that is parallel to the first." That proposition defines flat geometry, it does not apply to the surface of a tennis ball, let alone a mango, and was ousted by the discovery of curved spaces, first in geometry and then in physics and cosmology where they are now used as playthings, more or less. Implicit in the fifth postulate is a deeper and more interesting misconception: the idea that everything in the universe, including ourselves, must be evident to us. It is, of course, a preposterous claim. How presumptuous on our part! We as humans are part of the universe. But why should we have been selected in order to understand it, or even evolved in that direction?

I am not quite finished with Euclid. He may have been refuted here or there, but he also demonstrated many things that are simply true. One of them is the so-called theorem of Pythagoras. It is not something that humanity owes to Euclid, or to the Greeks for that matter. It is well known that such theorems are also found in China and India. In India that particular theorem is often, and with equal justification, called the Theorem of Baudhāyana.

Thousands or more such theorems have their place in what is now called modern mathematics and illustrate, in passing, that modern science is not simply a product of the
European Scientific Revolution, but that the way was paved by the earlier history of ancient and medieval science. That history can only be adequately understood if the Eurasian continent is treated as an undivided unit. During that period, the sciences of the Babylonians, Indians, Chinese, Greeks and Arabs were all in contact with each other. It does not follow that Pythagoras, Baudhayāṇa and the Chou Pei borrowed from each other. It would be enough for there to have been borrowings or influences in the area of geometry, one would have led to the other and it is a topic that deserves serious investigation. If, incidentally, you don’t believe that that famous and multinational theorem is true, you better give a reason. The best reason is to prove that it is false. It will not earn you a Nobel price but you may end up with the Fields Medal in mathematics.

I conclude that Euclid’s legacy is the axiomatic method which does not belong to Europe but to modern science and therefore to the world.

We are now in a position to make a momentous leap and jump to Isaac Newton, the paragon of modern science, though he regarded himself, like some of his colleagues, as a Natural Philosopher. Newton’s *Principia* follows Euclid’s method entirely and in all details. He derives propositions from axioms. He accompanies each proposition with a picture and ends with Q.E.D. But his subject matter is different. He adds what were later regarded as physical entities such as *force*. It was a topic about which Aristotle had already speculated, but in the seventeenth century, the discussion about force was infused with new life by philosophers such as Descartes and Leibniz who were better informed than Aristotle had been. Both these thinkers went beyond Newton in matters of method. The reason is that they made use of the language of *algebra*. Descartes founded what is now called *analytical geometry*, which established a relationship between geometrical figures and algebraic expressions. Leibniz created the largest number of symbolic expressions and notations that are still in use today. As for Newton, he sometimes wrote equations, for example, to express infinite series, but he formulated his most famous laws in Latin which was not always clear. Formulas such as “$f$ equals $m$ times $a$”, which we are now taught in school, were created by later mathematicians such as Euler. It is true that we, today, can easily read them into Newton’s Latin expressions, but we do so by hindsight.

Many of the great philosophers and mathematicians, the natural philosophers of the seventeenth century, including Newton and Descartes, preferred the geometry of the ancients, that is, Euclid’s *Elements*, to the algebra of the moderns. At the same time, most of them, except Leibniz, regarded that algebra as a barbaric art. The case of Descartes is remarkable and paradoxical because he had himself established a link between geometry and algebra. The dislike of algebra may be due to the fact that it had been introduced by aliens, *paradesis*, in the first place the Arabs who did not only use what they had inherited from ancient Mesopotamia, India and China, but made
substantial new contributions. The ambivalence about algebraic expressions of the seventeenth century had entirely disappeared a century later, when awareness of the mathematization of physics had reached the point where Lagrange, in his work on analytical mechanics, could declare: “I require neither constructions, nor geometrical arguments, but only algebraic operations.”

The case of Newton, the one that concerns us, is the most interesting. He stood on the edge between old and new. Gravity demolished his view of flat space and turned out to be no force at all. It was replaced by a curvature of space-time in which all other particles and forces were subsequently housed. But Newton’s view was a simple leftover of Euclid’s parallel postulate with its implicit presumption. Newton stood at the end of the geometrical tradition in physics and hesitated to enter the new era of artificial languages. That is an important part of what the economist Maynard Keynes, a lifelong student of Newton, had in mind when he wrote that Newton, who was obsessed by alchemy throughout his life, was the last of the Magi rather than the first modern physicist.

We should not conclude that, because of Newton, Euclid is now done with. There remains his axiomatic method which others applied in different contexts. Spinoza, a kind of Advaitin as you know and another excellent mathematician, applied the art of demonstration from axioms to what he called ethics – a subject that covered a much wider area but included what is nowadays called by that name. Whether such an approach is fruitful remains to be seen.

Let us retrace our steps. Inspired by Aristotle, Euclid introduced the axiomatic method. He applied it to geometry and Newton extended its use to physics. Its applications to physics and the life sciences are still rather limited, but its applications to logic and mathematics have been spectacular and have led to some of the most celebrated theorems of the last century. One of these is Gödel’s incompleteness theorem.

We are now ready to take another, not necessarily greater jump, and go to the second truncated half of the thesis that we are considering, namely: what is Pāṇini to India? Looking at him from the Greek perspective, Pāṇini did something that is tantalizingly similar to Euclid. He composed a grammar of Sanskrit which starts with a list of syllables or sounds, called the Śivasūtra, from which all of his grammar can be logically derived.

Since we are in India, I shall be brief about Pāṇini’s background. He was, roughly speaking, a contemporary of Euclid. It is a matter on which I expatiated yesterday during the discussion meeting on nature and culture that some of you may have attended. If I had to summarize what I said there and try to adapt it to our context, I would say the following. The background of Pāṇini is the linguistic analysis of the Vedic Prāṭīṣṭhākhya treatises, which started with a discovery that was crucial to the canonization of the Vedas: namely, Sākalya’s fixation of the precise form of
the Rigveda. That took place one or two centuries before Panini and was the paradigm that the other three Vedas adopted — the decisive step that led to the canonization of what were subsequently referred to as "The Four Vedas."

Panini, in other words, did not start from scratch. But he was more innovative than Euclid. His grammar incorporated what his predecessors had done, but it revolutionized the science of language. He did not compose separate treatises on the languages of the different schools or sakhas of the Vedas like the Pratiśākhyaas and from which they derive their name: pratiśākhyā, "one for each school." Panini wrote a totally different kind of grammar for the spoken language of his day and thereby laid the foundation for Classical Sanskrit as well as modern linguistics.

If you contrast the discovery of Śākalya or Vidagdha Śākalya, "Clever Śākalya", as he was called, with Panini’s Śivasūtra you are in a position to appreciate how Panini’s grammar turned the science of language upside down. His Vedic predecessors started with KA, KHA, GA, GHA, NA in one direction, and KA, CA, TA, TA, PA in another; that is they constructed a varga or square. To this they added the vowels and diphthongs: A, AA, I, II, U, UU, R, RR, L, E, O, AI and AU. You do the same in Kannada insofar as I have been able to find out. If I had to summarize what the composers of the Pratiśākhyaas contributed to linguistics I would say: they discovered the natural order of the sounds of language — any language — as articulated in the mouth and the surrounding regions, moving from the larynx to the lips, unvoiced to voiced, non-aspirate to aspirate, etc.

To a modern Indian that insight may still be obvious but the Vedic analysis of the sounds of language was a major discovery and a contribution that seems to have been made only once in world history. It was adopted by most of the languages of India and adopted or adapted by many other Asian languages and scripts.

\[
\text{ai au N/ ī K/ e o N/ ai au C/ ha ya va ra T/ la N/}
\]
\[
\text{aṁ ṽaṁ ṽaṁ jha ṽaṁ/ ha ṽaṁ/ ha ṽaṁ/ ṽaṁ/ ṽaṁ/ ṽaṁ/}
\]
\[
\text{ja ba ga da ṽa/ kha cha thā ca ta ta V/}
\]
\[
\text{ka pa Y/ ū sa sa R/ ha L/}
\]

The Śivasūtra

Panini was, of course, familiar with these achievements. His Śivasūtra starts: ai i u N/ ī K/ e o N/ ai au C. It is strange, but not yet startling. He continues with semi-vowels and then comes to the consonants I
mentioned just now. They are listed as: ञa  마련 �a M /
(I mark the retroflexes or मुर्धयाया in my Roman
transliterations with a dot underneath) jha bha ḇ / gha धha
dha $ / ja ba ga da ḍ / kha pha cha tha tha ca ī ta v /
ka pa Y / and so on. This is rather odd, to say the least.

If you listen to and/or look at these enumerations
carefully you will find two strange deviations from what I
have called the natural order of the sounds of language.
First, Pāṇini garbles or scrambles the order; and second he
inserts all kinds of other sounds. The latter can be easily
recognized because they are consonants such as ḇ, K, C,
that are not followed by a short a. Moreover, I have in my
recitation stopped after each of these latter sounds to mark
a boundary, and the written texts that are before you do the
same by making use of vertical bars. I have given this list
in Nagari and in Roman, simplifying a little, not only
because I cannot do it in Kannada, but because the Roman
has one practical advantage over the Indian scripts: it
possesses capitals. I have used them to mark the sounds
that are not followed by a short -a- more clearly.

European and American scholars have assumed as a
matter of course that Pāṇini’s grammar was composed in
writing which I consider extremely unlikely. As for the
earlier analysis of the Vedic treatises, it was not only about
the mouth, but it was certainly done orally, not merely
because it belonged to a strictly oral tradition, but because
the art of writing had not yet been invented or imported
from elsewhere. Pāṇini does refer to writing, that is, he was
familiar with the fact that some people write. He was born,
after all, in Salatura, near Attock on the Indus, an area that
was then part of the Achaemenid Empire where several
kinds of writing had been known for a long time and where
an Aramaic script was commonly used for administrative
and commercial purposes. Pāṇini was a great scientist and
he had, of course, heard of, and may even have been
familiar with some shapes or features of that Aramaic
script. But he was also a Vedic Brahman and that is one
reason for assuming that he composed his grammar orally.

In Europe, Japan, or the United States, I must tell my
audiences that the ancient Indians did everything orally
which, to them, is astounding; but to you it is nothing new.
For me it is, in fact, a stumbling block. The pandits from
whom I must learn what I want to know, know everything
by heart. They rattle off their Sanskrit at a speed that I do
not only fail to comprehend, I can barely follow it. I am
sometimes regarded as a specialist in oral traditions but,
unfortunately, I myself have to look up everything in books
and papers. I am at this point not even referring to my
advanced age, at which my memory, which has always
been bad, seems at times to have totally given out.

Back to the Śivasūtra. It has been called by that name
at a much later time, closer to the bhakti period and perhaps
in order to suggest that it was revealed by the god Śiva. I
have retained that attractive appellation, but at Pāṇini’s
time, and for many centuries thereafter, that initial list was
called Pratyāhārasūṭrāṇi ("The Rules of Condensation")
or Akṣarasamāṇṇāya ("The Enumeration of Syllables.") I must now account for its two strange deviations from what I have called the natural order of the sounds of language. Both can be explained by introducing the concept of pratyāhāra or "condensation" that I have just mentioned. Pāṇini condenses a set of sounds because he needs them, and only them, for the statement of one of his grammatical rules. That was a momentous innovation and was expressed by means of two other equally great innovations: the use of metalinguistic markers, and the use of metarules which are rules about rules, in Sanskrit paribhāṣā. The latter concept probably antedates Pāṇini.

I am able to explain these two concepts together, because the consonants followed by a short -a- are metalinguistic markers, and their use is explained by the following metarule:

"An initial sound joined to a final metalinguistic marker denotes the intervening sounds as well."

It works as follows. Please look at the picture on page 13. If Pāṇini needs the sounds a, i and u he simply says aN. If he needs i, u, r, l he says iK. If he needs ya, va, ra, la he says yaN. The two latter condensations are combined to state a rule that explains something with which I am sure many of you are familiar. In Sanskrit, dadhi followed by atra becomes dadhvatra, "milk here," and similarly, madhu followed by atra becomes madhvatra, "honey here." Pāṇini combines these facts with many others and arrives at a general rule which says: "iK (that is, i, u, r, l) becomes yaN (that is, ya, va, ra, la), respectively, when aC (that is, any vowel) follows."

Paul Kiparsky, who worked with Chomsky at MIT and with S.D. Joshi at Poona, has shown that Pāṇini introduces abbreviatory conventions into his metalanguage, if and only if they make it possible to bring out significant generalizations in the grammar. Economy, in other words, is Pāṇini's way of achieving generalization. It is a long demonstration and provides a rational explanation for the popular maxim, that grammarians rejoice over the saving of half a syllable as over the birth of a son. It should perhaps be quoted in Sanskrit: ardhamātrāghavena putrotsavam manyante vaiyākaranāḥ.

I have a few more things to say about Pāṇini before we shall change course and revert to the original thesis.

First of all, Pāṇini needed, like Euclid and as a matter of course, definitions. Even if they deal with simple things, as some definitions should, they are not simple and sometimes deeply embedded in the grammar. I like the definition of padam or "word." It basically says that a word is a nominal or a verbal form, that is, a noun or a verb. Pāṇini defines both these categories in terms of their endings since Sanskrit is, as you know, a language with a rich system of declensions and conjugations. The list of endings of the nominal declensions are condensed and referred to as suP. The list of endings of verbal conjugations are condensed and referred to as tīN. Now comes the definition of "word": "a word is what ends in suP or tīN" or in the original Sanskrit: supiṇantaṃ padam.
Quite as succinct and attractive, I think, as “a point is that which has no part”, and, more importantly, an equally significant generalization about our world in which humans and their languages are included. Also another artificial expression that goes beyond Euclid in not being merely stated in a natural language such as Sanskrit or Greek.

Pāṇini’s Sanskrit grammar was composed in sūtra-form. The genre of sūtra or “rule” was destined to have a great future in Sanskrit scientific and philosophic literature. It was later defined as “a brief and concise statement which should capture the essence, be undoubted and face all directions.” Sūtras are often expressed by a formalized kind of Sanskrit. The Sanskrit of Pāṇini’s rules is unintelligible to someone who knows Sanskrit but has not studied Pāṇini. They are highly formalized and resemble formulas. Since they are generally unintelligible in isolation, that is, outside the system in which they played a role, they need to be explained. This led to other new forms of Sanskrit literature, in particular the genre of writing commentaries or bhāṣya, subcommentaries, glosses, vṛtti, varttika, tika and so on. All these works use expressions and linguistic conventions that are to some extent formalized and have their counterparts in medieval Latin, though Latin is less formalized than the language of Indian linguistics. As for the sutras themselves, Pāṇini’s grammar was not only the paradigm, but it remained their most perfect example.

Pāṇini permits himself an occasional joke, or perhaps pleasantry is a better term. One is the final rule of his grammar which is: a a. It is, like many other rules, interrelated with many others and I shall not try to explain it. But it happens to illustrate a recent event in the history of linguistics, a subject on which I shall be even more sketchy than I was in the case of Euclid and Newton.

Pāṇini’s grammar led to a vast output of works on grammar, in different schools and with ramifications into other disciplines such as poetics. Grammar was, in India, the Science of the Sciences, and the number of works on grammar may be as large as that of all the other Indian sciences together. One reason is that all writers of Sanskrit studied Pāṇini’s grammar or later incarnations such as the grammar of Candragomin that Buddhist authors used. Pāṇini is similar to Euclid also in another respect. Euclid had a great commentator, the Neo-Platonist Proclus who lived seven centuries later. Pāṇini had an even greater commentator, Patañjali who lived two or two and a half centuries later. Perhaps the pace of progress was greater in India than in ancient Greece toward the end of its flourish. Patañjali stated clearly that Sanskrit is infinite, a basic property of language that was implied by Pāṇini’s grammar but never stated explicitly since Pāṇini left us nothing but his rules.

Philosophers of language depended on Pāṇini and I should mention at least Bhartrhari, the greatest and most original of them. Indian linguistics was also influential in other Asian countries, especially in Tibet. In Europe, it led via Franz Bopp to the beginning of modern linguistics.
There is a curious reason for the importance of Pāṇini’s grammar to the development of synchronistic linguistics in Europe. That type of linguistics, that treats language not as a development but as a system, was a reaction against the diachronic or historical philology of textual scholars. Its founder, Ferdinand de Saussure, did not like or understand Pāṇini’s grammar which is structurally similar to his own. But the reasons, in the case of Pāṇini, were different and based upon an erroneous belief: that of the eternity of Sanskrit. It illustrates that science can grow out of mud just like the lotus which is pañkaja.

Pāṇini’s witticism is repeated by the only other linguist who is of a similar stature: Noam Chomsky. Chomsky has never mentioned the name of Pāṇini in any of his numerous writings, as far as I know. But the major work on phonology of the 1960’s, a large volume that was written by Chomsky in cooperation with his closest colleague at MIT, the phonologist and Indo-Europeanist Morris Halle, ends with a rule of the same form: $a a$. I would not be able to explain it, but it is a small bow to the Indic master that not every reader may appreciate or understand.

Chomsky is well known in India and you may be familiar with his politics, if not his linguistics. When he returned from his first visit to this country, I asked him what did strike him most. He said: the ease of access to the leaders of the government: “I was immediately invited for lunch by Indira Gandhi, but would have to wait very long or for ever before I would be able to see (US) President –”.

and here followed a name that I have forgotten. I can imagine one reason. Chomsky is as clever as were Śākalya and Pāṇini. That does not generally hold for an American president.

I conclude that Pāṇini’s greatest contribution was the structural system of his grammar which was based upon a unique method and led to deep generalizations, many of which are valid across languages and may be linguistic universals. Insight in the infinity of language was part of that package.

I must now change course and place early Indian grammar in the scientific context in which it belongs and fits most closely: that of the science of ritual or kalpa. It is the first in the Vedic list of sciences and includes geometry. You may wonder whether there exists such a science and where it comes from. It is a large topic and I don’t have much time but shall treat one example: the notion of default. It is, like the concept of metarule, a feature of both the science of ritual and that of language. The two sciences share many structural features. In many cases, the ritual analysis seems to have preceded that of the grammarians and that may apply to the discovery of default options also.

The clearest account of the notion of default occurs in the Śrauta Sūtra of Āpastamba. The Āpastambas lived on the banks of the Yamuna river in the region of Mathura during the Kuru period, but their Śrauta Sūtra was composed further east and later, perhaps as late as Pāṇini. It singles out the default options for oblations, priests and
ritual implements. It specifies that the default oblation is clarified butter (juhotiti codyamāne sarpīryam pratiyāt; I shall continue to quote them in Sanskrit so that you can appreciate how brief most metarules of ritual are). The metarule on the default oblation means that if an oblation is prescribed, but it is not specified what it is an oblation of, it has to be assumed that it is an oblation of clarified butter. If it is an oblation of anything else, it will be stated explicitly. The default priest is the Adhvaryu (adhvaryum kartāram). That means that if a sūtra says that “he” has to perform such and such an act, the “he” refers to the Adhvaryu. If another priest has to perform an act, the name of his office will be specified. Among the ritual implements, the default implement is the juhū ladle (juhūm pātram). There are degrees of default: when the juhū is already used, and no other implement is specified, the oblation has to be made with the help of the srūva (vyāprtayam sruvena).

The notion of multiple default echoes or is echoed by Pāṇini’s metarule: anabhihite, “(the following rules apply) when it [i.e., the kāraka] is not (already) expressed.” It is a very abstract metarule that appears in the section on syntax in which kāraka relations are studied. These are relations that are similar to the relations between subject and object, subject and indirect object, and the like. It is a rather technical topic in any grammar, and certainly in that of Pāṇini. There exists an extensive literature on kāraka in the Sanskrit tradition, in modern Indian languages such as Hindi and Marathi, in English, French, German and Japanese. I shall not attempt to explain any of it. All it shows is that the notion of default is an early notion that seems to have traveled from the science of ritual to that of language. And there is a technical term for it: anabhidhānam.

Young Bangaloreans may be inclined to believe that the concept of default originated in Bangalore. They are partly right, since it happened in India, not in Karnatak but in Kosala or Videha, now eastern Uttar Pradesh and Bihar north of the Ganges. That is, it happened at the eastern extremity of Vedic India and at the end of the Vedic period.

Back to our thesis: “What Euclid is to Europe, Pāṇini is to India”, but we must now address the question I added in the title of my talk: “Or Are They?”

To begin at the end – we must, in the case of India, add the science of ritual to the science of language. It is not redressing the balance, but rather the opposite: add qualifications to what seemed to be a balanced comparison between two sciences in two civilizations. It is really two in one and one in the other.

We have seen that Pāṇini was preceded by clever Śākalya in the discipline of grammar. If the science of ritual is equally important, we are entitled to know the name of an equally clever ritualist. It is easy, for it can only be Baudhāyana, who was far more important than Āpastamba, since he was the author of the most detailed and authoritative of the ritual sutras. His name is the same as that of the author of the geometrical theorem that is also
called after Pythagoras, for both Baudhāyanas belonged to
the same Vedic school of that name and their apparently
personal names reflect that affiliation.

These additions amplify and complicate the symmetry
of the original thesis, that Euclid is to Europe what Pāñini
is to India. But there are other asymmetries in store.

One is concerned with the position and status of the
sciences we have considered within their respective
traditions. The science of grammar or linguistics that was
put on a firm foundation by Pāñini seems to constitute a
unique event in the history of mankind. No other
civilization has created anything similar until we come to
modern linguistics, which was not only influenced by the
Indian tradition, but would not exist without it. We can not
say the same about the geometry of Euclid, but it does
apply to his axiomatic method. So here we have a unique
science on the one side, and a unique method on the other.
An interesting but asymmetrical relationship.

This particular asymmetry is related to another: while
the mathematician Euclid in Europe was not accompanied
or followed by numerous systems of linguistics, the linguist
Pāñini lived in a country that can boast of a great tradition
of mathematicians. Apart from the Baudhāyanas and their
Vedic colleagues, I need only mention Āryabhata and
Brahmagupta in addition to the extraordinary geniuses of
Mādhava in the fourteenth and Ramanujan in the twentieth
century. But India also made the anonymous contribution
of the Indian numerals and the zero. These appeared
elsewhere in the world in some form or other, but are in
their Indian form an essential part of civilization. If the
natural order of the sounds of language, that was
discovered in India and adopted and adapted in many
writing systems of Asia, had also reached the Near East and
Europe, there would not be so many irrational and messy
alphabets like the ABC, and the modern world would have
rational and practical Indian syllabaries as well as rational
and practical Indian numerals.

We would like our life and our sciences to be simple
but it did not happen for reality is often more messy than it
appeared to be at first. There may be more to it, but with
these imbalances I have explained the Or Are They of my
title and take my leave.

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