India Discovery Center

Study of the Mughal-Maratha Period (1500AD-1800AD)

Science and Technology

Bijoy Misra

References:

Baburnāma – Memoirs of Babur (*Zāhiruddin Mohammad Bābur Pādśāh Ghazi*) in Turkish, translated into English by Annette Suzzanah Beveridge, Luzac & Co, London, 1922

Humāyunnāma – The History of Humayun written by Gul Badan Begum (Humayun's daughter) in Persian, translated into English by Annette Suzzanah Beveridge, Royal Asiatic Society, London, 1902

Aīn-i-Akbarī – Vo III of Akbarnāma – The History of Akbar by Abul Fazl-i-Allami in Persian, translated into English by Col. H. S. Jarett, Royal Asiatic Society, Kolkata, 1948.

The History and Culture of Indian People (in eleven volumes) - Edited by R. C. Majumdar, Vol. 7 The Moghul Empire, Vol. 8 The Martha Supremacy, Bharatiya Vidya Bhavan, Mumbai, 2001(3rd Edition)

New History of the Marathas (in three volumes) – G. S. Sardesai, Phoenix Publications, Mumabi, 1946.

A Concise History of Science in India – Edited by D.M.Bose, S.N.Sen, B.V. Subbarayappa, 2009.
(Reference help is acknowledged from Prof JSR Prasad of University of Hyderabad, India)

Miscellaneous internet resources.

Scientific research spanned the following fields:

- Astronomy
- Mathematics
- Chemistry
- Musicology
- Material Science
- Musical Instruments
- Performing Arts
- Military and Naval Science
- Botany and Agricultural Science

Astronomy

- Madhava, a brilliant mathematician-astronomer established a school of Mathematics and Astronomy in Kerala in 14th century with the goal of extending the earlier findings of Aryabhatta of 5th century. The school remained active till the 16th century
- Nilakanthan Somayaji deduced the equations for the motion of the planets and established their motion around the sun. But he erroneously conjectured that the sun was moving around the Earth. Copernicus did work on his heliocentric theory during the same period.
- Astronomical Observatories were constructed by Raja Jai Singh in Ujjain, Jaipur, Delhi, Varanasi and Mathura.
- Observations were made on the accurate time measurement, solar declination and

Ujjain

Jaipur

Delhi

Varanasi

Mathematics

- Important in the work of Kerala school is the infinite series expansion of the trigonometric functions. This includes the expansion of sin θ, cos θ, $\tan^{-1} x$.
- They developed the theory of approximations and infinitesimals that are later codified as Newtonian calculus.
- Mathematical induction:

$$1^p + 2^p + 3^p \ldots + n^p \sim \frac{n^{p+1}}{p+1}$$

- Partial fraction expansion

$$\frac{\pi}{4} = \frac{3}{4} + \frac{1}{3^3 - 3} - \frac{1}{5^3 - 5} + \frac{1}{7^3 - 7} - \ldots$$

New Kerala school, Kozhikode, Kerala, Est 2009

- Important personalities – Nilakanthan Somayaji, Achyuta Pisharati, Narayana Bhattahiri
- Most work is lost, partly some were discovered by British mathematicians in 19th century. Transmission to Europe via the traders is conjectured.

Chemistry

- Chemical applications continued in the process to refine metals, particularly mercury, which was used in medicinal applications.
- Mercury had other applications in efforts of transmuting elements and dye preparations.
- Experimentation on grouts and glues created empirical processes of compounding from plant and animal products.
- Persian methods experimented on plant and animal extracts as medicine as against nutritional therapy of Ayurveda.
- Perfume making through distillation became a new industry.
- Gunpowder came in use and chemistry of explosives was studied.
- Desiccation and brine treatment were applied in food preservation.
- Rich color textile and silk dyes were processed and applied.
- Major innovation was on ink dyes for use in calligraphy, manuscripts and sketches.

Musicology

- Almost all music was composed in *rāga* protocol. Hundreds of *rāga*s were set up to help simulate different human emotions.
- Two separate genres of vocal music developed : Hindustani (northern style) and Karnataki (southern style).
- The violin became the accompanying instrument for the Karnataki music and the harmonium became the accompanying instrument in the Hindustani music.
- Persian influence and the Mughal court rendering influenced the Hindustani classical music.
- Tabla was introduced into the coding of Hindustani classical music. This helped produce complicated rhythm structures through the same *rāga.*
- Various new percussion beats came into use to simulate the melody in the vocal rendering.
- Several new musical instruments ere introduced and eventually genres of Indo-Persian fusion music developed and were used.

Material Science

- Clay compaction and tile making were refined to deal with the wet climate of India.
- Grouting and stucco waterproofing were experimented using local forest products, marble powder and powdered ores.
- Fiber hardening was studied. Hardening baths were experimented for textile fiber, silk, ropes and the sails.
- New dyes were discovered to produce color palettes for the textiles and silk.
- Metal inlay and metal molding were experimented. Lost wax technique of creating single piece objects without seams was perfected through the use of proper clay and heat.
- Various kinds of wood, shells, leather skins, vegetable pastes were experimented to create musical instruments. A massive variety of instruments was produced and used.
- Gunpowder and rocket technology were studied. Compact rockets were used in warfare.
- Glass and bead making were experimented. Various alloyed glass were used in ornamentation.
- Diamond cutting and polishing became a scientific art.

String and Wind Instruments (sample)

Plucked Instruments

Veena

Sitar

Tambura

Ek-tara

Bowed Instruments

Violin

Sharangi

Wind Instruments

Shehnai

Flute

Harmonium

Percussion Instruments (sample)

Mridangam

Dholak

Pakhvaj

Tabla

Manjira

Manjira (Wood)

Ghatam

Jal-tarang

Science of Performing Arts

- Traditional music and dance had to be recoded for the short duration court performance.
- Music composition was redesigned to be more mood-oriented than story oriented.
- Lyric was replaced by style with romantic aberrations.
- Music was composed for various musical instruments to tally with the Quranic descriptions of nature.
- Tone improvisations and repetition of phrases were experimented to map the music to the natural environment of water, space and colors.
- Military music and coronation music were composed and performed.
- Music as performance needed experimentation with various combination of instruments, rhythmic structure and harmonic arrangement. This helped develop new novelty of *rāgas*.
- Dance routines were modified to create the mood for the court and romantically appealing.
- Experiments were done for hall resonance, pillar resonance and echo in order to create musical effects.
- Chorus groups and dance groups emerged with coordinated effects.

Military and Naval Science

- A strategy of siege was sharpened as a battle technique.
- Preparing for siege needed supply lines and a large overhead.
- While the loss of life was reduced, the organization and planning the siege was elaborate.
- Seige technique helped develop transportation through the riverways and coastal areas.
- Self-contained mountain forts with multiple tunnel exits were constructed for military defense.
- Boat making technology advanced including gunboat technology.
- Ports were fortified to be defensive posts used in battles.
- Boat traffic helped develop studies on weather and coastal currents.
- Cartography developed to delineate coastal contours in determining future port locations.

Botany and Agricultural Science

- Plant hybridization was experimented. Thousands of rice varieties were created in order to help increase yield and create export market.
- Many new crops from foreign lands were planted and experimented. Most of the new planting was geared to increase revenue. Cashew, pepper, coffee were important cash crops.
- Jahangir (17th century) took interest in studying and documenting native animals and plants from the preservation point of view.
- Complete cataloging of Indian flora was published by the Dutch by the end of 17th century.
- Oil extraction from the plants was experimented and used for food preservation and medicine.
- Sandalwood, flowers, spices were grown for creating perfume products.
- Opium was introduced as sedative and was made into a profitable export.
- Water management techniques were tried, but were not implemented in all areas.

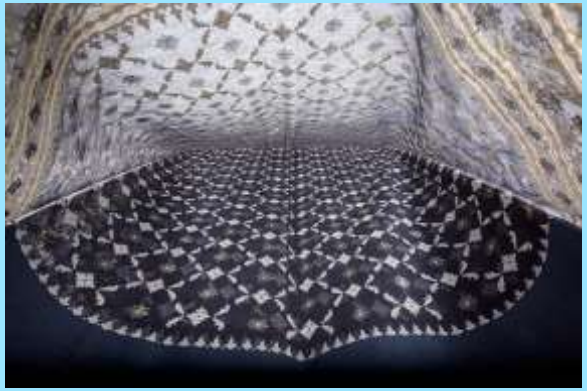
Technological Innovation spanned the following fields:

- Muslin fabric
- Silk weaving
- Grouting and Stucco
- Jewelry and Metalcraft
- Miniature painting
- Manuscript illustration
- Calligraphy
- Ports and Boat building

Muslin Fabric and Silk Weaving

Muslin:

Dacca became the center for muslin production for the world



Fine Muslin

Muslin Weaving

Jamdani weaving

Woman in Muslin

Silk:

Silk Weaving

Silk Factory

Silk Embroidery

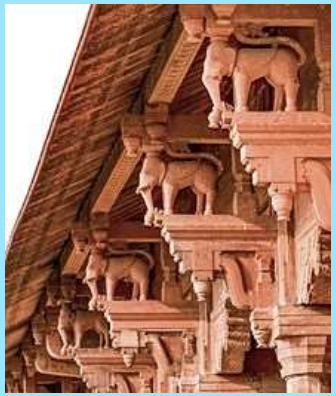
Men's Dress (prince)

Women's Dress (princess)

Grouting and Stucco

Grouting:

Curved Support



Hindu Design

Inlay and Grout

Hawa Mahal, Jaipur

Stucco:

Floral Design

External Stucco work

Interior Stucco work

Walls and Covering

Jewelry and Metal Craft

Jewelry:

Islamic Neck ornament
(Lucknow)

Studded Ring
(Gwalior)

Bangles
(Dacca)

Ear ornaments
(Pune)

Hindu Necklace
(Madurai)

Metal Craft:

Bidri Work

Designed Jar

Peacock Throne

Moghul Coins

Art, Portraits, Miniature Paintings

Art and Portraits:

Babur

Pencil Drawing

Singer Tansen

Cartographic map

Miniature Paintings:

Hunting Trip

2D Projection

Court – Perspective Picture

Hindu Art

Calligraphy, Manuscript Illustrations

Mughal - Maratha Period

Calligraphy:

Bihari Script

Quran in Marble etching
Taj Mahal

Quran on gemstone
Emerald

Art Calligraphy

Hindu Calligraphy

Manuscript Illustrations:

Kashmiri Quran

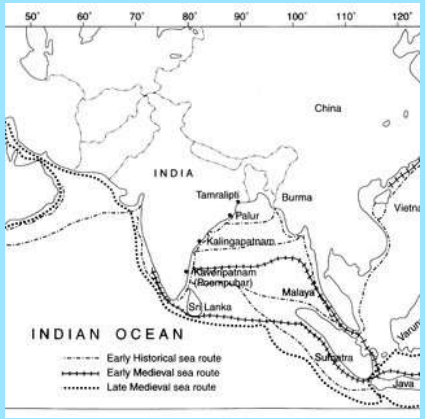
Illustrated Book

Jaina and Buddhist
manuscripts

Kabutarnama
Book of Sparrows

Maritime Traffic, Ports, Boats

Maritime Traffic, Ports:



Maritime Traffic 1650AD

Shivaji's ports

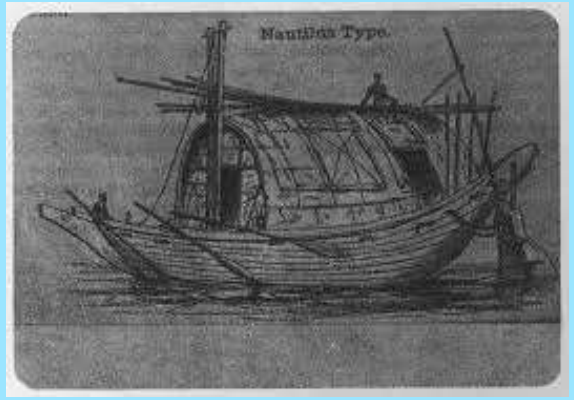
Port Maland

Port St. George

Port Surat

Boats:

Mughal Ghurab



River Voyage

Military Boat

British-Maratha Naval Warfare

Thank you!