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Study of the Golden Period (200BC-500AD)

Science and Technology

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Contributions and research spanned the following fields:

- Number Theory
- Science of Cognition
- Science of Speech
- Science of Prosody
- Musicology
- Science of Dramatics, Storytelling
- Science of Mind, Yoga, Psychology
- Medical Sciences, Hygiene
- Astronomy
- Metallurgy, Chemistry

References

- Aṣṭādhyāyī (अष्टाध्यायी) by Pāṇini
- Chandaḥśāstra (छन्दःशास्त्र) by Piṅgala
- Arthaśāstra (अर्थशास्त्र) by Kauṭilya
- Nāṭyaśāstra (नाट्यशास्त्र) by Bharata
- Rāmāyaṇaṁ (रामायणम्) by Vālmīki
- Carakasaṁhitā (चरकसंहिता) by Charaka
  (recompiled by Agnivaesha in 4th century AD)
- Tattvārthasūtra (तत्त्वार्थसूत्र) by Umāsvāti
- Gaṇitānuyoga (गणितानुयोग) Jaina compilation
- Mūlamādhyamakakārikā (मूलमाध्यमककारिका) by Nāgārjuna
- Dattilam (दत्तिलम्) by Dattila
- Yogasūtraṁ (योगसूत्रम्) by Pātañjali
- āryabhaṭiyaṁ (आर्यभटियम्) by Aryabhatta
- Vākyapadīyaṁ (वाक्यपदीयम्) by Bhartṛhari
- Various internet resources

Number Theory

- Jaina Philosophers led by Mahavira conceived of a bounded but measurable universe.
- Measuring unit of length in the form of अंगुल āṁgula *(*width of a finger) and unit of time through पक्ष्म pakṣma (wink of an eye) were discovered.
- The bounded universe was conceived to be self-contained with a large but comprehensible expanse. The term लोकाकाश *lokākāśa* referred to a finite innumerable extent.
- Boundedness helped to conceive of large numbers and the concept of arithmetic in producing numbers.
- Infinitesmals, fractions and zero could be conceived
- Beyond लोकाकाश, there was the idea of अलोकाकाश with an extent अनन्त Ananta, no “end”. This was the first definition of the concept of infinity, that has no boundary.

Science of Cognition

- Jainas discovered that our senses have limited information gathering ability and our views of impression could be less than optimum.
- There was discovery that the individual mind can create its own view and hence any object and scene can have multiple views of perception.
- Respect to human observations demands that all views need have acceptance leading to a philosophy of अनेकान्त *anekānta,* meaning multiple inferences.
- Philosophy developed to argue the logic of reality, articulated as सत् *sat* in the Vedas.
- Object reality was settled as object realization through योग *yoga,* than by object comprehension by the sensess.
- Various theories developed to define “reality.”

Science of Speech

- Speech was considered an endowment for the humans.
- Speech consisted of expressing in वर्ण (varṇa), the unit of articulation, that has acoustic manifestation.
- Empirically, sixrty four वर्ण (s) were identified through the vocabulary of the old languages.
- The वर्ण was believed to be cosmic in origin, appearing to carry the semantic information of the objects in the universe.
- वर्ण(s) were grouped into स्वर (svara) and व्यञ्जन (vyañjana). व्यञ्जन originating in the body carried the thrust of articulation, while स्वर applied the rendering through the vocal apparatus.
- व्यञ्जन was divided into eight groups signifying the quality of sound production.
- Sound was considered the tracer of the evolution.

Science of Prosody (छन्द:)

- The Vedas had declared that various parts of the universe were orchestrated with rhythms.
- Classical Prosody declared that the rhythm is an arrangement of binary patterns, two time units, one double than the other.
- Science of Prosody developed to capture the emotional thrust of a composition through voice rendering using the binary patterns embedded in the rhythm.
- The patterns appear as natural sets of binary series, suggesting the creation of harmony through mathematical progressions.
- Prosody छन्द: was defined as प्राणमात्रा prāṇamātrā., the time measure of the life force.
- छन्द: is expressed through the voice, hence the term वाचिकप्राण vācikaprāṇa, life as expressed through the voice.
- छन्द: is an आच्छादन ācchādana, an envelope for the words.

Musicology (Theory of Music)
(from Dattilam, 1st century BC.)

- Acoustic perception consists of twenty-two श्रुति *śruti*, which form a pitch hierarchy.
- The pitch perception has three levels – मन्द्र *mandra* in the chest, मध्य *madhya* at the throat and तार *tāra* at the head.
- Seven locations in the श्रुति spectrum are matched to be स्वर *svara,* following natural external sounds.
- The selection of श्रुति in establishing a स्वर, creates a ग्राम *grāma*
- Sequencing the स्वर creates मूर्छना *mūrchanā* (melody)
- श्रुति is supported by ताल *tāla,* the musical time measure.
- ताल guides लय *laya,* the rate.
- Three लय can be sustained, द्रुत *druta* “fast”, मध्य *Madhya* “medium”, विलम्बित *vilambita “slow”.*
- लय is measured through काल *kāla,* an aggregate of निमेष *nimeṣa*, the wink of an eye.

Science of Dramatics, Storytelling

- Perception and psychology developed a theory of aesthetics, called रस rasa, an *upaniṣad* word denoting “essence”.
- An elaborate model of रस manifestation was created through performing arts of music, dance and drama.
- Detailed dramatical instructions in performing arts suggest an old empirical discovery of rendering emotion through physical expressions through voice or body muscles.
- The dramatics were possibly rooted in the empirical art of storytelling, which helped develop the oral literature.
- Storytelling and dramatization through words resulted in a climax through the composition of रामायण *rāmāyaṇa* by *V*ālmīki
- रस theory helped develop अलंकार *alaṁkāra, “ornamentation”* as a part of literature, blossoming in Kalidasa’s poetry.

Science of Mind, Yoga, Psychology

- Mind was considered a sense organ, controlling the other sense organs.
- Mind can have concentration and thus providing psychic energy to other sense and activity organs.
- Mind concentration can be achieved by chanting मन्त्र *mantra,* tuned for different parts of the body.
- Mind has a cognitive substratum called चित्त *citta,* which provides us the reasoning faculty and the power of cognition.
- Stray thoughts infest चित्त as a part of our psychological makeup.
- The principles of योग *yoga* declared that चित्त can be retained pure through practicing restraint in the operation of life.
- Mind can be made शून्य *śūnya*, leading us to a state of कैवल्य *kaivalya,* a state of no personal bias, a state of pure joy.

Medical Sciences, Hygiene

- A happy mind was declared to be a pre-requisite for a healthy body.
- Good health was dependent on nutrition, vegetarianism was advocated.
- Physicians discovered the emprical use of herbs and other plant products as nutritional supplements and as medicines.
- Massive exports of herbs and medicines to neighboring countries as far as Greece popularized Indian medicine and health system
- Charaka stressed the use of clean water and a daily bath. Teeth and tongue cleaning were part of the basic hygiene.
- There was empirical analysis of food supplements in treatment procedures with a listing of meat of various animals as medicine.
- Charaka prescribed health habits for pregnant women, mothers, infants, young and old individuals in nutrition and hygiene.

Astronomy
(Following Aryabhatia, 500AD)

- Various instruments were fabricated to observe the movement of the stars and of the Sun and Moon.
- Aryabhatta declared the rotation of the Earth in 24 hours and suggested the relative motion of the stars.
- The solar and the lunar eclipses were determined to be caused by the shadows on the Moon and the Earth and projective geometry was used to calculate the shadows (not correct).
- Small time measures and small space measures were conceived leading to the generation of massive numbers.
- Decimal system was applied in counting the scales.
- Numerals were expressed as constructed from the Sanskrit alphabet.
- The alphabet was structured in groups of five allowing the decimal representation.

Technology

Technological developments during this period led to the development of :

- Steel making, metallurgy
- Stone carving, rock-cut caves and temples
- Epigraphy, Calligraphy
- Herb discovery, Medicine Preparation
- Forest products, barks, leaves
- Dyes, Application of dyes
- Civil engineering, Construction
- Terracotta work, Use of Ivory
- Farming and agriculture
- Silk making and weaving
- Marine engineering

Steel-making, Metallurgy

- Ukku steel from South India
- Layer of Carbon was deposited through a crucible smelting process.
- Carbon deposit was made by adding fresh bamboo and leaves.
- It added plasticity to iron in making daggers and knives.





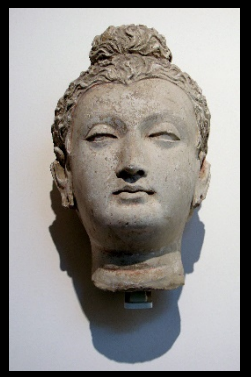
- Metallurgy involved alloy making through copper, zinc, tin and iron.
- Silver and gold ornaments were used





Stone Carvings, Rock-cut Temples

- With the use of iron tools, stone carvings were popular and skilled.




- Mountains were cut for meditative habitation and for places of worship



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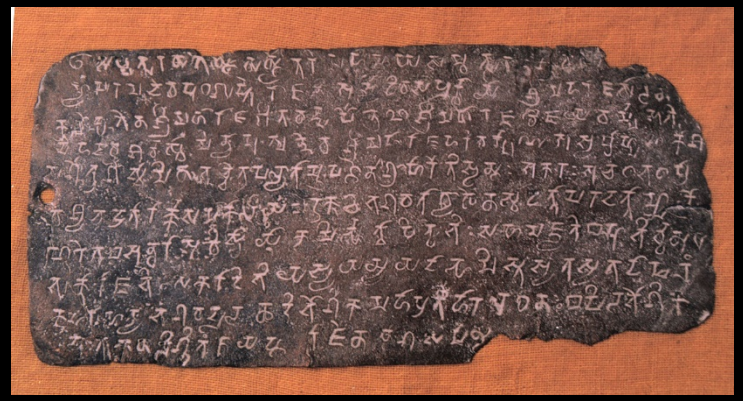
Epigraphy, Calligraphy

- Writing appeared through a local syllable-engineered Brahmi script





- A pointed stylus with carbon soot and other dyes helped produce calligraphy.




Herb Discovery, Medicine Preparation

- Healing herbs were located at mountain slopes and at high altitudes.

- Herbs were used raw by grinding, or used in dried mixtures by powdering

Forest Products, Barks and Leaves

- Discovery of forest products encouraged profitable exports.




- Wild fruits, roots and berries were highly prized as healing agents.





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Dyes, Application of Dyes and Fixing

- Dyes were plant or animal products, some natural, some processed.




- Frescos were created. Silk was dyed.


Civil Engineering, Construction

- Brick work, urban construction. Plant glue was used as grouts.

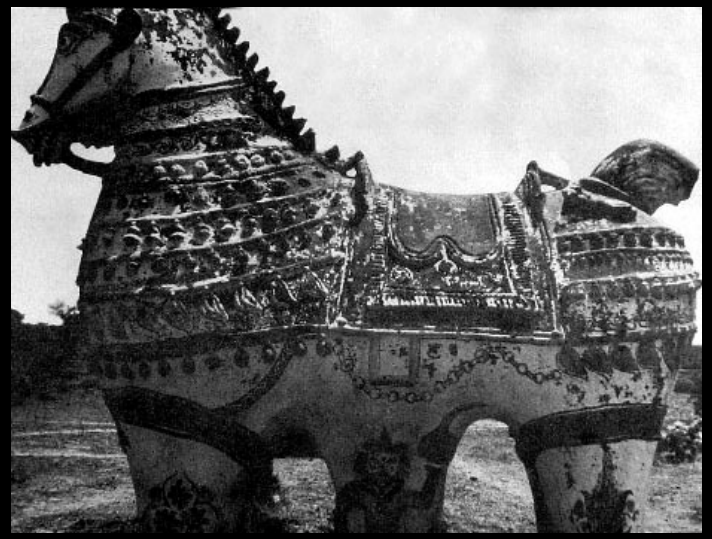



- Tanks and roads.



Terracotta Work, Use of Ivory

- Art in pottery. Quality of work excelled.

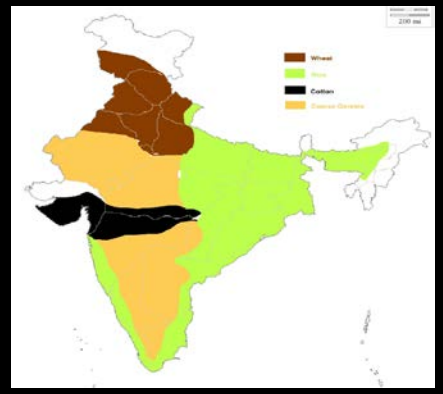



- Ivory became export item.

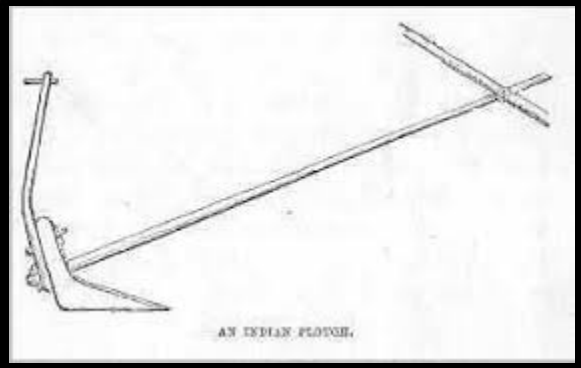



Farming and Farming Tools

- Farm produce was the principal revenue generator.
- Wheat, rice, cotton, oilseeds and sugarcane was cultivated.



- Farm tools



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Silk making, Weaving

- Fine silk was an export product. Silk making was a cottage industry.




- Silk weaving was a fine art.




Marine Engineering

- Boat making was a well developed technology.

- Boats in pictures

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Thank you!