During the Crusades, the Christian warriors encountered Muslim soldiers, who had better weapons. The weapons were made of a harder steel with a sharper cutting edge known as Damascus steel.

In his famous book, The Talisman, 19th century British writer Sir Walter Scott describes the weapons of Sultan Saladin of the Saracens. His description of Saladin’s fearful scimitar as opposed to the English broadsword wielded by Richard the Lionheart is graphic. The scimitar was made of Damascus steel, with “a curved and narrow blade, which glittered not like the swords of the Franks, but was, on the contrary, of a dull blue colour, marked with ten millions of meandering lines...” Little did Scott know that the famed Damascus steel encountered by the ancient crusaders was forged from the specialty Wootz steel of South India.

Wootz steel was developed in India hundreds of years before the Christian era. Ancient Indian manuscripts mention steel razors, surgical instruments, stone cutting instruments and files made of steel. A chisel with a hardened point, found in Sri Lanka, dates back to 500 B.C. The 12th century Arab scholar Edrisi has commented, “The Hindus excelled in the manufacture of iron, and it is impossible to find anything to surpass the edge from Hindustani steel.”

In the West, metallurgists discovered the importance of adding carbon to iron to make it hard only in the 19th century, by which date the process for producing hard, tool steel was already centuries old in India. The strong, high carbon steel was the handiwork of specialized artisans called Kammaras of South India. It was made in the iron ore belt of Kamataka, Andhra and Tamil Nadu, ranging from the southern tip of India to Vidarbha. Golconda, Bhadravati in Kamataka and the megalithic site of Kodumanal in Tamil Nadu.

The name Wootz is a corruption of the Kannada word ‘Ukku’, which means steel. In Tamil, it is called ‘Irku’. The steel was prized so much in the West, that Alexander the Great is said to have carried some Indian steel swords on his return from India. Herodotus, Tsesius and other Greek philosophers have expressed their admiration for the Indian steel. The steel ingots were exported to the Middle East and they were forged again in Damascus to make daggers and swords.

By the turn of the 18th century, tens of thousands of tons of the steel buttons were exported to Damascus from the Coromandel coast and from Malabar. There is evidence that Jewish traders of South India shipped ingots of Wootz steel to Syria in the 12th century.

Wootz steel is synonymous with Damascus steel. ‘Damas’ means water in Arabic, and the watered pattern on the blade inspired the name. The daggers and scimitars made of Damascus steel were prized all over the world because of their strength that enabled them to cut through any other blade. They had such incredible flexibility that they could bend 90 degrees without breaking.

The blades made of Wootz Damascus steel typically have a beautiful pattern in the material itself. This is because of the presence of the carbide molecules in the matrix of the material produced during cooling. The blade smiths skillfully made use of these patterns in the material by manipulating the angle of the blades, and polishing the blade. The final product had grey patterns on a black background, making it a thing of beauty. The more famous patterns were the rose pattern and the ladder pattern. Tipu Sultan’s famous blades had the bubris tiger stripe pattern ingrained in them.

Medieval observers have written about the production of Wootz steel, which was made using the crucible process. Iron ore was fed into clay crucibles, making of which was a specialized skill. The ore was melted and wrought iron was separated from the slag. To the iron, a measured quantity of carbon in the form of charcoal or wood pieces was added, and the charge heated to high temperature in tightly covered crucibles. A batch of covered crucibles were placed in a furnace and fired for 14 to 24 hours at temperatures of round 650 to 7500 C. The fire was regulated using buffalo hide bellows. Then the lid was removed from the crucible and the slag was poured out. The steel was formed in the form of ‘buttons.’

Swords were made by forging the steel and quenching it. The blade had to be quenched rapidly to make it strong. Indian blacksmiths quenched the red-hot blade by plunging it into a banana plant and cooling it overnight. The ancient Indian scientist Varahamihira has written that the sword should be quenched with a solution of banana plant ashes.

In order to get the desired quality of steel, the Kammaras had to take the greatest care while selecting the raw materials. It had to be poured out at the
exact time, or the steel would be useless. The clay crucible had to be made perfectly. The wood or charcoal used had to be from specific trees. It is known that the wood of the Tanner’s Cassia or Thangadi tree Cassia aurantifolia was used in the production of the highest quality Wootz steel.

There is a record of a highly skilled blade smith in Tanjore. The swords of the Mughal princes were made of the famous steel, and the handles were decorated with rubies and emeralds. The legendary sword of Tipu Sultan, which brought fear into the hearts of the British troops, was forged in Bednur in India. Tipu Sultan had many weapons made of Wootz steel. The blades were decorated with the bubris tiger stripes design, while the gold handles were inlaid with precious stones. The light coloured tiger stripes on the black background of the blades are at once beautiful and intimidating.

The manufacturing units of the steel were mainly in Mysore, Tanjore and Golkonda, but unfortunately none of them survive today. There is evidence of crucible steel production centres in the megalithic site of Kodumanal. In places like Lahore, Rampur and Allahabad, fine knives and daggers were fashioned from this steel during the Sepoy Mutiny of 1857. After the Mutiny was quelled, the British confiscated and destroyed hundreds of weapons.

Although Wootz steel excited the imagination of the scientists of the 18th and 19th centuries, none could duplicate it. Such greats as Michael Faraday were fascinated by this patterned steel from India. He attributed the high strength, ductility and beauty of the steel to the presence of silica and alumina, which is found to be erroneous. It has been found that that true Damascus steel has the etched crystalline structure due to the presence 1.3 to 1.5% carbon.

Incredibly, Wootz steel disappeared from the market after 1860, and the process of manufacturing it was lost forever. Benjamin Huntsman of Sheffield who is credited with the invention of the modern crucible method of steel making in 1750, most likely got his inspiration from the processes described by the European travelers in India.

Interest about this high quality steel has revived in recent times, but all efforts to produce it have been in vain. Although it was not studied in the early part of the 20th century, in the later half of the century, Oleg Sherby and Jeff Wadsworth conclusively proved that the material exhibited superplasticity. Superplastic materials are in high demand as they can be fashioned into complex shapes. Scientists including J.D. Verhoeven, A. Pendray, S. Srinivasan and Sharada Srinivasan have done commendable research on Wootz steel. J.D. Verhoeven showed that the presence of small quantities of Vanadium was the cause of the patterns created by the carbide particles. There is a belief that when the iron ore that contained minute quantities of vanadium became exhausted, Wootz steel production also stopped. The blacksmiths of ancient India took away the secret of making the super steel with them.

**Indigo for Independence**

The Panchatantra, the Indian collection of fables dating back to the third century BC, has a story of a jackal that falls into a vat of blue dye and is turned permanently blue. He then pretends that he is a superior animal and bosses over his companions. There are other mentions of the ‘Blue Vat’ in ancient Sanskrit texts.

Indigo dye was known to the Indians since more than five thousand years. It is one of the oldest dyes made by man. Besides the Indians, it was known to the ancient Egyptians and the Phoenicians. Indigo dyeing was one of the earliest specialty professions of the world. The indigo dyers in India were a highly
Indigo dye was known to the Indians since more than five thousand years. It is one of the oldest dyes made by man. Besides the Indians, it was known to the ancient Egyptians and the Phoenicians.

respected class of people. There is evidence that indigo was used during the Mauryan period.

The ingenuity of the ancient Indian artisans who had perfected the technique of manufacturing a precious dye from a common plant and finding ingenious ways of using the dye on cotton and silk fabric is something to be proud of.

The indigo plant Indigofera tinctoria is an insignificant, small, wild herb or shrub that is found in disused fields and vacant plots all over India. However, this plant was the source of ‘Blue Gold’, as the indigo dye was known in the Middle Ages.

Although there are nearly 700 varieties of the Indigo plant, it is the Indigofera tinctoria that gives the largest amount of the dye. All the indigo dye now produced is synthetic, but until early 1900s it was produced using the leaves of the Indigofera tinctoria plant.

To obtain the dye, the indigo plants are cut and steeped in water for 12 hours in vats. The extract, which is a greenish colour, is again poured into vats and fermented. The fermented liquid is stirred vigorously to bring it into contact with oxygen. An insoluble precipitate forms, which is collected and pressed into cubes. Since this process uses vats, it is known as a vat process. This process is very labour intensive and expensive, but, on the other hand, toxic wastes released by this process are minimal compared to the waste released by the synthetic manufacture of indigo.

Since natural indigo dye was insoluble in water, it did not stick to the fabric as most dyestuffs did, and it was a challenge to the dyers. But by reducing it in the presence of an alkali, it can be made to colour the fabric. In an Indigo dye vat, the dye is in solution in an alkaline medium. The fabric to be dyed is immersed in the greenish yellow solution in the vat and taken out. As soon as the indigo molecules come in contact with the oxygen in the air, oxidation takes place, and they change colour to a deep blue. The oxidation traps the molecules in the matrix of the fabric to give it a deep indigo colour. The process is fascinating to watch.

The dye has a long history of usage. The Romans and the Greeks prized the dye that was imported from India. The name Indigo is from the Greek word Indikon, meaning ‘Blue dye from India’. In the Middle Ages, silk from China was dyed by indigo, and so indigo came to be associated with luxury goods from the Orient.

In Japan, indigo was put in a vat where a culture of special anaerobic bacteria was maintained. The vat was kept warm at all times, and the fabric was dipped into the indigo solution in the vat. Japanese tie and die Shibori and Kasuri were made using this technique. The summer kimonos of the Japanese, which were made of cotton, were dyed using indigo. In America, indigo plantations were established in Carolina, and slaves were made to work in them. The indigo dye is still used to colour the blue jeans that are popular among all sections of people.

Until Vasco da Gama discovered the sea route to India, spices and indigo were meant only for the royalty and nobility in Europe. After the discovery of the sea route to India, indigo became a much sought-after commodity in the West. It became the most expensive and fashionable dye in Europe during the time of the Industrial Revolution, and this led the entrepreneurs of the time to acquire large plantations of indigo in India and the West Indies.

It is hard to believe that this common wild plant inspired one of the earliest non-violent movements by the people. Many of the British petty officers of the East India Company bought up land in Bengal and Bihar after their retirement, and started growing indigo. The planters exploited the local farmers of Bengal and amassed great wealth in the 18th and 19th centuries. The farmers were forced to cultivate indigo plants instead of food crops. They were given loans at exorbitant rates of interest by the planters, so that the farmer remained in bondage till his death, and his family after his death.

The inhuman conditions made the farmers revolt against the planters. Farmers belonging to all communities joined in the revolt. The farmer Haji Mulla said that he would rather beg than plant indigo in his farm. When the Biswas brothers took up arms against the planters, the revolt spread like wildfire. It was quickly suppressed by the government and the leaders of the revolt were executed.

But the Indigo Revolt sowed the seeds of a desire for independence and was the precursor to the non-violent Satyagraha movement that brought independence finally to India.

Ms Padma Rao teaches Physics and Mathematics at the National Hill View Public School, Bangalore. Address: 69, 12th Main, Ideal Homes Township, Raja Rajeshwari Nagar, Bangalore-560098; Email: mrvpadma@yahoo.co.in; Blog: http://indianflowersandherbs.blogspot.com