



## Science during the Gupta Period

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**Abstract:** The Gupta Empire reigned for numerous centuries and was well-known for a variety of reasons. One of the factors was the Gupta family's scientific advancement. In the scientific field, many new developments were made. The advancement of metallurgy was one of the most significant scientific breakthroughs. The creation of pillars like the Iron Pillar demonstrates the advancement of metallurgy. The pillar is an example of artistic capabilities during the Gupta period. Another significant achievement was the development of a contemporary numerical system. This invention created the groundwork for modern science.

**Keywords:** Gupta, empire, modern, science, period, modern, advancements, developments, creation, artistic.

### Introduction

For a multitude of reasons, the Gupta Empire was well-known. The Guptas' achievements in the field of mathematics were one of the factors. Many innovative inventions have been developed to aid in the solving of mathematical problems. <sup>1</sup>Aryabhatta was a strong supporter of maths education. 1- Decimal system – In mathematics, the decimal system notation was a key development. The place-value system reached its pinnacle at this time. During the Gupta dynasty, there was no symbol for “zero.” Aryabhatta, on the other hand, used powers of ten with null coefficients to signify “zero” in the place-value system. Following the Sanskrit tradition, the Guptas used alphabetical characters to represent numbers. They didn't employ the Brahmi numbering system. It is hypothesised that pi ( $\pi$ ) was considered irrational during the Gupta era. The precise five significant figures in estimating the diameter of a surface were reached using Aryabhatta's technique. In Europe, the same principle of pi's irrationality was proven considerably later, in 1761. This depicts the Gupta period's degree of development. Trigonometry was another major topic discovered during this period. The area of a triangle has been described in Ganitapada as the consequence of a perpendicular with the half-side. The Guptas were also aware of concepts such as “sine.”<sup>2</sup>

During this time, new techniques for solving problems based on Diophantine equations like the Aryabhatta algorithm, algebra, and geometry emerged. Aryabhatta's inventions in the subject of mathematics have proven to be quite useful to the next generation. Prior to Varahamihira's Brihat Samhita, which is a compendium of ancient Indian learning and sciences, the Vriddha Garga Samhita is the only<sup>3</sup> work on astrology. Aside from the astrology portions in the Brihat Samhita, Varahamihira also wrote four other works on the subject, which deal with auspicious muhurtas for marriage and auspicious portents for kings' expeditions, and the moment of man's birth and its impact on his future. The most important works of medicine were the Charaka Samhita and the Sushruta Samhita, written by Charaka and Susruta. In the Ashtanga Sangraha, Vagbhatta presents their conclusions. <sup>4</sup>A doctor is expected to be a yogi, a person of high moral character, and a supporter of humanity. He wasn't supposed to charge a lot of money for the drugs he prescribed. He shouldn't make a distinction between affluent and poor people. The government and the general people both contributed to the

construction and upkeep of hospitals that cared for both men and animals. The process of distillation and the application of disinfectants had been discovered by Nagarjuna.<sup>5</sup>

The Indians were also aware of vaccines for smallpox. Indian medicine was concerned with a certain field of study. The organs, ligaments, muscles, arteries, and tissues of the body were all detailed in detail. In Hindu medical texts, a large number of medications from the mineral, vegetable, and animal kingdoms are referenced. More emphasis was placed on hygiene, physical regimen, and diet. Amputations and procedures had been performed, as well as improvements to malformed ears and noses. Surgical instruments were likewise meticulously constructed. Bower discovered seven works, three of which are related to medicine.<sup>6</sup> The manuscript has been dated to the second half of the fourth-century A.D. based on palaeographical evidence. The document covers topics like the usage of garlic to treat ailments, digestion, and eye problems. Navanitaka is a book that discusses various powders, decoctions, oils, elixirs, and children's ailments. Susruta is the only well-known name of a medical authority mentioned in the Bower manuscript. During this time, astronomy achieved significant advances. The major astronomers were Varahamihira and Aryabhata. According to Aryabhata, Eclipses are created by the moon passing through the earth's shadow or passing between the earth and the moon. In astronomy, he used trigonometry. He devised precise algorithms for measuring two days in a row. He'd also figured out the correct orbital equation for the planet. Aryabhata was much ahead of the European astronomers in terms of knowledge. In 505 A.D.<sup>7</sup> He most likely began authoring Panchasiddhantika. He examines the concepts of the five astronomical schools in this work, which were thought to be the most authoritative at the time. The Romika Siddhanta is the only one of these five schools that clearly shows the Western influence.<sup>8</sup>

As a result of intensive trade contacts between the Roman Empire and the Gupta Empire, this is likely to happen. The Surya Siddhanta is the period's most important and comprehensive astronomical work. The Surya-Siddhanta appears to have been founded on Greek astronomy. Varahamihira also discusses the Paitamaha Siddhanta, Vasishtha Siddhanta, and Paulisa Siddhanta, which are the other three schools of astronomy. Varahamihira has kept the core teachings of these five astronomical schools in his work. Under the Gupta Empire, chemistry and metallurgy were developed.<sup>10</sup> There are no texts about chemistry or metallurgy from the Gupta era. Nagarjuna is referred to as a brilliant chemist. The famed Iron Pillar near the Qutub-Minar sits silently as a testament to the Hindus' remarkable metallurgical prowess. Despite being exposed to rain and sun for the past 1500 years, this pillar has not rusted or corroded. Varahamihira was an astronomer, mathematician, astrologist, metallurgist, chemist, jeweller, botanist, zoologist, civil engineer, water-divining, and meteorologist. Because of the significant achievements of Indians in the domains of mathematics, astronomy, science, religion, and philosophy during the Gupta Empire, the time between the 4th and 6th century C.E. is regarded as the Golden Age of India. The scientists of the Gupta period realised that the solar system had seven planets. They also developed technology that allowed them to detect solar and lunar eclipses. Aryabhata was one of the Gupta Empire's most famous scientists, having discovered that the earth rotates on its axis and revolves around the sun.<sup>9</sup>

## Discussion

The famous Gupta Empire was an ancient empire in India. Existing from the early 4th century CE to the late 6th century CE, it covered the Indian subcontinent significantly. Historians consider the Gupta period as the Golden Age of India. King Sri Gupta founded the ruling dynasty of the empire, and some of the most notable rulers of the Gupta dynasty were Chandragupta I, Samudragupta, and Chandragupta II. Chandragupta II was also popularly known as Vikramaditya.<sup>11</sup>

The renowned Sanskrit poet Kalidasa credited the Guptas to have conquered about 21 kingdoms. These 21 kingdoms were from both in and outside of India. The period is also appreciated for finding various ways to flourish factory production. The origin-country of the Guptas is not yet certain. According to one hypothesis, they started in the present-day lower-Doab locale of Uttar Pradesh, where the more significant part of the engravings and coins of the early Gupta rulers were discovered.

This hypothesis is additionally upheld by the Purana, as contended by the proponents, that notice the region of the early Gupta rulers as Prayaga, Saketa, and Magadha regions in the Ganges basin.<sup>12</sup>

The Gupta records don't specify their varna (social class). Few historians, like A.S. Altekar, has guessed that they were of Vaishya class, as specific antiquated Indian texts recommend the name "Gupta" for the individuals from the Vaishya varna. Whereas some, like S.R. Goyal hypothesizes that the Guptas were Brahmanas since they had wedding relations with Brahmans, others reject this proof as inconclusive. Development in Science and technology was immensely appreciated in ancient India.<sup>13</sup> The scientists and astronomers of the Gupta period made numerous significant contributions to the field. Although undoubtedly it is one of the most exemplary contributions that they discovered that there were seven planets in the solar system, it is not the only appreciable one. The scientists in the Gupta empire made numerous other contributions to Mathematics, astronomy, medicine, astrology, chemistry, zoology, botany, and metallurgy.<sup>14</sup> The Gupta Period scientists made some of the most notable contributions to the field of Mathematics. The most significant of these contributions was the decimal system of notation discovery. Based on the principle of the place value of the first nine numbers, this notation system also depended upon the use of zero. This ancient Indian empire also saw Geometry attaining great heights. It was because of the numerous theorems related to circles and triangles. Still, the most appreciated work in Mathematics<sup>15</sup> was by the Aryabhata scientists in the Gupta Empire. In 499 AD, the Aryabhata scientists in the Gupta Empire wrote the Aryabhattiyam. It was majorly about algebra, geometry, and mathematics. The list of achievements of the Gupta empire in the field of Mathematics does not end here, as the period also witnessed the cultivation of Trigonometry. The period is also said to have witnessed the rise of Indians over the Greeks as far as Mathematics is concerned.<sup>16</sup>

When it comes to medicine, the most important works were the Charaka Samhita by Charaka and the Sushruta Samhita by Susruta. The two placed high ideals for physicians and suggested that a physician must be a yogi and not charge high for his prescriptions. They suggested that a physician should be kind and support mankind, i.e., he must not be partial to people based on their social class or economical status. During the Gupta period, the process of distillation and the use of disinfectants was discovered by Nagarjuna. By now, the smallpox vaccination was also introduced.<sup>17</sup> The surgical field also noticed a rise as the doctors could amputate and improve deformed ears and noses. Numerous surgical instruments were developed. The principal astronomers of this period were Varahamihira and Aryabhata. One of the notable discoveries by Aryabhata was that the moon comes over the shadow of the earth or between the earth, which caused the eclipses. He is known to be much more advanced than the astronomers of Europe, and he soon began composing his work Panchasiddhahtikain 505 AD. The astronomers and scientists of the Gupta period are also credited with the achievement they discovered that there were seven planets in the solar system<sup>18</sup>. The Vriddhi Garga Samhita, an assortment of old-fashioned Indian learning and sciences, is the leading work before Varahamihira's Brihat Samhita. Other than the areas on astrology in the Brihat Samhita, Varahamihira likewise made four different works related to astrology, which manage favourable muhurtas for marriage, and propitious omens for the endeavours of lords and the hour of man's birth to the world, and its effect on his future. Although no books from the Gupta age are found related to Chemistry and metallurgy, Nagarjuna is considered a great chemist.<sup>19</sup> Also, the Iron Pillar near Qutub Minar from the Gupta period depicts the metallurgical skills of the people of that time. The Gupta Empire was an ancient Indian empire known for the great rulers of the Gupta dynasty.<sup>40</sup> But, the Gupta period is also significant to study due to its numerous contributions to the world of Science, technology, art, and architecture. The period also witnessed the flourishing of factory production. Hence, not only the rulers of the Gupta dynasty are worth studying; the scientists, astronomers, physicians, artists, architects, astronomers, and astrologists must also be appreciated for their significant contributions to their respective fields.<sup>20</sup>

## Results

Gupta period with the tremendous development of science during this period. With the growth and intensification in the arena of mathematics, astrology, astronomy, medicine, Chemistry, Metallurgy, Botany, Zoology and Engineering Gupta period gained a striking facet.<sup>21</sup>

### **Mathematics under Gupta Empire**

In the realm of arithmetic the most important achievement was the discovery of the decimal system of notation. It was based upon the principle of the place value of the first nine numbers and the use of the zero. Geometry attained great heights and many theorems relating to circles and triangles are mentioned. The most famous work in mathematics was that of Aryabhata, the *Aryabhattiyam* which was written in 499 A.D. the work deals with arithmetic, geometry and algebra. Trigonometry was also being cultivated during this time. Indians took the lead over the Greeks as far as mathematics is considered.<sup>22</sup>

### **Astronomy under Gupta Empire**

Astronomy made great progress during the age. Varahamihira and Aryabhata were the major astronomers. Aryabhata pointed out that eclipses were caused by the moon coming within the earth's shadow or between the earth<sup>39</sup>. He utilized trigonometry in astronomy. He worked out accurate formulas to measure two consecutive days. He had also obtained correct equation for the planet's orbit. Aryabhata was much more advanced than the European astronomers. Most probably he began composing his work *Panchasiddhantika* in 505 A.D. He discusses in this work the principles of the five astronomical schools, which were considered as the most authoritative one in his time.<sup>23</sup> Of these five schools the *Romaka Siddhanta* clearly betrays Western influence. This is expected to happen as a result of active trade contacts between the Roman Empire and the Gupta Empire. The *Surya Siddhanta* is the most important and complete astronomical work of the period. It seems that Greek astronomy served as the basis of the *Surya-Siddhanta*. The other three schools of astronomy discussed by Varahamihira are the *Paitamaha Siddhanta*, the *Vasistha Siddhanta*, and the *Paulish Siddhanta*.<sup>24</sup> In his work Varahamihira has preserved the essential teachings of these five schools of astronomy. The *Charaka samhita* and the *Sushruta samhita* by Charaka and Susruta were the most important works of medicine. Their conclusions are presented in the *Ashtanga Sangraha* by Vagbhatta I. Charaka and Susruta placed very high ideals for a physician. A physician is supposed to be a yogi, noble in character and supporter of mankind. He was not to charge high for the medicines he prescribes. He should not distinguish between the rich and the poor.<sup>38</sup> The government and the public provided for the establishment and maintenance of hospitals where men and animals both were looked after. Nagarjuna had discovered the process of distillation and use of disinfectants. Vaccination for small pox was also known to the Indians.<sup>25</sup> Indian medicine dealt with the whole area of the science. The structure of the body, its organs, ligaments, muscles, vessels and tissues were described in detail. Vast collections of drugs belonging to the mineral, vegetable and animal kingdoms are mentioned in the Hindu books of medicine. Hygiene, regimen of the body and diet was paid more attention. Doctors had conducted amputations and operations as well as improved deformed ears and noses. Surgical instruments were also carefully made. Susruta describes around 120 surgical instruments. The Bower manuscript was discovered by Lt. H. Bower in a Buddhist stupa in Kashgar in 1890.<sup>26</sup> Out of the seven works discovered by Bower three deal with medicine. The manuscript on the basis of palaeographical grounds has been dated to the second half of the fourth century A.D. The manuscript deals with such subjects as the use of garlic in curing diseases, digestion, and eye diseases. A book named *Navanitaka* deals with different kinds of powders, decoctions, oils, elixirs and children's diseases. The only familiar name of a medical authority referred to in the Bower manuscript is that of Susruta.<sup>27</sup>

### **Astrology under Gupta Empire**

The *Vridhdha Garga Samhita* is the only work on astrology prior to Varahamihira's *Brihat samhita*, which is a collection of ancient Indian learning and sciences. Besides the sections on astrology in the *Brihat samhita*, Varahamihira also composed four other works on astrology, which deal with auspicious *muhurtas* for marriage, auspicious portents for the expeditions of kings and the time of man's birth, and its influence on his future.<sup>28</sup>

### **Chemistry and Metallurgy under Gupta Empire**

In the Gupta age no books dealing with Chemistry and metallurgy are found. Nagarjuna is mentioned as a great chemist. The famous Iron Pillar near the Qutub-Minar stands as a silent witness to assert the striking metallurgical skill of the Hindus<sup>37</sup>. This pillar has not yet been rusted or corroded despite it

being exposed to rain and sun for the last 1500 years. The use of mercury and iron in medicine shows that chemistry must have been practiced. Varahamihira was a scientist who was comfortable in dealing with astronomy, mathematics, astrology, metallurgy, chemistry, jewellery, botany, zoology, civil engineering, water-divining and meteorology.<sup>29</sup>

Science was cultivated with enthusiasm in ancient India and many important discoveries were made which were passed on to Europe by the Greeks and the Arabs.<sup>30</sup>

### Conclusions

The Gupta period saw the development of mathematics, astronomy, medicine, chemistry, physics and metallurgy.<sup>31</sup> The science of mathematics was cultivated with success. Numerals had been in use for some time. They were later introduced to the European world as Arabic numerals. In the field of mathematics Aryabhata wrote Aryabhatiya. This mathematician was well versed in various kinds of calculations. The Aryabhatiya refers to some of the important properties of circles and triangles. The most epoch making achievement of this age in the realm of arithmetic was the discovery of the decimal system of notation.<sup>32</sup> The Bakshali manuscripts give us a fairly comprehensive idea of the state of mathematics during Gupta period. It deals with varied topics like fractions, square roots, arithmetical and geometric progressions, summation of complex series, simultaneous linear equations and indeterminate equations of the second degree. The first major expositions of Indian astronomy in the last few centuries BC are recorded in two works, the Jyotisha-Vedanga and the Surya Prajnapti.<sup>33</sup> Vasishtha Siddhanta marked a further progress in astronomy. Paulisa Siddhanta was another important work. It laid down a rough rule for calculating the lunar and solar eclipses. The Surya Sidhanta was most popular before the time of Aryabhata.<sup>34</sup> It had formulated some rules for calculating eclipses and discovered solutions for some of the problems in spherical astronomy. Another important writer on astronomy was Varahamihira. His work the study of Astronomy is divided into three branches each of equal importance-astronomy and mathematics and astrology.<sup>35</sup> The most interesting work of Varahamihira is the Pancha Sidhantika a concise account of the five currently used schools of which two reflect a close knowledge of Greek astronomy. Medicine also progressed during this period. The famous Buddhist scholar Nagarjuna was a student of chemistry, metallurgy and medicine. Dhanavantari was a renowned Ayurvedic physician. Hastyaurveda or the veterinary science authored by Palakapya attests to the advances made in medical science during the Gupta period.<sup>36</sup>

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