The Bicycle Story

K R Y Simha,

The Bicycle Story
Vijay Gupta
Vigyan Prasar
2001, pp. 39, Rs 25/-.

Present day science and technology is increasingly focussing attention on biological phenomena to extend life and reduce human suffering. Bio-science and bio-technology seem to offer the most exciting research prospects today. It is rather paradoxical that we hardly know anything about ourselves! This ignorance has unleashed many science and technology related problems to our physical and mental health. In favour of bicycling for increasing our health, it is hard to improve upon the profound eloquence of 1912 Medicine Nobel Laureate Dr. Alexis Carrel in *The Man, Unknown*, first published way back in 1935.

The elasticity, strength and adaptiveness of the lower limbs, whose pendulum-like oscillations determine walking and running, have never been equalled by our machines, which only make use of the principle of the wheel. The three levers, articulated on the pelvis, adapt themselves with marvellous suppleness to all postures, efforts, and movements. They carry us on the polished floor of the ballroom and in the chaos of the ice fields, upon the sidewalks of Park Avenue and on the slopes of the Rocky Mountains. They enable us to walk, to run, to fall, to climb, to swim, to wander all over the earth under all conditions …

… It seems that the work of the mind is helped by the rhythmic contractions of the muscles. Certain exercises appear to stimulate thought. For this reason, perhaps, Aristotle and his disciples were in the habit of walking while discussing the fundamental problems of philosophy and science...

Perhaps, Carrel was not thinking about the bicycle. Perhaps, Aristotle and his disciples would have given up their habit of walking if they had some bicycles! Perhaps it is a good idea for school children to learn more about walking, swimming, gardening, bicycling etc., and perhaps learn less about cars, computers, planes, rockets etc. There is no question that computers and rockets provide great excitement and inspiration for young minds, and that activities like swimming and bicycling cause a lot of perspiration. But, let us not forget the famous Edison formula popularized by Einstein: Genius is 99% perspiration and 1% inspiration!!!

Vijay Gupta's *The Bicycle Story* is a mix of some history (10 pages with 16 illustrations), some structural design (15 pages with 24 illustrations), and some bicycling science (11 pages with 7 graphs and 9 illustrations). The history of the bicycle begins with a 1791 French toy made of wood and ends around 1890 with Rover Safety. The basic design of the bicycle has changed little ever since. The second part dealing with bicycle structure

includes wheels, tyres, bearings, chain, freewheel, brakes, gears and frames. The last part is a discussion on the forces involved during different riding situations such as air drag, braking and balancing actions (stability). Thus, this booklet is an essay on the essential bicycle facts and factors that all school children ought to learn as a part of their education.

In summary, the historical facts gathered and the scientific factors discussed make Vijay Gupta's book interesting. But some additional specific information on typical Indian bicycles could make this booklet more useful. Finally, this booklet includes a list of some internet sites, but, sadly and ominously, there is no mention of other bicycle books and articles!

This is rather a disturbing trend in publishing protocol. The internet is ill-advised for elementary education as this medium is fast acquiring all the undesirable qualities of mass media like films and television. Uncensored promotion of the internet has already become a major source of concern in schools and universities. Further, there are serious doubts about the originality and authenticity of internet information. It is indeed high time that the need for internet use for primary education is seriously debated and discussed by teachers, parents and the general public. Of course, some occasional demonstration of internet power is certainly beneficial on young minds. Again turning to Carrel, in *The Man, Unknown:*

There is, indeed, an enormous diversity in the quantity and quality of the intelligence possessed by each one…incomplete and superficial observations, a rapid succession of impressions, multiplicity of images, multiplicity of images, and lack of intellectual discipline hinder the development of mind. We know how unintelligent the children are who live in a crowded city, among multitudes of people and events, in trains and automobiles, in the confusion of the streets, among the absurdities of the cinemas, in schools where intellectual concentration is not required…We are almost totally ignorant of the genesis of intelligence. And we believe that the mind of the children can be developed by the mere training of their memory and by the exercises practised in modern schools!

The value of the days of early childhood is very great. Every moment should be utilised for education. The waste of this period of life can never be compensated. Instead of being allowed to grow like plants or little animals, children should be the object of the most enlightened training. But this training calls for a profound knowledge of physiology and psychology, which modern educators have not yet been given the opportunity of acquiring.

Perhaps the new generation of health- and environment-conscious parents and educators will heed Carrel's advice to rekindle the pursuit of true intelligence in school children, and guard them from superficial 'intelligence' contests conducted by dubious 'quiz masters' for promoting vulgar products and ideas. Perhaps then we can hope to see more of the great minds like Shakespeare, Newton, Einstein, Gandhi, Raman and Ramanujan.

Box 1

In an article for the *Scientific American*, the author (Wilson) compared the mechanical efficiency of the bicycle with that of a man walking and found that the cyclist needs only one fifth of the walker's expenditure of energy to travel three or four times faster. In fact this improves on nature to such an extent that it makes the cyclist the most efficient of all moving animals and machines (Penguin Book, p.79).

An enthusiastic and entertaining article in the *British Medical Journal* by a Medical doctor (Williams) writes: (Penguin Book, p.81) says :

Our patients, the long-suffering and generally under-exercised British public, continue to show such massive unawareness of the bicycle that it becomes a therapeutic duty to contrast for them that this clean, quick, quiet and civilized machine with that oxygen-eating, air-defiling dissipater of energy – my faithful motor car. I say faithful because anything less would be churlish, and it is with real reluctance that I expose to public gaze the imperfections of a family friend. But already the clouds are gathering round the internal combustion engine as we have used it, and we are being forced to consider less wasteful ways of getting ourselves about. For a car uses only 20% of the combustible energy of its fuel in moving forward: 4% goes to essentials such as transmission, dynamo, fan, and water pump, but over 75% is lost as heat – 40% through the exhaust and most of the remaining 35% by conduction and convection through misleadingly called a radiator (the only thing it does hardly at all). The cyclist is altogether more temperate. Indeed from the standpoint of physics, he is not a heat engine at all, but a constant temperature energy converter more analogous to a fuel cell; and his contribution to the increasing entropy of our solar system is commendably small (Penguin Book, p.81).

In the past three years I have traveled 6,000 miles (9660 km) on my bicycle which otherwise I should have done in my car – an average of 8 miles (12.9 km) per working day. The saving in time has been more hours than I can count, in petrol more than 240 gallons (1090 liters), and to the atmosphere 2,000,000 liters of oxygen, 13, 00000 liters of carbon dioxide and 3,00000 liters of carbon monoxide at NTP. Now, 2,000,000 of oxygen sounds a lot but you well say Why the fuss? The earth is large and its atmosphere miles deep; 2,000,000 liters per car compounded for a city the amounts are disturbing. At continental levels they require at least some thought (Penguin Book, p.81).

Transportation beyond bicycle speeds demands power inputs from the environment. Velocity translates directly into power, and soon power needs increase exponentially. In the United States, 22 percent of the energy converted drives vehicles, and another 10 percent keeps roads open for them. The amount of energy is comparable to the total energy-except for domestic heating-required for combined economies of India and China. The energy used in the United States for the sole purpose of driving vehicles built to accelerate beyond bicycle speeds would suffice to add auxiliary motors to about twenty times that many vehicles for the people all over the world who want to move at bicycle speeds and do not or cannot push the pedals because they are sick or old, or because they want to transport a heavy load or move over a great distance, or because they just want to relax. Simply on the basis of equal distribution on a world wide scale, speeds above those obtained by bicycles could be ruled out. It is of course mere fantasy to assume an egalitarian consensus sufficiently

strong to accept such a proposal. At closer inspection though, many communities will find that the very same speed limit necessary for equal distribution of mobility is also very close to the optimum velocity giving maximum value to community life. At 20 mph constant speed Phineas Fogg could have made his trip around the world in half of 80 days. Simulation studies would be useful for exploring imaginative policies that seek optimal liberty with convivial power tools. To whose advantage would Calcutta's traffic flow stabilize if speeds are limited to 10 mph? What price would Peru's military pay for limiting the speed to 20 mph? What gains in equality, activity, health and freedom would result from limiting all other vehicles to the speed of bicycles and sailing ships? (Penguin Book p. 281).

The typical American male devotes more than 1,600 hours a year to his car. He sits in it while it goes and while it stands idling. He parks it and searches for it. He earns the money to put down on it and meet the monthly installments. He works to pay for petrol, tolls, insurance, taxes and tickets. He spends four of his sixteen waking hours on the road or gathering his resources for it. And this figure does not take into account the time consumed by other activities dictated by transport: time spent watching automobile commercial or attending consumer education meetings to improve the quality of the next buy. The model American puts in 1,600 hours to get 7,500 miles: less than five miles per hour. In countries deprived of a transportation industry people manage to do the same walking wherever they want to go and they allocate only 3 to 8 per cent of their society's time budget to traffic instead of 28 per cent. What distinguishes traffic in rich countries from the traffic in poor countries is not more mileage per hour of lifetime for the majority, but more hours of compulsory consumption of high doses of energy, packaged and unequally distributed by the transportation industry. (Penguin Book, p. 283)

Let us hope that school children will continue to enjoy playing with their innocent toys, bicycles and enjoy reading some bicycle books as well. Vijay Gupta's bicycle book is a good start indeed.

There are quite a few interesting bicycle books, but the Penguin book by Watson and Gray is a great inspiration. There is another classic book on bicycle science by Whitt and Wilson. The Penguin book includes interesting anecdotes and excerpts from experienced western writers, but their concerns are rapidly becoming equally relevant and applicable to India as well; some samples are given in *Box* 1.

Suggested Reading

[1] Alexis Carrel, *The Man, Unknown* , Wilco Publishing, 1959.

[2] F R Whitt and D G Wilson, Bicycling Science, MIT Press, 1974.

[3] Roderick Watson and Martin Gray, *The Penguin Book of the Bicycle*, Penguin, 1978.

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A Review – Michael Faraday and the Royal Institution

Vasant Natarajan

Michael Faraday and the Royal Institution
John Meurig Thomas
Institute of Physics Publishing
Bristol & Philadelphia, USA
1997, p. 234.

It is always inspiring to read about the life of a great scientist. This is all the more true when the person you are reading about is one of the founding fathers of modern science, Michael Faraday. Faraday's story is perhaps the most romantic story in the annals of science and it continues to inspire in countless ways. He rose from humble origins as an errand boy to become one of the greatest scientists of all time. Even though he was self-educated and knew practically no mathematics, he introduced one of the most fundamental concepts in modern mathematical physics, the concept of the *'field'*. Today, every schoolchild reads about the magnetic *field*, the electric *field*, or the gravitational *field*, and these concepts are woven very early on into the mathematical foundation of physics. Can you imagine that this was introduced by someone who knew no mathematics!

The book brings alive the story of Faraday's life, his work, and his contributions both to science and to the Royal Institution. It is filled with numerous photographs, drawings, cartoons and figures, all of which present a fascinating picture that offers something for the young student and the practising scientist alike. Reading the book shows you how science is actually done with a behind-the-scenes look at the hard work and long hours involved, and shows that the history of discovery in science is not always a straight and narrow road as finally presented in textbooks. Instead, it is filled with false trails, and hard work and perseverance are necessary to overcome these difficulties.

The book is conveniently divided into sections, each of which provides an insight into a different aspect of Faraday's life. After setting the historical context for his early life, there are separate chapters that cover his rise from an errand boy to becoming Sir Davy's assistant at the Royal Institution, his scientific contributions, his writings, his personal life, and finally his impact on both the Royal Institution and the popularization of science. This last aspect of his life, the fact that he was such a good presenter of the latest discoveries in science and technology to the lay person, is a thread that runs throughout the latter part of the book. He initiated the Christmas Lectures for Children and the Friday Evening Discourses at the Royal Institution for the express purpose of increasing public understanding of science. His remarkable insight and clarity of thought is evident in his writings and that is what made him so successful at presenting science in clear and simple terms. A typical example is his analysis of the supposed forms of lightning, written in a

letter to the Editor of the *Philosophical Magazine*. Not only does this letter elucidate a simple phenomenon and the misinterpretations that are possible, it also demonstrates the elegance of Faraday's writing and his genius in finding good science hidden in everyday phenomena.

The photographs of original apparatuses used by Faraday and some of his illustrations give us a feel for the state of the art during his time. It gives an idea of his genius that he was able to achieve so much with that kind of equipment. His tireless efforts at understanding and explaining a wide range of topics are covered throughout the book. As an example, consider the following anecdote. Sir George Porter was giving a lecture to school students on the chemical bond. In order to demonstrate standing wave patterns, similar to those formed by electrons in atoms, he decided to use the well-known Chladni plate, on which sand accumulates at the nodes when the plate is set into vibration. While doing the demonstration, he noticed something unusual. If he used talcum powder instead of sand, it behaved in an opposite manner and accumulated at the antinodes! He excitedly showed this to a colleague, who calmly said that a full account and explanation of the effect had been published more than a century ago, by none other than Faraday. Note the thoroughness of Faraday's study. In his paper in the *Philosophical Transactions of the Royal Society* (1831), he had described 129 experiments covering all aspects of these vibrating plates. And, in true Faraday style, he had done controlled experiments to *prove* that his explanation was correct. In other words, he hypothesized that the effect was caused by something, but to prove this conclusively he showed that if the cause was removed, the effect also disappeared. What a perfect example of the scientific method of inquiry. I have deliberately withheld the simple but clever explanation, but I hope I have whetted your appetite enough to want to find out more.

What I gained most from reading this book was an insight into the character of Faraday as a person. Often, biographies tend to humanize their subjects and show that great people are subject to the same human foibles as us lesser mortals, given to the same pettiness that seems to occupy most of our lives. But in the case of Faraday, reading about his personal life makes him appear even greater. We should be grateful that he lived at a time when the only mode of long-distance communication was through letters. He left behind a large collection, a sampling of which is presented in the book. What comes through is his tenderness and his rare insight into human nature. Faraday has indeed been acknowledged as one of the greatest thinkers of his time. Einstein repeatedly claimed to be inspired by his thinking on the theoretical basis of physics. And his wisdom is evident in the following statement:

"A philosopher should be a man willing to listen to every suggestion but determined to judge for himself. He should not be biased by appearances,

have no favourite hypothesis, be of no school and in doctrine have no master. He should not be a respecter of persons, but of things. Truth should be his primary object. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of nature."

Profound words for all of us to live by.

The book is a must-read for all lovers of science, from students to scientists. For students, it is the inspiring story of a great scientist with several easy-to-understand illustrations of great scientific experiments. For practising scientists, it has several useful tips on what it takes to do good science and what kind of effort goes into it. For teachers of science, his general comments on *the lecturer's art* are absolutely essential reading. If more of us could follow this lecturing technique, and particularly implement his use of demonstrations and experiments in a lecture, science would become the most popular subject in schools and colleges! But most importantly, the book teaches the importance of popularizing science to the wider public, and shows how a great practitioner was able to explain the latest developments in science to a wide audience. Indeed, this is also the primary motivation of the journal you are reading. The Christmas Lectures were particularly targeted at a young audience of schoolchildren. Today, 175 years after Faraday initiated them, inspiring young minds to have a scientific temper is ever more important. The words of H G Wells, spoken while giving a discourse at the Royal Institution and quoted in the book, could be said equally well today:

"... If we care to look, we can foresee growing knowledge, growing order, and presently a deliberate improvement of the blood and character of the race. And what we can see and imagine gives us a measure and gives us faith for what surpasses the imagination. It is possible to believe that all the past is but the beginning of a beginning, and that all that is and has been is but the twilight of the dawn. It is possible to believe that all that the human mind has ever accomplished is but the dream before the awakening."

Awaken into this new world, my dear young readers!

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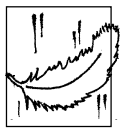
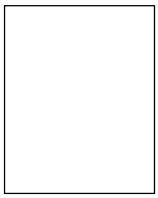


"Keep me away from the wisdom which does not cry, the philosophy which does not laugh, and the greatness which does not bow before children"

Kahlil Gibran
Poet (1883-1931)

The Chemical History of a Candle

H R Madhusudan



The Chemical History of a Candle
Michael Faraday
Vigyan Prasar Reprint, Vigyan Prasar
C-24, Qutab Institutional Area
New Delhi 110 016, India
p.146, Rs. 35/-.

"Without Observations and Experiments our natural philosophy could only be a Science of Terms and an unintelligible jargon."

– J T Desaguliers (1683–1744) in his book *Course of Experimental Philosophy*

Michael Faraday, who had little schooling but excellent education during his tenure as assistant to the famous Humphry Davy, went on to become one of the most effective proponents of science. His masterly exposition of the subjects he spoke on and the well thought out experiments that supported them formed the nucleus around which Faraday successfully conveyed the joy of doing science to the young and the old alike – skills that would have made Desaguliers proud.

The book under review is an excellent material to study not only the chemical history of a candle but to illumine us on Faraday, the supreme observationist and an experimenter par excellence.

The book is, actually, a written record of the six lectures he delivered at the Royal Institution during the Christmas holidays of 1860. Faraday himself had introduced the tradition of Christmas lectures to the 'juvenile auditory', as he put it, in 1826. The same year also saw another great tradition started -– the Friday Evening Discourses. Since then, the two programmes have inspired a number of 'juveniles' to pursue a career in science. And, they continue to this day. So, it is not at all an exaggeration when we hear Humphry Davy, the discoverer of several elements as well as the famous Davy's safety lamp, admit that his greatest discovery was Faraday!

The greatness of Faraday as an articulate speaker and skillful experimenter shines through the book on Candle. The experiments are simple, easy to perform and unambiguous in demonstrating the scientific principles they are intended to. Some of the experiments if introduced in the regular school syllabus would make great impact on the learning outcome. For instance, capillary action is introduced with an experiment involving saturated salt solution and a column of salt crystals. The experiment conveys the concept most dramatically. But, we do not find this experiment in any book even at undergraduate level. It is no wonder that, the topic of candle captured the minds of the young amateur scientists of the time. Faraday, in fact, repeated the lectures on public demand on more than two occasions. The first time was in 1848. The book was published in 1861. Since then, the book has hardly been out of circulation. It tells us two things. That, we may not be most knowledgeable about the

most familiar things. Secondly, that even a commonplace object like a candle, in the hands of a diligent observer can be transformed into matter of scientific curiosity. In fact, Faraday himself sets the tone at the very beginning of the lecture series when he says:

" There is no better, there is no more open door by which you can enter into the study of natural philosophy than by considering the physical phenomena of a candle."

What follows is a wonderful excursion into the history of candle making, the structure and behaviour of the flame, the mechanism by which molten wax is carried to the tip of the wick. There are lots of interesting questions Faraday poses and goes on to answer through excellent demonstrations. The one that illustrates the mechanism of wax rising up the wick is very good. I guess, not many students would be aware of the finer aspects. The wax rising up is much more than the capillary action that is often invoked to answer the question.

Here is a description of the flame by Faraday:

" It is steady and equal, and its general form is that which is represented in the diagram, varying with atmospheric disturbances, and also varying according to the size of the candle. It is bright, oblong, brighter at the top than towards the bottom, with the wick in the middle, and besides the wick in the middle, certain darker parts towards the bottom, where the ignition is not so perfect as in the part above."

Faraday, then goes on to elucidate every observation with further experiments to understand the phenomenon. The interest, intensity and the tempo is more or less the same throughout the six lectures. There is hardly a dull moment in the book. A very wide range of phenomena are covered with a candle as the prop – combustion, factors affecting combustion products of combustion. The experiments leading to identifying the composition of the products of combustion are very interesting and appear easy only after having read them. At the end, one may be left with a feeling , "Well, even I could have thought of these experiments." Make no mistake. Experiments are simple. But, it takes a Faraday to come out with such ideas.

Though all the lectures are good, the last two are very engaging. The fifth lecture dealing with the nature of the atmosphere and its properties and the last one comparing the process of combustion with that of respiration have very good but less popular demonstrations. Faraday sends a powerful message, actually a reminder, when he says:

"So are we made dependent not merely on our fellow-creatures, but upon our fellow existers, all Nature being tied together by the laws that make one part conduce to the good of another."

Vigyan Prasar, which earlier brought to us the reprint of the book on soap bubbles by C V Boys, has done a commendable job in publishing this book. The explanatory notes at the end of the book introducing the reader

to scientists and scientific terms is a good addition.

A couple of suggestions to improve the readability of the book

Faraday uses units of measurements like pints, grains, cubic foot and so on. Conversions of these into the relevant measures in SI system would appeal to students. Secondly, a reference to the diagrams could be given in the text itself. There is also immense scope to introduce new diagrams (not present in the original) to help understand some of the experimental set-up. They are not too difficult to figure out either.

Lastly, an appeal to Vigyan Prasar. They should put efforts to make this book accessible at leading bookshops all over the country. There is no point in having a good book that does not reach the intended audience – the students. Today, the largest sales of the book is not in Great Britain or the US. It is in Japan, where it has been introduced to schoolchildren as an experience in observational science. Schools here could very well emulate the Japanese experiment.

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