APPENDIX I

COSMOLOGY AND GEOGRAPHY

The universe of the Vedas was a simple affair—a flat circular earth below, a heaven above, through which sun, moon and stars moved, and between them the middle air (antarika), the abode of birds, clouds and demigods. This picture of the world was much complicated by later religious thought.

Indian ideas on the origin and evolution of the universe are rather a matter of religion than of science and are considered elsewhere (p. 323ff). All Indian religions, however, maintained certain cosmological doctrines which were fundamental presuppositions of Indian thought, and were strikingly at variance with the Semitic ideas which long influenced the thinking of the West—the universe is very old; its evolution and decline are cyclic, repeated ad infinitum; it is immensely large; and there are other universes beyond our own.

The Hindus believed that the universe was shaped like an egg—the Brahmāṇḍa, or Egg of Brahmā—divided into twenty-one zones or regions, of which the earth was seventh from the top. Above the earth were six heavens (not, as with the Greeks, associated with the planets), of increasing beatitude. Below earth were the seven stages of Pātāla, the nether world, which were the abode of nāgas and other mythical beings and were not thought of as in any way unpleasant. Below Pātāla lay Narakā, or purgatory, also divided into seven zones, which were of increasing misery, and were inhabited by souls in torment. The universe hung in empty space, and was virtually isolated from other universes.

The cosmic schemes of the Buddhists and Jainas differed from this in many details, but in fundamentals they were the same. All originally postulated a flat earth, but this was recognized by Indian astronomers to be incorrect early in the Christian era, and, though the idea of a flat earth remained for religious purposes, the learned realized, perhaps through the influence of Greek astronomy, that it was in fact spherical. Various estimates of its size were made, the most popular being that of Brahmagupta (7th century A.D.), who gave its circumference as 5,000 yojanas. Assuming Brahmagupta’s yojana to be the short league of about 4½ miles (7-2 km.), this figure is not far out, and is as accurate as any given by ancient astronomers.

The modest spherical earth of the astronomers did not satisfy the theologians, however, and even later religious literature described the earth as a flat disc of enormous size. In its centre was Mount Meru, round which sun, moon and stars revolved. Around Meru were four continents (dvīpa), separated from the central peak by oceans, and named according to the great trees which stood on their shores opposite Meru. The southern continent, on which human beings dwell, had a jambu (rose-apple) as its distinctive tree, and it was therefore called Jambudvīpa. The southern zone of this continent,
separated from the rest by the Himalayas, was "the Land of the Sons of Bharata" (Bhāratavarṣa), or India. Bhāratavarṣa alone was 9,000 yojanas across, and the whole of Jambudvīpa 33,000, or, according to some sources, 100,000 yojanas.

This fantastic geographical scheme was not the only one. In the Purāṇas Jambudvīpa is described as a ring around Meru, separated from the next continent, Plakṣadvīpa, by an ocean of salt. Plakṣadvīpa in turn forms a concentric circle round Jambudvīpa, and so on to make a total of seven continents, each circular and divided from its neighbour by an ocean of different composition—starting with Jambudvīpa's salt ocean and moving outwards, of treacle, wine, ghee, milk, curds and fresh water respectively. This brilliantly imaginative picture of the world, which aroused the scorn of Lord Macaulay, seems to have been implicitly believed in by later Hindu theologians, and even the astronomers could not emancipate themselves from it, but adapted it to their spherical earth by making Meru the earth's axis, and the continents zones on the earth's surface.

The oceans of butter and seas of treacle formed an effective barrier to the growth of a true science of geography. The seven continents cannot in any way have been related to actual portions of the earth's surface (though some modern students have tried to identify them with parts of Asia) and, as far as is known, no attempt was made to collate the experience of travellers as practical geography. The astronomers gave fairly accurate longitudes of important places in India. In the early centuries of the Christian era Alexandria was known, and there are vague references to the city of the Romakas in astronomical works; but the geographical knowledge of the learned was of the vaguest description. Even within India distances and directions, as given in texts, are usually very inaccurate and vague. The conquerors who led armies thousands of miles on their campaigns, the merchants who carried their wares from one end of India to the other, and the pilgrims who visited sacred places from the Himalayas to Cape Comorin must have had a sound practical knowledge of Indian geography, while that of the seamen who sailed the ocean from Socotra to Canton must have been even wider; but there are few echoes of this knowledge in the literature of the time.

APPENDIX II

ASTRONOMY

One of the subsidiary studies (vedāṅga) of Vedic lore was jyotiṣa, a primitive astronomy designed mainly for the purpose of settling the dates and times at which periodical sacrifices were to be performed. The existing literature on this topic is comparatively late, and gives no true indication of India's astronomical knowledge in the Vedic period, though it is quite clear
from passages in the Vedic texts themselves that it was adequate for the practical purposes of the time. It is probable that even at this early period there was some Mesopotamian influence on Indian astronomical ideas, but this cannot be established with certainty. Virtually certain, however, is the influence of classical European astronomy, which was felt in the early centuries of the Christian era, if not before.

Several Greek words have become common in Sanskrit and in later Indian languages through astronomy (p. 233), and other technical terms, not so widely known, are indiscutably of Greek origin. Of the five astronomical systems (siddhānta) known to the 6th-century astronomer Varāhamihira one is called the Romaka Siddhānta and another the Paulisa Siddhānta, a title which can only be reasonably explained as a recollection of the name of the classical astronomer Paul of Alexandria.

The new astronomy was adopted chiefly for purposes of prognostication; for the establishment of dates the old luni-solar calendar, based on simpler observations, was quite adequate. Earlier times Indians, though no less interested than other ancient peoples in foretelling the future, preferred to do so by the interpretation of dreams and omens (utpāta), and by physiognomy, birthmarks, the shape and size of the features, and other signs which were believed to give tokens of an individual’s fate. The older systems of prognostication were not forgotten, but from Gupta times onwards they gave pride of place to astrology, which from that day to this has been implicitly believed in by nearly all Indians.

Before this great development of astronomical knowledge the heavens had been charted by means of the lunar mansions or nakṣatras, which were apparently known even in the time of the Rg Veda. The moon’s relation to the fixed stars changes through a cycle of approximately 27 solar days and 7½ hours and thus the heavens were divided into 27 portions, named according to the group of stars on the ecliptic (the apparent orbit of the sun) near which the moon passes on each day of its cycle. As the sidereal month is in fact nearly eight hours more than 27 days a twenty-eighth intercalary nakṣatra was added by later astronomers to correct the error.*

Western astronomy brought to India the signs of the zodiac, the seven-day week, the hour, and several other ideas. Thanks to their achievements

* The nakṣatras were: (1) Ṛcagīt (β and γ Arietis), (2) Bhārantī (35, 39, and 41 Arietis), (3) Kṛṣṇa (Pleiades), (4) Rohiṇī (Aldebaran), (5) Mrgaśīrṣa (λ, φ¹, and φ² Orionis), (6) Āḍrā (α Orionis), (7) Gālāvīṣa (α and β Geminorum), (8) Fagyā (ι, and 6 Cancris), (9) Hēni (δ, and δ Hydræ), (10) Maghā (α, γ, δ, ζ, η, and η Leonis), (11) Pūrva-phalguni (δ and η Leonis), (12) Uttara-phalguni (β and 93 Leonis), (13) Hastā (α, β, γ, δ, and ε Corvi), (14) Cittā (Spica, α Virginis), (15) Svāti (Arcturus), (16) Vitarthā (α, β, γ, and 1 Librae), (17) Anurādha (β, ε, and π Scorpionis), (18) Jyeṣṭhā (α, β, and γ Scorpionis), (19) Mūla (ι, ζ, η, ι, κ, λ, μ, and ν Scorpionis), (20) Pavāṇā (δ and ζ Sagittarii), (21) Uttarāṣāḍā (ι and ω Sagittarii), (22) Śrāvaṇā (α, β, and γ Aquilæ), (23) Dhanishta or Śravīṣṭha (α, β, γ, and δ Delphini), (24) Satabhisarā (γ Aquilæ etc.), (25) Pūrva-bhadrapāda (α and β Pegasi), (26) Uttara- bhadrapāda (γ Pegasi and α Andromedæ), and (27) Revati (ξ Piscium, etc.). The 28th nakṣatra was Abhijit (α, β, and ζ Lyrae), which was placed between Uttarāṣāḍā and Śrāvaṇā. It will be seen from this list that the ancient Indian system of constellations differed widely from that of the West.
in mathematics Indian astronomers made some advances on the knowledge of the Greeks, and passed their lore, with that of mathematics, back to Europe by way of the Arabs. As early as the 7th century the Syrian astronomer Severus Sebokht knew of the greatness of Indian astronomy and mathematics (p. vi), and the caliphs of Bāghdād employed Indian astronomers. One word of the terminology of medieval European astronomy, asc, the highest point of a planet's orbit, is certainly borrowed from the Sanskrit acsa through Arabic.

Like all ancient astronomy, that of India was restricted owing to ignorance of the telescope; but methods of observation were perfected which allowed very accurate measurement, and calculations were aided by the decimal system of numerals. We know of no remains of observatories of the Hindu period, but those of the 17th and 18th centuries, at Jaipur, Delhi and elsewhere, with their wonderfully accurate instruments constructed on an enormous scale to minimize error, may well have had their ancient counterparts.

With the naked eye as their sole means of observation the Indians knew only the seven planets (graha) of the ancients—Sun (Sīrya, Ravi), Moon (Candra, Soma), Mercury (Budha), Venus (Śukra), Mars (Maḥāgala), Jupiter (Bṛhaspati) and Saturn (Śani);* to these grahas two more were added, Rāhu and Ketu, the ascending and descending nodes of the moon.† At the beginning of each āeon all the planets were believed to commence their revolutions in line, and to return to the same position at the end of it. The apparently irregular course of the planets was explained on the hypothesis of epicycles, as in classical and medieval astronomy. Unlike the Greeks, the Indians believed that the planets had equal real motion, and that their apparently different angular motion was due to their different distances from the earth.

For purposes of calculation the planetary system was taken as geocentric, though Āryabhaṭa in the 5th century suggested that the earth revolved round the sun and rotated on its axis; this theory was also known to later astronomers, but it never affected astronomical practice. The precession of the equinoxes was known, and calculated with some accuracy by medieval astronomers, as were the lengths of the year, the lunar month, and other astronomical constants. These calculations were reliable for most practical purposes, and in many cases more exact than those of the Greco-Roman world. Eclipses were forecast with accuracy and their true cause understood.

* The names of the planets had many synonyms, some of which were evidently borrowed from the Greek, e.g. Ares, Ares, or Mars.

† At the “Churning of the Ocean” (p. 304f.) a demon named Rāhu stole some of the amṛta. Viṣṇu destroyed his body, but as he had tasted of the divine drink he had become immortal. His head and tail survive for ever in the heavens, as Rāhu and Ketu, and the head causes eclipses by trying to swallow the planets. Of course the astronomers did not believe this myth, and some texts explicitly reject it.
APPENDIX III

THE CALENDAR

In recording dates the basic unit was not the solar day, but the tithi or lunar day, approximately thirty of which formed a lunar month (i.e. the four phases of the moon) of about 29½ solar days. The month was divided into two halves (paka) of fifteen tithis each, beginning with the full (purnimāvāsyā) and new (amāvāsyā or bakulāvāsyā) moons respectively. The fortnight beginning with the new moon was called the bright half (suklapakṣa) and the other the dark half (kṣṇapakṣa). According to the system followed in Northern India and much of the Deccan the month began and ended with the full moon, while in the Tamil country the month generally began with the new moon. The Hindu calendar is still in use throughout India for religious purposes.

The tithi might begin at any time of the solar day. For the practical purpose of recording dates that tithi current at sunrise was supposed to prevail for the whole day and gave that day its number in the pakṣa. If a tithi began just after sunrise and ended before the sunrise of the next day it was expunged, and there was a break in the numerical sequence of days.

The year normally contained twelve lunar months:

Caitra (March–April), Vaisākha (April–May), Jyaiṣṭha (May–June), Āṣāḍha (June–July), Śrāvana (July–August), Bhādrapada or Prauṣṭhapaḍa (August–September), Āśvina or Āsvayuja (September–October), Kārttika (October–November), Mārgaisīra or Agraḥāyaṇa (November–December), Pauṣa or Taśa (December–January), Māgha (January–February) and Phālguna (February–March).* According to the usual systems of reckoning the year began with Caitra, but it was sometimes taken as beginning with Kārttika or another month.

A group of two months formed a season (ṛtu). The six seasons of the Indian year were: Vasanta (Spring, March–May), Grīṣma (Summer, May–July), Varṣā (The Rains, July–September), Śarad (Autumn, September–November), Hemanta (Winter, November–January) and Śītāra (the Cool Season, January–March).

Twelve lunar months make only about 354 days, and the problem of the discrepancy between the lunar and solar years was solved very early; sixty-two lunar months are approximately equal to sixty solar months, and so every thirty months an extra month was added to the year, as in Babylonia. This leap-month was generally inserted after Āṣāḍha or Śravāṇa and called second (dvitiya) Āṣāḍha or Śravāṇa. Thus every second or third year contains thirteen months, and is some twenty-nine days longer than the others.

* The names of the months in early times were as follows: Madhva, Mādhava, Śukra, Suci, Nabhas, Nabhasya, Isa, Orja, Sahas, Sahasya, Tapas, Tapasya. These Vedic names are sometimes found in later poetry.
The Hindu calendar, though quite efficient, is thus rather cumbrous, and is so different from the solar calendar that it is impossible to reduce dates from one to the other without very complicated calculations or lengthy tables. It is even impossible to establish at a glance the month in which a given Hindu date falls with any certainty.

Indian dates are usually given in the order—month, pakṣa, tithi, the abbreviations śudī and badi being used for the bright and dark halves of the month; e.g. Caitra śudī 7 means the seventh day from the new moon of the month Caitra.

The solar calendar, imported with Western astronomy, was also known from Gupta times onwards though it did not oust the old luni-solar calendar until recent years. Where solar dates are given in early records they are usually mentioned for extra accuracy, with the prevailing nakṣatra of the day in question, after the regular luni-solar date. In the solar calendar the months are named after the signs of the zodiac, which are literal or nearly exact translations of their Greek originals: Meṣa (Aries), Ṭṛśabha (Taurus), Mithuna (Gemini), Karkaṭa (Cancer), Simha (Leo), Kanyā (Virgo), Tūlā (Libra), Ṭṛśčika (Scorpio), Dhanu (Sagittarius), Makara (Capricornus), Kumbha (Aquarius) and Mīna (Pisces). With the solar calendar the seven-day week was also introduced, the days being named after their presiding planets as in the Greco-Roman system: Rājivāra (Sunday), Somaśvara (Monday), Mahgalavāra (Tuesday), Budhavāra (Wednesday), Bhāspatīvāra (Thursday), Śukravāra (Friday) and Śanivāra (Saturday).

ERAS

Until the 1st century B.C. there is no good evidence that India had any regular system of recording the year of an event by dating in a definite era like the A.U.C. of Rome or the Christian era of medieval and modern Europe. Early inscriptions are dated if at all in the regnal year of the ruling king. The idea of dating over a long period of time from a fixed year was almost certainly introduced into India by the invaders of the North-West, who have left the earliest inscriptions thus dated in India. Unfortunately the Indians did not adopt a uniform era, and a number of systems of dating were in use from that time onwards, the chief of which, in order of importance, are as follows:

The Vikrama Era (58 B.C.), traditionally founded by a king called Vikramādiśya, who drove the Śakas out of Ujjayinī and founded the era to celebrate his-victory. The only king who both took the title Vikramādiśya and drove the Śakas from Ujjayinī was Candira Gupta II, who lived over 400 years later than the beginning of the Vikrama era, and so the legend is certainly false. In the earliest inscriptions using this era, all from Western India, it is called simply Kṛta ("established"), or "handed down by the Mālava tribe". Some authorities believe that many inscriptions of the Šakas
and Pahlavas of North-West India are to be read in this era, and that it was founded by Azes, one of their early kings; but this is by no means certain. This era was most popular in North India. Its year began originally with the month Kārttika, but by medieval times Vikrama years began in the bright half of Caitra in the North, and in the dark half of the same month in the Peninsula.

The Śaka Era (A.D. 78) was, according to tradition, founded by a Śaka king who occupied Ujjain 137 years after Vikramāditya. This era may in fact have been founded by Kaniśka, and was certainly used early in the 2nd century A.D. by the “Western Satraps”, who ruled Mālavā and Gujarāt. Thence the use of the-era spread through the Deccan and it was exported to South-East Asia.

The Gupta Era (A.D. 320) was probably founded by Candā Gupta I, and its use was continued by the Maitraka dynasty of Gujarāt for some centuries after the Gupta empire fell.

The Harṣa Era (A.D. 606), founded by Harṣavardhana of Kānyakubja, was popular in Northern India for a century or two after his death.

The Kalacuri Era (A.D. 248), perhaps founded by a small dynasty called the Traikūṭaka, was current in Central India down to the Muslim invasion.

Other eras of local or temporary importance were the Lakṣmaṇa Era of Bengal (A.D. 1119), wrongly said to have been founded by King Lakṣmaṇa Sena; the Saptarṣi or Lavikā Era, current in Kashmir in the Middle Ages, and recorded in cycles of one hundred years, each cycle commencing seventy-six years after each Christian century; the Nevar Era of Nepal (A.D. 878); the Kollam Era of Kerala (A.D. 825); and the Era of Vikramāditya VI Čāluśa (A.D. 1075). The Era of the Kaliyuga (5102 B.C., v. p. 89) was often used for religious dates and rarely for political. In Ceylon a Buddha Era from 544 B.C. was in use from an uncertain date, when it probably replaced an earlier reckoning from 483 B.C. The Jainas used an Era of Mahāvīra, reckoned from 528 B.C. The two latter eras, together with the Vikrama and Śaka Eras, are still in use for religious purposes, but the others are extinct.

In reducing dates in Indian eras to the Christian era it must be remembered that the year, according to most reckonings, begins with the month of Caitra, which usually commences in the middle of March. Thus the months Māgha and Phālgunī, and generally the second half of Pauṣa, occur in the Christian year after that in which the Hindu year began. Dates were usually given in expired years; this was sometimes explicitly stated (e.g. “when 493 years had passed from the establishment of the tribe of the Mālavas”), but more often taken for granted. In medieval dates it is best to assume an expired year, even when this is not specified, unless there is special reason to believe otherwise.

The following table will be useful for reducing Indian dates to the Christian era:
APPENDIX III

First 9½ months approx. (assuming the year to begin with Caitra)
Second (usually dark)
half of Pauṣa, and the whole of Māgha and Phālguna

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<th>Saka</th>
<th>Kalacuri</th>
<th>Gupta</th>
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APPENDIX IV

MATHEMATICS

Through the necessity of accurately laying out the open-air site of a sacrifice, Indians very early evolved a simple system of geometry, but in the sphere of practical knowledge the world owes most to India in the realm of mathematics, which were developed in Gupta times to a stage more advanced than that reached by any other nation of antiquity. The success of Indian mathematics was mainly due to the fact that the Indians had a clear conception of abstract number, as distinct from numerical quantity of objects or spatial extension. While Greek mathematical science was largely based on mensuration and geometry, India transcended these conceptions quite early, and, with the aid of a simple numeral notation, devised a rudimentary algebra which allowed more complicated calculations than were possible to the Greeks, and led to the study of number for its own sake.

In the earlier inscriptions of India dates and other numerals are written in a notation not unlike that of the Romans, Greeks and Hebrews, with separate symbols for the tens and hundreds. The earliest inscription recording the date by a system of nine digits and a zero, with place notation for the tens and hundreds, comes from Gujarāt, and is dated A.D. 595. Soon after this however, the new system had been heard of in Syria (p. vi),† and was being used as far afield as Vietnam. Evidently the system was known to mathematicians some centuries before it was employed in inscriptions, the scribes of which tended to be conservative in their methods of

* Epigraphia Indica, ii. 20.
† Some earlier authorities, disinclined to give India her due, have declared that none of these sources gives certain evidence of the existence of a sign for zero. But Āryabhata's text implies a knowledge of it, and Severus Sebokht's "nine symbols" would be quite useless for expressing quantities over nine without a zero sign and place notation. The Maya of Central America had a vigesimal numeral system with positional notation long before this time, but it had, of course, no effect on the world at large (S. G. Morley, The Ancient Maya, London, 1946, p. 274).
recording dates; in modern Europe the cumbrous Roman system is still
sometimes used for the same purpose. The name of the mathematician
who devised the simplified system of writing numerals is unknown, but the
earliest surviving mathematical texts—the anonymous “Bakshali Manu-
script”, which is a copy of a text of the 4th century A.D., and the terse
Āryabhaṭṭyā of Āryabhaṭa, written in A.D. 499—presuppose it.

For long it was thought that the decimal system of numerals was invented
by the Arabs, but this is certainly not the case. The Arabs themselves
called mathematics “the Indian (art)” (hindisat), and it appears that the
decimal notation, with other mathematical lore, was learnt by the Muslim
world either through merchants trading with the west coast of India or
through the Arabs who conquered Sind in A.D. 712.

The debt of the Western world to India in this respect cannot be over-
estimated. Most of the great discoveries and inventions of which Europe
is so proud would have been impossible without a developed system of
mathematics, and this in turn would have been impossible if Europe had
been shackled by the unwieldy system of Roman numerals. The unknown
man who devised the new system was from the world’s point of view, after
the Buddha, the most important son of India. His achievement, though
easily taken for granted, was the work of an analytical mind of the first order,
and he deserves much more honour than he has so far received.

Medieval Indian mathematicians, such as Brahmagupta (7th century),
Mahāvīra (9th century) and Bhāskara (12th century), made several
discoveries which in Europe were not known until the Renaissance or later.
They understood the import of positive and negative quantities, evolved
sound systems of extracting square and cube roots, and could solve quadratic
and certain types of indeterminate equations. For π Āryabhaṭa gave the
usual modern approximate value of 3.1416, expressed in the form of a fraction
\[ \frac{62832}{20000} \]. This value of π, much more accurate than that of the Greeks, was
improved to nine places of decimals by later Indian mathematicians. Some
steps were made in trigonometry, spherical geometry and calculus, chiefly
in connexion with astronomy. The mathematical implications of zero
(sānya) and infinity, never more than vaguely realized by classical authori-
ties, were fully understood in medieval India. Earlier mathematicians had
taught that \( \frac{1}{\infty} = 0 \), but Bhāskara proved that it was infinity. He also
established mathematically what had been recognized in Indian theology
at least a millennium earlier, that infinity, however divided, remains infinite,
represented by the equation \( \frac{a}{\infty} = \infty \).

APPENDIX V

PHYSICS AND CHEMISTRY

Ancient Indian ideas of physics were closely linked with religion and
theology, and differed somewhat from sect to sect. As early as the time
of the Buddha, if not before, the universe was classified by elements, of which
all schools admitted at least four—earth, air, fire and water. To these orthodox Hindu schools and Jainism added a fifth, ākāśa, which is generally translated "ether". It was recognized that air was not of infinite extension, and the Indian mind, with its abhorrence of a vacuum, found it hard to conceive of empty space. The five elements were thought of as the mediums of sense impressions—earth of smell, air of feeling, fire of vision, water of taste, and ether of sound. Buddhists and Ājīvikas rejected ether, but the latter added life, joy and sorrow, which were thought of as in some way material, making a total of seven elements.

Most schools believed that the elements other than ether were atomic. Indian atomism was certainly independent of Greek influence, for an atomic theory was taught by Pakudha Kātyāyana, an older contemporary of the Buddha, and was therefore earlier than that of Democritus. The Jainas believed that all atoms (aṇu) were identical, and that differences of the character of the elements were due to the manner in which the atoms were combined. Most schools, however, maintained that there were as many types of atom as there were elements.

The atom was generally thought to be eternal, but some Buddhists conceived of it not only as the minutest object capable of occupying space, but also as occupying the minutest possible duration of time, coming into being and vanishing almost in an instant, only to be succeeded by another atom, caused by the first. Thus the atom of Buddhism in some measure resembles the quantum of Planck. The atom was quite invisible to the human eye; the orthodox Vaiśeṣika school believed the single atom to be a mere point in space, completely without magnitude.

A single atom had no qualities, but only potentialities, which came into play when the atom combined with others. The Vaiśeṣika school, which specially elaborated its atomic doctrines and was the school of atomism par excellence, maintained that, before combining to form material objects, atoms made primary combinations of diads and triads. This doctrine of molecules was developed differently by Buddhists and Ājīvikas, who taught that in normal conditions no atoms existed in a pure state, but only combined in different proportions in a molecule (samghāta, kalāpa). Every molecule contained at least one atom of all four types, and obtained its character from the predominance of a given element. This hypothesis accounted for the fact that matter might show characteristics of more than one element; thus wax might melt and also burn, because its molecules contained proportions of water and fire. According to the Buddhists the molecules cohered by virtue of the atoms of water in each, which acted as an adhesive.

Indian atomic theories were not based on experiment but on intuition and logic. They were not universally held. The great theologian Śaṅkara (p. 330) did not believe in atoms and argued strongly against their existence. But the atomic theories of ancient India are brilliant imaginative explanations of the physical structure of the world; though it is probably mere coincidence that they agree in part with the discoveries of modern physics, they are nevertheless much to the credit of the intellect and imagination of early Indian thinkers.
Beyond this ancient Indian physics developed little. Without knowledge of an all-embracing law of gravity it remained in a rudimentary state, like all the physical systems of the ancient world. It was generally believed that the elements of earth and water tended to fall, and fire to rise, and it was recognized that solids and fluids alike generally expanded on heating, but no serious effort was made to study such phenomena experimentally. In the science of acoustics, however, India made real discoveries based on experiment, and the ear, highly trained by the phonetic study necessary for the correct recitation of the Vedas, learned to distinguish musical tones far closer than those of other ancient musical systems. Very early the octave was divided into twenty-two śrutis, or quarter-tones (p. 549) and their proportions were measured with great accuracy. It was recognized that differences of timbre were caused by overtones (anuṇaṇa), which varied with different instruments.

We know from the evidence of the Iron Pillar of Delhi (p. 231f) and other sources that Indian metallurgists gained great proficiency in the extraction of metal from ore and in metal-casting, and their products were known and valued in the Roman Empire and the Middle East; but their knowledge appears to have been largely pragmatic, and had no counterpart in a highly developed science of metallurgy. Chemistry in ancient India was the handmaid not of technology but of medicine; her chemists did not share the interest of medieval Europe in transmuting base metal into gold, but apparently devoted most of their attention to making medicines, drugs to promote longevity, aphrodisiacs, and poisons and their antidotes. These medical chemists did succeed in producing many important alkalis, acids and metallic salts by simple processes of calcination and distillation, and it has even been suggested, without good basis, that they discovered a form of gunpowder.

In the Middle Ages Indian chemists, like their counterparts in China, the Muslim World and Europe, became engrossed in the study of mercury, perhaps through contact with the Arabs. A school of alchemists arose, who experimented with the wonderful fluid metal and decided that it was the specific for all diseases, the source of perpetual youth, and even the surest means to salvation. In this infatuation with mercury Indian chemistry foundered, but not before it had passed many ideas on to the Arabs, who gave them to medieval Europe.

APPENDIX VI

PHYSIOLOGY AND MEDICINE

The Vedas show a very primitive stage of medical and physiological lore, but the basic textbooks of Indian medicine—the compendia of Caraka (1st–2nd centuries A.D.) and Suśruta (c. 4th century A.D.)—are the products
of a fully evolved system which resembled those of Hippocrates and Galen in some respects, and in others had developed beyond them. There is little doubt that two factors encouraged medical knowledge—the growth of interest in physiology through the phenomena of yoga and mystical experience, and Buddhism. Like the Christian missionary of later times the Buddhist monk often served as a doctor among the lay folk from whom he begged his food; moreover he was encouraged to care for his own health and that of his fellow-monks, and his creed tended towards rationalism and a distrust of the medical magic of earlier times. The development of medicine was also probably stimulated by contact with Hellenistic physicians, and the resemblances between Indian and classical medicine suggest borrowing on both sides. After Suśruta Indian medicine developed little, except in the growing use of mercurial drugs, and of others, such as opium and sarsaparilla, which were introduced by the Arabs. In its essentials the system practised by the ayurvedic physician of present day India remains the same.

The basic conception of Indian medicine, like that of ancient and medieval Europe, was the doctrine of the humours (doṣa). Most authorities taught that health was maintained through the even balance of the three vital fluids of the body—wind, gall and mucus, to which some added blood as a fourth humour. The three primary humours were connected with the scheme of the three guṇas, or universal qualities (p. 327), and associated with virtue, passion and dullness respectively.

The bodily functions were maintained by the five “winds” (vāyu): udāna, emanating from the throat, and causing speech; prāna, in the heart, and responsible for breathing and the swallowing of food; samāna, fanning the fire in the stomach which “cooked” or digested the food, and dividing it into its digestible and indigestible parts; apāna in the abdomen, responsible for excretion and procreation; and vyāna, a generally diffused wind, causing the motion of the blood and of the body generally. The food digested by the samāna became chyle, which proceeded to the heart, and thence to the liver, where its essence was converted into blood. The blood in turn was in part converted into flesh and the process was continued through the series fat, bone, marrow and semen; the latter, when not expelled, produced energy (ojas), which returned to the heart and was thence diffused over the body. This process of metabolism was believed to take place in thirty days.

Ancient Indian doctors had no clear knowledge of the function of the brain, and believed with many ancient peoples that the heart was the seat of intelligence. They realized, however, the importance of the spinal cord (p. 329), and knew of the existence of the nervous system, though it was not properly understood. The progress of physiology and biology was impeded by the taboo on contact with dead bodies, which much discouraged dissection and the study of anatomy, although such practices were not completely unknown.

Despite their inaccurate knowledge of physiology, which was by no means inferior to that of most ancient peoples, India evolved a developed empirical surgery. The cesarian section was known, bone-setting reached a high degree of skill, and plastic surgery was developed far beyond anything
known elsewhere at the time. Ancient Indian surgeons were expert at the repair of noses, ears and lips, lost or injured in battle or by judicial mutilation. In this respect Indian surgery remained ahead of European until the 18th century, when the surgeons of the East Indian Company were not ashamed to learn the art of rhinoplasty from the Indians.

Though Indians very early conceived of the existence of microscopic forms of life, it was never realized that these might cause diseases; but if Indian surgeons had no true idea of antisepsis or asepsis they encouraged scrupulous cleanliness as they understood it, and recognized the therapeutic value of fresh air and light. The pharmacopoeia of ancient India was very large, and comprised animal, vegetable and mineral products. Many Asian drugs were known and used long before their introduction into Europe, notably the oil of the *chaumugra* tree, traditionally prescribed as a specific for leprosy, and still the basis of the modern treatment of the disease.

The physician was a highly respected member of society, and the *vaidyas* rank high in the caste hierarchy to this day. The rules of professional behaviour laid down in medical texts remind us of those of Hippocrates and are not unworthy of the conscientious doctor of any place or time. We quote part of the sermon which Caraka instructs a physician to preach to his pupils at a solemn religious ceremony to be performed on the completion of their apprenticeship.

“If you want success in your practice, wealth and fame, and heaven after your death, you must pray every day on rising and going to bed for the welfare of all beings, especially of cows and brâhmans, and you must strive with all your soul for the health of the sick. You must not betray your patients, even at the cost of your own life. . . . You must not get drunk, or commit evil, or have evil companions. . . . You must be pleasant of speech. . . . and thoughtful, always striving to improve your knowledge.

“When you go to the home of a patient you should direct your words, mind, intellect and senses nowhere but to your patient and his treatment. . . . Nothing that happens in the house of the sick man must be told outside, nor must the patient’s condition be told to anyone who might do harm by that knowledge to the patient or to another.”

Under the patronage of the more benevolent kings and religious foundations free medical aid was given to the poor. Ashoka took pride in the fact that he had provided medicines for man and beast, and the traveller Fa-hsien, in the early 5th century A.D., made special note of the free hospitals maintained by the donations of pious citizens. Unfortunately we have no detailed descriptions of such establishments.

Veterinary medicine was also practised. The doctrine of non-violence encouraged the endowment of animal refuges and homes for sick and aged animals, and such charities are still maintained in many cities of India. The horse and elephant doctors were members of skilled and respected professions, much in demand at court, and texts on veterinary science survive from the Middle Ages.

*Caraka Saṁhitā, III, 8, 7.*
APPENDIX VII

LOGIC AND EPISTEMOLOGY

With such an intense interest in metaphysical problems and a tradition of lively debate and discussion it is not surprising that India developed her own distinctive system of logic. The basic logical text is the Nyāya Sūtras of Gautama, perhaps composed in the early centuries of the Christian era, a series of brief aphorisms much commented on by later writers, and the foundation-text of the Nyāya, one of the six schools of orthodox philosophy (p. 525). Logic was not, however, confined to this one school, but was utilized and adapted by Hindu, Buddhist and Jaina alike.

One of the most important topics of Indian thought in this field was the question of pramāṇa, which may be translated "means of reliable knowledge". According to the later Nyāya schools there were four pramāṇas, perception (pratyākṣa), inference (anumāṇa), inference by analogy or comparison (upamāṇa), and "word" (śabda), the pronouncement of a reliable authority, such as the Vedas. The Vedānta school added intuition or presumption (arthāpatti) and non-perception (anupalabdhi), the latter an unnecessary scholastic refinement. The six categories overlapped somewhat, and the Buddhists generally included all forms of knowledge under the first two categories, while the Jainas usually allowed only three, perception, inference and revelation. The materialists allowed only perception, and their opponents made short work of their efforts at proving by inference that inference could not give reliable knowledge.

It was probably in the study of the process of inference that schools of true logic arose. From the necessities of metaphysical discussion false arguments were analysed and classified; of these logicians recognized the chief fallacies of classical logic, such as reductio ad absurdum (arthāprāsaṅga), circular argument (caṅkra), infinite regression (anavasthā), dilemma (anonyādṛaya), and ignorantio elenchī (ātmāraṇa).

A correct inference was established by syllogism, of which the Indian form (pañcāvayāya) was somewhat more cumbersome than the Aristotelian. Its five members were known as proposition (pratijñā), reason (hetu), example (udāharana), application (upanaya) and conclusion (nigamana). The classical Indian example may be paraphrased as follows:

1. There is fire on the mountain,
2. because there is smoke above it,
3. and where there is smoke there is fire, as, for instance, in a kitchen;
4. such is the case with the mountain,
5. and therefore there is fire on it.

The third term of the Indian syllogism corresponds to the major premise of that of Aristotle, the second to Aristotle’s minor premise, and the first to his conclusion. Thus the Indian syllogism reversed the order of that of classical logic, the argument being stated in the first and second
clauses, established by the general rule and example in the third, and finally clinched by the virtual repetition of the first two clauses. The "example" (in the above syllogism the kitchen) was generally looked on as an essential part of the argument, and helped to strengthen its rhetorical force. Evidently this elaborate system of syllogism is the outcome of much practical experience in discussion. Three-membered syllogisms were admitted by the Buddhists, who rightly rejected the fourth and fifth members of the orthodox syllogism as tautological.

The basis of the generalization (for example "where there is smoke there is fire") on which every inference rests was believed to be the quality of universal concomitance (vyāpti). The nature and origin of this quality was much discussed, and its consideration led to theories of universals and particulars, which are too recondite for consideration in this book.

No treatment of Indian thought is complete without a brief reference to the remarkable epistemological relativity of Jainism. Jaina thinkers, and some other heterodox teachers also, explicitly rejected what in classical logic is called the law of the excluded middle. For the Jaina there were not merely the two possibilities of existence and non-existence, but seven. Thus we may affirm (1) that an object, say a knife, exists as a knife. We may further say (2) that it is not something else, say a fork. But it exists as a knife and does not exist as a fork, and so we may declare of it (3) that in one aspect it is and in another it is not. From another point of view (4) it is indescribable; its ultimate essence is unknown to us and we cannot posit anything final about it—it is inexpressible. By combining this fourth possibility with the three former ones we obtain three further possibilities of predication—(5) it is, but its nature is otherwise indescribable, (6) it is not, but its nature is indescribable, and (7) it both is and is not, but its nature is indescribable. This system of seven aspects of predication is known as syādvāda ("the doctrine of 'maybe'"), or saṭaprabhāgi ("the sevenfold division").

As well as syādvāda the Jainas had another sevenfold system of predication known as nayavāda, the theory of standpoints, or ways of approaching an object of observation or study. The first three of these are connected with the object itself (dṛavyārthika), and the latter four with its modifications and the words used to describe it (paryārthika). (1) A mango tree may be considered simultaneously as an individual having a definite size and shape and as a member of the species "mango tree"; (2) it may be treated merely as a representative of the "universal" mango tree, and as corresponding to the general concept of a mango tree, without taking its individual qualities into account; or (3) it may be considered merely as an individual, without taking note of its specific qualities. Further it may be thought of (4) as it is at the present moment, for instance as bearing ripe fruit, without any regard to its past as a sapling or its future as firewood. (5) We may think of it from the point of view of its name "mango", considering all the

* The Sanskrit terms for the seven aspects are: (1) syādastī, (2) syānāstī, (3) syādastināstī, (4) syādvakṛtī, (5) syādastīya-vakṛtī, (6) syānāstīya-vakṛtī, and (7) syādastināstīya-vakṛtī.
synonyms of that name, and their implications. These synonyms may be subtly differentiated, and (6) we may consider their nuances and connotations. Finally (7) we may consider an object in its relation to a given epithet; thus by referring to a hero as a “lion” we mentally remove all his unicornlike qualities, and think of him only as a being of strength and courage.* Some Jain schools rejected the last three standpoints, which are hardly consistent with the first four, being rather semantic than epistemological in character.

Modern logicians might make short work of these rather pedantic systems of ontological and epistemological relativity, but they have a fundamental quality of breadth and realism, implying a full realization that the world is more complex and subtle than we think it, and that what is true of a thing in one of its aspects may at the same time be false in another.

APPENDIX VIII

WEIGHTS AND MEASURES.

MEASURES OF WEIGHT

The basic weight of ancient India was the raktikā, the bright red seed of the gudīja (abrus precatorius), which was conventionally reckoned at about 1.83 grains (~118 grams). Many sources give series of weights rising from this, which are not wholly consistent, and show that standards varied very widely with time and place.

The goldsmith’s scale given by Manu, which was probably the most widely followed, was:

5 raktikās = 1 māṣa,
16 māṣas = 1 karaṇa, tolaka, or suvarṇa,
4 karaṇas = 1 pala,
10 palas = 1 dhanavāna.

The weight of the pala was thus approximately 1 1/2 oz., or 37.76 gms. Of heavier weights the chief were the prastha, usually given as of 16 palas, and the dōra of 16 prasthas. The prastha was thus approximately 21 oz. (600 gms.), and the dōra 21 1/2 lb. (9.6 kg.).

MEASURES OF LENGTH

The commonest table, omitting microscopic measurements, was:

8 yana (barleycorns) = 1 āṅgula (finger’s breadth, 1/4 in. or approx. 2 cm.)
12 āṅgulas = 1 viśati (span, 9 ins., 23 cm.)
2 viśatis = 1 hasta or ārāmi (cubit, 18 ins., 47 cm.)
4 hastas = 1 danda (rod) or dhanus (bow, 6 ft., 1.82 m.)
2,000 dharmas = 1 kraśa (cry) or gurutā (cow-call, 2½ miles, 3.6 km.)
4 kraśas = 1 yojana (stage, 9 miles approx., 14.5 km.).

* The Sanskrit names of the seven yanas are: (1) naigama, (2) saṅgroha, (3) yuva-kūṭra, (4) ṇuṣṭra, (5) labda, (6) samabhīrāṅka, and (7) evamabhaṅka.
Though most sources give the *krota* (in modern Indian languages *kāla*) as 2,000 *daṇḍas* the *Arthasastra* gives it as only 1,000; the *yojana*, which was the commonest measure of long distances in ancient India, would thus be only 4½ miles (7·2 km.). It is therefore clear that there were at least two yojanas, and distances as given in texts are thus very unreliable. It would seem that for practical purposes the shorter *yojana* was more often used than the longer, especially in earlier times.

**MEASURES OF TIME**

Ancient Indian learned men devised a detailed terminology for minute intervals of time, which had little relation to everyday life and must be looked on as a flight of fancy. The longer measurements in most general use were:

- 18 *nimāras* (winks) = 1 *kāṭhā* (3½ secs.)
- 30 *kāṭhās* = 1 *kāla* (1½ mins.)
- 15 *kāls* = 1 *nāḍikā* or *nālīkā* (24 mins.)
- 30 *kāls* or 2 *nāḍikās* = 1 *muhūrta* or *kṣanā* (48 mins.)
- 30 *muhūrtes* = 1 *aḥo-rātra* (day and night, 24 hours).

A measurement frequently used, but not consistent with this system, was the *yāma* or watch, one-eighth of a day and night, or three hours. In some sources, however, the *yāma* is given as three *muhūrtes*, or one-tenth of a day and night. The hour (*korā*) was introduced from the West in the Gupta period and was used in astronomy, but was not widely employed in everyday life.

For longer measures of time see p. 494ff.

**APPENDIX IX**

**COINAGE**

**EARLY PUNCH MARKED COINS**

Uninscribed punchmarked coins were probably minted from the 6th century B.C. onwards, and were in circulation for many centuries. Among the earliest silver specimens are those in the shape of a small bent bar, the largest of which, the *satamāna*, weighed 180 grains (11·66 gms.). Half, quarter and half-quarter *satamānas* are attested.

The basic silver punchmarked coin of the usual type was the *kārdāpana* or *pāṇa*, of 57·8 grains (3·76 gms.). The *māṣa* or *māṣika* weighed one-sixteenth of this, or 3·6 grains (0·26 gms.). Various intermediate weights are attested, as well as large silver coins of 30 and 20 *māṣas* and small half-*māṣa* pieces.

Punchmarked copper coins were generally based on a different standard —a *māṣa* of 9 grains (0·56 gms.) and a *kārdāpana* of 144 grains (9·33 gms.).

* We are much indebted to Professor A. K. Narain, of Banaras Hindu University, for providing the material for this appendix.
Quarter-māṣas in copper, or kākipīs (2.25 grains or 0.15 gms.) are attested, as well as large coins of 20, 30 and 45 copper māṣas.

Only one gold punchmarked coin is known, and it must be assumed that gold was very rarely minted before the beginning of the Christian era.

**INDO-GREEK COINS**

The earlier Greek kings minted coins according to the Attic standard, based on the drachm of 67.2 grains (4.34 gms.) and the obol (¼ drachm) of 11.2 grains (0.71 gms.). Silver coinage of this type ranges from hemiobols to the very large double decadrachms, struck by a king Amyntas, which have recently been found in Afghanisītan. After their southward expansion the Greeks adopted a reduced weight, with silver coins of 152 and 38 grains (9.85 and 2.46 gms.).

The Greek kings issued numerous copper coins, but their metrology is not clear. Gold coins must have been very rare. There exist a very large 20 stater piece of the Bactrian usurper Eucratides and rare staters of a few other kings. Śaka and Pahlava coins in silver and copper follow the reduced Indo-Greek standard.

**KUṢĀṆA COINS**

These were minted in gold and copper. The gold dināras or svavāras were based on the Roman denarius and were of 124 grains (8.04 gms.). Double and quarter dināras were also issued. The copper coins were large, of from 26 to 28 māṣas, or 240 to 260 grains (15.55 to 16.85 gms.).

**PRE-GUPTAN AND GUPTAN COINS**

A large range of coins in silver and copper, of very varied weight and character, was issued by the indigenous kings, tribes, and cities of Northern India in the centuries immediately preceding and following the beginning of the Christian era. The Sātavāhanas of the Deccan also issued coins of lead and potin (base silver), while the Śakas of Gujarāt, Mālwā and the Western Deccan issued a distinctive series of coins in silver.

The gold coins of the Guptas (dināra) originally approximated to the Kuṣāṇa standard, but in the middle of the 5th century rose in weight to 144 grains (9.33 gms.), thus returning to the Indian standard of the copper kārsāpana. Guptas silver coins (rūpaka), based on those of the Śakas of Ujjayinī, weighed 92–96 grains (2.07–2.33 gms.). The metrology of Gupta copper coinage is obscure, and weights of from 3.3 to 101 grains (0.19–6.54 gms.) are attested.

**MEDIEVAL COINS**

Gold coins (svavāna, ūkha) were minted by only a few dynasties in the 11th century. These approximated to the Greek drachm standard of 67 grains (4.34 gms.). Silver coins (dramma, ūkha) also conformed to this standard, and coins of ¼, ½ and ¼ dramma are attested. Numerous types of copper coin were issued, of diverse metrology. The coinage of the medieval dynasties of the Peninsula was very varied and a full study of its metrology is yet to be made.
APPENDIX X

THE ALPHABET AND ITS PRONUNCIATION

The alphabet devised by ancient Indian phoneticians and adapted to all the chief Indian languages except Urdû is as follows:

I. VOWELS

(a) simple

<table>
<thead>
<tr>
<th></th>
<th>short</th>
<th>long</th>
</tr>
</thead>
<tbody>
<tr>
<td>guttural</td>
<td>(1) a</td>
<td>(2) ḍ</td>
</tr>
<tr>
<td>palatal</td>
<td>(3) i</td>
<td>(4) ĩ</td>
</tr>
<tr>
<td>labial</td>
<td>(5) u</td>
<td>(6) ō</td>
</tr>
<tr>
<td>retroflex</td>
<td>(7) r</td>
<td>(8) ų</td>
</tr>
<tr>
<td>dental</td>
<td>(9) ĭ</td>
<td>(10) ĭ*</td>
</tr>
</tbody>
</table>

(b) diphthongs

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>palatal</td>
<td>(11) e</td>
</tr>
<tr>
<td>labial</td>
<td>(12) ai</td>
</tr>
<tr>
<td></td>
<td>(13) o</td>
</tr>
<tr>
<td></td>
<td>(14) au</td>
</tr>
</tbody>
</table>

II. CONSONANTS

(a) visarga

<p>| | |</p>
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<tbody>
<tr>
<td>(15) h</td>
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(b) anusuvra

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<tr>
<td>(16) m</td>
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</table>

(c) stopped consonants

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<thead>
<tr>
<th></th>
<th>unvoiced</th>
<th>unvoiced</th>
<th>voiced</th>
<th>voiced</th>
<th>nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>guttural</td>
<td>(17) k</td>
<td>(18) kh</td>
<td>(19) g</td>
<td>(20) gh</td>
<td>(21) ḍ</td>
</tr>
<tr>
<td>palatal</td>
<td>(22) c</td>
<td>(23) ch</td>
<td>(24) j</td>
<td>(25) jh</td>
<td>(26) ḍ</td>
</tr>
<tr>
<td>retroflex</td>
<td>(27) ī</td>
<td>(28) īh</td>
<td>(29) ī</td>
<td>(30) īh</td>
<td>(31) ṣ</td>
</tr>
<tr>
<td>dental</td>
<td>(32) ī</td>
<td>(33) īh</td>
<td>(34) d</td>
<td>(35) dh</td>
<td>(36) n</td>
</tr>
<tr>
<td>labial</td>
<td>(37) ī</td>
<td>(38) pḥ</td>
<td>(39) b</td>
<td>(40) bh</td>
<td>(41) m</td>
</tr>
</tbody>
</table>

(d) semivowels

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>palatal</td>
<td>(42) y</td>
</tr>
<tr>
<td>retroflex</td>
<td>(43) ī</td>
</tr>
<tr>
<td>dental</td>
<td>(44) l</td>
</tr>
<tr>
<td>labial</td>
<td>(45) v</td>
</tr>
</tbody>
</table>

(e) sibilants

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>palatal</td>
<td>(46) l</td>
</tr>
<tr>
<td>retroflex</td>
<td>(47) ĭ</td>
</tr>
<tr>
<td>dental</td>
<td>(48) s</td>
</tr>
</tbody>
</table>

(f) aspiration

<p>| | |</p>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(49) ḍ</td>
<td></td>
</tr>
</tbody>
</table>

* This vowel is the invention of the pandita, and never occurs in practice. The short vocalic ĭ occurs only in the root ḍip and its derivatives.
To these letters the Dravidian languages and Sinhalese add the short vowels ā (between ē and ē) and ṭ (between ē and o). Sinhalese has also the additional vowels ā and ē (between ē and i). Tamil adds the consonants ḷ, ḷ (not the same as the vocalic ḷ of Sanskrit), ṛ, and ṣ at the end of the alphabet; these letters cannot stand at the beginning of a word. The Tamil alphabet omits the aspirate letters and several others, and the unvoiced letters serve to express the sound of the voiced. The system of transliteration used for Tamil words and quotations in this book does not show this peculiarity.

It will be seen that this alphabet is methodical and scientific, its elements classified first into vowels and consonants, and then, within each section, according to the manner in which the sound is formed. The gutturals are formed by the constriction of the throat at the back of the tongue, the palatals by pressing the tongue flat against the palate, the retroflexes by turning up the tip of the tongue to touch the hard palate, the dentals by touching the upper teeth with the tongue, and the labials by pursing the lips.

The vowels ā, ī, ū, ū, ē, ai, o, and au are pronounced approximately as in German or Italian, ē and o being "close" sounds, as in German boten and boten, but short ā has the dull sound of the English shut. In very early times ḷ and the vocalic ē were pronounced approximately as are the second syllables of the words water and bottle by Americans, but before the Christian era they were sounded as ri and bri. The Sinhalese ā and ē are pronounced approximately as the vowels in the English hat and hair respectively. According to traditional phonetics ē and o are classed as diphthongs and in Sanskrit are invariably long.

Of the two first consonants ḷ, occurring only at the end of words or syllables, is a rough breathing, replacing an original s or r. It is a distinct emission of breath, often followed by a faint continuation of the preceding vowel. Anuvāra, or ṭ, written in Indian scripts as a dot, is in part a mere abbreviation, representing a nasal sound before a stopped consonant. Thus sandhi is pronounced as sandhi, and amga as ātha. Before semi-vowels, sibilants or h it had the effect of nasalizing the preceding vowel, as in French or Portuguese; thus amtu was pronounced very approximately as the French un chou. By many modern speakers ṭ in this context is pronounced as the English ng in sing.

The distinction between the aspirate and unaspirate consonants is not immediately recognized by the Westerner, but it is clear to the Indian. K, for instance, is pronounced without any noticeable emission of breath, and ḷ (written as one letter in Indian scripts) with a strong emission, as in the usual pronunciation of the English c in come. Thus the reader should avoid the temptation to pronounce th and ph as the initial sounds of the English thing and phial; they approximate to the sounds in pothook and shepherd. C is pronounced approximately as the second consonantal sound in the English church, and ch as the first sound in the same word, i.e. with a stronger emission of breath. J is pronounced as in English, and not as in German or French. A clear distinction is made between the retroflex or cerebral
consonants and the dental, though it is not very evident to the untrained ear. The English $t$ and $d$ are nearer to the Indian retroflex $\hat{t}$ and $\hat{d}$ than to the Indian dentals $t$ and $d$, which approximate to the corresponding sounds in Italian.

Modern Indians do not generally differentiate in speaking between $s$ and $\hat{s}$, and inscriptions show that the two sounds began to be confused at an early date. Both resemble $sh$ in the English $shut$. Originally $\hat{s}$ was pronounced, like the other retroflex consonants, with the tip of the tongue touching the top of the hard palate.

Of the special Tamil letters $\hat{l}$ has the sound of an $l$ with the tongue turned as far back as possible. Many modern Tamil speakers pronounce this letter rather like the $s$ in the English measure or the French $j$, but more harshly. The consonantal $\hat{j}$ (which also occurs in Vedic and some Prakrits) is pronounced by placing the tongue on the top of the hard palate and flapping it forward; $\hat{r}$ at the end of a syllable is often pronounced as $t$; between two vowels it is approximately $dr$, and when doubled $tr$, while $\hat{nr}$ is usually pronounced as $n\acute{dr}$; though a distinction formerly existed, Tamil, $\acute{y}$ is in modern speech indistinguishable from $n$.

We have seen that Vedic Sanskrit, like Greek, had a tonic accent, but this, again as in Greek, disappeared very early from ordinary speech, its place being taken by a stress accent, as in most European languages. The stress is placed on the last prosodically long syllable of a word (i.e. a syllable containing either a long vowel or a short vowel followed by two consonants) other than the final syllable, which never has the accent. In a word with no long syllables the accent is on the first syllable. E.g. $\ddot{s}d\bar{b}h\ddot{a}$, Him\ddot{\iota}\lambda\ddot{\iota}a, $\ddot{S}\acute{a}k\ddot{\u{u}}nt\ddot{\u{a}}\lambda\ddot{\iota}$, $\ddot{d}v\acute{\iota}v\acute{a}v\acute{a}$. The stress is not as marked as in English.

APPENDIX XI

PROSODY

Like those of classical Europe the metres of Indian poetry are quantitative, based on the order of long and short syllables, and not, as in English, on stress. As in classical European languages a syllable was counted as long if it contained a long vowel ($\ddot{\alpha}$, $\ddot{\iota}$, $\ddot{\u{u}}$, $\ddot{\ddot{r}}$, $e$, $o$, $\ddot{\alpha}i$ or $\ddot{\alpha}u$) or a short vowel followed by two consonants. The favourite stanza form at all times was of four lines or “quarters” ($\ddot{\pi}\ddot{a}d\ddot{a}$), usually equal, and varying in length from eight to over twenty syllables each, with a full cæsura between the second and third quarters. Most of the metres of classical poetry were set in rigid patterns, and not divided into feet but broken only by one or two cæsurae in each quarter. The metres of the Veda, however, and the epic $\ddot{\iota}l\ddot{\acute{o}}k\ddot{a}$ metre, allowed considerable variation.

Though most of the Vedic hymns are in stanzas of four quarters there are some with three or five divisions. Of these one, called $G\acute{\ddot{a}y\ddot{a}tr\ddot{\ddot{i}}}$, is common, and is that of the famous $G\acute{\ddot{a}y\ddot{a}tr\ddot{\ddot{i}}}$ verse quoted on p. 183. It
consists of three sections of eight syllables each, the first four of which
are free while the last four have the cadence \( \odot - \odot \odot \).

The commonest Vedic stanza is Tristubh, consisting of four quarters of
eleven syllables each. The quarter normally has a cæsura after the fourth
or fifth syllable, and is prevailingly iambic. The last four syllables of each
quarter have the cadence \( \odot - \odot - \odot \). For example:

\[
\begin{align*}
\text{Indrasya nu vrishi
\text{yānī cakra prathamāni vajr.}}
\text{Ahann Ahim, anu apās tatārda,}
\text{pra vakṣyād abhinat pravatānāḥ. *}
\end{align*}
\]

Similar to this, but with an extra syllable in each quarter, was the twelve-
syllabled Jagati, with the cadence \( \odot - \odot - \odot \).

In the later hymns of the Rg Veda a stanza of four eight-syllable quar-
ters, called Anustubh, became popular. This was much the same as Gāyatrī,
with a fourth line added, but there was considerable variation in the final
cadence. For example:

\[
\begin{align*}
\text{Saḥdara-sīrā Pūruṣah,}
\text{sahasmād, sahdraśām.}
\text{Ṣā dhūmin viśvato vrīvā}
\text{diy atiṣṭhād daśāhulgām. †}
\end{align*}
\]

From the Anustubh of the Vedas developed the Śloka, the chief epic metre
of later times. This consisted of four quarters of eight syllables each, the
first and third normally ending with the cadence \( \odot - \odot \odot \), and the second
and fourth with \( \odot - \odot - \odot \). Certain specified variations were allowed.
As an example we quote the first verse of the account of Damayanti’s
svayamvara, translated on p. 412.

\[
\begin{align*}
\text{Atha kāle śubhe prāpte,}
\text{itiha puraye kṣaṇa tathā,}
\text{ājñāva mahāprān}
\text{Bhīmo rājā svayamvara.}
\end{align*}
\]

The śloka metre was widely used for poetry of all kinds, especially for
didactic and narrative verse. The courtly poets, however, favoured longer
metres, with their quantities rigidly fixed in complicated rhythmic patterns,
some with regular cæsures. Textbooks describe over 100 metres of this
kind, many with fanciful names, but only some twenty or thirty were popu-
lar. Of these we mention a few of the most common.

Indravajra (“Indra’s Thunderbolt”):

\[
4 \times 11: \odot - \odot - \odot - \odot - \odot - \odot - \odot - \odot.
\]

\[
\begin{align*}
\text{Bhāgtrath-niljharai-skandāṇam}
\text{vočha mukhā kampita-devadāruḥ}
\text{yad vāyur anvijamṛgaiḥ kiratair}
\text{dosyate bhinnā-śikhaṃdi-barhaḥ. ‡}
\end{align*}
\]

* The first verse of the hymn to Indra (R.V. i. 32) translated on p. 402.
† The first verse of the “Hymn of the Primeval Man” (R.V. x. 90), in part translated
on p. 242).
‡ Kundara Sambhava, 1, 18, translated on p. 425—“And the wind forever . . .”
Upendravajra (Secondary Indravajra), a variant of the above, with the first syllable short:

4x11: ॐ — ॐ — ॐ ॐ — ॐ — ॐ.

Quarter lines of Indravajra and Upendravajra were often combined in mixed stanzas. Such stanzas of varying metres were called Upajāti.

Vamsastha:

4x12: ॐ — ॐ — ॐ ॐ — ॐ — ॐ ॐ.

Indravamśa: like Vamsastha, but with a long first syllable:

4x12: ॐ — ॐ — ॐ ॐ — ॐ — ॐ ॐ.

Vamsastha and Indravamśa were often combined in an Upajāti metre, e.g. the verses of Kālidāsa quoted on p. 424, n.

Vasantatilākā (“The Ornament of Spring”):

4x14: ॐ — ॐ — ॐ ॐ ॐ — ॐ — ॐ — ॐ.

Adyāpi tāṁ prapayinīṁ mṛgatāvākāśīṁ
piyāśa-varṣa-seva-kumbha-vyugāṁ vakantān
paṇḍārya aham yadi punar divāsāvasāne
svargāpavarga-vara-rājya-sukham tyajāmi.

Mālinī (“The Girl wearing a Garland”):

4x15: ॐ ॐ ॐ — ॐ ॐ — ॐ — ॐ — ॐ.

Kim iha bahubhir uktaṁ yuktī-sūnyaiḥ pralāparī?
Dvayam api puruṣātman sarvadā sevanīyan—
abhinava-mada-lilā-lālitasam sundarīṇāṁ
stana-bhara-parikhimnaṁ yauvanāṁ vā vaṁ vā.

Pīthot (“The Earth”):

4x17: ॐ — ॐ — ॐ — ॐ — ॐ — ॐ — ॐ.

Labheta sikātānu tailam api yatnataḥ piḍayam
pipec ca mṛgatāvākāśai sahīlaṁ piḷāśārditaḥ
kadācid api paryataḥ chaṭaṇāṇiḥ āsādayet,
na tu pratiṇivitiā-mūrkha-jana-cittam ārdha-yayet.

Mandākāntā (“The Slow-stepper”):

4x17: — — — / ॐ ॐ ॐ — ॐ — / — — — — ॐ.

An example of this metre is given on p. 421, n.

Śikharīṇī (“The Excellent Lady”):

4x17: ॐ — ॐ — ॐ — ॐ — ॐ — ॐ — ॐ.

Yad’ āśīr aṭāṇam smara-timira-tayakā-jaṇitaṁ
tadda dṛṣṭaṁ nārī-mayam idam aṭāṇam jagad api.
Idānīṁ aṣṭaṁ paṭutara-vivakākhyajana-jaṇaṁ
samabhāyā dṛṣṭaṁ tirbhuvanam api Brahma manute.

* Bilhana, Cevapakotiḥ, 46, translated on p. 450: “Even today, if this evening . . .”
† Bhartiṛ, Sṛgṛṭalata, 63, translated on p. 428: “What is the use . . .?”
‡ Bhartiṛ, Nitiśalata, 8, translated on p. 427: “You may if you squeeze hard enough . . .”
§ Bhartiṛ, Pṛnāyalata, 82, translated on p. 428: “When I was ignorant . . .”
Hariṣī ("The Doe"):

\[ \times 17: \quad \ddots \quad \ddots \quad \ddots \quad / \ddots \quad \ddots \quad \ddots \quad \ddots \quad \ddots \]

Apara-jaladher Lakṣmīṃ yasmin Purīṃ Purabhīt-prabhē mada-gaja-gaṭākāraia nāvāṃ tātār amavāṇānāt jalada-paṭalānīkārṇaṃ navotpala-mecakāṃ jalanidhir iva vyoma vyomaḥ samāḥ bhavād ambaḍhiḥ. *

Śaḍāla-vikṛṣṭīta ("The Tiger's Sport"):

\[ \times 19: \quad \ddots \quad \ddots \quad \ddots \quad \ddots \quad \ddots \quad / \ddots \quad \ddots \quad \ddots \quad \ddots \quad \ddots \]

Kelāh samyamināḥ, truter api param pāramgata locane, cāntaraśaktam api svabhava-sucibhiḥ kīraṇaṃ dvijānām ganaṇāḥ, muktānāṃ satatādhiyāśa-ruciraṃ vakṣoja-kumbhādvaṃ cetthāṃ tanvi vapuḥ prāśāntam api te kṣobham karoly eva naḥ. †

Srādgārā ("The Girl with a Garland"):

\[ \times 21: \quad \ddots \quad \ddots \quad \ddots \quad / \ddots \quad \ddots \quad \ddots \quad \ddots \quad \ddots \]

The verses of Bāna quoted on p. 428, n. are in this metre.
In a few rather rare metres the first and third quarters differ in length from the second and fourth. The commonest of these is Puspītāgṛā:

\[ 2 \times (12 + 13): \quad \ddots \quad \ddots \quad \ddots \quad \ddots \quad / \ddots \quad \ddots \quad \ddots \quad \ddots \quad \ddots \]

"Aham iha nivasāmi. Tāhi Rādhām, anunaya madvacanena c' ānayethāḥ".
Iti Madhuripuṇā sakhi niyuktā, svayam idam etya punar jagā da Rādhām. ‡

As well as metres of this type there are others, the scansion of which is based on the number of syllabic instants (mārā) in each quarter-verse. The most common of these is Āryā ("The Lady"). This is divided into feet, each containing four instants, counting a prosodically short syllable as one and a long syllable as two instants (i.e. \(-\), \(-\), \(-\), \(-\), \(-\), \(-\), \(-\), \(-\)). The first quarter of the Āryā stanza contains three such feet; the second, four and a half; the third, three, and the fourth three and a half, with an extra short syllable after the second foot. The whole of Hāla’s Saptaśataka is written in this metre; for example:

Bhāḍantīta tānāṁ sottuṁ dināṁ jāi pahiiṣe. Tāi cca paḥde ajjā daḍḍhaṇi ruanī. §

* "Radiant as the god Śiva, he besieged Purl, the fortune of the Western Sea,
with hundreds of ships, like elephants in rut,
the dark blue sky, scattered with hosts of heavy clouds,
looked like the sea, and the sea looked like the sky." From a panegyric of King Pulakeśin II Cālukya in an inscription at Alīhoṭe, Mysore, composed by Ravikīrti and dated A.D. 634 (EI vi, 8ff.).
† Bhųtrhari, Āgārāṣṭaka, 12, translated on p. 427: "Your hair well combed . . . ."
‡ The introductory verse to the lyric of Jayadeva’s Gītā Govindā, translated on p. 430.
§ Saptaśataka, 379, translated on p. 463: "Last night with scorn . . . ."
This verse is to be scanned as follows:

\[
- - / - \textcircled{\text{-}} \textcircled{\text{-}} / - - / \\
- - / - - / - \textcircled{\text{-}} \textcircled{\text{-}} / - \textcircled{\text{-}} / - \\
- - / - \textcircled{\text{-}} \textcircled{\text{-}} / - - / \\
- - / - - / - / - / -
\]

The metres employed by Jayadeva in his Gita Govinda are exceptional, although imitated by later poets. They are no doubt borrowed from popular song. The stanzas of the lyric quoted on p. 431, excluding the refrain, consist of four quarters of nine, eight, nine and ten syllables respectively, all of which are short except the last rhyming syllable in the first and third quarters and the penultimate in the second and fourth.

The prosody of Tamil poetry differs considerably from that of Sanskrit. In Tamil the basic unit is the “metrical syllable” (\textit{atai}), which may be a single syllable or a long syllable preceded by a short one. Two, three or four of these form a foot, of which a line of poetry may contain from two to six or occasionally more. Complicated rules, which cannot be discussed here, much restrict the order of syllables and feet in the line.

\section*{APPENDIX XII}

\section*{THE GYPSIES}

Among India’s many gifts to the world we must include the Gypsies, who, with their music and dancing, have formed a romantic and colourful element in European life for over five centuries.

The European Gypsies have no recollection of their Indian origin, but have generally claimed to be Egyptians. The Russian Gypsies, it is said, even declare that their ancestors were a single soldier of the army of Pharaoh and a young girl, who escaped drowning when Moses led the Israelites over the Red Sea. This tradition of the Gypsies’ Egyptian origin was for long taken at its face value, until in 1783 a Hungarian protestant theological student, Stefan Vályi, published a brief paper pointing to the close similarity between the language of the Gypsies of his native plains and that of three Indians whom he had met at the University of Leyden. It was long before the true significance of this fact was recognized, but it is now universally agreed that the Gypsy language or Romani is an Indo-Aryan one, and that the fact can only be accounted for by postulating that the Gypsies came from India.

The relationship of Romani to the languages of Northern India is very obvious, even to those with no linguistic training, for many of the commonest words of Romani are little different from those of India. Thus:
APPENDIX XII

<table>
<thead>
<tr>
<th>Romani *</th>
<th>Indo-Aryan</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ek</em></td>
<td>Sanskrit <em>ek</em>, Hindi <em>ek</em></td>
<td>one</td>
</tr>
<tr>
<td><em>dui</em></td>
<td>Skt. <em>dva</em>, H. <em>do</em></td>
<td>two</td>
</tr>
<tr>
<td><em>tris</em></td>
<td>Skt. <em>tri</em>, H. <em>tīn</em></td>
<td>three</td>
</tr>
<tr>
<td><em>star</em></td>
<td>Skt. <em>cauṭr</em>, H. <em>cār</em></td>
<td>four</td>
</tr>
<tr>
<td><em>pañci</em></td>
<td>Skt. <em>pañcaka</em>, H. <em>pañca</em></td>
<td>five</td>
</tr>
<tr>
<td><em>do</em></td>
<td>Skt. <em>gaṇ</em></td>
<td>six</td>
</tr>
<tr>
<td><em>eśṭa</em></td>
<td>(Greek, ἐκτός)</td>
<td>seven</td>
</tr>
<tr>
<td><em>oḥto</em></td>
<td>(Greek, ὄχτο)</td>
<td>eight</td>
</tr>
<tr>
<td><em>tvaś</em></td>
<td>(Greek, ὕψος)</td>
<td>nine</td>
</tr>
<tr>
<td><em>dev</em></td>
<td>Skt. <em>daśa</em></td>
<td>ten</td>
</tr>
<tr>
<td><em>biś</em></td>
<td>H. <em>bīs</em></td>
<td>twenty</td>
</tr>
<tr>
<td><em>śiś</em></td>
<td>Skt. <em>śāla</em></td>
<td>hundred</td>
</tr>
<tr>
<td><em>manuś</em></td>
<td>Skt. <em>manuṣya</em></td>
<td>man</td>
</tr>
<tr>
<td><em>bāl</em></td>
<td>Skt. <em>bāla</em>, H. <em>bāl</em></td>
<td>hair</td>
</tr>
<tr>
<td><em>kan</em></td>
<td>Skt. <em>kāraṇa</em>, H. <em>kās</em></td>
<td>ear</td>
</tr>
<tr>
<td><em>nag</em></td>
<td>H. <em>nāk</em></td>
<td>nose</td>
</tr>
<tr>
<td><em>yak</em></td>
<td>Skt. <em>akṣa</em></td>
<td>eye</td>
</tr>
<tr>
<td><em>kalo</em></td>
<td>Skt. <em>kāla</em></td>
<td>black</td>
</tr>
<tr>
<td><em>caco</em></td>
<td>Skt. <em>sātya</em>, H. <em>sac</em></td>
<td>true, etc., etc.</td>
</tr>
</tbody>
</table>

Philologists have shown by the comparison of Romani with the Prākrits and modern Indian languages that the Gypsies originated in the Gangā basin, which they left before the time of Aśoka (3rd century B.C.), to reside for several centuries in North-Western India. Probably even at this time they were wandering musicians and entertainers. In modern India there is a lowly caste of such people called *Doms*, attested since the early Middle Ages, and with this word the word *Rom*, by which the Gypsies universally designate themselves, is probably connected. In Syrian Romani it occurs as *Doun*, very close to the Indian form.

According to the 11th c. Persian poet Firdūsī, who collected many legends and traditions of pre-Muslim Persia in his "Book of Kings" (*Shāh-nāmaḥ*), the 5th-century Sāsānian king Bahram Gūr invited ten thousand Indian musicians to his realm, and gave them cattle, corn and asses, so that they might settle in the land and entertain his poorer subjects, who had been complaining that the pleasures of music and dance were reserved for the rich. But the musicians refused to settle; they ate the cattle and seed-corn which the king had given them, and wandered about the land like wolves or wild dogs.

Though Firdūsī's story may not be wholly accurate, it shows that low caste Indian musicians were well known in the Middle East at a very early time. With the Arab conquest of Sind in the early 8th century further groups of Indian entertainers must have found their way westwards and later have moved on to Africa and Europe. Folk called Athinganoi are recorded as living in Constantinople in a.d. 810, and later Byzantine records refer to these Athinganoi or Azinganoi as magicians and conjurors.

* These words are taken from Serboianu's grammar and glossary of Rumanian Romani (*Le Trigéme*, Paris, 1930). His rather unscientific system of transliteration has been modified in accordance with the usual Indo-Aryan system.
These were probably the forerunners of the Tsigany bands who appeared in Central and Western Europe in the late Middle Ages. The earliest evidence of Gypsies in Europe other than in the Balkans comes from the German city of Hildesheim, where a passing band is recorded in 1407. A great horde of Gypsies passed through Basel in 1422, under a chief who called himself Michael, Prince of Egypt. Within a few decades they had overrun all Europe; the earliest records show that they had all the characteristics of their descendants—they were careless, lazy, dirty and cheerful, skilled in metal work and tinkering, splendid musicians and dancers, their bodies bedecked with bright garments and jewellery, their menfolk cunning horse-dealers, their womenfolk telling fortunes, and both sexes losing no opportunity to pilfer from the unsuspecting gorjo. It was not long before the Gypsies began to feel the fierce persecution which they were to suffer in most parts of Europe down to recent times, when many Gypsies perished in the gas-chambers of the Third Reich.

From numerous loan-words in the various dialects of Romani we may roughly trace the course of their migrations. All the Romani dialects of West and Central Europe contain many Greek and South Slavonic words, which prove that the ancestors of our western Gypsies dwelt long in the Balkans. The Spanish Gypsies appear to have arrived in their new homeland from two directions, a first immigration coming via Egypt and the north coast of Africa, no doubt during the Moorish occupation of southern Spain, and a second, later, over the Pyrenees.

Little but their language remains to connect the Gypsies with their original home, and even their speech is full of borrowings from almost every tongue of Europe and many of Asia. Though the Gypsies have always tended to marry their own kind, centuries of wandering have left their mark on the Gypsy type and there are now many fair Gypsies, though others, if suitably attired, would not seem out of place in a modern North Indian city. On analysis their music is that of the lands in which they dwell. Whether in Hungary, Rumania or Spain, it is based on local folk-song and dance. Unfortunately the English Gypsies have largely forgotten their traditional art, but when they sing they sing folk-songs and music-hall ballads; in Ireland the tinkers sing Irish folk-songs. Yet, wherever the Gypsies go, their musicians tend to give their music a character of its own. A predilection for ornamentation of the melody, especially with quarter-tones, a preference for the minor mode, a tendency to introduce progressions by augmented whole tones into their melodies, and a love of complex rhythm, are perhaps survivals of the Indian musical tradition which the first Romanies brought with them from their homeland. Some Gypsy folktales resemble those of India, but the same may be said of the traditional tales of every country of Europe. A few Gypsy customs and beliefs may be genuine Indian survivals. Though by no means a hygienically inclined people, the Gypsies have ideas of ritual purity and birth and death taboos which remind us of those of Hinduism. Thus a woman in childbirth is impure, and must bear her child outside her caravan or tent lest she pollute it. Gypsy midwives are impure throughout their lives, and are taboo to all respectable
Gypsies, like the outcast village midwives of India. Corpses are also impure, and dying Gypsies are carried from their caravans to end their lives in the open air, for fear of pollution. The Gypsy taboo on horse-slaughterers may have an Indian origin. But all these resemblances might well be accounted for otherwise.

The Gypsies have, in fact, forgotten their ancestry. In one respect, however, they have kept to the traditions of their homeland. Though they have adapted their ways to time and place, and have always been open to new influences, they are still governed by their own laws and their own code of morality. They have doggedly retained their individuality against persecution and persuasion alike—an independent social group, transcending regional and national boundaries, knit together by common customs, common means of livelihood, and common blood. In this respect they are Indian. They are a caste, as their Indian counterparts, the Doms, are a caste, and even the innovations of the Twentieth Century have not been able to destroy their caste solidarity.